



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

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PLAINTIFF'S EXHIBIT

UC-4925

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FUNCTION OF THERMAL INSULATION

The primary function of thermal insulation is to provide substantial resistance to heat flow. For high temperature equipment and piping, the flow is from hot bodies to bodies at a lower temperature or to the ambient air. For low temperature equipment or piping, the heat flow is, of course, in the opposite direction.

Its use in an industrial plant provides the means whereby heat in process pipe and vessels is contained within its boundaries. Conversely, it retards heat from entering low temperature equipment and piping. It is essential not only for economical plant operation, but in some cases it is a basic essential that makes a process possible. In addition to its primary functions, insulation serves to control temperature and condensation and in providing protection from burns to personnel. It also protects pipe and structural steel from external fire.

Because that energy used in processes does have monetary value, and insulation conserves energy, it also conserves money. Properly designed insulation will provide an excellent return on money invested in it.

Besides its use on plant process equipment and piping, thermal insulation is also necessary in buildings. Its functions in buildings are similar to those listed for industrial plants. It serves to conserve energy, control temperature, control condensation, as fire protection and to protect persons from being burned on hot surfaces.

THERMAL INSULATION MANUALS AND STANDARDS

This "THERMAL INSULATION MANUAL - VOLUME 2, DESIGN" presents information to assist in the design of insulation systems for industrial plants of UCC. For convenience it is separated into four sections.

SECTION I presents the theory of heat transfer and mathematical solutions to problems common to industrial plants. It presents the basis for selection of thickness of insulation, information regarding corrosion problem, and information on weather-barrier, vapor barriers, finishes and overcoatings used to protect the insulation from mechanical damage and weather. In addition it contains many tables which are needed by the designer of insulation systems.

SECTION II presents recommendation for selection of one, or more, standard insulation system based on installation requirements. These insulation systems are the individual Material and Application Specifications contained in "THERMAL INSULATION MANUAL - VOLUME 1, SPECIFICATION". They consist of materials specifications for procurement of materials and installation specifications for the application of the materials.



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THERMAL INSULATION MANUALS AND STANDARDS - Continued

SECTION III presents recommended insulation thickness tables. Included are precalculated tables for use of UCC's various locations. Included are tables for insulation thickness to prevent surface condensation, insulation thickness to provide most economical thickness for heat conservation, thickness tables for fire protection, thickness tables to provide safe surface temperature, and thickness tables for steam and electric traced piping.

SECTION IV presents field work sheets for use of field personnel. These work sheets provide space for filling in individual job information, a list of materials needed and a condensed form of application instructions. References to the "THERMAL INSULATION MANUAL - VOLUME 1, SPECIFICATIONS" and "ENGINEERING STANDARDS" are provided so that more detailed information can be obtained from these sources when it is needed.

This "DESIGN MANUAL" provides information necessary for engineering both for new construction and for individual plants needing such information when piping or equipment changes or maintenance requires insulation installations. The "SPECIFICATION MANUAL" provides material specifications for procurement of materials and the application of these materials into an insulated system. The "ENGINEERING STANDARDS" generally supply the information regarding materials and application where the insulation technology must be coordinated with other technologies.



THEORY - HEAT TRANSFER

1. HEAT TRANSFER - GENERAL

Heat is a form of energy. In a state of steady flow, the flow of energy through any medium of transmission is directly proportional to the force causing the flow of the energy, and is inversely proportional to the resistance to the flow.

$$\text{Energy flow:} = \frac{\text{Force causing flow of energy}}{\text{Resistance to flow of energy}}$$

In terms of heat

$$\text{Heat flow:} = \frac{\text{Temperature difference}}{\text{Thermal resistance}}$$

The thermal resistance to the flow of energy through a solid is expressed:

$$\text{Thermal resistance} = \frac{\text{Thickness of the solid}}{\text{Conductivity of the solid}}$$

Therefore, the basic heat transfer formula is:

$$\text{Heat flow} = \frac{\text{Temperature difference}}{\frac{\text{Thickness of the solid}}{\text{Conductivity of the solid}}}$$

Substituting symbols for words:

If q_a	= Heat flow rate (Btu per hour per square foot of surface)
t_1	= Temperature of inner surface of insulation in °F
t_2	= Temperature of outer surface of insulation in °F
$t_1 - t_2$	= Temperature difference in °F
L	= Thickness of insulation in inches
k	= Conductivity of insulation in Btu per square foot, inch thickness, hour, degree F temperature difference

Through one single flat material the equation is:

$$q_a = \frac{t_1 - t_2}{\frac{L}{k}} \quad (\text{Equation 1})$$

Any surface which is of a different temperature than the surrounding air has a film of air next to it through which the temperature varies from the surface temperature to the ambient air temperature. This film has a resistance of $\frac{1}{h}$ to heat flow through where h is the conductance of the air film.

THEORY - HEAT TRANSFER

1. HEAT TRANSFER - GENERAL - Continued

In a state of steady heat flow, all heat flowing to a surface must equal the heat flowing from the surface to ambient air temperature (t_a), thus

$$q_a = \frac{t_1 - t_2}{\frac{L}{k}} = \frac{t_2 - t_a}{\frac{1}{h}} \quad (\text{Equation 2})$$

Or

$$t_2 = q_a \left(\frac{1}{h} \right) + t_a \quad (\text{Equation 2A})$$

When the resistance of insulation is combined with the resistance of an air film, the equation for the heat flow from the inner surface of the insulation to the ambient air is:

$$q_a = \frac{t_1 - t_a}{\frac{L}{k} + \frac{1}{h}} \quad (\text{Equation 3})$$

This is illustrated schematically in Figure 1.

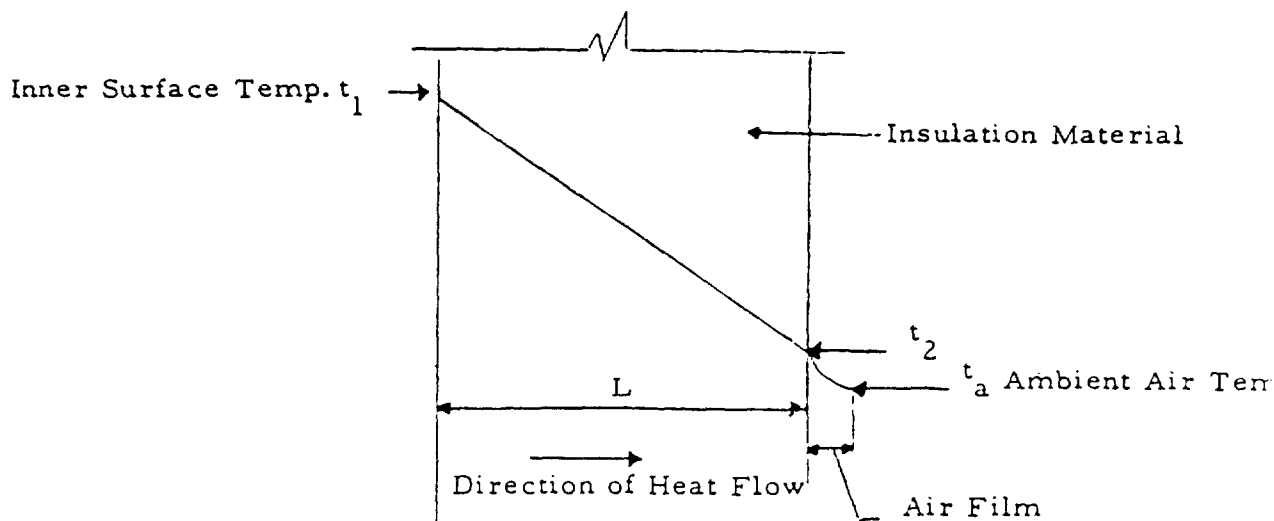


Figure 1

Heat Flow Through One Material and One Air Film

THEORY - HEAT TRANSFER

1. HEAT TRANSFER - GENERAL - Continued

In a similar manner, an equation can be developed with an air film on both sides of the insulation. Let the resistance of the inner air film be designed at $\frac{1}{h_1}$, and the resistance of the outer film as $\frac{1}{h_2}$, and the air temperature on

the inner side as t_i , then

$$q_a = \frac{t_i - t_1}{\frac{1}{h_1}} = \frac{t_1 - t_2}{\frac{L}{k}} = \frac{t_2 - t_a}{\frac{1}{h_2}} \quad (\text{Equation 4})$$

Through one single flat material with an air film on each side, the equation is:

$$q_a = \frac{t_i - t_a}{\frac{1}{h_1} + \frac{L}{k} + \frac{1}{h_2}} \quad (\text{Equation 5})$$

This is illustrated schematically in Figure 2.

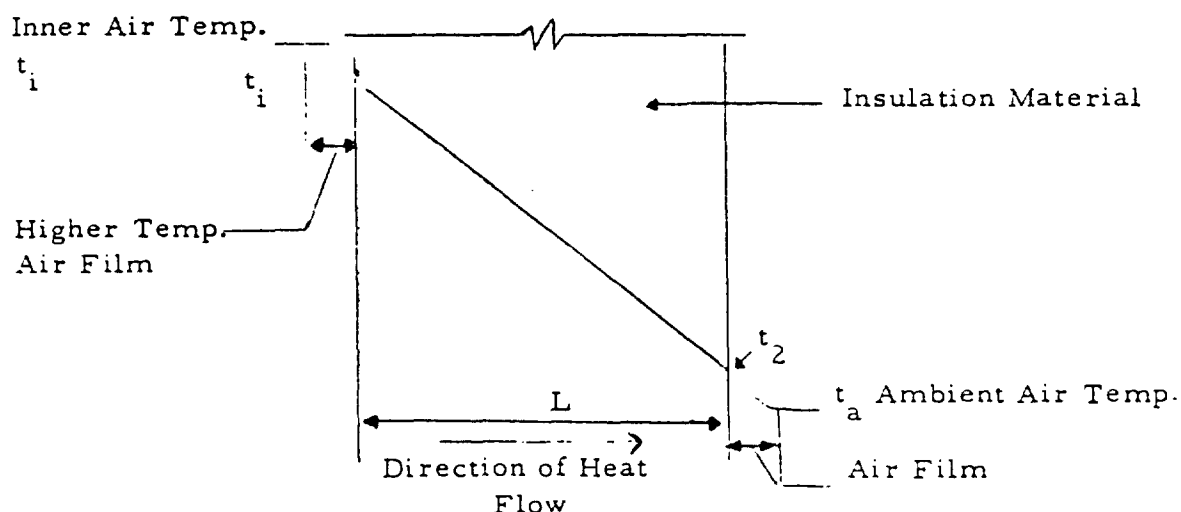


Figure 2
Heat Flow Through One Material and Two Air Films



THEORY - HEAT TRANSFER

1. HEAT TRANSFER - GENERAL - Continued

Heat Transfer Through Two Materials:

In many instances, more than one insulation material is used. Additional materials are then added to the equation in the same manner as was the additional air film.

When	t_i	The air temperature inside the insulation
	t_1	The temperature of the inner surface of the inner insulation
	t_2	The temperatures of the outer surface of the inner insulation and inner surface of the outer insulation
	t_3	The temperature of the outer surface of the outer insulation
	t_a	The outside or ambient air temperature
	L_1	The thickness of the inner insulation
	L_2	The thickness of the outer insulation
	k_1	The conductivity of the inner insulation
	k_2	The conductivity of the outer insulation
	h_1	The conductance of the inner air film
	h_2	The conductance of the outer air film
	q_a	The rate of heat transfer per unit area

Then

$$q_a = \frac{t_i - t_1}{\frac{1}{h_1}} = \frac{t_1 - t_2}{\frac{L_1}{k_1}} = \frac{t_2 - t_3}{\frac{L_2}{k_2}} = \frac{t_3 - t_a}{\frac{1}{h_2}} \quad (\text{Equation 6})$$

Also

$$q_a = \frac{t_i - t_a}{\frac{1}{h_1} + \frac{L_1}{k_1} + \frac{L_2}{k_2} + \frac{1}{h_2}} \quad (\text{Equation 7})$$

The equations so far have all been presented for flat materials with parallel surfaces. Most industrial insulation is applied to cylindrical surfaces. To compensate for the difference between the inner and outer areas, the thickness (L) is converted to "equivalent thickness" in order to obtain the heat transfer per square foot of outer surface. If r_1 equals the inside radius of the insulation material and r_2 equals the outside radius of the insulation, this "equivalent thickness" is represented by the formula

$$r_2 \log_e \frac{r_2}{r_1}$$



THEORY - HEAT TRANSFER

1. HEAT TRANSFER - GENERAL - Continued

Substituting the "equivalent thickness" of curved surfaces for the thickness (L) of flat surfaces, the following equations will be developed:

Through one single cylindrical material

$$q_a = \frac{t_1 - t_2}{\frac{r_2 \text{ Log}_e \frac{r_2}{r_1}}{k}} \quad (\text{Equation 8})$$

Through one single cylindrical material and one air film

$$q_a = \frac{t_1 - t_a}{\frac{r_2 \text{ Log}_e \frac{r_2}{r_1}}{k} + \frac{1}{h}} \quad (\text{Equation 9})$$

Through two cylindrical materials and one air film

$$q_a = \frac{t_1 - t_a}{\frac{r_3 \text{ Log}_e \frac{r_2}{r_1}}{k_1} + \frac{r_3 \text{ Log}_e \frac{r_3}{r_2}}{k_2} + \frac{1}{h}} \quad (\text{Equation 10})$$

When r_1 Inside radius of inner layer of insulation

r_2 Outside radius of inner layer of insulation and inside radius of outer layer of insulation

r_3 Outside radius of outer layer of insulation

Through one single cylindrical material and two air films

$$q_a = \frac{t_1 - t_a}{\frac{1}{h_1} + \frac{r_2 \text{ Log}_e \frac{r_2}{r_1}}{k} + \frac{1}{h_2}} \quad (\text{Equation 11})$$

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THEORY - HEAT TRANSFER

1. HEAT TRANSFER - GENERAL - Continued

Through two cylindrical materials and two air films

$$q_a = \frac{t_i - t_a}{\frac{1}{h_1} + \frac{r_3 \text{Log}_e \frac{r_2}{r_1}}{k_1} + \frac{r_3 \text{Log}_e \frac{r_3}{r_2}}{k_2} + \frac{1}{h_2}} \quad (\text{Equation 12})$$

Also

$$q_a = \frac{t_i - t_1}{\frac{1}{h_1}} = \frac{t_i - t_2}{\frac{r_3 \text{Log}_e \frac{r_2}{r_1}}{k_1}} = \frac{t_2 - t_3}{\frac{r_3 \text{Log}_e \frac{r_3}{r_2}}{k_2}} = \frac{t_3 - t_a}{\frac{1}{h_2}} \quad (\text{Equation 13})$$

For a single cylindrical material and single air film as shown in Equation 9

$$q_a = \frac{t_1 - t_2}{\frac{r_2 \text{Log}_e \frac{r_2}{r_1}}{k}} = \frac{t_2 - t_a}{\frac{1}{h}} = q_{ra} + q_{ca} \text{ or } q_{ra} + q_{cva} \quad (\text{Equation 14})$$

as the case may be

When = Emittance (the emissive power of a surface compared to a black body)

 T_2 = Surface temperature of the insulation, Rankine scale (t_a in °F + 459.6) T_a = Temperature of ambient air, Rankine scale (t_a in °F + 459.6)

By the Stefan-Boltzmann Law, the equation for radiation is

$$q_{ra} = 0.174 \left[\left(\frac{T_2}{100} \right)^4 - \left(\frac{T_a}{100} \right)^4 \right] \quad (\text{Equation 15})$$

The heat transmitted by convection, still air conditions, is determined by Langmuir's equation

$$q_{ca} = 0.296 (t_2 - t_a)^{5/4} \quad (\text{Equation 16})$$



THEORY - HEAT TRANSFER

1. HEAT TRANSFER - GENERAL - Continued

When V = Velocity of air in feet per minute, then the heat transmitted by convection of a velocity (V) is

$$q_{cva} = 0.296 (T_2 - T_a)^{5/4} \left(\frac{V + 68.9}{68.9} \right)^{1/2} \quad (\text{Equation 17})$$

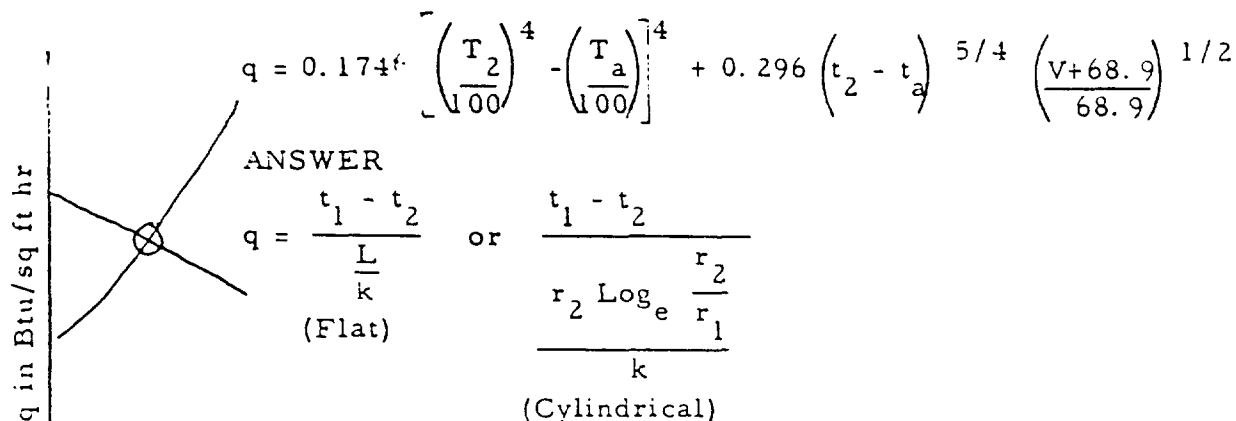
Therefore, for a single cylindrical material with one air film

$$q_a = \frac{t_1 - t_2}{\frac{r_2 \text{ Log}_e \frac{r_2}{r_1}}{k}} = 0.174 \left[\left(\frac{T_2}{100} \right)^4 - \left(\frac{T_a}{100} \right)^4 \right] + 0.296 (t_2 - t_a)^{5/4} \left(\frac{V + 68.9}{68.9} \right)^{1/2} \quad (\text{Equation 18})$$

For two cylindrical materials with one air film

$$q_a = \frac{t_1 - t_3}{\frac{r_3 \text{ Log}_e \frac{r_2}{r_1}}{k_1} + \frac{r_3 \text{ Log}_e \frac{r_3}{r_2}}{k_2}} = 0.174 \left[\left(\frac{T_3}{100} \right)^4 - \left(\frac{T_a}{100} \right)^4 \right] + 0.296 (t_3 - t_a)^{5/4} \left(\frac{V + 68.9}{68.9} \right)^{1/2} \quad (\text{Equation 19})$$

In most instances q_a and t_2 (or t_3), the outer insulation surface temperature, are unknown, so these equations must be solved by trial and error, or by plotting a graph for assumed values of insulation surface temperature. Graphic solution for flat surface and cylindrical surface (18) shown in Figure 3.



°F Assumed Value of Insulation Surface Temperature

FIGURE 3

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THEORY - HEAT TRANSFER

1. HEAT TRANSFER - GENERAL - Continued

Various factors appear in the preceding equations which are used frequently in the calculation of heat transfer. For rapid calculation, the following factors have been determined and tabulated, and are included:

Factor

$$N^4 \quad (N = \text{any number}) \quad (\text{Table 1})$$

$$N^{5/4} \quad (N = \text{any number}) \quad (\text{Table 2})$$

$$0.174 \cdot \left(\frac{T}{100} \right)^4 \quad (\text{Table 3})*$$

$$0.296 (t_2 - t_a)^{5/4} \text{ or } 0.296 (t_3 - t_a)^{5/4} \quad (\text{Table 4})$$

$$\left(\frac{V+68.9}{68.9} \right)^{1/2} \quad (\text{Table 5})$$

$$0.296 (t_1 - t_a)^{5/4} \left(\frac{V+68.9}{68.9} \right)^{1/2} \quad (\text{Table 6})$$

$$r_2 \text{ Log}_e \frac{r_2}{r_1} \text{ for NPS pipe} \quad (\text{Table 7})$$

* In reference to absolute zero



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THEORY - HEAT TRANSFER
FOURTH POWER OF NUMBERS
N = ANY NUMBER

N	N ⁴	N	N ⁴	N	N ⁴	N	N ⁴
0.01	0.00000001	0.67	0.20151121	1.33	3.1290072	1.99	15.682392
0.02	0.00000016	0.68	0.21331376	1.34	3.2241793	2.00	16.000000
0.03	0.00000081	0.69	0.22667121	1.35	3.3215052	2.01	16.322408
0.04	0.00000256	0.70	0.24101000	1.36	3.4210201	2.02	16.649664
0.05	0.00000625	0.71	0.25411681	1.37	3.5227536	2.03	16.981816
0.06	0.00001296	0.72	0.26873356	1.38	3.6267393	2.04	17.318914
0.07	0.00002401	0.73	0.28390241	1.39	3.7330104	2.05	17.661006
0.08	0.00004096	0.74	0.29935576	1.40	3.8416000	2.06	18.008140
0.09	0.00006561	0.75	0.31640625	1.41	3.9525416	2.07	18.360348
0.10	0.00010000	0.76	0.33362176	1.42	4.0658589	2.08	18.717736
0.11	0.00014541	0.77	0.35153041	1.43	4.1816160	2.09	19.080297
0.12	0.00020736	0.78	0.37015056	1.44	4.2998159	2.10	19.448100
0.13	0.00028561	0.79	0.38950081	1.45	4.4205062	2.11	19.821194
0.14	0.00038416	0.80	0.40960000	1.46	4.5437185	2.12	20.199631
0.15	0.00050625	0.81	0.43046721	1.47	4.6694888	2.13	20.583461
0.16	0.00065536	0.82	0.45212176	1.48	4.7978521	2.14	20.972736
0.17	0.00083521	0.83	0.47458321	1.49	4.9288440	2.15	21.367506
0.18	0.00104976	0.84	0.49787136	1.50	5.0625000	2.16	21.767823
0.19	0.00130321	0.85	0.52200625	1.51	5.1988560	2.17	22.173739
0.20	0.00160000	0.86	0.54700816	1.52	5.3379481	2.18	22.585505
0.21	0.00194481	0.87	0.57289761	1.53	5.4798128	2.19	23.002575
0.22	0.00234256	0.88	0.59969536	1.54	5.6244865	2.20	23.425600
0.23	0.00279841	0.89	0.62742241	1.55	5.7720062	2.21	23.854432
0.24	0.00331776	0.90	0.65610000	1.56	5.9224089	2.22	24.289126
0.25	0.00390625	0.91	0.68574961	1.57	6.0757320	2.23	24.729734
0.26	0.00456976	0.92	0.71639296	1.58	6.2330129	2.24	25.176309
0.27	0.00531441	0.93	0.74805201	1.59	6.3912896	2.25	25.628906
0.28	0.00614656	0.94	0.78074896	1.60	6.5536000	2.26	26.087577
0.29	0.00707281	0.95	0.81450625	1.61	6.7189324	2.27	26.552378
0.30	0.00810000	0.96	0.84934656	1.62	6.8874753	2.28	27.023362
0.31	0.00923521	0.97	0.88529281	1.63	7.0591176	2.29	27.500584
0.32	0.01048576	0.98	0.92236816	1.64	7.2339481	2.30	27.984100
0.33	0.01185921	0.99	0.96059601	1.65	7.4120062	2.31	28.473963
0.34	0.01336336	1.00	1.00000000	1.66	7.5933313	2.32	28.970279
0.35	0.01500625	1.01	1.04060400	1.67	7.7779532	2.33	29.472955
0.36	0.01679616	1.02	1.0824321	1.68	7.9659417	2.34	29.982195
0.37	0.01874161	1.03	1.1255088	1.69	8.1573072	2.35	30.498006
0.38	0.02085136	1.04	1.1698585	1.70	8.3521000	2.36	31.020444
0.39	0.02313441	1.05	1.2155062	1.71	8.5503608	2.37	31.549565
0.40	0.02560000	1.06	1.2624769	1.72	8.7521305	2.38	32.085427
0.41	0.02825761	1.07	1.3107960	1.73	8.9574504	2.39	32.628086
0.42	0.03111696	1.08	1.3604889	1.74	9.1663517	2.40	33.177600
0.43	0.03410801	1.09	1.4115816	1.75	9.3789062	2.41	33.734025
0.44	0.03724306	1.10	1.4641000	1.76	9.5951257	2.42	34.297420
0.45	0.04052625	1.11	1.5180704	1.77	9.8150624	2.43	34.867844
0.46	0.04407456	1.12	1.5735193	1.78	10.038758	2.44	35.445352
0.47	0.04789581	1.13	1.6304736	1.79	10.266256	2.45	36.030006
0.48	0.05190416	1.14	1.6889601	1.80	10.497600	2.46	36.621862
0.49	0.05614801	1.15	1.7490062	1.81	10.732831	2.47	37.220980
0.50	0.06250000	1.16	1.8106393	1.82	10.971993	2.48	37.827420
0.51	0.06765201	1.17	1.8738872	1.83	11.215131	2.49	38.441240
0.52	0.07311616	1.18	1.9397777	1.84	11.462227	2.50	39.062500
0.53	0.07890481	1.19	2.0083392	1.85	11.713506	2.51	39.691260
0.54	0.08503056	1.20	2.0796000	1.86	11.968832	2.52	40.327580
0.55	0.09150625	1.21	2.1435888	1.87	12.228309	2.53	40.971520
0.56	0.09834496	1.22	2.2103345	1.88	12.491983	2.54	41.623142
0.57	0.10555601	1.23	2.2808664	1.89	12.759898	2.55	42.282506
0.58	0.11316456	1.24	2.3642137	1.90	13.032100	2.56	42.949672
0.59	0.12111361	1.25	2.4414062	1.91	13.308633	2.57	43.624704
0.60	0.12940000	1.26	2.5204737	1.92	13.589544	2.58	44.307660
0.61	0.13845841	1.27	2.6014464	1.93	13.874880	2.59	44.998605
0.62	0.14776336	1.28	2.6843545	1.94	14.164684	2.60	45.697600
0.63	0.15752761	1.29	2.7692288	1.95	14.459006	2.61	46.404706
0.64	0.16777216	1.30	2.8561000	1.96	14.757890	2.62	47.119987
0.65	0.17850625	1.31	2.9449992	1.97	15.061384	2.63	47.843505
0.66	0.18974736	1.32	3.0359577	1.98	15.369536	2.64	48.575324

TABLE I



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THEORY - HEAT TRANSFER FOURTH POWER OF NUMBERS N = ANY NUMBER

N	N ⁴	N	N ⁴	N	N ⁴	N	N ⁴
2.65	49.315506	3.30	118.59210	3.95	243.43800	4.60	447.74560
2.66	50.064115	3.31	120.03612	3.96	245.91257	4.61	451.65175
2.67	50.821215	3.32	121.49330	3.97	248.40596	4.62	455.58341
2.68	51.586869	3.33	122.96370	3.98	250.91827	4.63	459.54068
2.69	52.361143	3.34	124.44741	3.99	253.44958	4.64	463.52361
2.70	53.144100	3.35	125.94450	4.00	256.00000	4.65	467.53250
2.71	53.935804	3.36	127.45506	4.01	258.56961	4.66	471.56728
2.72	54.736322	3.37	128.97917	4.02	261.15852	4.67	475.62811
2.73	55.545718	3.38	130.51691	4.03	263.76683	4.68	479.71512
2.74	56.364057	3.39	132.06936	4.04	266.39462	4.69	483.82841
2.75	57.191406	3.40	133.63360	4.05	269.04200	4.70	487.96810
2.76	58.027827	3.41	135.21270	4.06	271.70906	4.71	492.13429
2.77	58.873394	3.42	136.80577	4.07	274.39591	4.72	496.32710
2.78	59.728166	3.43	138.41287	4.08	277.10263	4.73	500.54665
2.79	60.592212	3.44	140.03408	4.09	279.82932	4.74	504.79304
2.80	61.465600	3.45	141.66950	4.10	282.57610	4.75	509.06640
2.81	62.348395	3.46	143.31920	4.11	285.34304	4.76	513.36683
2.82	63.240665	3.47	144.98327	4.12	288.13025	4.77	517.69445
2.83	64.142479	3.48	146.66178	4.13	290.93783	4.78	522.04938
2.84	65.053903	3.49	148.35483	4.14	293.76588	4.79	526.43172
2.85	65.975006	3.50	150.06250	4.15	296.61450	4.80	530.84160
2.86	66.905856	3.51	151.78486	4.16	299.48379	4.81	535.27912
2.87	67.846521	3.52	153.52201	4.17	302.37384	4.82	539.74440
2.88	68.797071	3.53	155.27402	4.18	305.28476	4.83	544.23757
2.89	69.757574	3.54	157.04099	4.19	308.21654	4.84	548.75873
2.90	70.728100	3.55	158.82300	4.20	311.16960	4.85	553.30800
2.91	71.708717	3.56	160.62013	4.21	314.14372	4.86	557.88550
2.92	72.699496	3.57	162.43247	4.22	317.13911	4.87	562.49134
2.93	73.700508	3.58	164.26010	4.23	320.15587	4.88	567.12564
2.94	74.711820	3.59	166.10312	4.24	323.19410	4.89	571.78852
2.95	75.733506	3.60	167.96160	4.25	326.25390	4.90	576.48010
2.96	76.765634	3.61	169.83563	4.26	329.33538	4.91	581.20048
2.97	77.808276	3.62	171.72529	4.27	332.43864	4.92	585.94980
2.98	78.861504	3.63	173.63069	4.28	335.56377	4.93	590.72816
2.99	79.925388	3.64	175.55190	4.29	338.71089	4.94	595.53569
3.00	81.000000	3.65	177.48900	4.30	341.88010	4.95	600.37250
3.01	82.085412	3.66	179.44209	4.31	345.07149	4.96	605.23872
3.02	83.181696	3.67	181.41126	4.32	348.28517	4.97	610.13446
3.03	84.288924	3.68	183.39659	4.33	351.52125	4.98	615.05984
3.04	85.407170	3.69	185.39817	4.34	354.77982	4.99	620.01498
3.05	86.536506	3.70	187.41610	4.35	358.06100	5.00	625.00000
3.06	87.677004	3.71	189.45044	4.36	361.36489	5.01	630.01502
3.07	88.828740	3.72	191.50131	4.37	364.69158	5.02	635.06016
3.08	89.991784	3.73	193.56878	4.38	368.04120	5.03	640.13554
3.09	91.166213	3.74	195.65295	4.39	371.41383	5.04	645.24128
3.10	92.352100	3.75	197.75590	4.40	374.80960	5.05	650.37750
3.11	93.549518	3.76	199.87173	4.41	378.22859	5.06	655.54435
3.12	94.758543	3.77	202.00652	4.42	381.67092	5.07	660.74188
3.13	95.979249	3.78	204.15837	4.43	385.13670	5.08	665.97028
3.14	97.211712	3.79	206.32736	4.44	388.62602	5.09	671.22964
3.15	98.456006	3.80	208.51360	4.45	392.13900	5.10	676.52010
3.16	99.712207	3.81	210.71715	4.46	395.67575	5.11	681.84176
3.17	100.98039	3.82	212.93813	4.47	399.23536	5.12	687.19476
3.18	102.26063	3.83	215.17662	4.48	402.82095	5.13	692.57922
3.19	103.55301	3.84	217.43271	4.49	406.42963	5.14	697.99525
3.20	104.85760	3.85	219.70650	4.50	410.06250	5.15	703.44300
3.21	106.17447	3.86	221.99808	4.51	413.71966	5.16	708.92257
3.22	107.50371	3.87	224.30753	4.52	417.40124	5.17	714.43409
3.23	108.84540	3.88	226.63495	4.53	421.10733	5.18	719.97768
3.24	110.19960	3.89	228.98045	4.54	424.83805	5.19	725.55348
3.25	111.56640	3.90	231.34410	4.55	428.59250	5.20	731.16160
3.26	112.94588	3.91	233.72600	4.56	432.37380	5.21	736.80216
3.27	114.33811	3.92	236.12624	4.57	436.17904	5.22	742.47530
3.28	115.74317	3.93	238.54493	4.58	440.00935	5.23	748.18113
3.29	117.16114	3.94	240.98215	4.59	443.86483	5.24	753.91979

TABLE I (Contd)



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
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SECTION I
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THEORY - HEAT TRANSFER
FOURTH POWER OF NUMBERS
N = ANY NUMBER

N	N ⁴	N	N ⁴	N	N ⁴	N	N ⁴
5.25	759.69140	5.91	1219.9721	6.57	1863.2085	7.23	2732.4560
5.26	765.49603	5.92	1228.2501	6.58	1874.5782	7.24	2747.6047
5.27	771.33397	5.93	1236.5701	6.59	1885.9998	7.25	2762.8164
5.28	777.20518	5.94	1244.9324	6.60	1897.4736	7.26	2778.0910
5.29	783.10985	5.95	1253.3370	6.61	1908.9996	7.27	2793.4290
5.30	789.04810	5.96	1261.7840	6.62	1920.5780	7.28	2808.8304
5.31	795.02005	5.97	1270.2737	6.63	1932.2090	7.29	2824.2953
5.32	801.02584	5.98	1278.8062	6.64	1943.8928	7.30	2839.8241
5.33	807.06559	5.99	1287.3815	6.65	1955.6295	7.31	2855.4167
5.34	813.13944	6.00	1296.0000	6.66	1967.4192	7.32	2871.0735
5.35	819.24750	6.01	1304.6616	6.67	1979.2622	7.33	2886.7946
5.36	825.38991	6.02	1313.3665	6.68	1991.1585	7.34	2902.5802
5.37	831.56680	6.03	1322.1150	6.69	2003.1084	7.35	2918.4305
5.38	837.77829	6.04	1330.9071	6.70	2015.1121	7.36	2934.3455
5.39	844.02451	6.05	1339.7430	6.71	2027.1695	7.37	2950.3256
5.40	850.30560	6.06	1348.6227	6.72	2039.2810	7.38	2966.3708
5.41	856.62167	6.07	1357.5466	6.73	2051.4467	7.39	2982.4814
5.42	862.97287	6.08	1366.5147	6.74	2063.6668	7.40	2998.6576
5.43	869.35932	6.09	1375.5271	6.75	2075.9414	7.41	3014.8994
5.44	875.78116	6.10	1384.5841	6.76	2088.2706	7.42	3031.2071
5.45	882.23850	6.11	1393.6856	6.77	2100.6547	7.43	3047.5809
5.46	888.73149	6.12	1402.8320	6.78	2113.0937	7.44	3064.0210
5.47	895.26025	6.13	1412.0234	6.79	2125.5880	7.45	3080.5275
5.48	901.82492	6.14	1421.2598	6.80	2138.1376	7.46	3097.1005
5.49	908.42562	6.15	1430.5415	6.81	2150.7426	7.47	3113.7404
5.50	915.06250	6.16	1439.8685	6.82	2163.4033	7.48	3130.4472
5.51	921.73567	6.17	1449.2411	6.83	2176.1196	7.49	3147.2212
5.52	928.44527	6.18	1458.6594	6.84	2188.8923	7.50	3164.0625
5.53	935.19144	6.19	1468.1235	6.85	2201.7210	7.51	3180.9712
5.54	941.97431	6.20	1477.6336	6.86	2214.6059	7.52	3197.9477
5.55	948.79400	6.21	1487.1898	6.87	2227.5473	7.53	3214.9920
5.56	955.65066	6.22	1496.7922	6.88	2240.5454	7.54	3232.1044
5.57	962.54442	6.23	1506.4412	6.89	2253.6002	7.55	3249.2850
5.58	969.47540	6.24	1516.1366	6.90	2266.7121	7.56	3266.5339
5.59	976.44375	6.25	1525.8789	6.91	2279.8810	7.57	3283.8515
5.60	983.44960	6.26	1535.6679	6.92	2293.1073	7.58	3301.2379
5.61	990.49307	6.27	1545.5041	6.93	2306.3910	7.59	3318.6931
5.62	997.57432	6.28	1555.3873	6.94	2319.7323	7.60	3336.2176
5.63	1004.6934	6.29	1565.3160	6.95	2333.1315	7.61	3353.8113
5.64	1011.8506	6.30	1575.2961	6.96	2346.5886	7.62	3371.4745
5.65	1019.0460	6.31	1585.3218	6.97	2360.1038	7.63	3389.2074
5.66	1026.2796	6.32	1595.3953	6.98	2373.6773	7.64	3407.0102
5.67	1033.5517	6.33	1605.5167	6.99	2387.3093	7.65	3424.8830
5.68	1040.8624	6.34	1615.6862	7.00	2401.0000	7.66	3442.8260
5.69	1048.2118	6.35	1625.9040	7.01	2414.7494	7.67	3460.8394
5.70	1055.6001	6.36	1636.1701	7.02	2428.5578	7.68	3478.9235
5.71	1063.0273	6.37	1646.4848	7.03	2442.4253	7.69	3497.0783
5.72	1070.4936	6.38	1656.8481	7.04	2456.3521	7.70	3515.3041
5.73	1077.9993	6.39	1667.2603	7.05	2470.3385	7.71	3533.6010
5.74	1085.5443	6.40	1677.7216	7.06	2484.3844	7.72	3551.9692
5.75	1093.1289	6.41	1688.2319	7.07	2498.4902	7.73	3570.4090
5.76	1100.7521	6.42	1698.7916	7.08	2512.6559	7.74	3588.9205
5.77	1108.4171	6.43	1709.4007	7.09	2526.8818	7.75	3607.5039
5.78	1116.1211	6.44	1720.0594	7.10	2541.1681	7.76	3626.1593
5.79	1123.8652	6.45	1730.7680	7.11	2555.5148	7.77	3644.8870
5.80	1131.6496	6.46	1741.5264	7.12	2569.9221	7.78	3663.6872
5.81	1139.4742	6.47	1752.3349	7.13	2584.3904	7.79	3682.5599
5.82	1147.3394	6.48	1763.1936	7.14	2598.9196	7.80	3701.5056
5.83	1155.2453	6.49	1774.1038	7.15	2613.5100	7.81	3720.5242
5.84	1163.1919	6.50	1785.0625	7.16	2628.1617	7.82	3739.6160
5.85	1171.1795	6.51	1796.0728	7.17	2642.8749	7.83	3758.7812
5.86	1179.2081	6.52	1807.1341	7.18	2657.6499	7.84	3778.0199
5.87	1187.2779	6.53	1818.2463	7.19	2672.4867	7.85	3797.3325
5.88	1195.3891	6.54	1829.4097	7.20	2687.3856	7.86	3816.7189
5.89	1203.5418	6.55	1840.6245	7.21	2702.3466	7.87	3836.1795
5.90	1211.7361	6.56	1851.8907	7.22	2717.3700	7.88	3855.7145

TABLE I (Contd)

**STANDARD**CHEMICALS AND PLASTICS OPERATIONS DIVISION
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MAY, 1968THEORY - HEAT TRANSFER
FOURTH POWER OF NUMBERS
N = ANY NUMBER

N	N ⁴	N	N ⁴	N	N ⁴	N	N ⁴
7.89	3675.3239	8.55	5343.9755	9.21	7195.1279	9.87	9490.0524
7.90	3895.0081	8.56	5369.0204	9.22	7226.4230	9.88	9528.5710
7.91	3714.7671	8.57	5394.1533	9.23	7257.8302	9.89	9567.2069
7.92	3934.6012	8.58	5419.3743	9.24	7289.3345	9.90	9605.9601
7.93	3954.5106	8.59	5444.6837	9.25	7320.9414	9.91	9644.8309
7.94	3974.4955	8.60	5470.0816	9.26	7352.6509	9.92	9683.8195
7.95	3994.5560	8.61	5495.5682	9.27	7384.4633	9.93	9722.9263
7.96	4014.6923	8.62	5521.1438	9.28	7416.3788	9.94	9762.1513
7.97	4034.9047	8.63	5546.8086	9.29	7448.3976	9.95	9801.4950
7.98	4055.1933	8.64	5572.5627	9.30	7480.5201	9.96	9840.9574
7.99	4075.5583	8.65	5598.4065	9.31	7512.7453	9.97	9880.5389
8.00	4096.0000	8.66	5624.3400	9.32	7545.0765	9.98	9920.2396
8.01	4116.5184	8.67	5650.3635	9.33	7577.5109	9.99	9960.0599
8.02	4137.1138	8.68	5676.4772	9.34	7610.0499		
8.03	4157.7864	8.69	5702.6813	9.35	7642.6935		
8.04	4178.5364	8.70	5728.9761	9.36	7675.4420		
8.05	4199.3640	8.71	5755.3616	9.37	7708.2956		
8.06	4220.2693	8.72	5781.8382	9.38	7741.2546		
8.07	4241.2526	8.73	5808.4061	9.39	7774.3192		
8.08	4262.3140	8.74	5835.0654	9.40	7807.4896		
8.09	4283.4537	8.75	5861.8164	9.41	7840.7660		
8.10	4304.6721	8.76	5888.6592	9.42	7874.1486		
8.11	4325.9691	8.77	5915.5941	9.43	7907.6378		
8.12	4347.3451	8.78	5942.6214	9.44	7941.2337		
8.13	4368.8001	8.79	5969.7411	9.45	7974.9365		
8.14	4390.3345	8.80	5995.9536	9.46	8008.7464		
8.15	4411.9485	8.81	6024.2589	9.47	8042.6639		
8.16	4433.6421	8.82	6051.6574	9.48	8076.6887		
8.17	4455.4156	8.83	6079.1493	9.49	8110.8216		
8.18	4477.2692	8.84	6106.7347	9.50	8145.0625		
8.19	4499.2031	8.85	6134.4140	9.51	8179.4115		
8.20	4521.2176	8.86	6162.1872	9.52	8213.8694		
8.21	4543.3126	8.87	6190.0545	9.53	8248.4358		
8.22	4565.4886	8.88	6218.0163	9.54	8283.1113		
8.23	4587.7457	8.89	6246.0728	9.55	8317.8960		
8.24	4610.0840	8.90	6274.2241	9.56	8352.7901		
8.25	4632.5039	8.91	6302.4704	9.57	8387.7939		
8.26	4655.0054	8.92	6330.8120	9.58	8422.9075		
8.27	4677.5887	8.93	6359.2490	9.59	8458.1314		
8.28	4700.2542	8.94	6387.7818	9.60	8493.4656		
8.29	4723.0019	8.95	6416.4105	9.61	8528.9103		
8.30	4745.8321	8.96	6445.1352	9.62	8564.4659		
8.31	4768.7449	8.97	6473.9564	9.63	8600.1326		
8.32	4791.7406	8.98	6502.8741	9.64	8635.9105		
8.33	4814.8124	8.99	6531.8885	9.65	8671.8000		
8.34	4837.9814	9.00	6561.0000	9.66	8707.8012		
8.35	4861.2270	9.01	6590.2086	9.67	8743.9143		
8.36	4884.5561	9.02	6619.5146	9.68	8780.1397		
8.37	4907.9692	9.03	6648.9183	9.69	8816.4775		
8.38	4931.4663	9.04	6678.4199	9.70	8852.9281		
8.39	4955.0477	9.05	6708.0195	9.71	8889.4915		
8.40	4978.7136	9.06	6737.7173	9.72	8925.1680		
8.41	5002.4641	9.07	6767.5137	9.73	8962.9579		
8.42	5026.2995	9.08	6797.4089	9.74	8999.8615		
8.43	5050.2200	9.09	6827.4029	9.75	9036.8789		
8.44	5074.2257	9.10	6857.4951	9.76	9074.0103		
8.45	5098.3170	9.11	6887.6866	9.77	9111.2561		
8.46	5122.4929	9.12	6917.9808	9.78	9148.6164		
8.47	5146.7567	9.13	6948.3727	9.79	9186.0915		
8.48	5171.1055	9.14	6978.8647	9.80	9223.6816		
8.49	5195.5408	9.15	7009.4570	9.81	9261.3869		
8.50	5220.0625	9.16	7040.1497	9.82	9299.2077		
8.51	5244.6708	9.17	7070.9431	9.83	9337.1443		
8.52	5269.3661	9.18	7101.8374	9.84	9375.1963		
8.53	5294.1485	9.19	7132.8328	9.85	9413.3555		
8.54	5319.0182	9.20	7163.9296	9.86	9451.6506		

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STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
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SECTION I
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THEORY - HEAT TRANSFER
FOURTH POWER OF NUMBERS
N = ANY NUMBER

N	N ⁴	N	N ⁴	N	N ⁴	N	N ⁴
10.0	10000.000	16.6	75933.313	23.2	289702.29	29.8	788615.04
10.1	10406.040	16.7	77779.632	23.3	294729.55	29.9	799253.88
10.2	10824.321	16.8	79659.417	23.4	299821.95	30.0	810000.00
10.3	11255.088	16.9	81573.072	23.5	304980.05	30.1	820854.12
10.4	11698.585	17.0	83521.000	23.6	310204.44	30.2	831816.96
10.5	12155.062	17.1	85503.608	23.7	315495.65	30.3	842889.24
10.6	12624.769	17.2	87521.305	23.8	320854.27	30.4	854071.70
10.7	13107.950	17.3	89574.504	23.9	326280.84	30.5	865365.06
10.8	13604.889	17.4	91663.617	24.0	331776.00	30.6	876770.04
10.9	14115.816	17.5	93789.062	24.1	337340.25	30.7	888287.40
11.0	14641.000	17.6	95951.257	24.2	342974.20	30.8	899917.84
11.1	15180.704	17.7	98150.624	24.3	348678.44	30.9	911662.13
11.2	15735.193	17.8	100387.58	24.4	354453.52	31.0	923521.00
11.3	16304.736	17.9	102662.56	24.5	360300.05	31.1	935495.18
11.4	16889.601	18.0	104976.00	24.6	366218.62	31.2	947585.43
11.5	17490.052	18.1	107328.31	24.7	372209.80	31.3	959792.49
11.6	18106.393	18.2	109719.93	24.8	378274.20	31.4	972117.12
11.7	18738.872	18.3	112151.31	24.9	384412.40	31.5	984560.06
11.8	19387.777	18.4	114622.87	25.0	390525.00	31.6	997122.07
11.9	20053.392	18.5	117135.06	25.1	396912.60	31.7	1009803.9
12.0	20736.000	18.6	119688.32	25.2	403275.80	31.8	1022606.3
12.1	21435.888	18.7	122283.09	25.3	409715.20	31.9	1035530.1
12.2	22153.345	18.8	124919.83	25.4	415231.42	32.0	1048576.0
12.3	22888.664	18.9	127598.98	25.5	420825.06	32.1	1061744.7
12.4	23642.137	19.0	130321.00	25.6	427496.72	32.2	1075037.1
12.5	24414.062	19.1	133086.33	25.7	434247.04	32.3	1088454.0
12.6	25204.737	19.2	135895.44	25.8	441076.60	32.4	1101995.0
12.7	26014.454	19.3	138748.80	25.9	449986.05	32.5	1115664.0
12.8	26843.545	19.4	141646.84	26.0	456976.00	32.6	1129458.8
12.9	27692.288	19.5	144590.06	26.1	464047.06	32.7	1143381.1
13.0	28561.000	19.6	147578.90	26.2	471199.87	32.8	1157431.7
13.1	29449.992	19.7	150613.84	26.3	478435.05	32.9	1171611.4
13.2	30359.577	19.8	153695.36	26.4	485753.24	33.0	1185921.0
13.3	31290.072	19.9	156823.92	26.5	493155.06	33.1	1200361.2
13.4	32241.793	20.0	160000.00	26.6	500641.15	33.2	1214933.0
13.5	33215.062	20.1	163224.08	26.7	508212.15	33.3	1229637.0
13.6	34210.201	20.2	166496.64	26.8	515868.69	33.4	1244474.1
13.7	35227.536	20.3	169818.16	26.9	523611.43	33.5	1259445.0
13.8	36267.393	20.4	173189.14	27.0	531441.00	33.6	1274550.6
13.9	37330.104	20.5	176610.06	27.1	539358.04	33.7	1289791.7
14.0	38416.000	20.6	180081.40	27.2	547363.22	33.8	1305169.1
14.1	39525.416	20.7	183603.68	27.3	555457.18	33.9	1320683.6
14.2	40658.689	20.8	187177.36	27.4	563640.57	34.0	1336336.0
14.3	41816.160	20.9	190802.97	27.5	571914.06	34.1	1352127.0
14.4	42998.169	21.0	194481.00	27.6	580278.27	34.2	1368057.7
14.5	44205.062	21.1	198211.94	27.7	588733.94	34.3	1384128.7
14.6	45437.135	21.2	201996.31	27.8	597281.66	34.4	1400340.8
14.7	46694.288	21.3	205834.61	27.9	605922.12	34.5	1416695.0
14.8	47978.521	21.4	209727.36	28.0	614656.00	34.6	1433192.0
14.9	49288.440	21.5	213675.06	28.1	623483.95	34.7	1449832.7
15.0	50625.000	21.6	217678.23	28.2	632406.65	34.8	1466617.8
15.1	51988.560	21.7	221737.39	28.3	641424.79	34.9	1483548.3
15.2	53379.481	21.8	225853.05	28.4	650539.03	35.0	1500625.0
15.3	54799.128	21.9	230025.75	28.5	659750.06	35.1	1517848.4
15.4	56244.265	22.0	234256.00	28.6	669058.56	35.2	1535220.1
15.5	57720.062	22.1	238544.22	28.7	678465.21	35.3	1552740.2
15.6	59224.609	22.2	242891.26	28.8	687970.71	35.4	1570409.9
15.7	60757.220	22.3	247297.34	28.9	697575.74	35.5	1588230.0
15.8	62320.129	22.4	251763.09	29.0	707281.00	35.6	1606201.3
15.9	63912.896	22.5	256289.06	29.1	717087.17	35.7	1624324.7
16.0	65536.000	22.6	260875.77	29.2	726994.94	35.8	1642601.0
16.1	67189.024	22.7	265523.70	29.3	737005.08	35.9	1661031.2
16.2	68874.753	22.8	270233.62	29.4	747118.00	36.0	1679616.0
16.3	70591.174	22.9	275005.84	29.5	757335.06	36.1	1698356.3
16.4	72339.391	23.0	279841.00	29.6	767656.21	36.2	1717252.9
16.5	74120.642	23.1	284739.63	29.7	778082.75	36.3	1736306.9

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N	N ⁴	N	N ⁴	N	N ⁴	N	N ⁴
36.4	1755519.0	43.1	3450714.9	49.8	6150598.4	56.5	10190460.
36.5	1774890.0	43.2	3482851.7	49.9	6200149.8	56.6	10262796.
36.6	1794420.9	43.3	3515212.5	50.0	6250000.0	56.7	10335517.
36.7	1814112.6	43.4	3547798.2	50.1	6300150.2	56.8	10408624.
36.8	1833965.9	43.5	3580610.0	50.2	6350601.6	56.9	10482118.
36.9	1853981.7	43.6	3613648.9	50.3	6401355.4	57.0	10556001.
37.0	1874161.0	43.7	3646915.8	50.4	6452412.8	57.1	10630273.
37.1	1894504.4	43.8	3680412.0	50.5	6503775.0	57.2	10704936.
37.2	1915013.1	43.9	3714138.3	50.6	6555443.3	57.3	10779993.
37.3	1935687.8	44.0	3748096.0	50.7	6607418.8	57.4	10855443.
37.4	1956529.5	44.1	3782285.9	50.8	6659702.8	57.5	10931289.
37.5	1977539.0	44.2	3816709.2	50.9	6712296.4	57.6	11007531.
37.6	1998717.3	44.3	3851367.0	51.0	6765201.0	57.7	11084171.
37.7	2020065.2	44.4	3886260.2	51.1	6818417.6	57.8	11161211.
37.8	2041583.7	44.5	3921390.0	51.2	6871947.6	57.9	11238652.
37.9	2063273.6	44.6	3956757.5	51.3	6925792.2	58.0	11316496.
38.0	2085136.0	44.7	3992363.6	51.4	6979952.6	58.1	11394742.
38.1	2107171.5	44.8	4028209.5	51.5	7034430.0	58.2	11473394.
38.2	2129381.3	44.9	4064296.3	51.6	7089225.7	58.3	11552453.
38.3	2151766.2	45.0	4100625.0	51.7	7144340.9	58.4	11631919.
38.4	2174327.1	45.1	4137196.6	51.8	7199776.8	58.5	11711795.
38.5	2197065.0	45.2	4174012.4	51.9	7255534.8	58.6	11792081.
38.6	2210080.8	45.3	4211073.3	52.0	7311616.0	58.7	11872779.
38.7	2243075.3	45.4	4248380.5	52.1	7368021.6	58.8	11953891.
38.8	2266349.5	45.5	4285935.0	52.2	7424753.0	58.9	12035418.
38.9	2289804.5	45.6	4323738.0	52.3	7481811.3	59.0	12117361.
39.0	2313441.0	45.7	4361790.4	52.4	7539197.9	59.1	12199721.
39.1	2337260.0	45.8	4400093.5	52.5	7596914.0	59.2	12282501.
39.2	2361262.4	45.9	4438648.3	52.6	7654960.8	59.3	12365701.
39.3	2385449.3	46.0	4477456.0	52.7	7713339.7	59.4	12449324.
39.4	2409821.5	46.1	4516517.5	52.8	7772051.8	59.5	12533370.
39.5	2434380.0	46.2	4555834.1	52.9	7831098.5	59.6	12617840.
39.6	2459125.7	46.3	4595406.8	53.0	7890481.0	59.7	12702737.
39.7	2484059.6	46.4	4635236.7	53.1	7950200.5	59.8	12788062.
39.8	2509182.7	46.5	4675325.0	53.2	8010258.4	59.9	12873815.
39.9	2534495.8	46.6	4715672.8	53.3	8070655.9	60.0	12960000.
40.0	2560000.0	46.7	4756281.1	53.4	8131394.4	60.1	13046616.
40.1	2585696.1	46.8	4797151.2	53.5	8192475.0	60.2	13133665.
40.2	2611585.2	46.9	4838284.1	53.6	8253899.1	60.3	13221150.
40.3	2637668.3	47.0	4879681.0	53.7	8315668.0	60.4	13309071.
40.4	2663944.2	47.1	4921342.9	53.8	8377782.9	60.5	13397430.
40.5	2690420.0	47.2	4963271.0	53.9	8440245.1	60.6	13486227.
40.6	2717090.6	47.3	5005466.5	54.0	8503056.0	60.7	13575466.
40.7	2743959.1	47.4	5047930.4	54.1	8566216.7	60.8	13665147.
40.8	2771026.3	47.5	5090664.0	54.2	8629728.7	60.9	13755271.
40.9	2798293.2	47.6	5133668.3	54.3	8693593.2	61.0	13845841.
41.0	2825761.0	47.7	5176944.5	54.4	8757811.6	61.1	13936456.
41.1	2853430.4	47.8	5220493.8	54.5	8822385.0	61.2	14028320.
41.2	2881302.5	47.9	5264317.2	54.6	8887314.9	61.3	14120234.
41.3	2909378.3	48.0	5308416.0	54.7	8952602.5	61.4	14212598.
41.4	2937658.8	48.1	5352791.2	54.8	9018249.2	61.5	14305415.
41.5	2966145.0	48.2	5397444.0	54.9	9084236.2	61.6	14398685.
41.6	2994837.9	48.3	5442375.7	55.0	9150625.0	61.7	14492411.
41.7	3023738.4	48.4	5487587.3	55.1	9217356.7	61.8	14586594.
41.8	3052847.6	48.5	5533030.0	55.2	9284452.7	61.9	14681235.
41.9	3082166.4	48.6	5578855.0	55.3	9351914.4	62.0	14776336.
42.0	3111596.0	48.7	5624913.4	55.4	9419743.1	62.1	14871898.
42.1	3141437.2	48.8	5671256.4	55.5	9487940.0	62.2	14967922.
42.2	3171391.1	48.9	5717885.2	55.6	9556506.6	62.3	15064412.
42.3	3201558.7	49.0	5764801.0	55.7	9625444.2	62.4	15161366.
42.4	3231941.0	49.1	5812004.8	55.8	9694754.0	62.5	15258789.
42.5	3262539.0	49.2	5859498.0	55.9	9764437.5	62.6	15356679.
42.6	3293353.8	49.3	5907281.6	56.0	9834496.0	62.7	15455041.
42.7	3324386.4	49.4	5955356.9	56.1	9904930.7	62.8	15553873.
42.8	3355637.7	49.5	6003725.0	56.2	9975743.2	62.9	15653180.
42.9	3387108.9	49.6	6052387.2	56.3	10046934.	63.0	15752961.
43.0	3418801.0	49.7	6101344.6	56.4	10118506.	63.1	15853218.

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N	N ⁴	N	N ⁴	N	N ⁴	N	N ⁴
63.2	15953953.	69.8	23736773.	76.4	34070102.	83.0	47458321.
63.3	16055167.	69.9	23873093.	76.5	34248830.	83.1	47687449.
63.4	16156862.	70.0	24010000.	76.6	34428260.	83.2	47917406.
63.5	16259040.	70.1	24147494.	76.7	34608394.	83.3	48148194.
63.6	16361701.	70.2	24285578.	76.8	34789235.	83.4	48379814.
63.7	16464848.	70.3	24424253.	76.9	34970783.	83.5	48612270.
63.8	16568481.	70.4	24563521.	77.0	35153041.	83.6	48845561.
63.9	16672603.	70.5	24703385.	77.1	35336010.	83.7	49079692.
64.0	16777216.	70.6	24843844.	77.2	35519692.	83.8	49314663.
64.1	16882319.	70.7	24984902.	77.3	35704090.	83.9	49550477.
64.2	16987916.	70.8	25126559.	77.4	35889205.	84.0	49787136.
64.3	17094007.	70.9	25268818.	77.5	36075039.	84.1	50024641.
64.4	17200594.	71.0	25411681.	77.6	36261593.	84.2	50262995.
64.5	17307680.	71.1	25555148.	77.7	36448870.	84.3	50502200.
64.6	17415264.	71.2	25699221.	77.8	36636872.	84.4	50742257.
64.7	17523349.	71.3	25843904.	77.9	36825599.	84.5	50983170.
64.8	17631936.	71.4	25989196.	78.0	37015056.	84.6	51224939.
64.9	17741028.	71.5	26135100.	78.1	37205242.	84.7	51467567.
65.0	17850625.	71.6	26281617.	78.2	37396160.	84.8	51711056.
65.1	17950728.	71.7	26428749.	78.3	37587812.	84.9	51955408.
65.2	18051341.	71.8	26576499.	78.4	37780199.	85.0	52200625.
65.3	18152463.	71.9	26724867.	78.5	37973325.	85.1	52446708.
65.4	18254097.	72.0	26873856.	78.6	38167189.	85.2	52693661.
65.5	18406245.	72.1	27023466.	78.7	38361795.	85.3	52941485.
65.6	18518907.	72.2	27173700.	78.8	38557145.	85.4	53190182.
65.7	18632085.	72.3	27324560.	78.9	38753239.	85.5	53439755.
65.8	18745782.	72.4	27476047.	79.0	38950081.	85.6	53690204.
65.9	18859998.	72.5	27628164.	79.1	39147671.	85.7	53941533.
66.0	18974736.	72.6	27780910.	79.2	39346012.	85.8	54193743.
66.1	19089996.	72.7	27934290.	79.3	39545106.	85.9	54446837.
66.2	19205780.	72.8	28088304.	79.4	39744955.	86.0	54700815.
66.3	19322090.	72.9	28242953.	79.5	39945560.	86.1	54955682.
66.4	19438928.	73.0	28398241.	79.6	40146923.	86.2	55211438.
66.5	19556295.	73.1	28554167.	79.7	40349047.	86.3	55468086.
66.6	19674192.	73.2	28710735.	79.8	40551933.	86.4	55725627.
66.7	19792622.	73.3	28867946.	79.9	40755583.	86.5	55984065.
66.8	19911585.	73.4	29025802.	80.0	40960000.	86.6	56243400.
66.9	20031084.	73.5	29184305.	80.1	41165184.	86.7	56503635.
67.0	20151121.	73.6	29343455.	80.2	41371138.	86.8	56764772.
67.1	20271795.	73.7	29503256.	80.3	41577864.	86.9	57026813.
67.2	20392810.	73.8	29663708.	80.4	41785364.	87.0	57289761.
67.3	20514467.	73.9	29824814.	80.5	41993540.	87.1	57553616.
67.4	20636668.	74.0	29986576.	80.6	42202693.	87.2	57818382.
67.5	20759414.	74.1	30148994.	80.7	42412526.	87.3	58084061.
67.6	20882706.	74.2	30312071.	80.8	42623140.	87.4	58350654.
67.7	21006547.	74.3	30475809.	80.9	42834537.	87.5	58618164.
67.8	21130937.	74.4	30640210.	81.0	43046721.	87.6	58886592.
67.9	21255880.	74.5	30805275.	81.1	43259691.	87.7	59155941.
68.0	21381376.	74.6	30971005.	81.2	43473451.	87.8	59426214.
68.1	21507426.	74.7	31137404.	81.3	43688001.	87.9	59697411.
68.2	21634033.	74.8	31304472.	81.4	43903345.	88.0	59969556.
68.3	21761198.	74.9	31472212.	81.5	44119465.	88.1	60242589.
68.4	21888923.	75.0	31640625.	81.6	44336421.	88.2	60516574.
68.5	22017210.	75.1	31809712.	81.7	44554156.	88.3	60791493.
68.6	22146059.	75.2	31979477.	81.8	44772692.	88.4	61067347.
68.7	22275473.	75.3	32149920.	81.9	44992031.	88.5	61344140.
68.8	22405454.	75.4	32321044.	82.0	45212176.	88.6	61621872.
68.9	22536002.	75.5	32492850.	82.1	45433126.	88.7	61900545.
69.0	22667121.	75.6	32665339.	82.2	45654686.	88.8	62180163.
69.1	22798810.	75.7	32838515.	82.3	45877457.	88.9	62460728.
69.2	22931071.	75.8	33012379.	82.4	46100840.	89.0	62742241.
69.3	23063910.	75.9	33186931.	82.5	46325039.	89.1	63024704.
69.4	23197323.	76.0	33362173.	82.6	46550054.	89.2	63308120.
69.5	23331315.	76.1	33538113.	82.7	46775887.	89.3	63592490.
69.6	23465886.	76.2	33714745.	82.8	47002542.	89.4	63877818.
69.7	23601038.	76.3	33892074.	82.9	47229019.	89.5	64164105.

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N	N ⁴	N	N ⁴	N	N ⁴	N	N ⁴
89.6	64451352.	96.2	85644659.	127	260144640.	173	1387488000.
89.7	64739564.	96.3	86001326.	128	268435450.	194	1416468400.
89.8	65028741.	96.4	86359105.	129	276722860.	195	1445900600.
89.9	65316885.	96.5	86718000.	130	285610000.	196	1475789000.
90.0	65610000.	96.6	87078012.	131	294499920.	197	1506138400.
90.1	65902086.	96.7	87439143.	132	303595770.	198	1536953600.
90.2	66195146.	96.8	87801397.	133	312900720.	199	1568239200.
90.3	66489183.	96.9	88164775.	134	322417930.	200	1600000000.
90.4	66784199.	97.0	88529281.	135	332150620.	201	1632240800.
90.5	67080195.	97.1	88894915.	136	342102010.	202	1664966400.
90.6	67377173.	97.2	89261680.	137	352275360.	203	1698181600.
90.7	67675137.	97.3	89629579.	138	362673930.	204	1731891400.
90.8	67974088.	97.4	89998615.	139	373301040.	205	1766100600.
90.9	68274029.	97.5	90368789.	140	384160000.	206	1800814000.
91.0	68574961.	97.6	90740103.	141	395254160.	207	1836036800.
91.1	68876886.	97.7	91112561.	142	406586390.	208	1871773600.
91.2	69179808.	97.8	91486164.	143	418161600.	209	1908029700.
91.3	69483727.	97.9	91860915.	144	429981690.	210	1944810000.
91.4	69788647.	98.0	92236816.	145	442050620.	211	1982119400.
91.5	70094570.	98.1	92613869.	146	454371850.	212	2019963100.
91.6	70401497.	98.2	92992077.	147	466948880.	213	2058346100.
91.7	70709431.	98.3	93371443.	148	479785210.	214	2097273600.
91.8	71018374.	98.4	93751968.	149	492884400.	215	2136750600.
91.9	71328328.	98.5	94133655.	150	506250000.	216	2176782300.
92.0	71639296.	98.6	94516506.	151	519885600.	217	2217373900.
92.1	71951279.	98.7	94900524.	152	533794610.	218	2258530500.
92.2	72264280.	98.8	95285710.	153	547981280.	219	2300257500.
92.3	72578302.	98.9	95672069.	154	562448650.	220	2342560000.
92.4	72893345.	99.0	96059601.	155	577200620.	221	2385443200.
92.5	73209414.	99.1	96448309.	156	592240890.	222	2428912600.
92.6	73526509.	99.2	96838195.	157	607573200.	223	2472973400.
92.7	73844633.	99.3	97229263.	158	623201290.	224	2517630900.
92.8	74163708.	99.4	97621513.	159	639128960.	225	2562890600.
92.9	74483976.	99.5	98014950.	160	655360000.	226	2608757700.
93.0	74805201.	99.6	98409574.	161	671898240.	227	2655237800.
93.1	75127463.	99.7	98805309.	162	688747530.	228	2702336200.
93.2	75450765.	99.8	99202396.	163	705911760.	229	2750058400.
93.3	75775109.	99.9	99600599.	164	723374810.	230	2798410000.
93.4	76100499.	100	100000000.	165	741200520.	231	2847396300.
93.5	76426935.	101	104060400.	166	759333130.	232	2897022900.
93.6	76754420.	102	108243210.	167	777796320.	233	2947295500.
93.7	77082956.	103	112550880.	168	796594170.	234	2998219500.
93.8	77412546.	104	116985850.	169	815730720.	235	3049800600.
93.9	77743192.	105	121550620.	170	835210000.	236	3102044400.
94.0	78074896.	106	126247690.	171	855035080.	237	3154956500.
94.1	78407660.	107	131079500.	172	875213050.	238	3208542700.
94.2	78741486.	108	136048890.	173	895745040.	239	3262808600.
94.3	79076378.	109	141158150.	174	916636170.	240	3317760000.
94.4	79412337.	110	146410000.	175	937890620.	241	3373402500.
94.5	79749365.	111	151807040.	176	959512570.	242	3429742000.
94.6	80087464.	112	157351930.	177	981506240.	243	3486784400.
94.7	80426638.	113	163047250.	178	1003875800.	244	3544535200.
94.8	80766887.	114	168896010.	179	1026625600.	245	3603000500.
94.9	81109216.	115	174900620.	180	1049760000.	246	3662185200.
95.0	81450625.	116	181063930.	181	1073283100.	247	3722098000.
95.1	81794116.	117	187388720.	182	1097129300.	248	3782742000.
95.2	82138694.	118	193877770.	183	1121513100.	249	3844124000.
95.3	82484358.	119	200533920.	184	1146228700.	250	3906250000.
95.4	82831113.	120	207360000.	185	1171350600.	251	3969126000.
95.5	83178960.	121	214358880.	186	1196883200.	252	4032758000.
95.6	83527901.	122	221533450.	187	1222830900.	253	4097152000.
95.7	83877939.	123	228886640.	188	1249198300.	254	4162314200.
95.8	84229075.	124	236421370.	189	1275989800.	255	4228250600.
95.9	84581314.	125	244140620.	190	1303210000.	256	4294967200.
96.0	84934656.	126	252047370.	191	1330863300.	257	4362470400.
96.1	85289103.			192	1358954400.	258	4430766000.

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N	N ⁴	N	N ⁴	N	N ⁴	N	N ⁴
259	4499360500.	324	11019960000.	389	22898045000.	454	42483805000.
260	4569760000.	325	11156440000.	390	23134410000.	455	42859350000.
261	4640470600.	326	11294588000.	391	23372600000.	456	43237380000.
262	4711998700.	327	11433811000.	392	23612624000.	457	43617904000.
263	4784350500.	328	11574317000.	393	23854493000.	458	44000935000.
264	4857532400.	329	11716114000.	394	24098215000.	459	44386485000.
265	4931550600.	330	11859210000.	395	24343800000.	460	44774560000.
266	5006411500.	331	12003612000.	396	24591257000.	461	45165175000.
267	5032121500.	332	12149330000.	397	24840576000.	462	45558341000.
268	5158686900.	333	12295370000.	398	25091827000.	463	45954068000.
269	5236114300.	334	12444741000.	399	25344957000.	464	46352367000.
270	5314410000.	335	12594450000.	400	25600000000.	465	46753250000.
271	5393580400.	336	12745506000.	401	25856961000.	466	47156720000.
272	5473632200.	337	12897917000.	402	26115852000.	467	47562811000.
273	5554571800.	338	13051691000.	403	26376683000.	468	47971512000.
274	5636405700.	339	13206836000.	404	266394452000.	469	48382841000.
275	5719140600.	340	13363360000.	405	26904200000.	470	48796810000.
276	5802732900.	341	13521270000.	406	27170906000.	471	49213429000.
277	5887339400.	342	13680577000.	407	27439591000.	472	49632710000.
278	5972816600.	343	13841287000.	408	27710263000.	473	50054665000.
279	6059221200.	344	14003408000.	409	27982932000.	474	50479304000.
280	6146560000.	345	14166950000.	410	28257610000.	475	50905640000.
281	6234839500.	346	14331920000.	411	28534304000.	476	51336683000.
282	6324066500.	347	14498327000.	412	28813025000.	477	51769445000.
283	6414247900.	348	14666178000.	413	29093783000.	478	52204938000.
284	6505390300.	349	14835483000.	414	29376598000.	479	52643172000.
285	6597500600.	350	15006250000.	415	29661450000.	480	53084160000.
286	6690585600.	351	15178486000.	416	29948379000.	481	53527912000.
287	6784652100.	352	15352701000.	417	30237324000.	482	53974440000.
288	6879707100.	353	15527402000.	418	30528476000.	483	54423757000.
289	6975757400.	354	15704099000.	419	30821664000.	484	54875873000.
290	7072810000.	355	15882300000.	420	31116950000.	485	55330800000.
291	7170871700.	356	16062013000.	421	314141372000.	486	55788550000.
292	7269949600.	357	16243247000.	422	31713911000.	487	56249134000.
293	7370050800.	358	16426010000.	423	32015507000.	488	56712564000.
294	7471182000.	359	16610312000.	424	32319410000.	489	57178852000.
295	7573350600.	360	16796160000.	425	32625390000.	490	57648010000.
296	7676563400.	361	16983563000.	426	32933536000.	491	58120048000.
297	7780827600.	362	17172527000.	427	33243864000.	492	58594980000.
298	7886150400.	363	17363069000.	428	33556377000.	493	59072816000.
299	7992538800.	364	17555190000.	429	33871089000.	494	59553569000.
300	8100000000.	365	17748700000.	430	34188010000.	495	60033750000.
301	8208541200.	366	17944209000.	431	34507149000.	496	60523072000.
302	8318169600.	367	18141126000.	432	34828517000.	497	61013446000.
303	8428892400.	368	18339659000.	433	35152125000.	498	61505984000.
304	8540717000.	369	18539817000.	434	35477982000.	499	62001498000.
305	8653650600.	370	18741610000.	435	35806100000.	500	62500000000.
306	8767700400.	371	18945044000.	436	36136489000.	501	63001502000.
307	8882874000.	372	19150131000.	437	36469153000.	502	63506016000.
308	8999178400.	373	19356870000.	438	36804120000.	503	64013554000.
309	9116621300.	374	19565295000.	439	37141383000.	504	64524120000.
310	9235210000.	375	19775390000.	440	37480960000.	505	65037750000.
311	9354951800.	376	19987173000.	441	37822859000.	506	65554433000.
312	9475854300.	377	20200652000.	442	38167092000.	507	66074188000.
313	9597924900.	378	20415837000.	443	38513670000.	508	66597028000.
314	9721171200.	379	20632736000.	444	38862502000.	509	67122964000.
315	9845600600.	380	20851360000.	445	39213700000.	510	67652010000.
316	9971220700.	381	21071715000.	446	39567575000.	511	68184176000.
317	10098037000.	382	21293813000.	447	39923630000.	512	68719476000.
318	10226063000.	383	21517662000.	448	40282095000.	513	69257922000.
319	10355301600.	384	21743271000.	449	40642763000.	514	69799526000.
320	10485760000.	385	21970650000.	450	41006250000.	515	70344300000.
321	10617447000.	386	22199808000.	451	41371966000.	516	70892257000.
322	10750371000.	387	24430753000.	452	41740124000.	517	71443409000.
323	10884540000.	388	22663495000.	453	422110733000.	518	71997768000.

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N	N ⁴	N	N ⁴	N	N ⁴	N	N ⁴
519	72555348000.	585	117117950000.	651	179607280000.	717	264287490000.
520	73116160000.	586	117920810000.	652	180713410000.	718	265764990000.
521	73680216000.	587	118727790000.	653	181824630000.	719	267248670000.
522	74247530000.	588	119538910000.	654	182940970000.	720	268738560000.
523	74818113000.	589	120354180000.	655	184062450000.	721	270234660000.
524	75391979000.	590	121173610000.	656	185189070000.	722	271737000000.
525	75969140000.	591	121997210000.	657	186320850000.	723	273245600000.
526	76549608000.	592	122825010000.	658	187457820000.	724	274760470000.
527	77133397000.	593	123657010000.	659	188599980000.	725	276281640000.
528	77720518000.	594	124493240000.	660	189747360000.	726	277809100000.
529	78310985000.	595	125333700000.	661	190899960000.	727	279342900000.
530	78904910000.	596	126178400000.	662	192057800000.	728	280883040000.
531	79502005000.	597	127027370000.	663	193220900000.	729	282429530000.
532	80102584000.	598	127880620000.	664	194389380000.	730	283982410000.
533	80706559000.	599	128738150000.	665	195562950000.	731	285541670000.
534	81313944000.	600	129600000000.	666	196741920000.	732	287107350000.
535	81924750000.	601	130466160000.	667	197926220000.	733	288679460000.
536	82538991000.	602	131336650000.	668	199115850000.	734	290258020000.
537	83156680000.	603	132211500000.	669	200310840000.	735	291843050000.
538	83777829000.	604	133090710000.	670	201511210000.	736	293434550000.
539	84402451000.	605	133974300000.	671	202716950000.	737	295032560000.
540	85030560000.	606	134862270000.	672	203928100000.	738	296637080000.
541	85662167000.	607	135754660000.	673	205144670000.	739	298248140000.
542	86297287000.	608	136651470000.	674	206366680000.	740	299865760000.
543	86935932000.	609	137552710000.	675	207594140000.	741	301489940000.
544	87578116000.	610	138458410000.	676	208827060000.	742	303120710000.
545	88223850000.	611	139368560000.	677	210065470000.	743	304758090000.
546	88873149000.	612	140283200000.	678	211309370000.	744	306402100000.
547	89526025000.	613	141202340000.	679	212558800000.	745	308052750000.
548	90182493000.	614	142125980000.	680	213813760000.	746	309710050000.
549	90842563000.	615	143054150000.	681	215074260000.	747	311374040000.
550	91506250000.	616	143986850000.	682	216340330000.	748	313044720000.
551	92173567000.	617	144924110000.	683	217611980000.	749	314722120000.
552	92844527000.	618	145865940000.	684	218889230000.	750	316406250000.
553	93519144000.	619	146812350000.	685	220172100000.	751	318097120000.
554	94197431000.	620	147763360000.	686	221460990000.	752	319794770000.
555	94879400000.	621	148718900000.	687	222754730000.	753	321499200000.
556	95565066000.	622	149679220000.	688	224054540000.	754	323210440000.
557	96254442000.	623	150644120000.	689	225360020000.	755	324928500000.
558	96947540000.	624	151613650000.	690	226671210000.	756	326653390000.
559	97644375000.	625	152587870000.	691	227988100000.	757	328385150000.
560	98344950000.	626	153566790000.	692	229310730000.	758	330123790000.
561	99049307000.	627	154550410000.	693	230639100000.	759	331869310000.
562	99757432000.	628	155538730000.	694	231973230000.	760	333621760000.
563	100469340000.	629	156531800000.	695	233313150000.	761	335381130000.
564	101185060000.	630	157529610000.	696	234658860000.	762	337147450000.
565	101904800000.	631	158532120000.	697	236010380000.	763	338920740000.
566	102627950000.	632	159539530000.	698	237367730000.	764	340701020000.
567	103355170000.	633	160551670000.	699	238730930000.	765	342488300000.
568	104086240000.	634	161568630000.	700	240100000000.	766	344282600000.
569	104821180000.	635	162590400000.	701	241474940000.	767	346083940000.
570	105560010000.	636	163617010000.	702	242855780000.	768	347892350000.
571	106302750000.	637	164648420000.	703	244242530000.	769	349707820000.
572	107049360000.	638	165684310000.	704	245635210000.	770	351530410000.
573	107799930000.	639	166725030000.	705	247033850000.	771	353350100000.
574	108554450000.	640	167772160000.	706	248438440000.	772	355196920000.
575	109312890000.	641	168823190000.	707	249849020000.	773	357040900000.
576	110075310000.	642	169879150000.	708	251265570000.	774	358892050000.
577	110841710000.	643	170940070000.	709	252688180000.	775	360750390000.
578	111612110000.	644	172005940000.	710	254116810000.	776	362615950000.
579	112386520000.	645	173076800000.	711	255551400000.	777	364488700000.
580	113164960000.	646	174152640000.	712	256992210000.	778	366368720000.
581	113947420000.	647	175233470000.	713	258439040000.	779	368255990000.
582	114733940000.	648	176319360000.	714	259891960000.	780	370150560000.
583	115524560000.	649	177410200000.	715	261351000000.	781	372052420000.
584	116319190000.	650	178506250000.	716	262816170000.	782	373961600000.

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N	N ⁴	N	N ⁴	N	N ⁴	N	N ⁴
783	375878120000.	848	517110560000.	913	694837270000.	978	914861640000.
784	377801990000.	849	519554060000.	914	697886470000.	979	918609150000.
785	379732250000.	850	522006250000.	915	700945700000.	980	922368160000.
786	381671890000.	851	524467080000.	916	704014970000.	981	926138690000.
787	383617950000.	852	526936610000.	917	707094310000.	982	929920770000.
788	385571450000.	853	529414850000.	918	710183740000.	983	933714430000.
789	387532390000.	854	531901820000.	919	713283280000.	984	937519680000.
790	389500810000.	855	534397550000.	920	716392960000.	985	941336550000.
791	391476710000.	856	536902040000.	921	719512750000.	986	945165060000.
792	393460120000.	857	539415330000.	922	722642800000.	987	949005240000.
793	395451060000.	858	541937430000.	923	725783020000.	988	952857100000.
794	397449550000.	859	544468370000.	924	728933450000.	989	956720690000.
795	399455600000.	860	547008160000.	925	732094140000.	990	960596010000.
796	401469220000.	861	549556820000.	926	735265090000.	991	964483090000.
797	403490470000.	862	552114380000.	927	738446330000.	992	968381950000.
798	405519330000.	863	554680860000.	928	741637880000.	993	972292630000.
799	407555830000.	864	557256270000.	929	744839760000.	994	976215130000.
800	409600000000.	865	559840650000.	930	748052010000.	995	980149500000.
801	411651840000.	866	562434000000.	931	751274530000.	996	984095740000.
802	413711380000.	867	565036350000.	932	754507650000.	997	988053890000.
803	415778640000.	868	567647720000.	933	757751090000.	998	992023960000.
804	417853640000.	869	570268130000.	934	761004990000.	999	996005990000.
805	419936400000.	870	572897610000.	935	764269350000.		
806	422026930000.	871	575536160000.	936	767544200000.		
807	424125260000.	872	578183820000.	937	770829560000.		
808	426231400000.	873	580840610000.	938	774125460000.		
809	428345370000.	874	583506540000.	939	777431920000.		
810	430467210000.	875	586181640000.	940	780748960000.		
811	432596910000.	876	588865920000.	941	784076600000.		
812	434734510000.	877	591559410000.	942	787414860000.		
813	436880010000.	878	594262140000.	943	790763780000.		
814	439033450000.	879	596974110000.	944	794123370000.		
815	441194850000.	880	599695360000.	945	797493650000.		
816	443364210000.	881	602425890000.	946	800874540000.		
817	445541560000.	882	605165740000.	947	804266380000.		
818	447726920000.	883	607914930000.	948	807668870000.		
819	449920310000.	884	610673470000.	949	811082160000.		
820	452121760000.	885	613441400000.	950	814506250000.		
821	454331260000.	886	616218720000.	951	817941160000.		
822	456548860000.	887	619005450000.	952	821386940000.		
823	458774570000.	888	621801630000.	953	824843280000.		
824	461008400000.	889	624607250000.	954	828311130000.		
825	463250370000.	890	627422410000.	955	831789600000.		
826	465500540000.	891	630247040000.	956	835279010000.		
827	467758970000.	892	633081200000.	957	838779390000.		
828	470025420000.	893	635924900000.	958	842290750000.		
829	472300190000.	894	638778180000.	959	845813140000.		
830	474583210000.	895	641641050000.	960	849346560000.		
831	476874490000.	896	644513520000.	961	852891030000.		
832	479174060000.	897	647395640000.	962	856446590000.		
833	481481940000.	898	650287410000.	963	860013260000.		
834	483798140000.	899	653188850000.	964	863591050000.		
835	486122700000.	900	656100000000.	965	867180000000.		
836	488455610000.	901	659020860000.	966	870780120000.		
837	490796920000.	902	661951460000.	967	874391430000.		
838	493146630000.	903	664891830000.	968	878013970000.		
839	495504770000.	904	667841990000.	969	881647750000.		
840	497871260000.	905	670801950000.	970	885292310000.		
841	500246410000.	906	673771730000.	971	888949150000.		
842	502627950000.	907	676751370000.	972	892616800000.		
843	505020000000.	908	679740800000.	973	896295790000.		
844	507422270000.	909	682740290000.	974	899986150000.		
845	509831700000.	910	685749610000.	975	903687890000.		
846	512249390000.	911	688768860000.	976	907401030000.		
847	514675670000.	912	691798080000.	977	911125610000.		

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N = ANY NUMBER

N	0	1	2	3	4	5	6	7	8	9
0	0.0000	1.0000	2.3784	3.9482	5.6569	7.4767	9.3905	11.386	13.454	15.588
10	17.783	20.033	22.335	24.685	27.081	29.520	32.000	34.519	37.076	39.668
20	42.295	44.955	47.646	50.369	53.121	55.902	58.711	61.547	64.409	67.297
30	70.210	73.148	76.109	79.094	82.101	85.130	88.182	91.254	94.347	97.461
40	100.59	103.75	106.92	110.11	113.32	116.55	119.80	123.06	126.34	129.6
50	132.96	136.29	139.64	143.00	146.38	149.78	153.19	156.62	160.06	163.52
60	166.99	170.48	173.98	177.49	181.02	184.56	188.12	191.69	195.27	198.87
70	202.48	206.10	209.73	213.38	217.04	220.71	224.40	228.09	231.80	235.52
80	239.26	243.00	246.76	250.52	254.30	258.09	261.89	265.70	269.53	273.36
90	277.21	281.06	284.93	288.80	292.69	296.59	300.50	304.41	308.34	312.28
100	316.23	320.19	324.15	328.13	332.12	336.11	340.12	344.14	348.16	352.19
110	356.24	360.29	364.35	368.42	372.50	376.59	380.69	384.80	388.91	393.04
120	397.17	401.31	405.46	409.62	413.79	417.96	422.15	426.34	430.5	434.75
130	438.96	443.19	447.42	451.66	455.91	460.17	464.43	468.71	472.9	477.27
140	481.57	485.87	490.19	494.50	498.83	503.16	507.51	511.85	516.21	520.5
150	524.95	529.32	533.71	538.10	542.50	546.91	551.32	555.74	560.17	564.61
160	569.05	573.50	577.95	582.42	586.89	591.36	595.85	600.34	604.83	609.34
170	613.85	618.37	622.89	627.42	631.96	636.50	641.05	645.60	650.17	654.74
180	669.31	663.89	668.48	673.08	677.68	682.28	686.90	691.52	696.14	700.77
190	705.41	710.05	714.70	719.36	724.02	728.69	733.37	738.04	742.73	747.42
200	752.12	756.82	761.53	766.25	770.97	775.70	780.43	785.17	789.91	794.66
210	799.42	804.18	808.95	813.72	818.50	823.28	828.07	832.87	837.67	842.47
220	847.28	852.10	856.92	861.75	866.58	871.42	876.27	881.11	885.97	890.83
230	895.69	900.56	905.44	910.32	915.21	920.10	925.00	929.90	934.81	939.72
240	944.63	949.56	954.48	959.42	964.36	969.30	974.25	979.30	984.16	989.12
250	994.1	999.1	1004.0	1009.0	1014.0	1019.0	1024.0	1029.0	1034.0	1039.0
260	1044.0	1049.1	1054.1	1059.1	1064.2	1069.2	1074.2	1079.3	1084.3	1089.4
270	1094.5	1099.5	1104.6	1109.7	1114.8	1119.9	1125.0	1130.1	1135.2	1140.3
280	1145.4	1150.5	1155.6	1160.7	1165.9	1171.0	1176.1	1181.3	1186.4	1191.6
290	1196.7	1201.9	1207.1	1212.2	1217.4	1222.6	1227.8	1232.9	1238.1	1243.3
300	1248.5	1253.7	1259.0	1264.2	1269.4	1274.6	1279.8	1285.1	1290.3	1295.5
310	1300.8	1306.0	1311.3	1316.5	1321.8	1327.1	1332.3	1337.6	1342.9	1348.2
320	1353.4	1358.7	1364.0	1369.3	1374.6	1379.9	1385.2	1390.5	1395.9	1401.2
330	1406.5	1411.8	1417.2	1422.5	1427.9	1433.2	1438.5	1443.9	1449.3	1454.6
340	1460.0	1465.4	1470.7	1476.1	1481.5	1486.9	1492.3	1497.7	1503.1	1508.5
350	1513.9	1519.3	1524.7	1530.1	1535.5	1540.9	1546.4	1551.8	1557.2	1562.7
360	1568.1	1573.6	1579.0	1584.5	1589.9	1595.4	1600.9	1606.3	1611.8	1617.3
370	1622.8	1628.2	1633.7	1639.2	1644.7	1650.2	1655.7	1661.2	1666.7	1672.2
380	1677.8	1683.3	1688.8	1694.3	1699.9	1705.4	1710.9	1716.5	1722.0	1727.6
390	1733.1	1738.7	1744.2	1749.8	1755.4	1760.9	1766.5	1772.1	1777.7	1783.3
400	1788.9	1794.4	1800.0	1805.6	1811.2	1816.8	1822.5	1828.1	1833.7	1839.3
410	1844.9	1850.6	1856.2	1861.8	1867.5	1873.1	1878.7	1884.4	1890.0	1895.7
420	1901.3	1907.0	1912.7	1918.3	1924.0	1929.7	1935.4	1941.0	1946.7	1952.4
430	1958.1	1963.8	1969.5	1975.2	1980.9	1986.6	1992.3	1998.0	2003.7	2009.5

TABLE 2



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TABLE X = N TO THE 5/4 POWER
N = ANY NUMBER

N	0	1	2	3	4	5	6	7	8	9
440	2015.2	2020.9	2026.6	2032.4	2038.1	2043.9	2049.6	2055.3	2061.1	2066.8
450	2072.6	2078.4	2084.1	2089.9	2095.7	2101.4	2107.2	2113.0	2118.8	2124.5
460	2130.3	2136.1	2141.9	2147.7	2153.5	2159.3	2165.1	2170.9	2176.7	2182.6
470	2188.4	2194.2	2200.0	2205.9	2211.7	2217.5	2223.4	2229.2	2235.0	2240.9
480	2246.7	2252.6	2258.4	2264.3	2270.2	2276.0	2281.9	2287.8	2293.6	2299.5
490	2305.4	2311.3	2317.2	2323.0	2328.9	2334.8	2340.7	2346.6	2352.5	2358.4
500	2364.4	2370.3	2376.2	2382.1	2388.0	2393.9	2399.9	2405.8	2411.7	2417.7
510	2423.6	2429.5	2435.5	2441.4	2447.4	2453.3	2459.3	2465.3	2471.2	2477.2
520	2483.2	2489.1	2495.1	2501.1	2507.1	2513.0	2519.0	2525.0	2531.0	2537.0
530	2543.0	2549.0	2555.0	2561.0	2567.0	2573.0	2579.0	2585.0	2591.1	2597.1
540	2603.1	2609.1	2616.2	2621.2	2627.2	2633.3	2639.3	2645.4	2651.4	2657.5
550	2663.5	2669.6	2675.6	2681.7	2687.7	2693.8	2699.9	2705.9	2712.0	2718.1
560	2724.2	2730.3	2736.3	2742.4	2748.5	2754.6	2760.7	2766.8	2772.9	2779.0
570	2785.1	2791.2	2797.3	2803.5	2809.6	2815.7	2821.8	2827.9	2834.1	2840.2
580	2846.3	2852.5	2858.6	2864.7	2870.9	2877.0	2883.2	2889.3	2895.5	2901.6
590	2907.8	2914.0	2920.1	2926.3	2932.5	2938.6	2944.8	2951.0	2957.2	2963.4
600	2969.5	2975.7	2981.9	2988.1	2994.3	3000.5	3006.7	3012.9	3019.1	3025.3
610	3031.5	3037.7	3044.0	3050.2	3056.4	3062.6	3068.9	3075.1	3081.3	3087.5
620	3093.8	3100.0	3106.3	3112.5	3118.8	3125.0	3131.3	3137.5	3143.8	3150.0
630	3156.3	3162.5	3168.8	3175.1	3181.4	3187.6	3193.9	3200.2	3206.5	3212.7
640	3219.0	3225.3	3231.6	3237.9	3244.2	3250.5	3256.8	3263.1	3269.4	3275.7
650	3282.0	3288.3	3294.7	3301.0	3307.3	3313.6	3319.9	3326.3	3332.6	3338.9
660	3345.3	3351.6	3357.9	3364.3	3370.6	3377.0	3383.3	3389.7	3396.0	3402.4
670	3408.7	3415.1	3421.5	3427.8	3434.2	3440.6	3446.9	3453.3	3459.7	3466.1
680	3472.5	3478.8	3485.2	3491.6	3498.0	3504.4	3510.8	3517.2	3523.6	3530.0
690	3536.4	3542.8	3549.2	3555.6	3562.0	3568.5	3574.9	3581.3	3587.7	3594.2
700	3600.6	3607.0	3613.4	3619.9	3626.3	3632.8	3639.2	3645.6	3652.1	3658.5
710	3665.0	3671.4	3677.9	3684.4	3690.8	3697.3	3703.7	3710.2	3716.7	3723.2
720	3729.6	3736.1	3742.6	3749.1	3755.5	3762.0	3768.5	3775.0	3781.5	3788.0
730	3794.5	3801.0	3807.5	3814.0	3820.5	3827.0	3833.5	3840.0	3846.5	3853.1
740	3859.6	3866.1	3872.6	3879.1	3885.7	3892.2	3898.7	3905.3	3911.8	3918.3
750	3924.9	3931.4	3938.0	3944.5	3951.1	3957.6	3964.2	3970.7	3977.3	3983.8
760	3990.4	3997.0	4003.5	4010.1	4016.7	4023.2	4029.8	4036.4	4043.0	4049.6
770	4056.1	4062.7	4069.3	4075.9	4082.5	4089.1	4095.7	4102.3	4108.9	4115.5
780	4122.1	4128.7	4135.3	4141.9	4148.5	4155.2	4161.8	4168.4	4175.0	4181.6
790	4188.3	4194.9	4201.5	4208.1	4214.8	4221.4	4228.1	4234.7	4241.3	4248.0
800	4254.6	4261.3	4267.9	4274.6	4281.2	4287.9	4294.6	4301.2	4307.9	4314.5
810	4321.2	4327.9	4334.6	4341.2	4347.9	4354.6	4361.3	4367.9	4374.6	4381.3
820	4388.0	4394.7	4401.4	4408.1	4414.8	4421.5	4428.2	4434.9	4441.6	4448.3
830	4455.0	4461.7	4468.4	4475.1	4481.8	4488.6	4495.3	4502.0	4508.7	4515.5
840	4522.2	4528.9	4535.7	4542.4	4549.1	4555.9	4562.6	4569.3	4576.1	4582.8
850	4589.6	4596.3	4603.1	4609.8	4616.6	4623.4	4630.1	4636.9	4643.6	4650.4
860	4657.2	4663.9	4670.7	4677.5	4684.3	4691.0	4697.8	4704.6	4711.4	4718.2
870	4725.0	4731.8	4738.6	4745.3	4752.1	4758.9	4765.7	4772.5	4779.3	4786.1
880	4793.0	4799.8	4806.6	4813.4	4820.2	4827.0	4833.8	4840.7	4847.5	4854.3

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RADIATION HEAT TRANSFER TABLE

Btu/sq ft, hr to Absolute Zero

TEMPERATURE		EMITTANCE									
(F)	(R)	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
-210	250	6.80	6.12	5.44	4.76	4.08	3.40	2.72	2.04	1.36	0.68
-205	255	7.36	6.62	5.89	5.15	4.41	3.68	2.94	2.21	1.47	0.74
-200	260	7.95	7.16	6.36	5.57	4.77	3.98	3.18	2.39	1.59	0.80
-195	265	8.58	7.72	6.86	6.01	5.15	4.29	3.43	2.57	1.72	0.86
-190	270	9.25	8.32	7.40	6.47	5.55	4.62	3.70	2.77	1.85	0.92
-185	275	9.95	8.96	7.96	6.97	5.97	4.98	3.98	2.99	1.99	1.00
-180	280	10.70	9.63	8.56	7.49	6.42	5.35	4.28	3.21	2.14	1.07
-175	285	11.48	10.33	9.18	8.04	6.89	5.74	4.59	3.44	2.30	1.15
-170	290	12.31	11.08	9.85	8.61	7.38	6.15	4.92	3.69	2.46	1.23
-165	295	13.18	11.86	10.54	9.22	7.91	6.59	5.27	3.95	2.64	1.32
-160	300	14.09	12.68	11.28	9.87	8.46	7.05	5.64	4.23	2.82	1.41
-155	305	15.06	13.55	12.05	10.54	9.03	7.53	6.02	4.52	3.01	1.51
-150	310	16.07	14.46	12.86	11.25	9.64	8.03	6.43	4.82	3.21	1.61
-145	315	17.13	15.42	13.71	11.99	10.28	8.57	6.85	5.14	3.43	1.71
-140	320	18.25	16.42	14.60	12.77	10.95	9.12	7.30	5.47	3.65	1.82
-135	325	19.41	17.47	15.53	13.59	11.65	9.71	7.77	5.82	3.88	1.94
-130	330	20.64	18.57	16.51	14.44	12.38	10.32	8.25	6.19	4.13	2.06
-125	335	21.91	19.72	17.53	15.34	13.15	10.96	8.77	6.57	4.38	2.19
-120	340	23.25	20.93	18.60	16.28	13.95	11.63	9.30	6.98	4.65	2.33
-115	345	24.65	22.19	19.72	17.26	14.79	12.33	9.86	7.40	4.93	2.47
-110	350	26.11	23.50	20.89	18.29	15.67	13.06	10.44	7.83	5.22	2.61
-105	355	27.64	24.87	22.11	19.34	16.58	13.82	11.05	8.29	5.53	2.76
-100	360	29.23	26.30	23.38	20.46	17.54	14.16	11.69	8.77	5.85	2.92
-95	365	30.88	27.79	24.71	21.62	18.53	15.44	12.35	9.26	6.18	3.09
-90	370	32.61	29.35	26.09	22.83	19.57	16.31	13.04	9.78	6.52	3.26
-85	375	34.41	30.97	27.53	24.09	20.65	17.20	13.76	10.32	6.88	3.44
-80	380	36.28	32.65	29.03	25.40	21.77	18.14	14.51	10.88	7.26	3.63
-75	385	38.23	34.41	30.58	26.76	22.94	19.11	15.29	11.47	7.65	3.82
-70	390	40.25	36.23	32.20	28.18	24.15	20.13	16.10	12.08	8.05	4.03
-65	395	42.36	38.12	33.89	29.65	25.41	21.18	16.94	12.71	8.47	4.24
-60	400	44.54	40.09	35.64	31.18	26.73	22.27	17.82	13.36	8.91	4.45
-55	405	46.81	42.13	37.45	32.77	28.09	23.41	18.73	14.04	9.36	4.68
-50	410	49.17	44.25	39.33	34.42	29.50	24.58	19.67	14.75	9.83	4.92
-45	415	51.61	46.45	41.29	36.13	30.97	25.81	20.64	15.48	10.32	5.16
-40	420	54.14	48.73	43.31	37.90	32.49	27.07	21.66	16.24	10.83	5.41
-35	425	56.77	51.09	45.41	39.74	34.06	28.38	22.71	17.03	11.35	5.68
-30	430	59.49	53.54	47.59	41.64	35.69	29.74	23.79	17.85	11.90	5.95
-25	435	62.30	56.07	49.84	43.61	37.38	31.15	24.92	18.69	12.46	6.23
-20	440	65.22	58.70	52.17	45.65	39.13	32.61	26.09	19.57	13.04	6.52
-15	445	68.23	61.41	54.59	47.76	40.94	34.12	27.29	20.47	13.65	6.82
-10	450	71.35	64.22	57.08	49.95	42.81	35.68	28.54	21.41	14.27	7.14
-5	455	74.58	67.12	59.66	52.20	44.75	37.29	29.83	22.37	14.92	7.46
0	460	77.91	70.12	62.33	54.54	46.74	38.95	31.16	23.37	15.58	7.79
5	465	81.35	73.22	65.08	56.95	48.81	40.68	32.54	24.41	16.27	8.14
10	470	84.91	76.42	67.93	59.43	50.94	42.45	33.96	25.47	16.98	8.49
15	475	88.58	79.72	70.86	62.00	53.15	44.29	35.43	26.57	17.72	8.86
20	480	92.37	83.13	73.89	64.66	55.42	46.18	36.95	27.71	18.47	9.24
25	485	96.28	86.65	77.02	67.39	57.77	48.14	38.51	28.88	19.26	9.63
30	490	100.31	90.28	80.25	70.22	60.18	50.15	40.12	30.09	20.06	10.03
35	495	104.46	94.02	83.57	73.13	62.68	52.23	41.79	31.34	20.89	10.45
40	500	108.75	97.88	87.00	76.13	65.25	54.38	43.50	32.63	21.75	10.88
45	505	113.17	101.85	90.53	79.22	67.90	56.58	45.27	33.95	22.63	11.32
50	510	117.71	105.94	94.17	82.40	70.63	58.86	47.09	35.31	23.54	11.77
55	515	122.40	110.16	97.92	85.68	73.44	61.20	48.96	36.72	24.48	12.24
60	520	127.22	114.50	101.78	89.06	76.33	63.61	50.89	38.17	25.44	12.72
65	525	132.19	118.97	105.73	92.53	79.31	66.09	52.87	39.66	26.44	13.22

TABLE 3

Note: For conversion to °C use Temperature Conversion Table Page 218

**STANDARD**CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITEDSECTION I
INSULATION DESIGN
PAGE 28
MAY, 1968THEORY - HEAT TRANSFER
RADIATION HEAT TRANSFER TABLE
Btu/sq ft, hr to Absolute Zero

TEMPERATURE		EMITTANCE									
(F)	(R)	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
70	530	137.29	123.56	109.84	96.11	82.38	68.65	54.92	41.19	27.46	13.73
75	535	142.55	128.29	114.04	99.78	85.53	71.27	57.02	42.76	28.51	14.25
80	540	147.95	133.16	118.36	103.57	88.77	73.98	59.18	44.39	29.59	14.80
85	545	153.51	138.16	122.81	107.46	92.11	76.75	61.40	46.05	30.70	15.35
90	550	159.22	143.30	127.38	111.45	95.53	79.61	63.69	47.77	31.84	15.92
95	555	165.09	148.58	132.07	115.56	99.05	82.55	66.04	49.53	33.02	16.51
100	560	171.12	154.01	136.90	119.78	102.67	85.56	68.45	51.34	34.22	17.11
105	565	177.31	159.58	141.85	124.12	106.39	88.66	70.93	53.19	35.46	17.73
110	570	183.67	165.31	146.94	128.57	110.20	91.84	73.47	55.10	36.73	18.37
115	575	190.20	171.18	152.16	133.14	114.12	95.10	76.08	57.06	38.04	19.02
120	580	196.91	177.22	157.53	137.83	118.14	98.45	78.76	59.07	39.38	19.69
125	585	203.79	183.41	163.03	142.65	122.27	101.89	81.51	61.14	40.76	20.38
130	590	210.84	189.76	168.67	147.59	126.51	105.42	84.34	63.25	42.17	21.08
135	595	218.08	196.27	174.46	152.66	130.85	109.04	87.23	65.42	42.62	21.81
140	600	225.50	202.95	180.40	157.85	135.30	112.75	90.20	67.65	45.10	22.55
145	605	233.12	209.80	186.49	163.18	139.87	116.56	93.25	69.93	46.62	23.31
150	610	240.92	216.83	192.73	168.64	144.55	120.46	96.37	72.28	48.18	24.09
155	615	248.91	224.02	199.13	174.24	149.35	124.46	99.57	74.67	49.73	24.89
160	620	257.11	231.40	205.69	179.98	154.26	128.55	102.84	77.13	51.42	25.71
165	625	265.50	238.95	212.40	185.85	159.30	132.75	106.20	79.65	53.10	26.55
170	630	274.10	246.69	219.58	191.87	164.46	137.05	109.64	82.23	54.82	27.41
175	635	282.91	254.62	226.33	198.04	169.74	141.45	113.16	84.87	56.58	28.29
180	640	291.92	262.73	233.54	204.35	175.15	145.96	116.77	87.58	58.38	29.19
185	645	301.15	271.04	240.92	210.81	180.69	150.58	120.46	90.35	60.23	30.12
190	650	310.60	279.54	248.48	217.42	186.36	155.30	124.24	93.18	62.12	31.06
195	655	320.27	288.24	256.21	224.19	192.16	160.13	128.11	96.08	64.05	32.03
200	660	330.16	297.14	264.13	231.11	198.10	165.08	132.06	99.05	66.03	33.02
210	670	350.6	315.6	280.5	245.4	210.4	175.3	140.3	105.2	70.1	35.1
220	680	372.0	334.8	297.6	260.4	223.2	186.0	148.8	111.6	74.4	37.2
230	690	394.4	355.0	315.5	276.1	236.6	197.2	157.8	118.3	78.9	39.4
240	700	417.8	376.0	334.2	292.4	250.7	208.9	167.1	125.3	83.6	41.8
250	710	442.2	397.9	353.7	309.5	265.3	221.1	176.9	132.6	88.4	44.2
260	720	467.6	420.8	374.1	327.3	280.6	233.8	187.0	140.3	93.5	46.8
270	730	494.1	444.7	395.3	345.9	296.5	247.1	197.7	148.2	98.8	49.4
280	740	521.8	469.6	417.4	365.2	313.1	260.9	208.7	156.5	104.4	52.2
290	750	550.5	495.5	440.4	385.4	330.3	275.3	220.2	165.2	110.1	55.1
300	760	580.5	522.5	464.4	406.4	348.3	290.3	232.2	174.2	116.1	58.1
310	770	611.7	550.5	489.3	428.2	367.0	305.8	244.7	183.5	122.3	61.2
320	780	644.1	579.7	515.2	450.8	386.4	322.0	257.6	193.2	128.8	64.4
330	790	677.7	610.0	542.2	474.4	406.6	338.9	271.1	203.3	135.5	67.8
340	800	712.7	641.4	570.2	498.9	427.6	356.4	285.1	213.8	142.5	71.3
350	810	749.0	674.1	599.2	524.3	449.4	374.5	299.6	224.7	149.8	74.9
360	820	786.7	708.0	629.4	550.7	472.0	393.3	314.7	236.0	157.3	78.7
370	830	825.8	743.2	660.6	578.0	495.5	412.9	330.3	247.7	165.2	82.6
380	840	866.3	779.7	693.0	606.4	519.8	433.1	346.5	259.9	173.3	86.6
390	850	908.3	817.5	726.6	635.8	545.0	454.1	363.3	272.5	181.7	90.8
400	860	951.8	856.6	761.6	666.3	571.1	475.9	380.7	285.5	190.4	95.2
410	870	996.8	897.2	797.5	697.8	598.1	498.4	398.7	299.1	199.4	99.7
420	880	1043.5	939.1	834.8	730.4	626.1	521.7	417.4	313.0	208.7	104.3
430	890	1091.7	982.5	873.4	764.2	655.0	545.9	436.7	327.5	218.3	109.2
440	900	1141.6	1027.5	913.3	799.1	685.0	570.8	456.6	342.5	228.3	114.2
450	910	1193.2	1073.9	954.6	835.2	715.9	596.6	477.3	358.0	238.6	119.3
460	920	1246.5	1121.9	997.2	872.6	747.9	623.3	498.6	374.0	249.3	124.7
470	930	1301.6	1171.4	1041.3	911.1	781.0	650.8	520.6	390.5	260.3	130.2
480	940	1358.5	1222.7	1086.8	951.0	815.1	679.3	543.4	407.6	271.7	135.9
490	950	1417.2	1275.5	1133.8	992.1	850.3	708.6	566.9	425.2	283.4	141.7

TABLE 3 (Contd)

Note: For conversion to °C use Temperature Conversion Table Page 218



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
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SECTION I
INSULATION DESIGN
PAGE 29
MAY, 1968

THEORY - HEAT TRANSFER
RADIATION HEAT TRANSFER TABLE
Btu/sq ft, hr to Absolute Zero

TEMPERATURE		EMITTANCE									
(F)	(R)	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
500	960	1477.9	1330.1	1182.3	1034.5	886.7	738.9	591.1	443.4	295.6	147.8
550	1010	1811.	1630.	1449.	1267.	1086.	905.	543.	543.	362.	181.
600	1060	2197.	1977.	1757.	1538.	1318.	1098.	659.	659.	439.	220.
650	1110	2641.	2377.	2113.	1849.	1585.	1321.	792.	792.	528.	264.
700	1160	3131.	2835.	2520.	2205.	1890.	1575.	945.	945.	630.	313.
750	1210	3730.	3357.	2984.	2611.	2238.	1865.	1119.	1119.	746.	373.
800	1260	4386.	3947.	3508.	3070.	2631.	2193.	1316.	1316.	877.	439.
850	1310	5124.	4612.	4099.	3587.	3075.	2562.	1537.	1537.	1025.	512.
900	1360	5953.	5357.	4762.	4167.	3572.	2976.	1786.	1786.	1191.	595.
950	1410	6877.	6190.	5502.	4814.	4126.	3439.	2063.	2063.	1375.	688.
1000	1460	7906.	7115.	6325.	5534.	4744.	3953.	2372.	2372.	1581.	791.
1050	1510	9046.	8141.	7237.	6332.	5428.	4573.	2714.	2714.	1809.	905.
1100	1560	10305.	9274.	8244.	7213.	6183.	5152.	3091.	3091.	2061.	1030.
1150	1610	11691.	10522.	9353.	8184.	7015.	5846.	3507.	3507.	2338.	1169.
1200	1660	13212.	11891.	10570.	9249.	7927.	6606.	3964.	3964.	2642.	1321.
1250	1710	14878.	13390.	11902.	10414.	8927.	7439.	4463.	4463.	2976.	1488.
1300	1760	16696.	15026.	13356.	11687.	10017.	8348.	5009.	5009.	3339.	1670.
1350	1810	18675.	16808.	14940.	13073.	11205.	9338.	5603.	5603.	3735.	1868.
1400	1860	20826.	18743.	16661.	14578.	12495.	10413.	6248.	6248.	4165.	2083.
1450	1910	23157.	20841.	18526.	16210.	13894.	11579.	6947.	6947.	4631.	2316.
1500	1960	25679.	23111.	20543.	17975.	15407.	12839.	7704.	7704.	5136.	2568.
1550	2010	28401.	25561.	22272.	19881.	17041.	14200.	8520.	8520.	5680.	2840.
1600	2060	31334.	28201.	25067.	21934.	18800.	15667.	9400.	9400.	6267.	3133.
1650	2110	34489.	31040.	27991.	24142.	20693.	17244.	10347.	10347.	6898.	3449.
1700	2160	37876.	34038.	30301.	26513.	22726.	18938.	11363.	11363.	7575.	3788.
1750	2210	41507.	37356.	33205.	29055.	24904.	20753.	12452.	12452.	8301.	4151.
1800	2260	45302.	40853.	36314.	31775.	27235.	22696.	13618.	13618.	9078.	4539.
1850	2310	49345.	44590.	39626.	34681.	29727.	24772.	14863.	14863.	9909.	4954.
1900	2360	53976.	48578.	43180.	37783.	32385.	26988.	16193.	16193.	10795.	5398.
1950	2410	58697.	52827.	46958.	41088.	35218.	29349.	17609.	17609.	11739.	5870.
2000	2460	63722.	57350.	50978.	44605.	38233.	31861.	19117.	19117.	12744.	6372.
2050	2510	69063.	62157.	55250.	48344.	41438.	34531.	20719.	20719.	13813.	6906.
2100	2560	74732.	67259.	59786.	52313.	44839.	37366.	22420.	22420.	14946.	7473.
2150	2610	80744.	72670.	64595.	56521.	48447.	40372.	24223.	24223.	16149.	8074.
2200	2660	87112.	78400.	69689.	60978.	52267.	48556.	26133.	26133.	17422.	8711.
2250	2710	93848.	84463.	75079.	65694.	56309.	46924.	28154.	28154.	18770.	9385.
2300	2760	100968.	90872.	80775.	70678.	60581.	50484.	30291.	30291.	20194.	10097.
2350	2810	108486.	97638.	86789.	75940.	65092.	54243.	32546.	32546.	21697.	10849.
2400	2860	116416.	104775.	93133.	81491.	69850.	58208.	34925.	34925.	23283.	11642.
2450	2910	124773.	112296.	99819.	87341.	74864.	62387.	37432.	37432.	24955.	12477.
2500	2960	133572.	120215.	106858.	93501.	80143.	66786.	40072.	40072.	26714.	13357.
2550	3010	142829.	128546.	114263.	99980.	85697.	71414.	42849.	42849.	28566.	14283.
2600	3060	152558.	137302.	122046.	106791.	91535.	76279.	45767.	45767.	30512.	15256.
2650	3110	162776.	146499.	130221.	113943.	97666.	81308.	48833.	48833.	32555.	16278.
2700	3160	173499.	156149.	138799.	121449.	104100.	86750.	52050.	52050.	34700.	17350.
2750	3210	184744.	166269.	147795.	129320.	110846.	92372.	55423.	55423.	36949.	18474.
2800	3260	196526.	176873.	157221.	137568.	117915.	98263.	58958.	58958.	39305.	19653.
2850	3310	208863.	187977.	167090.	146204.	125318.	104431.	62659.	62659.	41773.	20886.
2900	3360	221772.	199595.	177417.	155240.	133063.	110886.	66532.	66532.	44354.	22177.
2950	3410	235270.	211743.	188216.	164689.	141162.	117635.	70581.	70581.	47054.	23527.
3000	3460	249375.	224438.	199500.	174563.	149625.	124688.	74813.	74813.	49875.	24938.

TABLE 3 (Contd)

Note: For conversion to °C use Temperature Conversion Table Page 218



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION I
INSULATION DESIGN
PAGE 30
MAY, 1968

THEORY - HEAT TRANSFER

RADIATION HEAT TRANSFER TABLE INSULATION TO AIR FOR SURFACE EMITTANCES = 1.0 to 0.1

q_r

Temp. Diff. Sur. To Air	EMITTANCE OF OUTER WEATHER BARRIER OR JACKET IN REFERENCE TO THERMAL BLACK BODY									
	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
2	1.8	1.6	1.4	1.3	1.1	0.9	0.7	0.5	0.4	0.2
4	3.5	3.2	2.8	2.5	2.1	1.8	1.4	1.1	0.7	0.4
6	5.6	5.0	4.5	3.9	3.4	2.8	2.2	1.7	1.1	0.6
8	7.5	6.8	6.0	5.2	4.5	3.8	3.0	2.3	1.5	0.8
10	9.5	8.6	7.6	6.6	5.7	4.8	3.8	2.9	1.9	1.0
15	14.4	13.0	11.5	10.1	8.6	7.2	5.8	4.3	2.9	1.4
20	19.6	17.6	15.7	13.7	11.8	9.8	7.8	5.9	3.9	2.0
25	24.7	22.2	19.8	17.3	14.8	12.4	9.9	7.4	4.9	2.5
30	30.2	27.2	24.2	21.1	18.1	15.1	12.1	9.1	6.1	3.0
35	35.8	32.2	28.6	25.1	21.5	17.9	14.4	10.8	7.2	3.6
40	41.5	37.4	33.2	29.0	24.9	20.8	16.6	12.4	8.3	4.2
45	47.4	42.6	37.9	31.5	28.4	23.7	19.0	14.2	9.5	4.7
50	53.1	47.8	42.4	37.2	31.9	26.6	21.2	15.9	10.6	5.3
60	65.9	59.4	52.7	46.1	39.5	33.0	26.4	19.8	13.2	6.6
70	79.2	71.3	63.3	55.5	47.5	39.6	31.6	23.8	15.8	7.9
80	93.1	83.9	74.4	65.2	55.8	46.6	37.2	27.9	18.6	9.3
90	107.8	97.2	86.3	75.5	64.7	53.9	43.2	32.3	21.6	10.8
100	123.2	111.1	95.5	87.2	73.9	61.6	49.3	37.0	24.6	12.3
110	139.4	125.6	111.5	95.5	83.6	69.7	55.8	41.8	27.9	13.9
120	156.4	141.0	125.1	109.0	93.2	78.2	62.6	45.9	31.3	15.6
130	174.2	157.1	139.3	122.0	104.5	87.1	69.8	52.4	34.8	17.4
140	192.9	173.7	154.0	135.0	115.8	96.5	77.2	57.8	38.6	19.3
150	212.4	191.3	169.9	143.7	127.7	106.2	85.1	63.8	42.6	21.2
160	232.9	209.0	185.5	163.0	139.8	116.5	93.3	70.0	46.7	23.3
170	254.3	229.1	203.5	178.0	152.6	127.2	101.9	76.4	50.8	25.4
180	276.7	249.3	221.1	192.9	166.0	138.4	110.8	83.1	55.4	27.7
190	300.1	270.0	240.0	210.0	180.0	150.0	120.0	90.0	60.0	30.0
200	324.5	292.5	259.5	227.5	194.8	162.3	130.0	97.5	64.8	32.4

TABLE 4



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION I
INSULATION DESIGN
PAGE 31
MAY, 1968

THEORY - HEAT TRANSFER

CONVECTION HEAT TRANSFER FROM HOT SURFACE TO AMBIENT AIR STILL AIR (NATURAL CONVECTION)

Temp. Diff. F	Heat Trans. q_c Btu/s.f., hr.	Temp. Diff. F	Heat Trans. q_c Btu/s.f., hr.	Temp. Diff. F	Heat Trans. q_c Btu/s.f., hr.	Temp. Diff. F	Heat Trans. q_c Btu/s.f., hr.
$t_s - t_a$	$0.296(t_s - t_a)^{\frac{5}{4}} \times C_s$	$t_s - t_a$	$0.296(t_s - t_a)^{\frac{5}{4}} \times C_s$	$t_s - t_a$	$0.296(t_s - t_a)^{\frac{5}{4}} \times C_s$	$t_s - t_a$	$0.296(t_s - t_a)^{\frac{5}{4}} \times C_s$
2	0.70	56	45.50	300	369.2	900	1459
4	1.67	58	47.38	320	400.5	925	1510
6	2.78	60	49.40	340	432.3	950	1561
8	3.92	70	59.90	360	464.3	975	1612
10	5.26	80	70.80	380	496.5	1000	1665
12	6.61	90	82.10	400	529.0	1050	1769
14	8.02	100	93.60	420	562.5	1100	1875
16	9.47	110	105.5	440	596.5	1150	1982
18	10.97	120	117.50	460	630.5	1200	2091
20	12.52	130	130.0	480	664.5	1250	2200
22	14.10	140	142.5	500	700.0	1300	2311
24	15.72	150	155.4	525	744.0	1350	2422
26	17.37	160	168.5	550	788.0	1400	2535
28	19.06	170	181.6	575	833.0	1450	2645
30	20.78	180	195.1	600	879.0	1500	2763
32	22.51	190	209.6	625	925.0	1550	2889
34	24.32	200	222.4	650	971.0	1600	2995
36	26.09	210	235.5	675	10.19	1650	3113
40	27.92	220	250.8	700	1066	1700	3231
42	29.78	230	265.3	725	1113	1750	3350
44	31.62	240	279.3	750	1162	1800	3470
46	33.42	250	294.1	775	1211	1850	3591
48	37.38	260	307.0	800	1259	1900	3713
50	39.32	270	323.8	825	1310	1950	3834
52	41.33	280	337.0	850	1358	2000	3959
54	42.25	290	354.2	875	1407		

C_s = A constant upon size and shape of the surface

C_s = For horizontal cylinders = 1.016

C_s = For long vertical cylinders = 1.235

C_s = For vertical plates = 1.394

C_s = For horizontal plates facing upward = 1.79

C_s = For horizontal plates facing downward = 0.89

(Symbols and Abbreviations on Pages 208-10)

TABLE 5

**STANDARD**CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITEDSECTION I
INSULATION DESIGN
PAGE 32
MAY, 1968

THEORY - HEAT TRANSFER

CONVECTION HEAT TRANSFER TABLE - SLOW CONVECTION CURRENTS

Btu/sq ft, hr

 q_{cu}

CONVECTION VELOCITY

$t_a - t_s$ °F	176 Ft/Min 2 Mi/Hr	352 Ft/Min 4 Mi/Hr	440 Ft/Min 5 Mi/Hr	528 Ft/Min 6 Mi/Hr	704 Ft/Min 8 Mi/Hr	880 Ft/Min 10 Mi/Hr	1056 Ft/Min 12 Mi/Hr	1232 Ft/Min 14 Mi/Hr	1320 Ft/Min 15 Mi/Hr	1408 Ft/Min 16 Mi/Hr
2	1.32	1.74	1.91	2.07	2.35	2.61	2.84	3.05	3.15	3.26
4	3.15	4.14	4.54	4.92	5.60	6.21	6.75	7.29	7.50	7.74
6	5.23	6.86	7.54	8.17	9.31	10.30	11.20	12.06	12.43	12.85
8	7.50	9.84	10.81	11.72	13.35	14.74	16.09	17.32	17.85	18.45
10	9.90	13.00	14.27	15.48	17.60	19.50	21.20	22.84	23.57	24.31
15	16.45	21.60	23.70	25.70	29.27	32.42	35.24	37.97	39.18	40.43
20	23.41	30.73	33.75	36.62	41.76	46.20	50.60	53.98	55.70	57.60
25	31.15	40.83	44.80	48.65	55.40	61.35	66.65	71.80	74.0	76.50
30	39.13	51.30	56.45	61.17	69.64	77.10	83.90	90.30	93.1	96.12
35	47.40	62.25	68.38	74.13	84.40	93.04	101.5	107.3	112.7	116.5
40	56.04	73.58	80.85	87.50	99.70	110.5	120.1	129.3	133.3	137.8
45	65.30	85.30	93.70	101.5	115.5	128.0	139.2	150.0	154.6	159.6
50	74.20	97.30	106.7	115.7	131.8	145.9	158.6	171.0	176.2	181.9
60	93.3	122.1	134.1	145.5	165.5	183.3	199.3	214.9	221.3	228.5
70	112.0	147.0	161.3	175.0	199.1	220.8	239.9	258.3	266.5	275.0
80	133.4	174.9	192.4	208.3	237.1	262.8	285.8	308.0	317.5	327.5
90	154.6	202.9	222.8	241.7	274.9	304.6	331.0	356.8	368.0	379.8
100	176.2	231.9	253.8	275.3	313.2	347.4	377.5	406.5	419.0	433.0
110	198.6	260.7	286.1	310.5	353.2	391.5	425.3	457.0	472.0	487.9
120	220.1	290.4	319.0	346.0	393.7	436.0	474.1	510.0	527.0	544.0
130	243.5	321.0	352.9	382.0	435.4	482.1	524.2	564.0	583.0	601.5
140	268.5	352.0	386.8	419.3	477.2	529.0	575.0	619.0	638.5	659.2
150	292.7	384.0	421.9	457.5	520.7	577.3	627.0	675.0	696.3	719.5
160	317.2	416.4	457.0	496.0	564.2	625.5	680.0	731.0	754.5	779.7
170	342.0	448.4	493.0	534.7	608.3	674.0	733.0	789.0	813.5	838.5
180	367.5	482.1	530.0	574.8	653.3	724.5	787.5	848.0	875.0	903.0
190	393.2	516.0	566.5	615.0	699.6	774.5	843.0	906.5	935.0	966.0
200	409.5	55.05	604.5	655.7	746.0	826.5	899.0	966.5	998.0	1030.0

(Symbols and Abbreviations on Page 208-10)

TABLE 6



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION I
INSULATION DESIGN
PAGE 33
MAY, 1968

THEORY - HEAT TRANSFER

CONVECTION HEAT TRANSFER TABLE - SLOW CONVECTION CURRENTS

Btu/sq ft, hr

q_{cv}

t - t _a ° F	CONVECTION VELOCITY									
	10 Ft/Min .1136 Mi/Hr	20 Ft/Min .2272 Mi/Hr	30 Ft/Min .3408 Mi/Hr	40 Ft/Min .4544 Mi/Hr	50 Ft/Min .5680 Mi/Hr	60 Ft/Min .6816 Mi/Hr	70 Ft/Min .7952 Mi/Hr	80 Ft/Min .9088 Mi/Hr	90 Ft/Min .0224 Mi/Hr	100 Ft/Min 1.1360 Mi/Hr
2	.752	.798	.842	.884	.922	.961	.996	1.033	1.068	1.100
4	1.790	1.900	2.001	2.101	2.195	2.285	2.370	2.457	2.537	2.617
6	2.971	3.157	3.327	3.490	3.648	3.798	3.926	4.081	4.217	4.350
8	4.262	4.530	4.775	5.010	5.233	5.450	5.655	5.860	6.050	6.240
10	5.63	5.98	6.31	6.62	6.90	7.19	7.47	7.74	7.99	8.23
15	9.35	9.94	10.47	10.98	11.45	11.94	12.38	12.83	13.25	13.67
20	13.61	14.44	15.23	16.00	16.70	17.40	18.04	18.70	19.20	19.90
25	17.68	18.78	19.80	20.77	21.70	22.60	23.43	24.28	25.08	25.85
30	22.20	23.61	24.90	26.12	27.29	28.42	29.50	30.54	31.55	32.52
35	26.95	28.62	30.16	31.65	33.05	33.67	35.70	37.00	38.20	39.40
40	31.90	33.85	35.72	37.50	39.13	40.76	42.30	43.80	45.24	46.61
45	36.93	39.22	41.33	43.40	45.30	47.20	48.92	50.70	52.40	54.02
50	42.10	44.70	47.19	49.48	51.68	53.80	55.82	57.83	59.76	61.58
60	52.90	56.18	59.23	62.21	64.93	67.60	70.18	72.70	75.06	77.37
70	64.10	68.05	71.80	75.35	78.70	81.95	85.00	88.10	91.00	93.70
80	75.90	80.50	84.05	90.40	93.10	96.90	100.0	104.0	107.4	110.7
90	87.95	93.30	95.84	103.1	107.7	112.2	116.4	120.6	124.5	128.4
100	100.2	106.2	112.0	117.5	122.8	127.8	132.6	137.5	141.9	146.3
110	112.7	119.7	126.3	132.5	137.1	144.1	149.5	154.9	160.0	164.8
120	125.7	133.5	140.8	147.7	154.4	160.6	166.7	172.8	178.4	183.8
130	139.1	147.7	155.8	163.5	170.7	177.7	184.5	191.1	197.4	203.3
140	152.5	161.9	170.8	179.2	187.0	194.8	202.1	209.5	216.3	223.0
150	166.3	176.5	186.2	195.3	204.0	212.3	220.5	228.2	236.0	243.0
160	180.2	191.3	201.9	211.8	221.0	230.1	239.0	247.5	255.7	263.3
170	194.3	206.3	217.5	228.3	238.4	248.2	257.5	267.0	275.8	284.2
180	208.9	221.8	234.0	245.5	256.3	266.9	277.0	286.9	296.4	305.3
190	223.3	237.1	250.1	262.3	273.9	285.2	296.2	306.9	317.0	326.7
200	238.2	253.0	266.9	280.0	292.2	304.2	315.9	327.2	338.0	348.2

TABLE 6 (Continued)

(Symbols and Abbreviations on Pages 208-210)



THEORY - HEAT TRANSFER

CONVECTION HEAT TRANSFER TABLE - SLOW CONVECTION CURRENTS

Btu/sq ft, hr

q_{cv}

CONVECTION VELOCITY

t - t _o ° F	110 Ft/Min 1.255 Mi/Hr	120 Ft/Min 1.332 Mi/Hr	130 Ft/Min 1.478 Mi/Hr	140 Ft/Min 1.594 Mi/Hr	150 Ft/Min 1.704 Mi/Hr	160 Ft/Min 1.816 Mi/Hr	170 Ft/Min 1.9312 Mi/Hr	180 Ft/Min 2.048 Mi/Hr	190 Ft/Min 2.1584 Mi/Hr	200 Ft/Min 2.2720 Mi/Hr
2	1.132	1.164	1.194	1.224	1.251	1.280	1.309	1.335	1.361	1.388
4	2.695	2.766	2.839	2.910	2.977	3.047	3.112	3.176	3.240	3.302
6	4.531	4.598	4.718	4.840	4.962	5.080	5.171	5.280	5.380	5.480
8	6.420	6.610	6.770	6.940	7.100	7.262	7.420	7.570	7.722	7.878
10	8.47	8.71	8.95	9.16	9.36	9.58	9.79	9.99	10.19	10.39
15	14.07	14.45	14.82	15.20	15.55	15.91	16.25	16.60	16.91	17.25
20	20.62	21.05	21.60	22.15	22.63	23.15	23.67	24.15	24.62	25.10
25	26.62	27.35	28.07	28.79	29.41	30.11	30.75	31.40	32.01	32.64
30	33.50	34.39	35.30	36.18	37.00	37.87	38.70	39.50	40.25	41.05
35	40.60	41.65	42.75	43.83	44.81	45.89	46.87	47.82	48.80	49.76
40	48.00	49.30	50.64	51.90	53.02	54.28	55.45	56.64	57.75	58.82
45	55.60	57.18	58.60	60.13	61.45	62.90	64.20	65.57	66.78	68.13
50	63.40	65.13	66.85	68.53	70.02	71.20	73.24	74.80	76.30	77.70
60	79.62	81.75	84.00	86.05	88.00	90.10	92.00	94.00	95.80	97.60
70	96.50	99.15	101.6	104.2	106.5	109.1	111.4	114.4	116.0	119.2
80	114.0	117.2	120.2	123.3	126.0	129.0	131.7	134.5	137.2	139.8
90	132.2	135.7	139.3	142.9	146.1	149.5	152.7	156.0	158.3	162.0
100	150.7	154.7	158.8	162.9	166.5	170.3	174.0	177.8	180.3	184.7
110	169.7	174.4	179.0	183.5	187.6	191.9	196.1	198.3	204.1	206.0
120	189.3	194.5	199.7	204.5	209.1	214.1	218.7	223.1	227.8	232.0
130	209.3	215.1	220.9	226.2	231.3	236.9	241.9	247.0	251.9	256.8
140	229.5	235.9	242.1	248.0	253.8	259.7	265.2	270.9	276.1	281.3
150	250.2	257.1	264.0	270.5	276.5	283.0	289.0	295.2	301.1	306.8
160	271.2	278.5	286.2	293.1	299.8	306.8	313.5	320.0	326.3	332.5
170	292.7	300.5	307.7	316.1	323.2	330.9	338.0	345.1	351.8	358.5
180	314.3	323.1	331.8	340.0	347.6	355.8	363.3	370.9	378.1	385.5
190	335.2	345.2	354.8	363.2	371.5	380.2	388.3	396.5	404.4	412.2
200	358.5	368.4	378.2	387.5	396.1	402.8	414.0	422.8	431.3	439.6

(Symbols and Abbreviations on Pages 208-210

TABLE 6 (Continued)



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION I
INSULATION DESIGN
PAGE 35
MAY, 1968

THEORY - HEAT TRANSFER

CONVECTION HEAT TRANSFER TABLE - FAST CONVECTION CURRENTS Btu/sq ft, hr

CONVECTION VELOCITY

t - t _a ° F	1584 Ft/Min 18 Mi/Hr	1760 Ft/Min 20 Mi/Hr	1935 Ft/Min 22 Mi/Hr	2112 Ft/Min 24 Mi/Hr	2200 Ft/Min 25 Mi/Hr	2288 Ft/Min 26 Mi/Hr	2464 Ft/Min 28 Mi/Hr	2640 Ft/Min 30 Mi/Hr	3080 Ft/Min 35 Mi/Hr	3520 Ft/Min 40 Mi/Hr	4000 Ft/Min 50 Mi/Hr
2	3.44	3.62	3.79	3.95	4.03	4.11	4.26	4.40	4.75	5.07	5.66
4	8.19	8.61	9.02	9.41	9.60	9.78	10.13	10.47	11.29	12.18	13.45
6	13.57	14.30	14.95	15.67	15.91	16.24	16.81	17.39	18.75	20.02	22.20
8	19.50	20.52	21.50	22.40	22.88	23.30	24.15	25.00	26.94	28.77	32.10
10	25.73	27.08	28.32	29.58	30.20	30.75	31.85	32.93	35.53	37.95	42.30
15	42.60	45.00	47.10	49.12	50.15	51.08	53.00	54.70	59.00	63.10	70.40
20	60.90	64.10	67.10	70.00	71.30	72.70	75.40	78.00	83.90	89.50	100.10
25	81.00	85.20	89.15	93.00	94.90	96.70	101.8	103.5	111.6	119.3	133.0
30	101.8	107.0	112.0	116.90	119.3	121.5	125.9	129.2	140.3	150.0	167.3
35	123.2	129.6	135.8	141.6	144.5	147.2	152.7	157.5	170.0	181.7	202.6
40	145.8	153.4	160.6	167.5	170.8	174.0	180.5	186.6	201.0	214.8	239.4
45	169.0	177.7	186.0	194.2	198.3	201.8	209.2	216.1	233.0	248.7	277.8
50	192.5	202.4	211.9	221.3	225.8	230.0	238.3	246.2	265.9	283.7	316.5
60	242.0	254.4	266.6	278.0	283.7	288.8	299.7	310.0	333.8	356.5	397.8
70	291.1	306.2	320.8	334.4	341.7	347.6	360.2	372.4	401.8	429.0	478.7
80	346.5	364.8	381.5	398.2	406.8	414.0	429.4	443.9	478.3	510.8	570.2
90	402.0	422.6	442.4	461.7	471.3	480.0	497.9	514.0	554.3	592.0	660.5
100	457.9	481.9	504.9	526.2	537.0	547.0	567.3	586.2	632.3	674.5	753.0
110	516.0	543.0	566.3	593.2	605.0	616.3	639.9	660.8	711.5	761.0	849.0
120	575.8	605.3	633.7	661.2	674.5	687.0	712.5	736.3	793.5	848.0	946.0
130	637.0	670.0	701.0	731.5	746.0	760.0	788.0	814.0	878.0	939.0	1046.0
140	697.7	734.0	768.0	801.0	813.0	833.5	864.5	893.0	963.0	1028.0	1146.0
150	761.0	801.0	838.5	874.5	891.0	908.0	942.5	974.5	1049.0	1121.0	1251.0
160	825.5	867.5	909.0	947.5	966.5	985.0	1021.0	1055.0	1136.0	1215.0	1355.0
170	889.0	936.0	979.0	1021.0	1-41.0	1061.0	1110.0	1137.0	1226.0	1310.0	1462.0
180	955.0	981.0	1052.0	1097.0	1120.0	1141.0	1184.0	1223.0	1318.0	1408.0	1572.0
190	1021.0	1074.0	1125.0	1174.0	1193.0	1221.0	1255.0	1307.0	1410.0	1503.0	1650.0
200	1060.0	1145.0	1231.0	1252.0	1278.0	1302.0	1350.0	1394.0	1503.0	1605.0	1770.0

TABLE 6 (Continued)

(Symbols and Abbreviations on Pages 208-210)

THEORY - HEAT TRANSFER

SURFACE HEAT LOSS TABLE - HOT SERVICE
Heat Transfer From Surface To Lower Temperature Air - Btu/Hour, Sq. Ft.

Temp. Diff. Sur. to Air ° F ($t_s - t_a$)	≤ 1.0					≤ 0.9					≤ 0.8						
	Air Movement In Miles Per Hour					Air Movement In Miles Per Hour					Air Movement In Miles Per Hour						
	0	2	4	8	20	0	2	4	8	20	0	2	4	8	20		
2	2.5	3.1	3.5	4.2	5.4	2.3	2.9	3.3	4.0	4.4	5.2	2.1	2.7	3.1	3.8	4.2	5.0
4	5.2	6.6	7.6	9.1	10.3	4.9	6.3	7.1	8.8	10.0	11.8	4.5	5.9	6.9	8.4	9.6	11.4
6	8.4	10.8	12.5	13.8	16.8	7.8	10.2	11.9	14.3	16.2	19.3	7.3	9.7	11.4	13.8	15.7	18.8
8	11.5	15.0	16.9	19.2	24.4	10.8	14.3	16.6	20.1	23.7	27.3	10.0	13.5	15.8	19.3	22.9	26.5
10	14.8	19.4	22.5	27.4	30.7	13.9	18.5	21.6	26.2	29.8	35.7	12.9	17.5	20.6	25.2	28.8	34.7
15	23.2	30.9	36.0	43.7	49.6	21.7	29.	34.6	42.3	48.2	58.0	20.2	27.9	33.1	40.8	46.7	56.5
20	32.0	44.4	50.5	61.4	70.2	30.0	41.0	48.3	59.4	68.2	81.7	28.1	39.1	46.4	57.5	66.3	79.8
25	41.2	55.8	65.5	80.1	91.4	38.7	53.4	63.0	77.6	88.9	107.4	36.3	51.0	60.6	75.2	86.5	105.0
30	51.0	69.3	81.5	99.8	112.1	48.0	66.3	78.5	96.8	110.1	134.2	45.0	63.3	75.5	93.8	107.1	131.2
35	61.0	83.2	98.1	120.2	137.3	57.4	79.6	94.5	116.6	133.7	161.8	53.8	76.0	90.9	113.0	130.1	158.2
40	71.3	97.5	115.1	141.2	161.6	67.2	93.4	111.0	137.1	157.5	191.8	63.0	89.2	106.8	132.9	153.3	186.6
45	81.9	112.7	132.7	162.9	166.6	77.1	107.9	127.9	158.1	181.8	220.3	72.4	103.2	123.2	153.4	177.1	215.6
50	92.5	127.3	150.4	184.9	211.7	87.2	122.0	145.1	179.6	206.4	259.2	81.8	116.6	139.7	194.2	201.0	248.8
60	115.3	159.2	188.0	231.4	265.2	108.8	152.7	181.5	224.9	258.7	313.8	102.1	146.0	174.8	218.2	252.0	307.1
70	138.7	191.3	228.2	278.3	391.1	130.8	183.	219.2	270.4	311.2	377.5	122.8	175.3	211.2	262.4	303.2	369.5
80	164.0	226.5	268.1	330.2	378.9	154.8	217.1	258.8	321.0	369.7	448.7	145.3	207.8	249.1	311.5	360.2	439.2
90	189.9	262.4	310.7	382.7	438.8	179.3	251.8	299.6	372.1	428.2	519.8	168.4	240.9	289.2	361.2	417.3	508.9
100	216.8	299.5	355.1	436.4	500.7	204.7	287.3	343.0	424.3	488.6	594.0	189.1	271.7	327.4	408.7	473.0	577.4
110	244.8	338.0	400.1	492.6	564.7	231.0	324.2	386.3	478.8	550.9	668.6	216.9	310.1	372.2	464.7	536.8	654.5
120	273.9	376.5	446.8	550.1	630.5	258.3	361.1	431.4	534.7	615.1	746.3	242.6	345.2	415.5	518.8	599.2	730.4
130	304.2	417.7	493.2	609.6	698.4	287.1	400.6	478.1	592.5	681.3	827.1	269.3	382.8	460.3	574.7	663.5	809.4
140	335.4	461.4	544.9	670.1	767.9	316.2	442.2	525.7	650.9	748.7	907.7	296.5	422.5	506.0	631.2	729.0	888.0
150	367.8	510.1	396.4	733.1	849.4	346.7	484.0	575.3	712.0	828.3	992.3	323.3	462.6	553.9	690.6	808.9	970.9
160	400.4	550.1	649.3	797.1	912.9	377.1	521.2	625.0	771.2	889.9	1076.5	353.6	502.7	601.5	749.7	865.5	1052.0
170	435.9	596.3	702.7	862.6	987.3	410.7	571.1	677.1	827.4	932.1	1165.1	385.1	545.5	651.5	811.8	936.5	1139.5
180	471.9	644.2	758.8	930.0	1064.2	445.5	616.8	731.3	902.6	1037.8	1300.3	416.3	588.6	703.1	874.4	1008.6	1202.1
190	508.9	693.3	861.1	999.7	1143.1	478.8	663.2	768.0	969.6	1113.0	1344.0	448.8	633.2	756.0	939.6	1083.0	1314.0
200	547.2	734.0	885.0	1070.5	1223.5	515.2	702.0	843.0	1038.5	1191.5	1458.5	482.2	669.0	810.0	1003.5	1158.5	1403.5

(Symbols and Abbreviations given on Pages 208-210)

TABLE 7



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION I
INSULATION DES:
PAGE 37
MAY, 1968

THEORY - HEAT TRANSFER

SURFACE HEAT LOSS TABLE - HOT SERVICE
Heat Transfer From Surface To Lower Temperature Air - Btu/Hour, Sq. Ft.

Temp. Diff. Surf. to Air ° F (t _s -t _a)	ζ = 0.7												ζ = 0.6												ζ = 0.5											
	Air Movement In Miles Per Hour						Air Movement In Miles Per Hour						Air Movement In Miles Per Hour						Air Movement In Miles Per Hour																	
	0	2	4	8	12	20	0	2	4	8	12	20	0	2	4	8	12	20	0	2	4	8	12	20												
2	2.0	2.6	3.0	3.7	4.1	4.9	1.8	2.4	2.8	3.5	3.9	4.7	1.6	2.2	2.6	3.3	3.7	4.5	3.5	4.9	6.9	7.4	8.6	10.4												
4	4.2	5.6	6.6	8.1	9.3	11.1	3.8	5.2	6.2	7.7	8.9	10.7	3.5	4.9	6.9	7.4	8.6	10.4	5.6	8.0	9.7	12.1	14.0	17.1												
6	6.7	9.1	10.8	13.2	15.1	19.2	6.2	8.6	10.3	12.7	14.6	17.7	7.8	11.3	13.6	17.1	20.7	24.3	7.8	11.3	13.6	17.1	20.7	24.3												
8	9.2	12.7	15.0	18.5	22.1	25.7	8.5	12.0	14.3	17.8	21.4	25.0	10.1	14.7	17.8	22.4	26.0	31.9	10.1	14.7	17.8	22.4	26.0	31.9												
10	11.9	16.3	19.6	24.2	27.8	33.7	11.0	15.6	18.7	23.3	26.9	32.8	15.9	23.6	28.8	36.5	42.4	52.2	15.9	23.6	28.8	36.5	42.4	52.2												
15	18.8	26.3	31.7	39.4	45.3	55.1	17.3	25.0	30.2	37.9	43.8	53.6	22.2	33.2	40.5	51.6	60.4	73.9	22.2	33.2	40.5	51.6	60.4	73.9												
20	26.1	37.1	44.4	53.5	64.3	77.8	24.2	35.2	42.5	53.6	62.4	75.9	28.9	43.6	53.2	67.8	79.1	97.6	28.9	43.6	53.2	67.8	79.1	97.6												
25	33.8	48.5	58.1	72.7	84.0	102.5	31.3	46.0	55.6	70.2	81.5	100.0	35.9	54.2	66.4	84.7	98.0	122.1	35.9	54.2	66.4	84.7	98.0	122.1												
30	41.9	60.2	72.4	90.7	104.0	128.1	38.9	57.2	69.4	87.7	101.0	125.1	43.1	65.3	80.2	102.5	119.2	147.5	43.1	65.3	80.2	102.5	119.2	147.5												
35	50.3	72.5	87.4	109.5	126.4	154.7	46.7	68.9	83.8	105.9	123.0	151.1	50.6	76.8	94.4	120.5	140.9	174.2	50.6	76.8	94.4	120.5	140.9	174.2												
40	57.8	84.0	101.6	127.7	148.1	181.4	54.7	80.9	98.5	129.6	145.0	178.3	58.2	89.0	109.0	139.2	162.9	201.4	58.2	89.0	109.0	139.2	162.9	201.4												
45	66.0	96.8	116.8	147.0	170.7	209.2	62.9	93.7	113.7	143.9	167.6	205.1	66.0	100.8	123.9	158.4	185.2	229.0	66.0	100.8	123.9	158.4	185.2	229.0												
50	76.7	111.4	134.5	169.0	195.8	239.6	71.3	106.1	129.2	163.7	190.5	234.1	82.4	126.3	155.1	198.5	232.3	287.4	82.4	126.3	155.1	198.5	232.3	287.4												
60	95.5	139.4	168.2	211.6	245.4	300.5	85.9	132.8	161.6	205.0	238.8	293.9	117.5	180.0	221.5	283.7	332.4	411.4	117.5	180.0	221.5	283.7	332.4	411.4												
80	136.1	198.6	240.1	302.3	351.0	429.0	126.7	189.0	230.7	292.9	341.6	420.6	136.0	208.5	256.8	328.8	384.9	476.5	136.0	208.5	256.8	328.8	384.9	476.5												
90	159.6	230.1	278.4	350.4	406.5	498.1	146.8	219.3	267.6	339.6	395.7	487.3	195.2	237.8	293.5	374.8	439.1	543.5	195.2	237.8	293.5	374.8	439.1	543.5												
100	180.8	263.4	319.1	400.4	464.7	569.1	167.5	250.1	305.8	387.1	451.4	555.8	175.1	268.3	330.4	422.9	495.0	612.7	175.1	268.3	330.4	422.9	495.0	612.7												
110	200.9	294.1	366.2	448.7	520.8	638.5	189.0	282.2	344.3	436.8	518.9	626.6	195.7	298.3	368.6	471.9	552.3	683.5	195.7	298.3	368.6	471.9	552.3	683.5												
120	226.5	322.1	399.4	502.7	583.1	714.3	210.7	313.3	383.6	486.9	567.3	698.5	217.1	320.6	408.1	522.5	611.3	757.1	217.1	320.6	408.1	522.5	611.3	757.1												
130	252.0	365.5	443.0	557.4	646.2	792.0	234.5	348.0	425.5	539.9	628.7	774.5	239.0	365.0	448.5	573.7	671.5	830.5	239.0	365.0	448.5	573.7	671.5	830.5												
140	277.5	403.5	487.0	612.2	710.0	869.0	258.3	384.3	467.8	593.0	690.8	849.8	284.6	398.9	490.2	626.9	743.2	907.2	284.6	398.9	490.2	626.9	743.2	907.2												
150	302.1	441.1	532.7	669.4	785.7	949.7	283.1	420.4	511.7	648.4	764.7	928.7	284.6	433.7	532.5	680.7	796.5	983.0	284.6	433.7	532.5	680.7	796.5	983.0												
160	331.1	480.2	579.0	727.2	843.0	1030.5	307.9	457.0	553.8	704.0	819.8	1007.3	309.2	469.2	575.2	735.5	860.2	1063.2	309.2	469.2	575.2	735.5	860.2	1063.2												
170	359.6	520.0	626.0	786.3	911.0	1114.0	334.2	494.6	600.6	760.9	883.6	1088.6	333.6	506.9	620.4	791.7	925.8	1119.4	333.6	506.9	620.4	791.7	925.8	1119.4												
180	388.1	560.4	674.9	846.2	980.4	1173.9	361.2	533.5	648.0	819.3	953.5	1147.0	358.8	543.2	666.0	849.6	993.0	1224.0	358.8	543.2	666.0	849.6	993.0	1224.0												
190	418.8	603.2	726.0	909.6	1033.0	1284.0	388.8	573.2	696.0	876.6	1023.0	1254.0	404.3	571.8	712.8	908.3	1061.3	1308.3	404.3	571.8	712.8	908.3	1061.3	1308.3												
200	437.0	637.0	778.0	973.5	1126.5	1373.5	404.3	604.3	745.3	940.8	1093.8	1340.8	404.3	571.8	712.8	908.3	1061.3	1308.3	404.3	571.8	712.8	908.3	1061.3	1308.3												

TABLE 7 (Continued)



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
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SECTION I
INSULATION DESIGN
PAGE 38
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THEORY - HEAT TRANSFER

SURFACE HEAT LOSS TABLE - HOT SERVICE
Heat Transfer: From Surface to Lower Temperature Air - Btu/Hour, Sq. Ft.
 $q_r + q_{cv}$

Temp. Diff. Surf. to Air ° F ($t_s - t_a$)	$\epsilon = 0.4$										$\epsilon = 0.3$										$\epsilon = 0.2$									
	Air Movement In Miles Per Hour					Air Movement In Miles Per Hour					Air Movement In Miles Per Hour					Air Movement In Miles Per Hour					Air Movement In Miles Per Hour					Air Movement In Miles Per Hour				
	0	2	4	8	12	20	0	2	4	8	10	20	0	2	4	8	10	20	0	2	4	8	12	20	0	2	4	8	12	20
2	1.4	2.0	2.4	3.1	3.5	4.3	1.2	1.8	2.2	2.9	3.3	4.1	1.1	1.7	2.1	2.8	3.2	4.0	1.1	1.7	2.1	2.8	3.2	4.0	1.1	1.7	2.1	2.8	3.2	4.0
4	3.1	4.5	5.5	7.0	8.2	10.0	2.8	4.2	5.2	6.7	7.9	9.7	2.4	3.8	4.8	6.3	7.5	9.3	2.4	3.8	4.8	6.3	7.5	9.3	2.4	3.8	4.8	6.3	7.5	9.3
6	5.0	7.4	9.1	11.5	13.4	16.5	4.5	6.9	8.6	11.0	12.9	16.0	3.9	6.3	8.0	10.4	12.3	15.4	3.9	6.3	8.0	10.4	12.3	15.4	3.9	6.3	8.0	10.4	12.3	15.4
8	7.0	10.5	12.8	16.3	19.9	23.5	6.3	9.8	12.1	15.6	19.2	22.8	5.5	9.0	11.3	14.8	18.4	22.0	5.5	9.0	11.3	14.8	18.4	22.0	5.5	9.0	11.3	14.8	18.4	22.0
10	9.1	13.7	16.8	21.4	25.0	30.9	8.2	12.8	15.9	20.5	24.1	30.0	7.2	11.8	14.9	19.5	23.1	29.0	7.2	11.8	14.9	19.5	23.1	29.0	7.2	11.8	14.9	19.5	23.1	29.0
15	14.5	22.2	26.4	35.1	41.0	50.8	13.0	20.7	25.9	33.6	39.5	49.3	11.6	19.3	24.5	32.1	38.1	47.9	11.6	19.3	24.5	32.1	38.1	47.9	11.6	19.3	24.5	32.1	38.1	47.9
20	20.2	31.2	38.5	49.6	58.4	71.9	18.3	29.3	36.6	47.7	56.3	70.0	16.3	27.3	34.6	45.7	54.5	68.0	16.3	27.3	34.6	45.7	54.5	68.0	16.3	27.3	34.6	45.7	54.5	68.0
25	26.4	41.1	50.7	65.3	76.6	95.1	23.9	38.6	48.2	62.8	74.1	92.6	21.4	36.1	45.7	60.3	71.6	90.1	21.4	36.1	45.7	60.3	71.6	90.1	21.4	36.1	45.7	60.3	71.6	90.1
30	32.9	51.2	63.4	81.7	93.0	119.1	29.9	48.2	60.4	78.7	92.0	116.1	26.9	45.2	57.4	75.7	89.0	113.1	26.9	45.2	57.4	75.7	89.0	113.1	26.9	45.2	57.4	75.7	89.0	113.1
35	39.6	61.8	76.7	98.8	115.9	144.0	36.0	58.2	73.1	95.2	112.3	140.4	32.4	54.6	69.5	91.6	108.7	136.8	32.4	54.6	69.5	91.6	108.7	136.8	32.4	54.6	69.5	91.6	108.7	136.8
40	46.4	72.6	90.2	116.3	136.7	170.0	42.2	68.4	86.0	111.1	132.5	165.8	38.1	64.3	81.9	108.0	128.4	161.7	38.1	64.3	81.9	108.0	128.4	161.7	38.1	64.3	81.9	108.0	128.4	161.7
45	53.5	84.3	104.3	134.5	158.2	196.7	48.7	79.5	99.5	129.7	153.4	191.9	44.0	74.8	94.8	125.0	148.7	187.2	44.0	74.8	94.8	125.0	148.7	187.2	44.0	74.8	94.8	125.0	148.7	187.2
50	60.6	95.4	118.5	153.0	179.8	223.6	55.3	90.1	113.2	147.7	174.5	218.3	50.0	84.8	107.9	142.4	169.2	213.0	50.0	84.8	107.9	142.4	169.2	213.0	50.0	84.8	107.9	142.4	169.2	213.0
60	75.8	119.7	148.5	191.9	223.7	280.8	69.2	113.6	141.9	185.3	219.1	274.2	62.6	105.5	135.3	178.7	212.5	267.6	62.6	105.5	135.3	178.7	212.5	267.6	62.6	105.5	135.3	178.7	212.5	267.6
70	91.9	144.5	179.5	230.7	272.5	337.8	83.3	135.8	173.7	222.9	262.7	330.0	75.3	127.8	163.7	214.9	255.7	322.0	75.3	127.8	163.7	214.9	255.7	322.0	75.3	127.8	163.7	214.9	255.7	322.0
80	108.1	170.6	212.1	274.3	323.0	401.8	98.8	161.3	202.8	265.0	313.7	392.7	89.4	152.0	193.5	255.7	304.4	383.4	89.4	152.0	193.5	255.7	304.4	383.4	89.4	152.0	193.5	255.7	304.4	383.4
90	125.3	197.8	245.1	317.1	374.2	465.8	114.4	186.9	235.2	307.2	363.3	454.9	103.7	176.2	224.5	296.5	352.6	444.2	103.7	176.2	224.5	296.5	352.6	444.2	103.7	176.2	224.5	296.5	352.6	444.2
100	142.9	225.5	281.2	362.5	426.8	531.2	130.6	213.2	268.9	350.2	414.5	516.9	118.2	201.2	256.5	337.8	402.1	506.5	118.2	201.2	256.5	337.8	402.1	506.5	118.2	201.2	256.5	337.8	402.1	506.5
110	161.2	254.4	316.5	409.0	486.6	598.8	146.2	240.4	302.5	395.0	466.1	584.8	133.3	226.5	288.6	381.1	453.2	570.9	133.3	226.5	288.6	381.1	453.2	570.9	133.3	226.5	288.6	381.1	453.2	570.9
120	180.1	282.6	353.0	456.3	536.7	667.9	164.4	267.0	337.3	440.6	521.0	652.2	148.8	251.4	321.7	425.0	505.4	636.6	148.8	251.4	321.7	425.0	505.4	636.6	148.8	251.4	321.7	425.0	505.4	636.6
130	199.8	312.5	390.8	505.2	594.0	747.8	182.4	295.9	373.4	487.8	576.6	722.4	164.8	278.3	359.8	470.2	572.8	712.8	164.8	278.3	359.8	470.2	572.8	712.8	164.8	278.3	359.8	470.2	572.8	712.8
140	219.7	345.7	429.2	554.4	652.2	821.2	199.3	325.3	409.8	534.0	632.8	791.8	181.1	307.1	390.6	515.8	613.6	772.6	181.1	307.1	390.6	515.8	613.6	772.6	181.1	307.1	390.6	515.8	613.6	772.6
150	240.5	377.8	469.1	605.8	712.1	886.1	217.2	356.5	447.8	584.5	690.8	864.8	195.0	335.3	426.6	573.3	679.6	843.6	195.0	335.3	426.6	573.3	679.6	843.6	195.0	335.3	426.6	573.3	679.6	843.6
160	261.4	410.6	509.3	657.5	773.3	960.8	238.1	387.1	486.0	634.2	750.0	937.5	214.8	363.9	462.7	611.8	726.7	914.2	214.8	363.9	462.7	611.8	726.7	914.2	214.8	363.9	462.7	611.8	726.7	914.2
170	283.5	443.9	549.9	710.2	834.9	1037.9	258.0	418.4	525.4	684.7	809.4	1012.4	232.4	392.8	498.8	659.1	783.8	986.8	232.4	392.8	498.8	659.1	783.8	986.8	232.4	392.8	498.8	659.1	783.8	986.8
180	306.0	468.3	592.8	764.1	898.3	1091.8	278.3	450.6	565.1	736.4	870.6	1064.1	250.5	422.9	537.4	708.7	842.9	1036.4	250.5	422.9	537.4	708.7	842.9	1036.4	250.5	422.9	537.4	708.7	842.9	1036.4
190	328.8	513.2	636.0	819.6	963.0	1194.0	298.8	493.2	606.0	789.6	933.0	1164.0	268.8	453.2	576.0	759.6	903.0	1134.0	268.8	453.2	576.0	759.6	903.0	1134.0	268.8	453.2	576.0	759.6	903.0	1134.0
200	352.7	539.5	680.5	876.0	1024.0	1276.0	320.2	507.0	648.0	843.5	996.5	1243.5	287.5	474.3	515.3	810.8	963.8	1212.8	287.5	474.3	515.3	810.8	963.8	1212.8	287.5	474.3	515.3	810.8	963.8	1212.8

(Symbols and Abbreviations given on Pages 208-210)



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
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THEORY - HEAT TRANSFER

SURFACE HEAT LOSS TABLE - HOT SERVICE
Heat Transfer From Surface To Lower Temperature Air - Btu/Hour, Sq. Ft.
 $q_t + q_{cv}$

Temp. Diff. Sur. to Air °F ($t_s - t_a$)	$C = 0.1$										$C = 0.05$									
	Air Movement In Miles Per Hour					Air Movement In Miles Per Hour					Air Movement In Miles Per Hour					Air Movement In Miles Per Hour				
	0	2	4	8	12	20	0	2	4	8	12	20	0	2	4	8	12	20	0	2
2	0.9	1.5	1.9	2.6	3.0	3.8	0.8	1.4	1.8	2.5	2.9	3.7	0.8	1.4	1.8	2.5	2.9	3.7	0.8	1.4
4	2.1	3.5	4.5	6.0	7.2	9.0	1.9	3.3	4.3	5.8	7.0	8.8	1.9	3.3	4.3	5.8	7.0	8.8	1.9	3.3
6	3.4	5.8	7.5	9.9	11.8	14.9	3.1	5.5	7.2	9.6	11.5	14.6	3.1	5.5	7.2	9.6	11.5	14.6	3.1	5.5
8	4.8	8.3	10.6	14.1	17.7	21.3	4.4	7.9	10.2	13.7	17.3	20.9	4.4	7.9	10.2	13.7	17.3	20.9	4.4	7.9
10	6.3	10.9	14.0	18.6	22.2	28.1	5.8	10.4	13.5	18.1	21.7	27.6	5.8	10.4	13.5	18.1	21.7	27.6	5.8	10.4
15	10.1	17.8	23.0	30.7	36.6	46.4	9.4	17.1	22.3	30.0	35.9	45.7	9.4	17.1	22.3	30.0	35.9	45.7	9.4	17.1
20	14.4	25.4	32.7	43.8	52.6	65.1	13.4	24.4	31.7	42.8	51.6	65.1	13.4	24.4	31.7	42.8	51.6	65.1	13.4	24.4
25	19.0	33.7	43.3	57.9	69.2	87.7	17.8	32.5	42.1	55.7	69.0	85.5	17.8	32.5	42.1	55.7	69.0	85.5	17.8	32.5
30	23.8	42.1	54.3	72.6	85.9	110.0	22.3	40.6	52.8	71.1	84.4	103.5	22.3	40.6	52.8	71.1	84.4	103.5	22.3	40.6
35	28.8	51.0	65.9	88.0	104.9	133.2	27.0	49.2	64.1	86.2	103.1	131.4	27.0	49.2	64.1	86.2	103.1	131.4	27.0	49.2
40	34.0	60.2	73.2	103.9	124.3	157.6	31.9	58.1	75.7	101.8	122.2	155.5	31.9	58.1	75.7	101.8	122.2	155.5	31.9	58.1
45	39.2	70.0	90.0	120.2	143.9	182.4	36.9	67.7	87.7	117.9	141.6	180.1	36.9	67.7	87.7	117.9	141.6	180.1	36.9	67.7
50	44.7	79.5	102.6	137.1	163.9	205.7	42.1	76.9	100.0	134.5	161.3	205.1	42.1	76.9	100.0	134.5	161.3	205.1	42.1	76.9
60	56.0	99.9	128.7	172.1	205.9	261.0	52.7	96.6	125.4	168.8	202.6	257.7	52.7	96.6	125.4	168.8	202.6	257.7	52.7	96.6
70	67.4	119.9	155.8	207.0	247.8	314.1	63.5	116.0	151.9	203.1	243.9	310.2	63.5	116.0	151.9	203.1	243.9	310.2	63.5	116.0
80	80.2	142.7	184.2	246.4	295.1	374.1	75.6	138.1	179.6	241.8	290.5	369.5	75.6	138.1	179.6	241.8	290.5	369.5	75.6	138.1
90	92.9	165.4	213.7	285.7	341.8	433.4	87.5	160.0	208.3	280.3	336.4	428.0	87.5	160.0	208.3	280.3	336.4	428.0	87.5	160.0
100	105.9	188.5	244.2	325.5	389.8	494.2	99.8	182.4	238.1	319.4	383.7	488.1	99.8	182.4	238.1	319.4	383.7	488.1	99.8	182.4
110	119.1	212.5	274.6	367.1	439.2	556.2	112.4	205.6	267.7	360.2	432.3	550.0	112.4	205.6	267.7	360.2	432.3	550.0	112.4	205.6
120	133.1	235.7	306.0	409.3	489.7	620.9	125.3	227.9	298.2	401.5	481.9	613.1	125.3	227.9	298.2	401.5	481.9	613.1	125.3	227.9
130	147.4	260.9	338.4	452.8	541.6	687.4	138.7	252.2	329.7	444.1	532.9	678.7	138.7	252.2	329.7	444.1	532.9	678.7	138.7	252.2
140	161.8	287.8	371.3	496.5	594.3	753.3	152.2	278.2	361.7	485.9	584.7	743.7	152.2	278.2	361.7	485.9	584.7	743.7	152.2	278.2
150	174.6	313.9	405.2	541.9	650.2	822.2	164.0	303.3	394.6	531.3	637.6	811.6	164.0	303.3	394.6	531.3	637.6	811.6	164.0	303.3
160	191.4	340.5	439.3	587.5	703.3	890.8	179.8	328.9	427.7	575.9	691.7	879.2	179.8	328.9	427.7	575.9	691.7	879.2	179.8	328.9
170	207.0	367.4	473.4	633.7	758.4	961.4	194.3	354.7	460.7	621.0	745.7	948.7	194.3	354.7	460.7	621.0	745.7	948.7	194.3	354.7
180	222.9	395.2	509.7	681.0	815.2	1008.2	209.1	381.4	495.9	667.2	801.4	994.9	209.1	381.4	495.9	667.2	801.4	994.9	209.1	381.4
190	235.8	423.2	545.0	729.6	873.0	1104.0	223.8	403.2	531.0	714.6	852.0	1059.0	223.8	403.2	531.0	714.6	852.0	1059.0	223.8	403.2
200	255.1	441.9	572.9	778.4	931.4	1178.4	235.9	425.7	555.7	762.2	915.2	1122.2	235.9	425.7	555.7	762.2	915.2	1122.2	235.9	425.7

(Symbols and Abbreviations on Pages 208-210)

TABLE 7 (Continued)

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THEORY - HEAT TRANSFERTHICKNESS OF FLAT INSULATION
EQUIVALENT TO
NOMINAL PIPE INSULATION THICKNESS
Based on IPS Pipe and A S T M Dimensional Standard Pipe Insulation

$$\text{Values of } r_2 \log_e \frac{r_2}{r_1}$$

NOMINAL PIPE SIZE	NOMINAL PIPE INSULATION THICKNESS									
	$\frac{1}{2}$	1	1 $\frac{1}{2}$	2	2 $\frac{1}{2}$	3	3 $\frac{1}{2}$	4	4 $\frac{1}{2}$	5
$\frac{1}{2}$	0.76	1.74	3.08	4.41	6.78	8.34	9.96	11.65	13.69	15.39
$\frac{3}{4}$	0.55	1.43	2.65	3.86	6.05	7.50	9.02	10.59	12.42	14.10
1	0.69	1.69	2.74	3.98	5.32	6.65	8.06	9.52	11.22	12.79
1 $\frac{1}{2}$	0.78	1.29	2.73	3.34	4.55	5.78	7.37	8.41	9.99	11.44
1 $\frac{3}{4}$	0.58	1.47	2.40	4.11	5.27	6.49	7.77	9.27	10.66	12.08
2	0.66	1.41	2.33	3.36	4.40	5.51	6.67	8.05	9.32	10.63
2 $\frac{1}{2}$	0.64	1.36	2.73	3.68	4.69	5.77	7.03	8.21	9.43	11.01
3	0.55	1.26	2.08	2.94	3.85	4.83	5.98	7.06	8.18	9.64
3 $\frac{1}{2}$	0.54	1.65	2.43	3.28	4.19	5.27	6.28	7.34	8.71	8.71
4	0.57	1.26	1.98	2.78	3.63	4.64	5.60	6.59	7.90	8.98
6	0.49	1.09	1.74	2.54	3.30	4.10	5.16	6.04	6.96	7.91
8			1.76	2.43	3.33	4.08	4.87	5.69	6.54	7.42
10			1.80	2.44	3.12	3.83	4.57	5.34	6.14	6.96
12			1.76	2.38	3.04	3.72	4.43	5.16	5.92	6.70
14			1.59	2.20	2.84	3.50	4.19	4.90	5.63	6.39
16			1.57	2.17	2.79	3.44	4.11	4.80	5.51	6.24
18			1.56	2.15	2.76	3.39	4.04	4.71	5.40	6.11
20			1.55	2.13	2.73	3.35	3.99	4.65	5.32	6.01
24			1.54	2.10	2.69	3.29	3.91	4.54	5.19	5.86
30			1.52	2.08	2.64	3.23	3.82	4.43	5.06	5.69
36			1.51	2.06	2.61	3.18	3.76	4.36	4.96	5.58

Note: Find nominal pipe insulation thickness for the particular pipe size which has an equivalent thickness equal to the required flat insulation thickness.

THICKNESS OF FLAT INSULATION
EQUIVALENT TO
NOMINAL PIPE INSULATION THICKNESS

$$\text{Values of } r_2 \log_e \frac{r_2}{r_1}$$

NOMINAL PIPE SIZE	NOMINAL PIPE INSULATION THICKNESS									
	5	6	6 $\frac{1}{2}$	7	7 $\frac{1}{2}$	8	8 $\frac{1}{2}$	9	9 $\frac{1}{2}$	10
$\frac{1}{2}$	17.22	19.56								
$\frac{3}{4}$	15.82	18.03								
1	14.40	16.47	18.16	19.89						
1 $\frac{1}{2}$	12.94	14.86	16.44	18.05						
1 $\frac{3}{4}$	13.92	13.92	15.43	16.97						
2	12.33	13.73	15.16	16.62						
2 $\frac{1}{2}$	11.01	12.31	13.65	15.02						
3	10.85	12.17	13.36	14.66	15.99	17.34	18.72	20.12	21.55	22.99
3 $\frac{1}{2}$	9.85	11.03	12.23	13.47	14.73	16.02	17.33	18.67	20.02	21.41
4	10.09	11.24	12.41	13.62	14.85	16.10	17.38	18.68	20.00	21.35
6	8.89	9.90	10.93	11.99	13.07	14.18	15.30	16.45	17.62	18.81
8	8.32	9.25	10.20	11.18	12.17	13.19	14.23	15.28	16.36	17.45
10	7.80	8.66	9.55	10.46	11.39	12.34	13.30	14.29	15.29	16.30
12	7.50	8.33	9.17	10.03	10.91	11.81	12.73	13.66	14.61	15.57
14	7.16	7.96	8.78	9.61	10.46	11.33	12.22	13.12	14.04	14.97
16	6.99	7.75	8.54	9.34	10.16	11.00	11.85	12.72	13.60	14.49
18	6.84	7.58	8.35	9.12	9.92	10.72	11.55	12.38	13.23	14.10
20	6.72	7.45	8.19	8.94	9.71	10.50	11.29	12.11	12.93	13.77
24	6.53	7.23	7.94	8.66	9.39	10.14	10.90	11.67	12.45	13.25
30	6.34	7.00	7.67	8.36	9.05	9.76	10.48	11.21	11.94	12.69
36	6.21	6.84	7.49	8.15	8.82	9.49	10.19	10.88	11.58	12.30

TABLE 8



THEORY - HEAT TRANSFER

1. HEAT TRANSFER - GENERAL - Continued

CALCULATION BY PREDETERMINED AIR FILM RESISTANCE

By the use of predetermined film resistances, $\frac{1}{h}$, a simplified method for calculating insulation in hot service is possible which eliminates need for plotting as shown in Figure 3. This method is not as accurate as can be obtained by the simultaneous plot method, but it is quicker, easier, and, in most instances, provides answers as to heat transfer within 3%. When used to determine surface temperature, it is inaccurate as the $\frac{1}{h}$ values given are based on an average correction factor in respect to shape, size and position of surface, and ambient air temperatures.

The heat transfer equation for flat surfaces, in which these film resistances appear, is Equation 3, and for curved surfaces is Equation 9.

The following examples illustrate the manner in which these film resistances can be used to determine heat transfer of insulated hot surface.

Flat Surface

Given: Operating temperature 600F, t_1
Ambient air temperature 70F, t_a
Wind 20 mph
Surface flat
Conductivity of insulation at 335F = 0.45 Btu/sq ft, hr, in, F, k
Thickness of insulation 2 inches, L

Emissance of outer jacket surface = 0.9

q_a = Btu heat transfer per sq ft of insulation surface

Equation 3 states

$$q_a = \frac{t_1 - t_a}{\frac{L}{k} + \frac{1}{h}}$$

$$q_a = \frac{600 - 70}{\frac{2}{.45} + \frac{1}{h}}$$

$$\text{The insulation resistance } \frac{L}{k} = \frac{2}{.45} = 4.45$$

From $\frac{1}{h}$ table at emissance = .9 Resistance 5 to 10 at 20 mph wind and operating temp. = 600 $\frac{1}{h} = .25$

$$q_a = \frac{600-70}{4.45 + .25} = \frac{530}{4.7} = 113 \text{ Btu/sq ft, hr}$$

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THEORY - HEAT TRANSFER

1. HEAT TRANSFER - GENERAL - Continued

CALCULATION BY PREDETERMINED AIR FILM RESISTANCE

Continued

Curved Surfaces

Identical problem with insulation on 6" NPS pipe instead of flat surface.

Given: $t_1 = 600$ $t_a = 70$, wind = 20 mph

k of insulation at 335F = 0.45, thickness L = 2

Emittance of surface = .9

Equation 9 states

$$q_a = \frac{t_1 - t_a}{\frac{r_2 \text{ Log}_e \frac{r_2}{r_1}}{k} + \frac{1}{h}}$$

$$q_a = \frac{600 - 70}{\frac{r_2 \text{ Log}_e \frac{r_2}{r_1}}{0.45} + \frac{1}{h}}$$

$$\text{From Table 8 } r_2 \text{ Log}_e \frac{r_2}{r_1}$$

For 2" insulation on 6" NPS pipe = 2.54

$$\text{or } q_a = \frac{600 - 70}{\frac{2.54}{0.45} + \frac{1}{h}}$$

From air film resistance table $\frac{1}{h} = 0.25$, same as in first problem which illustrates correction factor for shape and position was averaged and that neither value of $\frac{1}{h}$ is exactly correct.

$$q_a = \frac{530}{5.64 + 0.25} = \frac{530}{5.89} = 90 \text{ Btu/sq ft, hr}$$

Similar calculation can be made to determine the heat transfer from insulated cold service by use of tables of value for $\frac{1}{h}$ - cold service



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1. HEAT TRANSFER - GENERAL - Continued

CALCULATION BY PREDETERMINED AIR FILM RESISTANCE

Continued

Curved Surfaces - Continued

Table No. 10. Again, the use of these $\frac{1}{h}$ values will provide relatively close determinations for heat transfer, but they are unsuitable for calculation of surface temperature. This method of calculation should not be used to determine thickness of insulation to prevent outer surface compensation.



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THEORY - HEAT TRANSFER

AIR FILM RESISTANCE

Values of $\frac{1}{h}$

ϵ Emittance	Wind Velocity MPH	Insulation Resistance Min. Max.	Operating Temperature (t_1) Degree F																
			200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
			1.0	2.5	5.0	10.0	15.0	20.0	25.0	1.0	2.5	5.0	10.0	15.0	20.0	25.0	1.0	2.5	5.0
1.0	0	1.0	0.61	0.58	0.55	0.54	0.51	0.48	0.46	0.44	0.42	0.46	0.45	0.50	0.53	0.56	0.51	0.55	0.54
		2.5	0.65	0.63	0.60	0.58	0.55	0.54	0.52	0.49	0.47	0.46	0.51	0.50	0.49	0.52	0.51	0.55	0.54
		5.0	0.69	0.65	0.63	0.61	0.59	0.58	0.56	0.54	0.52	0.56	0.55	0.54	0.53	0.56	0.55	0.55	0.54
		10.0	0.72	0.69	0.67	0.65	0.63	0.61	0.59	0.58	0.57	0.56	0.58	0.58	0.57	0.56	0.58	0.57	0.56
		15.0	0.77	0.72	0.69	0.67	0.65	0.63	0.62	0.61	0.60	0.59	0.58	0.59	0.59	0.58	0.58	0.57	0.56
2	0	20.0	0.80	0.75	0.72	0.69	0.66	0.65	0.64	0.63	0.61	0.60	0.59	0.59	0.59	0.58	0.58	0.57	0.56
		1.0	0.48	0.46	0.44	0.43	0.41	0.39	0.37	0.36	0.35	0.37	0.37	0.40	0.39	0.41	0.40	0.43	0.43
		2.5	0.50	0.48	0.46	0.45	0.42	0.41	0.40	0.39	0.38	0.37	0.41	0.40	0.39	0.42	0.40	0.43	0.43
		5.0	0.56	0.52	0.50	0.49	0.47	0.45	0.44	0.43	0.42	0.44	0.43	0.42	0.42	0.41	0.40	0.43	0.43
		10.0	0.60	0.56	0.53	0.52	0.50	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.42	0.41	0.40	0.43	0.43
4	0	15.0	0.62	0.60	0.57	0.56	0.54	0.52	0.50	0.48	0.47	0.46	0.45	0.45	0.44	0.44	0.43	0.43	0.43
		20.0	0.64	0.62	0.60	0.58	0.56	0.54	0.52	0.50	0.48	0.48	0.47	0.47	0.46	0.46	0.45	0.45	0.45
		1.0	0.41	0.38	0.37	0.36	0.34	0.32	0.31	0.30	0.29	0.32	0.31	0.34	0.34	0.36	0.35	0.37	0.37
		2.5	0.44	0.42	0.41	0.39	0.37	0.36	0.35	0.33	0.32	0.32	0.35	0.35	0.37	0.38	0.38	0.37	0.37
		5.0	0.48	0.46	0.44	0.43	0.41	0.40	0.38	0.37	0.36	0.39	0.39	0.37	0.37	0.36	0.35	0.37	0.37
8	0	10.0	0.53	0.51	0.48	0.47	0.45	0.43	0.42	0.41	0.40	0.41	0.40	0.39	0.38	0.38	0.37	0.37	0.37
		15.0	0.55	0.53	0.51	0.49	0.47	0.45	0.43	0.42	0.42	0.41	0.40	0.39	0.38	0.38	0.37	0.37	0.37
		20.0	0.56	0.54	0.53	0.51	0.48	0.46	0.44	0.43	0.43	0.42	0.42	0.41	0.40	0.40	0.39	0.39	0.38
		1.0	0.34	0.33	0.31	0.30	0.28	0.27	0.26	0.25	0.25	0.27	0.26	0.29	0.29	0.29	0.29	0.29	0.29
		2.5	0.38	0.36	0.34	0.33	0.31	0.30	0.29	0.28	0.27	0.27	0.26	0.29	0.29	0.29	0.29	0.29	0.29
12	0	5.0	0.43	0.40	0.38	0.36	0.34	0.33	0.32	0.31	0.30	0.30	0.32	0.32	0.31	0.31	0.30	0.31	0.31
		10.0	0.45	0.43	0.41	0.39	0.37	0.36	0.35	0.34	0.33	0.33	0.32	0.31	0.31	0.30	0.30	0.31	0.31
		15.0	0.46	0.44	0.43	0.41	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.33	0.33	0.32	0.32	0.31	0.31
		20.0	0.46	0.44	0.43	0.41	0.39	0.38	0.37	0.36	0.35	0.36	0.35	0.34	0.34	0.33	0.33	0.33	0.32
		1.0	0.30	0.29	0.28	0.27	0.25	0.24	0.24	0.23	0.23	0.24	0.23	0.27	0.27	0.28	0.28	0.29	0.29
20	0	2.5	0.33	0.32	0.30	0.29	0.28	0.26	0.26	0.25	0.24	0.24	0.27	0.27	0.27	0.28	0.28	0.29	0.29
		5.0	0.38	0.36	0.33	0.32	0.31	0.29	0.29	0.29	0.28	0.28	0.29	0.29	0.29	0.29	0.29	0.29	0.29
		10.0	0.41	0.39	0.37	0.36	0.33	0.32	0.31	0.30	0.30	0.30	0.30	0.30	0.30	0.29	0.29	0.29	0.29
		15.0	0.42	0.40	0.39	0.38	0.36	0.34	0.32	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.29
		20.0	0.43	0.41	0.40	0.39	0.37	0.35	0.34	0.32	0.32	0.32	0.31	0.31	0.30	0.30	0.30	0.30	0.29
	Natural Convection	1.0	0.26	0.25	0.24	0.23	0.22	0.21	0.20	0.20	0.19	0.20	0.20	0.23	0.23	0.24	0.24	0.24	0.24
		2.5	0.29	0.27	0.26	0.25	0.24	0.23	0.22	0.21	0.21	0.20	0.23	0.23	0.23	0.24	0.24	0.24	0.24
		5.0	0.33	0.31	0.29	0.28	0.26	0.25	0.25	0.24	0.24	0.23	0.23	0.23	0.23	0.24	0.24	0.24	0.24
		10.0	0.36	0.34	0.32	0.31	0.29	0.28	0.27	0.26	0.25	0.25	0.25	0.25	0.25	0.24	0.24	0.24	0.24
		15.0	0.38	0.36	0.34	0.33	0.31	0.29	0.28	0.27	0.26	0.26	0.25	0.25	0.25	0.24	0.24	0.24	0.24

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TABLE 9



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AIR FILM RESISTANCE

Values of $\frac{1}{h}$

ϵ Emittance	Wind Velocity MPH	Insulation Resistance Min. - Max.	Operating Temperature (t) Degree F																	
			200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	
			1.0 2.5 5.0 10.0 15.0 20.0	0.61 0.63 0.69 0.72 0.77 0.80 0.83	0.58 0.61 0.63 0.68 0.72 0.74 0.76	0.56 0.59 0.61 0.63 0.67 0.69 0.72	0.53 0.56 0.59 0.62 0.66 0.68 0.70	0.50 0.53 0.56 0.59 0.62 0.65 0.67	0.48 0.50 0.52 0.54 0.58 0.60 0.62	0.47 0.49 0.51 0.53 0.56 0.58 0.60	0.46 0.48 0.50 0.52 0.55 0.57 0.59	0.45 0.47 0.49 0.51 0.53 0.55 0.57	0.44 0.46 0.48 0.50 0.52 0.54 0.56	0.43 0.45 0.47 0.49 0.51 0.53 0.55	0.42 0.44 0.46 0.48 0.50 0.52 0.54	0.41 0.43 0.45 0.47 0.49 0.51 0.53	0.40 0.42 0.44 0.46 0.48 0.50 0.52	0.39 0.41 0.43 0.45 0.47 0.49 0.51	0.38 0.40 0.42 0.44 0.46 0.48 0.50	
0.9	0	1.0 2.5 5.0 10.0 15.0 20.0	0.65 0.68 0.72 0.77 0.80 0.83	0.61 0.63 0.69 0.72 0.74 0.76	0.58 0.61 0.63 0.68 0.72 0.74	0.56 0.59 0.61 0.63 0.67 0.69	0.53 0.56 0.59 0.62 0.66 0.68	0.50 0.53 0.56 0.59 0.62 0.65	0.48 0.50 0.52 0.54 0.58 0.60	0.47 0.49 0.51 0.53 0.56 0.58	0.46 0.48 0.50 0.52 0.55 0.57	0.45 0.47 0.49 0.51 0.53 0.55	0.44 0.46 0.48 0.50 0.52 0.54	0.43 0.45 0.47 0.49 0.51 0.53	0.42 0.44 0.46 0.48 0.50 0.52	0.41 0.43 0.45 0.47 0.49 0.51	0.40 0.42 0.44 0.46 0.48 0.50	0.39 0.41 0.43 0.45 0.47 0.49	0.38 0.40 0.42 0.44 0.46 0.48	
	2	1.0 2.5 5.0 10.0 15.0 20.0	0.50 0.52 0.58 0.63 0.68 0.72	0.47 0.49 0.51 0.53 0.56 0.58	0.45 0.47 0.49 0.51 0.54 0.56	0.43 0.45 0.47 0.49 0.52 0.54	0.41 0.43 0.45 0.47 0.50 0.52	0.39 0.41 0.43 0.45 0.48 0.50	0.37 0.39 0.41 0.43 0.46 0.48	0.36 0.38 0.40 0.42 0.45 0.47	0.35 0.37 0.39 0.41 0.44 0.46	0.34 0.36 0.38 0.40 0.43 0.45	0.33 0.35 0.37 0.39 0.42 0.44	0.32 0.34 0.36 0.38 0.41 0.43	0.31 0.33 0.35 0.37 0.40 0.42	0.30 0.32 0.34 0.36 0.39 0.41	0.29 0.31 0.33 0.35 0.38 0.40	0.28 0.30 0.32 0.34 0.37 0.39	0.27 0.29 0.31 0.33 0.36 0.38	
	4	1.0 2.5 5.0 10.0 15.0 20.0	0.42 0.45 0.50 0.56 0.61 0.66	0.40 0.43 0.48 0.53 0.58 0.63	0.38 0.41 0.46 0.51 0.56 0.61	0.36 0.39 0.44 0.49 0.54 0.59	0.34 0.37 0.42 0.47 0.52 0.57	0.32 0.35 0.40 0.45 0.50 0.55	0.31 0.33 0.36 0.39 0.44 0.49	0.30 0.32 0.35 0.38 0.43 0.48	0.29 0.31 0.34 0.37 0.42 0.47	0.28 0.30 0.33 0.36 0.41 0.46	0.27 0.29 0.32 0.35 0.40 0.45	0.26 0.28 0.31 0.34 0.39 0.44	0.25 0.27 0.30 0.33 0.38 0.43	0.24 0.26 0.29 0.32 0.37 0.42	0.23 0.25 0.28 0.31 0.36 0.41	0.22 0.24 0.27 0.30 0.35 0.40	0.21 0.23 0.26 0.29 0.34 0.39	0.20 0.22 0.25 0.28 0.33 0.38
	8	1.0 2.5 5.0 10.0 15.0 20.0	0.35 0.39 0.44 0.50 0.56 0.63	0.34 0.37 0.41 0.46 0.52 0.58	0.32 0.35 0.39 0.44 0.50 0.56	0.30 0.33 0.37 0.42 0.48 0.54	0.28 0.31 0.35 0.40 0.46 0.52	0.27 0.29 0.33 0.38 0.44 0.50	0.26 0.28 0.31 0.36 0.42 0.48	0.25 0.27 0.30 0.35 0.41 0.47	0.24 0.26 0.29 0.34 0.40 0.46	0.23 0.25 0.28 0.33 0.39 0.45	0.22 0.24 0.27 0.32 0.38 0.44	0.21 0.23 0.26 0.31 0.37 0.43	0.20 0.22 0.25 0.30 0.36 0.42	0.19 0.21 0.24 0.29 0.35 0.41	0.18 0.20 0.23 0.28 0.34 0.40	0.17 0.19 0.22 0.27 0.33 0.39	0.16 0.18 0.21 0.26 0.32 0.38	
	12	1.0 2.5 5.0 10.0 15.0 20.0	0.31 0.35 0.39 0.44 0.50 0.56	0.29 0.33 0.37 0.41 0.46 0.52	0.28 0.31 0.35 0.40 0.46 0.52	0.27 0.30 0.34 0.39 0.45 0.51	0.25 0.28 0.32 0.37 0.43 0.49	0.24 0.27 0.31 0.36 0.42 0.48	0.23 0.25 0.29 0.34 0.40 0.46	0.22 0.24 0.28 0.33 0.39 0.45	0.21 0.23 0.27 0.32 0.38 0.44	0.20 0.22 0.26 0.31 0.37 0.43	0.19 0.21 0.25 0.30 0.36 0.42	0.18 0.20 0.24 0.29 0.35 0.41	0.17 0.19 0.23 0.28 0.34 0.40	0.16 0.18 0.22 0.27 0.33 0.39	0.15 0.17 0.21 0.26 0.32 0.38	0.14 0.16 0.20 0.25 0.31 0.37	0.13 0.15 0.19 0.24 0.30 0.36	
	20	1.0 2.5 5.0 10.0 15.0 20.0	0.27 0.30 0.34 0.39 0.44 0.50	0.26 0.28 0.32 0.37 0.42 0.48	0.25 0.27 0.31 0.36 0.41 0.47	0.24 0.26 0.30 0.35 0.40 0.46	0.23 0.25 0.29 0.34 0.39 0.45	0.22 0.24 0.28 0.33 0.38 0.44	0.21 0.23 0.27 0.32 0.37 0.43	0.20 0.22 0.26 0.31 0.36 0.42	0.19 0.21 0.25 0.30 0.35 0.41	0.18 0.20 0.24 0.29 0.34 0.40	0.17 0.19 0.23 0.28 0.33 0.39	0.16 0.18 0.22 0.27 0.32 0.38	0.15 0.17 0.21 0.26 0.31 0.37	0.14 0.16 0.20 0.25 0.30 0.36	0.13 0.15 0.19 0.24 0.29 0.35	0.12 0.14 0.18 0.23 0.28 0.34	0.11 0.13 0.17 0.22 0.27 0.33	

(Symbols and Abbreviations shown on Pages 208-210)

TABLE 9 (Continued)



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION I
INSULATION DESIGN
PAGE 46
MAY, 1968

THEORY - HEAT TRANSFER

AIR FILM RESISTANCE

Values of $\frac{1}{h}$

Entrance Coefficient	Wind Velocity MPH	Insulation Resistance Min. Max.	Operating Temperature (°F)																
			200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
			1.0 2.5 5.0 10.0 15.0 20.0	0.65 0.69 0.73 0.78 0.82 0.87 0.89	0.65 0.69 0.73 0.77 0.81 0.85 0.89	0.62 0.67 0.71 0.75 0.79 0.83 0.87	0.60 0.65 0.70 0.74 0.78 0.82 0.86	0.55 0.60 0.65 0.70 0.74 0.78 0.82	0.52 0.57 0.62 0.67 0.71 0.75 0.79	0.51 0.56 0.61 0.66 0.70 0.74 0.78	0.50 0.55 0.60 0.65 0.69 0.73 0.77	0.49 0.54 0.59 0.64 0.68 0.72 0.76	0.49 0.53 0.58 0.63 0.67 0.71 0.75	0.52 0.57 0.62 0.67 0.71 0.75 0.79	0.56 0.61 0.66 0.71 0.75 0.79 0.83	0.60 0.65 0.70 0.74 0.78 0.82 0.86	0.62 0.67 0.71 0.75 0.79 0.83 0.87	0.63 0.68 0.73 0.77 0.81 0.85 0.89	0.63 0.68 0.73 0.77 0.81 0.85 0.89
0.8	Natural Convection	1.0	0.69	0.65	0.62	0.60	0.55	0.52	0.51	0.50	0.49	0.49	0.53	0.52	0.57	0.60	0.62	0.61	0.61
		2.5	0.73	0.69	0.67	0.65	0.62	0.60	0.58	0.56	0.54	0.53	0.59	0.58	0.57	0.56	0.58	0.61	0.61
		5.0	0.78	0.75	0.73	0.71	0.69	0.66	0.64	0.62	0.60	0.60	0.64	0.63	0.62	0.61	0.62	0.63	0.63
		10.0	0.82	0.79	0.77	0.75	0.73	0.70	0.69	0.67	0.65	0.64	0.63	0.62	0.61	0.60	0.62	0.63	0.63
		15.0	0.87	0.83	0.81	0.79	0.77	0.74	0.72	0.70	0.68	0.67	0.65	0.64	0.63	0.62	0.63	0.63	0.63
		20.0	0.89	0.85	0.81	0.80	0.77	0.76	0.74	0.72	0.70	0.69	0.68	0.67	0.66	0.65	0.64	0.63	0.63
2	Natural Convection	1.0	0.51	0.49	0.46	0.45	0.43	0.40	0.38	0.37	0.37	0.37	0.39	0.39	0.44	0.45	0.44	0.45	0.45
		2.5	0.54	0.52	0.51	0.49	0.46	0.45	0.43	0.41	0.40	0.39	0.39	0.44	0.45	0.45	0.44	0.45	0.45
		5.0	0.60	0.57	0.54	0.53	0.51	0.49	0.48	0.46	0.45	0.45	0.45	0.45	0.45	0.45	0.44	0.45	0.45
		10.0	0.63	0.61	0.57	0.55	0.53	0.51	0.50	0.48	0.47	0.45	0.45	0.45	0.45	0.45	0.44	0.45	0.45
		15.0	0.68	0.65	0.62	0.60	0.58	0.55	0.54	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.45	0.45
		20.0	0.70	0.69	0.65	0.62	0.60	0.58	0.56	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.47	0.47
4	Natural Convection	1.0	0.43	0.41	0.40	0.38	0.36	0.34	0.32	0.32	0.31	0.31	0.34	0.33	0.37	0.39	0.39	0.40	0.39
		2.5	0.47	0.45	0.43	0.41	0.40	0.38	0.36	0.35	0.34	0.34	0.37	0.37	0.36	0.39	0.39	0.40	0.39
		5.0	0.52	0.50	0.48	0.46	0.44	0.42	0.41	0.40	0.39	0.38	0.37	0.40	0.40	0.41	0.40	0.40	0.39
		10.0	0.57	0.54	0.52	0.50	0.48	0.46	0.44	0.43	0.42	0.41	0.40	0.42	0.42	0.41	0.40	0.40	0.39
		15.0	0.61	0.57	0.54	0.52	0.50	0.48	0.46	0.45	0.44	0.43	0.42	0.43	0.42	0.41	0.40	0.40	0.39
		20.0	0.64	0.59	0.56	0.54	0.52	0.50	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.42	0.41	0.41	0.41
8	Natural Convection	1.0	0.36	0.35	0.33	0.31	0.29	0.28	0.27	0.27	0.27	0.27	0.28	0.28	0.31	0.32	0.32	0.33	0.33
		2.5	0.40	0.38	0.36	0.35	0.33	0.32	0.31	0.30	0.29	0.28	0.28	0.31	0.30	0.32	0.32	0.33	0.33
		5.0	0.45	0.42	0.40	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.34	0.33	0.35	0.34	0.33	0.33
		10.0	0.48	0.46	0.44	0.42	0.40	0.38	0.37	0.36	0.35	0.34	0.34	0.34	0.33	0.35	0.34	0.33	0.33
		15.0	0.50	0.48	0.46	0.44	0.42	0.40	0.39	0.38	0.37	0.36	0.36	0.35	0.36	0.36	0.35	0.35	0.34
		20.0	0.52	0.50	0.48	0.46	0.44	0.42	0.40	0.39	0.38	0.37	0.37	0.36	0.36	0.36	0.35	0.35	0.34
12	Natural Convection	1.0	0.32	0.30	0.29	0.28	0.26	0.25	0.24	0.24	0.24	0.24	0.25	0.25	0.28	0.29	0.29	0.30	0.30
		2.5	0.36	0.34	0.31	0.31	0.29	0.28	0.27	0.26	0.25	0.25	0.25	0.28	0.28	0.29	0.29	0.30	0.30
		5.0	0.40	0.38	0.36	0.35	0.33	0.32	0.31	0.30	0.29	0.28	0.28	0.31	0.30	0.32	0.32	0.33	0.33
		10.0	0.44	0.41	0.39	0.38	0.36	0.35	0.34	0.33	0.31	0.30	0.30	0.31	0.30	0.32	0.31	0.30	0.30
		15.0	0.46	0.44	0.42	0.40	0.38	0.36	0.35	0.34	0.33	0.32	0.32	0.31	0.30	0.30	0.30	0.30	0.30
		20.0	0.48	0.46	0.44	0.42	0.40	0.38	0.36	0.35	0.34	0.33	0.33	0.32	0.32	0.31	0.31	0.31	0.31
20	Natural Convection	1.0	0.29	0.26	0.25	0.24	0.22	0.21	0.20	0.20	0.20	0.20	0.22	0.22	0.24	0.24	0.24	0.25	0.25
		2.5	0.33	0.30	0.29	0.28	0.26	0.25	0.24	0.23	0.22	0.22	0.22	0.24	0.24	0.24	0.24	0.25	0.25
		5.0	0.37	0.34	0.33	0.31	0.30	0.29	0.28	0.27	0.26	0.25	0.25	0.26	0.25	0.26	0.25	0.25	0.25
		10.0	0.40	0.38	0.36	0.35	0.33	0.32	0.31	0.30	0.29	0.28	0.28	0.29	0.28	0.29	0.28	0.27	0.27
		15.0	0.44	0.41	0.39	0.38	0.36	0.35	0.34	0.33	0.31	0.30	0.30	0.31	0.30	0.30	0.30	0.29	0.29
		20.0	0.46	0.44	0.42	0.40	0.38	0.36	0.35	0.34	0.33	0.32	0.32	0.31	0.30	0.30	0.31	0.31	0.31

(Symbols and Abbreviations shown on Pages 208-210)

TABLE 9 (Continued)



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION I
INSULATION DES
PAGE 47
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THEORY - HEAT TRANSFER

AIR FILM RESISTANCE Values of $\frac{1}{h}$

ϵ Emittance	Wind Velocity MPH	Insulation Resistance		Operating Temperature (t_1) Degree F																																																													
		Min.	Max.	200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600																																													
0.7	0 Natural Convection	1.0	2.5	0.73	0.69	0.66	0.64	0.59	0.56	0.53	0.52	0.51																																																					
		2.5	5.0	0.78	0.74	0.71	0.68	0.66	0.63	0.60	0.58	0.56	0.55	0.54																																																			
		5.0	10.0	0.83	0.81	0.78	0.76	0.73	0.70	0.68	0.65	0.63	0.62	0.61	0.60	0.59	0.63	0.62	0.65	0.64																																													
		10.0	15.0	0.88	0.85	0.82	0.80	0.77	0.74	0.72	0.70	0.69	0.68	0.67	0.65	0.64	0.67	0.66	0.69	0.68																																													
		15.0	20.0	0.93	0.90	0.86	0.84	0.81	0.78	0.76	0.74	0.73	0.71	0.70	0.69	0.68	0.67	0.66	0.69	0.68																																													
		20.0	25.0	0.95	0.92	0.88	0.86	0.83	0.80	0.78	0.76	0.75	0.73	0.72	0.71	0.70	0.69	0.68	0.67	0.66																																													
		1.0	2.5	0.53	0.50	0.48	0.47	0.43	0.41	0.39	0.38	0.38																																																					
		2.5	5.0	0.57	0.54	0.53	0.51	0.49	0.47	0.45	0.43	0.42	0.41	0.40	0.40	0.46	0.45	0.47	0.46	0.48																																													
		5.0	10.0	0.63	0.61	0.58	0.56	0.54	0.52	0.50	0.49	0.48	0.47	0.46	0.45	0.49	0.48	0.47	0.46	0.49	0.48																																												
		10.0	15.0	0.69	0.66	0.63	0.61	0.57	0.55	0.53	0.52	0.51	0.50	0.50	0.49	0.51	0.50	0.49	0.49	0.49	0.48																																												
4	20.0	15.0	20.0	0.71	0.69	0.65	0.63	0.60	0.58	0.57	0.56	0.54	0.53	0.52	0.51	0.50	0.49	0.49	0.49	0.48																																													
		20.0	25.0	0.74	0.71	0.69	0.67	0.63	0.60	0.59	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48																																													
		1.0	2.5	0.44	0.42	0.41	0.39	0.37	0.35	0.33	0.32	0.32	0.35	0.34	0.38	0.37	0.41	0.40	0.40	0.40																																													
		2.5	5.0	0.50	0.47	0.45	0.44	0.41	0.39	0.38	0.37	0.36	0.35	0.34	0.39	0.38	0.42	0.41	0.40	0.40																																													
		5.0	10.0	0.54	0.51	0.49	0.47	0.45	0.44	0.42	0.41	0.40	0.39	0.38	0.42	0.41	0.40	0.40	0.40	0.40																																													
		10.0	15.0	0.61	0.56	0.54	0.52	0.49	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.40	0.40	0.40	0.40																																													
		15.0	20.0	0.63	0.59	0.57	0.55	0.52	0.50	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.42	0.42	0.41	0.40																																													
		20.0	25.0	0.66	0.64	0.61	0.57	0.55	0.52	0.50	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.42	0.41	0.40																																													
		1.0	2.5	0.37	0.36	0.34	0.42	0.30	0.29	0.28	0.28	0.28	0.28	0.29	0.29	0.32	0.31	0.30	0.29	0.29	0.28																																												
		2.5	5.0	0.41	0.39	0.37	0.36	0.34	0.33	0.32	0.32	0.31	0.30	0.29	0.29	0.32	0.31	0.30	0.29	0.29	0.28																																												
9	20.0	5.0	10.0	0.46	0.43	0.41	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.32	0.31	0.30	0.29	0.29	0.28																																													
		10.0	15.0	0.49	0.47	0.45	0.43	0.41	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.29	0.29	0.28																																												
		15.0	20.0	0.52	0.50	0.48	0.46	0.44	0.42	0.40	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.29	0.28																																											
		20.0	25.0	0.54	0.52	0.50	0.48	0.46	0.44	0.42	0.40	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.29	0.28																																										
		1.0	2.5	0.33	0.31	0.30	0.29	0.27	0.26	0.25	0.25	0.25	0.25	0.26	0.26	0.32	0.31	0.30	0.29	0.29	0.28																																												
		2.5	5.0	0.37	0.35	0.33	0.32	0.30	0.29	0.28	0.27	0.26	0.26	0.29	0.29	0.34	0.33	0.32	0.31	0.30	0.29	0.28																																											
		5.0	10.0	0.41	0.39	0.37	0.36	0.34	0.33	0.32	0.31	0.30	0.29	0.29	0.32	0.31	0.30	0.29	0.29	0.28	0.27	0.26	0.25	0.24																																									
		10.0	15.0	0.45	0.42	0.41	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.29	0.29	0.28	0.27	0.26	0.25	0.24	0.23																																									
		15.0	20.0	0.47	0.45	0.43	0.41	0.39	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.29	0.29	0.28	0.27	0.26	0.25	0.24	0.23	0.22																																								
		20.0	25.0	0.49	0.47	0.45	0.43	0.41	0.39	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.29	0.29	0.28	0.27	0.26	0.25	0.24	0.23	0.22																																							
12	20.0	1.0	2.5	0.28	0.26	0.25	0.25	0.23	0.22	0.21	0.21	0.21	0.22	0.22	0.28	0.27	0.31	0.30	0.29	0.29	0.28																																												
		2.5	5.0	0.31	0.30	0.29	0.27	0.26	0.25	0.23	0.23	0.23	0.23	0.24	0.24	0.30	0.29	0.33	0.32	0.31	0.30	0.29	0.28	0.27	0.26	0.25	0.24																																						
		5.0	10.0	0.35	0.33	0.31	0.30	0.29	0.27	0.26	0.26	0.26	0.27	0.27	0.33	0.32	0.36	0.35	0.39	0.38	0.40	0.39	0.38	0.37	0.36	0.35	0.34	0.33																																					
		10.0	15.0	0.38	0.36	0.35	0.33	0.31	0.30	0.29	0.28	0.27	0.27	0.29	0.28	0.34	0.33	0.37	0.36	0.40	0.39	0.41	0.40	0.39	0.38	0.37	0.36	0.35	0.34	0.33																																			
		15.0	20.0	0.40	0.38	0.37	0.35	0.33	0.31	0.30	0.30	0.29	0.31	0.30	0.36	0.35	0.39	0.38	0.42	0.41	0.43	0.42	0.41	0.40	0.39	0.38	0.37	0.36	0.35	0.34	0.33																																		
		20.0	25.0	0.42	0.40	0.38	0.37	0.35	0.33	0.32	0.31	0.30	0.30	0.29	0.31	0.30	0.36	0.35	0.39	0.38	0.42	0.41	0.43	0.42	0.41	0.40	0.39	0.38	0.37	0.36	0.35	0.34	0.33																																
		1.0	2.5	0.28	0.26	0.25	0.25	0.23	0.22	0.21	0.21	0.21	0.21	0.22	0.22	0.28	0.27	0.31	0.30	0.29	0.29	0.28	0.27	0.26	0.25	0.24	0.23	0.22	0.21	0.20	0.19	0.18																																	
		2.5	5.0	0.31	0.30	0.29	0.27	0.26	0.25	0.23	0.23	0.23	0.23	0.24	0.24	0.30	0.29	0.33	0.32	0.31	0.30	0.29	0.28	0.27	0.26	0.25	0.24	0.23	0.22	0.21	0.20	0.19	0.18																																
		5.0	10.0	0.35	0.33	0.31	0.30	0.29	0.27	0.26	0.26	0.26	0.27	0.27	0.33	0.32	0.36	0.35	0.39	0.38	0.40	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.29	0.28	0.27	0.26	0.25	0.24																												
		10.0	15.0	0.38	0.36	0.35	0.33	0.31	0.30	0.29	0.28	0.27	0.27	0.29	0.28	0.34	0.33	0.37	0.36	0.40	0.39	0.41	0.40	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.29	0.28	0.27	0.26	0.25	0.24																										
15.0	20.0	0.40	0.38	0.37	0.35	0.33	0.31	0.30	0.30	0.29	0.31	0.30	0.36	0.35	0.39	0.38	0.42	0.41	0.43	0.42	0.41	0.40	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.29	0.28	0.27	0.26	0.25	0.24																											
20.0	25.0	0.42	0.40	0.38	0.37	0.35	0.33	0.32	0.31	0.30	0.30	0.29	0.31	0.30	0.36	0.35	0.39	0.38	0.42	0.41	0.43	0.42	0.41	0.40	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.29	0.28	0.27	0.26	0.25	0.24																									
20	20.0	1.0	2.5	0.28	0.26	0.25	0.25	0.23	0.22	0.21	0.21	0.21	0.22	0.22	0.28	0.27	0.31	0.30	0.29	0.29	0.28	0.27	0.26	0.25	0.24	0.23	0.22	0.21	0.20	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.10	0.09	0.08	0.07	0.06	0.05	0.04	0.03	0.02	0.01	0.00																
		2.5	5.0	0.31	0.30	0.29	0.27	0.26	0.25	0.23	0.23	0.23	0.23	0.24	0.24	0.30	0.29	0.33	0.32	0.31	0.30	0.29	0.28	0.27	0.26	0.25	0.24	0.23	0.22	0.21	0.20	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.10	0.09	0.08	0.07	0.06	0.05	0.04	0.03	0.02	0.01	0.00														
		5.0	10.0	0.35	0.33	0.31	0.30	0.29	0.27	0.26	0.26	0.26	0.27	0.27	0.33	0.32	0.36	0.35	0.39	0.38	0.40	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.29	0.28	0.27	0.26	0.25	0.24	0.23	0.22	0.21	0.20	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.10	0.09	0.08	0.07	0.06	0.05	0.04	0.03	0.02	0.01	0.00				
		10.0	15.0	0.38	0.36	0.35	0.33	0.31	0.30	0.29	0.28	0.27	0.27	0.29	0.28	0.34	0.33	0.37	0.36	0.40	0.39	0.41	0.40	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.29	0.28	0.27	0.26	0.25	0.24	0.23	0.22	0.21	0.20	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.10	0.09	0.08	0.07	0.06	0.05	0.04	0.03	0.02	0.01	0.00		
		15.0	20.0	0.40	0.38	0.37	0.35	0.33	0.31	0.30	0.30	0.29	0.31	0.30	0.36	0.35	0.39	0.38	0.42	0.41	0.43	0.42	0.41	0.40	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.29	0.28	0.27	0.26	0.25	0.24	0.23	0.22	0.21	0.20	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.10	0.09	0.08	0.07	0.06	0.05	0.04	0.03	0.02	0.01	0.00	
		20.0	25.0	0.42	0.40	0.38	0.37	0.35	0.33	0.32	0.31	0.30	0.30	0.29	0.31	0.30	0.36	0.35	0.39	0.38	0.42	0.41	0.43	0.42	0.41	0.40	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.29	0.28	0.27	0.26	0.25	0.24	0.23	0.22	0.21																				

(Symbols and Abbreviations shown on Pages 208-210)

TABLE 9 (Continued)



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION I
INSULATION DESIGN
PAGE 48
MAY, 1968

THEORY - HEAT TRANSFER

AIR FILM RESISTANCE

Values of $\frac{1}{h}$

ξ Emittance	Wind Velocity MPH	Insulation Resistance		Operating Temperature (t_1) Degree F																	
		Min.	Max.	200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	
0.6	0	1.0	2.5	0.78	0.73	0.69	0.66	0.63	0.60	0.57	0.56	0.55		0.59		0.63	0.67	0.71	0.72	0.71	0.68
		2.5	5.0	0.83	0.80	0.76	0.75	0.70	0.68	0.75	0.72	0.70	0.68	0.67	0.65	0.64	0.69	0.68		0.69	0.68
		5.0	10.0	0.91	0.87	0.84	0.82	0.77	0.75	0.80	0.77	0.75	0.73	0.71	0.70	0.73	0.72	0.71	0.70	0.69	0.68
		10.0	15.0	0.95	0.91	0.89	0.87	0.83	0.80	0.77	0.75	0.73	0.71	0.74	0.73	0.76	0.74	0.73	0.72	0.71	0.68
		15.0	20.0	0.99	0.95	0.92	0.90	0.87	0.84	0.82	0.80	0.78	0.76	0.77	0.76	0.79	0.77	0.76	0.75	0.74	0.71
2	2	20.0	25.0	1.04	0.98	0.95	0.93	0.90	0.87	0.85	0.83	0.81	0.79	0.77	0.76	0.79	0.77	0.76	0.75	0.74	0.71
		1.0	2.5	0.55	0.52	0.50	0.48	0.45	0.42	0.41	0.40	0.40		0.42		0.46	0.48	0.47	0.46	0.45	0.50
		2.5	5.0	0.60	0.58	0.55	0.53	0.50	0.48	0.47	0.45	0.44	0.43	0.47	0.47	0.49	0.48	0.47	0.46	0.45	0.51
		5.0	10.0	0.66	0.63	0.61	0.59	0.56	0.53	0.51	0.50	0.49	0.48	0.51	0.50	0.52	0.51	0.50	0.49	0.48	0.50
		10.0	15.0	0.71	0.68	0.66	0.63	0.60	0.58	0.56	0.54	0.53	0.52	0.55	0.54	0.56	0.55	0.54	0.53	0.52	0.51
4	4	15.0	20.0	0.76	0.71	0.68	0.67	0.63	0.61	0.59	0.57	0.56	0.55	0.54	0.53	0.56	0.55	0.54	0.53	0.52	0.51
		20.0	25.0	0.79	0.73	0.72	0.69	0.66	0.63	0.61	0.59	0.58	0.57	0.56	0.55	0.58	0.57	0.56	0.55	0.54	0.51
		1.0	2.5	0.45	0.43	0.42	0.40	0.38	0.36	0.35	0.34	0.34		0.35		0.38	0.41	0.41	0.43	0.42	0.43
		2.5	5.0	0.52	0.49	0.47	0.45	0.42	0.41	0.39	0.38	0.37	0.36	0.35	0.40	0.39	0.42	0.42	0.43	0.43	0.42
		5.0	10.0	0.57	0.53	0.51	0.50	0.47	0.45	0.44	0.43	0.42	0.41	0.40	0.43	0.42	0.44	0.45	0.45	0.44	0.43
8	8	10.0	15.0	0.64	0.58	0.56	0.53	0.51	0.49	0.48	0.46	0.45	0.44	0.46	0.45	0.48	0.47	0.46	0.45	0.44	0.42
		15.0	20.0	0.68	0.63	0.58	0.56	0.53	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.48	0.47	0.46	0.45	0.44	0.42
		20.0	25.0	0.71	0.68	0.64	0.60	0.57	0.54	0.52	0.50	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.43
		1.0	2.5	0.38	0.36	0.34	0.33	0.31	0.30	0.29	0.29	0.29	0.29	0.30	0.30	0.32	0.32	0.32	0.32	0.32	0.32
		2.5	5.0	0.42	0.40	0.38	0.37	0.35	0.34	0.33	0.32	0.31	0.30	0.30	0.32	0.32	0.32	0.32	0.32	0.32	0.32
12	12	5.0	10.0	0.47	0.44	0.42	0.40	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.32	0.32	0.32	0.32	0.32	0.32
		10.0	15.0	0.50	0.48	0.46	0.44	0.42	0.40	0.39	0.38	0.37	0.36	0.35	0.35	0.35	0.34	0.34	0.34	0.34	0.34
		15.0	20.0	0.54	0.52	0.49	0.47	0.45	0.43	0.41	0.40	0.39	0.38	0.38	0.37	0.37	0.37	0.36	0.36	0.35	0.34
		20.0	25.0	0.56	0.54	0.52	0.50	0.47	0.45	0.43	0.41	0.40	0.40	0.39	0.39	0.39	0.38	0.37	0.37	0.36	0.36
		1.0	2.5	0.34	0.32	0.31	0.30	0.28	0.26	0.25	0.25	0.25	0.25	0.27	0.27	0.29	0.29	0.29	0.29	0.29	0.29
20	20	2.5	5.0	0.38	0.36	0.34	0.33	0.31	0.30	0.29	0.28	0.27	0.27	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.31
		5.0	10.0	0.42	0.40	0.38	0.37	0.35	0.33	0.32	0.31	0.31	0.30	0.30	0.32	0.32	0.32	0.32	0.32	0.32	0.32
		10.0	15.0	0.46	0.44	0.42	0.40	0.38	0.36	0.35	0.34	0.33	0.32	0.32	0.33	0.33	0.32	0.32	0.32	0.32	0.32
		15.0	20.0	0.48	0.46	0.44	0.42	0.40	0.38	0.37	0.36	0.35	0.34	0.33	0.33	0.34	0.34	0.33	0.33	0.32	0.32
		20.0	25.0	0.50	0.48	0.46	0.44	0.42	0.40	0.38	0.37	0.36	0.35	0.34	0.34	0.34	0.34	0.33	0.33	0.32	0.32
20	20	1.0	2.5	0.28	0.27	0.25	0.25	0.23	0.22	0.21	0.21	0.21	0.21	0.22	0.22	0.24	0.25	0.25	0.25	0.26	0.26
		2.5	5.0	0.32	0.30	0.29	0.28	0.26	0.25	0.24	0.23	0.22	0.22	0.22	0.24	0.24	0.26	0.26	0.26	0.26	0.26
		5.0	10.0	0.35	0.34	0.33	0.32	0.30	0.28	0.27	0.26	0.26	0.25	0.24	0.24	0.26	0.26	0.26	0.26	0.26	0.26
		10.0	15.0	0.39	0.37	0.35	0.34	0.32	0.30	0.29	0.29	0.28	0.28	0.28	0.28	0.28	0.28	0.27	0.27	0.26	0.26
		15.0	20.0	0.41	0.39	0.37	0.36	0.34	0.33	0.32	0.32	0.31	0.30	0.29	0.29	0.29	0.29	0.28	0.28	0.28	0.27
20	20	20.0	25.0	0.43	0.41	0.39	0.37	0.35	0.34	0.33	0.32	0.31	0.30	0.29	0.29	0.29	0.28	0.28	0.28	0.28	0.27
		1.0	2.5	0.28	0.27	0.25	0.25	0.23	0.22	0.21	0.21	0.21	0.21	0.22	0.22	0.24	0.25	0.25	0.25	0.26	0.26
		2.5	5.0	0.32	0.30	0.29	0.28	0.26	0.25	0.24	0.23	0.22	0.22	0.22	0.24	0.24	0.26	0.26	0.26	0.26	0.26
		5.0	10.0	0.35	0.34	0.33	0.32	0.30	0.28	0.27	0.26	0.26	0.25	0.24	0.24	0.26	0.26	0.26	0.26	0.26	0.26
		10.0	15.0	0.39	0.37	0.35	0.34	0.32	0.30	0.29	0.29	0.28	0.28	0.28	0.28	0.28	0.28	0.27	0.27	0.26	0.26

(Symbols and Abbreviations shown on Pages 208-210)

TABLE 9 (Continued)



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION I
INSULATION DES
PAGE 49
MAY, 1968

THEORY - HEAT TRANSFER

AIR FILM RESISTANCE

Values of $\frac{1}{h}$

Emittance ϵ	Wind Velocity MPH	Insulation Resistance Min. Max.	Operating Temperature (t_1) Degree F																
			200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
0.5	0	1.0	0.82	0.77	0.74	0.71	0.67	0.64	0.61	0.60	0.59	0.65	0.64	0.67	0.66	0.73	0.72	0.74	0.73
		2.5	0.88	0.84	0.81	0.79	0.76	0.71	0.68	0.66	0.64	0.70	0.68	0.75	0.74	0.76	0.75	0.74	0.73
		5.0	0.98	0.95	0.90	0.87	0.83	0.79	0.77	0.75	0.73	0.77	0.76	0.80	0.78	0.81	0.80	0.79	0.78
		10.0	1.03	1.00	0.97	0.94	0.89	0.85	0.82	0.80	0.78	0.83	0.81	0.85	0.83	0.86	0.85	0.84	0.83
		15.0	1.07	1.03	1.00	0.97	0.92	0.87	0.85	0.83	0.81	0.80	0.79	0.83	0.82	0.85	0.84	0.83	0.82
	2	20.0	1.11	1.06	1.03	1.00	0.95	0.90	0.88	0.87	0.84	0.83	0.82	0.81	0.80	0.79	0.78	0.77	0.76
		1.0	0.57	0.54	0.51	0.48	0.46	0.44	0.42	0.41	0.41	0.44	0.43	0.48	0.48	0.51	0.50	0.52	0.51
		2.5	0.64	0.60	0.57	0.55	0.52	0.50	0.48	0.46	0.45	0.50	0.49	0.52	0.51	0.51	0.50	0.52	0.51
		5.0	0.70	0.66	0.64	0.62	0.58	0.55	0.54	0.52	0.51	0.54	0.53	0.56	0.55	0.54	0.53	0.52	0.51
		10.0	0.75	0.71	0.68	0.66	0.63	0.60	0.57	0.56	0.55	0.58	0.57	0.60	0.59	0.58	0.57	0.56	0.55
	4	15.0	0.80	0.75	0.72	0.69	0.66	0.64	0.62	0.60	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50
		20.0	0.83	0.78	0.75	0.72	0.69	0.66	0.64	0.62	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52
		1.0	0.48	0.45	0.43	0.41	0.39	0.37	0.36	0.35	0.35	0.37	0.36	0.40	0.40	0.42	0.42	0.45	0.44
		2.5	0.54	0.51	0.49	0.47	0.44	0.42	0.40	0.39	0.38	0.37	0.36	0.40	0.40	0.42	0.42	0.45	0.44
		5.0	0.60	0.56	0.54	0.52	0.49	0.47	0.46	0.44	0.43	0.42	0.41	0.44	0.43	0.42	0.42	0.45	0.44
	8	10.0	0.67	0.61	0.59	0.56	0.53	0.51	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.42	0.45	0.44
		15.0	0.72	0.67	0.62	0.59	0.56	0.54	0.52	0.50	0.49	0.48	0.47	0.47	0.46	0.45	0.45	0.45	0.44
		20.0	0.75	0.72	0.67	0.62	0.59	0.56	0.54	0.52	0.51	0.50	0.49	0.48	0.47	0.47	0.47	0.46	0.45
		1.0	0.39	0.37	0.35	0.34	0.32	0.30	0.29	0.29	0.29	0.31	0.31	0.34	0.33	0.35	0.35	0.36	0.35
		2.5	0.42	0.40	0.38	0.37	0.35	0.34	0.33	0.32	0.31	0.31	0.31	0.34	0.33	0.35	0.35	0.36	0.35
	12	5.0	0.49	0.47	0.45	0.43	0.41	0.39	0.37	0.36	0.35	0.35	0.34	0.36	0.35	0.38	0.37	0.36	0.35
		10.0	0.54	0.52	0.49	0.47	0.44	0.42	0.41	0.40	0.39	0.38	0.37	0.36	0.35	0.38	0.37	0.36	0.35
		15.0	0.57	0.54	0.52	0.50	0.47	0.45	0.43	0.42	0.40	0.40	0.39	0.39	0.38	0.38	0.37	0.36	0.35
		20.0	0.59	0.56	0.54	0.52	0.49	0.47	0.45	0.43	0.42	0.41	0.40	0.40	0.39	0.39	0.39	0.38	0.37
		1.0	0.35	0.34	0.32	0.31	0.28	0.27	0.26	0.26	0.25	0.28	0.27	0.30	0.30	0.32	0.32	0.32	0.32
	20	2.5	0.38	0.36	0.35	0.34	0.32	0.31	0.29	0.28	0.28	0.28	0.27	0.30	0.30	0.32	0.32	0.32	0.32
		5.0	0.44	0.41	0.39	0.38	0.35	0.34	0.34	0.33	0.33	0.34	0.33	0.34	0.33	0.34	0.33	0.32	0.32
		10.0	0.48	0.45	0.43	0.41	0.38	0.37	0.36	0.35	0.34	0.34	0.33	0.34	0.33	0.34	0.33	0.32	0.32
		15.0	0.52	0.49	0.46	0.45	0.42	0.39	0.38	0.37	0.36	0.36	0.35	0.35	0.35	0.34	0.34	0.34	0.33
		20.0	0.54	0.51	0.48	0.46	0.43	0.41	0.39	0.38	0.37	0.36	0.35	0.35	0.35	0.34	0.34	0.34	0.33
		1.0	0.29	0.27	0.26	0.25	0.23	0.22	0.21	0.21	0.21	0.23	0.22	0.25	0.25	0.26	0.26	0.27	0.27
		2.5	0.33	0.31	0.29	0.28	0.27	0.26	0.25	0.24	0.23	0.26	0.25	0.25	0.25	0.26	0.26	0.27	0.27
		5.0	0.37	0.35	0.33	0.32	0.30	0.29	0.28	0.27	0.26	0.28	0.27	0.27	0.27	0.28	0.27	0.27	0.27
		10.0	0.40	0.38	0.36	0.35	0.33	0.31	0.30	0.29	0.28	0.29	0.29	0.29	0.29	0.28	0.28	0.27	0.27
		15.0	0.42	0.40	0.38	0.37	0.35	0.33	0.32	0.31	0.30	0.31	0.30	0.30	0.29	0.29	0.29	0.28	0.28
		20.0	0.45	0.43	0.41	0.39	0.37	0.35	0.34	0.32	0.31	0.31	0.30	0.30	0.29	0.29	0.29	0.28	0.28
		1.0	0.45	0.43	0.41	0.39	0.37	0.35	0.34	0.32	0.31	0.31	0.30	0.30	0.29	0.29	0.29	0.28	0.28
		2.5	0.45	0.43	0.41	0.39	0.37	0.35	0.34	0.32	0.31	0.31	0.30	0.30	0.29	0.29	0.29	0.28	0.28
		5.0	0.45	0.43	0.41	0.39	0.37	0.35	0.34	0.32	0.31	0.31	0.30	0.30	0.29	0.29	0.29	0.28	0.28
		10.0	0.45	0.43	0.41	0.39	0.37	0.35	0.34	0.32	0.31	0.31	0.30	0.30	0.29	0.29	0.29	0.28	0.28

(Symbols and Abbreviations shown on Pages 208-210)

TABLE 9 (Continued)



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION I
INSULATION DESIGN
PAGE 50
MAY, 1968

THEORY - HEAT TRANSFER

AIR FILM RESISTANCE

Values of $\frac{1}{h}$

Emissivity	Wind Velocity MPH	Insulation Resistance		Operating Temperature Degree F																
		Min.	Max.	200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
0.4	0	1.0	2.5	0.87	0.83	0.79	0.75	0.71	0.68	0.65	0.64	0.63	0.68	0.67	0.74	0.73	0.77	0.76		
		2.5	5.0	0.96	0.90	0.87	0.84	0.79	0.76	0.74	0.71	0.69	0.77	0.75	0.80	0.79	0.82	0.81	0.80	0.79
		5.0	10.0	1.07	1.01	0.98	0.95	0.91	0.85	0.83	0.81	0.79	0.82	0.80	0.84	0.83	0.85	0.84	0.83	0.82
		10.0	15.0	1.13	1.08	1.04	1.01	0.96	0.90	0.88	0.86	0.84	0.86	0.85	0.88	0.87	0.89	0.88	0.87	0.86
		15.0	20.0	1.18	1.13	1.08	1.05	1.01	0.97	0.94	0.91	0.88	0.86	0.85	0.88	0.87	0.89	0.88	0.87	0.86
	2	20.0	25.0	1.24	1.17	1.12	1.09	1.04	1.00	0.97	0.94	0.91	0.89	0.88	0.91	0.90	0.92	0.91	0.90	0.89
		1.0	2.5	0.60	0.57	0.54	0.51	0.48	0.46	0.45	0.44	0.43	0.46	0.45	0.48	0.47	0.50	0.49	0.48	0.47
		2.5	5.0	0.68	0.64	0.61	0.59	0.55	0.52	0.50	0.48	0.47	0.46	0.45	0.50	0.50	0.53	0.52	0.51	0.50
		5.0	10.0	0.74	0.71	0.68	0.65	0.61	0.59	0.57	0.55	0.53	0.57	0.55	0.60	0.59	0.62	0.61	0.60	0.59
		10.0	15.0	0.81	0.75	0.73	0.71	0.68	0.64	0.62	0.60	0.58	0.57	0.56	0.60	0.59	0.62	0.61	0.60	0.59
4	4	15.0	20.0	0.85	0.80	0.75	0.73	0.70	0.68	0.66	0.64	0.62	0.60	0.59	0.63	0.62	0.65	0.64	0.63	0.62
		20.0	25.0	0.90	0.84	0.81	0.77	0.73	0.70	0.68	0.66	0.64	0.62	0.61	0.65	0.64	0.67	0.66	0.65	0.64
		1.0	2.5	0.50	0.47	0.45	0.43	0.40	0.39	0.38	0.37	0.36	0.38	0.37	0.42	0.42	0.44	0.43	0.42	0.41
		2.5	5.0	0.57	0.53	0.50	0.48	0.46	0.44	0.43	0.41	0.39	0.38	0.37	0.42	0.42	0.44	0.43	0.42	0.41
		5.0	10.0	0.63	0.60	0.58	0.56	0.53	0.49	0.47	0.46	0.45	0.44	0.43	0.48	0.47	0.49	0.48	0.47	0.46
	8	10.0	15.0	0.69	0.63	0.61	0.59	0.56	0.53	0.51	0.50	0.49	0.48	0.47	0.50	0.49	0.51	0.50	0.49	0.48
		15.0	20.0	0.73	0.68	0.65	0.62	0.59	0.57	0.54	0.52	0.51	0.50	0.49	0.52	0.51	0.53	0.52	0.51	0.50
		20.0	25.0	0.77	0.72	0.69	0.65	0.61	0.59	0.57	0.55	0.53	0.52	0.51	0.54	0.53	0.55	0.54	0.53	0.52
		1.0	2.5	0.40	0.38	0.36	0.35	0.33	0.31	0.20	0.20	0.29	0.31	0.31	0.34	0.34	0.36	0.35	0.34	0.33
		2.5	5.0	0.44	0.42	0.40	0.38	0.35	0.34	0.33	0.32	0.32	0.31	0.31	0.34	0.34	0.36	0.35	0.34	0.33
12	12	5.0	10.0	0.51	0.48	0.46	0.44	0.42	0.40	0.38	0.37	0.36	0.35	0.35	0.38	0.37	0.39	0.38	0.37	0.36
		10.0	15.0	0.56	0.53	0.50	0.48	0.45	0.43	0.42	0.41	0.40	0.39	0.38	0.40	0.40	0.41	0.40	0.39	0.38
		15.0	20.0	0.60	0.57	0.53	0.51	0.48	0.46	0.44	0.43	0.41	0.41	0.40	0.42	0.41	0.43	0.42	0.41	0.40
		20.0	25.0	0.63	0.59	0.56	0.54	0.51	0.49	0.47	0.45	0.44	0.43	0.42	0.44	0.43	0.45	0.44	0.43	0.42
		1.0	2.5	0.36	0.34	0.33	0.31	0.29	0.28	0.27	0.26	0.25	0.28	0.27	0.31	0.31	0.32	0.31	0.30	0.29
	20	2.5	5.0	0.40	0.38	0.37	0.35	0.33	0.31	0.30	0.29	0.28	0.28	0.27	0.31	0.31	0.32	0.31	0.30	0.29
		5.0	10.0	0.46	0.42	0.40	0.39	0.37	0.35	0.34	0.33	0.32	0.32	0.31	0.33	0.33	0.34	0.33	0.32	0.31
		10.0	15.0	0.50	0.47	0.45	0.42	0.40	0.38	0.37	0.36	0.35	0.34	0.33	0.35	0.34	0.36	0.35	0.34	0.33
		15.0	20.0	0.54	0.51	0.48	0.46	0.43	0.40	0.39	0.38	0.37	0.37	0.36	0.38	0.37	0.39	0.38	0.37	0.36
		20.0	25.0	0.56	0.53	0.50	0.48	0.45	0.42	0.40	0.40	0.39	0.38	0.37	0.39	0.38	0.40	0.39	0.38	0.37
20	20	1.0	2.5	0.30	0.28	0.26	0.25	0.25	0.24	0.23	0.22	0.22	0.24	0.23	0.25	0.25	0.26	0.25	0.24	0.23
		2.5	5.0	0.34	0.32	0.30	0.29	0.28	0.26	0.25	0.24	0.24	0.26	0.25	0.27	0.27	0.28	0.27	0.26	0.25
		5.0	10.0	0.38	0.35	0.34	0.32	0.31	0.30	0.29	0.28	0.27	0.29	0.28	0.30	0.29	0.31	0.30	0.29	0.28
		10.0	15.0	0.42	0.40	0.38	0.36	0.34	0.32	0.31	0.30	0.29	0.31	0.30	0.32	0.31	0.33	0.32	0.31	0.30
		15.0	20.0	0.44	0.42	0.40	0.38	0.35	0.34	0.33	0.32	0.31	0.31	0.30	0.32	0.31	0.33	0.32	0.31	0.30
	20	20.0	25.0	0.47	0.45	0.43	0.40	0.38	0.35	0.34	0.33	0.32	0.32	0.31	0.33	0.32	0.34	0.33	0.32	0.31
		1.0	2.5	0.22	0.20	0.19	0.18	0.17	0.16	0.15	0.14	0.14	0.16	0.15	0.17	0.17	0.18	0.17	0.16	0.15
		2.5	5.0	0.26	0.24	0.22	0.21	0.20	0.19	0.18	0.17	0.16	0.18	0.17	0.19	0.19	0.20	0.19	0.18	0.17
		5.0	10.0	0.30	0.28	0.26	0.25	0.24	0.23	0.22	0.21	0.20	0.22	0.21	0.23	0.23	0.24	0.23	0.22	0.21
		10.0	15.0	0.34	0.32	0.30	0.29	0.28	0.26	0.25	0.24	0.23	0.25	0.24	0.26	0.26	0.27	0.26	0.25	0.24

(Symbols and Abbreviations on Pages 208-210)

TABLE 9 (Continued)



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION I
INSULATION DESIGN
PAGE 51
MAY, 1968

THEORY - HEAT TRANSFER

AIR FILM RESISTANCE
Values of $\frac{1}{h}$

ϵ Emittance	Wind Velocity MPH	Insulation Resistance		Operating Temperature Degree F																	
		Min.	Max.	200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	
0.3	0	1.0	2.5	0.95	0.89	0.86	0.81	0.76	0.72	0.69	0.67	0.66		0.73	0.79	0.78	0.83	0.82			
		2.5	5.0	1.08	1.00	0.96	0.92	0.88	0.83	0.80	0.77	0.75	0.74	0.80	0.85	0.84	0.89	0.87			
		5.0	10.0	1.17	1.12	1.05	1.02	0.97	0.92	0.88	0.86	0.84	0.89	0.87	0.85	0.84	0.88	0.87	0.86	0.85	
		10.0	15.0	1.25	1.19	1.15	1.11	1.05	1.00	0.96	0.94	0.91	0.89	0.87	0.85	0.84	0.88	0.87	0.86	0.85	
		15.0	20.0	1.31	1.25	1.21	1.16	1.07	1.04	1.02	0.99	0.96	0.94	0.92	0.91	0.89	0.88	0.87	0.86	0.85	
	Natural Convection	20.0	25.0	1.34	1.28	1.25	1.20	1.15	1.10	1.07	1.04	1.01	0.98	0.96	0.94	0.92	0.91	0.90	0.89	0.88	
		1.0	2.5	0.64	0.60	0.57	0.54	0.51	0.48	0.47	0.46	0.45		0.48							
		2.5	5.0	0.71	0.67	0.64	0.61	0.58	0.55	0.53	0.51	0.50	0.49	0.48	0.52	0.52	0.55	0.54	0.57	0.57	
		5.0	10.0	0.78	0.75	0.72	0.68	0.66	0.62	0.60	0.58	0.56	0.54	0.59	0.58	0.56	0.59	0.58	0.60	0.59	
		10.0	15.0	0.85	0.81	0.77	0.75	0.71	0.67	0.66	0.63	0.61	0.60	0.62	0.60	0.59	0.60	0.59	0.60	0.59	
4	0	15.0	20.0	0.90	0.85	0.82	0.78	0.75	0.72	0.69	0.67	0.66	0.64	0.62	0.60	0.59	0.59	0.58	0.57	0.57	
		20.0	25.0	0.95	0.88	0.85	0.82	0.77	0.75	0.73	0.70	0.68	0.67	0.66	0.64	0.61	0.60	0.60	0.60	0.59	
		1.0	2.5	0.53	0.50	0.48	0.45	0.42	0.40	0.39	0.38	0.37		0.38							
		2.5	5.0	0.59	0.56	0.53	0.51	0.48	0.45	0.43	0.42	0.40	0.39	0.38	0.44	0.44	0.43	0.46	0.45	0.48	0.47
		5.0	10.0	0.65	0.62	0.59	0.57	0.54	0.52	0.50	0.48	0.47	0.45	0.50	0.49	0.48	0.47	0.49	0.48	0.47	
	Natural Convection	10.0	15.0	0.72	0.68	0.65	0.62	0.58	0.56	0.54	0.52	0.51	0.50	0.52	0.51	0.50	0.49	0.48	0.48	0.47	
		15.0	20.0	0.77	0.73	0.68	0.66	0.62	0.59	0.57	0.55	0.53	0.52	0.52	0.51	0.50	0.49	0.48	0.48	0.47	
		20.0	25.0	0.81	0.76	0.72	0.68	0.65	0.62	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	
		1.0	2.5	0.42	0.40	0.38	0.37	0.34	0.32	0.31	0.30	0.30	0.33	0.32	0.35	0.35	0.37	0.37	0.39	0.38	
		2.5	5.0	0.47	0.45	0.43	0.41	0.39	0.37	0.35	0.34	0.33	0.33	0.36	0.39	0.38	0.37	0.37	0.40	0.39	
8	0	5.0	10.0	0.53	0.50	0.48	0.46	0.43	0.41	0.40	0.39	0.38	0.37	0.40	0.40	0.39	0.38	0.37	0.37	0.39	0.38
		10.0	15.0	0.58	0.55	0.52	0.50	0.48	0.45	0.43	0.42	0.41	0.40	0.42	0.41	0.40	0.40	0.39	0.39	0.38	
		15.0	20.0	0.62	0.59	0.56	0.53	0.50	0.48	0.45	0.44	0.43	0.42	0.41	0.40	0.40	0.40	0.39	0.39	0.38	
		20.0	25.0	0.68	0.61	0.58	0.56	0.53	0.50	0.48	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.40	0.40	0.39	
	Natural Convection	1.0	2.5	0.37	0.35	0.34	0.32	0.30	0.29	0.27	0.26	0.26	0.29	0.28	0.31	0.31	0.33	0.33	0.34	0.33	
		2.5	5.0	0.41	0.39	0.38	0.36	0.34	0.32	0.31	0.30	0.29	0.29	0.31	0.31	0.34	0.34	0.34	0.34	0.33	
		5.0	10.0	0.46	0.43	0.41	0.40	0.38	0.36	0.35	0.34	0.33	0.32	0.34	0.34	0.35	0.34	0.34	0.34	0.33	
		10.0	15.0	0.51	0.48	0.45	0.43	0.41	0.39	0.38	0.37	0.36	0.35	0.36	0.37	0.36	0.35	0.34	0.34	0.33	
		15.0	20.0	0.55	0.52	0.49	0.47	0.44	0.42	0.40	0.39	0.38	0.37	0.36	0.37	0.36	0.35	0.34	0.34	0.33	
12	0	20.0	25.0	0.57	0.54	0.51	0.49	0.46	0.43	0.42	0.41	0.40	0.39	0.38	0.37	0.36	0.36	0.35	0.35	0.35	
		1.0	2.5	0.30	0.29	0.28	0.27	0.26	0.24	0.24	0.23	0.23	0.23	0.24	0.26	0.26	0.27	0.27	0.28	0.28	
		2.5	5.0	0.34	0.33	0.30	0.29	0.28	0.27	0.26	0.25	0.24	0.24	0.26	0.26	0.25	0.25	0.27	0.27	0.28	
		5.0	10.0	0.40	0.37	0.35	0.33	0.32	0.30	0.29	0.29	0.28	0.27	0.29	0.28	0.28	0.29	0.29	0.29	0.28	
	Natural Convection	10.0	15.0	0.44	0.42	0.39	0.38	0.35	0.33	0.32	0.30	0.30	0.31	0.30	0.30	0.29	0.29	0.29	0.29	0.28	
		15.0	20.0	0.46	0.44	0.42	0.40	0.37	0.35	0.34	0.33	0.32	0.31	0.30	0.30	0.29	0.29	0.29	0.29	0.28	
		20.0	25.0	0.49	0.47	0.45	0.42	0.40	0.37	0.35	0.34	0.33	0.32	0.31	0.31	0.30	0.30	0.29	0.29	0.28	
		1.0	2.5	0.27	0.26	0.25	0.24	0.23	0.22	0.21	0.20	0.20	0.20	0.21	0.21	0.21	0.21	0.21	0.21	0.21	
		2.5	5.0	0.30	0.29	0.28	0.27	0.26	0.24	0.24	0.23	0.23	0.23	0.24	0.24	0.24	0.24	0.24	0.24	0.24	
20	0	5.0	10.0	0.34	0.33	0.30	0.29	0.28	0.27	0.26	0.25	0.24	0.24	0.26	0.26	0.25	0.25	0.27	0.27	0.28	
		10.0	15.0	0.40	0.37	0.35	0.33	0.32	0.30	0.29	0.29	0.28	0.27	0.29	0.28	0.28	0.29	0.29	0.29	0.28	
		15.0	20.0	0.44	0.42	0.39	0.38	0.35	0.33	0.32	0.30	0.30	0.31	0.30	0.30	0.29	0.29	0.29	0.29	0.28	
		20.0	25.0	0.46	0.44	0.42	0.40	0.37	0.35	0.34	0.33	0.32	0.31	0.30	0.30	0.29	0.29	0.29	0.29	0.28	
	Natural Convection	1.0	2.5	0.20	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.13	0.13	0.14	0.14	0.14	0.14	0.14	0.14	0.14	
		2.5	5.0	0.22	0.21	0.20	0.19	0.18	0.17	0.16	0.15	0.14	0.14	0.15	0.15	0.15	0.15	0.15	0.15	0.15	
		5.0	10.0	0.25	0.24	0.23	0.22	0.21	0.20	0.19	0.18	0.17	0.17	0.18	0.18	0.18	0.18	0.18	0.18	0.18	
		10.0	15.0	0.28	0.27	0.26	0.25	0.24	0.23	0.22	0.21	0.20	0.20	0.21	0.21	0.21	0.21	0.21	0.21	0.21	
		15.0	20.0	0.30	0.29	0.28	0.27	0.26	0.25	0.24	0.23	0.23	0.23	0.24	0.24	0.24	0.24	0.24	0.24	0.24	

(Symbols and Abbreviations on Pages 208-210)

TABLE 9 (Continued)



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION I
INSULATION DESIGN
PAGE 52
MAY, 1968

THEORY - HEAT TRANSFER

AIR FILM RESISTANCE

Values of $\frac{1}{h}$

ξ Emissance	Wind Velocity MPH	Insulation Resistance Min. - Max.	Operating Temperature (t) Degree F																
			200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
0.2	0	1.0	1.02	0.96	0.93	0.88	0.81	0.78	0.74	0.71	0.69		0.76	0.75					
		2.5	1.17	1.10	1.05	1.01	0.95	0.91	0.87	0.85	0.81	0.78	0.76	0.75	0.83				
		5.0	1.29	1.23	1.17	1.12	1.06	1.01	0.99	0.95	0.93	0.90	0.87	0.85	0.91	0.90	0.89		
		10.0	1.39	1.30	1.26	1.23	1.15	1.09	1.04	1.02	1.00	0.97	0.95	0.93	0.91	0.90	0.89		
		15.0	1.45	1.39	1.34	1.29	1.22	1.17	1.12	1.08	1.05	1.03	1.01	0.99	0.97	0.96	0.95	0.94	0.93
		20.0	1.52	1.43	1.38	1.33	1.26	1.21	1.17	1.13	1.10	1.07	1.05	1.02	1.01	1.00	0.99	0.98	0.97
		25.0																	
		1.0	0.67	0.63	0.59	0.57	0.55	0.52	0.51	0.50	0.49		0.50						
		2.5	0.75	0.71	0.67	0.64	0.61	0.58	0.56	0.54	0.52	0.51	0.50	0.56	0.55	0.54			
		5.0	0.84	0.80	0.76	0.73	0.69	0.65	0.62	0.60	0.58	0.57	0.56	0.61	0.60	0.59	0.58	0.57	
	2	10.0	0.92	0.87	0.82	0.79	0.76	0.71	0.68	0.66	0.64	0.62	0.61	0.60	0.59	0.58	0.57		
		15.0	0.98	0.93	0.88	0.84	0.79	0.76	0.73	0.70	0.68	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59
		20.0	1.03	0.96	0.92	0.89	0.84	0.80	0.77	0.74	0.72	0.69	0.68	0.67	0.66	0.65	0.64	0.63	0.62
		25.0																	
		1.0	0.55	0.52	0.49	0.47	0.44	0.42	0.40	0.39	0.38		0.41						
		2.5	0.62	0.58	0.55	0.53	0.50	0.47	0.45	0.44	0.43	0.42	0.41	0.45	0.44				
		5.0	0.69	0.65	0.62	0.59	0.57	0.54	0.51	0.49	0.48	0.47	0.46	0.49	0.48	0.47	0.46		
		10.0	0.76	0.73	0.69	0.65	0.61	0.59	0.57	0.55	0.53	0.51	0.50	0.53	0.52	0.51	0.50	0.49	0.48
		15.0	0.80	0.76	0.72	0.69	0.65	0.62	0.60	0.58	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48
		20.0	0.85	0.80	0.75	0.72	0.68	0.64	0.62	0.60	0.59	0.58	0.56	0.55	0.54	0.53	0.52	0.51	0.50
	4	25.0																	
		1.0	0.44	0.41	0.39	0.38	0.35	0.33	0.32	0.31	0.30		0.33						
		2.5	0.50	0.47	0.44	0.42	0.40	0.38	0.36	0.35	0.34	0.34	0.33	0.36	0.36				
		5.0	0.56	0.52	0.50	0.48	0.45	0.42	0.41	0.40	0.39	0.38	0.37	0.36	0.39	0.38	0.38		
		10.0	0.62	0.58	0.53	0.52	0.49	0.47	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.38		
		15.0	0.66	0.61	0.59	0.56	0.52	0.50	0.48	0.47	0.45	0.44	0.43	0.42	0.41	0.40	0.40	0.39	0.39
		20.0	0.68	0.64	0.62	0.59	0.55	0.52	0.50	0.49	0.48	0.46	0.45	0.44	0.43	0.42	0.42	0.41	0.40
		25.0																	
		1.0	0.38	0.36	0.34	0.32	0.30	0.29	0.28	0.27	0.27		0.29						
		2.5	0.42	0.40	0.38	0.37	0.35	0.33	0.31	0.30	0.30	0.30	0.29	0.32	0.31	0.31	0.33		
	8	5.0	0.48	0.46	0.43	0.41	0.39	0.37	0.36	0.35	0.34	0.33	0.32	0.32	0.34	0.34	0.33		
		10.0	0.53	0.50	0.47	0.45	0.43	0.41	0.39	0.38	0.37	0.36	0.35	0.35	0.36	0.36	0.35	0.35	0.34
		15.0	0.57	0.53	0.50	0.48	0.45	0.42	0.42	0.40	0.39	0.38	0.37	0.37	0.36	0.36	0.35	0.35	0.34
		20.0	0.57	0.53	0.50	0.48	0.45	0.42	0.42	0.40	0.39	0.38	0.37	0.37	0.36	0.36	0.35	0.35	0.34
		25.0	0.60	0.56	0.53	0.51	0.48	0.45	0.43	0.42	0.41	0.40	0.39	0.38	0.37	0.37	0.36	0.36	0.35
		1.0	0.31	0.29	0.28	0.27	0.26	0.25	0.25	0.24	0.24		0.24						
		2.5	0.35	0.34	0.32	0.31	0.29	0.28	0.27	0.26	0.25	0.25	0.25	0.27	0.26	0.26	0.27		
		5.0	0.41	0.38	0.36	0.34	0.33	0.31	0.30	0.29	0.28	0.28	0.27	0.27	0.26	0.26	0.27	0.27	0.28
		10.0	0.46	0.43	0.41	0.39	0.37	0.34	0.32	0.31	0.30	0.30	0.29	0.29	0.28	0.28	0.27	0.29	0.28
		15.0	0.48	0.46	0.44	0.42	0.39	0.36	0.35	0.34	0.33	0.32	0.31	0.31	0.30	0.30	0.29	0.29	0.28
	12	20.0	0.50	0.48	0.46	0.44	0.41	0.38	0.36	0.35	0.34	0.33	0.32	0.32	0.32	0.31	0.30	0.30	0.29
		25.0																	
		1.0	0.29	0.28	0.28	0.27	0.26	0.25	0.25	0.24	0.24		0.24						
		2.5	0.31	0.29	0.28	0.27	0.26	0.25	0.25	0.24	0.24	0.24	0.24	0.25	0.25	0.25	0.25	0.25	0.25
		5.0	0.35	0.34	0.32	0.31	0.29	0.28	0.27	0.26	0.25	0.25	0.25	0.27	0.26	0.26	0.27	0.27	0.28
		10.0	0.41	0.38	0.36	0.34	0.33	0.31	0.30	0.29	0.28	0.28	0.27	0.27	0.26	0.26	0.27	0.27	0.28
		15.0	0.46	0.43	0.41	0.39	0.37	0.34	0.32	0.31	0.30	0.30	0.29	0.29	0.28	0.28	0.27	0.29	0.28
		20.0	0.48	0.46	0.44	0.42	0.39	0.36	0.35	0.34	0.33	0.32	0.31	0.31	0.30	0.30	0.29	0.29	0.28
		25.0	0.50	0.48	0.46	0.44	0.41	0.38	0.36	0.35	0.34	0.33	0.32	0.32	0.32	0.31	0.30	0.30	0.29
		1.0	0.24	0.23	0.23	0.22	0.21	0.20	0.20	0.19	0.19		0.19						
	20	2.5	0.27	0.26	0.26	0.25	0.24	0.23	0.22	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
		5.0	0.31	0.30	0.29	0.28	0.27	0.26	0.25	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
		10.0	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.29	0.28	0.28	0.27	0.27	0.26	0.26	0.27	0.27	0.28
		15.0	0.41	0.40	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.31	0.30	0.30	0.29	0.29	0.28
		20.0	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.30	0.29
		25.0																	
		1.0	0.19	0.18	0.18	0.17	0.16	0.15	0.15	0.14	0.14		0.14						
		2.5	0.21	0.20	0.20	0.19	0.18	0.17	0.16	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
		5.0	0.24	0.23	0.23	0.22	0.21	0.20	0.19	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
		10.0	0.28	0.27	0.26	0.25	0.24	0.23	0.22	0.21	0.20	0.20	0.19	0.19	0.18	0.18	0.17	0.17	0.17

(Symbols and Abbreviations on Pages 208-210)

TABLE 9 (Continued)



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION I
INSULATION DESIGN
PAGE 53
MAY, 1968

THEORY - HEAT TRANSFER

AIR FILM RESISTANCE Values of $\frac{1}{h}$

Emittance ϵ	Wind Velocity MPH	Insulation Resistance		Operating Temperature (t_1)																
		Min.	Max.	200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
0.1	0	1.0	2.5	1.15	1.07	1.02	0.98	0.91	0.87	0.83	0.80	0.78	0.87	0.85	0.94	0.92	0.99	0.97	1.02	1.01
	2.5	5.0	1.30	1.21	1.17	1.12	1.05	0.99	0.95	0.92	0.89	0.87	0.85	0.94	0.92	0.99	0.97	1.02	1.01	
	5.0	10.0	1.47	1.36	1.30	1.24	1.17	1.12	1.07	1.04	1.01	0.98	0.96	1.03	1.01	1.05	1.04	1.07	1.06	
	10.0	15.0	1.57	1.42	1.43	1.35	1.27	1.21	1.17	1.12	1.10	1.07	1.05	1.08	1.06	1.05	1.08	1.07	1.06	
2	0	1.0	2.5	1.71	1.62	1.57	1.51	1.43	1.35	1.29	1.25	1.21	1.19	1.16	1.14	1.12	1.10	1.08	1.07	1.06
	2.5	5.0	1.81	1.75	1.71	1.69	1.64	1.60	1.58	1.56	1.54	1.50	1.53	1.52	1.58	1.57	1.61	1.60	1.63	1.62
	5.0	10.0	1.90	1.84	1.80	1.77	1.73	1.69	1.66	1.64	1.62	1.60	1.59	1.63	1.62	1.65	1.64	1.67	1.66	
	10.0	15.0	2.05	1.99	1.94	1.89	1.84	1.80	1.77	1.74	1.72	1.70	1.68	1.67	1.66	1.65	1.65	1.67	1.66	
4	0	1.0	2.5	2.58	2.42	2.35	2.28	2.20	2.12	2.05	2.00	1.95	1.90	1.85	1.80	1.75	1.70	1.68	1.67	1.66
	2.5	5.0	2.65	2.50	2.42	2.35	2.28	2.20	2.12	2.05	2.00	1.95	1.90	1.85	1.80	1.75	1.70	1.68	1.67	1.66
	5.0	10.0	2.74	2.59	2.52	2.44	2.36	2.28	2.20	2.12	2.05	1.99	1.94	1.89	1.84	1.79	1.77	1.76	1.75	
	10.0	15.0	2.85	2.70	2.62	2.54	2.46	2.38	2.30	2.22	2.15	2.09	2.04	2.00	1.95	1.90	1.88	1.87	1.86	
8	0	1.0	2.5	4.45	4.20	4.00	3.80	3.60	3.40	3.30	3.20	3.10	3.00	2.90	2.80	2.70	2.60	2.55	2.50	2.48
	2.5	5.0	4.52	4.27	4.07	3.87	3.67	3.47	3.27	3.17	3.07	2.97	2.87	2.77	2.67	2.57	2.52	2.47	2.45	
	5.0	10.0	4.60	4.35	4.15	3.95	3.75	3.55	3.35	3.25	3.15	3.05	2.95	2.85	2.75	2.65	2.55	2.50	2.48	
	10.0	15.0	4.69	4.44	4.24	4.04	3.84	3.64	3.44	3.24	3.14	3.04	2.94	2.84	2.74	2.64	2.54	2.49	2.47	
12	0	1.0	2.5	6.39	6.07	5.80	5.50	5.20	4.90	4.70	4.50	4.30	4.10	3.90	3.70	3.50	3.30	3.10	2.90	2.70
	2.5	5.0	6.44	6.12	5.85	5.55	5.25	4.95	4.75	4.55	4.35	4.15	3.95	3.75	3.55	3.35	3.15	2.95	2.75	
	5.0	10.0	6.50	6.18	5.90	5.60	5.30	5.00	4.80	4.60	4.40	4.20	4.00	3.80	3.60	3.40	3.20	3.00	2.80	
	10.0	15.0	6.59	6.27	6.00	5.70	5.40	5.10	4.90	4.70	4.50	4.30	4.10	3.90	3.70	3.50	3.30	3.10	2.90	
20	0	1.0	2.5	8.39	7.97	7.60	7.20	6.80	6.40	6.10	5.80	5.50	5.20	4.90	4.60	4.30	4.00	3.70	3.40	3.10
	2.5	5.0	8.44	8.02	7.65	7.25	6.85	6.45	6.15	5.85	5.55	5.25	4.95	4.65	4.35	4.05	3.75	3.45	3.15	
	5.0	10.0	8.50	8.08	7.70	7.30	6.90	6.50	6.20	5.90	5.60	5.30	5.00	4.70	4.40	4.10	3.80	3.50	3.20	
	10.0	15.0	8.59	8.17	7.80	7.40	7.00	6.60	6.30	6.00	5.70	5.40	5.10	4.80	4.50	4.20	3.90	3.60	3.30	

(Symbols and Abbreviations on Pages 208-210)

TABLE 9 (Continued)



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION I
INSULATION DESIGN
PAGE 54
MAY, 1968

THEORY - HEAT TRANSFER

AIR FILM RESISTANCE

Values of $\frac{1}{h}$

ϵ Emittance	Wind Velocity MPH	Insulation Resistance Min. Max.	Operating Temperature (t_1) Degree F																
			200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
			1.0 2.5 5.0 10.0 15.0 20.0 25.0	1.16 1.31 1.43 1.58 1.74 1.83	1.10 1.22 1.36 1.50 1.60 1.72	1.06 1.18 1.32 1.43 1.54 1.60	0.98 1.10 1.22 1.35 1.42 1.49	0.94 1.05 1.17 1.28 1.36 1.42	0.89 1.00 1.12 1.19 1.26 1.33	0.85 0.96 1.08 1.15 1.22 1.29	0.82 0.94 1.05 1.15 1.22 1.29	0.92 1.03 1.11 1.19 1.24	0.91 1.00 1.08 1.16 1.21	0.98 1.06 1.14 1.19	0.96 1.04 1.12 1.16	1.03 1.10 1.12 1.14	1.02 1.08 1.10 1.12	1.06 1.11	1.04 1.10
0.05	0	1.0	1.24	1.16	1.10	1.06	0.98	0.94	0.89	0.85	0.82								
		2.5	1.37	1.31	1.22	1.18	1.10	1.05	1.00	0.96	0.94	0.92	0.91	0.98	0.96				
		5.0	1.55	1.43	1.36	1.32	1.22	1.17	1.12	1.08	1.05	1.03	1.00	0.98	0.96	1.03	1.02		
		10.0	1.68	1.58	1.50	1.43	1.35	1.28	1.22	1.19	1.15	1.11	1.08	1.06	1.04	1.10	1.08	1.06	1.04
		15.0	1.74	1.66	1.60	1.54	1.42	1.36	1.31	1.26	1.22	1.19	1.16	1.14	1.12	1.10	1.08	1.06	1.04
		20.0	1.83	1.72	1.66	1.60	1.49	1.42	1.36	1.33	1.29	1.24	1.21	1.19	1.16	1.14	1.12	1.11	1.10
2	2	1.0	0.74	0.70	0.66	0.63	0.58	0.55	0.54	0.53	0.52	0.55	0.54						
		2.5	0.84	0.78	0.74	0.71	0.65	0.62	0.60	0.58	0.56	0.62	0.61	0.60	0.59				
		5.0	0.94	0.88	0.83	0.80	0.75	0.71	0.68	0.65	0.63	0.68	0.66	0.65	0.64	0.63	0.62		
		10.0	1.02	0.96	0.91	0.88	0.82	0.77	0.74	0.72	0.70	0.75	0.73	0.70	0.69	0.68	0.67	0.66	0.65
		15.0	1.09	1.01	0.97	0.94	0.88	0.83	0.79	0.77	0.75	0.73	0.71	0.70	0.69	0.68	0.67	0.66	0.65
		20.0	1.15	1.07	1.01	0.98	0.92	0.88	0.84	0.81	0.78	0.76	0.74	0.72	0.71	0.70	0.69	0.68	0.67
4	4	1.0	0.60	0.55	0.52	0.50	0.46	0.44	0.42	0.41	0.41	0.45	0.44						
		2.5	0.67	0.63	0.60	0.57	0.53	0.50	0.48	0.47	0.46	0.45	0.49	0.48	0.47	0.51	0.50		
		5.0	0.76	0.71	0.67	0.64	0.61	0.57	0.55	0.53	0.51	0.55	0.54	0.53	0.52	0.51	0.50	0.53	0.52
		10.0	0.82	0.78	0.74	0.71	0.66	0.63	0.61	0.59	0.57	0.60	0.59	0.57	0.56	0.55	0.54	0.53	0.52
		15.0	0.87	0.82	0.79	0.76	0.71	0.67	0.65	0.62	0.61	0.60	0.59	0.57	0.56	0.55	0.54	0.53	0.52
		20.0	0.93	0.86	0.82	0.78	0.75	0.71	0.67	0.65	0.63	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54
8	8	1.0	0.46	0.43	0.41	0.39	0.37	0.35	0.34	0.33	0.32	0.36	0.35						
		2.5	0.53	0.50	0.47	0.44	0.42	0.40	0.38	0.37	0.36	0.39	0.38	0.38	0.38	0.41	0.40		
		5.0	0.59	0.56	0.53	0.51	0.47	0.45	0.43	0.41	0.40	0.45	0.42	0.42	0.41	0.41	0.40	0.42	0.41
		10.0	0.66	0.61	0.58	0.56	0.52	0.50	0.48	0.46	0.44	0.47	0.46	0.45	0.44	0.43	0.42	0.42	0.41
		15.0	0.70	0.65	0.62	0.59	0.56	0.53	0.51	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.42	0.41
		20.0	0.74	0.69	0.65	0.63	0.58	0.55	0.53	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42
12	12	1.0	0.40	0.37	0.36	0.34	0.32	0.30	0.29	0.29	0.28	0.31	0.30						
		2.5	0.45	0.42	0.40	0.39	0.37	0.35	0.33	0.32	0.31	0.34	0.33	0.33	0.33	0.35	0.35		
		5.0	0.51	0.47	0.44	0.42	0.41	0.39	0.37	0.36	0.35	0.38	0.37	0.36	0.36	0.37	0.37	0.36	0.36
		10.0	0.56	0.53	0.49	0.46	0.44	0.42	0.41	0.40	0.39	0.40	0.39	0.38	0.38	0.37	0.37	0.36	0.36
		15.0	0.61	0.56	0.53	0.50	0.46	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.38	0.37	0.37	0.36	0.36
		20.0	0.64	0.60	0.56	0.53	0.49	0.46	0.44	0.43	0.42	0.42	0.41	0.40	0.39	0.39	0.38	0.38	0.37
20	20	1.0	0.33	0.31	0.29	0.28	0.26	0.25	0.24	0.24	0.24	0.25	0.25						
		2.5	0.37	0.35	0.33	0.32	0.30	0.28	0.27	0.26	0.25	0.28	0.28	0.28	0.27	0.29	0.29	0.30	0.29
		5.0	0.43	0.41	0.39	0.37	0.34	0.32	0.31	0.30	0.29	0.31	0.31	0.30	0.29	0.29	0.30	0.30	0.29
		10.0	0.48	0.45	0.42	0.41	0.38	0.36	0.34	0.33	0.32	0.33	0.32	0.31	0.31	0.31	0.30	0.30	0.29
		15.0	0.51	0.48	0.46	0.44	0.40	0.38	0.36	0.35	0.34	0.34	0.33	0.32	0.32	0.31	0.31	0.31	0.29
		20.0	0.53	0.51	0.49	0.47	0.44	0.41	0.39	0.37	0.36	0.35	0.34	0.33	0.32	0.32	0.31	0.31	0.29

(Symbols and Abbreviations on Pages 208-210)

TABLE 9 (Continued)

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SECTION I
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AIR FILM SURFACE RESISTANCE VALUES OF $1/h$ OR "R_s"
 Heat Transfer From Air To Lower Temperature Surface (Cold Service)

[illegible]



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AIR FILM SURFACE RESISTANCE VALUES OF "1/h OR 'R_s"
Heat Transfer From Air To Lower Temperature Surface (Cold Service)

TEMPERATURE OF AIR FILM SURFACE (°F)	t = 0.0			t = 0.8			t = 0.6			t = 0.4			t = 0.2		
	AIR MOVEMENT			AIR MOVEMENT			AIR MOVEMENT			AIR MOVEMENT			AIR MOVEMENT		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
60	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
61	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
62	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
63	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73
64	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
65	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
66	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
67	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77
68	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
69	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79
70	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
71	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81
72	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
73	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
74	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
75	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
76	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
77	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
78	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
79	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
80	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
81	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
82	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
83	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
84	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
85	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
86	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
87	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
88	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
89	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
91	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
92	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
93	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
94	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
95	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
96	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06
97	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07
98	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
99	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09
100	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10

(Symbols and Abbreviations on Page)

TABLE 10 (Contd)

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THEORY - HEAT TRANSFER

1. HEAT TRANSFER - GENERAL - Continued

CALCULATION OF HEAT TRANSFER BY COMPUTER

The six most used heat transfer problems have been programmed on the UCC Time-Sharing Computer System. These programs are now operational and are set up so that all plants or departments connected to the Time-Sharing Computer can use these six programs.

The following is a brief review of the equations, the purpose of the calculation, instructions for use of these programs, and sample solutions.

In addition, tables of dimensions for inside and outside radii for pipe and tubing (R1 and R2); thermal conductivities for commonly used insulation materials (EK); surface emittance factors for weather barriers commonly used over insulation (EPS); and a table of conversions for change in wind velocity from miles per hour to feet per minute (V) are included. It should be noticed the symbols used are different than those previously used. This was necessary due to limitations of entering in symbols in the computer.

INTRODUCTION - Except in rare cases, certain equations employed by process and project design personnel for calculating heat transfer, cannot be solved directly. The solution of these equations is usually arrived at by a trial and error technique, a procedure which can be both tedious and time consuming. However, this type of problem is ideally suited to computerization, particularly on the UCC Time Sharing System.

The following heat transfer equations are in continuous use by UCC personnel, and their solution normally is both time consuming and certainly tedious, depending on how good the first assumptions are:

$$QA = \frac{(T1-T2)EK}{R2 \log_e(R2/R1)} = 0.174 \times EPS \left[\left(\frac{T2+460}{100} \right)^4 - \left(\frac{TA+460}{100} \right)^4 \right] + 0.296(T2-TA)^{5/4} \left(\frac{V+68.9}{68.9} \right)^{1/2} \quad (1) \text{ for pipe}$$

$$QA = \frac{(T1-T2)EK}{EL} = 0.174 \times EPS \left[\left(\frac{T2+460}{100} \right)^4 - \left(\frac{TA+460}{100} \right)^4 \right] + 0.296 (T2-TA)^{5/4} \left(\frac{V+68.9}{68.9} \right)^{1/2} \quad (2) \text{ for flat surfaces}$$



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Where:

QA	=	HEAT LOSS OR GAIN, BTU/SQ. FT., HR.
T1	=	OPERATING TEMPERATURE, DEG. F
T2	=	SURFACE TEMP OF INSULATION PROTECTIVE COVER, DEG F
TA	=	AMBIENT AIR TEMPERATURE, DEG F
R1	=	INSIDE RADIUS OF INSULATION, INCHES
R2	=	OUTSIDE RADIUS OF INSULATION, INCHES
EL	=	THICKNESS OF INSULATION, INCHES
EK	=	CONDUCTIVITY OF INSULATION, BTU/SQ. FT., HR, INCHES
EPS	=	SURFACE EMITTANCE, RATIO TO BLACK BODY
V	=	VELOCITY OF WIND, FT./MIN.

As noted, equation (1) pertains to insulated pipe, and equation (2) to insulated flat surfaces.* The middle term in the three part equation calculates the heat transfer through an insulated wall by conduction, whereas the right hand terms calculate the same heat flow to or from the atmosphere by a combination of radiation and convection. For a specific problem, the input data for all terms in the formulas will be known or can be obtained, but two. The two unknowns are then obtained by simultaneous solution of the two heat flow equations.

There are three typical problems normally encountered in process or project design that employ equations (1) or (2).

Solutions are needed to define:

1. The heat loss or gain for a given thickness of insulation. Numerical values for all terms in the equations are known except for QA and T2.
2. The required thickness of insulation for a specified heat loss or gain. Numerical values for all terms are known except for R2** and T2.
3. The required thickness of insulation to limit the outside surface temperature, T2, of the insulation jacket or covering to some predetermined amount. Numerical values for all terms are known except for R2** and QA.

The computer programs listed in the following table are operational on the UCC Time Sharing System, and are filed under User Number C693:

- * The walls of process vessels over 36 inches in diameter may be considered as flat surfaces.
- ** For flat surfaces, the required insulation thickness is defined by the term "EL".

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JULY 1969A - Insulated Pipe (Formula 1)Formula Terms

<u>Program Name</u>	<u>Purpose</u>	<u>Known</u>	<u>To Be Calculated</u>
INSQAP	For calculation of heat loss or gain.	T1, TA, R1, R2, EK, EPS, V	QA, T2
INSTHP	For calculation of the required insulation thickness for a specified heat loss or gain.	T1, TA, R1, QA, EK, EPS, V	R2, T2
INST2P	For calculation of the required insulation thickness to assure a specified maximum temperature at the outer surface of the insulation jacket.	T1, TA, R1, T2, EK, EPS, V	R2, QA

B - Insulated Flat Surfaces (Formula 2)

INSQAF	For calculation of heat loss or gain.	T1, TA, EL, EK, EPS, V	QA, T2
INSTHF	For calculation of required insulation thickness for a specified heat loss or gain.	T1, TA, QA, EK, EPS, V	EL, T2
INST2F	For calculation of required insulation thickness to assure a specified maximum temperature at the outer surface of the insulation.	T1, TA, T2 EK, EPS, V	EL, QA

Operating Procedure - The operating procedure may be outlined as follows:

1. Call computer using assigned USER NUMBER.
2. After the computer acknowledges the "USER NUMBER", it will ask, "NEW OR OLD".
3. Computer will ask for Program Name. Type in name of the desired program (INSQAP, INSTHP, INST2P, INSQAF, INSTHF, INST2F, C-693). For example, INSQAP, C-693. Note that it is necessary to type "C-693", preceded by comma after the program name each time.



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4. After computer responds with "READY", type in "RUN".
5. The computer will type out the program title, then will ask whether definition of variables is wanted. After the question mark appears, print "YES" if definitions are wanted; otherwise type "NO".
6. After the definitions are typed in following "YES"; or immediately after "NO", the computer will print a line number followed by another question mark. This is an invitation to type in the data.
7. The data for each program must be typed in the exact order as listed in the preceding table. Any variation in order will result in erroneous answers.
8. The numerical value of each known term, must be typed in the correct sequence on the same line, and each term must be separated by a comma.
9. After all data has been typed in, the "return" key is punched.
10. The computer will first print out the input data. This permits the operator to check the accuracy of his input.
11. The calculated results will then be printed by the computer.
12. Following solution of a problem, the computer is programmed to request data for a second problem without going thru the routine of inquiring whether definitions are wanted.
13. If there is no second problem, type "STOP".
14. After print-out of running time, the computer will print "READY".
15. Type "BYE" to release the computer.

NOTE: After each typed direction by the Operator, it is necessary to punch the "Return" key, returning the teletypewriter carriage to the extreme right.

REPRESENTATIVE EXAMPLES

1 - EXAMPLE NO. 1

UNION CARBIDE TIME SHARING

ON AT -- 08:14 TTY: 24

USER NUMBER: Assigned User Number

TCH-2000-4613 (Terminal identification typed in by computer)

TYPE OLD OR NEW: Old

PROGRAM NAME: INSTHP, C-693



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READY
RUN

INSTHP 08:15 UCC TUESDAY 02/11/69

CALCULATION OF INSULATION THICKNESS FOR A SPECIFIED HEAT
LOSS OR GAIN, QA - INSULATED PIPE

DO YOU WANT DEFINITIONS OF THE VARIABLES?
TYPE YES OR NO

INPUT: 00150

?YES

DEFINITIONS

QA = HEAT LOSS OR GAIN, BTU/SQ FT, HR
T1 = OPERATING TEMPERATURE, DEG. F
T2 = SURFACE TEMP OF OUTER INSULATION JACKET, DEG F
TA = AMBIENT AIR TEMPERATURE, DEG. F
R1 = INSIDE RADIUS OF INSULATION, INCHES
R2 = OUTSIDE RADIUS OF INSULATION, INCHES
EK = CONDUCTIVITY OF INSULATION, BTU/SQ FT, HR IN
EPS = SURFACE EMITTANCE, RATIO TO BLACK BODY
V = VELOCITY OF WIND, FT/MIN

WHEN QUESTION MARK APPEARS, TYPE IN DATA
INPUT: 00320 (Example 1A)
? 500, 90, 3, 29.3, .3, .8, 1760

T1= 500.0	TA= 90.0	R1= 3.000	QA= 29.3
EK= 0.3000	EPS= 0.8000	V= 1760.0	
T2= 98.3 DEGREES	R2= 5.974 INCHES		

INPUT: 00320 (Example 1B)
? -150, 90, 3, 17.1, .3, .8, 1760.

T1= -150.0	TA= 90.0	R1= 3.000	QA= 17.1
EK= 0.3000	EPS= 0.8000	V= 1760.0	
T2= 84.7 DEGREES	R2= 5.976 INCHES		



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INPUT: 00320
? STOP

RT802 00320

RUNNING TIME: 06.9 SECS I/O TIME: 09.6 SECS

READY
BYE
OFF AT 08:19

2 - EXAMPLE NO. 2

INSOAF 08:20 UCC FRIDAY 02/07/69

CALCULATION OF HEAT LOSS OR GAIN
INSULATED FLAT SURFACES

DO YOU WANT DEFINITIONS OF THE VARIABLES?
TYPE YES OR NO

INPUT: 00150
? NO

INPUT: 00320 (Example 2A)
? 750, 80, 4, .4, .9, 880.

T1= 750.0	TA= 80.0	EL= 4.000
EK= 0.4000	EPS= 0.9000	V= 880.0
T2= 99.5 DEGREES	QA= 65.3 BTU	

INPUT: 00320 (Example 2B)
? -200, 80, 4, .4, .9, 880.

T1= -200.0	TA= 80.0	EL= 4.000
EK= 0.4000	EPS= 0.9000	V= 880.0
T2= 70.6 DEGREES	QA= 27.1 BTU	



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3 - EXAMPLE NO. 3

INST2F 09:13

UCC FRIDAY 02/07/69

CALCULATION OF REQUIRED INSULATION THICKNESS TO ASSURE A
SPECIFIED OUTSIDE SURFACE TEMPERATURE, T2 - INSULATED FLAT
SURFACES

DO YOU WANT DEFINITIONS OF THE VARIABLES?
TYPE YES OR NO

INPUT: 00160

? NO

INPUT: 00330 (Example 3A)

? 750, 80, 99.5, .4, .9, 880.

T1= 750.0

TA= 80.0

T2= 99.5

EK= 0.4000

EPS= 0.9000

V= 880.0

QA= 65.3 BTU

EL= 3.984 INCHES

INPUT: 00330 (Example 3B)

? -200, 80, 70.6, .4, .9, 880.

T1= -200.0

TA= 80.00

T2= 70.6

EK= 0.4000

EPS= 0.9000

V= 880.0

QA= 27.1 BTU

EL= 3.992 INCHES



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APPENDIX

Derivation of Program Names

INSQAP

INS-QA-P

Insulation - Heat Transfer - Pipe

INSQAF

INS-QA-F

Insulation - Heat Transfer - Flat Surface

INSTHP

INS-TH-P

Insulation - Thickness - Pipe

INSTHF

INS-TH-F

Insulation - Thickness - Flat Surface

INST2P

INS-T2-P

Insulation - Term for Surface Temp. - Pipe

INST2F

INS-T2-F

Insulation - Term for Surface Temp. - Flat Surface



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INNER AND OUTER RADII OF INSULATION FOR NPS PIPE

BASED ON AVERAGE TOLERANCE

NPS Pipe Size	Inside Radius of Insul. R1	Outer Radius Inches R2												
		Nominal Insulation Thickness												
		1	1½	2	2½	3	3½	4	4½	5	5½	6	6½	7
3/8	0.39	1.44	2.00	2.50	2.78	3.31	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.50
1/2	0.45	1.44	2.00	2.50	3.31	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.50	8.00
3/4	0.56	1.44	2.00	2.50	3.31	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.50	8.00
1	0.69	1.75	2.25	2.78	3.31	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.50	8.00
1½	0.86	1.75	2.50	2.78	3.31	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.50	8.00
2	0.98	2.00	2.50	3.31	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.50	8.00	8.50
2½	1.24	2.25	2.78	3.31	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.50	8.00	8.50
3	1.49	2.50	3.31	3.81	4.31	4.81	5.37	5.82	6.37	6.37	7.00	7.50	8.00	8.50
3½	1.80	2.78	3.31	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.50	8.00	8.50	9.00
4	2.05	3.31	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.00	7.50	8.00	8.50	9.00
4½	2.30	3.31	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.50	8.00	8.50	9.00	9.50
5	2.55	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.50	8.00	8.50	9.00	9.50	10.00
6	2.83	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.50	8.00	8.50	9.00	9.50	10.00
6	3.37	4.31	4.81	5.37	5.82	6.37	7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50
7	3.87		5.37	5.82	6.37	7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50	11.00
8	4.37		5.82	6.37	7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50	11.00	11.50
9	4.87		6.37	7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50	11.00	11.50	12.00
10	5.40		7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50	11.00	11.50	12.00	12.50
11	5.90		7.50	8.00	8.50	9.00	9.50	10.00	10.50	11.00	11.50	12.00	12.50	13.00
12	6.40		8.00	8.50	9.00	9.50	10.00	10.50	11.00	11.50	12.00	12.50	13.00	13.50
14	7.08		8.50	9.00	9.50	10.00	10.50	11.00	11.50	12.00	12.50	13.00	13.50	14.00
16	8.08		9.50	10.00	10.50	11.00	11.50	12.00	12.50	13.00	13.50	14.00	14.50	15.00
18	9.08		10.50	11.00	11.50	12.00	12.50	13.00	13.50	14.00	14.50	15.00	15.50	16.00
20	10.08		11.50	12.00	12.50	13.00	13.50	14.00	14.50	15.00	15.50	16.00	16.50	17.00
22	11.08		12.50	13.00	13.50	14.00	14.50	15.00	15.50	16.00	16.50	17.00	17.50	18.00
24	12.08		13.50	14.00	14.50	15.00	15.50	16.00	16.50	17.00	17.50	18.00	18.50	19.00
30	15.08		16.50	17.00	17.50	18.00	18.50	19.00	19.50	20.00	20.50	21.00	21.50	22.00
36	18.06		19.50	20.00	20.50	21.00	21.50	22.00	22.50	23.00	23.50	24.00	24.50	25.00

INNER AND OUTER RADII OF INSULATION FOR TUBES
 BASED ON AVERAGE TOLERANCE

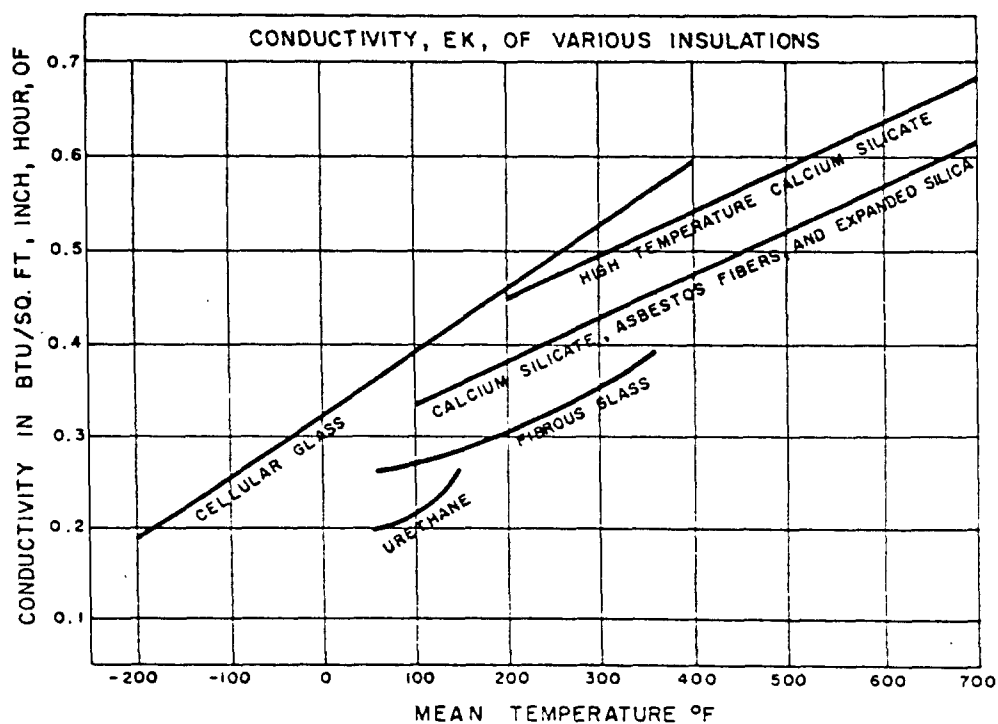
Nom. Tube Size	Outside Diameter of Tube Inches	Inside Radius of Insul. Inches, R1	Outside Radius of Insulation - Inches R2										
			Nominal Insulation Thickness										
			1	1½	2	2½	3	3½	4	4½	5	5½	6
¼	0.250	0.15	1.44	1.75	2.25	2.78	3.31	3.81	4.31	4.81	5.37	5.87	6.37
3/8	0.375	0.21	1.44	1.75	2.25	2.78	3.31	3.81	4.31	4.81	5.37	5.87	6.37
½	0.500	0.28	1.44	1.75	2.25	2.78	3.31	3.81	4.31	4.81	5.37	5.87	6.37
½	0.625	0.34	1.44	1.75	2.25	2.78	3.31	3.81	4.31	4.81	5.37	5.87	6.37
¾	0.750	0.40	1.44	2.00	2.50	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00
¾	0.875	0.46	1.44	2.00	2.50	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00
1	1.000	0.53	1.44	2.00	2.50	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00
1	1.125	0.59	1.44	2.00	2.50	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00
1½	1.250	0.65	1.75	2.25	2.78	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00
1½	1.500	0.78	1.75	2.25	2.78	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00
1½	1.625	0.84	1.75	2.25	2.78	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00
2	2.000	1.03	2.00	2.50	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00	7.50
2	2.125	1.09	2.00	2.50	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00	7.50
2½	2.500	1.28	2.25	2.78	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00	7.50
2½	2.625	1.34	2.25	2.78	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00	7.50
3	3.000	1.53	2.50	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00	7.50	8.00
3	3.125	1.59	2.50	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00	7.50	8.00
3½	3.625	1.84	2.78	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00	7.50	8.00
4	4.000	2.05	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00	7.50	8.00	8.50
4	4.125	2.11	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00	7.50	8.00	8.50
5	5.000	2.55	3.81	4.31	4.81	5.37	5.87	6.37	7.00	7.50	8.00	8.50	9.00
5	5.125	2.61	3.81	4.31	4.81	5.37	5.87	6.37	7.00	7.50	8.00	8.50	9.00
6	6.000	3.05	4.31	4.81	5.37	5.87	6.37	7.00	7.50	8.00	8.50	9.00	9.50
6	6.125	3.11	4.31	4.81	5.37	5.87	6.37	7.00	7.50	8.00	8.50	9.00	9.50
8	8.000	4.05		5.87	6.37	7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50
8	8.125	4.11		5.87	6.37	7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50
10	10.000	5.05		6.37	7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50	11.00
10	10.125	5.11		7.00	7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50	11.00



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APPROXIMATE VALUES OF EMITTANCE, EPS, OF MASTICS AND JACKETS

MATERIAL	EMITTANCE, EPS	
	NEW	OLD
Aluminum Jacket	.05	.08 to .10
Stainless Steel Jacket	.30	.45 to .50
Treated Steel Jacket (Medium Gray Painted Surface)	.75	.65 to .75
Treated Steel Jacket (Painted with Gloss White)	.25	.40 to .50
Mastic (Acrylic or PVA) Dark Gray	.80	.85 to .90
Mastic (Acrylic or PVA) White	.50	.65 to .75
Mastic (Asphalt)	.90	.93 to .97

CONVERSION TABLE OF WIND VELOCITY FROM MILES PER HOUR TO FEET PER MINUTE, V

WIND (OR AIR) VELOCITY					
MILES PER HOUR	FEET PER MIN. V	MILES PER HOUR	FEET PER MIN. V	MILES PER HOUR	FEET PER MIN. V
1	88	11	968	21	1848
2	176	12	1056	22	1936
3	264	13	1144	23	2024
4	352	14	1232	24	2112
5	440	15	1320	25	2200
6	528	16	1408	30	2640
7	616	17	1496	35	3080
8	704	18	1584	40	3520
9	792	19	1672	45	3960
10	880	20	1760	50	4400



THEORY - ECONOMIC THICKNESS

II. ECONOMIC EQUATIONS

As the thickness of insulation is increased, the cost of heat loss per year of insulation is increased. The thickness at which the sum of these two costs is a minimum is obviously the most economical.

For flat surfaces this may be determined

- When C Cost constant (this is eliminated in final derivation)
 When L Most economical thickness
 When B Cost of insulation factor
 When R The sum of all thermal resistances, including film resistance, other than the insulation
 When k Conductivity of the insulation
 When Y Hours of operation per year
 When t_o Operating temperature
 When t_{av} Average temperature of surrounding air
 When M Value of heat, in dollars per 1,000,000 Btu
 When B_p Cost factor for pipes in 8/lin ft, yr, in
 When B_s^p Cost factor for flat surfaces 8/sq ft, yr, in

Then

$$L = \left(\frac{Y (t_o - t_{av}) M}{\frac{1,000,000}{B}} \times k \right)^{1/2} - Rk \quad (\text{Equation 20})$$

For one layer cylindrical material (including one air film)

From the cost per linear foot, B is determined by the following equation

$$B = (B_p - C) \frac{12}{2\pi r_2} (r_2 - r_1) \quad (\text{Equation 21})$$

- When R_s = Surface resistance
 k_1 = Conductivity of insulation

Then solve for r_2 by trial and error, which determines (L)

$$\left(r_2 \log_e \frac{r_2}{r_1} + R_s k_1 \right) \left(\frac{2r_2 - r_1}{r_2 - R_s k_1} \right)^{1/2} = \left(\frac{Y (t_a - t_{av}) M}{\frac{1,000,000}{B}} \times k_1 \right)^{1/2} \quad (\text{Equation 22})$$



THEORY - ECONOMIC THICKNESS

II. ECONOMIC EQUATIONS - Continued

For two-layer cylindrical material (including one air film) the equation when r_s is outer radius and k_2 conductivity of other insulation, is

$$\left[r_s \log_e \frac{r_s}{r_2} + \frac{r_s}{\eta} \left(\frac{r_s \log_e \frac{r_2}{r_1}}{k_2} \right) k_1 + R_s k_1 \right] \left(\frac{2r_s - r_2}{r_s - R_s k_1} \right)^{1/2} = \left(\frac{Y (t_o - t_{av}) M}{\frac{1,000,000}{V}} \times k_1 \right)^{1/2}$$

(Equation 23)

These equations have been electronically calculated for most conditions on high temperature insulation, and are published in manual "Economic Thickness of Insulation for Flat Surfaces and Pipes".

Using this "Economic Thickness" manual, and specific cost at each plant, the economic thickness tables of UCC plants for steam lines and steam heated process equipment and lines have been calculated. These are in Section III of this manual.

These tables are correct only when the basic heat medium is steam.

The economic thickness for Dowtherm heated equipment and lines were not calculated for various plants for it was found the Dowtherm heated process costs differed considerably from one unit to another within a single plant. In general, Dowtherm heat is higher than steam cost so it justifies greater insulation thickness, but any economic thickness table must be based on the heat cost of the unit being considered.

The same holds true for any process heated by direct fire, electric, or hot water. The correct insulation thickness must be based on the individual unit in question.



THEORY - THICKNESS TO PREVENT CONDENSATION

III. THICKNESS TO PREVENT CONDENSATION

On low temperature service it is frequently necessary to calculate the thickness of the insulation so that its surface temperature is above dew point.

The insulation thickness to prevent condensation is only one consideration in final choice of insulation thickness. Another consideration may be the economic thickness of insulation based on conservation of energy and investment in refrigeration equipment. In cases of storage of expensive liquefied gases the rate of boil-off of gas determines the required insulation thickness, or safety requirements may dictate that insulation thickness must be sufficient to protect contents of vessels or pipes for given length of time. Therefore, the problem must be considered in all its aspects to assure a properly engineered installation.

This section presents the reasons for maintaining the outer weather-vapor barrier above dew point, the factors involved in determining dew point, the basic formulas for calculating thickness of insulation whose outer surface temperature will be above dew point, tables for the solution of the problem, and illustrative examples.

The method presented, as compared to other methods, considers all of the factors which have a bearing on the determination of the thickness. Although the system is complex, an accurate answer can be obtained by use of the tables and a simple computation.

When dry, most insulations are quite effective. When insulation becomes wet, its effectiveness is impaired. The conductivity of wet insulation can be from 16 to 20 times greater than dry insulation. It is thus apparent why insulation must be kept dry.

Insulation must be protected from two forms of moisture: (1) in the liquid state and, (2) in the vapor state. The protection from moisture in liquid state, such as rain, is provided by a weather barrier. The protection from moisture in the vapor state is provided by a vapor barrier. In many instances both are provided by a single material -- a weather-vapor barrier.

The above points out the importance of weather and vapor barriers. However, to protect the insulation, the vapor barrier must remain effective.

Many experiments have shown that when the surface of a vapor barrier is wet with liquid water its transmission of moisture is approximately four times that than when the surface is dry. This more rapid transmission of moisture shortens the effective life of the insulation.



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THEORY - THICKNESS TO PREVENT CONDENSATION

III. THICKNESS TO PREVENT CONDENSATION - Continued

In addition to protection of the insulation from moisture, there are other practical reasons why the surface should be above design dew point. These are:

1. Water dripping or flowing onto steel columns, beams or equipment causes excessive rusting.
2. Continually wetted surfaces become moldy and slippery.
3. Continually wetted surfaces are impossible to coat with mastic or to paint.
4. The weather-vapor barrier deteriorates more rapidly when continually wetted.

Unfortunately, no thickness of insulation installed on a low temperature surface can prevent condensation on its weather-vapor barrier when ambient relative humidity reaches 100%. However, periods of 100% relative humidity are generally short so that insulation thickness can be provided which can prevent excessive condensation until the relative humidity drops to a more reasonable percentage. Selection of design conditions of air temperature and relative humidity should be such that they are not expected to be exceeded for any extended length of time.

Due to the variables in weather conditions and other factors surrounding a given installation, no general recommendation of "design" conditions can be made in this manual. The engineer must analyze the conditions to which the installation is to be subjected. Expected maximum temperature; proximity to moisture producing equipment, such as steam discharge or cooling towers; ventilation; location, such as above decorative ceilings; will need to be considered in determining the ambient air temperature and relative humidity to which he must design.

Good judgment must be exercised in selecting realistic conditions. Conditions that are too severe require an excess of insulation and conditions that are too mild result in insufficient insulation, allowing surface condensation too much of the time.

After design ambient air dry-bulb and wet-bulb temperatures have been selected, this method can be used to arrive at required insulation thickness to prevent condensation under those conditions.



THEORY - THICKNESS TO PREVENT CONDENSATION

MATHEMATICAL SOLUTION

Previous approaches to this problem depended upon equating the temperature difference across the insulation, divided by the insulation resistance, to the temperature difference across the air film divided by the air film resistance. The air film resistance was assumed. Any error in the assumed value of the air film resistance caused a corresponding error in the calculated insulation thickness. Using the assumed air film resistance method, errors of insulation thickness can range from 50% more insulation than needed to 33% of the thickness of insulation required.

The mathematical method of solving the problem is based on calculating the heat gain from the ambient air to the lower temperature surface. It eliminates the need for guessing at the air film resistance.

Solution to this problem is divided into three basic steps:

- Step 1. Determination of Design Surface Temperature
- Step 2. Determination of Surface Heat Gain
- Step 3. Determination of Insulation Thickness

- A. Step 1 is no different from any other method of determining insulation thickness to prevent condensation. The surface temperature to which the installation must be designed depends upon the conditions to which the installation is subjected. Tables I and II are provided in this manual to eliminate the need for a psychometric chart. To prevent condensation the insulation surface temperature must be slightly above dew point.
- B. Step 2 is the key to the solution of the problem. The heat gain from ambient air to the lower temperature surface by radiation and convection determines the maximum allowable heat flow through the insulation if the design surface temperature is to be maintained. The radiation heat gain and convection heat gain must be found separately, then added together to obtain total heat gain.

When q_a = Total heat gain to surface

q_{ra} = Heat gain due to radiation

q_{ca} = Heat gain due to convection

$q_a = q_{ra} + q_{ca}$



THEORY - THICKNESS TO PREVENT CONDENSATION

MATHEMATICAL SOLUTION - Continued

B. Step 2 - Continued

Table III gives the values of radiation heat transfer rates in reference to absolute zero. It is based on Stefan - Boltzmann Formula:

When q_r = Radiation heat transfer rate from a body at temperature to a body at absolute zero

ϵ = Absorptance which is 1.00 (black body conditions)

t = Temperature of body °F

$$q_{ra} = 0.174 \times 10^{-8} (t + 460)^4$$

Since we are concerned with radiation between the surface and ambient air and absorptance other than 1.00

When q_{ra} = Radiation heat transfer rate from ambient air and surrounding bodies at temperature t_a to the insulation surface at a temperature t_2

ϵ = Absorptance of the insulation surface or its outer barrier

$$\text{Then } q_{ra} = \left[0.174 \times 10^{-8} (t_a + 460)^4 \right] - \left[0.174 \times 10^{-8} (t_2 + 460)^4 \right] \epsilon$$

The values of the expression $0.174 \times 10^{-8} (t + 460)^4$ have been calculated for different values of t_a and are tabulated in Table III. Using the temperature of $t_a = t$ the value of the expression $0.174 \times 10^{-8} (t_a + 460)^4$ can be determined. In similar manner the value of the expression $0.174 \times 10^{-8} (t_2 + 460)^4$ can be determined using temperature $t_2 = t$. Multiplying the difference of these values by the correct value of ϵ will determine q_{ra} . This multiplication has been precalculated in Table IV.

As surface heat gain due to solar radiation lessens the possibility of condensation, the heat gain to insulated vessels and pipes located outdoors where they are exposed to solar heat is not included in this manual. If for reasons other than condensation control, the maximum heat gain rate must be known, solar radiation must be taken into consideration.

The cooling effect of radiation from the insulation surface into space during darkness also has not been considered because it is not practical to attempt to insulate for this condition.



THEORY - THICKNESS TO PREVENT CONDENSATION

MATHEMATICAL SOLUTION - Continued

B. Step 2 - Continued

Table V gives values of convection heat transfer rates for various conditions of shape, size and position of surfaces. The proper table and correction factor, dictated by installation conditions, must be selected. In case the installation has several conditions and it is impractical to have various insulation thicknesses, then the most severe condition is the controlling factor. These tables are based on the Heilmann Formula:

When q_{ca} = Convection heat gain for Δt

C = A constant depending on shape of surface (horizontal cylinders, $C = 1.016$, etc.)

D = Outside diameter of cylindrical surface or height of vertical flat surface. (For anything 24 inches or more use values listed for 24)

T = Average absolute temperature. For this study this was taken as 540R (80F).

Note: A change to 500R would produce an error of slightly more than 1%

Δt_1 = Dry bulb ambient air temperature (t_a) less design insulation surface temperature (t_2)

$$\text{Then } q_{ca} = C \left(\frac{1}{D} \right)^{0.2} \left(\frac{1}{T} \right)^{0.181} 1.266 \{ \Delta t_1 \}$$

The effect of a forced air velocity has not been considered, as air velocity most often will tend to retard condensation due to faster evaporation. If for other reasons other than condensation control, the maximum heat rate must be known, then air velocity must be considered. To obtain convection loss for a certain forced air velocity, all that is necessary is to multiply q_{ca} by $\sqrt{\frac{V + 68.9}{68.9}}$ when V equals air velocity in feet per minute.

The insulation (or its outer barrier) surface heat gain rate q_a is found by:

$$q_a = q_{ra} + q_{ca}$$



THEORY - THICKNESS TO PREVENT CONDENSATION

MATHEMATICAL SOLUTION - Continued

B. Step 2 - Continued

This q_a is the key factor for design of insulation to prevent condensation. It is the maximum allowable surface heat gain rate if the design surface temperature is to be maintained. Under static conditions the heat gain to a surface must equal the heat loss from that surface, thus, all that remains is to determine the thickness of insulation which provides sufficient resistance so that the heat flow from the outer surface, of "design" temperature t_2 , to inner surface, of temperature t_1 (operating) is equal or less than q_a .

C. Step 3 - The required resistance to heat flow is determined. Table VI gives the values of resistance R. This table is based on the following formula:

When q_a = Heat gain to the surface of the insulation and through insulation

Δt_2 = Design surface temperature t_2 less operating temperature t_1 of pipe or equipment

R = Thermal resistance

$$\text{Then } q_a = \frac{\Delta t_2}{R}$$

Table VII gives the flat surface (or equivalent) thickness. This table is based on the following formula:

When L = Insulation thickness, flat surface (or equivalent)

k = Conductivity of insulation, Btu/sq ft, hr, in $^{\circ}$ F

Then L = Rk

The thickness L is the minimum thickness of insulation on flat surfaces to prevent condensation. However, L is equivalent thickness of insulation to prevent condensation on curved surfaces. Table VII provides the conversion from equivalent thickness to nominal thicknesses of pipe covering, and actual insulation thickness for small diameter equipment. This formula is based on the formula:

$$L = r_2 \text{ Log}_e \frac{r_2}{r_1}$$



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MATHEMATICAL SOLUTION - Continued

C. Step 3 - Continued

When r_1 = Inner radius of insulation

r_2 = Outer radius of insulation

The above r_1 and r_2 were used to calculate Table VIII, but do not appear in the tabulation, as tabulation is presented in NPS pipe diameters and nominal thicknesses are those manufactured for certain combinations of $r_2 - r_1$.

The curved thickness is selected so that its equivalent thickness is equal to or more than required thickness L for flat surface.

A diagram of this method for selection of insulation thickness to prevent condensation is shown on Page 7.



THEORY - THICKNESS TO PREVENT CONDENSATION

SOLUTION BY USE OF TABLES AND WORK SHEET

Although the mathematical solution appears relatively complex, the actual solution to a problem is easy. Selection of proper design wet and dry bulb temperatures is based on installation requirements. After this selection is made, determination of insulation thickness to prevent condensation can be made by using the tables in this manual.

A. Step 1 - Determination of Design Surface Temperature

Using the selected dry-bulb (t_a) and wet-bulb temperatures, the percent relative humidity is found in Table I.

Using the selected dry bulb (t_a) and determined relative humidity, the dew-point temperature is found in Table II.

The design surface temperature (t_2) must be slightly higher than dew point. Add 1°F to dew-point temperature to obtain design surface temperature.

B. Step 2 - Determination of Surface Heat Gain

The total heat gain by radiation (q_{ra}) and convection (q_{ca}) to the surface at temperature t_2 from ambient air at temperature t_a must be determined.

Radiation gain is found by determining the difference in radiation levels of surface temperature t_2 and ambient temperature t_a in reference to absolute zero.

Determine radiation level of ambient temperature t_a using Table III. From this, subtract the radiation level of surface temperature t_2 . The result is radiation from t_a to t_2 if the surface has black body absorptance (ϵ) equal to one. Should surface absorptance be a ratio less than one, the previous determined result is multiplied by the proper absorptance ratio ϵ . This multiplication is found in Table IV. This final result is the heat gain by radiation q_{ra} .

Convection heat gain (q_{ca}) is found using the proper column in Table V. The heat gain by convection (q_{ca}) is found opposite the proper temperature difference, t_1 ($t_1 = t_a - t_2$) between air and surface. In some instances this result must be multiplied by a correction factor as shown at bottom of table.

THEORY - THICKNESS TO PREVENT CONDENSATION
SOLUTION BY USE OF TABLES AND WORK SHEET - ContinuedB. Step 2 - Determination of Surface Heat Gain - Continued

Add radiation heat gain (q_{ra}) and convection heat gain (q_{ca}) to obtain total heat gain (q_a). This is also maximum allowable heat transfer through the insulation (q_1).

C. Step 3 - Determination of Insulation Thickness

Using maximum allowable heat transfer through the insulation q and the temperature difference across the insulation $t_2 - t_1$ (which equals the operating temperature t_1 subtracted from the outer surface temperature t_2) the required thermal resistance (R) of the insulation is found in Table VI.

Using required thermal resistance, R , and the conductivity of insulation (k) the flat surface (or equivalent) thickness of insulation (L) is found in Table VII. This thickness table gives thickness, L , in decimals. The insulation's actual thickness must be that which is commercially available and is equal to or slightly larger than the figure given. This is the thermal insulation thickness required to prevent condensation for flat surfaces.

Using the flat surface thickness, L , for various pipe sizes, the nominal thickness required can be found in Table VIII. This is the thermal insulation thickness for pipe, or curved surfaces, required to prevent condensation.

To assist in the use of these tables, a work sheet has been prepared and several illustrative examples are given.

D. Illustrative Examples

Three design problems applying different ambient air conditions, different installation requirements and different insulations are presented to illustrate the use of the tables to determine the insulation thickness to prevent condensation.

1. Example 1

DATA

Brine lines 2", 4", and 6" IPS in both horizontal and vertical positions
Ambient air, high mean average is 90F dry bulb, 80F wet bulb
Operating temperature - 20F
Black outer weather-vapor surface, absorptance = .9
Insulation - Cellular glass, conductivity $k = .35$



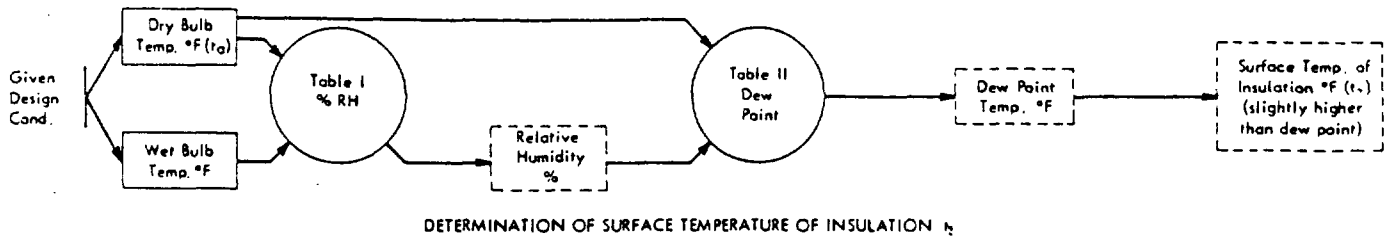
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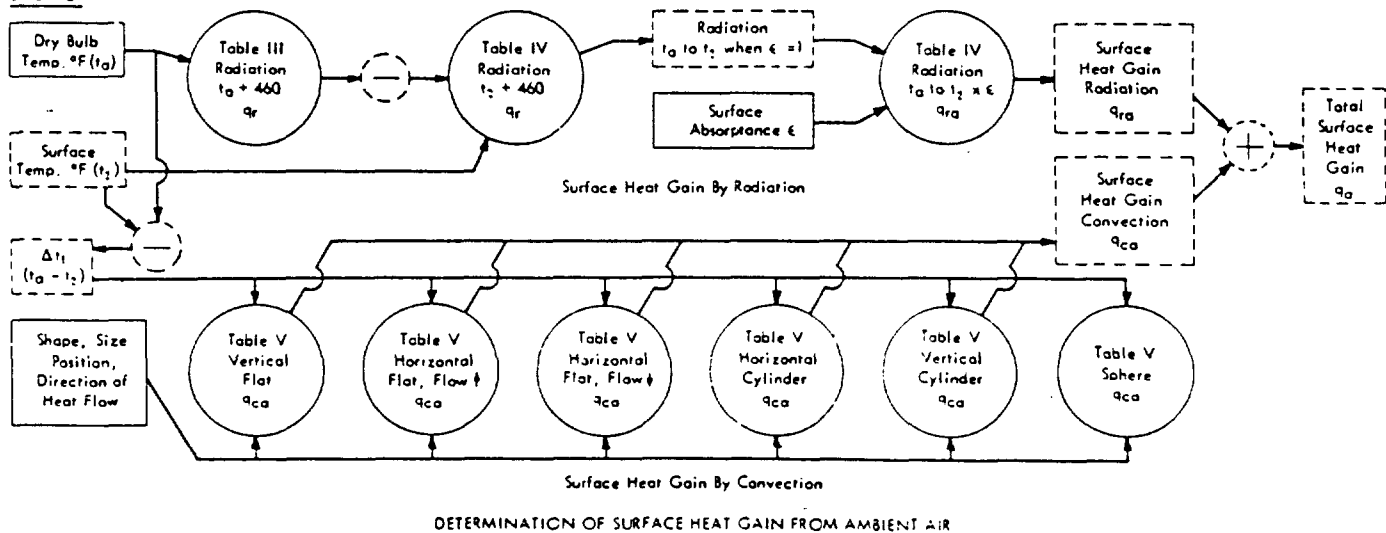
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THEORY - THICKNESS TO PREVENT CONDENSATION DIAGRAM OF SOLUTION

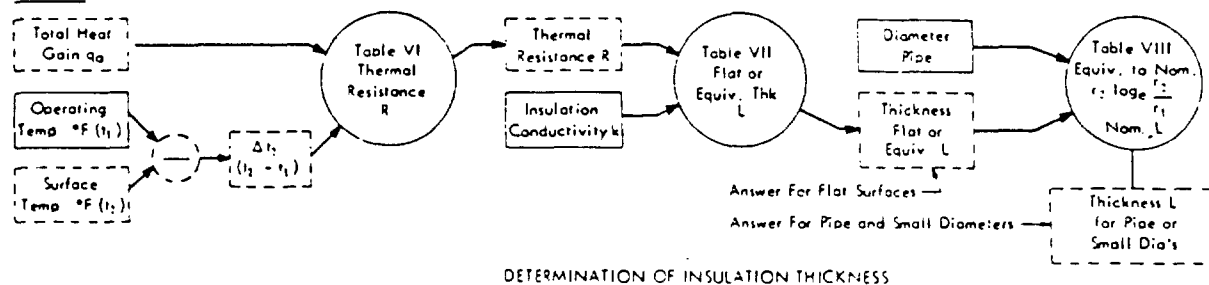
STEP 1



STEP 2



STEP 3



SYMBOLS

Design or Installation Requirements

Determined Conditions

Tables in Manual

Arithmetical Function

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MAY, 1968**THEORY - THICKNESS TO PREVENT CONDENSATION**
SOLUTION BY USE OF TABLES AND WORK SHEET - Continued**D. Illustrative Examples - Continued****1. Example 1 - Continued**

Enter data on work sheet

Description - Work order - Example 1

Pipe or vessel - Pipe

Description of surface - cylindrical, vertical and
horizontal 2", 4", and 6" NPS.

Heat flow - does not apply

Dry bulb temperature in column a	90F
Wet bulb temperature in column b	80F
Surface absorptance in column i	= .9
Operating temperature in column q	-20F
Conductivity of insulation in column t	k = 0.35

Step 1Determine relative humidity from Table I, 90F dry bulb 80F wet
bulb = 65% RH.

Enter in column c.

Determine dew point from Table II, 90F dry bulb - 65% RH = 77F
dew point.

Enter in column d.

Add 1°F to dew point temperature $77 + 1 = 78$ is surface temperature
above, and at which condensation will not occur.

Enter in column e.

Step 2From Table III determine radiation from absolute zero to ambient
dry bulb temperature t_a of 90F, this equals 159.2 Btu.
Enter in column f.From Table III determine radiation from absolute zero to surface
 t_s of 78F, this equals 145.8 Btu.
Enter in column g.



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D. Illustrative Examples - Continued

1. Example 1 - Continued

Step 2 - Continued

Subtract amount of Btu in column g from that in column f, this equals 13.4. Enter in column h.

Multiply amount in column h by column i (given in Table IV). Enter in column j.

Enter Δt_1 which is t_a (column a) less t_2 (column e) which is 12F in column k.

Selection of proper convection from Table V is necessary to obtain Btu heat gain for column l.

In this case, as the problem is with piping, the answer will be in column 5 or 6 of Table V. Also in this case the pipes are installed both in horizontal and vertical position and, as it is impractical to change insulation thickness for various positions, the most severe conditions must be used; thus, column 6 for vertical cylinders and pipes is selected. For 12F Δt_1 this equals 4.87.

At the bottom of the same table are correction factors for outside diameters of insulation. An assumed thickness of the insulation must be made at this point. Assuming the insulation thickness to be about 2", then the outside diameter of the 2" NPS by 2" thick insulation would be approximately 6" OD. These figures are entered in column m.

The correction factors of the OD of insulation are entered in column n. These are 1.32, 1.25, and 1.22. As can be seen, an error of 1" thickness in assumed to actual thickness of insulation makes a relatively small difference in the correction factor.

Total convection heat gain is obtained by the multiplication of column l by n. These results, which are 6.43, 6.08, and 5.93, are entered in column o.

Total heat gain to surface is obtained by adding Btu by radiation q_{ra} , column j, to Btu by convection q_{ca} , column o. These, which are 18.62, 18.28, and 18.13, are entered in column p.



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THEORY - THICKNESS TO PREVENT CONDENSATION SOLUTION BY USE OF TABLES AND WORK SHEET - Continued

DATE 1-15-64		WORK ORDER 936-4901		CALCULATED BY HENSON							
EXAMPLE 1		STEP 1 SELECT DESIGN SURFACE TEMPERATURE ATMOSPHERIC DESIGN CONDITION									
PIPE OR VESSEL NUMBER	DESCRIPTION OF SURFACE (HORIZONTAL, VERTICAL, FLAT, CYLINDRICAL, CONICAL, ETC.) REF. (FIG. NO.)	HEAT FLOW	DESIGN TEMP. OF FL.	DESIGN TEMP. OF FL.	DESIGN TEMP. OF FL.	DESIGN TEMP. OF FL.	DESIGN TEMP. OF FL.	DESIGN TEMP. OF FL.	DESIGN TEMP. OF FL.	DESIGN TEMP. OF FL.	DESIGN TEMP. OF FL.
P-117	14 H CYL 2" NPS	-	90	80	65	77	78	1592	1458	134	9
P-118	" " 4"	-	"	"	"	"	"	"	"	"	"
P-119	" " 6"	-	"	"	"	"	"	"	"	"	"
STEP 2 DETERMINE SURFACE HEAT GAIN RATE											
HEAT GAIN RATE DUE TO RADIATION											
TOTAL HEAT GAIN RATE											
STEP 3 DETERMINATION OF THICKNESS OF INSULATION											
TOTAL HEAT GAIN RATE											

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SOLUTION BY USE OF TABLES AND WORK SHEET - ContinuedD. Illustrative Examples - Continued

1. Example 1 - Continued

Step 3

Operating temperature t_1 in column q is given.

The Δt_2 is surface temperature t_2 column e minus operating temperature t_1 or $78 - (-20) = 98$. Enter in column r.

Insulation resistance is found in Table VI. Using 18 Btu as heat flow to surface at $98 \Delta t_2$, resistance R would be approximately 5.45. Enter in column s. Note total differences in column p are so small in this case that they have little effect on thickness.

Flat or equivalent thickness L is found in Table VII. Using resistance of 5.5 with insulation k of .35, L equals 1.925.

From Table VIII find the nominal pipe insulation thickness equivalent to a flat thickness of 1.925. 2" NPS pipe requires 1 1/2" nominal thickness. 4" IPS pipe requires 1 1/2" nominal thickness, and 6" IPS pipe requires 2" nominal thickness of pipe insulation.

2. Example II

Less explanation is provided in solving this problem.

DATA

Large duct 48" x 47" passing through high humidity space.

Ambient air temperature dry bulb = 70F, relative humidity = 90%.

Operating temperature of duct 40F.

Outer coating on duct insulation - light gray $\epsilon = .7$.

Insulation, glass fiber, conductivity (published) = .25 + 20% = 0.3.
(20% safety factor to allow for some moisture in the insulation)

Enter data on work sheet

Description - Example II

Duct

Flat surfaces, one horizontal - heat upward, one
horizontal heat downward, one vertical

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SOLUTION BY USE OF TABLES AND WORK SHEET - Continued**D. Illustrative Examples - Continued****2. Example II - Continued**

column a = dry bulb temperature 70F
column b not needed - RH given
column c = 90% RH
column i = surface absorptance = .7.
column q = operating temperature $t_1 = 40F$
column t = conductivity of insulation $k = 0.3$

Step 1

column d, From Table II dew point = 67F
column e surface temperature = 68F

Step 2

column f, From Table III absolute 0 to 70 = 137.3 Btu
column g, From Table III absolute 0 to 68 = 135.2 Btu
column h $137.3 - 135.2 = 2.1$
column j $2.1 \times .7 = 1.47$
column k $t_a - t_2 \quad 70 - 68 = 2$
column l horizontal flat, facing down, Table V 0.73
horizontal flat, facing up, Table V 0.36
vertical flat, Table V 0.57
column m horizontal flat, facing down, no correction factor
column n horizontal flat, facing up, no correction factor
column o vertical flat, above 24", no correction required
column p columns j and l = 2.20, 1.83, and 2.04
column q given as 40F
column r $t_2 - t_1 = 68 - 40 = 28F$
column s In this case of small differences, it is more accurate to divide results in column r by results in column p $28/2.20 = 12.3$
 $28/1.83 = 15.3 \quad 28/2.04 = 13.7$
column t $k = 0.3$ given



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D. Illustrative Examples - Continued

2. Example II - Continued

column u, From Table VII $L = 3.7$
 $L = 4.6$
 $L = 4.0$
Or in practical thickness
horizontal flat, surface facing down,
requires 4" thickness
horizontal flat, surface facing up,
requires 5" thickness
vertical flat, requires 4" thickness

Note: With relatively small temperature difference, air to operating temperatures, if in a very humid atmosphere, heavy thicknesses of insulation are required to prevent condensation.

3. Example III

DATA

Heat exchanger, horizontal, 310" diameter with dished heads.
Ambient air, high mean average of 100F dry bulb 85F wet bulb.
Operating temperature - 100F
White outer weather barrier surface, absorptance $\epsilon = .5$
Insulation - Cellular glass, conductivity $k = .33$.

Enter data on work sheet

Body is horizontal cylinder
Ends being over 24" will be considered as vertical flat
Surface facing up or down does not apply

Column	Given	Found
a	100	
b	85	
c		From Table I = 50
d		From Table II = 78
e		$78 + 1 = 79$
f		From Table III = 171.1
g		From Table III = 146.9



THEORY - THICKNESS TO PREVENT CONDENSATION
SOLUTION BY USE OF TABLES AND WORK SHEET - Continued

D. Illustrative Examples - Continued

3. Example III - Continued

Column	Given	Found
h		171.1 - 146.9 = 24.2
i	.5	
j		$24.2 \times .5 = 12.1$
k		$100 - 79 = 21$
l		Hor - cyl (Table V) = 8.13, Vert - flat (Table V) = 11.2
m		Greater than 24"
n		None (above 24")
o		8.13, 11.2
p		$12.1 + 8.13 = 20.23$, $12.1 + 11.2 = 23.3$
q	-100	
r		$79 - (-100) = 179$
s		$179/20.3 = 8.83$, $179/23.3 = 7.68$
t	.33	
u		$8.83 \times .33 = 2.91$, $7.68 \times .33 = 2.54$

Therefore, 3" thickness would be required.

Note: The resultant thickness of only 3" is the direct result of the basic ambient condition that 50% RH would be highest relative humidity.

E. Discussion on Illustrative Examples

After using this method of determining insulation thickness to prevent condensation, it becomes apparent that accurate answers can be obtained in just a few minutes. As can be observed, the thickness is directly affected by the ambient conditions to which the installation is exposed. The three illustrative examples show this.

In Example I where dry-bulb temperature and wet-bulb temperature dictate a maximum relative humidity of only 65%, only 1 1/2, and 2 inches of insulation, with a conductivity of .35 are required to prevent condensation at an operating temperature of -20F.

In Example II where the relative humidity is 90% at 70F dry bulb and 5 inches of insulation are required to prevent condensation with an insulation conductivity equal to .3 and operating temperature being only 40F.

THEORY - THICKNESS TO PREVENT CONDENSATION
SOLUTION BY USE OF TABLES AND WORK SHEET - Continued

EXAMPLE III

**SELECTION OF INSULATION THICKNESS TO
PREVENT CONDENSATION - WORK SHEET**

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[illegible]

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SOLUTION BY USE OF TABLES AND WORK SHEET - ContinuedE. Discussion on Illustrative Examples - Continued

In Example III with a very dry condition of 50% maximum relative humidity 3 inches of insulation will prevent condensation even when the operating temperature is -100F.

The above shows the importance of an accurate analysis of conditions to which the installation will be subjected. In most instances design conditions should be selected which are seldom exceeded for more than a few hours per year.

$$q_a = \frac{t_a - t_2}{R_s} \quad \text{Film Resistance} \quad \text{or} \quad R_s = \frac{t_a - t_2}{q_a}$$

For Example I the film resistances for the three different surfaces would be:

$$R_s = \frac{12}{18.62} = 0.644$$

$$R_s = \frac{12}{18.28} = 0.657$$

$$R_s = \frac{12}{18.13} = 0.662$$

For Example II the film resistances for the three different surfaces would be:

$$R_s = \frac{2}{2.20} = 0.91$$

$$R_s = \frac{2}{1.83} = 1.09$$

$$R_s = \frac{2}{2.04} = 0.97$$

For Example III the film resistances for the two different surfaces would be:

$$R_s = \frac{21}{20.3} = 1.09$$

$$R_s = \frac{21}{23.3} = 0.90$$

THEORY - THICKNESS TO PREVENT CONDENSATION
SOLUTION BY USE OF TABLES AND WORK SHEET - ContinuedE. Discussion on Illustrative Examples - Continued

Had the surface been black instead of white then the film resistances would have been:

$$R_s = \frac{21}{32.33} = 0.65$$

$$R = \frac{21}{35.5} = 0.59$$

From just these three examples the surface resistances ranged from 0.59 to 1.04, which shows that a single assumed surface resistance cannot be used to determine insulation thickness to prevent condensation, as it leads to considerable error. As shown in the following:

If q_a is determined by $\frac{t_a - t_2}{R_s}$ by an assumed R_s , then R for insulation is

determined by $R \frac{t_2 - t_1}{q_{ca}}$ the R is no more accurate than assumed R_s . Thus,

in assuming R_s the R which determines insulation thickness basically is also assumed. Unless the values of R_s are known for each particular condition of wet-bulb temperature, dry-bulb temperature, surface shape, size, position, and emittance. As such tabulation for values of R_s does not exist, the use of R_s to determine insulation thickness to prevent condensation is not recommended.



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SOLUTION BY USE OF TABLES AND WORK SHEETS - Continued

DEW POINT TEMPERATURE

Dry Bulb	PER CENT RELATIVE HUMIDITY																		
Temp °F	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	
5	-35	-30	-25	-21	-17	-14	-12	-10	- 8	- 6	- 5	- 4	- 2	- 1	1	2	3	4	
10	-31	-25	-20	-16	-13	-10	- 7	- 5	- 3	- 2	0	2	3	4	5	7	8	9	
15	-28	-21	-16	-12	- 8	- 5	- 3	- 1	1	3	5	6	8	9	10	12	13	14	
20	-24	-16	-11	- 8	- 4	- 2	2	4	6	8	10	11	13	14	15	16	18	19	
25	-20	-15	- 8	- 4	0	3	6	8	10	12	15	16	18	19	20	21	23	24	
30	-15	- 4	- 3	2	5	8	11	13	15	17	20	22	23	24	25	27	28	29	
35	-12	- 5	1	5	9	12	15	18	20	22	24	26	27	28	30	32	33	34	
40	- 7	0	5	9	14	16	19	22	24	26	28	29	31	33	35	36	38	39	
45	- 4	3	9	13	17	20	23	25	28	30	32	34	36	38	39	41	43	44	
50	- 1	7	13	17	21	24	27	30	32	34	37	39	41	42	44	45	47	49	
55	3	11	16	21	25	28	32	34	37	39	41	43	45	47	49	50	52	53	
60	6	14	20	25	29	32	35	39	42	44	46	48	50	52	54	55	57	59	
65	10	18	24	28	33	38	40	43	46	49	51	53	55	57	59	60	62	63	
70	13	21	28	33	37	41	45	48	50	53	55	57	60	62	64	65	67	68	
75	17	25	32	37	42	46	49	52	55	57	60	62	64	66	69	70	72	74	
80	20	29	35	41	46	50	54	57	60	62	65	67	69	72	74	75	77	78	
85	23	32	40	45	50	54	58	61	64	67	69	72	74	76	78	80	82	83	
90	27	36	44	49	54	58	62	66	69	72	74	77	79	81	83	85	87	89	
95	30	40	48	54	59	63	67	70	73	76	79	82	84	86	88	90	91	93	
100	34	44	52	58	63	68	71	75	78	81	84	86	88	91	92	94	96	98	
105	38	48	56	62	67	72	76	79	82	85	88	90	93	95	97	99	101	103	
110	41	52	60	66	71	77	80	84	87	90	92	95	98	100	102	104	106	108	
115	45	56	64	70	75	80	84	88	91	94	97	100	102	105	107	109	111	113	
120	48	60	68	74	79	85	88	92	96	99	102	105	107	109	112	114	116	118	
125	52	63	72	78	84	89	93	97	100	104	107	109	111	114	117	119	121	123	

TABLE II

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SOLUTION BY USE OF TABLES AND WORK SHEETS - Continued

RADIATION HEAT TRANSFER RATE FOR BLACK-BODY CONDITIONS (To Absolute Zero)

Values of $q_r = 0.174 \epsilon (t + 460)^4$ When $\epsilon = 1.0$

t Temp °F	q _r , Btu/ hr, sq ft	t Temp °F	q _r , Btu/ hr, sq ft	t Temp °F	q _r , Btu/ hr, sq ft	t Temp °F	q _r , Btu/ hr, sq ft	t Temp °F	q _r , Btu/ hr, sq ft
-35	56.77	- 3	75.90	29	99.49	61	128.2	93	162.7
-34	57.30	- 2	76.56	30	100.3	62	129.2	94	163.9
-33	57.84	- 1	77.23	31	101.1	63	130.2	95	165.1
-32	58.39	0	77.91	32	102.0	64	131.2	96	166.3
-31	58.94	1	78.59	33	102.8	65	132.2	97	167.5
-30	59.49	2	79.27	34	103.6	66	133.2	98	168.7
-29	60.04	3	79.96	35	104.5	67	134.2	99	169.9
-28	60.60	4	80.65	36	105.3	68	135.2	100	171.1
-27	61.17	5	81.35	37	106.2	69	136.3	101	172.4
-26	61.73	6	82.05	38	107.0	70	137.3	102	173.6
-25	62.30	7	82.76	39	107.9	71	138.3	103	174.8
-24	62.88	8	83.47	40	108.8	72	139.4	104	176.1
-23	63.46	9	84.19	41	109.6	73	140.4	105	177.3
-22	64.04	10	84.91	42	110.5	74	141.5	106	178.6
-21	64.63	11	85.63	43	111.4	75	142.6	107	179.8
-20	65.22	12	86.36	44	112.3	76	143.6	108	181.1
-19	65.81	13	87.10	45	113.2	77	144.7	109	182.4
-18	66.41	14	87.83	46	114.1	78	145.8	110	183.7
-17	67.01	15	88.58	47	115.0	79	146.9	111	185.0
-16	67.62	16	89.33	48	115.9	80	148.0	112	186.3
-15	68.23	17	90.08	49	116.8	81	149.1	113	187.6
-14	68.85	18	90.84	50	117.7	82	150.2	114	188.9
-13	69.47	19	91.60	51	118.6	83	151.3	115	190.2
-12	70.09	20	92.37	52	119.6	84	152.4	116	191.5
-11	70.72	21	93.14	53	120.5	85	153.5	117	192.9
-10	71.35	22	93.92	54	121.5	86	154.6	118	194.2
- 9	71.99	23	94.70	55	122.4	87	155.8	119	195.6
- 8	72.63	24	95.48	56	123.4	88	156.9	120	196.9
- 7	73.27	25	96.28	57	124.3	89	158.1		
- 6	73.92	26	97.07	58	125.3	90	159.2		
- 5	74.58	27	97.87	59	126.3	91	160.4		
- 4	75.23	28	98.68	60	127.2	92	161.6		

TABLE III



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION I
INSULATION DESIGN
PAGE 83
MAY, 1968

THEORY - THICKNESS TO PREVENT CONDENSATION SOLUTION BY USE OF TABLES AND WORK SHEETS - Continued RADIATION HEAT TRANSFER RATE TO SURFACE WITH ABSORPTANCE ϵ LISTED

NOTE: In cases of radiation of low level with a decimal in the term such as 0.3 use 0.3 in table and shift answer decimal point one figure to left

ABSORPTANCE ϵ																				
	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
1	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
2	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00
3	0.15	0.30	0.45	0.60	0.75	0.90	1.05	1.20	1.35	1.50	1.65	1.80	1.95	2.10	2.25	2.40	2.55	2.70	2.85	3.00
4	0.20	0.40	0.60	0.80	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	3.00	3.20	3.40	3.60	3.80	4.00
5	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00
6	0.30	0.60	0.90	1.20	1.50	1.80	2.10	2.40	2.70	3.00	3.30	3.60	3.90	4.20	4.50	4.80	5.10	5.40	5.70	6.00
7	0.35	0.70	1.05	1.40	1.75	2.10	2.45	2.80	3.15	3.50	3.85	4.20	4.55	4.90	5.25	5.60	5.95	6.30	6.65	7.00
8	0.40	0.80	1.20	1.60	2.00	2.40	2.80	3.20	3.60	4.00	4.40	4.80	5.20	5.60	6.00	6.40	6.80	7.20	7.60	8.00
9	0.45	0.90	1.35	1.80	2.25	2.70	3.15	3.60	4.05	4.50	4.95	5.40	5.85	6.30	6.75	7.20	7.65	8.10	8.55	9.00
10	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00
11	0.55	1.10	1.65	2.20	2.75	3.30	3.85	4.40	4.95	5.50	6.05	6.60	7.15	7.70	8.25	8.80	9.35	9.90	10.45	11.00
12	0.60	1.20	1.80	2.40	3.00	3.60	4.20	4.80	5.40	6.00	6.60	7.20	7.80	8.40	9.00	9.60	10.20	10.80	11.40	12.00
13	0.65	1.30	1.95	2.60	3.25	3.90	4.55	5.20	5.85	6.50	7.15	7.80	8.45	9.10	9.75	10.40	11.05	11.70	12.35	13.00
14	0.70	1.40	2.10	2.80	3.50	4.20	4.90	5.60	6.30	7.00	7.70	8.40	9.10	9.80	10.50	11.20	11.90	12.60	13.30	14.00
15	0.75	1.50	2.25	3.00	3.75	4.50	5.25	6.00	6.75	7.50	8.25	9.00	9.75	10.50	11.25	12.00	12.75	13.50	14.25	15.00
16	0.80	1.60	2.40	3.20	4.00	4.80	5.60	6.40	7.20	8.00	8.80	9.60	10.40	11.20	12.00	12.80	13.60	14.40	15.20	16.00
17	0.85	1.70	2.55	3.40	4.25	5.10	5.95	6.80	7.65	8.50	9.35	10.20	11.05	11.90	12.75	13.60	14.45	15.30	16.15	17.00
18	0.90	1.80	2.70	3.60	4.50	5.40	6.30	7.20	8.10	9.00	9.90	10.80	11.70	12.60	13.50	14.40	15.30	16.20	17.10	18.00
19	0.95	1.90	2.85	3.80	4.75	5.70	6.65	7.60	8.55	9.50	10.45	11.40	12.35	13.30	14.25	15.20	16.15	17.10	18.05	19.00
20	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00
21	1.05	2.10	3.15	4.20	5.25	6.30	7.35	8.40	9.45	10.50	11.55	12.60	13.65	14.70	15.75	16.80	17.85	18.90	19.95	21.00
22	1.10	2.20	3.30	4.40	5.50	6.60	7.70	8.80	9.90	11.00	12.10	13.20	14.30	15.40	16.50	17.60	18.70	19.80	20.90	22.00
23	1.15	2.30	3.45	4.60	5.75	6.90	8.05	9.20	10.35	11.50	12.65	13.80	14.95	16.10	17.25	18.40	19.55	20.70	21.85	23.00
24	1.20	2.40	3.60	4.80	6.00	7.20	8.40	9.60	10.80	12.00	13.20	14.40	15.60	16.80	18.00	19.20	20.40	21.60	22.80	24.00
25	1.25	2.50	3.75	5.00	6.25	7.50	8.75	10.00	11.25	12.50	13.75	15.00	16.25	17.50	18.75	20.00	21.25	22.50	23.75	25.00
26	1.30	2.60	3.90	5.20	6.40	7.60	8.80	10.00	11.20	12.40	13.60	14.80	16.00	17.20	18.40	19.60	20.80	22.00	23.20	24.40
27	1.35	2.70	4.05	5.40	6.75	8.10	9.45	10.80	12.15	13.50	14.85	16.20	17.55	18.90	20.25	21.60	22.95	24.30	25.65	27.00
28	1.40	2.80	4.20	5.60	7.00	8.40	9.80	11.20	12.60	14.00	15.40	16.80	18.20	19.60	21.00	22.40	23.80	25.20	26.60	28.00
29	1.45	2.90	4.35	5.80	7.25	8.70	10.15	11.60	13.05	14.50	15.95	17.40	18.85	20.30	21.75	23.20	24.65	26.10	27.55	29.00
30	1.50	3.00	4.50	6.00	7.50	9.00	10.50	12.00	13.50	15.00	16.50	18.00	19.50	21.00	22.50	24.00	25.50	27.00	28.50	30.00
31	1.55	3.10	4.65	6.20	7.75	9.30	10.85	12.40	13.95	15.50	17.05	18.60	20.15	21.70	23.25	24.80	26.35	27.90	29.45	31.00
32	1.60	3.20	4.80	6.40	8.00	9.60	11.20	12.80	14.40	16.00	17.60	19.20	20.80	22.40	24.00	25.60	27.20	28.80	30.40	32.00
33	1.65	3.30	4.95	6.60	8.25	9.90	11.55	13.20	14.85	16.50	18.15	19.80	21.45	23.10	24.75	26.40	28.05	29.70	31.35	33.00
34	1.70	3.40	5.10	6.80	8.50	10.20	11.90	13.60	15.30	17.00	18.70	20.40	22.10	23.80	25.50	27.20	28.90	30.60	32.30	34.00
35	1.75	3.50	5.25	7.00	8.75	10.50	12.25	14.00	15.75	17.50	19.25	21.00	22.75	24.50	26.25	28.00	29.75	31.50	33.25	35.00
36	1.80	3.60	5.40	7.20	9.00	10.80	12.60	14.40	16.20	18.00	19.80	21.60	23.40	25.20	27.00	28.80	30.60	32.40	34.20	36.00
37	1.85	3.70	5.55	7.40	9.25	11.10	12.95	14.80	16.65	18.50	20.35	22.20	24.05	25.90	27.75	29.60	31.45	33.30	35.15	37.00
38	1.90	3.80	5.70	7.60	9.50	11.40	13.30	15.20	17.10	19.00	20.90	22.80	24.70	26.60	28.50	30.40	32.30	34.20	36.10	38.00
39	1.95	3.90	5.85	7.80	9.75	11.70	13.65	15.60	17.55	19.50	21.45	23.40	25.35	27.30	29.25	31.20	33.15	35.10	37.05	39.00
40	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.00	32.00	34.00	36.00	38.00	40.00
41	2.05	4.10	6.15	8.20	10.25	12.30	14.35	16.40	18.45	20.50	22.55	24.60	26.65	28.70	30.75	32.80	34.85	36.90	38.95	41.00
42	2.10	4.20	6.30	8.40	10.50	12.60	14.70	16.80	18.90	21.00	23.10	25.20	27.30	29.40	31.50	33.60	35.70	37.80	39.90	42.00
43	2.15	4.30	6.45	8.60	10.75	12.90	15.05	17.20	19.35	21.50	23.65	25.80	27.95	30.10	32.25	34.40	36.55	38.70	40.85	43.00
44	2.20	4.40	6.60	8.80	11.00	13.20	15.40	17.60	19.80	22.00	24.20	26.40	28.60	30.80	33.00	35.20	37.40	39.60	41.80	44.00
45	2.25	4.50	6.75	9.00	11.25	13.50	15.75	18.00	20.25	22.50	24.75	27.00	29.25	31.50	33.75	36.00	38.25	40.50	42.75	45.00
46	2.30	4.60	6.90	9.20	11.50	13.80	16.10	18.40	20.70	23.00	25.30	27.60	29.90	32.20	34.50	36.80	39.10	41.40	43.70	46.00
47	2.35	4.70	7.05	9.40	11.75	14.10	16.45	18.80	21.15	23.50	25.85	28.20	30.55	32.90	35.25	37.60	39.95	42.30	44.65	47.00
48	2.40	4.80	7.20	9.60	12.00	14.40	16.80	19.20	21.60	24.00	26.40	28.80	31.20	33.60	36.00	38.40	40.80	43.20	45.60	48.00
49	2.45	4.90	7.35	9.80	12.25	14.70	17.15	19.60	22.05	24.50	26.95	29.40	31.85	34.30	36.75	39.20	41.65	44.10	46.55	49.00
50	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00	27.50	30.00	32.50	35.00	37.50	40.00	42.50	45.00	47.50	50.00
51	2.55	5.10	7.65	10.20	12.75	15.30	17.85	20.30	22.85	25.40	27.95	30.50	33.05	35.60	38.15	40.70	43.25	45.80	48.35	51.00
52	2.60	5.20	7.80	10.40	13.00	15.60	18.20	20.80	23.40	26.00	28.60	31.20	33.80	36.40	39.00	41.60	44.20	46.80	49.40	52.00
53	2.65	5.30	7.95	10.60	13.25	15.90	18.55	21.10	23.75	26.40	29.05	31.70	34.35	37.00	39.65	42.				



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
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INSULATION DESIGN
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THEORY - THICKNESS TO PREVENT CONDENSATION
SOLUTION BY USE OF TABLES AND WORK SHEETS - Continued

CONVECTION HEAT GAIN RATE (q_{ca})
Free Convection

HEAT GAIN RATE, BTU/HR, SQ FT							HEAT GAIN RATE, BTU/HR, SQ FT						
Temp Diff Δt	Vertical Flat Surfaces ¹	Horizontal Flat Surfaces, Facing Upward ²	Horizontal Flat Surfaces, Facing Downward ²	Horizontal Cylinders and Pipes ^{1,3}	Vertical Cylinders and Pipes ^{1,3}	Spheres	Temp Diff Δt	Vertical Flat Surfaces ¹	Horizontal Flat Surfaces, Facing Upward ²	Horizontal Flat Surfaces, Facing Downward ²	Horizontal Cylinders and Pipes ^{1,3}	Vertical Cylinders and Pipes ^{1,3}	Spheres
1	0.24	0.15	0.30	0.17	0.21	0.31	37	22.9	14.6	29.4	16.7	20.3	29.8
2	0.57	0.36	0.73	0.41	0.50	0.74	38	23.6	15.1	30.4	17.2	20.9	30.9
3	0.95	0.61	1.22	0.69	0.84	1.24	39	24.4	15.6	31.4	17.8	21.7	31.9
4	1.37	0.87	1.76	1.00	1.21	1.79	40	25.2	16.1	32.4	18.4	22.4	32.9
5	1.81	1.16	2.33	1.32	1.61	2.37	41	26.0	16.6	33.4	19.0	23.1	34.0
6	2.29	1.46	2.93	1.67	2.02	2.98	42	26.8	17.1	34.5	19.6	23.8	35.0
7	2.78	1.77	3.56	2.02	2.46	3.63	43	27.7	17.7	35.5	20.2	24.5	36.1
8	3.29	2.10	4.22	2.40	2.91	4.29	44	28.5	18.2	36.6	20.7	25.2	37.2
9	3.82	2.44	4.90	2.78	3.38	4.98	45	29.3	18.7	37.6	21.3	25.9	38.2
10	4.36	2.79	5.60	3.18	3.86	5.69	46	30.1	19.2	38.7	22.0	26.7	39.3
11	4.92	3.14	6.31	3.58	4.36	6.43	47	30.9	19.7	39.7	22.6	27.4	40.4
12	5.49	3.51	7.06	4.00	4.87	7.17	48	31.8	20.3	40.8	23.2	28.2	41.5
13	6.08	3.88	7.80	4.43	5.39	7.94	49	32.6	20.8	41.9	23.8	28.9	42.6
14	6.68	4.26	8.57	4.86	5.92	8.72	50	33.5	21.4	43.0	24.4	29.7	43.7
15	7.29	4.65	9.36	5.31	6.46	9.52	51	34.3	21.9	44.1	25.0	30.4	44.8
16	7.91	5.05	10.2	5.76	7.01	10.3	52	35.2	22.5	45.2	25.6	31.2	45.9
17	8.54	5.45	11.0	6.22	7.57	11.1	53	36.0	23.0	46.3	26.3	31.9	47.0
18	9.18	5.86	11.8	6.69	8.13	12.0	54	36.9	23.5	47.4	26.9	32.7	48.2
19	9.83	6.28	12.6	7.17	8.71	12.8	55	37.8	24.1	48.5	27.5	33.5	49.3
20	10.4	6.70	13.5	7.65	9.29	13.7	56	38.6	24.7	49.6	28.2	34.2	50.4
21	11.2	7.12	14.3	8.13	9.89	14.6	57	39.5	25.2	50.7	28.8	35.0	51.6
22	11.8	7.56	15.2	8.63	10.5	15.5	58	40.4	25.8	51.9	29.4	35.8	52.7
23	12.5	7.99	16.1	9.13	11.1	16.4	59	41.3	26.3	53.0	30.1	36.6	53.9
24	13.2	8.44	17.0	9.63	11.7	17.3	60	42.2	26.9	54.1	30.7	37.3	55.0
25	13.9	8.88	17.9	10.1	12.3	18.2	61	43.0	27.5	55.3	31.4	38.1	56.2
26	14.6	9.34	18.8	10.7	13.0	19.1	62	43.9	28.1	56.4	32.0	38.9	57.4
27	15.3	9.79	19.7	11.2	13.6	20.1	63	44.8	28.6	57.6	32.7	39.7	58.5
28	16.1	10.3	20.6	11.7	14.2	21.0	64	45.7	29.2	58.7	33.3	40.5	59.7
29	16.8	10.7	21.6	12.2	14.9	21.9	65	46.7	29.8	59.9	34.0	41.3	60.9
30	17.5	11.2	22.5	12.8	15.5	22.9	66	47.6	30.4	61.1	34.7	42.1	62.1
31	18.3	11.7	23.5	13.3	16.2	23.9	67	48.5	31.0	62.2	35.3	42.9	63.3
32	19.0	12.1	24.4	13.9	16.8	24.8	68	49.4	31.5	63.4	36.0	43.8	64.5
33	19.8	12.6	25.4	14.4	17.5	25.8	69	50.3	32.1	64.6	36.7	44.6	65.7
34	20.5	13.1	26.4	15.0	18.2	26.8	70	51.2	32.7	65.8	37.3	45.4	66.9
35	21.3	13.6	27.4	15.5	18.9	27.8	71	52.2	33.3	67.0	38.0	46.2	68.1
36	22.1	14.1	28.4	16.1	19.6	28.8	72	53.1	33.9	68.2	38.7	47.0	69.3

See table at right for correction factors for surface height or diameter.

Figures in this column are more accurate for surfaces having dimensions of 24 inches or greater.

Figures in this column are more accurate for vertical heights over 24 inches.

CORRECTION FACTORS FOR SURFACE HEIGHT OR DIAMETER OF INSULATION

Approx. Height or OD, In.	1	2	3	4	5	6	7	8	9	10	12	14	16	18	20	22
Correction Factor C_s	1.89	1.64	1.52	1.43	1.37	1.32	1.28	1.25	1.22	1.19	1.15	1.11	1.08	1.06	1.04	1.02
No correction needed for heights or diameters 24 inches and greater.																

TABLE V



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION I
INSULATION DESIGN
PAGE 85
MAY, 1968

THEORY - THICKNESS TO PREVENT CONDENSATION

SOLUTION BY USE OF TABLES AND WORK SHEETS - Continued

VALUES OF RESISTANCE R ($R = \Delta t_2 / q_a$)

Note: $q_a = q_{cr} + q_{ca}$

Δt_1 °F	SURFACE HEAT GAIN q_a in Btu/ft ² hr																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
5	5.0	2.5	1.67	1.25	1.0	0.83	0.71	0.63	0.56	0.5	0.45	0.42	0.39	0.36	0.33	0.31	0.29	0.28	0.26	0.25
10	10.0	5.0	3.33	2.50	2.0	1.67	1.43	1.25	1.11	1.0	0.91	0.83	0.77	0.71	0.66	0.63	0.59	0.56	0.53	0.51
15	15.0	7.5	5.00	3.75	3.0	2.50	2.14	1.88	1.67	1.5	1.36	1.25	1.15	1.07	1.00	0.94	0.88	0.83	0.79	0.77
20	20.0	10.0	6.67	5.00	4.0	3.33	2.86	2.50	2.22	2.0	1.82	1.67	1.54	1.43	1.33	1.25	1.18	1.11	1.05	1.02
25	25.0	12.5	8.33	6.25	5.0	4.17	3.57	3.13	2.78	2.5	2.27	2.08	1.92	1.79	1.66	1.56	1.47	1.39	1.32	1.27
30	30.0	15.0	10.00	7.50	6.0	5.00	4.29	3.75	3.33	3.0	2.73	2.50	2.31	2.14	2.00	1.88	1.76	1.67	1.57	1.50
35	35.0	17.5	11.67	8.75	7.0	5.83	5.00	4.38	3.89	3.5	3.18	2.92	2.69	2.50	2.33	2.19	2.06	1.94	1.84	1.77
40	40.0	20.0	13.33	10.00	8.0	6.67	5.71	5.00	4.44	4.0	3.64	3.33	3.08	2.86	2.66	2.50	2.35	2.22	2.11	2.03
45	45.0	22.5	15.00	11.25	9.0	7.50	6.43	5.63	5.00	4.5	4.09	3.75	3.46	3.21	3.00	2.81	2.65	2.50	2.37	2.28
50	50.0	25.0	16.67	12.50	10.0	8.33	7.14	6.25	5.56	5.0	4.55	4.17	3.85	3.57	3.33	3.13	2.94	2.78	2.63	2.54
55	55.0	27.5	18.33	13.75	11.0	9.17	7.86	6.88	6.11	5.5	5.00	4.58	4.23	3.93	3.66	3.44	3.24	3.06	2.89	2.79
60	60.0	30.0	20.00	15.00	12.0	10.00	8.57	7.50	6.67	6.0	5.46	5.00	4.62	4.29	4.00	3.75	3.53	3.33	3.16	3.06
65	65.0	32.5	21.67	16.25	13.0	10.83	9.29	8.13	7.22	6.5	5.91	5.42	5.00	4.64	4.33	4.06	3.82	3.61	3.42	3.31
70	70.0	35.0	23.33	17.50	14.0	11.67	10.00	8.75	7.78	7.0	6.37	5.83	5.39	5.00	4.66	4.38	4.12	3.89	3.68	3.57
75	75.0	37.5	25.00	18.75	15.0	12.00	10.71	9.38	8.33	7.5	6.82	6.25	5.77	5.36	5.00	4.69	4.41	4.17	3.95	3.83
80	80.0	40.0	26.67	20.00	16.0	13.33	11.43	10.00	8.89	8.0	7.27	6.67	6.15	5.71	5.33	5.00	4.71	4.44	4.21	4.07
85	85.0	42.5	28.33	21.25	17.0	14.17	12.14	10.63	9.44	8.5	7.73	7.08	6.54	6.07	5.66	5.31	5.00	4.72	4.47	4.24
90	90.0	45.0	30.00	22.50	18.0	15.00	12.86	11.25	10.00	9.0	8.19	7.50	6.92	6.43	6.00	5.63	5.29	5.00	4.74	4.49
95	95.0	47.5	31.67	23.75	19.0	15.83	13.57	11.88	10.56	9.5	8.64	7.92	7.31	6.79	6.33	5.94	5.59	5.28	5.00	4.74
100	100.0	50.0	33.33	25.00	20.0	16.67	14.29	12.50	11.11	10.0	9.09	8.33	7.69	7.14	6.66	6.25	5.88	5.56	5.26	5.00
110	110.0	55.0	36.67	27.50	22.0	18.33	15.71	13.75	12.22	11.0	10.00	9.17	8.46	7.86	7.33	6.88	6.47	6.11	5.79	5.51
120	120.0	60.0	40.00	30.00	24.0	20.00	17.14	15.00	13.33	12.0	10.91	10.00	9.23	8.57	8.00	7.50	7.06	6.67	6.32	6.03
130	130.0	65.0	43.33	32.50	26.0	21.67	18.57	16.25	14.44	13.0	11.82	10.83	10.00	9.29	8.66	8.13	7.65	7.22	6.84	6.55
140	140.0	70.0	46.67	35.00	28.0	23.33	20.00	17.50	15.56	14.0	12.73	11.67	10.77	10.00	9.30	8.75	8.24	7.78	7.37	7.07
150	150.0	75.0	50.00	37.50	30.0	25.00	21.43	18.75	16.67	15.0	13.64	12.50	11.54	10.71	10.00	9.38	8.82	8.33	7.89	7.58
160	160.0	80.0	53.33	40.00	32.0	26.67	22.86	20.00	17.78	16.0	14.55	13.33	12.31	11.42	10.66	10.00	9.41	8.89	8.47	8.09
170	170.0	85.0	56.67	42.50	34.0	28.33	24.29	21.25	18.89	17.0	15.46	14.17	13.08	12.14	11.33	10.63	10.00	9.44	8.95	8.56
180	180.0	90.0	60.00	45.00	36.0	30.00	25.71	22.50	20.00	18.0	16.37	15.00	13.85	12.86	12.00	11.25	10.59	10.00	9.47	9.07
190	190.0	95.0	63.33	47.50	38.0	31.67	27.14	23.75	21.11	19.0	17.27	15.83	14.62	13.57	12.66	11.88	11.18	10.56	10.00	9.58
200	200.0	100.0	66.67	50.00	40.0	33.33	28.57	25.00	22.22	20.0	18.19	16.67	15.39	14.29	13.33	12.50	11.76	11.11	10.53	10.09
210	210.0	105.0	70.00	52.50	42.0	35.00	30.00	26.25	23.33	21.0	19.09	17.50	16.15	15.00	14.00	13.13	12.35	11.67	11.05	10.59
220	220.0	110.0	73.33	55.00	44.0	36.67	31.43	27.50	24.44	22.0	20.00	18.33	16.92	15.71	14.66	13.75	12.94	12.22	11.57	11.09
230	230.0	115.0	76.67	57.50	46.0	38.33	32.86	28.75	25.56	23.0	20.91	19.17	17.69	16.43	15.33	14.38	13.53	12.78	12.11	11.61
240	240.0	120.0	80.00	60.00	48.0	40.00	34.29	30.00	26.67	24.0	21.82	20.00	18.46	17.14	16.00	15.00	14.12	13.33	12.63	12.10
250	250.0	125.0	83.33	62.50	50.0	41.67	35.71	31.25	27.78	25.0	22.73	20.83	19.23	17.86	16.66	15.63	14.71	13.89	13.16	12.59
260	260.0	130.0	86.67	65.00	52.0	43.33	37.14	32.50	28.89	26.0	23.64	21.67	20.00	18.57	17.33	16.25	15.29	14.44	13.68	13.09
270	270.0	135.0	90.00	67.50	54.0	45.00	38.57	33.75	30.00	27.0	24.55	22.50	20.77	19.29	18.00	16.88	15.88	15.00	14.21	13.59
280	280.0	140.0	93.33	70.00	56.0	46.67	40.00	35.00	31.11	28.0	25.46	23.33	21.54	20.00	18.66	17.50	16.47	15.56	14.74	14.10
290	290.0	145.0	96.67	72.50	58.0	48.33	41.43	36.25	32.22	29.0	26.37	24.17	22.31	20.71	19.33	18.13	17.06	16.11	15.26	14.59
300	300.0	150.0	100.00	75.00	60.0	50.00	42.86	37.50	33.33	30.0	27.27	25.00	23.08	21.43	20.00	18.75	17.65	16.67	15.79	15.09

Δt_1 °F	SURFACE HEAT GAIN q_a in Btu/ft ² hr																			
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
5	0.24	0.23	0.22	0.21	0.20	0.20	0.19	0.18	0.17	0.17	0.16	0.16	0.15	0.15	0.14	0.14	0.14	0.13	0.13	0.13
10	0.48	0.46	0.44	0.42	0.40	0.39	0.37	0.36	0.35	0.33	0.32	0.31	0.30	0.30	0.29	0.28	0.27	0.26	0.26	0.25
15	0.71	0.68	0.65	0.63	0.60	0.58	0.56	0.54	0.52	0.50	0.48	0.47	0.46	0.44	0.43	0.42	0.41	0.40	0.39	0.38
20	0.95	0.91	0.87	0.83	0.80	0.77	0.74	0.71	0.69	0.67	0.65	0.63	0.61	0.59	0.57	0.56	0.54	0.53	0.51	0.50
25	1.19	1.14	1.09	1.04	1.00	0.96	0.93	0.89	0.86	0.83	0.81	0.78	0.76	0.74	0.72	0.70	0.68	0.66	0.64	0.62
30	1.43	1.36	1.30	1.25	1.20	1.15	1.11	1.07	1.04	1.00	0.97	0.94	0.91	0.88	0.86	0.83	0.81	0.79	0.77	0.75
35	1.67	1.59	1.52	1.46	1.40	1.35	1.30	1.25	1.21	1.17	1.13	1.09	1.06	1.03	1.00	0.97	0.95	0.92	0.90	0.87
40	1.91	1.82	1.74	1.67	1.60	1.54	1.48	1.43	1.38	1.33	1.29	1.25	1.21	1.18	1.14	1.11	1.08	1.05	1.03	1.00
45	2.14	2.05	1.96	1.88	1.80	1.73	1.67	1.61	1.55	1.50	1.45	1.41	1.36	1.32	1.29	1.25	1.22	1.18	1.15	1.12
50	2.38	2.27	2.17	2.08	2.00	1.92	1.85	1.79	1.72	1.67	1.61	1.56	1.52	1.47	1.43	1.39	1.35	1.32	1.28	1.25
55	2.62	2.50	2.39	2.29	2.20	2.12	2.04	1.96	1.90	1.83	1.77	1.72	1.67	1.62	1.57	1.53	1.49	1.45	1.41	1.37
60	2.86	2.73	2.61	2.50	2.40	2.31	2.22	2.14	2.07	2.00	1.94	1.88	1.82	1.77	1.71	1.67	1.62	1.58	1.54	1.50
65	3.10	2.96	2.83	2.71	2.60	2.50	2.41	2.32	2.24	2.17	2.10	2.03	1.97	1.91						



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION I
INSULATION DESIGN

PAGE 86

MAY, 1968

THEORY - THICKNESS TO PREVENT CONDENSATION
SOLUTION BY USE OF TABLES AND WORK SHEETS - Continued
FLAT (OR EQUIVALENT) THICKNESS OF INSULATION, L (L = Rk)

R	k OF INSULATION IN Btu/ft, hr, °F, INCH																				
	0.10	0.12	0.14	0.16	0.18	0.20	0.22	0.24	0.26	0.28	0.30	0.35	0.40	0.45	0.50	0.60	0.70	0.80	0.90	1.00	
0.5	0.05	0.06	0.07	0.08	0.09	0.10	0.11	0.12	0.13	0.14	0.15	0.18	0.20	0.23	0.25	0.30	0.35	0.40	0.45	0.50	
1.0	0.10	0.12	0.14	0.16	0.18	0.20	0.22	0.24	0.26	0.28	0.30	0.35	0.40	0.45	0.50	0.60	0.70	0.80	0.90	1.00	
1.5	0.15	0.18	0.21	0.24	0.27	0.30	0.33	0.36	0.39	0.42	0.45	0.53	0.60	0.68	0.75	0.90	1.05	1.20	1.35	1.50	
2.0	0.20	0.24	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00	
2.5	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.88	1.00	1.13	1.25	1.50	1.75	2.00	2.25	2.50	
3.0	0.30	0.36	0.42	0.48	0.54	0.60	0.66	0.72	0.78	0.84	0.90	1.05	1.20	1.35	1.50	1.80	2.10	2.40	2.70	3.00	
3.5	0.35	0.42	0.49	0.56	0.63	0.70	0.77	0.84	0.91	0.98	1.05	1.23	1.40	1.58	1.75	2.10	2.45	2.80	3.15	3.50	
4.0	0.40	0.48	0.56	0.64	0.72	0.80	0.88	0.96	1.04	1.12	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	
4.5	0.45	0.54	0.63	0.72	0.81	0.90	0.99	1.08	1.17	1.26	1.35	1.58	1.80	2.03	2.25	2.70	3.15	3.60	4.05	4.50	
5.0	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.75	2.00	2.25	2.50	3.00	3.50	4.00	4.50	5.00	
5.5	0.55	0.66	0.77	0.88	0.99	1.10	1.21	1.32	1.43	1.54	1.65	1.93	2.20	2.48	2.75	3.30	3.85	4.40	4.95	5.50	
6.0	0.60	0.72	0.84	0.96	1.08	1.20	1.32	1.44	1.56	1.68	1.80	2.10	2.40	2.70	3.00	3.60	4.20	4.80	5.40	6.00	
6.5	0.65	0.78	0.91	1.04	1.17	1.30	1.43	1.56	1.69	1.82	1.95	2.28	2.60	2.93	3.25	3.90	4.55	5.20	5.85	6.50	
7.0	0.70	0.84	0.98	1.12	1.26	1.40	1.54	1.68	1.82	1.96	2.10	2.45	2.80	3.15	3.50	4.20	4.90	5.60	6.30	7.00	
7.5	0.75	0.90	1.05	1.20	1.35	1.50	1.65	1.80	1.95	2.10	2.25	2.63	3.00	3.38	3.75	4.50	5.25	6.00	6.75	7.50	
8.0	0.80	0.96	1.12	1.28	1.44	1.60	1.76	1.92	2.08	2.24	2.40	2.80	3.20	3.60	4.00	4.80	5.60	6.40	7.20	8.00	
8.5	0.85	1.02	1.19	1.36	1.53	1.70	1.87	2.04	2.21	2.38	2.55	2.98	3.40	3.83	4.25	5.10	5.95	6.80	7.65	8.50	
9.0	0.90	1.08	1.26	1.44	1.62	1.80	1.98	2.16	2.34	2.52	2.70	3.15	3.60	4.05	4.50	5.40	6.30	7.20	8.10	9.00	
9.5	0.95	1.14	1.33	1.52	1.71	1.90	2.09	2.28	2.47	2.66	2.85	3.33	3.80	4.28	4.75	5.70	6.65	7.60	8.55	9.50	
10.0	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	3.00	3.50	4.00	4.50	5.00	6.00	7.00	8.00	9.00	10.00	
11.0	1.10	1.32	1.54	1.76	1.98	2.20	2.42	2.64	2.86	3.08	3.30	3.85	4.40	4.95	5.50	6.60	7.70	8.80	9.90	11.00	
12.0	1.20	1.44	1.68	1.92	2.16	2.40	2.64	2.88	3.12	3.36	3.60	4.20	4.80	5.40	6.00	7.20	8.40	9.60	10.80	12.00	
13.0	1.30	1.56	1.82	2.08	2.34	2.60	2.86	3.12	3.38	3.64	3.90	4.55	5.20	5.85	6.50	7.80	9.10	10.40	11.70	13.00	
14.0	1.40	1.68	1.96	2.24	2.52	2.80	3.08	3.36	3.64	3.92	4.20	4.90	5.60	6.30	7.00	8.40	9.80	11.20	12.60	14.00	
15.0	1.50	1.80	2.10	2.40	2.70	3.00	3.30	3.60	3.90	4.20	4.50	5.25	6.00	6.75	7.50	9.00	10.50	12.00	13.50	15.00	
16.0	1.60	1.92	2.24	2.56	2.88	3.20	3.52	3.84	4.16	4.48	4.80	5.60	6.40	7.20	8.00	9.60	11.20	12.80	14.40	16.00	
17.0	1.70	2.04	2.38	2.72	3.06	3.40	3.74	4.08	4.42	4.76	5.10	5.95	6.80	7.65	8.50	10.20	11.90	13.60	15.30	17.00	
18.0	1.80	2.16	2.52	2.88	3.24	3.60	3.96	4.32	4.68	5.04	5.40	6.30	7.20	8.10	9.00	10.80	12.60	14.40	16.20	18.00	
19.0	1.90	2.28	2.66	3.04	3.42	3.80	4.18	4.56	4.94	5.32	5.70	6.65	7.60	8.55	9.50	11.40	13.30	15.20	17.10	19.00	
20.0	2.00	2.40	2.80	3.20	3.60	4.00	4.40	4.80	5.20	5.60	6.00	7.00	8.00	9.00	10.00	12.00	14.00	16.00	18.00	20.00	
21.0	2.10	2.52	2.94	3.36	3.78	4.20	4.62	5.04	5.46	5.88	6.30	7.35	8.40	9.45	10.50	12.60	14.70	16.80	18.90	21.00	
22.0	2.20	2.64	3.08	3.52	3.96	4.40	4.84	5.28	5.72	6.16	6.60	7.70	8.80	9.90	11.00	13.20	15.40	17.60	19.80	22.00	
23.0	2.30	2.76	3.22	3.68	4.14	4.60	5.06	5.52	5.98	6.44	6.90	8.05	9.20	10.35	11.50	13.80	16.10	18.40	20.70	23.00	
24.0	2.40	2.88	3.36	3.84	4.32	4.80	5.28	5.76	6.24	6.72	7.20	8.40	9.60	10.80	12.00	14.40	16.80	19.20	21.60	24.00	
25.0	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.75	10.00	11.25	12.50	15.00	17.50	20.00	22.50	25.00	
26.0	2.60	3.12	3.64	4.16	4.68	5.20	5.72	6.24	6.76	7.28	7.80	9.10	10.40	11.70	13.00	15.60	18.20	20.80	23.40	26.00	
27.0	2.70	3.24	3.78	4.32	4.86	5.40	5.94	6.48	7.02	7.56	8.10	9.45	10.80	12.15	13.50	16.20	18.90	21.60	24.30	27.00	
28.0	2.80	3.36	3.92	4.48	5.04	5.60	6.16	6.72	7.28	7.84	8.40	9.80	11.20	12.60	14.00	16.80	19.60	22.40	25.20	28.00	
29.0	2.90	3.48	4.06	4.64	5.22	5.80	6.38	6.96	7.54	8.12	8.70	10.15	11.60	13.05	14.50	17.40	20.30	23.20	26.10	29.00	
30.0	3.00	3.60	4.20	4.80	5.40	6.00	6.60	7.20	7.80	8.40	9.00	10.50	12.00	13.50	15.00	18.00	21.00	24.00	27.00	30.00	
31.0	3.10	3.72	4.34	4.96	5.58	6.20	6.82	7.44	8.06	8.68	9.30	10.85	12.40	13.95	15.50	18.60	21.70	24.80	27.90	31.00	
32.0	3.20	3.84	4.48	5.12	5.76	6.40	7.04	7.68	8.32	8.96	9.60	11.20	12.80	14.40	16.00	19.20	22.40	25.60	28.80	32.00	
33.0	3.30	3.96	4.62	5.28	5.94	6.60	7.26	7.92	8.58	9.24	9.90	11.55	13.20	14.85	16.50	19.80	23.10	26.40	29.70	33.00	
34.0	3.40	4.08	4.76	5.44	6.12	6.80	7.48	8.16	8.84	9.52	10.20	11.90	13.60	15.30	17.00	20.40	23.80	27.20	30.60	34.00	
35.0	3.50	4.20	4.90	5.60	6.30	7.00	7.70	8.40	9.10	9.80	10.50	12.25	14.00	15.75	17.50	21.00	24.50	28.00	31.50	35.00	
36.0	3.60	4.32	5.04	5.76	6.48	7.20	7.92	8.64	9.36	10.08	10.80	12.60	14.40	16.20	18.00	21.60	25.20	28.80	32.40	36.00	
37.0	3.70	4.44	5.18	5.92	6.66	7.40	8.14	8.88	9.62	10.36	11.10	12.95	14.80	16.65	18.50	22.20	25.90	29.60	33.30	37.00	
38.0	3.80	4.56	5.32	6.08	6.84	7.60	8.36	9.12	9.88	10.64	11.40	13.30	15.20	17.10	19.00	22.80	26.60	30.40	34.20	38.00	
39.0	3.90	4.68	5.46	6.24	7.02	7.80	8.58	9.36	10.14	10.92	11.70	13.65	15.60	17.55	19.50	23.40	27.30	31.20	35.10	39.00	
40.0	4.00	4.80	5.60	6.40	7.20	8.00	8.80	9.60	10.40	11.20	12.00	14.00	16.00	18.00	20.00	24.00	28.00	32.00	36.00	40.00	
41.0	4.10	4.92	5.74	6.56	7.38	8.20	9.02	9.84	10.66	11.48	12.30	14.35	16.40	18.45	20.50	24.60	28.70	32.80	36.90	41.00	
42.0	4.20	5.04	5.88	6.72	7.56	8.40	9.24	10.08	10.92	11.76	12.60	14.70	16.80	18.90	21.00	25.20	29.40	33.60	37.80	42.00	
43.0	4.30	5.16	6.02	6.88	7.74	8.60	9.46	10.													

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SOLUTION BY USE OF TABLES AND WORK SHEETS - Continued

NOMINAL PIPE INSULATION THICKNESS EQUIVALENT TO FLAT INSULATION THICKNESS

Nom. Pipe Size	NOMINAL PIPE INSULATION THICKNESS																			
	1/2	1	1-1/2	2	2-1/2	3	3-1/2	4	4-1/2	5	5-1/2	6	6-1/2	7	7-1/2	8	8-1/2	9	9-1/2	
1/2	0.76	1.74	3.08	4.41	6.78	8.34	9.96	11.65	13.60	15.39	17.22	19.56								
3/4	0.55	1.43	2.65	3.86	6.05	7.50	9.02	10.59	12.42	14.10	15.82	18.03								
1	0.69	1.69	2.74	3.98	5.32	6.65	8.06	9.52	11.22	12.79	14.40	16.47	18.16	19.89						
1-1/4	0.78	1.29	2.73	3.34	4.55	5.78	7.07	8.41	9.99	11.44	12.94	14.86	16.44	18.05						
1-1/2	0.58	1.47	2.40	4.11	5.27	6.49	7.77	9.27	10.66	12.08	13.92	15.43	16.97							
2	0.66	1.41	2.33	3.36	4.40	5.51	6.67	8.05	9.32	10.63	12.33	13.73	15.16	16.62						
2-1/2	0.64	1.36	2.73	3.68	4.69	5.77	7.03	8.21	9.43	11.01	11.01	12.31	13.65	15.02						
3	0.55	1.26	2.08	2.94	3.85	4.83	5.98	7.06	8.18	9.64	10.85	12.09	13.36	14.66	15.99	17.34	18.72	20.12	21.55	
3-1/2	0.54	1.65	2.43	3.28	4.19	5.27	6.28	7.34	8.71	8.71	9.85	11.03	12.23	13.47	14.73	16.02	17.33	18.67	20.02	
4	0.57	1.26	1.98	2.78	3.63	4.64	5.60	6.59	7.90	8.98	10.09	11.24	12.41	13.62	14.85	16.10	17.38	18.68	20.00	
6	0.49	1.09	1.74	2.54	3.30	4.10	5.16	6.04	6.96	7.91	8.89	9.90	10.93	11.99	13.07	14.18	15.30	16.45	17.62	
8			1.76	2.43	3.33	4.08	4.87	5.69	6.54	7.42	8.32	9.25	10.20	11.18	12.17	13.19	14.23	15.28	16.36	
10			1.60	2.44	3.12	3.83	4.57	5.34	6.14	6.96	7.80	8.66	9.55	10.46	11.39	12.34	13.30	14.29	15.29	
12			1.76	2.38	3.04	3.72	4.43	5.16	5.92	6.70	7.50	8.33	9.17	10.03	10.91	11.81	12.73	13.66	14.61	
14			1.59	2.20	2.84	3.50	4.19	4.90	5.63	6.39	7.16	7.96	8.78	9.61	10.46	11.33	12.22	13.12	14.04	
16			1.57	2.17	2.79	3.44	4.11	4.80	5.51	6.24	6.99	7.75	8.54	9.34	10.16	11.00	11.85	12.72	13.60	
18			1.56	2.15	2.76	3.39	4.04	4.71	5.40	6.11	6.84	7.58	8.35	9.12	9.92	10.72	11.55	12.38	13.23	
20			1.55	2.13	2.73	3.35	3.99	4.65	5.32	6.01	6.72	7.45	8.19	8.94	9.71	10.50	11.29	12.11	12.93	
24			1.54	2.10	2.69	3.29	3.91	4.54	5.19	5.86	6.53	7.23	7.94	8.66	9.39	10.14	10.90	11.67	12.45	
30			1.52	2.08	2.64	3.23	3.82	4.43	5.06	5.69	6.34	7.00	7.67	8.35	9.05	9.76	10.48	11.21	11.94	
36			1.51	2.06	2.61	3.18	3.76	4.36	4.96	5.58	6.21	6.84	7.49	8.15	8.82	9.49	10.18	10.88	11.58	

NOTE: Find nominal pipe size in first column and read across table until you find required flat insulation thickness (or greater), then read equivalent nominal pipe insulation thickness at top of column.

Dimensions given in table for pipe sizes 14-in. OD and larger can be used for equipment of same diameters.

TABLE VIII



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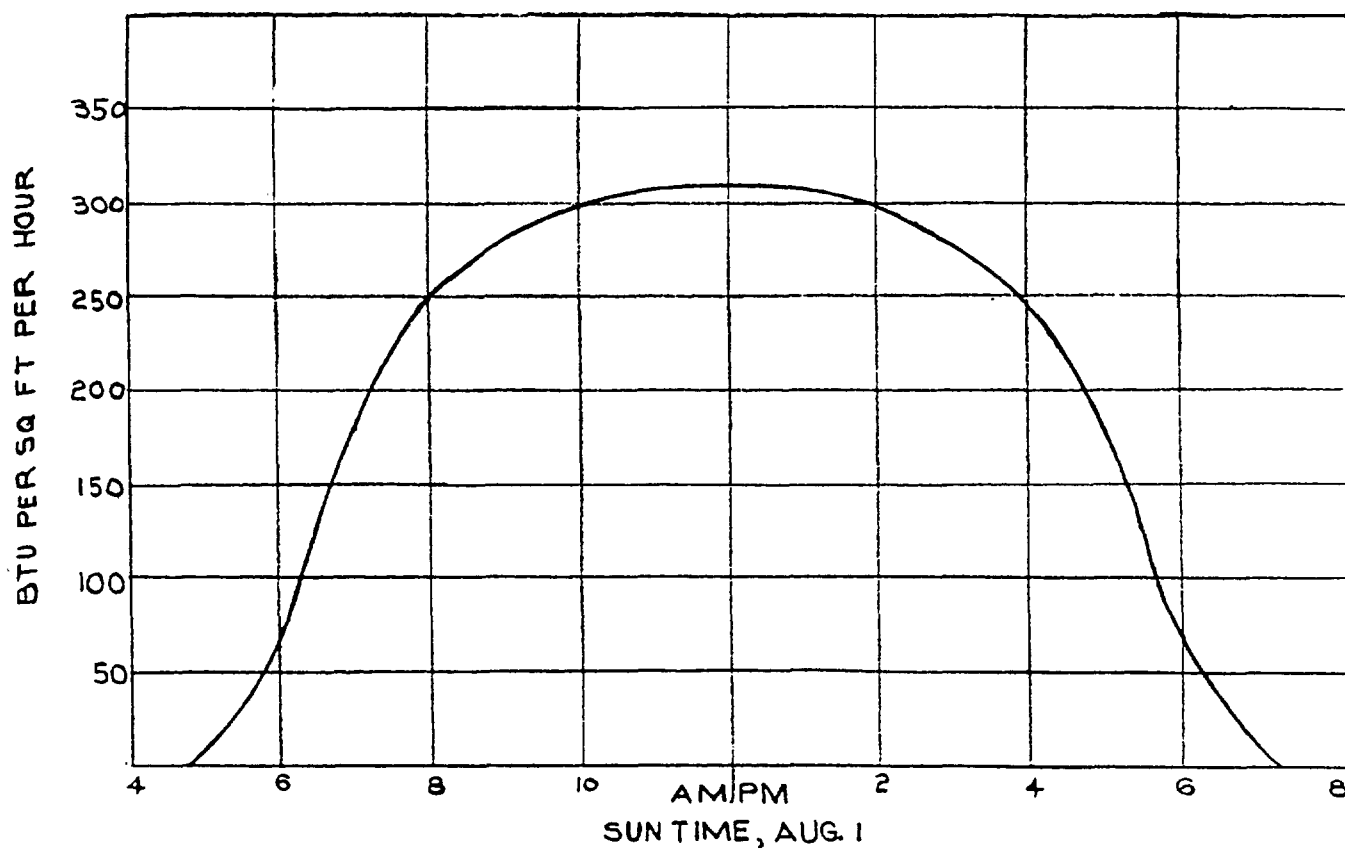
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THEORY - SOLAR RADIATION

IV. RADIATION PROBLEMS - Continued

A. Solar Radiation to Insulated Vessels - Continued

2. Continued



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THEORY - SOLAR RADIATION

IV. RADIATION PROBLEMS

A. Solar Radiation to Insulated Vessels - Continued

2. Continued

The heat transferred by radiation is based on absolute temperature T , but when heat radiation from above graph is used in the following equations, ordinary temperature t in $^{\circ}\text{F}$ may be used as the radiation affect has already been determined. As the heat gain is given in $3\text{tu's per sq ft, hr}$ on surface normal to the sun, the total heat gain will be this value times the projected area of vessel in relation to the sun's rays. Although there will be differences existing in the rate of heat transfer for any one particular surface in accordance with angle from normal, if total heat input is the major importance it will be obtained by using the projected area.

3. To illustrate this operation, the following example is presented:

Sphere is exposed to sun 40° latitude
 is insulated with 2" thickness (L) cellular glass
 is coated with black asphalt mastic $\epsilon = .97$
 is operated at 70°F (t)
 is 225 feet in diameter

Ambient air temperature is 90°F (t_a)

What savings in heat gain would be obtained if vessel was overcoated with aluminum paint with absorption $\epsilon = 0.26$ instead of asphalt $\epsilon = .97$. In this instance for asphalt mastic ϵ and α have identical values.

Solution:

Projected sun area A_1 of sphere $\pi \left(\frac{225}{2} \right)^2 = 39,850$

Solar intensity normal to sun at 12 noon, August 1, 40°N latitude
 = 310 Btu/sq ft/hr (from ASHVE guide) = Value of H_s α when
 $\alpha = 1.0$

Total surface absorption (max. conditions) $A_1 \alpha H_s$ would be for black asphalt. $.97 (39850 \times 310) = 12,010,000 \text{ Btu's per hour.}$



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THEORY - SOLAR RADIATION

IV. RADIATION PROBLEMS - Continued

A. Solar Radiation to Insulated Vessels - Continued

3. Solution: - Continued

For aluminum painted. $.26 (39850 \times 310) = 3,285,000 \text{ Btu/hr}$

The heat of solar radiation will raise the surface temperature t_2 above ambient temperature t_o and above the operating temperature t_a . Thus, it will be split, part reversing direction and going to the air and the other part going into the vessel.

$$\text{or } \left(\frac{t_2 - t_o}{\frac{L}{k}} \right) \frac{A_2}{2} + \left(\frac{t_2 - t_a}{\frac{1}{h}} \right) \frac{A_2}{2} = q$$

(temperatures in °F)

When A_2 = surface area of sphere.

The film resistance $\frac{1}{h} = \frac{1}{2}$, L is given as 2, the conductivity $k = .42$

$$A_2 = 4 \pi r^2 = 4 \pi (112.50)^2 = 159,400 \text{ sq ft}$$

$$\frac{A_2}{2} \text{ the area on sun side} = 79,700 \text{ sq ft}$$

$$t_o = 70\text{F}, t_a = 90\text{F}$$

To find t_2 for black asphalt surface, the average surface on sun side

$$\left(\frac{t_2 - 70}{\frac{2}{0.42}} \right) 79,700 + \left(\frac{t_2 - 90}{\frac{1}{2}} \right) 79,700 = 12,010,000 \text{ Btu, therefore } t_2 = 156\text{F}$$



THEORY - SOLAR RADIATION

IV. RADIATION PROBLEMS - Continued

A. Solar Radiation to Insulated Vessels - Continued

3. Continued

To find t_2 for aluminum overcoated surface

$$\left(\frac{t_2 - 70}{\frac{2}{0.42}} \right) 79,700 + \left(\frac{t_2 - 90}{\frac{1}{2}} \right) 79,700 = 3,285,000 \text{ Btu}$$

$$t_2 = 107$$

Heat gain sun side per hour

For black asphalt surface

$$q_{rb} = \frac{t_2 - t_o}{\frac{L}{k}} = \frac{156 - 70}{\frac{2}{0.42}} = 18.1 \text{ Btu/sq ft, hr}$$

For aluminum overcoated

$$q_{ra} = \frac{t_2 - t_o}{\frac{L}{k}} = \frac{107 - 70}{\frac{2}{0.42}} = 7.8 \text{ Btu/sq ft, hr}$$

Heat gain shade side (either asphalt or aluminum overcoated)

$$\frac{1}{h} = .9 \text{ still air conditions}$$

$$q_{rs} = \frac{t_a - t_o}{\frac{L}{k} + \frac{1}{h}} = \frac{90 - 70}{\frac{2}{0.42} + .9} = \frac{20}{5.66} = 3.53 \text{ Btu/sq ft, hr}$$

Total maximum gain per hour caused by maximum sun load

Asphalt black

$$\left(\frac{A_1}{2} \times q_{rb} \right) + \left(\frac{A_1}{2} \times q_{rs} \right) = \text{Btu/hr}$$

$$(79700 \times 18.1 + 79700 \times 3.53) = 1,440,000 + 286,000 = 1,726,000 \text{ Btu/hr}$$

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THEORY - SOLAR RADIATION

IV. RADIATION PROBLEMS - Continued

A. Solar Radiation to Insulated Vessels - Continued

3. Continued

Aluminum overcoated

$$\left(\frac{A_1}{2} \times q_{ra} \right) + \left(\frac{A_1}{2} \times q_{rs} \right) = \text{Btu/hr}$$
$$(79700 \times 7.8) + (79700 \times 3.53) = 620,000 + 286,000 = 906,000 \text{ Btu/hr}$$

V. TIME-TEMPERATURE CALCULATIONS

A. Temperature Drop of Liquids From Inlet to Outlet of Line

Such problems are frequent, as it is necessary that many materials be above a certain temperature for proper flow.

The allowance for Btu loss is determined by the amount of allowable temperature drop of the liquid as shown below.

$$Q = \Delta t \times W \times c$$

When Δt = Allowable temperature drop

W = Weight of material in lbs

c = Specific heat

This gives amount of allowable heat loss of the material passing from one end of the pipe to the other. To obtain maximum allowable heat loss per hour from the pipe, time required for the material to pass through the line must be established in hours.

Thus $q \text{ (Btu/hr)} = \frac{Q}{\text{hrs}}$, which is the allowable heat loss for the

entire length of line per hour, and $\frac{q}{\text{linear ft of pipe}}$

From previously stated formulas for determining heat loss through cylindrical insulation, the required insulation thickness can be determined.



THEORY - MISCELLANEOUS

V. TIME-TEMPERATURE CALCULATIONS - Continued

B. Temperature Drop of Stored Liquids

Another frequent problem is: If a vessel is filled with a liquid at a given temperature, what is the length of time before it arrives at certain lower (or higher) temperature closer to ambient temperature?

The solution is to determine the number of Btu's available for transfer from (or to) the material and the vessel, based on the temperature difference ($\Delta_1 t$) between material and vessel temperature and ambient temperature.

$$\text{Btu's} = (\Delta_1 t \times W_m \times c_m) + (\Delta_1 t \times W_v \times c_v)$$

When $\Delta_1 t$ = Temperature difference of material and vessel in relation to ambient temperature

W_m = Weight of material in lbs

c_m = Specific heat of material

W_v = Weight of vessel in lbs

c_v = Specific heat of vessel metal

Next is to determine Btu's of material and the vessel at difference between final allowable temperature and ambient temperature.

When $\Delta_2 t$ = Temperature difference of material and vessel at final allowable temperature in relation to ambient temperature

$$\text{Btu's} = (\Delta_2 t \times W_m \times c_m) + (\Delta_2 t \times W_v \times c_v)$$

Subtracting one from the other will give allowable Btu's heat gain or loss to the ambient air.

The heat loss (or gain) per hour per sq ft is calculated based on expected temperature differences between vessel temperature and ambient temperatures in accordance with formulas previously presented. Total loss (or gain) per hour is obtained by multiplying this result by insulation outside surface area.

Allowable Btu's divided by Btu loss per hour will give number of hours to reach allowable temperature.

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THEORY - MISCELLANEOUS

VI. MISCELLANEOUS EQUATIONS

A number of equations are used to determine the transfer of heat to the pipe or tube on which insulation is installed. Some of the most used equations follow:

A. Reynolds Number, R

$$R = \frac{VD\rho}{\mu}$$

When V = Velocity of stream, ft/hr
 ρ = Density of fluid, lb/ft³
 D = Inside diameter of tube (or pipe) ft
 μ = Viscosity of fluid, lb/ft, hr

Note: Laminar flow is stable only below value $R = 2320$ and turbulent flow above this critical value.

B. Critical Velocity, V_{cr}

$$V_{cr} = \frac{0.643\mu}{D\rho_o} \frac{\text{ft}}{\text{sec}}$$

When density of fluid, lb/ft³ (at 32F and 29.92" of Hg)

C. Surface Conductance of Superheated Steam to a Pipe (with temperature above saturation point)

$$h = \left(0.432 + 0.151 \frac{t}{1000} \right) \frac{V_o^{0.79}}{D^{0.16} L^{0.03}} \frac{\text{Btu}}{\text{sq ft, hr } ^\circ\text{F}}$$

When t = Temperature of steam $^\circ\text{F}$ ($V = 3$ ft/sec as per Nusselt)
 V_o = Velocity of steam at standard conditions

$$V_o = 33.53 \frac{pV}{460t} \frac{\text{ft}}{\text{sec}}$$

V = Velocity in ft/sec
 p = Steam pressure lb/in² absolute
 t = Temperature of steam F

D = Equivalent inside diameter of cross sectional area of gas stream F_t

L = $8.7 + 8.9 D$ = length of pipe required to reach minimum surface conductance.

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THEORY - MISCELLANEOUS

VI. MISCELLANEOUS EQUATIONS - Continued

D. Surface Conductance of Water in Pipe, h

$$h = 163 V^{0.83} (1 + 0.0104 t_w) \frac{\text{Btu}}{\text{sq ft, hr, } ^\circ\text{F}}$$

When t_w = Temperature of water, F
 V = Velocity of water, ft/sec

E. Surface Conductance of Condensing Saturated Steam, h_v or h_H

Vertical pipe

$$h_v = \frac{1590 + 4.07 (t_s + t_w)}{[H (t_s - t_w)]^{1/4}} \frac{\text{Btu}}{\text{sq ft, hr, } ^\circ\text{F}}$$

Horizontal pipe

$$h_h = \frac{1225 + 3.15 (t_s + t_w)}{[D (t_s - t_w)]^{1/4}} \frac{\text{Btu}}{\text{sq ft, hr, } ^\circ\text{F}}$$

Where t_s = Steam temperature, F
 t_w = Wall temperature
 D = Diameter of pipe, ft
 H = Height in ft of vertical run

F. Conductance of Condensate Film, h_v or h_H

Vertical pipe

$$h_v = k \left(\frac{\rho_g^2}{3c} \right)^{1/3} \frac{\text{Btu}}{\text{sq ft, hr, } ^\circ\text{F}}$$

Horizontal pipe

$$h_H = 0.78 K \left(\frac{\rho_g^2}{1.5 D \alpha \mu} \right)^{1/3} \frac{\text{Btu}}{\text{sq ft, hr, } ^\circ\text{F}}$$

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THEORY - MISCELLANEOUS

VI. MISCELLANEOUS EQUATIONS - Continued

F. Conductance of Condensate Film - Continued

When k	= Thermal conductivity of condensate	$\frac{\text{Btu}}{\text{sq ft, hr, } ^\circ\text{F}}$
p	= Density of condensate	lb/ft^3
g	= Acceleration of gravity	$\text{ft/hr}^2 = 4.18 \times 10^8$
c	= Rate of flow of condensate per unit length of perimeter	$\frac{\text{lbs}}{\text{ft, hr}}$
D	= Diameter of pipe,	ft
a	= Rate of condensation per unit area	$\frac{\text{lbs}}{\text{cu ft, hr}}$
μ	= Absolute viscosity of condensate	$\frac{\text{lbs}}{\text{ft, hr}}$



THEORY - HEAT TRACING

VII. HEAT TRACING

A. General

Transfer and storage of materials which freeze or become highly viscous at normal ambient temperatures, frequently require heat from an external source to keep them liquid. This source of heat can be obtained from heated liquids, steam, or electricity.

Heated liquids are sometimes used to furnish heat to process lines and equipment containing material having a critically high temperature. Heated liquid systems have certain disadvantages, such as the problem of controlling the temperature of the liquid, cycling the liquid, and preventing the liquid itself from freezing. For these reasons, we seldom use this system, and when it is necessary, it is a special design problem.

Steam or electric tracing systems are generally used as sources of external heat. The basic heat transfer equations for applying these sources of external heat are presented. This manual provides only heat transfer information which affects design of insulation. Information for the design of steam piping or electrical systems is provided in the appropriate manual.

B. Steam Heating

1. Steam Jacketing

The heat from steam can be transferred to a pipe or vessel in a number of ways. One is the use of jackets which enclose the pipe or vessel. Where jackets are used, the temperature of the metal of the pipe or vessel encased by the jacket is within a few degrees of the steam temperature. In the past, where maintenance of high temperatures only has been required, jackets have been used. However, steam jacketing of vessels, lines and fittings is undesirable from an initial cost and maintenance viewpoint and limits flexibility of design.

2. Steam Tracing

Another way to maintain high temperature in pipe is the close wrapping of steam tracers around a pipe. When installed on horizontal lines, this system has a trapping problem. The condensate pocket at the bottom of each loop creates excessive



THEORY - HEAT TRACING

VII. HEAT TRACING - Continued

B. Steam Heating - Continued

2. Steam Tracing - Continued

pressure drop, thus requiring frequent trapping. As the installed cost of a trapping station is \$150 to \$300, this system is very expensive.

Because of the excessive cost of the spirally wrapped system, the parallel system of steam tracing is recommended. This way of heat tracing is used both with steam and electricity as the heat source; however, it can be installed with two methods of heat transfer: one is the air convection heat transfer method and the other is the high-conductive cement method.

Each of the methods presented provides an equation for determining line temperature based on static conditions and no flow in the pipe. Thus, they are independent of velocity, density, specific heat, and conductivity of the material in the pipe or vessel. Heat input of the tracer provides only for loss of heat through the insulation, and provides no heat for the process material.

a. Air Convection Method

In most instances where it is necessary to add only moderate heat to the process pipe, the air convection system is the least costly. Also, it is more economical to use one larger tracer size than two smaller tracers. In cases where heat requirements indicate that more than one large tracer is needed to supply the heat, it is more efficient to use the high-conductive cement method and use only one tracer. Under such conditions care should be taken in using the high-conductive cement method to be certain that this does not give too high a maintained temperature.

It should be noted that there is a broad range between the maximum temperatures possible with conventional air conduction tracing and the minimum temperatures possible with the high-conductive cement method. Where temperature levels fall within this range, it is suggested that electric tracing be considered.

THEORY - HEAT TRACING

VII. HEAT TRACING - Continued

B. Steam Heating - Continued

2. Steam Tracing - Continued

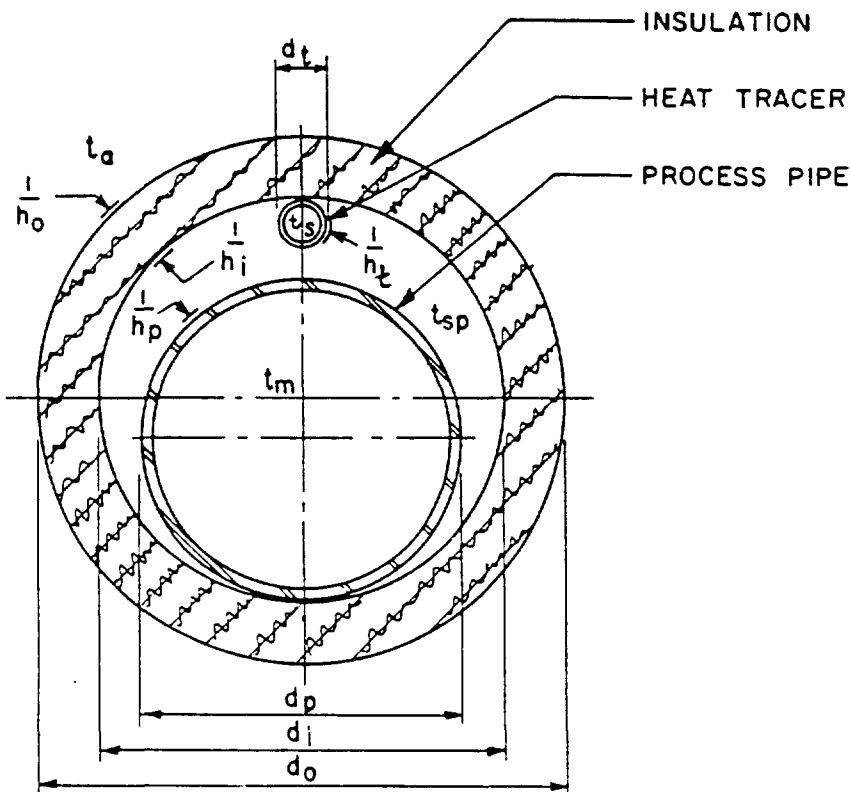
a. Air Convection Method - Continued

The formulas presented are based on certain assumptions. The first is that the insulation is oversize, and eccentric for cylindrical pipe.

If contour insulation is used, correction must be made in the factor $\frac{d_o}{d_i}$

Two other assumptions are present. One is the conductivity of the insulation and the other is the air film resistance. Although these assumptions are made as mean averages in the range of temperatures involved, they do change slightly with temperature. If the conductivity of the insulation to be used differs over 15% from the assumption, or if surrounding conditions are dissimilar, the constants in the equations must be altered to obtain correct results.

When, as shown in Figure 1



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VII. HEAT TRACING - Continued

B. Steam Heating - Continued

2. Steam Tracing - Continued

a. Air Convection Method - Continued

 d_o = Outside diameter of insulation in inches d_i = Inside diameter of insulation in inches d_p = Outside diameter of process pipe in inches d_t = Outside diameter of heat tracer in inches t_s = Temperature of heat tracer °F n = Number of heat tracers t_a = Temperature of ambient air °F $\frac{1}{h_p}, \frac{1}{h_o}, \frac{1}{h_i}, \frac{1}{h_t}$ = Air film resistance, each equals 1/2 k = Conductivity of insulation = 0.45 Btu/sq ft, hr, in °FThe temperature, t_m , of the pipe which can be maintained by the heat tracer is:

$$t_m = \frac{t_s d_t (2.22 d_o \text{Log}_e \frac{d_o}{d_i} + 2) + d_o t_a}{d_o + d_t (2.22 d_o \text{Log}_e \frac{d_o}{d_i} + 2)}$$

To calculate the maximum distance between steam traps, where

 Δ = Loss in pressure, psi lg = Length of pipe in feet d_{ti} = Inside diameter of pipe in inches ρ = Weight of one cubic foot of steam W = Pounds of steam per hour



THEORY - HEAT TRACING

VII. HEAT TRACING - Continued

B. Steam Heating - Continued

2. Steam Tracing - Continued

a. Air Convection Method - Continued

The maximum length (lg) between traps is:

$$lg = \left[\frac{\Delta \rho (d_{ti})^6 (d_o \log_e \frac{d_o}{d_i} \times 0.9)^2}{d_o^2 (d_{ti} + 3.6) (t_m - t_a)^2} \right]^{\frac{1}{3}} + 74500$$

This maximum length (L) is in equivalent feet, not actual footage. The proper number of equivalent feet for elbows, valves, and other fittings must be taken into consideration in determining trap spacing. Pressure drop in tracer (Δ) is usually assumed as 10% of steam pressure.

b. High-Conductive Cement Method

Where it is necessary to provide high temperature for the process pipe, it can be done by attaching the steam tracer to the process pipe with high-conductive cement as shown in Figure 2.

The assumptions made for the conductivity of the insulation and the film factors are the same in the formula for calculating high-conductive cement heat tracing as were used in the air convection method. If actual conditions differ too greatly from these assumptions, the constants in the equations must be altered to obtain correct results.

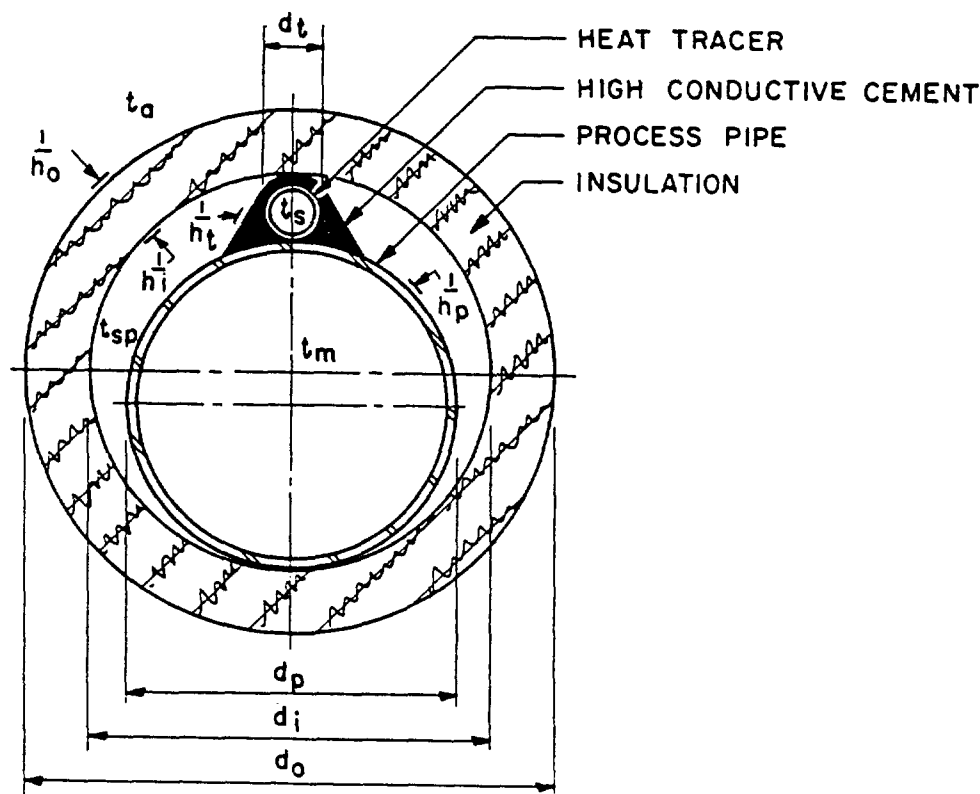
THEORY - HEAT TRACING

VII. HEAT TRACING - Continued

B. Steam Heating - Continued

2. Steam Tracing - Continued

b. High-Conductive Cement Method - Continued



With the same relationship as stated previously, and when overall transfer coefficient (U), between the tracer through the high-conductivity cement to the process pipe, is taken to equal 15 Btu/ sq ft/ hr °F, then

The temperature (t_m) of the pipe which can be maintained by the heat tracer is:

$$t_m = \frac{(2.22 d_o \log_e \frac{d_o}{d_i} + 2) n d_t (8.5 d_p - n d_t) t_s + d_o [n d_t (7.5 t_s - t_a) + t_a d_p]}{(2.22 d_o \log_e \frac{d_o}{d_i} + 2) n d_t (8.5 d_p - n d_t) + d_o (d_p + 6.5 n d_t)}$$



THEORY - HEAT TRANSFER

VII. HEAT TRACING - Continued

B. Steam Heating - Continued

2. Steam Tracing - Continued

b. High-Conductive Cement Method - Continued

The maximum distance between steam traps is:

The maximum distance between steam traps is:

$$lg=74,500 \left[\frac{\Delta P_n^2 (d_{ti})^6 (d_p - nd_t)^2 (d_o \log_e \frac{d_o}{d_i} + 0.9)^2}{d_o^2 (d_{ti} + 3.6) t_m (d_p + 14 nd_t) - nd_t 15 (t_s - t_a) - d_p t_a} \right]^{\frac{1}{3}}$$

Again lg is in equivalent feet.

The steam tracing equations on the preceding pages have been electronically calculated for various conditions of steam pressure and ambient conditions. These tables are shown in the "Engineering Standards", P-142 through P-142E, which are included in Section III of this manual.

C. Electric Tracing

Electric heating of process lines and equipment can be accomplished by induction heating or resistance heating. Induction heating has seldom been used; however, for certain applications, it might be useful.

1. Induction Heating

Induction heating differs from other types of heating in that the current-carrying coils are located outside the insulation. The non-metallic type of insulation provides an air gap between the induction coil and pipe or vessel. Heat is generated in the pipe or vessel by induced currents and the induction coil, outside the insulation remains at low operating temperature. The desired temperature of the pipe or vessel can be maintained by manual or automatic controls.

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THEORY - HEAT TRANSFER

VII. HEAT TRACING - Continued

C. Electric Tracing - Continued

1. Induction Heating - Continued

a. Static Conditions

Under static conditions, the electric heat source must supply just sufficient heat to compensate for the losses through the insulation from the vessel or pipe. The electric power, in KWH, necessary to make up the losses can be determined as follows:

For flat surfaces

When: t_1 = Surface temperature of the insulation on hot side (vessel or pipe temperature)

t_3 = Ambient air temperature

L = Thickness of insulation

k = Conductivity of insulation

h = Conductivity of air film outside the insulation

$$\text{Then: } KW = \frac{t_1 - t_3}{\frac{L}{k} + \frac{1}{h}} \times \frac{1}{3413} \text{ per sq ft of surface, per hr}$$

For cylindrical surfaces

When: r_1 = Inside radius of insulation in inches

r_2 = Outside radius of insulation in inches

$$KW = \frac{t_1 - t_3}{\frac{r_2}{r_1 \log_e \frac{r_2}{r_1}} + \frac{1}{h}} \times \frac{1}{3413} \times \frac{\pi r_2}{6} \text{ per linear foot of pipe, per hr}$$



THEORY - HEAT TRANSFER

VII. HEAT TRACING - Continued

C. Electric Tracing - Continued

1. Induction Heating - Continued

b. Operating Conditions

In many instances where inductive heating is used, it is necessary to raise the temperature of the material in the pipe as it passes through. The length of pipe then becomes a factor. Under these conditions,

When: L_{bm} = Weight of material per hour

S_{pm} = Specific heat of material

Δt = Degrees F material is to be raised

t_1 = Mean temperature of pipe or vessel

lg = Length of pipe in feet

$$KW = \frac{L_{bm} \times S_{pm} \times \Delta t}{3413} + \left[\frac{\frac{t_1 - t_3}{r_1 \log_e \frac{r_2}{r_1}} \times \frac{1}{3413}}{\frac{k}{r_1} + \frac{1}{h}} \right] \times \frac{lg r^2 \pi}{12} \text{ per hour}$$

The above equation can be used for cylindrical vessels if the area of the heads is added to the area of the cylindrical section.

c. Heatup Conditions

In presenting the first two equations, it was assumed that the temperature of the pipe or vessel was for static conditions, thus requiring no heating. However, where it is necessary to heat up from one temperature to another, it is necessary to calculate the amount of heat necessary, not only to raise the temperature of the material but also the heat required to raise the temperature of pipe or vessel. Also it is necessary to consider time required under these conditions.



THEORY - HEAT TRANSFER

VII. HEAT TRACING - Continued

C. Electric Tracing - Continued

1. Induction Heating - Continued

c. Heatup Conditions - Continued

When L_{be} = Weight of pipe or vessel S_{pe} = Specific heat of metal, pipe or vessel

hr = Hours allowed for heating up

Then

$$KWH = \frac{L_{bm} \times S_{pm} \times \Delta t}{3413} + \frac{L_{be} \times S_{pe} \times \Delta t}{3413} + \left[\frac{t_1 - t_3}{\frac{r_1 \log_e \frac{r_2}{r_1} + \frac{1}{h}}{k}} \times \frac{1}{6826} \right] \times \lg r^2 \times hr$$

The above equation can be used for cylindrical vessels if the area of the heads is added to the area of the cylindrical section. To determine KW

$$KW = \frac{KWH}{hr}$$

These equations indicate the electrical energy needed for the process material, pipe, and vessel. Such considerations as coil design, coil efficiency, power factors, controls, and power supply are covered in the electrical section of the Design Engineering Manual.

2. Resistance Heating

Resistance heating may be accomplished by two methods. One is by use of the pipe as a conductor. The other is by the use of a heater cable attached to the pipe. The first requires low voltage and high current, thus the power supply equipment must be heavy and large. In addition, if a break occurs in the pipe, sparking will be present at the break. These two factors make the system unsatisfactory for use in a chemical plant.



THEORY - HEAT TRANSFER

VII. HEAT TRACING - Continued

C. Electric Tracing - Continued

2. Resistance Heating - Continued

Until the development of the use of mineral insulated cable, the system of electric cable heat tracing was limited to spots of little hazard. However, the mineral insulated, metal sheath cable now has Underwriter's approval for use in hazardous areas.

The application of this mineral insulated cable to the process pipe is similar to ordinary steam tracing which is thermally connected by high conductive cement. However, in this installation, the high conductive cement is essential to keep the sheath temperature below its maximum limits, thus all the calculations are based on this application method.

The calculations to determine watts input and heat loss through the insulation is by the finite difference or nodal method. Because these equations are complex and trial and error method must be used for solution, the answers must be obtained by electronic computation. For this reason, the formulas are not presented here. Tables for determination of electric heated cable size and insulation thickness for various requirements are given in "Electric Heat Tracing Manual" and also in Section III of this manual.

D. Importance of Insulation in Function of Electric Heated Systems

The selection of the correct insulation and its correct installation is essential for the proper function of electrically traced heated pipe and equipment. Electric tracing has a limit on heat input, whereas the heat input by steam can change considerably due to the fact the rate of its condensation can change considerably. This being true, the heat loss through the insulation must be regulated more closely than is necessary for steam heated lines and equipment. This means that insulation efficiency must be maintained.

The most detrimental element to mass insulation efficiency is moisture. For this reason electric traced lines should always be insulated with insulation which resists water absorption. In addition, the following



THEORY - HEAT TRANSFER

VII. HEAT TRACING - Continued

D. Importance of Insulation in Function of Electric Heated Systems - Contd

is suggested: (1) Electric heated lines should be insulated from all beam crossings, (2) Where possible, the heated lines should be supported by cradles under the insulation rather than "T" supports, (3) Insulation should be full thickness and notching out the insulation to fit over tracer should not be allowed. (4) Pipe area under tracer should be cleaned to obtain excellent bond with heat transfer cement, (5) Sufficiently more tracer must be applied at flanges, elbows, and valves to compensate for additional metal area, (6) It is essential that all tracers -- without gaps -- be correctly bonded to pipe, fittings and equipment with heat transfer cement. Any unbonded length may excessively heat up then burn out. Properly installed electric tracing will operate with very little maintenance.

E. Basis of Selection Tracing Medium

Steam always being some temperature over 212F makes it unsuitable for tracing of chemicals which may degrade or otherwise change in nature at temperatures lower than 212F. In these instances electric tracing provides a means to heat the lines to some lower temperature without overheating.

Where close control of temperature, at any level, electric tracing can be controlled to much closer limits than steam tracing.

Where overheating or close control of temperature of the chemical is of no importance, then steam tracing is most generally less costly than electric tracing if suitable steam supply is available. However, if the traced lines are considerable distance for steam supply, it is most frequently less expensive to run electric supply cables to the installation rather than steam piping.

Electric tracing eliminates the problem of condensate discharge to the atmosphere, or the complex problem of collecting steam condensate.

The selection must be determined by installation requirements.



BASIC REQUIREMENTS FOR SELECTION OF INSULATING MATERIAL

Most thermal insulations possess relatively low heat transfer characteristics, thus will provide a good thermal barrier. For this reason, the choice of an insulation is seldom based only on the conductivity of the material. In most instances the material is selected which will most nearly satisfy the physical, chemical, and temperature requirements dictated by service, fabrication, and installation.

I. PROCESS INSULATION REQUIREMENTS

- A. Physical Requirements most often determine the insulation or type of insulations which should be used for a certain installation. It is fundamental that an insulation must remain intact in its location if it is to fulfill its function as an insulant. The physical properties it must have to accomplish this depend upon the requirements of the installation. In addition, it must also fulfill the requirements imposed upon it by fabrication and application.

When rigid insulation is prefabricated into solid shapes it must have properties which allow it to be easily cut or formed. Surfaces should be smooth and suitable for bonding with cements or adhesives. Completed covers must have sufficient strength, both the material itself and its joints, to withstand abuse of transportation and application.

In service, rigid insulation must withstand the normal mechanical demands. In many instances the insulation must support the weight of the pipe and its contents. It must support the weight of a man walking on it. It must withstand the vibration and abrasion to which it is subjected. In all instances, it must be capable of being installed in such a manner that it will not be fractured or otherwise damaged by forces of expansion and contraction.

The above requirements are common to most chemical plant uses of insulation. A great percentage of the insulation is installed on the outer surfaces of pipes and vessels where it is subjected to mechanical abuse. Also, much insulation is preformed into the proper shapes before it is delivered to the field insulators for erection. Therefore, it must be sufficiently strong to withstand handling and shipping. This is true of both high and low temperature insulation.

Installations requiring internal insulation impose very exacting physical conditions upon the insulation. As the imposed conditions for this type of installation follow no general pattern, each must be solved and designed individually.



BASIC REQUIREMENTS FOR SELECTION OF INSULATING MATERIAL

I. PROCESS INSULATION REQUIREMENTS

A. Continued

Contrary to the above, there are many installations which require the insulation to be flexible instead of rigid. Insulation on expansion joints must be able to move with the metal to which it is applied, so insulation blanket is used.

In some instances, flexible blanket must be used as a cushion between rigid insulation and expanding and contracting surfaces. This is common practice in both high and low temperature applications where a rigid shell of insulation is isolated from expansion and contraction of the vessel or pipe on which it is installed. In many instances the flexible blanket serves a dual function, not only to protect the outer insulation from excessive strain, but also protects the rigid insulation from thermal shock or vibration.

There are applications where insulation must be installed prior to the final shaping or assembling of the insulated object. Typical is application of insulation on tubing before the tubing is installed.

There are services which require the insulating material to have little or no mechanical strength. Such applications, as insulation powder poured in place between vessel and vessel jacket, or poured around a pipe in a trench which is to be backfilled are typical. However, in these applications it is essential that the insulation maintain its original volume without settling or decomposing.

Another consideration for a large number of installations is the physical ability of an insulation which allows it to be removed and then be replaced rapidly without breakage. In many instances the design must be such that operations personnel can remove and replace the insulation with the assistance of an insulator.

- B. Chemical Requirements may be either or both of two different needs. The first is that the insulation should be resistant to any chemicals to which it might be subjected by spillage, atmospheric contamination or, in the case of interior insulation, by direct contact.

The second is that the insulation should be of the correct chemical nature so as to not damage the vessels or pipe to which it is applied.



BASIC REQUIREMENTS FOR SELECTION OF INSULATING MATERIAL

I. PROCESS INSULATION REQUIREMENTS - Continued

B. Continued

When applied on steel the insulation should be neutral or slightly alkaline, and when applied on aluminum it should be neutral or slightly acid. Where used on austenitic stainless steel, the insulation should be free of water-soluble chlorides so as to not contribute to or cause possible stress-corrosion cracking.

Thermal insulation on pipe or vessels never replaces the need for their being protected from corrosion. If it is necessary to protect metal from corrosion, such protection is needed under the insulation. As most insulations are absorbent, they provide the means of holding moisture in contact with the surface to which they are applied. In many instances insulation can accelerate corrosion rather than retard it.

C. Moisture Conditions to which insulation is to be subjected determine the properties the insulation should have, how it should be installed, and how it should be protected.

When dry, most insulations are quite effective. When insulation becomes wet, or damp, all or part of the small air spaces become filled with water. Heat transmission through the water filled spaces then approaches the rate of conductivity of the liquid instead of air.

Insulation must be protected from two forms of moisture: (1) that in the liquid state, and (2) in the vapor state. Thermal insulation, of any temperature range, located outdoors where it is subjected to rain, sleet or snow must be protected from liquid moisture by a weather barrier. Indoor applications in most chemical process plants must also be protected by weather barriers as it is common practice to wash down vessels and pipes with water streams when spillage occurs. Most high temperature insulations are highly absorbent and if they once become wet considerable heat is necessary to dry them out. Where absorbent insulations are used on vessels and lines which operate below 250°F, it is virtually impossible to dry them out if they once become wet. For this reason moisture-resistant insulation is recommended to be used where service temperatures are below 250°F.

Wherever insulation is used on services at temperatures below ambient, not only must it be protected from liquid moisture, but also from moisture in the vapor state. Moisture in the vapor state is a gas, and



BASIC REQUIREMENTS FOR SELECTION OF INSULATING MATERIAL

I. PROCESS INSULATION REQUIREMENTS - Continued

C. Continued

in this state it will always seek to equalize any pressure difference by flowing from the high pressure area to the low pressure area. Whenever a barrier exists between a high and a low pressure area, the vapor will seek all means to reach the lower pressure by going through the insulation itself, through joints or cracks in the insulation, or around ends. When insulation is applied to equipment or piping which operates at temperatures less than ambient, this lower temperature on the inner surface of the insulation causes a lower vapor pressure area to exist at this point than exists in the ambient air. This vapor force is pressing inward on the entire outside area of the insulation, seeking any crack, hole, or weakness to penetrate. If the vapor does penetrate, as it encounters lower temperatures on its way toward the inner surface, the vapor will reach its dewpoint. At this point the vapor will condense to a liquid. This water will then replace some of the air in the air spaces. As the condensation continues, the air spaces in the insulation become filled with water or frost and the thermal conductivity is increased, with a resultant loss of insulating efficiency. Therefore, wherever insulation is used on low temperature application, provision must be made to prevent it being ruined by moisture vapor

One method of fulfilling this application requirement is to use vapor-resistant insulation. However, with vapor resistant insulation the weak point is in the joints. These joints have to be vapor sealed. This is also true of slip joints which are provided to take care of expansion and contraction.

Where it is necessary to use insulation which is limited in its vapor resistance, it is also necessary to provide a vapor barrier to protect the insulation. The barrier may be of mastic, tapes, jackets, or metal outer container, depending upon individual requirements.

Another method used for vapor control is to construct an inner and an outer vessel with insulated space between them. This space is kept dry by dry gas purge or by partial vacuum. This method can be the most efficient of all applications, but is also the most expensive and can only be warranted for the most critical of low temperature installations.



BASIC REQUIREMENTS FOR SELECTION OF INSULATING MATERIAL

I. PROCESS INSULATION REQUIREMENTS - Continued

- D. Electrical considerations are not often thought to be a function of thermal insulation. There are, however, some applications of electrically heated ovens and muffles where the insulation may also be required to be an electrical insulation.

Other than this, where dissimilar metals are separated by insulation, if the insulation becomes wet it can become an electrolyte, thus setting up galvanic currents. These galvanic currents soon damage the metal. In such applications, non-absorbent insulation must be used, or suitable corrosion precautions must be taken.

- E. Hazards which might be caused by, or corrected by, a combination of previously given requirements are listed separately. Fire protection of pipe and vessels requires not only that an insulation have sufficient strength to withstand ordinary abuse, but should also withstand explosion shock of considerable force. It is required to withstand the high temperature of the fire, then the thermal shock and high physical force of a powerful stream of cold water. It is required to have a minimum of shrinkage at high temperatures to prevent gaps which in turn would allow the fire to reach the exposed metal. This service requires the retardation of the flow of heat for as long a time as possible.

Another application where time is a factor is where insulation is required on a vessel or pipe to prevent the vapor, or liquid, being heated above a certain temperature by solar radiation. Such a problem is one of insulating with the correct insulation of sufficient thickness to produce the needed time lag.

Hot lines and vessels are insulated to protect personnel from burns by hot surfaces. Due to its conductivity, metal will cause burns at a temperature where a mastic or fibrous surface does not. Metal surfaces, for safety, should not exceed 135°F, whereas mastic and fibrous surfaces are safe up to 150°F.

Chemical leakage and atmospheric contamination may be absorbed by many insulations. Insulation saturated with chemicals can be a hazard in two ways. One, due to the large amount of liquid it can absorb, which can be over five times the original weight of the insulation, it can provide large quantities of fuel for a fire and be responsible for fire spread. Two, many chemicals react with insulation to cause fires, or their flash point and flame point temperature is so reduced that they are easily ignited.



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BASIC REQUIREMENTS FOR SELECTION OF INSULATING MATERIAL

I. PROCESS INSULATION REQUIREMENTS - Continued

E. Continued

In one year the Process Safety Department reported 35 fires in the South Charleston Plant caused by flammable chemicals in insulation. Results of testing self-ignition of chemicals in contact with insulation, although incomplete, are included as a guide for selection of materials. Chemicals in the following list have caused insulation fires; therefore, when these chemicals are present, selection of materials should be made with care.

Acetic Anhydride	Ethyl Butanol
Alcohol Ethanol	Ethyl Hexaldehyde
Anhydrous Amines	Ethyl Amines
Butanol	Hexanol
Butyraldehyde	Isopropanolamine
Carbowax	Merrill Oil
Carbowax Polyethylene Glycol 400	Methoxypolyglycol
Diethanolamine	Monocyclopentadiene
Dowtherm	Oil (Lube)
Ethylene Diamine	Plasticizer
Ethylene Oxide	Ucon Lubricant 75-H-90,000

Some insulations when heated to a certain point react within themselves. Temperatures produced by this self-internal heating can be above 2000°F. A critical mass sometimes causes this self-internal heating.

Saturable insulations may hold toxic chemicals, acids, or caustics. When once saturated, the insulation can hold these chemicals for years. When these chemicals are a personnel hazard, non-absorbent insulations should be used where possible. Should it be necessary to use absorbent insulation, special care must be used in the removal and handling of contaminated material.

Saturated insulations may also cause damage to equipment or piping by providing contact of corrosion causing chemicals with the metal. The breathing action, present through any insulation, can concentrate the corrosion producing chemical, or it can leach water-soluble chemicals from the insulation. This property is evident as one factor contributing to stress corrosion cracking of austenitic stainless steel.



BASIC REQUIREMENTS FOR SELECTION OF INSULATING MATERIAL

II. COMMERCIAL INSULATION REQUIREMENTS

- A. Physical Requirements as determined by its use in the building generally indicate the type of insulation to be used. The uses of insulation in a building are many. Depending upon its use, the insulation can range from fill type to structural type insulation materials.

The use of insulation in the walls, floor and roof of a building should be part of the architectural design. However, the engineer can assist the architect in the selection of the insulation which will best serve the thermal and structural needs of the building.

Depending upon the chosen construction, the insulation may be placed above, below, or it might be the roof deck. Mechanical abuse, method of application, and structural considerations determine the physical requirements of the insulation.

Wall and floor constructions are so varied that no general statement can be made as to the physical requirements of the insulation component. Like the insulation used in roofs, the insulation must withstand the mechanical abuse, installation requirements and structural demands which are imposed upon it. In addition, the insulation may serve a dual function as an acoustical material.

In addition to serving in the structural frame of the building, insulation is also used on piping, equipment, ductwork, and cold storage rooms. The physical requirements of the piping and equipment are similar to those mentioned in process insulation requirements. Ductwork may be insulated on its interior or exterior. When interior insulation is used, the insulation must be able to withstand the velocity of the air passing through the duct. Exterior duct insulation is exposed to mechanical abuse depending upon its use and location.

Cold storage and constant temperature and humidity rooms are generally structures consisting mainly of insulation. In many instances the insulation itself is the principal structural material. The physical requirements are severe, in that the doors are heavy, causing a securement problem. When such doors are slammed, heavy vibrations are transmitted to the walls and ceiling. Where materials are trucked into these rooms, severe bumping of walls can be expected.



BASIC REQUIREMENTS FOR SELECTION OF INSULATING MATERIAL

II. COMMERCIAL INSULATION REQUIREMENTS - Continued

- B. Moisture Requirements of building insulation depend upon the building's location, its construction and its use.

Each location has a climate made up of many things: air temperature, sun, fog, rain, snow, hail, wind, and humidity. All of these, plus the use given the building, influence the moisture in liquid and vapor form to which the building will be subjected. Excessive moisture causes a great deal of harm to a building. It can blister outside paints, can cause transient salt stains or efflorescence on brick masonry, can cause wood to rot, can cause steel and iron to rust and ruin insulation. Most building moisture problems arise from vapor within the building and insulations with proper vapor barriers are necessary to solve this problem.

In cold climates, the warm air inside a building holds more water vapor than the cold air outside. This causes a vapor pressure difference and, since water vapor is a gas, it seeks its way out. Water vapor readily penetrates materials such as stone, brick, concrete, wood, and plaster.

While air does not move in the same way as the water vapor, there is air within these building materials and in the hollow spaces of the structure. The vapor seeking its way out increases the moisture content of the air at each place until, due to the colder temperature, the air cannot absorb any more moisture. Theoretically, the vapor will begin to condense into water at that point. However, if the vapor can keep on moving it will disperse itself in still colder air, but should there be any surface to resist this flow, and that surface is lower than dew point temperature, the vapor will condense to a liquid on this surface. This is the reason that vapor barriers must be located in the walls and roofs in a location where they remain at a temperature above dew point.

In the case of buildings located in cold climates where vapor pressure, for the greater part of the year, is outward, then the vapor barrier must be on the inner side of the wall or roof. Buildings located in warm climates which are air conditioned, thus causing the vapor pressure to be inward, require the vapor barrier on the outer side of the wall or roof. This last is also true of cold storage rooms.



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BASIC REQUIREMENTS FOR SELECTION OF INSULATING MATERIAL

II. COMMERCIAL INSULATION REQUIREMENTS - Continued

B. Continued

Again, these same principles are true when insulation is applied to ductwork. If the duct is cold, a vapor seal is required on the outer surface. If the ductwork is hot, a vapor barrier should not be installed on the outer surface.

As previously stated, insulation to be efficient must be dry, and there are installations in buildings where insulation may be subjected to liquid water. Such applications are exterior installations on walls and below grade, and beneath concrete slab floors. These require water-resistant cellular insulations.

- C. Hazards - Besides the ordinary insulating function, insulating materials are used as fireproofing of building members. The time that the protected member must withstand a fire is the criterion. This time depends on importance of the member in the building, the use of the building, and governmental and insurance codes.

Unfortunately, some insulations can increase fire hazards. Many will burn. Where such insulations are used within a building they should be used with care and should be fire protected. Other insulations, when melted or burned, release toxic gases. Little has been published on this aspect, but until definite information is available, caution must be used in the selection of insulation for buildings.

Another consideration is smoke. Some materials release large quantities of smoke when heated or burned. The smoke can cause considerable damage to the interior of a building even though fire damage is slight. Even more important, in buildings of high occupancy, smoke can cause disastrous panic.



BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

I. INDUSTRIAL INSULATION THICKNESS REQUIREMENTS

For any particular temperature, there is no single correct thickness of insulation. The proper thickness depends on many factors. Some of these factors are location indoors or outdoors, ambient temperature, solar exposure, cost of heat, cost of insulation, process requirements, hours of operation, rate of amortization, safety, dew point, freezing point of materials, flash point of material, condensation point of material. Any one single factor may be paramount for a given problem. However, in most instances a combination of many of the factors decides the proper insulation thickness.

A. Elevated Temperature - External Insulation

1. Economic Consideration is based on savings of energy, as heat energy has a monetary value. However, there is no direct conversion from BTU's into dollars, as the cost of heat depends upon many factors, such as its form, location, and use. Insulation also has monetary value and, like heat, its cost varies. However, at some thickness of insulation the total cost of heat loss per year, plus the cost of insulation per year, adds up to the lowest possible cost per year. The thickness which provides this lowest possible cost per year is the economic thickness of insulation.

Many factors enter into the cost of heat on an annual basis. These are:

- (a) Cost of fuel.
- (b) Capital investment in heat producing equipment and heat distribution system to point of use.
- (c) Cost of money for capital investment.
- (d) Interest on investment.
- (e) Depreciation.
- (f) Maintenance.
- (g) Number of hours of operation per year.



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BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

I. INDUSTRIAL INSULATION THICKNESS REQUIREMENTS - Continued

A. Elevated Temperature - External Insulation - Continued

1. Economic Consideration - Continued

Most of the cost factors of heat also apply to insulation. These are:

- (a) Capital investment of installed insulation.
- (b) Cost of money for capital investment.
- (c) Interest on investment.
- (d) Depreciation.
- (e) Maintenance.

In addition to the cost factors, the following physical and thermal factors enter into the determination of economic thickness:

- (a) Temperature difference.
- (b) Shape.
- (c) Conductivity of the insulation.

The basic McMillan formula for determining economic thickness is presented in the section on theory. For special conditions, it may be necessary to calculate economic thickness using this formula, but for most conditions in process design the economic thickness can be determined from tables in manual on "Economic Thickness of Insulation for Flat Surfaces and Pipes".

To illustrate the influence of economical insulation on the capital investment and operating cost of a typical actual installation of insulation, consider an 8-inch steam line operation at 425°F. The insulation is calcium silicate. Its conductivity at this mean temperature is 0.45 Btu/hr/sq ft/in/°F. The average ambient temperature was 50°F. The cost factors were:



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BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

I. INDUSTRIAL INSULATION THICKNESS REQUIREMENTS - Continued

A. Elevated Temperature - External Insulation - Continued

1. Economic Consideration - Continued

Capital Investment in Steam Production - \$12.00/lb steam/hr

Capital Investment in Insulation - Installed Prices -

1-1/2" thickness	\$3.30/linear foot
2" thickness	\$4.10/linear foot
2-1/2" thickness	\$4.84/linear foot
3" thickness	\$5.90/linear foot

Depreciation Period - 15 years

Production Cost of Steam - \$0.877/1000 lb

With no insulation at all, the heat loss would have been 2,841 Btu per hour, per linear foot of pipe. (The heat contained in 2.36 pounds of steam per hour, per linear foot of pipe.) To produce this lost heat, a capital investment for steam production of \$28.32 per linear foot of pipe was required. The yearly cost of this lost heat would have been \$18.13 per linear foot of pipe. It is apparent that insulation was necessary. The question is, what thickness would provide the best return on investment.

The following table presents comparative costs:

Insulation Thickness	Capital Investment to Provide Steam for Heat Loss	Capital Investment in Insulation	Total Capital Investment	Yearly Cost of Heat	Additional Cost for Each Added 1/2-in of Insulation	Fuel Savings For Each Added 1/2-in of Insulation
In.	\$	\$/L. F.	\$	\$	\$	\$
Bare	28.32	None	28.32	18.13	-	-
1-1/2	2.57	3.30	5.87	1.64	1.10	6.04
2	2.10	4.10	6.20	1.34	0.33	0.30
2-1/2	1.74	4.84	6.58	1.14	0.38	0.20
3	1.52	5.90	7.42	0.98	0.84	0.16



BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

I. INDUSTRIAL INSULATION THICKNESS REQUIREMENTS - Continued

A. Elevated Temperature - External Insulation - Continued

1. Economic Consideration - Continued

These figures give direct cost, not including maintenance, cost of money, interest on investment, all of which must be considered. By including these and using the "Economic Thickness Manual", it can be rapidly shown that 2-1/2 inch is the proper insulation thickness.

In the absence of compelling reasons otherwise, the economic thickness should determine insulation thickness. It should be remembered that even within a single chemical unit the economic thickness may differ from one pipe to another, even if all operate at the same temperature. The difference is caused by difference in cost of the heat to be conserved. For example: Heat caused by chemical reaction may have little value and might even be required to be dissipated. The cost of high pressure steam might be different from that of low pressure steam. Heat from a Dowtherm boiler is more expensive than steam. Electric heat or electrically heated Dowtherm is very costly energy. Good economy demands that each be insulated with the correct thickness.

2. Process Control is sometimes the paramount consideration to determine insulation thickness. The particular function which the insulation is to fulfill may be one of the following:

- (a) It may have to prevent a critical Btu loss above which the vessel or system is unable to operate satisfactorily.
- (b) It may have to maintain a critical temperature below which the vessel or system will not operate.
- (c) It may have to maintain a critical temperature below which materials would solidify.
- (d) It may have to maintain vessels, pipes or ducts above a given temperature to prevent condensation of contained gases.
- (e) It may have to maintain vessels or pipes within limits to prevent thermal stresses or thermal shock.



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BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

I. INDUSTRIAL INSULATION THICKNESS REQUIREMENTS - Continued

A. Elevated Temperature - External Insulation - Continued

2. Process Control - Continued

- (f) It may have to contain heat within vessels or pipes which must be heated up within given time limits.
- (g) It may have to control heat loss and act as heat container in vessels and pipe where external heat (tracers) must be added.
- (h) Where surface temperatures are critical for the function of the weather barrier.

3. Safety Requirements frequently determine the thickness of insulation. The outer surface temperature of the insulation should be sufficiently low that it will protect personnel from burns if they accidentally come into contact with its surface. This safe surface temperature is dependent upon the nature of the external surface. If the surface is mastic of fibrous nature, the safe temperature is 150°F. If the surface is metal, the temperature should not exceed 135°F. This is due to the high conductivity of metal which, when touched, will transfer large quantities of heat to the skin in a short time.

A number of tables have been published giving surface temperatures of insulation in relation to temperature difference, ambient temperature and insulation thickness. All such tables are based on high emissive jacket surfaces. A low emissive jacket surface, such as aluminum, will raise the surface temperature as much as 100°F. For this reason, low emissive metal jacket surfaces may require two to three times the thickness of insulation as mastic jacket surfaced insulations to be within the safe surface temperature range. In many instances the thickness is in excess of that which can be economically justified.

Insulations may provide fire protection. Where they are designed to retard fire, they may act as "fireproofing" of vessels and pipe. Accurate calculation of temperature time lag is difficult. Approximate protection obtained by some insulations are as follows: One-inch cellular glass with fire resistant weather barrier will retard the temperature rise of steel in a gasoline fire to approximately 1,000°F for one hour. One-inch high-temperature insulation such



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I. INDUSTRIAL INSULATION THICKNESS REQUIREMENTS - Continued

A. Elevated Temperature - External Insulation - Continued

3. Safety Requirements - Continued

as calcium silicate, under the same conditions, the temperature rise of steel to 1000F will be approximately two hours. Vessels completely protected by insulation of sufficient thickness in moderately hazardous location may not require water spray protection.

Insulation is required in hazardous locations for the protection of skirts, vessels, instrument conduits, tank legs, pipe, and structural steel from fire. The length of time protection from fire exposure is required and the possible fire temperature determines the type and thickness of the insulation.

Another application of insulation, which is primarily for protection, is its use on a vessel to prevent the vapor, or liquid, from being heated beyond its safe temperature limits by solar radiation. This again is a problem of time log and the thickness of the insulation must be calculated as a special problem.

B. Elevated Temperature - Internal Insulation

1. Economic Consideration for insulation used internally in vessels, pipe, flues, and ducts is the same as for that of insulation used externally. Of course, proper cost factors must be used in the calculations.
2. Process Control most frequently determines the thickness of internal insulation. Some of the determining factors are similar to those listed for external insulation, and are:
 - (a) A critical heat loss which should not be exceeded.
 - (b) A critical temperature which must be obtained.
 - (c) A temperature which must be maintained above a condensation level.



BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

I. INDUSTRIAL INSULATION THICKNESS REQUIREMENTS - Continued

B. Elevated Temperature - Internal Insulation - Continued

2. Process Control - Continued

(d) A temperature drop which must be obtained through the insulation so that temperature is sufficiently low as to not damage outer shell or lining.

(1) Prevention of excessive thermal expansion on inside of shell.

(2) Prevention of temperature in excess of limits of lining -- such as lead lined vessels.

(3) Prevention of thermal shock.

Another function of internal insulation is to reduce the amount of heat absorbed by the heavy metal shell in heating and returned to interior of vessel when cooling. In cyclic operation the lower the mass which must be heated and cooled, the shorter the time required for the operation. The amount of heat available and allowable time of cycle will determine thickness of insulation required. Except in the case of extremely short time cycles where carry-over might be helpful, a low mass and high rate of diffusivity are desirable characteristics of the insulation.

C. Elevated Temperature Insulation - Underground

1. Economics of underground lines are influenced by several factors not present in the consideration on lines above grade. One is the extremely high cost of repair or replacement. In most instances if extensive insulation repair is needed, it is cheaper to install a new insulated line than it is to dig up the old one and repair it.

Another factor is that on conduit protected underground lines the conduit must be considered as part of the insulation cost. Likewise, with fill type insulation, extra width of trench, forming, pouring, tamping, insulation top protection, and curing must all be considered as insulation costs. However, as many of the costs are relatively fixed in underground installations, clear-cut economic thicknesses as determined by the "Economic Thickness Manual" are not always possible for this type of installation.



BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

I. INDUSTRIAL INSULATION THICKNESS REQUIREMENTS - Continued

C. Elevated Temperature Insulation - Underground - Continued

2. Process Requirements influence the thickness of underground insulation. Most common is that on long underground lines must be sufficiently thick to ensure that sufficient steam is available at the outlet to supply the demand. Heat losses of underground pipes can be excessive and many a long, small, underground steam line has ended up having only the ability to supply condensate at its outlet.

The proximity of other lines also influences the thickness of insulation on lines. Due to the fact that soil, especially when dry, becomes a fair insulant, the temperature gradient spreads over a large area. For this reason process lines, or water lines which should not be heated, should be spaced a minimum of 6 ft 0 in from any insulated steam lines. If this is not possible, then the insulation of the hot line must be increased. In addition to lines running parallel, care must be taken with lines which cross under or over heated insulated lines. At cross-over spots the insulation may be required to be considerably thicker for a distance on either side to prevent a hot spot in the lower temperature pipes.

Location in the ground and type of soil affects the heat loss of underground lines, and insulation thickness should be designed accordingly. If the line is located where soil is water saturated, heat will be wasted both by heating and the vaporization of the water which comes in contact with the outer surface of the insulation, or its protective conduit.

The deeper an insulated hot line is buried in dry soil, the more effective it is. However, the deeper it is buried in wet soil, the greater the heat loss. These conditions should be considered in the determination of insulation thickness.

Underground heated lines always tend to dry out the soil above, and for this reason it is difficult to grow grass above these lines unless they are buried deeply and well insulated. This might be a factor if a line runs under a lawn where good appearance is desired.



THEORY - SOLAR RADIATION

IV. RADIATION PROBLEMS

A. Solar Radiation to Insulated Vessels

1. In many instances, vessels are insulated to retard solar heat flow inward. The basic formula to determine net heat flow to outer projected surface area with no insulation is:

$$q = A_1 \left(0.174 \times 10^{-8} \right) \epsilon \left(T_2^5 - T_a^4 \right) = A_1 \alpha H_s$$

When A_1 = Projected area of body

ϵ = Emittance of surface

T_2 = Absolute temperature of body surface ($t_2 + 460$)

T_a = Absolute temperature of space for prevailing conditions ($t_a + 460$)

α = Absorptivity of body surface

H_s = Net radiation, Btu/hr, sq ft at given latitude

2. Of the Btu's radiated to surface from solar radiation, some of the heat continues to flow inward to heat the body and some are transferred from the surface to the ambient air by convection. The amount of heat which is transferred to the air and to the body is dependent upon the temperature differences existing divided by the thermal resistance. As the entire amount of solar heat to the surface must equal the total of the two heat transfers from the surface, the surface temperature t_2 will adjust itself

or q = Solar heat Btu/sq ft/hr of surface normal to the sun

q_{sc} = Solar heat convected to the air, Btu/sq ft/hr

q_{sb} = Solar heat conducted through the insulation to the body, Btu/sq ft/hr

$q = q_{sc} + q_{sb}$

The following graph gives values of q_s in Btu/sq ft/hr



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BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

I. INDUSTRIAL INSULATION THICKNESS REQUIREMENTS - Continued

D. Low Temperature - External Insulation

1. Economic Consideration of low temperature insulation, like high, is based on the savings of energy. All the factors which apply to calculation of economic thickness of insulation for high temperature insulation also apply to low. The difference is in the values. For example, the cost of removing a Btu by refrigeration generally costs eight to ten times more than supplying a Btu for heating.

Using the proper values, the McMillan formula will determine the economic thickness for low temperature insulation. These thicknesses are tabulated in the Manual for "Economic Thickness for Low Temperature Insulation for Flat Surfaces and Pipes". However, the thickness required to prevent condensation on the external surface of the insulation is often the determining factor. These thicknesses are also listed in the "Manual".

2. Process Control is often the controlling factor in low temperature insulation thickness design. Many of the factors are similar to those of high temperature except that the insulation is to prevent heat gain instead of heat loss. Some process requirements might be:
 - (a) A heat gain above which the vessel or system cannot operate satisfactorily.
 - (b) A temperature above which the vessel or piping will not operate.
 - (c) The amount of refrigeration available to the system.
 - (d) The amount of solar heat allowable.
 - (e) The allowable time for cooling to a given temperature.
 - (f) The surface temperature should be above frost point.
 - (g) The surface temperature should be above condensation point.

Wherever other factors determine a thickness which will be less than that necessary to keep the surface above condensation temperature,



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I. INDUSTRIAL INSULATION THICKNESS REQUIREMENTS - Continued

D. Low Temperature - External Insulation - Continued

2. Process Control - Continued

the thickness to ensure a temperature above this point is generally used. This is due three important facts: (1) insulation surfaces operating at less than condensation temperature provide a continual water drip which rusts steel and causes slime, (2) vapor migration from a wetted surface is four to six times greater than from an unwetted surface. This reduces the life of the insulation to one-fourth that which could otherwise be obtained, (3) the weather vapor barrier life is similarly reduced.

3. Safety Requirements are sometimes the determining factor of low temperature insulation thickness. Wherever an insulation is to protect the piping or vessel from fire for a stipulated length of time, the insulation must be of sufficient thickness to retard heat for that period. In some very hazardous installations it is required that the low temperature insulation be of thickness decided by low temperature factors and then a high temperature insulation be used on the outside to protect the inner insulation from fire.

E. Low Temperatures - Cryogenic

This type of insulation, although externally separated from the space it insulates, is different in that it is contained by an outer shell and that the space between the inner and outer shell is evacuated. This system is more costly than non-vacuum insulation, so that basis of calculation is resistance to heat flow. These "super-insulations" are justified only when:

- (a) Heat leak is very costly, such as losses of liquefied gases due to vaporization.
- (b) Space is at a premium and highly efficient insulation is required, as in shipping containers for liquefied gases.
- (c) Insulation must be covered by impervious casing to avoid the migration of air or water.



BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

II. COMMERCIAL INSULATION

Commercial insulation falls into several different categories. These are: (1) piping and vessel insulation; (2) duct insulation; (3) cold storage insulation; and (4) the actual building insulation. Each of these have particular factors influencing thickness.

A. Piping and Vessel Insulation

1. Economic Considerations for both high and low temperature insulation have the same factors for their determination as previously mentioned, with one exception. This exception is that when hot lines are in air-conditioned space, not only is the loss of heat involved, but also the lost heat must be removed by refrigeration. In this case the removal of the heat costs approximately eight times more than the value of the heat itself. This warrants considerable insulation to keep heat from escaping from vessels and pipes into cooled areas.
2. Functional Considerations for both high and low temperature insulations must also enter into thickness design, such as whether a building is for process, storage, laboratory or office. Hot piping which makes an area completely unusable voids the function for which the building was erected. Where excessive heat loads are present, the insulation must be increased accordingly. Low temperature lines also can ruin the function of a building. Typical is the case of cold water lines which are not insulated to keep the water cold, but to prevent condensate drip.

B. Ductwork Insulation

1. Economic Consideration is based not on the insulation alone, but on use of insulation to obtain an economic heating and cooling system which provides the required air-conditioning in all the areas where it is needed. These requirements determine thickness.
2. Functional Considerations may be of acoustical control as well as heat control. Many ducts are lined with insulation to control sound as well as heat. In many instances the thickness of insulation required to control sound is greater than that required to control heat. In such cases sound control becomes the deciding factor. Fire control may also dictate minimum thicknesses of insulation used in or on ducts, especially if the ducts are of aluminum or plastic.



BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

II. COMMERCIAL INSULATION - Continued

C. Cold Storage Rooms

1. Economic Consideration is based on savings of refrigeration. The economic thickness can be calculated from the McMillan formula. However, cold storage rooms are a structure composed mostly of insulation. Therefore, methods of construction and materials used can change the cost with no direct relationship to thickness. For this reason it is necessary to compare the cost of various methods of construction with resistance to heat flow.
2. Functional Consideration may be used on amount of refrigeration available, or time allowed to reduce temperature of contents in room. Also, the thickness might be determined by condensation temperature of outer surface.

D. Building Insulation

1. Economic Considerations in buildings must include the determination of heating and cooling costs related to the thermal performance of its roofs, walls, and floors. Analysis and evaluation of thermal performance of building constructions and their mechanical systems prove the need for thermal insulation to provide a return on investment by reducing operating costs and capital cost of air-conditioning equipment. Insulation is part of the design in building. Thus, to obtain maximum economic benefits it is essential that the engineers and architects work together.

In buildings the insulation is not just added to a wall, floor, or ceiling, but is one of the building components. For this reason, it is impossible to use McMillan's formula for economic thickness. In the design of buildings it is necessary to compare design and methods of construction. A method for such comparison has been developed by Owens-Corning Fiberglas and is named "Dividend Engineering for Buildings".

2. Functions of the building may in some cases require more insulation than shown necessary by economics. The building must be thermally tight enough to maintain the desired environment. In addition, its walls and roofs must be so designed that its vapor barrier is located



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II. COMMERCIAL INSULATION - Continued

D. Building Insulation

2. Functions - Continued

to be above condensation temperature. Floors on soil should also have their exposed surfaces at a temperature above dew point.

Even additional functions such as fire protection, sound absorption, or sound transmission using the insulation in dual function may be the factor which controls the thickness.



PROPERTIES OF INSULATION MATERIALS

I. BASIC TYPES OF THERMAL INSULATIONS

Basically, there are four types of thermal insulation materials: fibrous, granular, cellular, and reflective. These differ widely in properties.

Some of the more common fibrous materials are rock wool, slag wool, glass wool, asbestos, hair felt, and quartz fibers.

Granular materials consist of small nodules which contain voids or hollow spaces. They are not considered as true cells since gas can be transferred between the individual spaces. Materials such as magnesia, calcium silicate, diatomaceous earth, expanded silica, and vegetable cork are in this classification.

Cellular materials consist of small individual cells sealed from each other. Cellular materials are produced of glass, rubber, and plastics. Their major difference from granular materials is that each cell is hermetically sealed from all others.

Reflective insulation is composed of parallel thin sheets, or foil, of high thermal reflectance, spaced to direct radiant heat back toward its source. The spacing also is designed to provide restricted air (or gas) spaces. It reduces heat transfer by convection and conduction. In most instances, the thin sheets or foil are made of aluminum or stainless steel. Reflective insulation may be installed by the construction of air spaces separated by the reflective metal, as is practiced in building insulation or cold storage installations; or it may be obtained as preformed pipe and vessel insulation for industrial purposes.

Of course, there are many instances of intermixing of the various types. For example, fibers are added to some granular materials to add to the tensile strength of the insulation. Also, reflective sheets are used with light-density fiber materials to obtain increased efficiencies. Some cryogenic insulations are produced with reflective sheets separated by light-weight fibers in high vacuum space. Thus, a single finished produce may use more than one basic type of insulation material.

II. FORMS OF INSULATION MATERIALS

Depending upon the material and its intended use, insulation is produced in many forms. Some of these are as follows:



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PROPERTIES OF INSULATION MATERIALS

II. FORMS OF INSULATION MATERIALS - Continued

- A. Rigid board, block, and preformed pipe covering
- B. Semi-rigid board, block, and preformed pipe covering
- C. Flexible board and preformed pipe covering
- D. Blanket
- E. Felts
- F. Tape
- G. Rope
- H. Cement
- I. Loose
- J. Fill
- K. Reflective
 - 1. Preformed
 - 2. Sheets
 - 3. Foil
- L. Combination blanket and reflective
- M. Preformed cryogenic - vacuum space
- N. Insulation mastics

III. PROPERTIES OF INSULATION MATERIALS

The type of material and the form in which it is produced influences the properties of the finished product. Some of the properties are of a nature which can be tested and numerically evaluated. Others, although of no less importance, cannot be so evaluated. Some of the latter are:

- A. Availability
- B. Price
- C. Shape and sizes available
- D. Straightness of sides and ends
- E. Smoothness of surfaces
- F. Cutting characteristics
- G. Dusting characteristics
- H. Dust hazard - health
- I. Compatibility with adhesive or cement
- J. Speed and cost of fabrication
- K. Speed and cost of installation
- L. Shelf life



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PROPERTIES OF INSULATION MATERIALS

III. PROPERTIES OF INSULATION MATERIALS - Continued

- M. Cost of shipping, handling, and storage
- N. Dimensional stability
- O. Packaging

The physical, chemical, moisture, and thermal properties of insulation are:

- A. Abrasion resistance
- B. Alkalinity, pH
- C. Capillarity
- D. Combustibility -
 - 1. Flash point
 - 2. Fire point
 - 3. Self-ignition point
 - 4. Melting point
- E. Coefficient of expansion
- F. Corrosion - rusting of carbon steel
- G. Corrosion - stress corrosion of stainless steel
- H. Cracking - hot surface
- I. Density
- J. Drop resistance
- K. Hardness
- L. Hygroscopicity
- M. Resistance to acids
- N. Resistance to caustics
- O. Resistance to solvents
- P. Shrinkage, heat
 - 1. Linear
 - 2. Volumetric
- Q. Specific gravity
 - 1. Real
 - 2. Apparent



PROPERTIES OF INSULATION MATERIALS

III. PROPERTIES OF INSULATION MATERIALS - Continued

R. Strength

1. Breaking
2. Compressive
3. Flexural
4. Shear
5. Tensile

S. Temperature limits, minimum and maximum

1. Continuous
2. Short periods
3. Cyclic

T. Temperature rise - self-internal heating

U. Thermal diffusivity

V. Thermal shock resistance

W. Vibration resistance

X. Warpage - in service

Y. Water absorption

Z. Water vapor transmission

Materials which are installed in a wet state, such as cements or mastics, have all the above listed properties as dry materials, but in addition have the following:

A. Adhesion

1. Wet
2. Dry

B. Shrinkage - wet to dry

1. Linear
2. Volumetric

These properties, their significance, and available or suggested method of test, are presented in the Design and Construction Manual "Properties of Thermal Insulation Materials and Their Significance". A tabulation of the general properties and characteristics of insulation are presented in the manual "Thermal Insulations and Accessories".

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PROPERTIES OF INSULATION MATERIALS

III. PROPERTIES OF INSULATION MATERIALS - Continued

FIRE TESTS OF INSULATION MATERIALS

The fire resistance properties of insulation systems have been studied by the Fire Research Group of Research and Development. The results of these studies were published in the manual "Fire Tests on Thermal Insulation and Weather Barriers". However, these tests were run in 1957 so that materials developed since that time are not included in the report. Also, this report was not condensed to provide information on generic materials. For this reason, this condensation of results is included.

Temperature of Pipe After 60 Minutes - °F
Insulation on 3" Pipe

<u>Insulation Material</u>	<u>1" Thick</u>	<u>2-1/2" Thick</u>	<u>Remarks</u>
Aluminum Reflective - Aluminum Jacket		(1000F-12 min)	Melted after 11-1/2 min
Aluminum Reflective - S. S. Jacket		910	
Asbestos Fibers	710	200	
Asbestos Fibers and Perlite	515	200	
Calcium Silicate	710	218	
Calcium Silicate - High Temp	700	180	
Cellular Glass	1250	770	
Cellular Silica	760	400	
Diatomaceous Earth - Standard	615	190	
Diatomaceous Earth - High Temp	710	210	
Urethane Foam With 15 Mils of intumescent paint		(1000F-31 min)	
With stainless steel outer jacket		(1000F-10.5 min)	



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III. PROPERTIES OF INSULATION MATERIALS - Continued

FIRE TESTS OF INSULATION MATERIALS - Continued

Temperature of Pipe After 60 Minutes - °F

Insulation on 3" Pipe

Continued

<u>Insulation Material</u>	<u>1" Thick</u>	<u>2-1/2" Thick</u>	<u>Remarks</u>
Glass Fiber		(1000F - 32 min)	Melted and dripped in 4-1/2 min
Magnesia, 85%	750	180	
Polystyrene, expanded		(1000F - 13 min)	Melted, burned and dripped - first min
Silica, expanded and binders	710	210	
Vegetable Cork		680	Supported combustion & continued burning after test

The Fire Research Group set up the criterion that if insulation could provide a one-hour time duration before the pipe or equipment would reach 1000F, this time delay would be of considerable assistance in fire protection. This does not apply to "fireproofing" where insurance regulations or codes require two to four hours protection.

Of the materials listed above, the following did not prove satisfactory:

Aluminum reflective with aluminum jacket melted after 11-1/2 minutes in the fire area, leaving the pipe exposed to direct flame impingement. Glass fibers melted in 4-1/2 minutes, leaving the pipe exposed to direct fire. 85% magnesia, although it protected the pipe for the required time, was reduced to almost a powder and washed away when hit by the water stream from a fire hose. Expanded polystyrene melted, burned, and provided burning drip, and was completely gone within the fire area in one minute. It also continued to burn outside the fire area. Vegetable cork supported combustion and continued to punk for hours after the fire test. Water from the fire hose could not stop this punking.



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PROPERTIES OF INSULATION MATERIALS

III. PROPERTIES OF INSULATION MATERIALS - Continued

FIRE TESTS OF INSULATION MATERIALS - Continued

Of the materials which did pass the fire test, the following was observed:

The reflective insulation depended completely upon the outer stainless steel jacket for protection of the inner aluminum reflective sheets. After one hour of exposure, several of the outermost aluminum reflective sheets had melted. Cellular glass failed by thermal shock and was broken into pieces and would have fallen from the pipe if it has not been contained by fire resistant type weather barrier.

Asbestos fibers, asbestos fibers and perlite, calcium silicate, diatomaceous earth, expanded silica and binders all had shrinkage from 1/8" to 1-1/2" for each 3'-0" section. For this reason, when used as "fireproofing", double layer, staggered joint construction, or stainless steel jacket is required to prevent hot spots.

The fire hazard which might be caused by chemical contamination of chemicals has been investigated at times when fires were known to have started from this cause. Because of the complex nature of the problem, no complete investigation was ever attempted, nor any comprehensive report written. For this reason, available information is presented in this design manual. The flash points of insulations, by themselves and in contact with contaminated chemicals, are presented in the following tables. Table A provides information obtained by ASTM Open Cup Flash Point and Electric Furnace Rising Temperature Test Method. Table B provides information obtained by the Fire Research Group's Ignition Test and Spontaneous Heat Test.

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MAY, 1968**PROPERTIES OF INSULATION MATERIALS****III. PROPERTIES OF INSULATION MATERIALS - Contd****TABLE A - FLASH POINT TEST**

MATERIAL	OPEN CUP METHOD				RISING TEMPERATURE METHOD			
	Temperature ° F				Temperature ° F			
	Insula. Only	With Carbowax	With DEA	With Dowtherm	Insula. Only	With Carbowax	With DEA	With Dowtherm
Chemical only	(a)	470	270	240		470	270	320
Asbestocel	(a)	455	410		(b)	(c)	(c)	
Bunroc	(a)	430	460		(b)	437	718	
Glass Wool - White	(a)	300	425		(b)	450	430	
Hairfelt	480	415	280		555	602	523	
Calcium Silicate	(a)	420	383	210	(b)	455	415	389
85% Magnesite	(a)	375	310	175	(b)	410	455	277
Rock Cork	(a)	500	288		(b)	400	720	
Diatomaceous Earth	(a)	325	380	238	(b)	510	(d)	235
Asbestos Fiber	(a)	390	385	190	(b)	472	480	359
Vegetable Cork		220	360		650	640	665	
Mineral Wool Cem.	(a)	400	360		(b)	500	710	
Mineral Wool Blk.	(a)	305	280		(b)	431	320	
Mineral Wool Cem. Hydraulic Setting					(b)	565	525	

Symbols: (a) No flash or burning up to limit of open cup test
 (b) No flash or burning up to limit of rising temperature heat
 (c) Liquid completely vaporized without flashing
 (d) Dense smoke - Pilot light would not burn

TABLE B**FIRE RESEARCH GROUP****IGNITION TEST AND SPONTANEOUS HEAT TEST**

Insulation	Ignition Temperature ° F	Spontaneously Heats When in Contact With			
	Ethylene Oxide/Air Contact	Ucon Lubricant 75-H - 90,000	Carbowax PCG 400	Tergitol Nonionic NPX	Dowtherm
Coreytemp	752	Yes	Yes	No	
Fiberglas - Phenolic	779	No Data			
Fiberglas - White	779	No Data			
Foamglas	833	No Data			
Foamglas	890	No	No	No	No
Glass - Pyrex (Standard Auto-ignition temperature)	824	No Data			
Kaylo, Standard	617	Yes	Yes	No	Yes
Kaylo, No. 20		Yes	Yes	No	Yes
Magnesite, 85%	482	Yes	Yes	No	Yes
Magnesite, 85% (damp)	438				
Stainless - Reflective		No	No	No	
Superex	545	No Data			
Superex, (damp)	444	No Data			
Unibestos	572	No Data			



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WATER, WEATHER, VAPOR BARRIERS, FINISHES AND OVERCOATINGS

I. GENERAL

Thermal insulation, with the exception of reflective types, depends upon finely divided spaces containing air or gas to retard the flow of heat. When insulation becomes wet, or partly so, all or part of the small spaces become filled with water. The conductivity (in Btu/sq ft, $^{\circ}$ F, inch thickness) of water at 70F is 4.1 as compared with 0.17 for air. Therefore, from a completely dry to a completely wet state, the transmission of heat through insulation will increase 16 to 20 times. The function of water, weather, and vapor barriers is to keep insulation dry.

Insulation must be protected from liquid water if it is installed below ground. It must be protected from rain, sleet, snow, and liquid spillage when installed above ground. It must protect for moisture vapor if the temperature of the surface to which it is applied is below ambient. The protection against these conditions can be classified as water barrier, weather barrier, and vapor barrier. Depending upon conditions, the protection of the insulation may require any one, combination of two, or all three to maintain its initial efficiency.

II. WATER BARRIERS

Water barriers are required to protect insulation where it is submerged in water, or is located underground where ground moisture and water level present severe water resisting problems.

When submerged in any liquid, the only positive way to keep insulation dry is to encase it in a liquid-tight metal pipe, conduit, or container. In most instances, this requires special design to determine suitable metal closures, sealing, expansion and contraction, and corrosion resistance.

Underground lines must also be provided with water barriers. Soil is generally moist and sometimes becomes saturated due to rain and snow. Underground high temperature lines are generally insulated and water protected in one of three ways. One is by use of a granular bituminous fill insulation. Another is by use of conduit-encased insulation, and still another by use of reinforced mastic-sealed insulation.

A. Granular Bituminous Fill Insulation and Water Barrier

Granular bituminous fill materials are a combination water barrier and insulation. The material is installed by pouring and tamping around on



WATER, WEATHER, VAPOR BARRIERS, FINISHES AND OVERCOATINGS

II. WATER BARRIERS - Continued

A. Granular Bituminous Fill Insulation and Water Barrier - Continued

underground pipe. It is cured by heat from the pipe at recommended temperatures and time durations before the line is placed in service. The curing process forms a consolidated core around the pipe, a sintered core around this first core, then unchanged material, all enclosed by the fill. Material is furnished in various grades for different service temperatures.

The unchanged portion of the fill material, which provides most of the insulating value, is outside the consolidated core which protects the pipe from water. For this reason its efficiency as an insulation is limited to locations where it is located above the ground water table and where it will not be subjected to drainage water. Also, as the consolidated core and sintered core are formed by heat, when heat is removed from the line, the contraction causes cracks in the protective core sections. For this reason they do not protect the line from corrosion when it is unheated, nor do they protect a line which cycles in temperature.

During periods of little rainfall, soil and sand can dry out and become relatively good insulation. This will cause a temperature rise of the fill insulation and the soil around it. To illustrate: if a pipe is operating at above 500F, the soil near the fill insulation may be well above 200°F. For this reason gas lines, water pipes, or any lines which should not be heated must be placed a minimum of 6'-0" from the hot insulated line. Likewise, lines which cross the hot insulated line, which should not be subjected to heating, should be a minimum of 2'-0" above or below the insulation of the heated pipe.

Fill insulation is not suitable for installation on hills or steep slopes.

B. Conduit Water Barriers

This system is basically an insulated line encased in another pipe or conduit. The outer pipe or conduit is made of galvanized steel or cast iron, and is so designed that the insulated encased pipe can slide so that its expansion and contraction is not transmitted to the outer enclosure. The system, including expansion loops, anchors, and fittings, must be



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II. WATER BARRIERS - Continued

B. Conduit Water Barriers - Continued

designed to fulfill the operating and location conditions. The outer enclosure conduit may be metal, cement-asbestos conduit or plastic conduit. The conduits can be designed to contain one, two, or more pipes at the same or different temperatures. The temperature of each pipe would determine its insulation thickness. This system is also suitable for heat traced piping.

Properly installed, these systems are completely watertight, so they are suitable where the water table is high and soil is saturated. It is also suitable for installation on hills and steep slopes.

Although the ground temperature around a conduit will rise, due to the low conductivity of insulation inside the conduit, this increase will be less than the soil temperature increase around the granulated fill system. Unless the temperature of the hot pipe is very high, water and gas lines can be located within 2" of the side of the conduit. In some instances, this eliminates digging of separate trenches.

C. Reinforced Mastic-Sealed Insulation

The third method of water sealing insulation is to use weather-barrier jackets or mastics to seal the insulation from water entry. The materials used are also used as weather-barrier above grade and will be discussed in the following section. The only major difference in the application is that where these materials are used below grade, all joints and laps must be sealed sufficiently to withstand water pressure.

III. WEATHER AND VAPOR BARRIERS

A. General

As previously stated, insulation must be kept dry to retain its efficiency. Thus, it must be protected against moisture in liquid and vapor state. Insulation operating above ambient temperature needs only to be protected against liquid water, as the vapor pressure is outward. Such protection is called a weather barrier. Insulation operating at less than ambient temperature must be protected from moisture vapor which



WATER, WEATHER, VAPOR BARRIERS, FINISHES AND OVERCOATINGS

III. WEATHER AND VAPOR BARRIERS

A. General - Continued

attempts to reach the cold surface of the pipe or vessel. The barrier to this vapor migration is called a vapor barrier. All lines and equipment operating at lower than ambient conditions, either indoors or outdoors, must be provided with a vapor barrier because the vapor pressure is inward.

Some coatings, jackets, or films are both weather and vapor barriers, whereas others are not. In many instances, a material such as a metal jacket, which is used more often as a weather barrier, may also be used as a vapor barrier if all its joints are vapor sealed.

Insulation on warm or hot applications indoors, where not subjected to water, may require only a surface finish to protect it from mechanical abuse, or to provide a decorative appearance. In a few instances, warm or hot applications of insulation which are located in building pipe chases, not subject to any abuse nor having any need for decorative appearance, are installed with no outer barrier or finish.

Overcoatings are sometimes required over weather or vapor barriers on either hot or low temperature insulations. In instances where it is necessary to match existing colors, or to color code the surface, the barrier is painted as desired. Paints which are compatible with the weather or weather-vapor barrier must be selected for this application. Another instance where overcoating is required is when the location is such that contamination or spillage of chemicals will attack the barrier. A third use of overcoatings is the use of intumescent paint on the barrier to provide fire protection.

Depending upon conditions, insulation may require: (1) no outer protection, (2) weather barrier, (3) vapor barrier, (4) weather and vapor barrier, (5) surface finish, or (6) overcoating over one of the barriers.

B. Weather Barriers

The fundamental purpose of a weather barrier on insulation is to prevent the insulation from getting wet. Wherever pipe or equipment insulation is subjected to rain, sleet, snow, liquid spillage, or hose washing, it



WATER, WEATHER, VAPOR BARRIERS, FINISHES AND OVERCOATINGS

III. WEATHER AND VAPOR BARRIERS - Continued

B. Weather Barriers - Continued

must be protected. In addition to this primary function, weather barriers must also protect insulation from physical damage and abuse.

For successful protection of thermal insulation, the weather barrier must stay in place on the insulation and withstand movement caused by expansion and contraction without cracking or breaking. To accomplish this, the weather barrier must possess mechanical strength. It is also exposed to mechanical abuse from external forces. As most insulation materials are relatively soft, any load placed on the outside of the insulation surface must be transmitted by the weather barrier to the insulation without damage to the weather barrier. Mechanical abuse, such as walking on a weather barrier, involves impact, shear, compression, and abrasion. The barrier must be able to withstand all four.

Of course, a weather barrier's primary function is to resist the weather to which it is subjected. The ambient temperature may reach -40F or up to 110F. Over high temperature insulation, in summer under solar radiation, the temperature of weather barrier can exceed 180F. Therefore, the weather barrier must retain its characteristics over a wide range of temperatures.

In addition to weather, acid, caustics, and chemical, fumes can damage the weather barrier. It is of paramount importance that it be resistant to fumes and spillages to which it may be subjected.

Weather barriers used in chemical plants must not increase the fire hazard within the plant. Fire hazard can be increased in several ways. One is that the weather barrier could contribute to a fire or assist it to spread. Another is that it could react with chemical spillage or fumes to cause an accidental fire. A good weather barrier should resist fire and help protect the insulation so as to provide a thermal shield between the fire and piping and equipment.

Many materials have been used as weather barriers for thermal insulation. In general, they fall within two classifications -- jackets or mastics.



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III. WEATHER AND VAPOR BARRIERS - Continued

B. Weather Barriers - Continued

1. Jackets

Various types of jackets are used as weather barriers for insulation. They can be applied around straight piping with relative ease. As barriers over fittings such as elbows, valves, and irregular surfaces, jackets are difficult and costly to apply. However, factory fabricated fitting jackets may partly solve this difficulty. Unless considerable care is exercised, the joints between jackets are not watertight. Some of the materials used for insulation weather barrier jackets are:

- Roofing rag felts
- Asbestos-asphalt felts
- Asbestos and asbestos-asphalt felts
- Mylar film
- Polyvinyl chloride film
- Asbestos sheets and asbestos-asphalt felts
- Foil faced rag felts
- Aluminum
- Aluminum-clad steel
- Painted steel
- Galvanized steel
- Prepainted galvanized steel
- Stainless steel
- Fiberglass reinforced plastic

2. Mastics

Similar to the jackets, there are many materials used as mastics for weather barriers. In most instances, it is recommended that the mastics be reinforced with a membrane to provide higher tensile strength. For this reason, the reinforcing membrane will be given with the mastic for which it is recommended.

Mastic

Reinforcing Membrane

Cutback asphalt and fiber	20 x 20 asphaltic binder glass cloth
Emulsion asphalt and fiber	1" hexagonal mesh monel wire netting
Chemically dispersed asphalt	1" hexagonal mesh monel wire netting



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III. WEATHER AND VAPOR BARRIERS - Continued

B. Weather Barriers - Continued

2. Mastics - Continued

<u>Mastic</u>	<u>Reinforcing Membrane</u>
Polyvinyl acetate and fiber	8 x 8 Dynel cloth
PVA - Acrylic	8 x 8 Dynel cloth
Acrylic	8 x 8 Dynel cloth
Neoprene or Elastomers	

Where color is desired, the polyvinyl acetate and acrylic can be obtained in many standard colors. The asphaltic materials are black and may be overcoated with suitable paint for final color.

3. Recommendations on Selection of Weather Barrier

Metal jackets are most useful where they are installed on uninterrupted cylindrical surfaces -- such as long straight pipe runs. All metal pipe jackets should be installed with "Z" joints on longitudinal lap and with a double sealed closure band around circumferential butt joints. This installation, as specified in General Specifications GS XV, will allow the jacket to expand and contract with the changes of dimension of the pipe. Metal jackets used on vessels should be installed as called for in General Specifications GS XV and Figure GA-7.

Aluminum jacketing should only be used where fire hazard is of no concern and where its high reflectance does not cause excessively high surface temperature.

Galvanized and prepainted steel is the most useful general purpose jacketing as it is much stronger than aluminum, does not cause excessive surface temperatures and will resist direct fire impingement for a considerable length of time.

Stainless steel jacketing is the most chemical resistant and fire resistant of all metal jackets. It is recommended where fire resistance is of utmost importance and where chemical contamination would damage the precoated galvanized steel jacketing.

**WATER, WEATHER, VAPOR BARRIERS, FINISHES AND OVERCOATINGS****III. WEATHER AND VAPOR BARRIERS - Continued****B. Weather Barriers - Continued****3. Recommendations on Selection of Weather Barrier - Continued**

Mastics are most useful to provide weather barrier protection on complex piping, equipment having many nozzles, flanges or projections, heads and other irregular surfaces, where fitting of metal and water sealing of metal joints are difficult. On flat surfaces where the barrier depends on bond to the insulation for its support, mastics are easier to apply than metal.

Asphaltic mastics stiffen with age and have poor low temperature flexibility characteristics, thus have poor service life. They also are combustible and will spread fire. For these reasons they are not recommended.

The polyvinyl acetate, PVA-acrylic, and acrylic mastics have proven to be better weather barriers than the asphalts. Properly formulated, they provide long service life and they are fire resistant.

The ability of a mastic reinforced system to elongate without breaking or rupture, as the pipe or vessel expands, is essential for maintaining its function as a water barrier. Past practice of using glass fabric as the reinforcing membrane prevents elongation and should not be used as mastic reinforcement. The reinforcement should be Dynel cloth which can elongate 50% of its length.

The water emulsion PVA, PVA-acrylic, and acrylic mastics do have high vapor transmission; thus, when used on hot service insulation, any entrapped moisture vapor can escape without causing water blisters on the surface.

C. Vapor Barriers

Moisture in the vapor state is a gas, and in this state will always seek to equalize any pressure difference by flowing from the high pressure area to the low pressure area. When thermal insulation is on a surface which operates as a temperature less than the ambient temperature, this lower temperature on the inner surface of the insulation causes a lower vapor



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III. WEATHER AND VAPOR BARRIERS - Continued

C. Vapor Barriers - Continued

pressure at this point than exists in the ambient air. To show the force of this vapor pressure, the following is presented:

Assuming the temperature of the insulated surface as 30F and the air film on this surface at 100% relative humidity, the vapor pressure is 11.6 lbs/sq ft. If the ambient air is 90F with a relative humidity of 80%, the vapor pressure is 77.8 lbs/sq ft. The force is the difference, which is 66.2 lbs/sq ft. This force is pressing inward, seeking any hole or weakness in the outer surface. If the vapor does get through the barrier and enters the insulation, as it encounters lower temperatures on its way toward the inner surface, it will reach its dew point. At this point it will condense to a liquid. As this process continues, the insulation becomes saturated and its efficiency is lowered. Although the moisture migration cannot be entirely stopped, the vapor barrier must retard this vapor sufficiently to obtain a maximum economic life for the low temperature insulation.

The selection and installation of vapor barriers depend upon the characteristics of the thermal insulation to which it is to be applied. If the insulation is not highly vapor-resistant, a completely sealed vapor barrier must be provided. If the insulation is vapor-resistant, it can be sealed at its joints to form its own vapor barrier.

1. Vapor Barriers on Semi-Vapor Resistant Insulations

Semi-vapor resistant insulations depend upon a vapor barrier to maintain their thermal efficiency. Because of this, a superior vapor barrier is imperative. If the vapor barrier is broken or punctured, the moisture migrates into the insulation and condensate will form. Any outer surface vapor barrier, no matter how strong, may be subjected to fracture. Whenever multiple layers of insulation are warranted, an inner vapor barrier is good insurance to prevent excessive damage by moisture if the outer barrier is punctured. It is also advisable to install the barrier in sectional type construction. This can be accomplished by providing barriers in the butt joints at intervals to form sealed sections. By this method, only moisture entering a break in the outer vapor barrier will be restricted to that section. This is illustrated as follows:

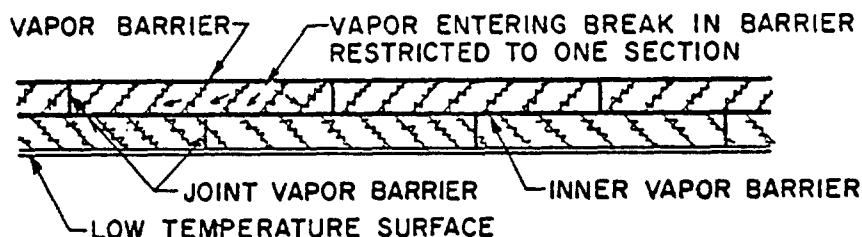


WATER, WEATHER, VAPOR BARRIERS, FINISHES AND OVERCOATINGS

III. WEATHER AND VAPOR BARRIERS - Continued

C. Vapor Barriers - Continued

1. Vapor Barriers on Semi-Vapor Resistant Insulations - Continued

PROPER METHOD FOR SEALING SEMI-VAPOR RESISTANT INSULATION

In like manner, whenever straight pipe insulation on lines is to be jointed with fitting insulation, the straight insulation should be stepped back from the fitting and the vapor barrier carried down over the butt ends and sealed to metal. This also applies to equipment insulation.

Low temperature insulations which fall into the semi-vapor resistant class are glass fibers, mineral wools, hair felt, cork organic foams. In most instances, these materials are less expensive than hermetically sealed cellular insulations. However, the expense of installing proper vapor barriers causes installed cost of this class of low temperature insulation to be quite high.

Selection of material and method of installation depend upon the insulation to be vapor protected, the temperatures to which the insulation and barrier are to be subjected, the mechanical and chemical exposure, and fire hazard. Vapor barriers are formed from many types of materials such as jackets, foils, tapes, and mastics, and various combinations of them.

Application where severe vibration is present, or extreme conditions of expansion and contraction exist, or where the insulation is also used as a sound absorber, require the use of semi-vapor resistant and flexible insulation. However, the vapor barrier must be carefully selected and designed.



WATER, WEATHER, VAPOR BARRIERS, FINISHES AND OVERCOATINGS

III. WEATHER AND VAPOR BARRIERS - Continued

C. Vapor Barriers - Continued

1. Vapor Barriers on Semi-Vapor Resistant Insulations - Continued

(a) Jackets, Foils, Tapes

Metal Jackets of aluminum or stainless steel have been used as vapor barriers. Although these are the most vapor resistant materials that can be obtained, the forming and fitting to the shapes required of vapor barriers is difficult. In addition, all joints and laps must be vapor sealed. Sealers used to bond metal to metal into a vaporproof mechanically strong joint have been found to be only partially successful.

Composition Jackets made of laminations of asbestos paper and aluminum foil or other materials, although more flexible than the metal jackets, still present the same difficulty of forming and sealing.

Foils of aluminum are used as vapor barriers. However, very lightweight foils have pinholes and have little mechanical strength. For this reason, foils have been produced which are reinforced with glass fiber and plastic coating. These reinforced foils are efficient and easier to apply. However, the major difficulty of lap sealing still remains.

Tapes with pressure sensitive adhesive have been produced of many materials, such as rubber, fabric, aluminum, polyethylene, polyvinyl chloride, glass fibers, or combinations of these materials. These tapes are applied on vapor barriers in themselves, as joint sealers with the jackets, or as a base over which mastic is applied.

The number of materials and combinations possible is too large to present in this manual. A listing of available material is presented in the "Thermal Insulation and Accessories Manual".

(b) Mastics

Mastic weather barriers are made of asphaltic compounds, rubber or resins. These are of solvent type and are most



WATER, WEATHER, VAPOR BARRIERS, FINISHES AND OVERCOATINGS

III. WEATHER AND VAPOR BARRIERS - Continued

C. Vapor Barriers - Continued

1. Vapor Barriers on Semi-Vapor Resistant Insulations - Continued

(b) Mastics - Continued

often applied over fabric tape, or are reinforced with a membrane such as glass fiber cloth.

Most of these mastics are quite flammable in the wet state, so they must be applied with caution. Even in the dried state, most will support combustion.

Frequently, an application will be made using jackets or reinforced foils on straight piping and cylindrical sides of vessels, with mastics completing the barriers over butt ends, valves and fittings, vessel heads, and irregular surfaces. No matter which system is used, it is essential that the vapor barrier is sectionalized in cell type enclosures.

After the vapor barriers are completed, unless the vapor barrier is also a weather barrier, it is necessary to install the outer finish or weather barrier on the outside surface.

D. Characteristics of Weather and Vapor Barriers

In selection of weather and vapor barriers, their properties must be considered in view of the requirements of the installation. The requirements as related to properties of materials are listed below to assist in such evaluation.

WEATHER AND VAPOR BARRIERS
REQUIREMENTS AS RELATED TO PROPERTIES OF MATERIALS

<u>Function</u>	<u>Requirement</u>	<u>Properties</u>
Transportation and storage	Economic handling	Can stability Freezing point Shell life Toxicity

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III. WEATHER AND VAPOR BARRIERS - Continued

D. Characteristics of Weather and Vapor Barriers - Continued

<u>Function</u>	<u>Requirement</u>	<u>Properties</u>
Field installation	Application - coatings	Adhesion - wet Build Coverage Curing time Drying time Flash point Fire point Freezing point Shrinkage Sag - thickness Temperature limits - application Toxicity
	Jackets, foils, tapes	Adhesion to surface Flammability Flexibility Tear strength Tensile strength
In service	To withstand impact, mechanical wear, forces of expansion and contraction	Abrasion resistance Adhesion - dry Flexibility Hardness Impact strength Peelback Tensile strength
Chemical	Compability with metal with which it may be on contact	Alkalinity Corrosiveness Soluble chlorides
	Resistance to spillage or atmospheric contamination	Resistance to acids Resistance to caustics Resistance to solvents



WATER, WEATHER, VAPOR BARRIERS, FINISHES AND OVERCOATINGS

V. OVERCOATINGS**C. Overcoating for Appearance - Continued**

Another instance where overcoating is required is where piping is color coded. Providing all colors to be applied as insulation mastics would be quite difficult, and on Union contracts this amount of color finishing would be claimed by the painters. For these reasons, color coding painting is done after insulation finishing has been completed.

D. Overcoating for Fire Protection

When fire protection becomes important, overcoating of the weather or vapor barrier with an intumescent coating system will provide additional protection.

An intumescent system cannot be used on surfaces which melt, soften, or release solvents at relatively low temperatures, due to the fact that its intumescence starts at approximately 350F. At this temperature puffing action occurs and forms a lightweight carbonized insulation which will resist flame temperatures.

To illustrate the heat resistant action of intumescent overcoating systems, the following results obtained by fire test are presented:

Aluminum jacket unprotected melted in 1 minute, 30 seconds.

Aluminum jacket protected with intumescent paint system melted in 11 minutes, 30 seconds.

1-1/2" thick Foamglas with PVA weather barrier on 3" pipe -- pipe temperature 1000F after 41 minutes fire exposure.

1-1/2" thick Foamglas with PVA weather barrier overcoated with intumescent system on 3" pipe -- pipe temperature 1000F after 56 minutes fire exposure.

In very hazardous locations, low temperature insulation application can obtain additional time before failure by use of intumescent paint systems.

It is also possible to use this system directly on steel pipe or other members which are not insulated. Time of failure of unprotected steel is approximately five minutes, whereas if protected by the intumescent system, the failure time is approximately 25 minutes.



FIRE TESTS ON WEATHER BARRIERS

I. GENERAL

Several properties of the weather barrier materials as related to fire are important. One is flame spread, another is fire-time resistance, another is flammability, and still another is reaction with chemicals which could cause fire.

The following fire exposure test data are results of fire tests by the Fire Research Group conducted in 1957. The test is described in the report "Fire Tests on Thermal Insulations and Weather Barriers?", March 1962. Many materials called "fire retardant" or "fire resistant" do not perform in accordance with their names. Thus these terms in manufacturers' literature should be ignored.

II. FIRE EXPOSURE TEST ON WEATHER BARRIERS

<u>Weather Barrier</u>	<u>Time to Start Burning</u>	<u>Fire Spread</u>	<u>Condition After Exposure</u>
Aluminum jacket .036" thick	Melted - 1 min 50 sec	None	Completely destroyed over fire area, 18 min
Aluminum jacket .016" thick	Melted - 53 sec	None	Completely destroyed over fire area, 18 min
Asbestos fire retardant felt	Started to burn after 1 min, 30 sec	Fire spread to end of test section	Completely destroyed over fire area, 18 min
Asphalt cutback mastic	Started to burn after 30 sec	Fire spread to end of test section	Completely destroyed full length of test section in 18 min
Asphalt emulsion mastic	Started to burn after 35 sec	Fire spread to end of test section	Completely destroyed full length of test section in 18 min
Asphalt-Gilsonite cutback mastic	Started to burn after 35 sec	Fire spread to end of test section	Completely destroyed full length of test section in 18 min
Asphalt-Gilsonite fire-resistant cutback mastic	Started to burn after 35 sec	Fire spread to end of test section	Completely destroyed full length of test section in 18 min

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MAY, 1968**FIRE TESTS ON WEATHER BARRIERS - Continued****II. FIRE EXPOSURE TEST ON WEATHER BARRIERS - Continued**

<u>Weather Barrier</u>	<u>Time to Start Burning</u>	<u>Fire Spread</u>	<u>Condition After Exposure</u>
Polyvinyl acetate emulsion mastic	Slight burning after 5 sec	Fire spread approximately 2'-0"	Carbonized over fire area but intact after 60 min
Polyvinyl chloride zip-on film jacket	Melted - 20 sec	None	Completely destroyed over fire area in 18 min
Roofing felt - 55 lb	Started to burn after 1 min, 30 sec	Fire spread to end of test section	Completely destroyed full length of test section in 18 min
Stainless steel	No burning or melting	None	Discolored over fire area. Undamaged after 60 min

FLASH POINT

<u>Material</u>	<u>Flash Point °F</u>	
	<u>Wet</u>	<u>Dried</u>
Asphalt, cutback weather barrier mastic	125	195
Asphalt, emulsion weather barrier mastic	*	510
Asphalt-Gilsonite cutback weather vapor barrier mastic	130	435
Asphalt-Gilsonite cutback insulating mastic	140	375
Asphalt vapor seal	165	-
Polyvinyl acetate weather barrier mastic	*	**

* No flash point, due to water boil-off.

** No flash at 525F (temperature limit of this open cup test).



FIRE TESTS ON THERMAL INSULATIONS AND WEATHER BARRIERS

I. GENERAL

Prior to the fire tests conducted by the Research and Development Department Fire Research Group, the effect of fire on insulation and weather barrier materials was unknown.

The damage to insulated piping and equipment from plant fires indicated that action should be taken to determine and record data on insulation and weather barrier materials exposed to direct flame impingement. The Insulation Committee requested the Fire Research Group to develop a test procedure and to conduct tests which would duplicate plant fire exposures.

Test procedures and equipment, to determine the effect of fire exposure on various insulation and weather barrier materials, were developed. The test results, conclusions, and recommendations are included in this report.

II. SUMMARY

A. Requirements

Insulations which did not retard the temperature rise of the test pipe to less than 1000F after fire exposure for 60 minutes were considered as failures. The failing point of 1000F was selected because at or near this temperature many reactive chemicals decompose with explosive violence; also, steel rapidly loses its strength at temperatures above this level.

B. Materials Tested

Insulations and weather barriers of different compositions and various manufacturers were tested. These basic materials and their classification are as follows:

1. Insulations

a. High Temperature

- (1) Calcium silicate
- (2) Diatomaceous earth
- (3) Asbestos fibers
- (4) Asbestos fibers and perlite
- (5) Magnesia
- (6) Aluminum and stainless steel reflective sheets with stainless steel jacket

**FIRE TESTS ON THERMAL INSULATIONS AND WEATHER BARRIERS****II. SUMMARY - Continued****B. Materials Tested - Continued****1. Insulations - Continued****b. Low Temperature**

- (1) Cellular glass
- (2) Vegetable cork
- (3) Cellular silica
- (4) Foamed polystyrene
- (5) Aluminum reflective sheets
- (6) Glass fiber

2. Weather Barriers**a. Jackets**

- (1) Aluminum corrugated (0.016" thick)
- (2) Aluminum corrugated (0.024" thick)
- (3) Asbestos felt roofing
- (4) Asphalt felt roofing
- (5) Polyvinyl chloride
- (6) Stainless steel

b. Mastics

- (1) Asphalt emulsion
- (2) Asphalt cutback
- (3) Gilsonite
- (4) Gilsonite (fire retardant)
- (5) Polyvinyl acetate
- (6) Polyvinyl acetate (overcoated with intumescent paint)

C. Conclusions

The test results indicate that many of the high-temperature and two of the low-temperature types of insulation adequately protected steel pipe from fire for one hour's duration and were considered satisfactory for use in plants of Union Carbide Corporation.

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FIRE TESTS ON THERMAL INSULATIONS AND WEATHER BARRIERS

II. SUMMARY - Continued**C. Conclusions - Continued**

Most of the commonly used weather barriers were not satisfactory because of excessive flame propagation and rapid deterioration. However, stainless steel jacketing and the polyvinyl acetate and acrylic mastics were considered satisfactory.

III. DISCUSSION**A. Test Procedure**

The Fire Research Group developed a test procedure which subjected the test materials to conditions similar to those experienced in plant fires. This test procedure was accepted by the Insulation Committee.

1. Equipment Required

- a. Pipe support rack and a 4' wide by 7'-6" long by 1'-6" deep fuel pan.
- b. Fuel supply and control equipment.
- c. Approximately 140 gallons of standard motor fuel was used for each test. This fuel was controlled at a rate of one gallon per minute for the first 5 minutes exposure, 1.8 gallons per minute for the next 10 minutes exposure, and 2.5 gallons per minute for the remainder of the exposure.
- d. Multipoint recording potentiometer (10 point minimum, two points for each pipe).
- e. Water supply and equipment for water stream and water spray application.
- f. Five 20-foot long, 3-inch IPS, Schedule 40 carbon steel pipes per test.
- g. Alumel-Chromel thermocouple wire, porcelain insulators, connections, etc.



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FIRE TESTS ON THERMAL INSULATIONS AND WEATHER BARRIERS

III. DISCUSSION - Continued

A. Test Procedure - Continued

2. Preparation

a. Thermocouples

Each 20-foot test pipe was cut at the center on a 30° angle to longitudinal centerline to form two sections. A thermocouple was installed on the inside wall of each section at points which located the thermocouples 180° apart and 10-feet from either end when pipe was reassembled. The two sections were welded together to reform the original 20-foot long test pipe.

b. Pipes (Test Materials Applied)

(1) Application of Insulation

Three methods of applying insulation were used.

- (a) Single-layer, mass-type, 1-inch or 2 1/2-inch thick, 36-inch long sections of semi-cylindrical molded-type pipe insulation applied to the middle 12 linear feet of the test pipe, the insulation stopping 4 feet from each end of the pipe. The butt edges and ends of the sections of low-temperature insulations were "Buttered" (sealed) with joint sealer before applying. Both high-temperature and low-temperature insulations were applied with all joints tightly butted and fitted.

The insulation was secured to the pipe with 16 gage stainless steel wire. The wire was applied on 18-inch centers (9 inches from ends of sections).

- (b) Double-layer, mass-type, 2 1/2-inch total thickness (the inner layer 1-inch thick, and the outer layer 1 1/2-inches thick), 36-inch long sections of semi-cylindrical molded-type pipe insulation. The sections of the inner layer were applied to the test pipe with the end joints staggered. The sections of the outer layer were applied with the longitudinal and the end butt-joints offset from the inner-layer joints a minimum of 2 inches. The butt edges and ends of the



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III. DISCUSSION - Continued

A. Test Procedure - Continued

2. Preparation - b. (1) (b) - Continued

sections of the outer layer of low-temperature insulations were "buttered" with joint sealer before applying.

Both high-temperature and low-temperature insulations were applied with all joints tightly butted and fitted. Insulation was applied to the middle 12 linear feet of the test pipe, the insulation stopping 4 feet from each end of the pipe.

The inner layer was secured to the pipe with 16 gage stainless steel wire. The outer layer was secured by 1/2-inch (0.020-inch thick) stainless steel bands. The wire and the bands were applied on 18-inch centers (9 inches from ends of sections).

- (c) Reflective insulation, five semi-circular metal sheets spaced 1/2-inch apart. The insulation consisted of all-metal prefabricated units 24-inches long. Each unit was composed of five reflective sheets spaced and reinforced by flush separators arranged to form isolated air chambers. Each unit was fabricated in two semi-cylindrical sections. One circumferential edge of each unit and the longitudinal edges of one section were extended to provide overlap and watershed. Longitudinal edges of the inner sheets were flanged inward to provide strength and tight butt-joints between the two sections which form a unit.

The semi-circular sections were applied to a test pipe with the extended longitudinal edges of the one section overlapping the flush edges of the opposite semi-circular section which formed one complete unit. The flush end of each unit was telescoped into the circumferential extended end of the adjacent unit. These units of insulation were secured to the test pipe by 3/8-inch (0.020-inch thick) stainless steel bands applied on 12-inch centers starting 6 inches from ends of each unit.



FIRE TESTS ON THERMAL INSULATIONS AND WEATHER BARRIERS

III. DISCUSSION - Continued

A. Test Procedure - Continued

2. Preparation - b. (1) (c) - Continued

Six units of insulation were applied, covering the middle 12 linear feet of the test pipe and stopping 4 feet from each end of the pipe.

(2) Application of Weather Barriers

(a) Metal sheets, 36-inches wide, were applied around the 1-inch thick insulation on the test pipe. The longitudinal lap joint was located on the lower part of the pipe at the 4 or 8 o'clock position to insure proper watershed. The longitudinal lap was 2 inches. One circumferential edge overlapped the adjoining sheet 3 inches. The jacket was secured by 1/2 inch (0.020-inch thick) stainless steel bands. One band was placed at each 3-inch lap and one band in between.

Felt roofing sheets were applied around the 1-inch insulation on the test pipe. The longitudinal lap joint was located on the lower part of the pipe at the 4 or 8 o'clock position to insure proper watershed. The circumferential and longitudinal joints were lapped 2 inches. All lap joints were sealed with a solvent asphalt sealer. The jacket was secured with 1/2-inch (0.020-inch thick) stainless steel bands. One band was placed at each circumferential lap and one band at each midpoint between joints.

Polyvinyl chloride, prefabricated jacket, enveloped the insulation of the test pipe. A longitudinal "zip-on" closure sealed the jacket in place.

(b) Mastics

Fibrated asphalt, asphalt emulsion, asphalt cutback, or Gilsonite cutback was applied by trowel over the insulation on the test pipe. Into this wet mastic coat a 20 x 20

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mesh asphalt-saturated glass-fiber cloth was embedded. The wrinkles in the cloth were smoothed out and the seams were lapped 2 inches. After a drying period of 24 hours, a final coat of mastic was applied and troweled smooth. The combined thickness of these applications, after drying, was not less than 1/8". These applications were air dried in a minimum of 30 days before being tested.

Polyvinyl-acetate mastic was applied with a trowel over the insulation on the test pipe. A 10 x 10 mesh starch-sized glass-fiber cloth was embedded into this wet mastic. The mastic was pressed through the mesh of the glass cloth and troweled smooth. The combined thickness was not less than 1/16" after drying.

Polyvinyl acetate (overcoated with intumescent paint) was applied, as above, with an additional overcoat of intumescent paint. This paint was evenly brushed over the entire mastic-coated insulation. The paint was not less than 15-mil thickness after drying.

(c) Pre-Test Assembly

Five pipes were placed 16" on centers (two insulated pipes on each side of a bare unprotected pipe) on the support rack in the same horizontal plane. The thermocouples were centered over the fuel pan. See Figure 1 in Appendix.

The thermocouples were checked for continuity and the lead wires were connected to a potentiometer.

The open ends of each pipe were packed with white glass wool insulation to prevent air movement through the pipes.

The fuel pan was charged with water until the level was 1'-8" below the horizontal centerlines of the pipes.



FIRE TESTS ON THERMAL INSULATIONS AND WEATHER BARRIERS

III. DISCUSSION - Continued

A. Test Procedure - Continued

3. Test Schedule - Insulation

- a. Fuel (gasoline) was fed into the fuel pan until the water surface was covered. The fuel was ignited. The five pipes were fully exposed, simultaneously, to the fire.
- b. The fuel flow into the pan was controlled so that the temperature in the bare pipe coincided with the ASTM Standard Fire Temperature Curve (1000F in 5 minutes, 1300F in 10 minutes, 1550F in 30 minutes, and 1700F in one hour).
- c. The insulations were exposed to the fire for one hour. The weather barriers were exposed to fire for 10 minutes. Temperatures related to time of exposure were recorded.
- d. The fuel was shut off. Each test pipe was inspected and observations recorded.
- e. The fuel was reignited after 16 minutes and burned for 5 minutes to re-establish full exposure. The fuel was shut off.
- f. Water at a rate of 75 gallons per minute was applied to the insulation in a straight stream through a 1-1/2" Elkhart Mystery Nozzle from a distance of 60' for 1-1/2 minutes.
- g. The water application was changed from a straight stream to a spray. The water application was continued until the residual fuel burned out.
- h. A second inspection of each test pipe was made and observations recorded.
- i. The insulation was removed from each pipe, section by section. The effect of the heat and water on each section of insulation and the covered surface of the pipes was recorded.



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III. DISCUSSION - Continued

B. General Test Results

The data that were recorded and the observations that were made during and after the tests were analyzed by grouping the results under headings which included major components of an insulation and methods of application. This kind of grouping gave generalized conclusions on the resistance in fire exposure of generic materials. Detailed results of each insulation and weather barrier that was tested are presented in the following tables,

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INSULATION SYSTEM	INTERNAL PIPE TEMPERATURE & EXPOSURE TIME	REACTION TO FIRE	THERMAL EFFECT	QUENCHING WATER EFFECT	REMARKS
2½" Thick Asbestos Fibers 1" inner 1½" outer layers PVA mastic weather barrier	130 F at 30 min 200 F at 60 min	Did not burn	Shrinkage (OL) 1/8" per 3 ft (IL) none visible	No physical damage	Pipe not exposed to flame impingement. No physical damage to insulation.
1" Thick Asbestos Fibers PVA mastic weather barrier	360 F at 30 min 710 F at 60 min	Did not burn, discolored	Shrinkage 1/2" per 3 ft	No physical damage	Pipe was exposed to flame impingement. Insulation became structurally weak.
2½" Thick Calcium Silicate 1" inner, 1½" outer layers PVA mastic weather barrier	170 F at 30 min 210 at 60 min	Did not burn	Shrinkage (OL) 1" per 3 ft (IL) ½" per 3 ft	No physical damage - Saturated	Broken joints prevent pipe from flame impingement. Structural strength of outer layer impaired.
1" Thick calcium silicate PVA mastic weather barrier	390 F at 30 min 710 at 60 min	Did not burn	Shrinkage 3/4" per 3 ft	Saturated	Pipe was exposed to flame impingement through shrinkage cracks. Structural strength of insulation impaired.
2½" Thick diatomaceous earth 1" inner, 1½" outer layer PVA mastic weather barrier	130 F at 30 min 210 at 60 min	Did not burn	Shrinkage (OL) ½" per 3 ft (IL) 1/16" per 3 ft	No physical damage - Saturated	Pipe not exposed to flame impingement. Structural strength of insulation impaired.
1" Thick diatomaceous earth PVA mastic weather barrier	370 F at 30 min 615 F at 60 min	Did not burn	Shrinkage 1/2" per 3 ft	No physical damage - Saturated	Pipe was exposed to flame impingement through shrinkage cracks. Insulation had some surface spalling.
2½" Thick expanded silica PVA mastic weather barrier	165 F at 30 min 335 F at 60 min	Did not burn	Shrinkage (OL) ½" per 3 ft (IL) none usable	No physical damage - Saturated	Pipe not exposed to flame impingement. Structural strength of insulation impaired.
1" Thick expanded silica PVA mastic weather barrier	410 F at 30 min 850 F at 60 min	Did not burn	1/2" per 3 ft	No physical damage - Saturated	Pipe was exposed to flame through shrinkage cracks. Structural strength of insulation impaired.
2½" Thick reflective Stainless steel outer jacket 3 intermediate sheets of aluminum; 1 inner sheet of stainless steel	420 F at 30 min 910 F at 60 min	Did not burn	Some inner aluminum sheets melted during test	No additional damage	Pipe not exposed to flame impingement. Melted aluminum did not leak through outer stainless steel jacket.
2½" thick reflective Aluminum outer jacket 4 spaced sheets of aluminum	1000 F at 12 min 1500 F at 30 min 1600 F at 60 min	Melted	Partly melted after 1½ min exposure		Pipe was exposed to flame impingement after 1½ min. Deflection of pipe after 10 min.
2½" Thick cellular glass 1" inner, 1½" outer layer PVA mastic weather barrier	620 F at 30 min 770 F at 60 min	Did not burn	Broken into pieces. 3" crack at bottom	Part washed off of pipe	Pipe was exposed to flame impingement through crack at bottom. Insulation was broken into pieces.
1" Thick cellular glass PVA mastic weather barrier	810 F at 30 min 1000 F at 42 min 1250 F at 60 min	Did not burn	Complete. Broken into small pieces	Washed off of pipe	Weather barrier retained insulation around pipe prior to quenching water application. Pipe sagged.
1" thick outer calcium silicate 1½" thick inner cellular glass PVA mastic weather barrier	117 F at 30 min 400 F at 60 min	Did not burn	Shrinkage (OL) 6" per 3 ft (IL) Broken into small pieces	OL Saturated	Pipe was exposed to flame impingement through cracks. Outer layer retained the inner layer.
2½" Glass fiber insulation PVA mastic weather barrier	1000 F at 32 min 1360 F at 60 min	Did not burn	Melted and dripped		Insulation melted completely exposing bare pipe to flame impingement.

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MAY, 1968**FIRE TEST ON THERMAL INSULATIONS AND WEATHER BARRIERS**

Insulation System	Internal Temp and Exposure Time	Reaction to Fire	Thermal Effect	Quenching Water Effect	Remarks
1" Foamed Styrene (self extinguishing) PVA mastic weather barrier	1000 F at 13 min 1150 F at 30 min 1180 F at 60 min	Combustible volatiles	Melted and dripped		Insulation failed completely exposing bare pipe to flame impingement.
1½" Outer layer cellular glass 1" Inner layer foamed styrene PVA Mastic weather barrier	640 F at 30 min 1000 F at 52 min 1160 F at 60 min	IL contributed combustible volatiles; OL did not burn	IL melted and dripped; OL broke into pieces	OL insulation dislodged	Insulation failed completely. IL burned between OL and pipe.
2½" Thick vegetable cork PVA mastic weather barrier	220 F at 30 min 680 F at 60 min	Supports and harbors hidden combustion	Completely charred. Shrinkage cracks	Did not extinguish hidden combustion	Effective as an insulation. In spite of attempts to extinguish with fire hose material continued to burn after test.
2½" Thick urethane foam PVA mastic weather barrier cover with 12 mils of intumescent paint	1000 F at 31 min	Considerable smoke. Intumescent paint foamed for good protection. All completely charred	Did not melt; completely charred	Washed away	Charred. Began to fall off after 26 min exposing pipe to flame impingement. Insulation completely disintegrated.
2½" Thick urethane foam 0.010" thick stainless steel jacket	1000 F at 10.5 min	Considerable smoke	Insulation completely charred	Stainless jacket remained around pipe	Pipe not exposed to direct flame impingement due to jacket remaining in place. Jacket rested on pipe in middle of fire.
1½" Outer layer calcium silicate 1" Inner layer urethane foam PVA mastic weather barrier	1000 F at 59.5 min	Considerable smoke	OL shrinkage ½" per 3 ft; IL completely charred	OL remained around pipe	Pipe exposed to direct flame impingement due to shrinkage of OL and complete charring of IL
Weather Barrier Systems All installed on 1" calcium silicate					
Asphalt cutback	15 min exposure	Propagated flame	Spalled and cracked	Disintegrated	Mastic started to burn after 35 sec, exposing insulation.
Asphalt emulsion	15 min exposure	Propagated flame	Spalled	Disintegrated	Mastic started to burn after 35 sec, exposing insulation.
Gilsonite cutback	15 min exposure	Propagated flame	Spalled and cracked	Disintegrated	Mastic started to burn after 35 sec, exposing insulation.
Polyvinyl acetate mastic (emulsion)	15 min exposure	Flame propagation limited to 2'-0" beyond fire	Cracked; brittle	Part washed away	Mastic in direct fire started burning in 53 sec. Was self-extinguishing 2'-0" from fire pan. Material directly in fire exposure still on insulation until water quenched.
Polyvinyl acetate mastic coated with intumescent paint	15 min exposure	Intumescent paint puffed	Paint ¾ to 1" puff PVA - brittle	Part washed away	Same as above except PVA was in a little better condition.
Aluminum jacket 0.016" thick	15 min exposure	Did not burn	Melted	(Had melted off prior to quenching)	Aluminum melted and dripped exposing insulation after 2 min of fire exposure.
Asbestos felt jacket Asbestos outer surface Asphalt inner surface	15 min exposure	Propagated fire	Asphalt melted and flow out thru the asbestos	(Had dropped off prior to quenching)	Jacket completely destroyed, exposing insulation after 10 min exposure.
Asphalt 55 lb felt jacket	15 min exposure	Propagated fire	Asphalt melted and dripped	(Had been burned away prior to quenching)	Jacket completely destroyed, exposing insulation after 10 min fire exposure.
Polyvinyl chloride jacket	15 min exposure	Burned	Melted	(Had melted off prior to quenching)	Jacket completely destroyed in fire area in 20 sec. Did not spread fire outside of fire area.
Stainless steel jacket	15 min exposure	Did not burn	Discolored	Undamaged except for color	Jacket was undamaged. Protected insulation during entire exposure.



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ACCESSORIES

I. GENERAL

Accessories are the materials used for an insulation installation other than the basic insulation and weather or vapor barriers. Many materials are used in the fabrication, support, securement, and reinforcement of insulation. Each must be selected to fulfill its function and be compatible with the other parts of the system. A listing of accessories is included in the "Insulation and Accessories Manual".

II. FABRICATION ACCESSORIES

- A. The basic insulation materials are shaped by cutting, grinding, or molding on suitable machines to sizes to fit equipment and piping. These sizes are dimensioned in the "Fabrication Manual for Insulation".

The cut shapes of insulation have to be assembled and cemented together to form the finished insulation fitting cover. The cements or adhesives used must provide a strong bond and also be suitable for the temperatures to which they will be subjected. In addition, the fabrication cements or adhesives used for low temperatures should be vapor resistant. Many of the properties listed for weather-vapor barriers apply to these materials used for bonding insulation together.

As a cement or adhesive must be suitable for bonding a particular insulation, it is well to list cements presently available for use on various insulations. There are new cements and adhesives being developed and some of these may prove to be better for certain services than those now being used. Also, as new insulation materials are introduced, it is likely that they may require different cements or adhesives.

FABRICATION CEMENTS AND ADHESIVES

<u>Insulation</u>	<u>Spec. No.</u>	<u>Cement</u>	<u>Temp. Limits of Cement °F</u>	<u>Remarks</u>
Cellular Glass	10B	Carey, Fire Chex No. 400		For bonding cellular glass to roof
Cellular Glass	10B	3M, CTA-H		Soft rubber based adhesive for bonding cellular glass to ceiling
Cellular Glass	10H, J & OX	Keene's Cement	Up to 850	Slow bonding and setting
Cellular Glass	10-J	Mimcle, RT-1000P	-40 to 400	Chemical setting, vapor resistant
Cellular Glass	10-L	Steeple Asphalt	-250 to 180	Fast setting
Cellular Glass	10-OX	Vimasco J Seal "S"	-250 to 200	Slow setting, suitable for oxygen service

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MAY, 1968**ACCESSORIES****II. FABRICATION ACCESSORIES - Continued****A. Continued****FABRICATION CEMENTS AND ADHESIVES - Continued**

Rigid Urethane	12-H	Armstrong 520 Armstrong 620	Up to 180 Up to 200	Contact adhesive Contact adhesive
Fibrous Glass (Preformed)	15-H	Foster No. 81-27		Fibrous adhesive
Fibrous Glass	15-L	Foster No. 81-33		Fire resistant adhesive
Asbestos Fibers or Calcium Silicate	21-H 23-H, 25-H	A. P. Green Insulation Adhesive Refractory & Insulating Block Stick	Up to 1100 Up to 1500	Fibrous, cuts well after drying Smooth, relatively hard after drying
Expanded Silica	22-H, 32-H	Philip Carey Careytemp Adhesive	Up to 1500	Will adhere to moisture resistant Careytemp

- B. In addition to the cements and adhesives used in fabrication, materials subject to wear from abrasion must be coated with an anti-abrasion coating. Although this can be applied in the field, it is most easily applied by spray or trowel (depending upon material) in the shop. Anti-abrasion coatings must be compatible with the material to which they are applied, the metal which they might contact, the chemicals to which they might be subjected, and the temperature to which they are subjected. The following anti-abrasive coatings are all suitable for fiber and cellular glass insulations. Their other properties are as follows:

<u>Anti-Abrasive Coating</u>	<u>Temperature Limits °F</u>	<u>Remarks</u>
Keene's Cement	32 to 850	Slow setting. Not recommended on stainless steel. Suitable for oxygen service.
Vimasco Vicarlon 500	-400 to 200	Relatively low maximum temperature limits. Will burn. Fast setting. Not recommended on stainless steel. Can be sprayed or brushed.
Dampney No. 70 Black	-400 to 850	Can be sprayed or brushed. Suitable for use on stainless Steel.



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ACCESSORIES

III. SUPPORTS

A. Pipe Supports and Cradles

1. High temperature piping, which is insulated, requires the use of pipe supports arranged to prevent the pipe from resting upon the insulation. Standards for pipe supports are presented in "Engineering Standards".
2. Low temperature insulated piping is supported on cradles as shown in Standard P-82 in "Engineering Standards". However, it should be noted that, as stated in this Standard, it applies only to horizontal piping and short vertical runs. Unless the pipe or cradle is spring supported on long vertical runs, such as to the top of a tall column, the expansion and contraction of the line or column will either cause compression forces which crush the insulation in the cradle, or lift all the weight off the cradle so that the weight of line and insulation is on the vessel nozzle.

B. Insulation Supports

1. Cylindrical vessels, either vertical or horizontal and operating at high or low temperatures, require insulation supports. Due to expansion and contraction, insulation cannot be banded sufficiently tight to hold it in place by friction. For this reason, supports must be provided to carry the insulation load. Insulation support details for cylindrical vessels up to 12'0" diameter are shown in Engineering Standards IS-31, IS-36, and IS-42. For vessels over 12'0" and 36'0" diameter, requiring insulation supports, details are shown on supplement to Standard IS-31. These are for use when vessels do not come equipped with supports from the vendor. Wherever possible supports should be obtained on the vessel from the vendor. In some instances, it is desirable on vessels above 12'0" to secure the insulation directly to the surface with blank nuts and wire, or studs and clips, similar to that used for flat surfaces.
2. Insulation supports must be provided above all vessel flanges so that insulation does not rest on the studs, and so that the insulation on body of the vessel will not slip down out of position should it be necessary to open the vessel at the flanges.
3. It is also necessary to provide insulation supports at the bottom of long vertical piping and above each pair of flanges in vertical piping to prevent insulation from slipping. These details are shown in "Specifications for Insulation".



ACCESSORIES

IV. INSULATION SECUREMENTS

- A. Insulation is secured in place by bands, wire, tape, studs and clips, adhesives, or a combination of them.

1. Bands are used for the securement of insulation on pipes where the diameter of the insulation exceeds 6" and for the securement to the surface of vertical vessels up to approximately 12'0" by single loop application. Vessels above 12'0" become difficult to bond in single loop applications, so the bands are attached to supports which divide the vessel into sections as shown in Supplement to Standard IS-31. Horizontal vessels of large diameter must also be divided into sections by supports to provide sufficient band lift to pull insulation into tight contact with the bottom of the vessel. Location of bottom supports is shown in Standard IS-36.

Insulation on heads of vessels is secured by either bands or wire, depending upon conditions. These conditions are, in general, stated in the "Thermal Insulation Specifications".

Bands can be obtained in various thicknesses and widths. Where necessary, due to heavy weights or large spans, 3/4" or 1" wide bands may be used. However, for most vessel applications, 1/2 x 0.020 stainless steel bands are sufficiently strong to secure insulation. Bands for pipe insulation shall be 3/8 x 0.015 stainless steel.

Clips for bands must fit the bands. For ease of application, the double pronged clip has been found to be the most suitable.

2. Wire is used for securement of high temperature insulation up to 12" outside diameter, on inner lay insulation, insulation on irregular shapes, and on flat surfaces. Where wire is used to secure pipe insulation, it is looped around the insulation and drawn tight as the ends are twisted together. The twisted ends are bent down and embedded in the insulation.

Wires used to secure insulation of flat or irregular surfaces must be fastened to blank nuts or pierced pins which are welded to the metal surface. Wires are brought out through the insulation then laced, criss-crossed, and drawn tight as ends are twisted together. Where insulation cements on outside of block insulation require wire netting reinforcement, the netting is drawn tight and secured with these same wires. Soft annealed, 18 gage, stainless steel wire is used except in special installations.



ACCESSORIES

IV. INSULATION SECUREMENTS - Continued

A. Continued

3. Bands and wire can be obtained in most metals. In the past, galvanized steel was used for insulation strap and wire, but its life proved to be only 3 to 7 years before it rusted to failure.

Stainless steel has proved the least expensive of metals for most insulation applications. In certain instances of highly corrosive atmosphere, such as in acid atmospheres, monel is better than stainless. Neither of these will cause galvanic attack on steel piping or equipment.

Aluminum bands and wire may be used with lightweight glass fiber insulation and aluminum jackets. If much weight is to be held in place, or if diameters are large, the width and thickness of aluminum bands must be increased. Likewise, aluminum wire must be of heavier gage than stainless steel wire.

As a general rule, copper bands or wire should be avoided, as contamination by acetone or acetates can form explosive copper acetylide.

4. Tape, vinyl backed, with glass filaments is used to install Foamglas up to 4" IPS outside diameter and for inner layers of Foamglas. Its use is restricted to relatively small diameters because insulation must be held tightly in place while the tape securement is installed. It cannot slip and draw tight as does wire and strap. Tape is also used on glass fiber and rigid urethane insulation up to large sizes as this type insulation will compress then spring back to shape as tape is wrapped around it.
5. Pins and clips are used to secure insulation to flat, large diameter, cylindrical surfaces and spherical surfaces. Because of direct passage through the insulation, their use is restricted to moderate and high temperature installations. Pins are welded to the surface to be insulated and the welding will damage the surface coating of vessel. For this reason, the vessel should be coated with "Dimetecote", as these weld spots will not destroy the effectiveness of the surrounding "Dimetecote" protection.



ACCESSORIES

IV. INSULATION SECUREMENTS - Continued

A. Continued

5. Continued

Pins can be pressed through glass fiber and Careytemp insulation, then welded to the metal surface. When pressed through calcium-silicate, diatomaceous earth, or magnesia material, a satisfactory weld cannot be obtained, as the dust from these materials, when heated, causes a gas which ruins the weld.

Insulation for vessels, with factory installed metal jackets, is attached to the sides by welded studs and nuts.

Lightweight pins and studs up to 1/4" diameter can be welded to metal surfaces by capacitor discharge welders. Larger than 1/4" diameter requires direct current power welding. Fasteners must be suitable for installation (metal, strength, and corrosion requirements) and for welding equipment and gun available.

6. Adhesives for temporary and permanent securement. Pamrod Code 550 is used to hold Foamglas in place on dished heads or irregular surfaces until outer bands or wires can be placed on its outer surface.

This hydraulic setting or catalytic type adhesive is used to bond insulation to metal. Due to temperature limitations, this is presently recommended only for attaching of Foamglas to moderate temperature spheres. Use of this type of application will probably grow as new and better adhesives are developed.

V. REINFORCEMENTS

- A. Reinforcements are used to add strength to insulations and to the weather barriers or finishes.

- B. Insulation reinforcement and reinforcement for mastics are most often 1" hexagonal 20-gage wire mesh. It is used over rigid insulation as a base for application of insulating cements. The insulating cement is troweled over the wire mesh. The pressure of this troweling forces the cement

**ACCESSORIES****V. REINFORCEMENTS - Continued****B. Continued**

under the wire and the mesh is effectively embedded in the cement. In the past, ordinary galvanized 1" mesh (chicken wire) was used; however, its life before rusting out was only 2 to 3 years. Presently, either Type 304 stainless steel or monel mesh is used. In installations of insulating mastic, the reinforcement is used only when the dried thickness of mastic is to exceed 1/4". In these applications, one coat of mastic is installed and allowed to dry. The mesh is then installed and stretched taut. The final coat of mastic follows. This provides a 3/16" to 1/2" thickness of reinforced mastic insulation.

- C. Weather barrier reinforcement is provided by high-strength glass cloth. The heavy mastics require an open weave cloth, approximately 10 threads per inch. The binder used to hold the weave in place must be compatible with the mastic. Starch binder is suitable for PVA mastics, whereas asphalt cloth binder should be used with asphaltic mastic. Other types of mastics must be checked with the cloth binders for suitability.

- D. Finish reinforcement may either be canvas or close weave cloth (20 threads per inch). Canvas should be used only where fire hazard is considered to be minimum.



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INSTALLATION REQUIREMENTS

- I. An installation must be studied to determine its requirements. These requirements are the total of the requirements through all the phases of construction and service.

II. TRANSPORTATION AND STORAGE REQUIREMENTS

After an insulation is manufactured it must be able to withstand the handling, stacking and abuses during shipping and storage. During this period it may be subjected to outdoor weather, and very damp atmosphere. In most instances the ability of a material to withstand these forces will be apparent when it is to the point where it is to be fabricated or installed.

III. FABRICATION REQUIREMENTS

When rigid insulation is preformed into shapes it should have the properties which allow it to be easily cut or formed with cut surfaces, and uncut surfaces, suitable for bonding with adhesives or cements. Completed covers must have sufficient strength, both the material itself and its joints, to withstand abuse of transportation and application. Material should be able to be cut without the causing of excessive or hazardous dust.

IV. FIELD ERECTION REQUIREMENTS

During application rigid materials must have sufficient strength to resist breakage, sufficient abrasion resistance that edges and corners are not worn round and have dimensional trueness and stability that they can be installed with precision.

Blanket insulations must be of sufficient tensile strength that when it is handled in application it does not pull apart. The compressive strength required depends upon its function in the insulation system.

Cements should be easily mixed and should have good wet adhesion to the surface.

As much insulation dust can be a health hazard if dust counts are of hazardous amounts, protective masks should be used.

If insulation is absorbant it must be kept dry during application until weather barrier is installed.



INSTALLATION REQUIREMENTS

V. SERVICE REQUIREMENTS

Service Temperature is most frequently one of the most deciding factors in the choice of insulation materials. As would be expected, the insulation must be suitable for the maximum temperature to which it is subject.

Another factor of service temperature is the manner in which it affects the vapor migration into or out from the insulation. Because vapor migration is a form of moisture, this effect will be presented under moisture requirements.

Physical Requirements of the installation should be investigated to determine if the insulation might be subjected to mechanical abuses such as being bumped or walked upon. Where insulation is supported by rings, it must have sufficient strength to be self support to the height to which is installed above each ring. If it applied on traced lines or between edge supports, then it must have sufficient tensile and shear strength to bridge these gaps.

Other physical forces such as abrasion and vibration imposed on it should be determined. Where movement occurs, the degree of flexibility necessary in the insulation necessary to accommodate that movement is essential.

One type of movement which must be considered in design is expansion and contraction of pipe and equipment and its relationship to the shrinkage or coefficient of expansion of the insulations.

As this is a basic problem of design, this subject is presented in more detail below.

Expansion, Contraction and Shrinkage

Expansion and contraction of vessels and pipe can cause serious damage to the thermal insulation and weather barrier covering. Other than the growth of high temperature vessels and pipes, the problem is further amplified because of the shrinkage of most high temperature insulations. The fact that the metal vessels and pipe expand with temperature increase and the insulation shrinks means that some method must be provided to allow for these dimensional changes. If not, the insulation and weather barrier will be fractured.

From an area standpoint, the size of the crack is insignificant. The amount of additional heat loss from heated vessels and pipes due to cracks would be quite small if all other factors remained the same. The big change is due to



INSTALLATION REQUIREMENTS

V. SERVICE REQUIREMENTS - Continued

Expansion, Contraction and Shrinkage - Continued

water which can enter the cracks. Wet insulation has a conductivity of approximately fifteen times that of dry insulation. Thus, besides the heat loss due to the crack, all the wet insulation becomes inefficient. In addition, each pound of water which enters a crack will absorb approximately 960 Btu's as it is vaporized by the heat of the vessel or pipe. These losses are significant.

Cracks in low temperature insulation and its weather-vapor barrier can cause even greater losses than in high temperature insulation. Entry of water causes ice formation which completely ruins low temperature insulation rapidly. Iced-up low temperature insulation will transmit approximately forty-five times more heat than dry conventional mass insulation. Thus it is important that either hot or low temperature insulation be kept free of cracks for efficient operation.

Expansion and Contraction Coefficients of Various Materials

The amount of growth of a vessel or pipe depends upon its coefficient of expansion and its temperature rise from ambient to service temperature. Of course, low temperature operation would be in reverse.

Most coefficients of expansion are given as coefficients at given mean temperatures, such as steel at 70F mean is 6.5×10^{-6} . These figures have little meaning from a field applicator's point of view. For this reason the following table is presented:

Thermal Expansion of Metals
Inches Per 100 Feet - Based on 70F Ambient

<u>Material</u>	<u>Operating Temperature °F</u>						
	<u>200</u>	<u>300</u>	<u>400</u>	<u>600</u>	<u>800</u>	<u>1000</u>	<u>1400</u>
Steel	0.99	1.82	2.70	4.60	6.70	8.89	13.34
Stainless steel	1.46	2.61	3.80	6.24	8.80	11.48	16.92
Aluminum	2.00	3.66	5.39	9.02			
Copper	1.51	2.69	3.89	6.40			

Unfortunately, most high temperature insulations shrink as they are heated. Only after this shrinkage occurs do they have a coefficient of expansion. The following table gives the shrinkage of some commonly used insulations:

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Expansion and Contraction Coefficients of Various Materials - Continued

Heat Shrinkage of Insulations Inches Per 100 Feet - Based on 70F Ambient

<u>Insulation</u>	<u>700</u>	<u>1000</u>	<u>1200</u>	<u>1500</u>	<u>1900</u>
Calcium Silicate	5.70	10.80	18.00		
*Cellular Glass	0				
Asbestos Fibers (Unibestos)	0.12	0.30	0.60		
Mineral Wool Block	7.00	9.80	12.00	15.50	24.00
Expanded Silica (Careytemp)	3.00	4.50	5.00	15.00	
Diatomaceous Silica	*	*	*	*	20.00

*Cellular glass has no high temperature shrinkage. Its coefficient of expansion is $0.0000046^{\circ}\text{F}$

From these tables, the magnitude of the problem can be determined. For example, if a steel column operating at 750F was 100 feet high, at ambient temperature it would increase approximately 6.2" in height when in operation. If calcium silicate insulation were the insulation, it would shrink 5.7". Thus the total difference in height between column and its insulation would be 11.9". This shows the need for expansion joints in the insulation to allow for the differential movement between the vessel and the insulation.

If the vessel were 10'-0" in diameter the change in diameter would be 0.62" (or 1.95" in circumference) and the circumferential change of insulation would be 1.8". Therefore, these differences demand a solution to prevent excessive cracks or insulation fracture. It must be further considered that any dimensional change affecting the insulation also affects the weather barrier.

Installation of Insulation on High Temperature Vessels

From the preceding, it can be understood that it becomes impractical to attempt to attach each piece of insulation directly to the shell of a vessel. Therefore, it is necessary to provide insulation supports on which the insulation will rest. Insulation supports for vertical vessels are shown in UCC Standard EG-64 and IS-31A. Insulation supports for horizontal vessels are shown in UCC Standard IS-36.



INSTALLATION REQUIREMENTS

V. SERVICE REQUIREMENTS - Continued

Installation of Insulation on High Temperature Vessels - Continued

It has been noticed that rigid block insulation installed on vessels, less than 6'-0" in diameter and less than 500F operating temperature, did not show cracks which could have been caused by circumferential expansion, even though the rigid curved sectorial insulation was strapped directly around the vessel. The probability was that the slight irregularities of the curved insulation and the insulation's relatively low compressive strength at low percentage of deformation combined to allow for growth of the vessel without outside insulation dimensional change.

Above these limits, cracks in the insulation and weather-barrier have occurred when the insulation was strapped to the vessel without provision for circumferential expansion. To provide an expansion space between the vessel wall, the vessel is first covered with a white glass wool blanket, installed with as little compression as possible. The curved sectorial insulation is cut to a 2" greater diameter than the vessel. The curved rigid insulation is placed over the wool blanket, then strapped in place. In effect, the rigid insulation is a cylinder of insulation, resting on the supports separated from the vessel by a compressible blanket. This system is satisfactory for vessels up to 12'-0" diameter and not over 1000F operating temperature. Should these limits be exceeded, other design methods must be considered.

Linear expansion joints must also be provided for vessels. The placement of insulation supports is a function of both the dimensional change of linear expansion and weight of insulation resting on support.

The remaining expansion problem concerning high temperature vessels is the movement of vessel nozzles, and lines connected to the vessel, in relation to the vessel insulation. The nozzle insulation covers should remain stationary with respect to the vessel insulation.

For this reason the nozzle covers are made oversize to allow movement of the nozzle and pipe within the insulation cover. Figures Nos. 3 and 4 show the application of insulation on blind nozzles and line nozzles.

Installation of Insulation on Hot Piping

The effect of expansion of hot piping will cause breaks in the insulation and its weather barriers. Due to size, and the fact that insulation manufacturers



INSTALLATION REQUIREMENTS

V. SERVICE REQUIREMENTS - Continued

Installation of Insulation on Hot Piping - Continued

produce insulation with clearance between outer pipe diameter and inner insulation diameter, circumferential expansion of the pipe causes no problem. Linear expansion does cause a problem.

Large vertical pipes (over 4" NPS), like vessels, require insulation supports. With the exception of the bottom support, an insulation expansion joint should be provided at each support and at the top elbow.

Horizontal pipe, although requiring no support, does require insulation expansion joints if the line has long straight runs between fittings. Again, it has been noticed that expansion cracks do not occur as frequently in horizontal piping as they do in vertical pipes and vessels. It is assumed that due to friction of the pipe covering resting on the line that the expansion movement is taken up slightly by movement of each section of covering, this causing a slight opening at each butt joint. However, when the movement is greater than the dimensional change which can be absorbed in the butt joints, then a fracture will occur. For this reason the expansion joints are placed further apart than for vertical piping. On single layer insulation an expansion joint is installed every 42 feet and on multiple layer insulation every 21 feet. The difference between single and multiple layer is, of course, because of the difference in temperature level. This expansion joint is shown in Figure 7.

Installation of Insulation on Cold Vessels

As the temperature of low temperature vessels goes down, the vessel shrinks in size. The vessel tends to pull away from the insulation. Similar to the application of high temperature rigid insulation, rigid low temperature insulation is installed as an isolated cylinder (and heads) tested on hung on insulation supports. In this application the space is also filled with glass fiber blanket. However, under these conditions the one-inch blanket which is installed on the vessel should be compressed to 1/2-inch by the rigid insulation as it is installed. By this method, as the vessel pulls away from the rigid insulation the fiber glass blanket is decompressed and holds the outer shell of cellular-glass firmly in its original position.

Actual installation of the low temperature cellular glass is quite similar to the installation of rigid high temperature insulation. The system of insulation supports is identical. Glass wool blanket is installed over the vessel.



INSTALLATION REQUIREMENTS

V. SERVICE REQUIREMENTS - Continued

Installation of Insulation on Cold Vessels - Continued

The cellular glass insulation is cut and fitted to be one inch greater in diameter than the vessel. When the rigid cellular glass is secured in position it compresses the glass wool 1/2-inch. Of course, on low temperature the outer layer of cellular glass joints are all vapor sealed to retard infiltration of moisture vapor.

The construction of compression joints at insulation supports, vessel flanges, are shown in Thermal Insulation Manual - Volume I, Specification 10-L, Figures 10-L-3 and 10-L-4. Vapor sealing of these joints is most important to obtain satisfactory service life.

Installation of Insulation on Cold Piping

The effect of contraction of cold piping will cause crushing or fracturing of rigid cellular glass insulation. This is due to the fact that the pipe becomes shorter as the operating temperature goes lower, and even though the insulation also becomes shorter, its reduction in length is not as great as the pipe. For this reason, insulation contraction joints must be placed in any long run of low temperature piping. Vertical contraction joints are shown in Specification 10-L, Figure 10-L-22, and horizontal contraction shown in Figure 10-L-19. Like the contraction joints of low temperature vessels, one of the most serious problems is to install and maintain an effective vapor barrier to retard the entry of moisture vapor.

Effect of Expansion and Contraction Motion on Weather-Vapor Barrier

From the previous discussion it is evident that the insulation is installed in such a manner as to try to eliminate as much movement as possible. However, even the best of applications cannot completely eliminate all motion of the rigid insulation. For this reason elasticity must be provided in the vapor-barrier and weather barriers.

Where motion is expected in low temperature insulation, the vapor barrier is specified to be a non-setting type sealer.

Motions affecting the weather barriers are handled in a number of ways. If the weather barrier is a stainless steel jacket, the metal is so installed as to have slip joints so constructed as to shed water, or joints which are sealed with non-setting sealer. All inside corners are caulked with a heavy fillet of caulking compound.



INSTALLATION REQUIREMENTS

V. SERVICE REQUIREMENTS - Continued

Effect of Expansion and Contraction Motion on Weather-Vapor Barrier
Continued

Investigation of failures of heavy-built PVA and acrylic mastic reveal that although the mastic itself was quite elastic, breaks were caused by the inability of the reinforcing membrane to elongate. Considerable research has taken place in trying to find a suitable reinforcing membrane. With the assistance of the Fibers Department, Dynel fabric having high elongation before tearing and suitable application properties was developed.

Tests proved that glass fabric reinforced membranes had a maximum elongation of 4-1/2% to 5% before the system would tear. Using Dynel reinforcing would provide elongation of 15% to 80% before the system would rupture. The wide spread of elongation, at which rupture occurs, is due to the difference of properties of the mastics tested and the temperature at which they were tested. Application of four years' duration show no joint tearing as was common with glass fabric reinforced mastic.

The use of Dynel fabric in the weather barrier does not eliminate the need for insulation expansion joints. These still are required for efficient operation of the insulation.

Chemical Requirements may be one of the necessities of insulation to resist product spillage or atmospheric contamination. Or, another chemical requirement may be that the insulation should be of such chemical nature that it does not damage the vessel or pipe to which it is applied.

Chemical Resistance of Insulations and Accessories

Where spillages occur or the atmosphere surrounding is contaminated, if at all possible the insulation selected should resist and not react with the chemicals involved.

In addition, under these conditions the insulation should resist saturation of these chemicals, for a number of reasons. If the chemical saturates the insulation the very presence of the chemical taking up air spaces reduces the thermal efficiency of the insulation. If the chemical is combustible, the saturated insulation can provide a large source of combustible fuel for a fire. If the chemical is toxic, the saturated insulation is toxic and almost no suitable means exists for its safe handling and disposal.



INSTALLATION REQUIREMENTS

V. SERVICE REQUIREMENTS - Continued

Chemical Resistance of Insulations and Accessories - Continued

The considerations for insulations are true of the weather barriers as well as the basic insulation.

Pipe and Vessel Surface Corrosion

Because insulation covers metal vessels or pipes, many think it will prevent rust or corrosion. This is not so. As a matter of fact, in many instances, the insulation may cause or accelerate rusting of the metal to which it is applied. Corrosion under insulation can be divided into three categories: (1) corrosion of steel, (2) stress corrosion of austenitic stainless steel, (3) attack by galvanic currents, and (4) direct chemical attack. The causes of such corrosion will be discussed and recommendations for proper use of insulation to minimize them will be made in this manual. However, specific recommendations for coatings or paints to retard rusting are part of the Painting Manual.

1. Corrosion

Rusting of steel is caused by the presence of air and water. The presence of acid accelerates the process of rusting. Insulation installed over a metal does not exclude air or moisture. Air is 90% of most mass insulations. Even the surfaces of sealed cell insulations are composed of broken cells containing air. Thus, air is always present to cause rusting.

Moisture gets to the metal surface in a number of ways. One is liquid water from rain or snow, which finds passage through cracks or holes in the weather barrier. Due to expansion and contraction of the pipe or vessel and the effects of weather, even the best of weather barriers will develop some leaks after a period of time. Another source of moisture is the insulation itself. Most high temperature insulations are hygroscopic and absorb moisture from the atmosphere. Unless the temperature of the steel surface is above 212F, and preferably above 250F, moisture from slight leakage and from absorbent insulation is sufficient to cause corrosion. Still another source of moisture is condensed water vapor from the ambient air. When the surface temperature of the steel is lower than ambient air, a low vapor pressure is set up at this surface. This causes the higher temperature moisture-laden vapor to be drawn to the pipe surface where it condenses to a liquid.

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V. SERVICE REQUIREMENTS - Continued

Pipe and Vessel Surface Corrosion - Continued

1. Corrosion - Continued

For these reasons, any steel operating at temperatures below 212F must be protected from corrosion regardless of the fact that it is insulated. One exception does exist. On piping or equipment which has continuous operating temperatures below 0 F, the tight frost film which forms on the surface excludes the air as a protective coating.

The choice of insulation materials and the tightness of the weather barrier do affect the rate of corrosion.

It is fundamental that the weather barrier be as water resistant as possible, and be properly maintained within practical economic limits, so as to preserve the insulation efficiency and limit the amount of moisture which causes rust. However, whenever a water leak does occur, the more absorbent the insulation, the greater the amount of water it will soak up and spread over a large area. In addition to this problem in service, hygroscopic, absorbent insulation picks up moisture in storage and during application. For these reasons it is advisable to use non-absorbent, non-hygroscopic insulations on services below 250F, or in cyclic or intermittent service, such as steam tracing on a bi-yearly cycle, where the lower temperature of the cycle is less than 212F.

When service temperatures are less than ambient temperature, vapor resistance of the insulation becomes a factor influencing the amount of moisture which can get to the steel surface. In these installations, the lower the vapor transmission rate of the insulation, the less moisture it will allow to reach the metal surface.

From the previous statements, it might be construed that if the operating temperature is above 250F, the problem of corrosion is eliminated. Unfortunately, this is not so. The previous statements are based upon relatively small amounts of moisture entering the insulation. In such cases, temperatures above 250F can provide sufficiently high vapor pressure that the steel surface remains dry. Where water can get directly to a steel surface and is then vaporized, rusting is greatly accelerated at elevated temperature. This occurs on uninsulated steel at high temperature, or poorly waterproofed, insulated piping underground. To prevent fast rusting of underground insulated piping, a water-tight jacket, casing, or protective system must be provided to prevent a head of water getting to the pipe surface.



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V. SERVICE REQUIREMENTS - Continued

Pipe and Vessel Surface Corrosion - Continued

1. Corrosion - Continued

For the above mentioned reasons the temperature of vessels and pipes are very important in regard to surface corrosion and where corrosion protection is required they should be painted or coated in accordance with Painting Manual. On some vessels which have temperature gradients the problem is even more difficult, especially those which have high temperature at bottom and low temperature at top. With these it is essential that the various temperature zones be isolated from each other and each properly protected.

The chemical composition of insulation also affects the corrosion of steel. As previously stated, acid causes steel to rust, therefore the insulation should be neutral or slightly alkaline. The pH should be between 7 and 11.

The chemical composition of soils affects the corrosion of underground conduits protecting insulation of buried pipes. Where insulated conduit pipe is in corrosive oxidizing or reducing soils or cinders, the conduit itself must be protected by galvanizing or other suitable corrosion-resistant coating, and where soil conditions warrant it should be cathodic protected. Otherwise, the conduit will rust out and cease to waterproof the insulated line. Aluminum should never be used underground for conduit due to the difficulty of successfully applying cathodic protection.

Corrosion of Substrate Metal

Other than ordinary rusting, the insulation used should not contain chemicals that attack the metal to which they are applied. As high temperature insulations are more often applied to steel than other metals, most are slightly alkaline. Where aluminum is the metal to be insulated, the insulation should be neutral or slightly acid, where possible. This means that the pH should be less than 8. Where this is not possible, a corrosion-resistant coating must be installed between the aluminum and the insulation.

In contaminated atmospheres, any absorbent insulation can gather the chemicals from the air and condense and concentrate them. In many instances these concentrations will not be equal over the entire surface and will result in pitting of the metal by single surface cell galvanic action, termed concentrated in cell attack.



INSTALLATION REQUIREMENTS

V. SERVICE REQUIREMENTS - Continued

Corrosion, Stress Cracking of Austenitic Stainless Steel

When insulations which contain water-soluble chlorides become moist, they can cause stress-corrosion of stressed austenitic stainless steel to which they are applied. Most high temperature insulations such as diatomaceous earth, calcium silicate, 85% magnesia, phenolic bonded glass fibers, and water-mixed cements contain these water soluble chlorides. Absorbent insulations which contain no chlorides may pick up chlorides from the atmosphere, or chlorides can get behind one insulation from leaks, etc., especially in coastal areas.

The stress corrosion cracking of austenitic stainless steel takes place in the presence of concentrated chlorides and when the stainless is under tensile stress, residual or applied. The corrosive environment may be very mild; however, under the influence of stress, the corrosion concentrates along few paths and the penetration of the steel can be rapid.

Moisture absorbed by the insulation from the atmosphere, or from rain, leaches out the water soluble chlorides. At the hot surface of the pipe or equipment, these are concentrated by the evaporation of the water. In this way the environmental conditions necessary for stress corrosion of austenitic stainless steel are established under insulation. Although temperature limits at which stress cracking occurs have not been established, the most rapid failure seems to occur when the pipe or equipment is operating between 122F and 572F.

Tests have revealed that some insulations do contain sufficient water soluble chlorides to cause stress corrosion of austenitic stainless. Such insulations should not be used, however; in most instances the major source of difficulty is from pickup of chlorides from the atmosphere.

The Thermal Insulation Specifications for Materials and application suitable for use on austenitic stainless steel are designated by SS on their number. The insulation and accessories called for in such specifications have been tested and found free of chlorides which would contribute to causing stress corrosion. Care should be exercised that no substitute of an accessory is used without checking its suitability for the service. However, the use of proper insulation materials will not prevent stress corrosion if the chlorides can be absorbed from the atmosphere, spillage, or water.



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V. SERVICE REQUIREMENTS - Continued

Corrosion, Stress Cracking of Austenitic Stainless Steel - Continued

For these reasons it is recommended that:

1. Thermal insulations and accessories which do not contribute to stress corrosion (designated SS in the Thermal Insulation Specifications) be used on stainless steel.
2. Austenitic stainless steel equipment and stress areas on stainless steel piping such as the surface beneath backup flanges and all critical piping be coated with protective coating in accordance with UCC Painting Specifications prior to installation of insulation.

VI. MOISTURE REQUIREMENTS

Moisture Conditions to which insulation is to be subjected determine the properties the insulation should have, how it should be installed and how it should be protected.

When dry, most insulations are quite effective. When insulation becomes wet, or damp, all or part of the small air spaces become filled with water. Heat transmission through the water filled spaces then approaches the rate of conductivity of liquid instead of air.

Insulation must be protected from two forms of moisture, (1) that in the liquid state and (2) that in the vapor state. Thermal insulation, of any temperature range, located outdoors where it is subjected to rain, sleet, or snow, must be protected from liquid moisture by a weather barrier. Indoor applications, in most chemical process plants, must also be protected by weather barriers as it is common practice to wash down vessels and pipe with a water stream when spillage occurs. Most high temperature insulations are highly absorbent and if they once become wet considerable heat is necessary to dry them out. Where absorbent insulations are used on vessels and lines which operate below 250F, it is virtually impossible to dry them out if they once become wet. For this reason, moisture resistant insulation is recommended to be used where service temperatures are below 250F.

Wherever insulation is used on services at temperatures below ambient, not only must it be protected from liquid moisture, but also from moisture in the vapor state. Moisture in the vapor state is a gas, and in this state it will



INSTALLATION REQUIREMENTS

VI. MOISTURE REQUIREMENTS - Continued

always seek to equalize any pressure difference by flowing from the high pressure area to the low pressure area. Whenever a barrier exists between a high and low pressure area, the vapor will seek all means to reach the lower pressure by going through the insulation itself, through joints and cracks in the insulation or around ends. When insulation is applied to equipment or piping which operates at temperatures less than ambient, this lower temperature causes a lower vapor pressure to exist at this point than exists in the ambient air. This vapor force is pressing inward on the entire outside area of the insulation, seeking any crack, hole or weakness to penetrate. If the vapor does penetrate, as it encounters lower temperatures on its way to the inner surface, the vapor will reach its dew point. At this point the vapor will condense to a liquid. This water will then replace some of the air in the air spaces. As condensation continues, the air spaces in the insulation become filled with water or frost, and the thermal conductivity is increased, with resultant loss of insulation efficiency. Therefore, wherever insulation is used on low temperature applications, provision must be taken to prevent it being ruined by moisture vapor.

One method of fulfilling this application requirement is to use vapor resistant insulation. However, with vapor resistant insulation the weak point is in the joints. These joints have to be vapor sealed. This is also true of slip joints which are provided to take care of expansion and contraction.

Where it is necessary to use insulation which is limited in its vapor resistance, it is necessary to provide a vapor barrier to protect the insulation. The barrier may be of mastic, tapes, jackets or metal outer container, depending upon individual requirements.

Another method used for vapor control is to construct an inner and an outer vessel with an insulated space between each. This space is kept dry by gas purge or partial vacuum. This method can be the most efficient of all insulating systems; however, in most instances, because of its expense, it can be warranted only for the most critical of low temperature installations.

VII. BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

Thermal Requirements on an installation determines the resistance to heat flow which the insulation must provide, the control of temperature required, or the retarding of temperature rise. The need for insulation may be any one or several different requirements.



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VII. BASIC CONSIDERATIONS FOR SELECTION OF THICKNESSES OF INSULATION Continued

Process Insulation Thickness Requirements

For any particular temperature there is no single correct thickness of insulation. The proper thickness depends on many factors. Some of these factors are location indoors or outdoors, ambient temperature, solar exposure, cost of heat, cost of insulation, process requirements, hours of operation, rate of amortization, safety, dew point, freezing point of material, flash point of material, condensation point of material. Any one single factor may be the paramount one for a given problem. However, in most instances, a combination of many of the factors decides the proper insulation thickness.

Elevated Temperature - External Insulation

Economic Consideration is based on savings of energy, as heat energy has a monetary value. However, there is no direct conversion from btu's into dollars, as the cost of heat depends upon many factors, such as its form, location and use. Insulation also has monetary value, and like heat its cost varies. However, at some thickness of insulation the total cost of heat loss per year, plus the cost of insulation per year, adds up to the lowest possible cost per year. The thickness which provides this lowest possible cost per year is the economic thickness of insulation.

Solar Radiation Requirements

Control of solar radiation is another application where time is a factor. Where it is necessary to prevent the vapor or liquid in a pipe or vessel being heated above a certain temperature by solar radiation, the correct insulation and correct thickness of this insulation must be installed to produce the needed time lag. In many instances a combination of reflective and mass insulation becomes necessary to accomplish the desired results.

Safety Requirements

Fire protection of pipe and vessels require not only that an insulation have sufficient strength to withstand ordinary abuse, but should also withstand explosion shock of considerable force. It is required to withstand the high temperature of the fire, then the thermal shock and high physical force of a powerful stream of water. It is required to have a minimum of shrinkage at high temperature to prevent gaps which in turn would allow the fire to reach the exposed metal. This service requires the retardation of the flow of heat for as long a time as possible.



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VII. BASIC CONSIDERATIONS FOR SELECTION OF THICKNESSES OF INSULATION Continued

Safety Requirements - Continued

Protection of personnel from burns from hot surfaces is a major function of thermal insulation. Due to its conductivity, metal will cause burns at a temperature where a mastic or fibrous surface does not. Metal surfaces, for safety should not exceed 140F, whereas mastic and fibrous surfaces are safe up to 150F. The emissivity of the surface material has a direct effect on the surface temperature. On insulated hot services the lower the emissivity of the outer weather barrier the higher the surface temperature will be. For this reason care must be exercised in the use of highly reflective metals on hot service where they are within possible personal contact.



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RELATION OF REQUIREMENTS TO PROPERTIES OF MATERIALS

The properties of an insulation are what makes it suitable to fulfill the requirements imposed on it by any specific installation. The first duty of an engineer is to determine all that he can about the facts of an installation. All functions, including installation, service, economics, safety, and their requirements should be considered. A table listing the basic functions and their requirements as related to the insulation properties follows:

<u>Basic Function</u>	<u>Requirement</u>	<u>Insulation Properties</u>
Transportation and Storage	To withstand transportation and handling without excessive breakage	Compressive strength Flexural strength Shear strength Tensile strength Abrasion resistance Weather resistance
	Economic handling	Density
	Protection from moisture	Absorptivity Capillarity
Fabrication	Dimensional	Shape and size available
	Fitting	Straightness Smoothness Tolerances
	Cutting or forming	Compressive strength Flexural strength Shear strength Tensile strength Abrasion resistance Hardness Cutting characteristics Dusting Dust hazard
	Joining	Surface dusting Compatibility with adhesive or cement Resistance to surface shear Comparable joint strength
	Application	Dimensional trueness Cutting characteristics Dusting Density Flexural strength Breaking strength
Field Erection		

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<u>Basic Function</u>	<u>Requirement</u>	<u>Insulation Properties</u>
	Securement	Shear strength Compressive strength Abrasion resistance
	Resistance to weather during application	Absorptivity Capillarity Effect of moisture on other properties
	Finishing	Compatibility with cements, sealers, adhesives, or weather-barrier mastics
<u>In Service</u>		
Physical	To withstand deadloads, live loads, impact and mechanical wear. To withstand forces of expansion and contraction Vibration	Compressive strength Flexural strength Shear strength Tensile strength Abrasion resistance Vibration resistance
Chemical	To be compatible with metal to which it is applied. Resistance to contamination by spillage, or atmosphere	Alkalinity, ph Soluble chlorides Resistance to acids Resistance to caustics Resistance to solvents
Moisture	Resistance to moisture in liquid or vapor forms, or both.	Absorptivity Capillarity Hygroscopicity Vapor permeability
Electrical	Resistance to flow of galvanic current set up by dissimilar metals	Dielectric constant (when dry, when wet)
Thermal	Maximum temperature Minimum temperature Cyclic temperature	Continuous temperature- High and low temperature lim. Cyclic temperature-high & lo temperature limit

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<u>Basic Function</u>	<u>Requirement</u>	<u>Insulation Properties</u>
<u>In Service - Contd</u>		
Thermal - Contd	Dimensional change	% linear shrinkage Coefficient of expansion
	Resistance to heat flow	Conductivity
	Heat buildup	Diffusivity
	Heat storage	Specific heat density
<u>Economic</u>		
Investment Cost	Material	Price of pipe covering Price of block Price of accessories
	Shipping and handling	Weather resistance of insulation Weather resistance of packages Ability to be mechanically handled
	Fabrication	Speed of cutting and fitting Time required for cementing
	Application	Speed and ease of installing Weather resistance Suitability for weather and vapor barrier
Maintenance Cost	Continuing	Ability of insulation to function under service replacement
	Changes or repair of equipment and piping	Reuseability Speed of removal and replacement
Operational Savings	Savings in energy	Conductivity Resistance to moisture
Insurance Cost	Overhead cost	Potential increase or decrease of hazard Fire resistance Fire retardance

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<u>Basic Function</u>	<u>Requirement</u>	<u>Insulation Properties</u>
<u>Hazards</u>		
Fire - Contribution to	Flammability	Flash point Fire point Self-ignition point Fuel contribution
	Contaminates, in contact with insulation	Absorptivity Hygroscopicity Lowering by contaminants of flash, fire and self-ignition points
Fire - Protection from	To protect pipe, equipment or steel	Diffusivity Specific heat Density Conductivity Resistance to thermal shock Resistance to water under pressure
	Personnel Protection	Conductivity of insulation Conductivity of weather-barrier Emissivity of weather-barrier
	Storage of toxic contaminants	Absorptivity Hygroscopicity Capillarity

After the installation requirements are determined, it is necessary to review the properties of obtainable materials to select the one which most nearly satisfied all the requirements.



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DEFINITIONS

Exact thermal definitions are not presented in standard dictionaries. To prevent misunderstanding of terms used in insulation engineering, the following terms are defined as to their thermal meaning.

Absolute pressure (psia) - Atmospheric pressure plus gauge pressure. The common units of measure are pounds per square inch.

Absolute temperature (T) - Temperature measured on one of the absolute scales (Kelvin or Rankine)

Absorptivity (α) - The ratio of the radiant flux absorbed by a body to that incident upon it. This term is restricted to materials having opaque, optically flat surfaces. (highly polished)

Absorptance (α) - The ratio of the radiant flux absorbed by a body to that incident upon it.

Ambient air - Generally, the atmospheric air surrounding an object or a surface.

Black body - An ideal, perfect emitter and absorber of thermal radiation. It emits radiant energy at each wave length of the maximum rate possible as a consequence of its temperature, and absorbs all incident radiant flux while reflecting none.

Blanket Insulation - A flexible material which will retard heat flow and can be readily conformed to curved or irregular surfaces, suitably bound together to provide units of substantial area for handling and application, and which may be faced or reinforced with confining media.

British Thermal Unit (BTU) - The quantity of heat required to raise one pound of water one °F from and at 32°F and 29.92 inches mercury pressure.

British Thermal Unit, mean (Btu) - The mean Btu is 1/180 of the quantity of heat required to raise the temperature of one pound of water from 32F to 212F at 29.92 inches mercury pressure. (Does not include latent heat.)

British Thermal Unit, I. T. (Btu) - Heat unit established by definition. One I. T. Btu equals 251.996 I. T. calories or 778.26 ft lbs. It is close in value to the other types of Btu's and is now commonly used for heat transfer work.

Calorie - The quantity of heat required to raise one gram of water one °C from and at 0°C and 760 millimeters mercury pressure. Sometimes called gram calorie or small calorie.

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At which the condensation of water vapor begins for a given pressure, as the temperature of the water vapor at that pressure corresponds to 100 percent relative humidity at constant pressure.

An important factor in problems that involve unsteady heat conduction is obtained by dividing thermal conductivity by the square root of the thermal diffusivity of the materials. For materials of the same thickness, heating or cooling time is directly proportional to the thermal diffusivity.

Temperature as shown by an ordinary thermometer.

Ratio of heat saved by the insulation to the heat lost by the insulation is not used.

For an opaque material having a highly polished surface, the emissivity is a result of its temperature. It is measured as the ratio of the radiant energy emitted by the material to the corresponding energy emitted by a black body at the same temperature. The emissivity is equal to its absorptivity value.

For an opaque material to emit radiant energy as a result of its temperature is the same as emissivity except that the surface is not a black body.

Directional emissivity (ϵ_n) - Takes into account the solid angle and per unit of projected area of a surface. May be from the surface (usually normal). May be

Spherical emissivity (ϵ_h) - Takes into account the total area of a source in all the radial directions. May be total or special emittance.

Spectral emissivity (ϵ_λ) - Takes into account only the radiant energy per unit of wavelength interval.

Total emissivity (ϵ_t) - Takes into account the radiant emission in all wavelengths. See Emittance.

Calorie: The amount of heat required to raise the temperature of one gram of water one degree Celsius at a pressure of 760 millimeters mercury pressure.

Calorie: One I. T. calorie equals 1/860 of a Btu. Only for heat transfer work.

Also called kilocalories or kilograms.

Calorific value: The amount of heat transferred from a unit area of a fuel in unit time for a unit temperature difference. Common units are Btu per square ft.

Calorific value: The amount of heat transmitted through a unit area of a material when a unit temperature difference is maintained across it.

Calorific value: The amount of heat transmitted from one part of a body to another part in unit time, without displacement of the body.

Calorific value: The amount of heat transmitted between two specified isothermal surfaces, per unit difference between the temperatures, for consideration. Usually expressed in Btu per square ft.

Calorific value: The amount of heat flow through a unit area of homogeneous material when a unit temperature difference is maintained in the direction perpendicular to the area.

Convection: The transfer of heat from place to another by the circulation of the fluid. Convection can be natural or forced. Natural convection is caused by a density difference in the fluid.

Calorific value: The amount of heat flow through a unit area of homogeneous material when a unit temperature difference is maintained in the direction perpendicular to the area.

Calorific value: The amount of heat flow through a unit area of homogeneous material when a unit temperature difference is maintained in the direction perpendicular to the area.

DEFINITIONS

which the condensation of water vapor begins for a given pressure, as the temperature of the water vapor at that pressure corresponds to 100 percent relative humidity at constant pressure.

An important factor in problems that involve unsteady-state heat transfer is obtained by dividing thermal conductivity by the square root of the thermal diffusivity of the materials. For materials of the same thickness, heating or cooling time is directly proportional to the square of the thermal diffusivity.

Temperature as shown by an ordinary thermometer.

Ratio of heat saved by the insulation to the heat lost when no insulation is not used.

For an opaque material having a highly polished surface, the emissivity is a result of its temperature. It is measured as the ratio of the radiant emission of the material to the corresponding emission of a black body at the same temperature. The emissivity is equal to its absorptivity value.

For an opaque material to emit radiant energy as a re-radiation, the emissivity is the same as absorptivity except that the surface is a reflecting surface.

Directional emissivity (ϵ_{θ}) - Takes into account the solid angle and per unit of projected area of a surface. May be from the surface (usually normal). May be

Spherical emissivity (ϵ_{θ}) - Takes into account the total area of a source in all the radial directions. May be total or special emittance.

Spectral emissivity (ϵ_{λ}) - Takes into account only the radiant emission per unit of wavelength interval.

Total emissivity (ϵ_t) - Takes into account the radiant emission over all wavelengths. See Emittance.

Use the temperature of one gram of water at 4 millimeters mercury pressure.

One. One I. T. calorie equals 1/860 of a Btu only for heat transfer work.

Also called kilocalories or kilogra.

Heat transferred from a unit area of a surface in unit time for a unit temperature difference. Common units are Btu per square ft,

of heat transmitted through a unit area for a unit temperature difference.

Heat that flows from one part of a body to another part in contact with it, without displacement of matter.

Heat flow between two specified isothermal surfaces, per unit difference between the temperatures for consideration. Usually expressed in Btu per square ft per degree F.

Heat flow through a unit area of homogeneous material when a unit temperature difference is maintained in the direction perpendicular to the area.

Heat transfer by the circulation of a fluid to maintain the heat. Convection can be natural or forced convection caused by a density difference in the fluid.

Volume of a material.

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Dew point - The temperature at which the condensation of water vapor begins for a given condition of humidity and pressure, as the temperature of the water vapor is reduced. The dew point temperature corresponds to 100 per cent relative humidity for a given absolute humidity at constant pressure.

Diffusivity, thermal (α) - An important factor in problems that involve unsteady conditions of heat flow. Its value is obtained by dividing thermal conductivity by heat capacity. ($\alpha = k/\rho c$). For materials of the same thickness, heating or cooling time is inversely proportional to the thermal diffusivity of the materials. For materials having the same diffusivity, heating time is directly proportional to the square of the thickness.

Dry bulb temperature - The air temperature as shown by an ordinary thermometer.

Efficiency, insulation (ϵ) - The ratio of heat saved by the insulation to the heat dissipated by the bare surface when insulation is not used.

Emissivity (ϵ) - The ability of an opaque material having a highly polished surface (optically flat) to emit radiant energy as a result of its temperature. It is measured by the ratio of the rate of radiant emission of the material to the corresponding emission of a perfect emitter, or black body at the same temperature. The emissivity value of a material is the same as its absorptivity value.

Emittance (ϵ) - The ability of an opaque material to emit radiant energy as a result of its temperature. This is the same as emissivity except that the surface is not necessarily polished for the material.

Emittance, directional (or directional emissivity) (ϵ_{θ}) - Takes into account the rate of radiant emission per unit of solid angle and per unit of projected area of a source in a stated angular direction from the surface (usually normal). May be total or spectral emittance.

Emittance, hemispherical (or hemispherical emissivity) (ϵ_h) - Takes into account the rate of radiant emission from a unit area of a source in all the radial directions of the overspreading hemisphere. May be total or special emittance.

Emittance, spectral (or spectral emissivity) (ϵ_{λ}) - Takes into account only the radiant emission from a unit area of a source per unit of wavelength interval. See Emittance.

Emittance, total (or total emissivity) (ϵ_t) - Takes into account the radiant emission from a unit area of a source in all wavelengths. See Emittance.



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Flame point - The temperature at which the vapors from a combustible material will ignite from an external spark.

Flash point - The temperature at which the vapors from a combustible material will ignite from an external spark and continue to burn.

Foot-pound - A unit of work. It is the work done in lifting a mass of one pound a distance of one foot.

Gauge pressure (psig) - Pressure measured from atmospheric pressure as a base.

Gray body - A body having the same spectral emittance at all wavelengths (less than unity).

Finishing cement - A prepared composition, in dry form, comprising fibrous or powdery materials, or both, which when mixed with a suitable proportion of water to develop a plastic consistency, readily adheres to thermal insulation over which it is applied, and dries to form a smooth, hard, protective surface for application of paint, fabric, or waterproofing.

Heat - A transient form of energy. It is the energy in transition from one body to another as a result of a temperature difference existing between the bodies.

Heat capacity - Ability of a substance to store and retain heat. Value is equal to the specific heat multiplied by its density.

Horsepower - A unit of the time rate of doing work. Equivalent to 550 foot-pounds per second or 2545 Btu per hour.

Insulation, thermal - A material having a relatively high resistance to the flow of heat per unit of thickness and used principally to retard the loss or gain of heat in pipes, vessels, equipment, appliances, and buildings.

Joule's equivalent (J) - A conversion factor between heat units and mechanical units.
 $J = 778.2 \text{ foot-pounds/Btu.}$

Latent heat - The heat absorbed or rejected by a substance in changing from solid to liquid, liquid to vapor, or vice versa, without any change in temperature. The values for water at atmospheric pressure are: Water to steam - 970.3 Btu per lb; water to ice - 143.4 Btu per lb.



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Length of path of heat flow (L) - The distance heat flows through a solid from a surface at one temperature to a surface at a lower temperature.

Mean temperature - The arithmetic mean of inner and outer surface temperatures of insulation. Mean temperature is used to select a value for conductivity in heat loss calculations.

Mechanical equivalent - Same as Joule's equivalent.

Micron - One one-thousandth of a millimeter.

Perm - A measure of vapor-transmission rate. Defined as one grain of water vapor per square ft/hour/inch of mercury-pressure difference.

Permeability - A rating of a material giving the amount of water vapor that will pass through one square foot of one inch thickness of the material. An accepted unit of permeability is a perm-inch, or 1 grain/inch/sq ft, hr, inch of mercury.

Permeance - Same as permeability except that it is a rating of the material of the thickness tested. An accepted unit of permeance is a perm, or 1 grain per square ft/hr/inch of mercury. Also stated as water vapor transmission divided by vapor pressure differential.

Radiance - The rate of radiant emission per unit of solid angle, and per unit of protected area of a source, in a stated angular direction from the surface (usually normal).

Radiation, thermal - The transmission of heat energy through space from one object to another by means of electromagnetic waves of very long wavelengths. Radiant energy may be absorbed, becoming thermal energy, and cause an increase in temperature of the absorbing body.

Radiant flux density (W) - The rate of radiant energy emission from a unit area of a source in all the radial directions of the overspreading hemisphere.

Reflectance - The ratio of the radiant flux reflected by a body to that incident upon it. For an opaque body, the sum of the reflectance and absorptance for the incident radiation is unity.

Reflective insulation - Thermal insulation depending for its efficiency in large part on reduction of radiant heat transfer across spaces by use of one or more surfaces of high reflectance and low emittance.



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Reflectivity - The same as reflectance except it is restricted to apply to materials having opaque, optically flat surfaces.

Refrigeration, ton of - The removal of heat at the rate of 12,000 Btu per hour. This figure is obtained from the commercial unit of refrigeration capacity which is the heat required to melt 2000 pounds of pure ice at 32F to water at 32F in 24 hours.

Relative humidity - The ratio of the actual water vapor in the air to the amount which could be in the air of saturation.

Resistance, unit thermal (R_a) - The reciprocal of unit thermal conductance.

Resistance, thermal (R) - The reciprocal of thermal conductance.

Resistivity, thermal - The reciprocal of thermal conductivity. A specific property of a material.

Resistance, surface (R_s) - The reciprocal of surface conductance.

Specific gravity - The ratio of the mass of any volume of a material to the mass of an equal volume of water at 60F. The specific gravity of a gas may also be expressed as the ratio of the mass of any volume of gas to the mass of an equal volume of oxygen, hydrogen, or air at the same temperature and pressure as the gas.

Specific heat (c) - The number of heat units required to raise the temperature of one unit mass of the substance one degree under specified conditions, such as constant pressure, constant volume, etc.

Temperature - The thermal state of matter regarding its tendency to communicate heat to matter in contact with it. If there is no temperature difference, no heat will flow on contact.

Temperature difference - A potential force causing the actual transfer of heat energy.

Thermal conductances (C) - See Conductance, thermal.

Thermal conductance, unit (C_a) - See Conductance, unit thermal.

Thermal conductivity (k) - See Conductivity, thermal.



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Thermal diffusivity (d) - See Diffusivity, thermal.

Thermal resistance (R) - See Resistance, thermal.

Thermal resistance, unit (R_a) - See Resistance, unit thermal.

Thermal resistivity - See Resistivity, thermal.

Thermal surface coefficient of heat transfer (h) - The heat flow rate per unit of area per degree temperature difference across a boundary surface. Also called surface conductance.

Transmission, heat - Heat transferred per unit of time. A general term for heat travel.

Transmittance, thermal (U) - Also called overall coefficient of heat transfer or U factor. The time rate of heat flow per unit area under steady conditions from the fluid on the warm side to the fluid on the cold side for a unit temperature difference of the fluids. The common unit is Btu per square foot, hour, °F.

U Factor - See Transmittance, thermal.

Vapor barrier - A material having a high resistance to the passage of water vapor. It is applied to surfaces to prevent vapor migration to regions of low temperatures where undesirable condensation may occur.

Vapor resistance - Reciprocal of Permeance.

Vapor resistivity - Reciprocal of Permeability. Resistance per inch thickness to the passage of water vapor.

Volume fluid flow rate (Q) - Rate of flow in units of volume per unit of time, such as cubic feet per hour.

Water vapor permeability - See Permeability.

Water vapor transmission, rate of (WVT) - The rate of water vapor transmission of a body between two specified parallel surfaces in the time rate of water vapor flow normal to the surfaces, under steady conditions, through unit area, under conditions of test. An accepted unit of WVT is 1 grain per square foot, hour (with test conditions stated).



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Wet bulb temperature (t_w) - The temperature given by a thermometer when the bulb is covered with an absorbent material wet with water and exposed to the atmosphere. The standard speed of air movement past the wet wick is 10 feet per second, or more.

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SYMBOLS AND ABBREVIATIONS

A	Area	g	Acceleration of gravity
A_l	Projected area of a body	H	Height, ft
A_i	Inside area	H_s	Net radiation, Btu/hr, sq ft, at given latitude (Solar)
A_m	Mean area	h	Conductance of air film
A_o	Outside area	hr	Hour
B	Cost of insulation per square foot per inch thickness per year	h_1	Conductance of inner or first air film
B_p	Cost of insulation per linear foot per inch thickness per year	h_2	Conductance of second air film
Btu	British thermal unit	IPS	Iron pipe size
Btuh	British thermal unit per hour	ID	Inside diameter
C	Conductance (area), Btu/(hr)(°F)	J	Joule's constant
C_a	Unit conductance (area), (Btu/(hr)(°F)	k	Thermal conductivity, Btu/(sq ft)(°F)(hr/inch thickness)
C_e	Unit conductance (area), (Btu/(hr)(°F)	k_1	Conductivity of inner or first insulation material
C_s	A constant depending on shape of surface	k_2	Conductivity of second insulation material
°C	Temperature in degrees Celsius (Centigrade)	k_3	Conductivity of third insulation material
c	Specific heat, Btu/(lb)(°F)	L	Length of heat transfer path (thickness of insulation)
cu ft	Cubic foot or cubic ft	L_1	Thickness of inner or first layer of insulation
D	Diameter	L_2	Thickness of second layer of insulation
d	Diameter	L_3	Thickness of third layer of insulation
d_1	Inside diameter of insulation, inches	lb	Pound or pounds
d_2	Outside diameter of insulation, inches	lin	Linear
d_p	Outside diameter of pipe, inches		
e	Insulation efficiency		
°F	Temperature in degrees (Fahrenheit)		
ft	Foot or feet		
G	Flow rate (mass velocity), lb/(sq ft)(hr)		

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M	Cost of heat, in dollars per million Btu	R_s	Thermal resistance of air film to the flow of heat
NPS	Nominal pipe size	$1/R$	Thermal conductance, same as C
OD	Outside diameter	$1/R_a$	Thermal conductance per unit of area
psi	Pounds per square inch	$^{\circ}R$	Temperature in degrees Rankine
psia	Pounds per square inch absolute pressure	r	Radius of pipe insulation, inches
psig	Pounds per square inch gauge pressure	r_1	Inside radius of inner pipe insulation, inches
Q	Total quantity of heat transferred	r_2	Outside radius of inner insulation and inside radius of outer insulation, inches
Q_f	Volume rate, fluid rate of flow by volume	r_3	Outside radius of outer insulation
q	Heat flow rate for a particular setup. Btu/hr (total per unit area)	sq	Square
q_a	Heat flow rate per unit area. Btu/hr, sq ft; or heat flow rate by convection and radiation per unit area	T	Absolute temperature, $^{\circ}R$ or $^{\circ}K$ or $= ^{\circ}F + 459.6$
q_c	Heat flow rate across air film by convection under still air conditions	T_1	Absolute temperature of first surface
q_{ca}	Heat flow rate by convection for Δt	T_2	Absolute temperature of second surface
q_{cv}	Heat flow rate across air film by convection of a given velocity (V)	T_A	Absolute temperature of ambient air
q_d	Heat flow rate for a unit of pipe length, Btu/(lin ft)(hr)	t	Temperature, $^{\circ}F$
q_r	Heat flow rate across air film by radiation	t_a	Ambient air temperature or outside air temperature
q_{ra}	Heat flow rate by radiation from ambient air at a temperature t_a to insulation surface at temperature t_2	t_{av}	Average ambient air temperature
R	Reynolds number	t_1	Air temperature inside of insulation
R	Thermal resistance	t_m	Mean temperature
R_a	Thermal resistance of a unit area		

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t_1	Temperature of inner surface of inner insulation; or operating temperature of equipment of pipe ($^{\circ}\text{F}$)	WVT	Water vapor transmission
t_2	Temperature of outer surface of inner insulation and inner surface of outer insulation. Temperature of outer surface of insulation if only one material. ($^{\circ}\text{F}$)	w	Flow rate, lbs/unit of time
t_3	Temperature of outer surface of outer insulation when two materials are used ($^{\circ}\text{F}$)	Y	Number of hours of operation per year
t_o	Operating temperature	α	Absorptivity of absorptance
t_s	Temperature of steam	α^d	Thermal diffusivity
t_w	Temperature of water	Δ	Difference or change in values
t_{wl}	Temperature of wall	Δt_1	Temperature difference $^{\circ}\text{F}$ from air t_a to outer insulation surface t_2
U	Overall coefficient of heat transfer for a system, per unit of area, expressed as $\text{Btu}/(\text{hr})(\text{sq ft})(^{\circ}\text{F})$	Δt_2	Temperature difference $^{\circ}\text{F}$ from outer insulation surface t_2 to inner surface t_1
U_1	Overall coefficient of transmittance based on area of pipe surface	ϵ	Absorptance (same values as emittance) ratio to black body
U_2	Overall coefficient of transmittance based on outside surface area of one layer of insulation	μ	Viscosity of fluid, lb/ft hr
U_3	Overall coefficient of transmittance based on outside surface area of two or more layers of insulation	ρ	Density
V	Velocity of air over surface, ft/min	Φ	Radiant flux
V	Volume, cu ft		
VPD	Vapor pressure difference		
W	Weight, lbs		
W	Radiant flux density, $\frac{\Delta \Phi}{\Delta A}$		

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DATA

I. GENERAL

This section contains data which is most frequently used by an engineer designing insulation installations or in calculation of heat gains or losses.

These are divided into general classifications:

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AND UNION CARBIDE CANADA LIMITED

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I. GENERAL

1. Conversion Tables

ENERGY, WORK AND HEAT EQUIVALENTS

BRITISH THERMAL UNITS	CENTIMETER-GRAMS	ERGS OR CENTIMETER- DYNES	FOOT-POUNDS	HORSEPOWER-HOURS	JOULES OR WATT-SECONDS	KILOCALORIES	KILOWATT-HOURS	METER-KILOGRAMS	WATT-HOURS
1	1.076 $\times 10^2$	1.055 $\times 10^{10}$	778.2	3.929 $\times 10^{-4}$	1054.8	0.2520	2.930 $\times 10^{-4}$	107.6	0.2930
9.297 $\times 10^{-4}$	1	980.7	7.233 $\times 10^{-3}$	3.654 $\times 10^{-11}$	9.807 $\times 10^{-3}$	2.343 $\times 10^{-4}$	2.724 $\times 10^{-11}$	1 $\times 10^{-3}$	2.724 $\times 10^{-4}$
9.480 $\times 10^{-11}$	1.020 $\times 10^{-3}$	1	7.367 $\times 10^{-4}$	3.722 $\times 10^{-14}$	1 $\times 10^{-7}$	2.389 $\times 10^{-11}$	2.778 $\times 10^{-14}$	1.020 $\times 10^{-4}$	2.778 $\times 10^{-11}$
1.285 $\times 10^{-3}$	1.383 $\times 10^4$	1.356 $\times 10^7$	1	5.050 $\times 10^{-7}$	1.356	3.239 $\times 10^{-4}$	3.766 $\times 10^{-7}$	0.1383	3.766 $\times 10^{-4}$
2.545	2.737 $\times 10^{10}$	2.684 $\times 10^{13}$	1.98 $\times 10^6$	1	2.684 $\times 10^6$	641.3	0.7457	2.737 $\times 10^3$	745.7
9.480 $\times 10^{-4}$	1.020 $\times 10^4$	1 $\times 10^7$	0.7376	3.722 $\times 10^{-7}$	1	2.389 $\times 10^{-4}$	2.778 $\times 10^{-7}$	0.1020	2.778 $\times 10^{-4}$
3.968	4.269 $\times 10^7$	4.186 $\times 10^{10}$	3.088	1.559 $\times 10^{-3}$	4.186	1	1.163 $\times 10^{-3}$	426.9	1.163
3.413	3.671 $\times 10^{10}$	3.6 $\times 10^{13}$	2.655 $\times 10^6$	1.341	3.6 $\times 10^6$	860.0	1	3.671 $\times 10^3$	1.000
9.297 $\times 10^{-3}$	1 $\times 10^3$	9.807 $\times 10^7$	7.233	3.653 $\times 10^{-4}$	9.807	2.343 $\times 10^{-3}$	2.724 $\times 10^{-6}$	1	2.724 $\times 10^{-3}$
3.413	3.671 $\times 10^7$	3.6 $\times 10^{10}$	2.655	1.341 $\times 10^{-3}$	3.600	0.8600	0.001	367.1	1



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POWER EQUIVALENTS

Btu per sec	Btu per minute	Kilo- calories per sec or Large calories per sec	Calories (small) per sec	Foot pounds per sec	Kilo- gram meters per sec	Watts	Kilo- watts	Horse- power
1	60	0.2520	252.0	778.2	107.6	1055	1.055	1.415
0.01667	1	0.0042	4.2	12.07	1.793	17.57	0.01757	0.02356
3.968	238.1	1	1000	3088	426.9	418.7	4.187	5.615
0.003968	0.2381	0.001	1	3.088	0.4269	4.187	0.004187	0.005615
0.001285	0.0771	0.0003238	0.3238	1	0.1383	1.356	0.001356	0.00182
0.009295	0.5577	0.002342	2.342	7.233	1	9.807	0.009807	0.01315
0.0009478	0.05687	0.0002388	0.2388	0.7376	0.102	1	0.001	0.00134
0.9478	56.87	0.2388	238.8	737.6	102.0	1000	1	1.341
0.7068	42.408	0.1781	178.1	550	76.04	745.7	0.7457	1

Example: 1 Btu per sec equals 778.2 Ft lbs per sec

TEMPERATURE CONVERSION FORMULAS

To Get	CONVERSION FORMULAS			
	From ° Fahrenheit	From ° Kelvin	From ° Celsius (Centigrade)	From ° Rankine
° F =		$9/5 (° K - 273.16) + 32$	$(9/5) ° C + 32$	$° R - 459.69$
° K =	$(5/9) (° F - 32) + 273.16$		$° C + 273.16$	$(5/9) ° R$
° C =	$5/9 (° F - 32)$	$° K - 273.16$		$5/9 (° R) - 273.16$
° R =	$° F + 459.69$	$(9/5) ° K$	$(9/5) ° C + 491.69$	

Example: To get ° F from ° K, use the formula of $9/5 (° K - 273.16) + 32$



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1. Conversion Tables

THERMAL CONDUCTIVITY CONVERSION FACTORS

TO GET k IN UNITS OF:					WITH k GIVEN IN UNITS OF $\frac{\text{Btu inches}}{\text{hr, sq ft, } ^\circ\text{F}}$
HEAT UNITS	TIME UNITS	AREA UNITS	TEMP UNITS	THICKNESS UNITS	DIVIDE k BY:
Btu	Hour	Square feet	$^{\circ}\text{F}$	Inch	1
Btu	Hour	Square feet	$^{\circ}\text{F}$	Foot	12
Gram-Calorie	Second	Square centimeter	$^{\circ}\text{C}$	Centimeter	2903
Watt-seconds	Second	Square centimeter	$^{\circ}\text{C}$	Centimeter	694
Kilowatt hour	Hour	Square feet	$^{\circ}\text{F}$	Inch	3415

Example: Given $k = 0.40 \frac{\text{Btu, inches}}{\text{hr, sq ft, } ^\circ\text{F}}$. Find k in $\frac{\text{Btu, ft}}{\text{hr, sq ft, } ^\circ\text{F}}$. Read the extreme right column opposite these units and find that we must divide by 12. Then $k = 0.40/12 = 0.033 \frac{\text{Btu ft}}{\text{hr, sq ft, } ^\circ\text{F}}$

Note: When converting to $\frac{\text{Btu, inches}}{\text{hr, sq ft, } ^\circ\text{F}}$ from other units, multiply by the constant opposite these other units.

WATER VAPOR TRANSMISSION CONVERSION FACTORS

To Obtain	A.S.T.M. Procedure	Multiply			
		$\frac{\text{g}}{24 \text{ Hr, Sq M}}$ By	$\frac{\text{g}}{24 \text{ Hr, 100 Sq In}}$ By	$\frac{\text{grains}}{\text{Hr, Sq Ft}}$ By	Perms± By
$\frac{\text{g}}{24 \text{ Hr, Sq M}}$	A & B, 73.4F	1	15.5	16.7	6.94
	C & D, 90F	1	15.5	16.7	11.9
	E 100F	1	15.5	16.7	29.1
$\frac{\text{g}}{24 \text{ Hr, 100 Sq In}}$	A & B 73.4F	0.0645	1	1.08	0.448
	C & D, 90F	0.0645	1	1.08	0.767
	E 100F	0.0645	1	1.08	1.88
$\frac{\text{grams}}{\text{Hr, Sq Ft}}$	A & B 73.4F	0.0597	0.926	1	0.415
	C & D 90F	0.0597	0.926	1	0.710
	E 100F	0.0597	0.926	1	1.740
Perms±	A & B 73.4F	0.144	2.23	2.41	1
	C & D 90F	0.0841	1.30	1.41	1
	E 100F	0.034	0.532	0.575	1

± The conversion to Perms is based on the following vapor pressure differentials.

Procedure (A.S.T.M. E-96-53T)	In Hg
A and B	0.415
C and D	0.710
E	1.740

Note: Data obtained by one procedure cannot be reliably converted to data obtained by another procedure.

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1. Conversion Tables

TEMPERATURE CONVERSION TABLE
(Centigrade Scale Listed in Even Numbers)

[illegible]

DATA

I. GENERAL

1. Conversion Tables

TEMPERATURE CONVERSION TABLE

FAHRENHEIT SCALE LISTED IN EVEN NUMBERS

[illegible]



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2. Thermal Properties of Materials

INCHES OF LINEAR EXPANSION PER 100 FEET												
Temperature, Degrees Fahrenheit	"A" Nickel	Monel	Carbon and Low-Alloy Steel	Cast Iron	Wrought Iron	18-8 Stainless Steel	Copper	Brass 70-30 to 85-15	25 and 35 Aluminum	"Hastelloy" Alloy B (Rolled)	"Hastelloy" Alloy C (Cast)	Silicon Bronze (Everdur-1010)
-300	-2.04	-2.28										
-280	-1.89	-2.04										
-260	-1.78	-1.92										
-240	-1.67	-1.80										
-220	-1.56	-1.66										
-200	-1.44	-1.49	-1.28	-1.06	-1.29	-2.03	-1.96	-2.07	-2.69			
-180	-1.32	-1.39	-1.18	-0.98	-1.18	-1.85	-1.78	-1.89	-2.42			
-160	-1.19	-1.22	-1.07	-0.89	-1.07	-1.67	-1.61	-1.71	-2.18			
-140	-1.03	-1.08	-0.95	-0.79	-0.96	-1.48	-1.43	-1.51	-1.92			
-120	-0.89	-0.96	-0.83	-0.69	-0.83	-1.30	-1.24	-1.31	-1.66			
-100	-0.72	-0.82	-0.69	-0.59	-0.71	-1.09	-1.04	-1.09	-1.40			
-80	-0.60	-0.66	-0.56	-0.48	-0.57	-0.88	-0.84	-0.89	-1.13			
-60	-0.46	-0.48	-0.43	-0.37	-0.44	-0.67	-0.63	-0.67	-0.86			
-40	-0.30	-0.34	-0.29	-0.25	-0.29	-0.45	-0.42	-0.45	-0.58			
-20	-0.12	-0.18	-0.15	-0.13	-0.15	-0.23	-0.21	-0.23	-0.30			
0	0	0	0	0	0	0	0	0	0	0	0	0
20	0.18	0.12	0.15	0.13	0.15	0.22	0.24	0.23	0.30	0.27	0.18	0.23
32	0.24	0.24	0.23	0.21	0.25	0.36	0.37	0.37	0.46	0.35	0.28	0.37
40	0.36	0.30	0.29	0.26	0.31	0.45	0.45	0.47	0.60	0.37	0.35	0.46
60	0.48	0.48	0.45	0.39	0.47	0.67	0.68	0.69	0.90	0.47	0.50	0.69
80	0.65	0.70	0.58	0.52	0.63	0.89	0.89	0.92	1.20	0.57	0.65	0.93
100	0.84	0.85	0.75	0.66	0.79	1.12	1.13	1.15	1.50	0.67	0.80	1.16
120	0.98	1.03	0.91	0.79	0.96	1.34	1.37	1.39	1.81	0.82	1.00	1.39
140	1.20	1.20	1.06	0.92	1.11	1.55	1.59	1.63	2.12	0.92	1.15	1.62
160	1.34	1.37	1.22	1.07	1.28	1.78	1.80	1.87	2.43	1.07	1.35	1.86
180	1.50	1.56	1.38	1.22	1.45	2.00	2.05	2.10	2.76	1.22	1.50	2.09
200	1.68	1.73	1.55	1.37	1.63	2.23	2.29	2.34	3.08	1.37	1.70	2.33
212	1.79	1.74	1.64	1.45	1.72	2.36	2.43	2.47	3.26	1.47	1.80	2.47
220	1.82	1.92	1.71	1.51	1.78	2.46	2.52	2.58	3.40	1.57	1.85	2.56
240	2.01	2.11	1.88	1.65	1.96	2.68	2.76	2.83	3.73	1.72	2.00	2.80
260	2.17	2.30	2.04	1.80	2.13	2.92	2.99	3.07	4.06	1.87	2.20	3.03
280	2.36	2.48	2.21	1.96	2.31	3.13	3.22	3.32	4.42	2.07	2.40	3.26
300	2.54	2.65	2.37	2.11	2.48	3.38	3.46	3.57	4.74	2.22	2.55	3.50
320	2.76	2.86	2.55	2.27	2.65	3.62	3.69	3.82	5.08	2.37	2.70	3.74
340	2.90	3.08	2.72	2.42	2.84	3.84	3.94	4.07	5.43	2.57	2.90	3.97
360	3.10	3.26	2.88	2.57	3.02	4.08	4.18	4.32	5.78	2.77	3.05	
380	3.30	3.48	3.07	2.73	3.19	4.35	4.42	4.56	6.12	2.92	3.25	
400	3.49	3.68	3.23	2.88	3.37	4.56	4.67	4.83	6.48	3.07	3.40	
420	3.70	3.86	3.42	3.06	3.57	4.80	4.91	5.08	6.82	3.21	3.60	
440	3.89	4.08	3.59	3.22	3.75	5.05	5.15	5.34	7.18	3.35	3.80	
460	4.08	4.32	3.78	3.38	3.94	5.34	5.41	5.60	7.54	3.49	3.95	
480	4.27	4.51	3.96	3.56	4.13	5.54	5.65	5.93	7.90	3.63	4.15	
500	4.50	4.73	4.15	3.72	4.33	5.80	5.91	6.12	8.27	3.77	4.30	
520	4.70	4.93	4.34	3.89	4.53	6.05	6.15	6.38	8.63	3.91	4.50	
540	4.91	5.16	4.53	4.06	4.71	6.32	6.41	6.65	8.99	4.05	4.70	
560	5.15	5.39	4.72	4.24	4.91	6.57	6.65	6.92	9.37	4.19	4.85	
580	5.34	5.62	4.91	4.41	5.12	6.80	6.92	7.17	9.73	4.33	5.05	
600	5.60	5.86	5.10	4.59	5.30	7.04	7.18	7.44	10.10	4.47	5.20	
620	5.77	6.05	5.29	4.77	5.51	7.29	7.43	7.72	10.46	4.60	5.40	
640	6.00	6.28	5.48	4.96	5.69	7.55	7.69	7.98	10.83	4.80	5.60	
660	6.20	6.50	5.69	5.13	5.92	7.80	7.95	8.24	11.19	4.95	5.75	
680	6.43	6.73	5.88	5.32	6.11	8.04	8.19	8.52	11.57	5.15	5.95	
700	6.67	6.98	6.08	5.50	6.33	8.31	8.47	8.78	11.95	5.30	6.15	
720	6.88	7.20	6.28	5.68	6.52	8.57	8.71	9.05	12.30	5.45	6.35	
740	7.10	7.44	6.49	5.88	6.75	8.83	8.99	9.32	12.69	5.65	6.50	
760	7.32	7.68	6.69	6.07	6.95	9.07	9.26	9.60	13.07	5.80	6.70	
780	7.56	7.92	6.90	6.26	7.16	9.35	9.53	9.87	13.45	6.00	6.90	
800	7.79	8.16	7.11	6.46	7.36	9.61	9.79	10.15	13.83	6.20	7.10	
820	8.00	8.39	7.32	6.65	7.61	9.87	10.07	10.43		6.35	7.30	
840	8.22	8.64	7.52	6.84	7.80	10.14	10.31	10.69		6.50	7.45	
860	8.47	8.87	7.74	7.05	8.04	10.40	10.61	10.98		6.60	7.65	
880	8.69	9.10	7.95	7.25	8.25	10.66	10.97	11.25		6.75	7.85	
900	8.94	9.35	8.17	7.45	8.49	10.93	11.16	11.55		6.90	8.05	
920	9.12	9.59	8.40	7.67	8.72	11.20	11.42	11.82		7.00	8.25	
940	9.36	9.80	8.61	7.86	8.94	11.46	11.71	12.12		7.10	8.45	
960	9.59	10.06	8.83	8.07	9.15	11.73	11.98	12.42		7.20	8.65	
980	9.84	10.30	9.05	8.28	9.39	11.99	12.27	12.72		7.35	8.85	
1000	10.10	10.54	9.28	8.49	9.62	12.26	12.54	13.08		7.45	9.05	
1050			9.81	9.06	10.25	12.88				7.80	9.55	
1100			10.41	9.56	10.85	13.58				8.25	10.05	
1150			11.01	10.06	11.45	14.28				8.60	10.60	
1200			11.61	10.66	12.05	14.98				9.00	11.10	
1250			12.21	11.26	12.65	15.58				10.10	11.65	
1300			12.81	11.86	13.25	16.28				10.80	12.20	
1350			13.41	12.46	13.95	16.98				11.45	12.75	
1400			14.11	13.06	14.55	17.58				12.10	13.35	
1450										12.75	13.95	
1500										13.40	14.50	
1550										14.05	15.15	
1600										14.70	15.75	
1650										15.40	16.40	
1700										16.00	17.00	
1750										16.70	17.70	
1800										17.40	18.35	

NOTE:

Tabulated data is intended primarily for calculating expansion and contraction in piping systems due to temperature changes.

For reference material used in developing this tabulation, refer to development file M-110, Standards Section, Department of Construction and Design.

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2. Thermal Properties of Materials - Continued

RADIATION EMITTANCE TABLE

Metals	Surface Temp °F	Total Normal Emittance
Aluminum		
Highly polished	440-1070	0.039-0.057
Polished	100-1000	0.04-0.06
Rough plate	78	0.055-0.070
Oxidized @ 1110F	390-1110	0.11-0.19
Roofing surface		0.216
Oxide	530-1520	0.63-0.26
Foil	212	0.087
Bismuth	175	0.34
Brass		
Highly polished	497-710	0.03-0.04
Polished	100	0.05
Rolled plate, natural	72	0.06
Rolled, coarse emiered	72	0.20
Oxidized @ 1110F	390-1110	0.61-0.59
Dull plate	120-660	0.22
Chromium	100-1000	0.08-0.26
Polished	100-500	0.06-0.08
Polished	Solar	0.50
Copper		
Electrolytic, polished	176	0.02
Commercial plate, polished	66	0.030
Heated @ 1110F	390-1110	0.57-0.57
Thick oxide coating	77	0.78
Cuprous oxide	1470-2010	0.66-0.54
Everdur, dull	200	0.11
Gold		
Highly polished	440-1160	0.02-0.40
Polished	100	0.06

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2. Thermal Properties of Materials - Continued

RADIATION EMITTANCE TABLE - Continued

<u>Metals</u>	<u>Surface Temp °F</u>	<u>Total Normal Emittance</u>
Iron and Steel		
Pure iron, polished	350-1800	0.05-0.37
Wrought iron, polished	100-480	0.28
Cast iron, polished		0.21
Smooth oxidized iron	260-980	0.78-0.82
Strongly oxidized iron	100-480	0.95
Steel polished	100-1000	0.07-0.14
Steel, polished	Solar	0.045
Steel, rolled sheet	70	0.657
Steel, rough plate	100-700	0.94-0.97
Smooth sheet iron	1650-1900	0.55-0.60
Plate steel, rusted	67	0.69
Steel, oxidized	100-1000	0.79-0.79
Lead		
Pure	260-440	0.06-0.08
Gray, oxidized	75	0.28
Oxidized @ 390F	390	0.63
Magnesium		
Polished	100-1000	0.07-0.22
Monel metal		
Washed, abrasive soap	75	0.17
Repeated heating	450-1610	0.46-0.65
Nickel and alloys		
Electrolytic, polished	74	0.05
Electroplated, not polished	68	0.11
Wire	368-1844	0.10-0.19
Oxidized @ 1110F	390-1110	0.37-0.48
Oxide	1200-2290	0.59-0.86
Nickel copper, polished	212	0.06
Nickel silver, polished	212	0.14
Nickelin, gray oxide	70	0.26
Nichrome wire, bright	120-1830	0.65-0.79
Nichrome wire, oxidized	120-930	0.95-0.98
Chrome - nickel		.36 - .97

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2. Thermal Properties of Materials - Continued

RADIATION EMITTANCE TABLE - Continued

Metals	Surface Temp °F	Total Normal Emittance
Platinum, polished	440-2960	0.05-0.17
Silver, pure, polished	440-1160	0.02-0.03
Stainless steels		
Type 316, cleaned	75	0.28
316, repeated heating	450-1600	0.57-0.66
304, 42 hrs @ 980F	420-980	0.62-0.73
310, furnace service	420-980	0.90-0.97
Tin, bright	76	0.04-0.06
Tungsten		
Filament	100-1000	0.03-0.08
Filament	2000-5000	0.19-0.34
Zinc		
Pure, polished	440-620	0.05
Galv. iron, bright	82	0.23
Galv. gray oxidized	75	0.28
Galv. iron, dirty	2500	0.90
Galv. iron, dirty	Solar	0.90
Galv. iron	Solar	0.54

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2. Thermal Properties of Materials - Continued

SURFACE EMITTANCES

<u>Refractories</u>	<u>Surface Temp °F</u>	<u>Total Normal Emittance ϵ</u>
Alumina Refractory	800	0.45
	1200	0.37
	1600	0.31
	2000	0.28
	2400	0.34
	2700	0.37
AL ₂ O ₃ Bonded Refractory	1500	0.47
Carbon Refractory	1500	0.97
Chrome Refractory	1500	0.97
Fosterlite Refractory	1500	0.95
Fused Castable Refractory	1500	0.51
Graphite Refractory	1500	0.97
Gypsum	100	0.91
Kaolin Insulating Brick	800	0.80
	1200	0.61
	1600	0.49
	2000	0.48
	2400	0.50
	2550	0.59
Magnesium Oxide Refractory	800	0.56
98% MgO	1200	0.38
	1600	0.33
	2000	0.32
	2400	0.35
Magnesite	1500	0.48

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I. GENERAL

2. Thermal Properties of Materials - Continued

SURFACE EMITTANCES - Continued

<u>Refractories</u>	<u>Surface Temp °F</u>	<u>Total Normal Emittance ε</u>
Mullite, Converted	1500	0.51
Mullite, Synthetic	1500	0.51
Silica Refractory	1500	0.76
Silica, Translucent, 3/16" thick over Kaolin	800	0.98
	1200	0.80
	1600	0.70
	2000	0.68
	2400	0.67
Silicon Carbide Refractory (Crystolon)	1000	0.95
	1200	0.93
	1600	0.92
	2000	0.90
	2400	0.88
Silicon - Nitride Refractory	1500	0.93
Superduty Fireclay Refractory	1500	0.54
Zircon Refractory	1500	0.53
Zirconia Refractory 98% Zirconia	800	0.74
	1200	0.44
	1600	0.33
	2000	0.31
	2400	0.25

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2. Thermal Properties of Materials - Continued

SURFACE EMITTANCES - Continued

<u>Miscellaneous Materials</u>	<u>Surface Temperature °F</u>	<u>Total Normal Emittance ϵ</u>
Aluminum paints	212	0.27-0.67
26% al, 27% lacquer	212	0.3
Asbestos board	100	0.96
Asbestos paper	100-700	0.93-0.95
Asbestos cloth	200	0.90
Asphalt pavement	Solar	0.93
Brick		
Glazed		0.75
Red, rough	Solar	0.70
Silica	2500	0.84
Refractory	200-1000	0.92-0.97
Carbon black	70-700	0.95
Concrete	2500	0.63
Concrete	Solar	0.65
Glass	72	0.937
Gypsum	70	0.903
Ice	32	0.96-0.99
Marble, polished	70	0.931
Mica	200	0.84
Oak, planed	70	0.895
Oil film	68	0.27-0.82
Paint, black	200-600	0.92-0.95
Black	1000	0.97
Black	Solar	0.90
Green	200-600	0.93-0.90
Green	1000	0.80
Green	Solar	0.50
White	200-600	0.92-0.84
White	1000	0.68
White	Solar	0.30
Aluminum	212	0.27-0.67
Oil paint		0.92-0.96
Paper, white	70	0.924-0.944
Paper, black roofing	100	0.95
Porcelain, glazed	70	0.924

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I. GENERAL

2. Thermal Properties of Materials - Continued

SURFACE EMITTANCES - Continued

<u>Miscellaneous Materials</u>	<u>Surface Temperature °F</u>	<u>Total Normal Emittance</u>
Refractories		0.65-0.90
Roofing paper		0.91
Rubber		
Hard, glossy	70	0.945
Soft, rough	76	0.859
Water	70	0.95-0.96
Wood	100	0.83-0.92

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2. Thermal Properties of Materials - Continued

SURFACE EMITTANCES

Oxide Surfaces	Observed Range Of Emittances	Probable Value For Oxide Forms on Smooth Metal
Aluminum Oxide	0.22-0.40	0.30
Beryllium Oxide	0.07-0.37	0.35
Cerium Oxide	0.58-0.80	
Chromium Oxide	0.60-0.80	0.70
Cobalt Oxide		0.75
Columbium Oxide	0.55-0.71	0.70
Copper Oxide	0.60-0.80	0.70
Iron Oxide	0.63-0.98	0.70
Magnesium Oxide	0.10-0.43	0.20
Nickel Oxide	0.85-0.96	0.90
Thorium Oxide	0.20-0.57	0.59
Tin Oxide	0.32-0.60	
Titanium Oxide		0.50
Uranium Oxide		0.39
Vanadium Oxide		0.70
Yttrium Oxide		0.60
Zirconium Oxide	0.18-0.43	0.40
Alumel (Oxidized)		0.87
Cast iron (Oxidized)		0.70
80 Ni 20 Cr (Oxidized)		0.90
60 Ni 24 Fe 16 Cr (Oxidized)		0.83
55 Fe 37.5 Cr 7.5 Al (Oxidized)		0.78
70 Fe 23 Cr 5 Al 2 Co (Oxidized)		0.75
Constantan (SS Co. 45 Ni) Oxidized)		0.84
Carbon Steel (Oxidized)		0.80
Stainless Steel (18-8) (Oxidized)		0.85

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2. Thermal Properties of Materials - Continued

SURFACE EMITTANCES

Refractories	Surface Temp °F	Total Normal Emittance ϵ
Alumina Refractory	800	0.45
	1200	0.37
	1600	0.31
	2000	0.28
	2400	0.34
	2700	0.37
AL ₂ O ₃ Bonded Refractory	1500	0.47
Carbon Refractory	1500	0.97
Chrome Refractory	1500	0.97
Fosterlite Refractory	1500	0.95
Fused Castable Refractory	1500	0.51
Graphite Refractory	1500	0.97
Gypsum	100	0.91
Kaolin Insulating Brick	800	0.80
	1200	0.61
	1600	0.49
	2000	0.48
	2400	0.50
	2550	0.59
Magnesium Oxide Refractory	800	0.56
98% Mg O	1200	0.38
	1600	0.33
	2000	0.32
	2400	0.35
Magnesite	1500	0.48
Mullite, Converted	1500	0.51
Mullite, Synthetic	1500	0.51
Silica Refractory	1500	0.76
Silica, Translucent,		
3/16" thick over Kaolin	800	0.98
	1200	0.80
	1600	0.70
	2000	0.68
	2400	0.67

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2. Thermal Properties of Materials - Continued

SURFACE EMITTANCES - Continued

Refractories	Surface Temp °F	Total Normal Emittance ϵ
Silicon Carbide Refractory	1000	0.95
(Crystolon)	1200	0.93
	1600	0.92
	2000	0.90
	2400	0.88
Silicon - Nitride Refractory	1500	0.93
Superduty Fireclay Refractory	1500	0.54
Zircon Refractory	1500	0.53
Zirconia Refractory	800	0.74
98% Zirconia	1200	0.44
	1600	0.33
	2000	0.31
	2400	0.25

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2. Thermal Properties of Materials - Continued

RADIATION EMITTANCE TABLE
WEATHER-BARRIERS AND FINISHES
USED ON THERMAL INSULATIONS

Weather-Barrier or Surface Finish	Condition	Emittance (At Surface Temp of Approx. 100F)
Aluminum	Polished	0.03 to 0.06
	Gray-Dull	0.06 to 0.09
	Oxidized	0.10 to 0.12
Aluminum Paint	New	0.20 to 0.30
	After Weathering	0.40 to 0.70
Asbestos Paper	Clean	0.90 to 0.94
Asphalt Asbestos Felts		0.93 to 0.96
Asphalt Mastics		0.90 to 0.95
Galvanized Steel	New - bright	0.06 to 0.10
	Dull	0.20 to 0.30
Paints	White - clean	0.55 to 0.70
	Green - clean	0.65 to 0.80
	Gray - clean	0.80 to 0.90
	Black - clean	0.90 to 0.95
Painted Canvas	Color as painted	Will be approx. the same as for color of paint used
PVA Mastics	White - clean	0.60 to 0.70
	Green - Clean	0.70 to 0.80
	Gray - medium - clean	0.85 to 0.90
	Black	0.85 to 0.95
Roofing Felts		0.90 to 0.95
Stainless Steel	Polished	0.22 to 0.26
	No. 4 mill finish	0.35 to 0.40
	Oxidized	0.80 to 0.85

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2. Thermal Properties of Materials - Continued

SPECIFIC HEATS AND WEIGHTS OF MATERIALS

Material	Temperature °F	Mean Specific Heat	Weight lbs/cu ft
Aluminum		0.215	168
Asbestos	32-212	0.20	150
Bakelite - Phenolic	32-212	0.3-0.4	
Brass, yellow	32-212	0.088	534
Brass, red	32-212	0.09	534
Bronze	32-212	0.014	509-554
Brick	32-212	0.20-0.22	125-143
Carbon	32-212	0.165	139
Chalk	32-212	0.215	143
Charcoal	32-212	0.20	25
Cinders	32-212	0.18	
Coal	32-212	0.24-0.3	81-94
Concrete	32-212	0.156	137
Cork	32-212	0.485	
Coke	32-212	0.203	75
Copper	32-212	0.094	556
Glass	32-212	0.12-0.19	162
Graphite	32-212	0.201	135
Gold		0.031	1205
Granite	32-212	0.195	168
Gypsum	32-212	0.259	155
Humus (soil)	32-212	0.44	76-100
Ice		0.465	56
Ice	32	0.487	64
Iron, cast		0.130	442
Iron, wrought	32-212	0.110	485
Iron, wrought	32-572	0.122	485
Iron, at high temperatures	1382-1832	0.213	485
Lead		0.031	710
Limestone		0.217	155-162

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2. Thermal Properties of Materials - Continued

SPECIFIC HEATS AND WEIGHTS OF MATERIALS - Continued

Material	Temperature °F	Mean Specific Heat	Weight lbs/cu ft
Marble	32-212	0.210	170
Mercury	32-212	0.033	850
Masonry, brick	32-212	0.20-0.22	
Nickel		0.109	537
Oil, machine	0.	0.400	
Porcelain	32-212	0.22	
Quartz	32-212	0.17-0.28	165
Sand	32-212	0.195	100-125
Sandstone	32-212	0.22	143
Silver		0.056	655
Silica		0.191	
Steel, mild		0.116	485
Steel, high carbon		0.117	485
Stone, average		0.200	150
Tin		0.056	459
Water		1.000	62.4
Wood, fir		0.650	25-32
Wood, oak		0.570	42-54
Wood, pine		0.67	27-42
Zinc		0.095	440

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I. GENERAL

2. Thermal Properties of Materials - Continued

THERMAL CONDUCTIVITY OF MATERIALS

 $k = \text{Btu in/ hr, sq ft, in, } ^\circ\text{F}$

Miscellaneous Solid Materials	Mean Temp $^\circ\text{F}$	k
Asbestos, 36 lb density	200	1.32
Asbestos, wool, 25 lb density	212	0.696
Asbestos paper, 61 lb density	212	1.089
Asbestos millboard, 60 lb density	86	0.84
Ashes, soft wood, 12 lb density	68	0.216
Ashes, volcanic, 51 lb density	300	1.476
Asphalt, 132 lb density	68	5.16
Bricks		
Building	70	5.0
Refractory, average	1000	9.0
Basalt	32-210	8.88-19.32
Carbon black, 12 lb density	133	0.144
Cardboard, corrugated		0.444
Celluloid, 87 lb density	86	1.44
Concrete, sand and gravel		
142 lb density	75	12.6
Concrete, cinder		
97 lb density	75	4.92
Charcoal, powder, 12 lb density	63	0.348
Cotton wool, 5 lb density	100	0.420
Earth plus 42% water, frozen, 108 lb density	0	7.44
Glass		3.6-7.32
Glass, pyrex, 139 lb density	200	7.08
Glass, soda lime	200	7.08
Gravel, 116 lb density	68	2.64

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I. GENERAL

2. Thermal Properties of Materials - Continued

THERMAL CONDUCTIVITY OF MATERIALS - Continued

k = Btu in/hr, sq ft, in, °F

Miscellaneous Solid Materials	Mean Temp °F	k
Gypsum plaster, sand aggregate		5.55
Gypsum plaster, light wt aggregate		1.56
Gypsum board, 51 lb density	99	0.744
Ice, 57.5 lb density		15.12
Leather, sole, 62.4 lb density		1.104
Mica, 122 lb density		3.0
Rubber, hard, 74.3 lb density	100	1.104
Rubber, soft, 68 lb density	86	0.96
Sand, dry, 94.8 lb density	68	2.26
Sawdust, dry, 13.4 lb density	68	0.504
Soil, dry	68	0.90
Soil, dry, including stones, 127 lb density	68	3.6
Soil, wet		to 12.0
Snow, 7 to 31 lb density	32	4.08-15.6
Titanium oxide, 52 lb density	1000	0.492
Wool, pure, 5.6 lb density	86	0.252
Wood, average		1.2

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Thermal Properties of Materials - Continued

THERMAL CONDUCTIVITY OF MATERIALS

 $k = \text{Btu in/hr, sq ft, in, } ^\circ\text{F}$

Metals	Mean Temp $^\circ\text{F}$	k
Aluminum	64 212 930	1404 1428 1855
Antimony	32 212	127 116
Bismuth	64 212	56 47
Brass (20% Cu, 30% Zn)	32 212	672 720
Bronze		1308
Cadmium	64 212	644 626
Copper, pure	64 212	2688 2616
Gold	64 212	2028 2040
Iron, pure	64 212	468 439
Iron, wrought	64 212	419 415
Iron, cast	129 216	332 322
Lead	64 212	241 238
Magnesium	32-212	1104
Mercury	32	58
Nickel	64	432

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I. GENERAL

2. Thermal Properties of Materials - Continued

THERMAL CONDUCTIVITY OF MATERIALS - Continued

k = Btu in/hr, sq ft, in, °F

Metals	Mean Temp °F	k
Platinum	64 212	482 503
Silver	64	2904 2856
Sodium	32	384
Steel, 1% carbon content	64 212	314 311
Steel, mild	212	312
Steel, 13% Cr, 0.2% Ni	932	199
Steel, 18% Cr, 8% Ni	932	149
Steel, 23% Cr, 12% Ni	932	130
Steel Wool, density 6.3 lbs/cu ft	50-212	0.607
Tantalum	64	384
Tin	64	432
Zinc	212 64 212	308 780 768

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2. Thermal Properties of Materials - Continued

THERMAL CONDUCTIVITY OF MATERIALS

 $k = \text{Btu in/hr, sq ft, in, } ^\circ\text{F}$

Gases	Mean Temp $^\circ\text{F}$	k
Air	32	0.168
Ammonia	32	0.151
Argon	32	0.110
Carbon dioxide	32	0.101
	212	0.154
Carbon monoxide	32	0.162
Chlorine	32	0.052
Ethane	32	0.127
Ethylene	32	0.121
Helium	32	0.982
Hydrogen	32	1.159
	122	1.488
Methane	32	0.210
Neon	32	0.0307
Nitrogen	32	0.168
Oxygen	32	0.170
Steam	32	0.117
Liquids	Mean Temp $^\circ\text{F}$	k
Acetone	68	1.236
Ammonia	45	3.480
Ethyl alcohol	68	1.260
Methyl alcohol	68	1.488
Petroleum oil (Average)	68	1.00
Sulphur dioxide	68	2.34
Water	68	4.10

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2. Thermal Properties of Materials - Continued

THERMAL CONDUCTIVITY OF MATERIALS

 $k = \text{Btu in/hr, sq ft, in, } ^\circ\text{F}$

<u>Woods, Oven Dried</u> <u>(heat flow across grain)</u>	<u>Density</u> <u>lb/cu ft</u>	<u>Mean</u> <u>Temp °F</u>	<u>k</u>
Aspen	26	85	0.828
Bald cypress	24	85	0.756
Balsa	10	85	0.408
Balsam wool	2.2	90	0.27
Boxwood	56	68	10.45
Basswood	24	85	0.696
Douglas fir	29	85	0.756
Elm rock	48	85	1.164
Elm, soft	34	75	0.88
Fir, white	26	85	0.828
Hemlock	29	85	0.792
Larch, western	36	85	0.936
Maple, sugar	43	85	1.128
Maple, soft	36	75	0.089
Oak, red	42	85	1.188
Pine, southern yellow	35	85	0.936
Pine, white	25	85	0.72
Red cedar, western	21	85	0.636
Redwood	25	85	0.744
Redwood, California	22	75	0.66
Spruce	21	85	0.624

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2. Thermal Properties of Materials - Continued

THERMAL CONDUCTANCES OF AIR SPACES

Btu/hr, sq ft, ° F

MEAN TEMPERATURE ° F	Width of Air Space, Inches						
	0.128	0.250	0.364	0.493	0.713	1.00	1.50
20	2.300	1.370	1.180	1.100	1.040	1.030	1.022
30	2.385	1.425	1.234	1.148	1.080	1.070	1.065
40	2.470	1.480	1.288	1.193	1.125	1.112	1.105
50	2.560	1.535	1.340	1.242	1.168	1.152	1.149
60	2.650	1.590	1.390	1.295	1.210	1.195	1.188
70	2.730	1.648	1.440	1.340	1.250	1.240	1.228
80	2.819	1.702	1.492	1.390	1.295	1.280	1.270
90	2.908	1.757	1.547	1.433	1.340	1.320	1.310
100	2.990	1.813	1.600	1.486	1.380	1.362	1.350
110	3.078	1.870	1.650	1.534	1.425	1.402	1.392
120	3.167	1.928	1.700	1.580	1.467	1.445	1.435
130	3.250	1.980	1.750	1.630	1.510	1.485	1.475
140	3.340	2.035	1.800	1.680	1.550	1.530	1.519
150	3.425	2.090	1.852	1.728	1.592	1.569	1.559

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1. GENERAL

2. Thermal Properties of Materials - Continued

HEAT UNITS FOR WATER AT VARIOUS TEMPERATURES

Temp., deg.F	Lb. per cu. ft.	B.t.u. per lb.	Temp., deg.F	Lb. per cu. ft.	B.t.u. per lb.	Temp., deg.F	Lb. per cu. ft.	B.t.u. per lb.	Temp., deg.F	Lb. per cu. ft.	B.t.u. per lb.
32	62.41	0.	91	62.10	58.99	150	61.19	117.84	208	59.92	175.98
33	62.41	1.01	92	62.08	59.98	151	61.17	118.85	209	59.90	176.99
34	62.42	2.01	93	62.07	60.98	152	61.15	119.85	210	59.87	177.99
35	62.42	3.02	94	62.06	61.97	153	61.13	120.85	211	59.85	179.00
36	62.42	4.03	95	62.05	62.96	154	61.11	121.85	212	59.82	180.00
37	62.42	5.03	96	62.04	63.96	155	61.09	122.85	214	59.81	182.02
38	62.42	6.04	97	62.02	64.95	156	61.07	123.85	216	59.77	184.03
39	62.42	7.04	98	62.01	65.94	157	61.05	124.85	218	59.70	186.04
40	62.42	8.05	99	62.00	66.94	158	61.03	125.85	220	59.67	188.06
41	62.42	9.05	100	61.99	67.93	159	61.01	126.85	230	59.42	198.15
42	62.42	10.05	101	61.98	68.92	160	60.99	127.85	240	59.17	208.26
43	62.42	11.05	102	61.96	69.92	161	60.97	128.85	250	58.89	218.39
44	62.42	12.05	103	61.95	70.91	162	60.95	129.85	260	58.62	228.55
45	62.42	13.05	104	61.94	71.91	163	60.93	130.85	270	58.34	238.74
46	62.41	14.06	105	61.93	72.91	164	60.91	131.85	280	58.04	248.95
47	62.41	15.06	106	61.91	73.90	165	60.89	132.85	290	57.74	259.20
48	62.41	16.06	107	61.90	74.90	166	60.87	133.85	300	57.41	269.48
49	62.41	17.06	108	61.89	75.90	167	60.85	134.85	310	57.08	279.80
50	62.40	18.06	109	61.87	76.89	168	60.83	135.85	320	56.75	290.17
51	62.40	19.06	110	61.86	77.89	169	60.81	136.85	330	56.40	300.59
52	62.40	20.06	111	61.84	78.89	170	60.79	137.85	340	56.02	311.05
53	62.39	21.06	112	61.83	79.89	171	60.77	138.85	350	55.65	321.55
54	62.39	22.06	113	61.81	80.89	172	60.75	139.85	360	55.25	332.10
55	62.38	23.06	114	61.80	81.89	173	60.73	140.85	370	54.85	342.71
56	62.38	24.05	115	61.78	82.89	174	60.71	141.85	380	54.47	353.39
57	62.38	25.05	116	61.77	83.88	175	60.68	142.86	390	54.05	364.14
58	62.37	26.05	117	61.75	84.88	176	60.66	143.86	400	53.62	374.96
59	62.37	27.05	118	61.74	85.88	177	60.64	144.86	410	53.19	385.86
60	62.36	28.05	119	61.72	86.88	178	60.62	145.86	420	52.74	396.84
61	62.35	29.05	120	61.71	87.88	179	60.60	146.87	430	52.33	407.91
62	62.35	30.05	121	61.69	88.88	180	60.57	147.87	440	51.87	419.07
63	62.34	31.05	122	61.68	89.88	181	60.55	148.87	450	51.28	430.3
64	62.34	32.04	123	61.66	90.88	182	60.53	149.87	460	51.02	441.7
65	62.33	33.04	124	61.64	91.88	183	60.51	150.87	470	50.51	453.2
66	62.32	34.04	125	61.63	92.87	184	60.49	151.87	480	50.00	465.0
67	62.32	35.04	126	61.61	93.87	185	60.46	152.87	490	49.50	477.0
68	62.31	36.03	127	61.60	94.87	186	60.44	153.88	500	48.78	489.1
69	62.30	37.03	128	61.58	95.87	187	60.42	154.88	510	48.31	501.6
70	62.30	38.03	129	61.56	96.86	188	60.40	155.88	520	47.62	514.2
71	62.29	39.03	130	61.55	97.86	189	60.37	156.89	530	46.95	527.0
72	62.28	40.02	131	61.53	98.86	190	60.35	157.89	540	46.30	540.0
73	62.27	41.02	132	61.51	99.86	191	60.33	158.90	550	45.66	553.2
74	62.26	42.02	133	61.50	100.86	192	60.30	159.90	560	44.84	566.7
75	62.25	43.01	134	61.48	101.85	193	60.28	160.90	570	44.05	580.4
76	62.25	44.01	135	61.46	102.85	194	60.26	161.91	580	43.29	594.4
77	62.24	45.01	136	61.44	103.85	195	60.23	162.91	590	42.37	608.7
78	62.23	46.00	137	61.43	104.85	196	60.21	163.92	600	41.49	623.2
79	62.22	47.00	138	61.41	105.84	197	60.19	164.92	610	40.49	638.0
80	62.21	48.00	139	61.39	106.84	198	60.16	165.93	620	39.37	653.4
81	62.20	49.00	140	61.37	107.84	199	60.14	166.93	630	38.31	669.5
82	62.19	50.00	141	61.36	108.84	200	60.11	167.94	640	37.17	686.6
83	62.18	51.00	142	61.34	109.84	201	60.09	168.95	650	35.97	705.2
84	62.17	52.00	143	61.32	110.84	202	60.07	169.95	660	34.48	725.3
85	62.16	53.00	144	61.30	111.84	203	60.04	170.96	670	32.89	747.5
86	62.15	54.00	145	61.28	112.84	204	60.02	171.96	680	31.06	772.6



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3. Psychrometric Information

TABLE II

DEW POINT TEMPERATURE
° F

DRY BULB TEMP. ° F	% RELATIVE HUMIDITY																		
	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
5	-35	-30	-25	-21	-17	-14	-12	-10	-8	-6	-5	-4	-2	-1	1	2	3	4	5
10	-31	-25	-20	-16	-13	-10	-7	-5	-3	-2	0	2	3	4	5	7	8	9	10
15	-28	-21	-16	-12	-8	-5	-3	-1	1	3	5	6	8	9	10	12	13	14	15
20	-24	-16	-11	-8	-4	-2	2	4	6	8	10	11	13	14	15	16	18	19	20
25	-20	-15	-8	-4	0	3	6	8	10	12	15	16	18	19	20	21	23	24	25
30	-15	-4	-3	2	5	8	11	13	15	17	20	22	23	24	25	27	28	29	30
35	-12	-5	1	5	9	12	15	18	20	22	24	26	27	28	30	32	33	34	35
40	-7	0	5	9	14	16	19	22	24	26	28	29	31	33	35	36	38	39	40
45	-4	3	9	13	17	20	23	25	28	30	32	34	36	38	39	41	43	44	45
50	-1	7	13	17	21	24	27	30	32	34	37	39	41	42	44	45	47	49	50
55	3	11	16	21	25	28	32	34	37	39	41	43	45	47	49	50	52	53	55
60	6	14	20	25	29	32	35	39	42	44	46	48	50	52	54	55	57	59	60
65	10	18	24	28	33	38	40	43	46	49	51	53	55	57	59	60	62	63	65
70	13	21	28	33	37	41	45	48	50	53	55	57	60	62	64	65	67	68	70
75	17	25	32	37	42	46	49	52	55	57	60	62	64	66	69	70	72	74	75
80	20	29	35	41	46	50	54	57	60	62	65	67	69	72	74	75	77	78	80
85	23	32	40	45	50	54	58	61	64	67	69	72	74	76	78	80	82	83	85
90	27	36	44	49	54	58	62	66	69	72	74	77	79	81	83	85	87	89	90
95	30	40	48	54	59	63	67	70	73	76	79	82	84	86	88	90	91	93	95
100	34	44	52	58	63	68	71	75	78	81	84	86	88	91	92	94	96	98	100
105	38	48	56	62	67	72	76	79	82	85	88	90	93	95	97	99	101	103	105
110	41	52	60	66	71	77	80	84	87	90	92	95	98	100	102	104	106	108	110
115	45	56	64	70	75	80	84	88	91	94	97	100	102	105	107	109	111	113	115
120	48	60	68	74	79	85	88	92	96	99	102	105	107	109	112	114	116	118	120
125	51	63	72	78	84	89	93	97	100	104	107	109	111	114	117	119	121	123	125

Problem: Given a 'Dry-Bulb' temperature of 60F and a relative humidity of 25%. Find the Dew Point Temperature.

Solution: From a 'Dry-Bulb' temperature of 60F in the left column, read across the table to the right. Where this line intersects the column of 25% relative humidity, we read a Dew Point Temperature of 25 F.



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VAPOR PRESSURES at 100% Relative Humidity

VAPOR PRESSURE			TEMP.			VAPOR PRESSURE			TEMP.			VAPOR PRESSURE			TEMP.			VAPOR PRESSURE		
° F	° C	In. of Hg.	° F	° C	In. of Hg.	° F	° C	In. of Hg.	° F	° C	In. of Hg.	° F	° C	In. of Hg.	° F	° C	In. of Hg.	° F	° C	In. of Hg.
-40	-40	.0039	32	0.0	.1803	77	25.0	.9352	134	56.7	5.03	198	92.2	22.52	150	65.6	7.57	216	102.2	32.38
-35	-37.2	.0052	33	0.6	.1878	78	25.6	.9666	136	57.8	5.30	199	93.3	23.47	152	66.7	7.95	218	103.3	33.66
-30	-34.4	.0070	34	1.1	.1955	79	26.1	.9989	138	58.9	5.59	200	94.4	24.46	154	67.8	8.35	220	104.4	34.90
-25	-31.7	.0094	35	1.7	.2035	80	26.7	1.032	140	60.0	5.88	202	95.6	25.48	156	68.9	8.77	228	106.6	36.14
-20	-28.9	.0126	36	2.2	.2118	81	27.2	1.066	142	61.1	6.19	204	96.7	26.53	158	70.0	9.20	236	108.9	37.38
-15	-26.1	.0167	37	2.8	.2203	82	27.8	1.102	144	62.2	6.51	206	97.8	27.63	160	71.1	9.65	244	111.1	38.62
-10	-23.3	.0210	38	3.3	.2292	83	28.3	1.138	146	63.3	6.85	208	98.9	28.76	162	72.2	10.12	252	113.3	39.86
-5	-20.6	.0269	39	3.9	.2383	84	28.9	1.175	148	64.4	7.20	210	100.0	29.92	164	73.3	10.61	260	115.6	41.10
0	-17.8	.0337	40	4.4	.2478	86	29.4	1.213	150	65.6	7.57	212	101.1	31.13	166	74.4	11.12	268	117.8	42.34
1	-17.2	.0357	41	5.0	.2576	86	30.0	1.253	152	66.7	7.95	214	102.2	32.38	168	75.6	11.65	276	120.0	43.58
2	-16.7	.0379	42	5.6	.2677	87	30.6	1.293	154	67.8	8.35	216	103.3	33.66	170	76.7	12.20	284	122.2	44.82
3	-16.1	.0401	43	6.1	.2782	88	31.1	1.335	156	68.9	8.77	218	104.4	34.90	172	77.8	12.77	292	124.4	46.06
4	-15.6	.0424	44	6.7	.2891	89	31.7	1.378	158	70.0	9.20	220	105.6	36.14	174	78.9	13.37	300	126.7	47.30
5	-15.0	.0448	45	7.2	.3004	90	32.2	1.422	160	71.1	9.65	222	106.7	37.38	176	80.0	13.98	308	128.9	48.54
6	-14.4	.0474	46	7.8	.3120	91	32.8	1.467	162	72.2	10.12	224	107.8	38.62	178	81.1	14.63	316	131.1	49.78
7	-13.9	.0502	47	8.3	.3240	92	33.3	1.513	164	73.3	10.61	226	108.9	39.86	180	82.2	15.29	324	133.3	51.02
8	-13.3	.0530	48	8.9	.3364	93	33.9	1.561	166	74.4	11.12	228	110.0	41.10	182	83.3	15.98	332	135.6	52.26
9	-12.8	.0559	49	9.4	.3493	94	34.4	1.610	168	75.6	11.65	230	111.1	42.34	184	84.4	16.70	340	137.8	53.50
10	-12.2	.0589	50	10.0	.3626	95	35.0	1.660	170	76.7	12.20	232	112.2	43.58	186	85.6	17.44	348	140.0	54.74
11	-11.7	.0611	51	10.6	.3764	96	35.6	1.712	172	77.8	12.77	234	113.3	44.82	188	86.7	18.21	356	142.2	55.98
12	-11.1	.0635	52	11.1	.3906	97	36.1	1.765	174	78.9	13.37	236	114.4	46.06	190	87.8	19.01	364	144.4	57.22
13	-10.6	.0660	53	11.7	.4052	98	36.7	1.819	176	80.0	13.98	238	115.6	47.30	192	88.9	19.84	372	146.7	58.46
14	-10.0	.0687	54	12.2	.4203	99	37.2	1.875	178	81.1	14.63	240	116.7	48.54	194	90.0	20.70	380	148.9	59.70
15	-9.4	.0716	55	12.8	.4359	100	37.8	1.933	180	82.2	15.29	242	117.8	49.78	196	91.1	21.59	388	151.1	60.94
16	-8.9	.0747	56	13.3	.4520	101	38.3	1.992	182	83.3	15.98	244	118.9	51.02	198	92.2	22.52	396	153.3	62.18
17	-8.3	.0789	57	13.9	.4686	102	38.9	2.052	184	84.4	16.70	246	120.0	52.26	200	93.3	23.47	404	155.6	63.42
18	-7.6	.0833	58	14.4	.4858	103	39.4	2.114	186	85.6	17.44	248	121.1	53.50	202	94.4	24.46	412	157.8	64.66
19	-7.2	.0879	59	15.0	.5035	104	40.0	2.178	188	86.7	18.21	250	122.2	54.74	204	95.6	25.48	420	160.0	65.90
20	-6.7	.0928	60	15.6	.5218	105	40.6	2.244	190	87.8	19.01	252	123.3	55.98	206	96.7	26.53	428	162.2	67.14
21	-6.1	.0978	61	16.1	.5407	106	41.1	2.311	192	88.9	19.84	254	124.4	57.22	208	97.8	27.63	436	164.4	68.38
22	-5.6	.1031	62	16.7	.5601	107	41.7	2.380	194	90.0	20.70	256	125.6	58.46	210	98.9	28.76	444	166.7	69.62
23	-5.0	.1086	63	17.2	.5802	108	42.2	2.451	196	91.1	21.59	258	126.7	59.70	212	100.0	29.92	452	168.9	70.86
24	-4.4	.1143	64	17.8	.6009	109	42.8	2.522	198	92.2	22.52	260	127.8	60.94	214	101.1	31.13	460	171.1	72.10
25	-3.9	.1203	65	18.3	.6222	110	43.3	2.600	200	93.3	23.47	262	128.9	62.18	216	102.2	32.38	468	173.3	73.34
26	-3.3	.1266	66	18.9	.6442	111	43.9	2.675	202	94.4	24.46	264	130.0	63.42	218	103.3	33.66	476	175.6	74.58
27	-2.8	.1332	67	19.4	.6669	112	44.4	2.751	204	95.6	25.48	266	131.1	64.66	220	104.4	34.90	484	177.8	75.82
28	-2.2	.1400	68	20.0	.6903	114	45.6	2.91	206	96.7	26.53	268	132.2	65.90	222	105.6	36.14	492	180.0	77.06
29	-1.7	.1471	69	20.6	.7144	116	46.7	3.08	208	97.8	27.63	270	133.3	67.14	224	106.7	37.38	500	182.2	78.30
30	-1.1	.1545	70	21.1	.7392	118	47.8	3.26	210	98.9	28.76	272	134.4	68.38	226	107.8	38.62	508	184.4	79.54
31	-0.6	.1623	71	21.7	.7648	120	50.0	3.45	212	100.0	29.92	274	135.6	69.62	228	108.9	40.12	516	186.7	80.78
32	0.0	.1705	72	22.2	.7912	124	51.1	3.85	214	101.1	31.13	276	136.7	70.86	230	110.0	41.10	524	188.9	82.02
			73	22.8	.8183	126	52.2	4.06	216	102.2	32.38	278	137.8	72.10	232	111.1	42.34	532	191.1	83.26
			74	23.3	.8462	128	53.5	4.29	218	103.3	33.66	280	138.9	73.34	234	112.2	43.58	540	193.3	84.50
			75	23.9	.8750	130	54.4	4.53	220	104.4	34.90	282	140.0	74.58	236	113.3	44.82	548	195.6	85.74
			76	24.4	.9064	132	55.6	4.77	222	105.6	36.14	284	141.1	75.82	238	114.4	46.06	556	197.8	86.98



PERCENT RELATIVE HUMIDITY ABOVE WHICH CONDENSATION WILL OCCUR
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4. Vapor Permeability of Materials

WATER VAPOR PERMEABILITY TABLE
MISCELLANEOUS MATERIALS

MATERIAL	PERMEABILITY, perms
Aluminum foil, 0.0025 inch thickness	0.005 to 0.01
Aluminum foil, 0.001 inch thickness	0.01 to 0.05
Aluminum foil, cloth backed	0.004
Aluminum tape, paper backed	0.006
Asphalt-saturated 15 lb felt, coated with 25 lb asphalt per 100 sq. ft.	0.05
Calcium-silicate insulation, one inch thickness	21 to 35
Cellular glass insulation, one-half inch thickness	0.00005
Cork, one inch thickness	3 to 7
Duplex laminated kraft paper (30-30-30)	0.20
Duplex laminated kraft paper, reinforced	0.70
Fiberboard, 3/4 inch thickness	12.5
Foil-faced kraft paper	0.01
Foil-faced reflective insulation, double faced	0.08 to 0.13
Friction tape, single layer	2.34
double layer	1.45
Gypsum lath, metallic aluminum backing	0.09 to 0.39
Laminated paper and foil	0.01
Mineral wool, unprotected, 4 inch thickness	29.07
Plaster, fiberboard or gypsum lath	19.7 to 20.6
Plywood, 2 coats aluminum paint	1.29
Plywood, 2 coats asphalt paint	0.43
Polyethylene, 0.004 inch thickness	0.10
Polyethylene, 0.03 inch thickness	0.002
Roll roofing, smooth 40-65 lb per 108 sq. ft.	0.13 to 0.17
Sheating paper, asphalt-impregnated, glossy	0.17 to 2.05
Vinyl membrane, 0.004 inch thickness	0.80 to 2.0



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4. Vapor Permeability of Materials

TABLE I -- PERMEANCE OF BUILDING MATERIALS

	Thick- ness Inches	Perme- ability Perm, in.	Permeance Perms
MEMBRANE TYPE MATERIALS			
Built-up roofing, tar and gravel	3/8	-	0.43
Roofing felt, 2 ply, 30 lb. asphalt saturated	-	-	0.14
Building paper, single thickness	-	-	49.0
Building felts			
Asphalt saturated asbestos	-	-	-
15 lb.	-	-	13.1
20 lb., one surface asphalt coated	-	-	0.16
50 lb., saturated, not coated	-	-	0.38
Asphalt saturated ray			
10 lb.	-	-	0.9
15 lb.	-	-	3.0
20 lb.	-	-	0.5
25 lb.	-	-	30.0
30 lb.	-	-	0.6
Johns Manville, 30 lb.	-	-	1.79
one sheet	-	-	1.16
two sheets	-	-	0.92
three sheets	-	-	0.21
Regal, one surface coated, 20 lb.	-	-	0.29
Super-Regal, coated one surface, 25 lb.	-	-	-
Suparite sheathing coated both surfaces	-	-	-
Light			
Heavy	-	-	0.14
Light, coated both surfaces, 15 lb.	-	-	0.91
Super, coated both surfaces, 18 lb.	-	-	0.17
Base felt, coated both surfaces, 42 lb.	-	-	0.06
Coated one surface	-	-	0.08
Carpet felt, 17 oz.	-	-	0.15
Tar saturated asbestos, 15 lb.	-	-	167.0
Tar saturated ray, 12.5 lb. (7 oz.)	-	-	28
15 lb. (10 oz.)	-	-	38
25 lb. (16 oz.)	-	-	34
Paper			
Asbestos, 14 lb.	0.28	-	138.0
Asphalt Coated Kraft (not saturated)	0.013	-	0.41-
Heavy, 4.8 lb.	-	-	0.742
Asphalt Saturated and Coated Kraft,			
9 lb.	0.013	-	0.19
	0.018	-	0.49
Asphalt Saturated Sheathing			
No. 2, 6.25 lb.	0.015	-	0.14-
	0.017	-	16.2
Remown, 6.25 lb.	0.017	-	4.18
Kraft, 6.25 lb.	0.015	-	1.54
COATING MATERIALS			
Bituplastic, no primer	1/16	-	0.32
1 coat of primer	1/16	-	0.26
2 coats of primer	1/16	-	0.63
Kopper's coating, "F-73," no primer	1/16	-	0.62
1 coat of primer	1/16	-	0.14
2 coats of primer	1/16	-	0.98
"Lumino," 3 coats and 2 coats of primer	*	-	7.10
I.P.C., no primer	1/16	-	12.50
Flinkkate No. 20, no primer	1/16	-	0.69
1 coat of primer	1/16	-	0.29
2 coats of primer	1/16	-	0.69
Flinkkate -- C-13-H.P.C., no primer	1/16	-	0.27
1 coat of primer	1/16	-	0.56
2 coats of primer	1/16	-	0.49
Robertson No. 460, 3 coats, no primer	*	-	7.30
Robertson No. 455, no primer	1/32	-	0.66
1 coat of primer	1/32	-	0.57
2 coats of primer	1/32	-	0.61
J. M. Asbestile, no primer	1/16	-	0.29
1 coat of primer	1/16	-	1.09
2 coats of primer	1/16	-	0.91
J. M. Airtite, no primer	1/16	-	0.14
1 coat of primer	1/16	-	0.30
2 coats of primer	1/16	-	0.39
Purafine Aluminum No. 6507, 3 coats,	-	-	-
no primer	*	-	0.75
3 coats, 1 coat of primer	*	-	1.15
Prutch -- Coat, no primer	1/16	-	0.35
1 coat of primer	1/16	-	0.14
2 coats of primer	1/16	-	0.29
Ceroseal, 2 coats, no primer	*	-	2.90
1 coat of primer	*	-	1.73
Bituplastic No. 50, no primer	1/16	-	5.70
1 coat of primer	1/16	-	2.94
2 coats of primer	1/16	-	0.63
Wm. L. Crow pitch marked	1/16	-	1.07
"before heating," no primer	1/16	-	0.45
"after heating," no primer	1/16	-	22.30
Uncoated discs of cinder blocks	-	-	-
Coatings on 1 in. Corkboard	1/4	-	0.73
Two coats of plastic emulsion	-	-	0.17
ditto with two coats of Aluminum Cold	-	-	-
Storage Paint	-	-	-



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION I
INSULATION DE
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DATA

I. GENERAL

4. Vapor Permeability of Materials - Continued

Material	Permeability (perms)	Material	Permeability (perms)	Material	Permeability (perms)
Flat Interior, white (Rosin Perrilla Oil vehicle)	-	Plasterboard	0.37	Plasterboard	34.6
on Plaster, two coats	-	Plaster between paper	-	Plywood	3.68-4.46
on Plaster, three coats	-	Plywood	0.25	Douglas Fir (G25)	4.52
Interior-Exterior Paint (Linseed vehicle)	-	with two coats white lead paint	0.25		1.95
on Plaster, two coats	-				
on Plaster,	-	INSULATION			
Sisal Coat, white (Varnish vehicle)	-	Batts, enclosed both sides	-		123
on Plaster, two coats	-	Cane fibreboard	-		9.5
on Plaster, three coats	-	Foamglas	-		0.0
Semi-gloss Interior, white (Lins. Tung vehicle)	-	Sawdust, dry	-		62.0
on Plaster, two coats	-	Rockwool	1.0		25.5
on Plaster, three coats	-				230.0
	-	MASONRY			
MANUFACTURED BOARDS		Clay tile, 4 in. Hollow	-		4.3
Fiberboard		Clay tile, 4 in. Hollow, glazed face	-		2.0
Plain	1.06	Clay tile, 8 in. Hollow	-		2.9
Plain	0.83	Tile and Terrazo for floors	-		-
Plain	0.599	Metal lath and 3/4 in. plaster	-		14.0
Plain	0.492	Brick, select hard common	-		-
Plain	0.405	Concrete, light weight aggregate	-		4.5
Plain	0.201	Concrete, sand and gravel aggregate	-		4.9
Dipped asphalt one surface	0.633	Two coats Portland Cement Mortar	1/2		2.6
Roller asphalt one surface	0.492				3.8
Two 1/2 in. samples joined with asphalt	0.985	MISCELLANEOUS			
Laminated, 6 layers fiberboard, 5 of asphalt	0.527	Plaster	-		16.5
Insulating Sheathing	25/32	1/2 in. on metal lath	-		13.5
Celotex insulating lath	0.50	3/4 in. on metal lath	-		11.1
with one coat aluminum paint	0.50	1 in. on metal lath	-		6.75
with two coats aluminum paint	0.50	1/2 in. on wood lath	-		11.3
Celotex vapor seal sheathing	0.78	1/2 in. on 3/8 in. gyp-lum board	-		16.4
Homasote	0.50	1/2 in. on 1/2 in. wood fiber board	-		13.3
with one coat aluminum paint	0.50	Solid plaster, 1.34 in.	-		1.78
with two coats aluminum paint	0.50	Wood, Pine, yellow, unpainted	-		0.80
Johns-Manville rock cork	0.523	Maple, unpainted	-		0.62
	0.984	Wood, Spruce, unpainted	-		0.86
Johns-Manville Flexboard	2.001	Maple, unpainted	-		0.62
Nu-wood	0.125	Wood, Spruce, unpainted	-		0.86
Pressed cork board	0.50	Cedar, siding, unpainted	-		1.82
	0.905-	Cedar, with 3 coats white lead paint	-		1.01
	0.985	Stiff air	-		126.0
Masonite	0.13	Ground cornstalks	2.0		42.0
Prestwood (Tempered)	1.13	Hole (1/16 in.) in sheet metal	-		0.42
Prestwood	-	Metal, sheets	-		0.0
5 thicknesses	-	Water surface, free standing	-		608.5
7 thicknesses	-	Air film any position, any velocity	-		Infinite
	-	Glass block	-		0
	-	Window glass	-		0

DATA

I. GENERAL

4. Vapor Permeability of Materials - Continued

REGAIN OF HYGROSCOPIC MATERIALS

Classification	Material	Description	10	20	30	40	50	60	70	80	90	Authority
Natural Textile Fibers	Cotton	Sea island--rowing	2.5	3.7	4.6	5.5	6.6	7.9	9.5	11.5	14.1	Hartshorne
	Cotton	American--cloth	2.6	3.7	4.4	5.2	5.9	6.8	8.1	10.0	14.3	Schloesing
	Cotton	Abakant	4.8	9.0	12.5	15.7	18.5	20.8	22.8	24.3	25.8	Fuwa
	Wool	Australian merino--skin	4.7	7.0	8.9	10.8	12.8	14.9	17.2	19.9	23.4	Hartshorne
	Silk	Raw chevennes--skin	3.2	5.5	6.9	8.0	8.9	10.2	11.9	14.3	18.8	Schloesing
	Linen	Table cloth	1.9	2.9	3.6	4.3	5.1	6.1	7.0	8.4	10.2	Atkinson
	Linen	Dry spun--yarn	3.6	5.4	6.5	7.3	8.1	8.9	9.8	11.2	13.8	Sommer
	Linen	Average of several grades	3.1	5.2	6.9	8.5	10.2	12.2	14.4	17.1	20.2	Storch
	Hemp	Manilla and sisal--rope	2.7	4.7	6.0	7.2	8.5	9.9	11.6	13.6	15.7	Fuwa
	Viscose Nitrocellu- lose Cuprammonium Cellulose Acetate	Average skin Fiber	4.0	5.7	6.8	7.9	9.2	10.8	12.4	14.2	16.0	Robertson Robertson
Rayons			0.8	1.1	1.4	1.9	2.4	3.0	3.6	4.3	5.3	
Paper	M. F. Newspring	Wood pump -- 24% ash	2.1	3.2	4.0	4.7	5.3	6.1	7.2	8.7	10.6	U. S. B. of S.
	H. M. F. Whiting	Wood pump -- 3% ash	3.0	4.2	5.2	6.2	7.2	8.3	9.9	11.9	14.2	U. S. B. of S.
	White Bond	Rag -- 12 ash	2.4	3.7	4.7	5.5	6.5	7.5	8.8	10.8	13.2	U. S. B. of S.
	Com. Ledger	75% rag -- 1% ash	3.2	4.2	5.0	5.6	6.2	6.9	8.1	10.3	13.9	U. S. B. of S.
	Kraft Wrapping	Coniferous	3.2	4.6	5.7	6.6	7.6	8.9	10.5	12.6	14.9	U. S. B. of S.
	Leather	Sole oak -- tanned	5.0	8.5	11.2	13.6	16.0	18.3	20.6	24.0	29.2	Phelps
Misc. Organic Materials	Catgut	Racquet strings	4.6	7.2	8.6	10.2	12.0	14.3	17.3	19.8	21.7	Fuwa
	Glue	Hide	3.4	4.8	5.8	6.6	7.6	9.0	10.7	11.8	12.5	Fuwa
	Rubber	Solid tires	0.11	0.21	0.32	0.44	0.54	0.66	0.76	0.88	0.99	Fuwa
	Wood	Timber (average)	3.0	4.4	5.9	7.6	9.3	11.3	14.0	17.5	22.0	Forest P. Lab.
	Sonp	White	1.9	3.8	5.7	7.6	10.0	12.9	16.1	19.8	23.8	Fuwa
	Tobacco	Cigarette	5.4	8.6	11.0	13.3	16.0	19.5	25.0	33.5	50.0	Ford
	White Bread		0.5	1.7	3.1	4.5	6.2	8.5	11.1	14.5	19.0	Atkinson
	Crackers		2.1	2.8	3.3	3.9	5.0	6.5	8.3	10.9	14.9	Atkinson
	Macaroni		5.1	7.4	8.8	10.2	11.7	13.7	16.2	19.0	22.1	Atkinson
	Flour		2.6	4.1	5.3	6.5	8.0	9.9	12.4	15.4	19.1	Bailey
Food- stuffs	Starch		2.2	3.8	5.2	6.4	7.4	8.3	9.2	10.6	12.7	Atkinson
	Gelatin		0.7	1.6	2.8	3.8	4.9	6.1	7.6	9.3	11.4	Atkinson
Misc. Inorganic Materials	Albestos Fiber	Finely Divided	0.16	0.24	0.26	0.32	0.41	0.51	0.62	0.73	0.84	Fuwa
	Silica Gel		5.7	9.8	12.7	15.2	17.2	18.8	20.2	21.5	22.6	Fuwa
	Domestic Cde		0.20	0.40	0.61	0.81	1.03	1.24	1.46	1.67	1.89	Selwig
	Activated Charcoal	Stream activated	7.1	14.3	22.8	26.2	28.3	29.2	30.0	31.1	32.7	Fuwa
	Sulfuric Acid	H ₂ SO ₄	33.0	41.0	47.5	52.5	57.0	61.5	67.0	73.5	82.5	Mason

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DATA

I. GENERAL

5. Pipe and Tube Insulation Dimensions

OUTSIDE DIAMETERS AND AVERAGE THICKNESSES FOR PIPE INSULATION
ASTM Recommended Practice

NPS Pipe		Insulation Thickness							
NOM SIZE	O.D. Inches	1/2 Nominal		1" Nominal		1 1/2" Nominal		2" Nominal	
		Avg. Thk. Inches	O.D. Inches	Avg. Thk. Inches	O.D. Inches	Avg. Thk. Inches	O.D. Inches	Avg. Thk. Inches	O.D. Inches
1/8	0.405	0.45	1.315	0.98	2.375	1.54	3.500	2.05	4.500
1/4	0.540	0.55	1.660	1.16	2.875	1.72	4.000	2.22	5.000
3/8	0.675	0.49	1.660	1.09	2.875	1.66	4.000	2.16	5.000
1/2	0.840	0.52	1.900	1.00	2.875	1.57	4.000	2.07	5.000
3/4	1.050	0.42	1.900	0.91	2.875	1.47	4.000	1.97	5.000
1	1.315	0.52	2.375	1.09	3.500	1.59	4.500	2.12	5.563
1 1/4	1.660	0.60	2.875	0.91	3.500	1.66	5.000	1.94	5.563
1 1/2	1.900	0.48	2.875	1.04	4.000	1.54	5.000	2.36	6.625
2	2.375	0.55	3.500	1.05	4.500	1.58	5.563	2.11	6.625
2 1/2	2.875	0.55	4.00	1.05	5.000	1.86	6.625	2.36	7.625
3	3.500	0.49	4.500	1.02	5.563	1.55	6.625	2.05	7.625
3 1/2	4.000	0.49	5.000	1.30	6.625	1.80	7.625	2.30	8.625
4	4.500	0.54	5.563	1.05	6.625	1.55	7.625	2.05	8.625
4 1/2	5.000	0.80	6.625	1.30	7.625	1.80	8.625	2.30	9.625
5	5.563	0.49	6.625	0.99	7.625	1.49	8.625	1.99	9.625
6	6.625	0.46	7.625	0.96	8.625	1.46	9.625	2.02	10.750
7	7.625					1.52	10.750	2.02	11.750
8	8.625					1.52	11.750	2.02	12.750
9	9.625					1.52	12.750	2.15	14.000
10	10.750					1.59	14.00	2.09	15.000
11	11.750					1.59	15.000	2.09	16.000
12	12.750					1.58	16.000	2.08	17.000
14	14.000					1.45	17.00	1.95	18.000
15	15.000					1.45	18.00	1.95	19.000
16	16.000					1.45	19.000	1.95	20.000
17	17.000					1.45	20.000	1.95	21.000
18	18.000					1.45	21.000	1.95	22.000
19	19.000					1.45	22.000	1.95	23.000
20	20.000					1.45	23.000	1.95	24.000
21	21.000					1.45	24.000	1.95	25.000
22	22.000					1.45	25.000	1.95	26.000
23	23.000					1.45	26.000	1.95	27.000
24	24.000					1.45	27.000	1.95	28.000
25	25.000					1.45	28.000	1.95	29.000
26	26.000					1.45	29.000	1.95	30.000
27	27.000					1.45	30.000	1.95	31.000
28	28.000					1.45	31.000	1.95	32.000
29	29.000					1.45	32.000	1.95	33.000
30	30.000					1.45	33.000	1.95	34.000
31	31.000					1.45	34.000	1.95	35.000
32	32.000					1.45	35.000	1.95	36.000
33	33.000					1.45	36.000	1.95	37.000
34	34.000					1.45	37.000	1.95	38.000
35	35.000					1.45	38.000	1.95	39.000
36	36.000					1.45	39.000	1.95	40.000

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INSULATION DESIGN
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MAY, 1968**DATA****I. GENERAL****5. Pipe and Tube Insulation Dimensions - Continued****OUTSIDE DIAMETERS AND AVERAGE THICKNESSES FOR PIPE INSULATION**
ASTM Recommended Practice

NPS Pipe		Insulation Thickness							
		2 1/2" Nominal		3" Nominal		3 1/2" Nominal		4" Nominal	
		Avg. Thk. Inches	O.D. Inches	Avg. Thk. Inches	O.D. Inches	Avg. Thk. Inches	O.D. Inches	Avg. Thk. Inches	O.D. Inches
1/8	0.405	2.57	5.563	3.10	6.625	3.60	7.625	4.10	8.625
1/4	0.540	2.50	5.563	3.04	6.625	3.54	7.625	4.04	8.625
3/8	0.675	2.44	5.563	2.97	6.625	3.47	7.625	3.97	8.625
1/2	0.840	2.89	6.625	3.39	7.625	3.89	8.625	4.39	9.625
3/4	1.050	2.78	6.625	3.28	7.625	3.78	8.625	4.28	9.625
1	1.315	2.64	6.625	3.15	7.625	3.65	8.625	4.15	9.625
1 1/4	1.660	2.48	6.625	2.98	7.625	3.48	8.625	3.98	9.625
1 1/2	1.900	2.86	7.625	3.36	8.625	3.86	9.625	4.42	10.750
2	2.375	2.61	7.625	3.11	8.625	3.61	9.625	4.17	10.750
2 1/2	2.875	2.86	8.625	3.36	9.625	3.92	10.750	4.42	11.750
3	3.500	2.55	8.625	3.05	9.625	3.61	10.750	4.11	11.750
3 1/2	4.000	2.80	9.625	3.36	10.750	3.86	11.750	4.36	12.750
4	4.500	2.55	9.625	3.11	10.750	3.61	11.750	4.11	12.750
4 1/2	5.000	2.86	10.750	3.36	11.750	3.86	12.750	4.49	14.000
5	5.563	2.56	10.750	3.06	11.750	3.56	12.750	4.18	14.000
6	6.625	2.52	11.750	3.02	12.750	3.65	14.000	4.15	15.000
7	7.625	2.52	12.750	3.15	14.000	3.65	15.000	4.15	16.000
8	8.625	2.65	14.000	3.15	15.000	3.65	16.000	4.15	17.000
9	9.625	2.65	15.000	3.15	16.000	3.65	17.000	4.15	18.000
10	10.750	2.59	16.000	3.09	17.000	3.59	18.000	4.09	19.000
11	11.750	2.59	17.000	3.09	18.000	3.59	19.000	4.09	20.000
12	12.750	2.58	18.000	3.08	19.000	3.58	20.000	4.08	21.000
14	14.000	2.45	19.000	2.95	20.000	3.45	21.000	3.95	22.000
15	15.000	2.45	20.000	2.95	21.000	3.45	22.000	3.95	23.000
16	16.000	2.45	21.000	2.95	22.000	3.45	23.000	3.95	24.000
17	17.000	2.45	22.000	2.95	23.000	3.45	24.000	3.95	25.000
18	18.000	2.45	23.000	2.95	24.000	3.45	25.000	3.95	26.000
19	19.000	2.45	24.000	2.95	25.000	3.45	26.000	3.95	27.000
20	20.000	2.45	25.000	2.95	26.000	3.45	27.000	3.95	28.000
21	21.000	2.45	26.000	2.95	27.000	3.45	28.000	3.95	29.000
22	22.000	2.45	27.000	2.95	28.000	3.45	29.000	3.95	30.000
23	23.000	2.45	28.000	2.95	29.000	3.45	30.000	3.95	31.000
24	24.000	2.45	29.000	2.95	30.000	3.45	31.000	3.95	32.000
25	25.000	2.45	30.000	2.95	31.000	3.45	32.000	3.95	33.000
26	26.000	2.45	31.000	2.95	32.000	3.45	33.000	3.95	34.000
27	27.000	2.45	32.000	2.95	33.000	3.45	34.000	3.95	35.000
28	28.000	2.45	33.000	2.95	34.000	3.45	35.000	3.95	36.000
29	29.000	2.45	34.000	2.95	35.000	3.45	36.000	3.95	37.000
30	30.000	2.45	35.000	2.95	36.000	3.45	37.000	3.95	38.000
31	31.000	2.45	36.000	2.95	37.000	3.45	38.000	3.95	39.000
32	32.000	2.45	37.000	2.95	38.000	3.45	39.000	3.95	40.000
33	33.000	2.45	38.000	2.95	39.000	3.45	40.000	3.95	41.000
34	34.000	2.45	39.000	2.95	40.000	3.45	41.000	3.95	42.000
35	35.000	2.45	40.000	2.95	41.000	3.45	42.000	3.95	43.000
36	36.000	2.45	41.000	2.95	42.000	3.45	43.000	3.95	44.000



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
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SECTION I
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DATA

I. GENERAL

5. Pipe and Tube Insulation Dimensions - Continued

INSIDE DIAMETERS FOR PIPE INSULATION
ASTM Recommended Practice

IRON PIPE NOM SIZE	O.D. Inches	Insulation Tolerance, Inches		Nominal Insulation I.D. Inches	Insulation I.D., Inches		Maximum Insulation I.D. Inches
		Minus	Plus		Minus	Plus	
1/8	0.405	0	1/16	0.421	0	0.421	0.483
1/4	0.540	0	1/16	0.556	0	0.556	0.618
3/8	0.675	0	1/16	0.691	0	0.691	0.753
1/2	0.840	0	1/16	0.856	0	0.856	0.918
3/4	1.050	0	1/16	1.066	0	1.066	1.128
1	1.315	0	1/16	1.331	0	1.331	1.393
1 1/4	1.660	0	1/16	1.676	0	1.676	1.738
1 1/2	1.900	0	1/16	1.916	0	1.916	1.978
2	2.375	1/64	3/32	2.406	1/64	2.391	2.499
2 1/2	2.875	1/64	3/32	2.906	1/64	2.891	2.999
3	3.500	1/64	3/32	3.531	1/64	3.516	3.624
3 1/2	4.000	1/64	3/32	4.031	1/64	4.016	4.124
4	4.500	1/64	3/32	4.531	1/64	4.516	4.624
4 1/2	5.000	1/64	3/32	5.031	1/64	5.016	5.124
5	5.563	1/32	3/32	5.641	1/32	5.610	5.734
6	6.625	1/32	3/32	6.703	1/32	6.672	6.796
7	7.625	1/32	3/32	7.703	1/32	7.672	7.796
8	8.625	1/32	3/32	8.703	1/32	8.672	8.796
9	9.625	1/32	3/32	9.703	1/32	9.672	9.796
10	10.750	1/32	3/32	10.828	1/32	10.797	10.921
11	11.750	1/32	3/32	11.828	1/32	11.797	11.921
12	12.750	3/64	5/32	12.844	3/64	12.797	13.000
14	14.000	3/64	5/32	14.094	3/64	14.047	14.250
15	15.000	3/64	5/32	15.094	3/64	15.047	15.250
16	16.000	3/64	5/32	16.094	3/64	16.047	16.250
17	17.000	3/64	5/32	17.094	3/64	17.047	17.250
18	18.000	3/64	5/32	18.094	3/64	18.047	18.250
19							
thru 32	.000	3/64	5/32	.094	3/64	.047	.250
33	33.000	3/64	5/32	33.094	3/64	33.047	33.250

OUTER SIZE FOR PIPE INSULATION
ASTM Recommended Practice
Expressed in Nominal Iron Pipe Size

IRON PIPE SIZE	O.D. Inches	Nominal Thickness						
		1	1 1/2	2	2 1/2	3	3 1/2	4
1/2	0.84	2 1/2	3 1/2	4 1/2	6	7	8	9
3/4	1.05	2 1/2	3 1/2	4 1/2	6	7	8	9
1	1.32	3	4	5	6	7	8	9
1 1/4	1.66	3	4 1/2	5	6	7	8	9
1 1/2	1.90	3 1/2	4 1/2	6	7	8	9	10
2	2.38	4	5	6	7	8	9	10
2 1/2	2.88	4 1/2	6	7	8	9	10	11
3	3.50	5	6	7	8	9	10	11
3 1/2	4.00	6	7	8	9	10	11	12
4	4.50	6	7	8	9	10	11	12
4 1/2	5.00	7	8	9	10	11	12	14
5	5.56	7	8	9	10	11	12	14
6	6.63	8	9	10	11	12	14	15
7	7.63	9	10	11	12	14	15	16
8	8.63	10	11	12	14	15	16	17
9	9.63	11	12	14	15	16	17	18
10	10.75	12	14	15	16	17	18	19
11	11.75	14	15	16	17	18	19	20
12	12.75	15	16	17	18	19	20	21
14	14.00	16	17	18	19	20	21	22
15	15.00	17	18	19	20	21	22	23
16	16.00	18	19	20	21	22	23	24
17	17.00	19	20	21	22	23	24	25
18	18.00	20	21	22	23	24	25	26
19	19.00	21	22	23	24	25	26	27
20	20.00	22	23	24	25	26	27	28
21	21.00	23	24	25	26	27	28	29
22	22.00	24	25	26	27	28	29	30
23	23.00	25	26	27	28	29	30	31
24	24.00	26	27	28	29	30	31	32
25	25.00	27	28	29	30	31	32	33
26	26.00	28	29	30	31	32	33	34
27	27.00	29	30	31	32	33	34	35
28	28.00	30	31	32	33	34	35	36
29	29.00	31	32	33	34	35	36	37
30	30.00	32	33	34	35	36	37	38
31	31.00	33	34	35	36	37	38	39
32	32.00	34	35	36	37	38	39	40
33	33.00	35	36	37	38	39	40	41
34	34.00	36	37	38	39	40	41	42
35	35.00	37	38	39	40	41	42	

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I. GENERAL

5. Pipe and Tube Insulation Dimensions - Continued

BASIC OUTSIDE DIAMETERS FOR TUBE INSULATION
ASTM Recommended Practice

Tube Size	O.D.	Nominal Thickness of Insulation							
		1/2	1	1½	2	2½	3	3½	4
1/4	0.250	1.315	2.875	3.500	4.500	5.625	6.625	7.625	8.625
3/8	0.375	1.660	2.875	3.500	4.500	5.625	6.625	7.625	8.625
1/2	0.500	1.660	2.875	3.500	4.500	5.625	6.625	7.625	8.625
1/2	0.625	1.660	2.875	3.500	4.500	5.625	6.625	7.625	8.625
3/4	0.750	1.900	2.875	4.000	5.000	5.625	7.625	8.625	9.625
3/4	0.875	1.900	3.500	4.000	5.000	6.625	7.625	8.625	9.625
1	1.000	2.375	3.500	4.000	5.000	6.625	7.625	8.625	9.625
1	1.125	2.375	3.500	4.000	5.000	6.625	7.625	8.625	9.625
1½	1.250	2.375	3.500	4.500	5.563	6.625	7.625	8.625	9.625
1½	1.500	2.875	4.000	4.500	5.563	6.625	7.625	8.625	9.625
1½	1.625	2.875	4.000	4.500	5.563	6.625	7.625	8.625	9.625
2	2.000	3.500	4.000	5.000	6.625	7.625	8.625	9.625	10.750
2	2.125	3.500	4.500	5.563	6.625	7.625	8.625	9.625	10.750
2½	2.500	3.500	4.500	5.563	6.625	7.625	8.625	9.625	10.750
2½	2.625	4.000	5.000	5.563	6.625	7.625	8.625	9.625	10.750
3	3.000	4.000	5.000	6.625	7.625	8.625	9.625	10.750	11.750
3	3.125	4.500	5.563	6.625	7.625	8.625	9.625	10.750	11.750
3 5/8	3.625	5.000	6.625	7.625	8.625	9.625	10.750	11.750	12.750
4	4.000	5.000	6.625	7.625	8.625	9.625	10.750	11.750	12.750
4	4.125	5.563	6.625	7.625	8.625	9.625	10.750	11.750	12.750
5	5.000	6.625	7.625	8.625	9.625	10.750	11.750	12.750	14.000
5	5.125	6.625	7.625	8.625	9.625	10.750	11.750	12.750	14.000
6	6.000	7.625	8.625	9.625	10.750	11.750	12.750	14.000	15.000
6	6.125	7.625	8.625	9.625	10.750	11.750	12.750	14.000	15.000
8	8.000			11.750	12.750	14.000	15.000	16.000	17.000
8	8.125			11.750	12.750	14.000	15.000	16.000	17.000
10	10.000			12.750	14.000	15.000	16.000	17.000	18.000
10	10.125			14.000	14.000	15.000	16.000	17.000	18.000
12	12.000			15.000	16.000	17.000	18.000	19.000	20.000
14	14.333			18.000	19.000	20.000	21.000	23.000	23.000
16	16.333			20.000	21.000	22.000	23.000	24.000	25.000
18	18.333			22.000	23.000	24.000	25.000	26.000	27.000
20	20.333			24.000	25.000	26.000	27.000	28.000	29.000
24	24.333			28.000	29.000	30.000	31.000	32.000	33.000

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1. GENERAL

5. Pipe and Tube Insulation Dimensions - Continued

SURFACE AREAS OF PIPE INSULATION
Based on NPS Pipe and ASTM Dimensional Standard
Pipe Insulation - Square Feet per linear foot

NOM. PIPE SIZE	Nominal Insulation Thicknesses											
	BARE	1	1½	2	2½	3	3½	4	4½	5	5½	6
1/8	0.106	0.62	0.92	1.18	1.46	1.73	2.00	2.26				
1/4	0.141	0.75	1.05	1.30	1.46	1.73	2.00	2.26				
3/8	0.177	0.75	1.05	1.30	1.46	1.73	2.00	2.26				
1/2	0.220	0.75	1.05	1.30	1.73	2.00	2.25	2.52				
3/4	0.275	0.75	1.05	1.30	1.73	2.00	2.25	2.52				
1	0.344	0.92	1.18	1.46	1.74	2.00	2.26	2.52				
1 1/4	0.435	0.92	1.31	1.46	1.74	2.00	2.26	2.52				
1 1/2	0.498	1.05	1.31	1.74	2.00	2.26	2.52	2.81				
2	0.622	1.18	1.46	1.73	2.00	2.26	2.52	2.81				
2 1/2	0.753	1.31	1.73	2.00	2.26	2.52	2.81	3.08				
3	0.917	1.46	1.73	2.00	2.26	2.52	2.81	3.08	3.34			
3 1/2	1.047	1.73	2.00	2.26	2.52	2.81	3.08	3.34	3.67			
4	1.178	1.73	2.00	2.26	2.52	2.81	3.08	3.34	3.67			
4 1/2	1.309	2.00	2.26	2.52	2.81	3.08	3.34	3.67	3.67			
5	1.456	2.00	2.26	2.52	2.81	3.08	3.34	3.67	3.93	4.19		
6	1.734	2.26	2.52	2.81	3.08	3.34	3.67	3.93	4.18	4.45		
7	1.996		2.81	3.08	3.34	3.67	3.93	4.19	4.45	4.71	4.97	
8	2.258		3.08	3.34	3.67	3.93	4.19	4.45	4.71	4.97	5.24	
9	2.520		3.34	3.67	3.93	4.19	4.45	4.71	4.97	5.24	5.50	
10	2.814		3.67	3.93	4.19	4.45	4.71	4.97	5.24	5.50	5.76	
11	3.076		3.93	4.19	4.45	4.71	4.97	5.24	5.50	5.76	6.02	
12	3.338		4.19	4.45	4.71	4.97	5.24	5.50	5.76	6.02	6.28	6.54
14	2.665		4.45	4.71	4.97	5.24	5.50	5.76	6.02	6.28	6.54	6.81
16	4.189		4.97	5.24	5.50	5.76	6.02	6.28	6.54	6.81	7.07	7.33
18	4.712		5.50	5.76	6.02	6.28	6.54	6.81	7.07	7.33	7.59	7.85
20	5.236		6.02	6.28	6.54	6.81	7.07	7.33	7.59	7.85	8.12	8.38
22	5.759		6.54	6.81	7.07	7.33	7.59	7.85	8.12	8.38	8.64	8.90
24	6.283		7.07	7.33	7.59	7.85	8.12	8.38	8.64	8.90	9.16	9.42
26	6.807		7.59	7.85	8.12	8.38	8.64	8.90	9.16	9.42	9.69	9.95
28	7.331		8.12	8.38	8.64	8.90	9.16	9.42	9.69	9.95	10.21	10.47
30	7.854		8.64	8.90	9.16	9.42	9.69	9.95	10.21	10.47	10.73	11.00



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I. GENERAL

5. Pipe and Tube Insulation Dimensions - Continued

VOLUMES OF PIPE INSULATION

Cubic Feet Per Linear Foot

IPS PIPE SIZE	Nominal Insulation Thickness																
	1	1½	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9
½																	
¾	0.013	0.040	0.083	0.133	0.231	0.313	0.400	0.498									
1	0.010	0.038	0.082	0.130	0.228	0.310	0.398	0.496									
1½	0.018	0.056	0.100	0.154	0.225	0.307	0.394	0.493									
2	0.029	0.051	0.122	0.148	0.219	0.302	0.388	0.487									
2½	0.027	0.071	0.120	0.218	0.300	0.388	0.486	0.611									
3	0.038	0.082	0.137	0.208	0.289	0.377	0.474	0.600									
3½	0.044	0.093	0.191	0.273	0.360	0.458	0.563	0.709									
4	0.044	0.098	0.169	0.251	0.338	0.437	0.562	0.688	0.818	1.003	1.162	1.331					
4½	0.049	0.148	0.229	0.317	0.414	0.540	0.665	0.796	0.892	0.982	1.140	1.309					
5	0.055	0.126	0.208	0.294	0.393	0.518	0.643	0.774	0.960	1.118	1.288	1.468					
6	0.082	0.169	0.268	0.393	0.518	0.649	0.834	0.993	1.162	1.342	1.533	1.734	1.948	2.171	2.405	2.651	2.908
8	0.223	0.349	0.480	0.666	0.823	0.993	1.173	1.363	1.565	1.778	2.002	2.237	2.482	2.738	3.005	3.283	3.573
10	0.257	0.442	0.600	0.769	0.949	1.140	1.342	1.554	1.778	2.013	2.258	2.514	2.782	3.060	3.349	3.649	3.960
12	0.343	0.513	0.693	0.883	1.086	1.298	1.522	1.757	2.003	2.258	2.525	2.803	3.093	3.393	3.703	4.025	4.356
14	0.328	0.508	0.698	0.900	1.113	1.337	1.571	1.817	2.073	2.340	2.618	2.908	3.207	3.518	3.840	4.173	4.516
16	0.363	0.573	0.786	1.009	1.243	1.489	1.745	2.013	2.291	2.580	2.88	3.191	3.513	3.845	4.189	4.543	4.909
18	0.414	0.638	0.873	1.118	1.374	1.642	1.920	2.209	2.509	2.820	3.142	3.474	3.818	4.173	4.538	4.914	5.302
20	0.458	0.703	0.960	1.228	1.505	1.794	2.094	2.405	2.728	3.060	3.403	3.758	4.123	4.500	4.887	5.285	5.694
24	0.546	0.834	1.134	1.445	1.768	2.100	2.443	2.798	3.163	3.540	3.927	4.325	4.734	5.154	5.585	6.027	6.480
30	0.677	1.031	1.397	1.773	2.160	2.558	2.968	3.388	3.818	4.259	4.713	5.176	5.651	6.136	6.633	7.139	7.658
36	0.808	1.222	1.658	2.100	2.553	3.016	3.491	3.976	4.473	4.980	5.498	6.027	6.567	7.118	7.679	8.253	8.836

Note: Density of insulation in lbs/cu ft times the cu ft per linear ft = lbs per linear ft

DATA

I. GENERAL

5. Pipe and Tube Insulation Dimensions - Continued

RECOMMENDED SIZES OF INSULATION LAYERS
TO OBTAIN TOTAL NOMINAL THICKNESS

NPS X NOMINAL LAYER THICKNESS

[illegible]



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I. GENERAL

5. Pipe and Tube Insulation Dimensions - Continued

RECOMMENDED SIZES OF INSULATION LAYERS
TO OBTAIN TOTAL NOMINAL THICKNESS
NPS X NOMINAL LAYER THICKNESS

		NOMINAL PIPE SIZE												
		4 1/2	5	6	8	10	12	14	16	18	20	22	24	
ONE LAYER	1	4 1/2 x 1	5 x 1	6 x 1	8 x 1	10 x 1	12 x 1	14 x 1	16 x 1	18 x 1	20 x 1	22 x 1	24 x 1	
	1 1/2	4 1/2 x 1 1/2	5 x 1 1/2	6 x 1 1/2	8 x 1 1/2	10 x 1 1/2	12 x 1 1/2	14 x 1 1/2	16 x 1 1/2	18 x 1 1/2	20 x 1 1/2	22 x 1 1/2	24 x 1 1/2	
	2	4 1/2 x 2	5 x 2	6 x 2	8 x 2	10 x 2	12 x 2	14 x 2	16 x 2	18 x 2	20 x 2	22 x 2	24 x 2	
	2 1/2	4 1/2 x 2 1/2	5 x 2 1/2	6 x 2 1/2	8 x 2 1/2	10 x 2 1/2	12 x 2 1/2	14 x 2 1/2	16 x 2 1/2	18 x 2 1/2	20 x 2 1/2	22 x 2 1/2	24 x 2 1/2	
	3	4 1/2 x 3	5 x 3	6 x 3	8 x 3	10 x 3	12 x 3	14 x 3	16 x 3	18 x 3	20 x 3	22 x 3	24 x 3	
	3 1/2	4 1/2 x 3 1/2	5 x 3 1/2	6 x 3 1/2	8 x 3 1/2	10 x 3 1/2	12 x 3 1/2	14 x 3 1/2	16 x 3 1/2	18 x 3 1/2	20 x 3 1/2	22 x 3 1/2	24 x 3 1/2	
	4	4 1/2 x 4	5 x 4	6 x 4	8 x 4	10 x 4	12 x 4	14 x 4	16 x 4	18 x 4	20 x 4	22 x 4	24 x 4	
	4 1/2	4 1/2 x 4 1/2	5 x 4 1/2	6 x 4 1/2	8 x 4 1/2	10 x 4 1/2	12 x 4 1/2	14 x 4 1/2	16 x 4 1/2	18 x 4 1/2	20 x 4 1/2	22 x 4 1/2	24 x 4 1/2	
TWO LAYERS	5	4 1/2 x 5	5 x 5	6 x 5	8 x 5	10 x 5	12 x 5	14 x 5	16 x 5	18 x 5	20 x 5	22 x 5	24 x 5	
	5 1/2	4 1/2 x 5 1/2	5 x 5 1/2	6 x 5 1/2	8 x 5 1/2	10 x 5 1/2	12 x 5 1/2	14 x 5 1/2	16 x 5 1/2	18 x 5 1/2	20 x 5 1/2	22 x 5 1/2	24 x 5 1/2	
	6	4 1/2 x 6	5 x 6	6 x 6	8 x 6	10 x 6	12 x 6	14 x 6	16 x 6	18 x 6	20 x 6	22 x 6	24 x 6	
	6 1/2	4 1/2 x 6 1/2	5 x 6 1/2	6 x 6 1/2	8 x 6 1/2	10 x 6 1/2	12 x 6 1/2	14 x 6 1/2	16 x 6 1/2	18 x 6 1/2	20 x 6 1/2	22 x 6 1/2	24 x 6 1/2	
THREE LAYERS	7	4 1/2 x 7	5 x 7	6 x 7	8 x 7	10 x 7	12 x 7	14 x 7	16 x 7	18 x 7	20 x 7	22 x 7	24 x 7	
	7 1/2	4 1/2 x 7 1/2	5 x 7 1/2	6 x 7 1/2	8 x 7 1/2	10 x 7 1/2	12 x 7 1/2	14 x 7 1/2	16 x 7 1/2	18 x 7 1/2	20 x 7 1/2	22 x 7 1/2	24 x 7 1/2	



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I. GENERAL

6. Pipe

RADIATING AREA OF FLANGED FITTINGS

(Including accompanying flanges in square feet and in equivalent length of same size pipe standard weight fittings)

Pipe size, in.	Flanged couplings		90° ells		Long radius ells		Tees		Crosses	
	Area, sq. ft.	Pipe length, ft.	Area, sq. ft.	Pipe length, ft.	Area, sq. ft.	Pipe length, ft.	Area, sq. ft.	Pipe length, ft.	Area, sq. ft.	Pipe length, ft.
1	.32	.93	.79	2.31	.89	2.59	1.24	3.59	1.62	4.72
1 1/4	.38	.88	.96	2.20	1.08	2.49	1.48	3.40	1.94	4.47
1 1/2	.48	.95	1.19	2.35	1.34	2.68	1.82	3.64	2.38	4.78
2	.67	1.08	1.65	2.65	1.84	2.96	2.54	4.08	3.32	5.34
2 1/2	.84	1.12	2.09	2.78	2.32	3.08	3.21	4.26	4.19	5.56
3	.95	1.03	2.38	2.60	2.68	2.93	3.66	3.99	4.77	5.70
3 1/2	1.12	1.07	2.98	2.85	3.28	3.13	4.48	4.28	5.83	5.56
4	1.34	1.14	3.53	2.90	3.96	3.36	5.41	4.59	7.03	5.97
4 1/2	1.47	1.13	3.95	3.01	4.43	3.38	6.07	4.63	7.87	6.01
5	1.62	1.11	4.44	3.05	5.00	3.43	6.81	4.67	8.82	6.06
6	1.82	1.05	5.13	2.95	5.99	3.45	7.84	4.53	10.08	5.81
7	2.17	1.05	6.17	3.09	7.38	3.70	9.37	4.69	12.00	6.01
8	2.41	1.07	6.98	3.09	8.56	3.79	10.55	4.67	13.44	5.96
9	3.00	1.19	8.71	3.46	10.57	4.20	13.18	5.23	16.78	6.66
10	3.43	1.22	10.18	3.61	12.35	4.38	15.41	5.47	19.58	6.95
12	4.41	1.32	13.08	3.92	16.35	4.90	19.67	5.89	24.87	7.45
14	5.39	1.47	16.38	4.47	20.17	5.47	24.81	6.78	31.48	8.60
16	6.69	1.60	20.17	4.82	25.41	6.07	30.32	7.23	38.34	9.15

AREAS, SIZES AND CAPACITIES OF STANDARD PIPE (All dimensions and weights are nominal)

Size, in.	Diameter, in.		Thickness, in.	Circumference, in.		Transverse areas, sq. in.		External surface area, sq. ft. in ft. of pipe	Length of pipe containing cu. ft.	Wt of water per foot, lb.
	External	Internal		External	Internal	External	Internal			
1/8	0.405	0.269	0.068	1.272	0.845	0.129	0.057	0.1060	2533.775	0.025
1/4	0.540	0.364	0.088	1.696	1.144	0.229	0.104	0.1414	1383.789	0.045
3/8	0.675	0.493	0.091	2.121	1.549	0.358	0.191	0.1767	754.360	0.083
1/2	0.840	0.622	0.109	2.639	1.954	0.554	0.304	0.220	473.906	0.132
3/4	1.050	0.824	0.113	3.299	2.589	0.866	0.533	0.275	270.034	0.231
1	1.315	1.049	0.133	4.131	3.296	1.358	0.861	0.344	166.618	0.375
1 1/4	1.660	1.380	0.140	5.215	4.335	2.164	1.495	0.435	96.275	0.65
1 1/2	1.900	1.610	0.145	5.969	5.058	2.835	2.036	0.498	70.733	0.88
2	2.375	2.067	0.154	7.461	6.494	4.430	3.355	0.622	42.913	1.45
2 1/2	2.875	2.469	0.203	9.032	7.757	6.492	4.788	0.753	30.077	2.07
3	3.500	3.068	0.216	10.996	9.638	9.621	7.393	0.917	19.479	3.20
3 1/2	4.000	3.548	0.226	12.566	11.146	12.566	9.886	1.047	14.565	4.29
4	4.500	4.026	0.237	14.137	12.648	15.904	12.730	1.178	11.312	5.50
4 1/2	5.000	4.506	0.247	15.708	14.156	19.635	15.947	1.3009	9.030	6.91
5	5.563	5.047	0.258	17.477	15.856	24.306	20.006	1.4586	7.198	8.67
6	6.625	6.065	0.280	20.813	19.054	34.472	28.891	1.7384	4.984	12.51
7	7.625	7.023	0.301	23.955	22.063	45.664	38.738	1.996	3.717	16.80
8	8.625	8.071	0.277	27.096	25.356	58.426	51.161	2.2350	2.815	22.18
8	8.625	7.981	0.322	27.096	25.073	58.426	50.027	2.2053	2.878	21.70
9	9.625	8.941	0.342	30.238	28.089	72.760	62.786	2.5220	2.294	27.20
10	10.750	10.192	0.279	33.772	32.019	90.763	81.585	2.8174	1.765	35.37
10	10.750	10.136	0.307	33.772	31.843	90.763	80.691	2.8104	1.826	34.20
10	10.750	10.020	0.365	33.772	31.479	90.763	78.855	2.8104	1.826	34.20
11	11.750	11.000	0.375	36.914	34.558	108.434	95.033	3.076	1.515	41.20
12	12.750	12.070	0.330	40.055	37.892	127.676	114.800	3.338	1.254	49.70
12	12.750	12.000	0.375	40.055	37.699	127.676	113.097	3.338	1.273	49.00

DATA

I. GENERAL

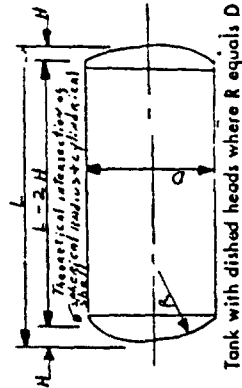
7. Surface Areas

AREAS OF TANKS
FOR INSULATION COVERAGE

Area of dished head equals $\frac{2\pi DH}{12}$

Area of flat head equals $0.7854 D^2$

Area per lin. ft. equals $\frac{1}{12} D$



Tank with dished heads where R equals D

D equals diameter in feet
R equals head radius in feet
H equals 1.608 R equals 1.608D

Tank Diameter Ft.	Dished Head Area Sq. Ft.	Flat Head Area Sq. Ft.	Area Per L.F. of Cyl. Sq. Ft.	"H" Dimension Inches
5'-0"	21.10	19.64	15.71	8.04
5'-1"	21.74	20.30	15.97	8.17
5'-2"	22.48	20.97	16.23	8.30
5'-3"	23.17	21.65	16.49	8.44
5'-4"	23.93	22.34	16.76	8.57
5'-5"	24.68	23.05	17.02	8.70
5'-6"	25.50	23.76	17.28	8.84
5'-7"	26.18	24.48	17.54	8.98
5'-8"	27.00	25.22	17.80	9.11
5'-9"	27.82	25.97	18.06	9.25
5'-10"	28.64	26.73	18.33	9.38
5'-11"	29.49	27.49	18.59	9.52
6'-0"	30.20	28.27	18.85	9.64
6'-1"	31.13	29.07	19.11	9.78
6'-2"	32.03	29.87	19.37	9.92
6'-3"	32.98	30.68	19.64	10.06
6'-4"	33.79	31.49	19.90	10.20
6'-5"	34.69	32.29	20.16	10.33
6'-6"	35.60	33.17	20.42	10.47
6'-7"	36.49	34.04	20.68	10.60
6'-8"	37.43	34.91	20.95	10.73
6'-9"	38.37	35.79	21.21	10.86
6'-10"	39.28	36.67	21.47	10.99
6'-11"	40.29	37.50	21.73	11.12

Tank Diameter Ft.	Dished Head Area Sq. Ft.	Flat Head Area Sq. Ft.	Area Per L.F. of Cyl. Sq. Ft.	"H" Dimension Inches
3'-0"	7.56	7.07	9.43	4.82
3'-1"	8.00	7.47	9.69	4.96
3'-2"	8.43	7.88	9.95	5.09
3'-3"	8.87	8.30	10.21	5.22
3'-4"	9.32	8.73	10.47	5.35
3'-5"	9.81	9.17	10.73	5.49
3'-6"	10.30	9.62	11.00	5.62
3'-7"	10.77	10.01	11.26	5.75
3'-8"	11.32	10.56	11.52	5.89
3'-9"	11.82	11.05	11.73	6.02
3'-10"	12.34	11.54	12.04	6.16
3'-11"	12.92	12.05	12.30	6.30
4'-0"	13.45	12.57	12.57	6.44
4'-1"	14.03	13.09	12.83	6.57
4'-2"	14.60	13.47	13.09	6.70
4'-3"	15.19	14.18	13.35	6.83
4'-4"	15.78	14.73	13.61	6.96
4'-5"	16.39	15.32	13.88	7.09
4'-6"	17.05	15.90	14.14	7.22
4'-7"	17.64	16.50	14.40	7.36
4'-8"	18.32	17.11	14.66	7.50
4'-9"	18.95	17.72	14.92	7.63
4'-10"	19.63	18.35	15.18	7.77
4'-11"	20.35	18.99	15.44	7.91

Tank Diameter Ft.	Dished Head Area Sq. Ft.	Flat Head Area Sq. Ft.	Area Per L.F. of Cyl. Sq. Ft.	"H" Dimension Inches
1'-0"	.84	.79	3.14	1.61
1'-1"	.99	.92	3.40	1.75
1'-2"	1.14	1.07	3.66	1.88
1'-3"	1.32	1.23	3.93	2.01
1'-4"	1.50	1.40	4.19	2.15
1'-5"	1.69	1.58	4.45	2.28
1'-6"	1.89	1.77	4.71	2.41
1'-7"	2.11	1.97	4.97	2.54
1'-8"	2.34	2.18	5.23	2.68
1'-9"	2.58	2.41	5.50	2.81
1'-10"	2.87	2.64	5.76	2.95
1'-11"	3.09	2.89	6.02	3.08
2'-0"	3.37	3.14	6.28	3.22
2'-1"	3.65	3.41	6.54	3.35
2'-2"	3.95	3.69	6.81	3.48
2'-3"	4.25	3.98	7.07	3.61
2'-4"	4.57	4.28	7.33	3.75
2'-5"	4.91	4.51	7.59	3.88
2'-6"	5.21	4.91	7.85	4.02
2'-7"	5.61	5.24	8.11	4.15
2'-8"	5.98	5.58	8.37	4.28
2'-9"	6.36	5.94	8.64	4.42
2'-10"	6.74	6.31	8.90	4.55
2'-11"	7.15	6.68	9.17	4.68



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I. GENERAL

7. Surface Areas - Continued

Tank Diam- eter Ft.	Dished Head Area Sq. Ft.	Flat Head Area Sq. Ft.	Area Per L. F. of Cyl. Sq. Ft.	"H" Dimen- sion Inches
13'-0"	142.22	132.73	40.84	20.91
13'-1"		134.44	41.10	
13'-2"		136.16	41.36	
13'-3"		137.89	41.63	
13'-4"		139.63	41.89	
13'-5"		141.38	42.15	
13'-6"	153.36	143.14	42.41	21.72
13'-7"		144.91	42.67	
13'-8"		146.69	42.94	
13'-9"		148.36	43.20	
13'-10"		150.30	43.46	
13'-11"		152.11	43.72	
14'-0"	164.94	153.94	43.98	22.53
14'-6"	176.93	165.13	45.55	23.31
15'-0"	189.34	176.31	47.12	24.13
15'-6"	202.18	188.69	48.70	24.94
16'-0"	215.43	201.06	50.27	25.75
16'-6"		213.83	51.84	
17'-0"		226.98	53.41	
17'-6"		240.53	54.98	
18'-0"		254.47	56.55	
18'-6"		268.80	58.12	
19'-0"		283.53	59.69	
19'-6"		298.65	61.26	
20'-0"		314.16	62.83	
21'-0"		346.36	65.97	
22'-0"		380.13	69.11	
23'-0"		415.58	72.40	
24'-0"		450.79	75.40	
25'-0"		490.86	78.54	

Tank Diam- eter Ft.	Dished Head Area Sq. Ft.	Flat Head Area Sq. Ft.	Area Per L. F. of Cyl. Sq. Ft.	"H" Dimen- sion Inches
10'-0"	84.15	78.54	31.42	16.08
10'-1"	85.54	79.85	31.63	16.21
10'-2"	86.96	81.18	31.94	16.34
10'-3"	88.37	82.52	32.20	16.48
10'-4"	89.78	83.86	32.46	16.61
10'-5"	91.26	85.22	32.73	16.74
10'-6"	92.71	86.59	32.99	16.87
10'-7"	94.15	87.97	33.25	17.00
10'-8"	95.68	89.35	33.51	17.14
10'-9"	97.22	90.76	33.77	17.27
10'-10"	98.69	92.11	34.03	17.40
10'-11"	100.26	93.60	34.30	17.53
11'-0"	101.89	95.03	30.56	17.68
11'-1"		96.48	34.82	
11'-2"		97.93	35.08	
11'-3"		99.40	35.34	
11'-4"		100.88	35.60	
11'-5"		102.37	35.87	
11'-6"	111.22	103.87	36.13	18.47
11'-7"		105.38	36.39	
11'-8"		106.90	36.65	
11'-9"		108.43	36.91	
11'-10"		109.98	37.18	
11'-11"		111.53	37.44	
12'-0"	121.18	113.10	37.70	19.31
12'-1"		114.67	37.96	
12'-2"		116.26	38.22	
12'-3"		117.86	38.48	
12'-4"		119.47	38.75	
12'-5"		121.09	39.01	
12'-6"	131.49	122.72	39.27	20.09
12'-7"		124.36	39.53	
12'-8"		126.01	39.79	
12'-9"		127.67	40.06	
12'-10"		129.35	40.32	
12'-11"		131.04	40.58	

Tank Diam- eter Ft.	Dished Head Area Sq. Ft.	Flat Head Area Sq. Ft.	Area Per L. F. of Cyl. Sq. Ft.	"H" Dimen- sion Inches
7'-0"	41.30	38.49	21.99	11.25
7'-1"	42.20	39.41	22.25	11.39
7'-2"	43.21	40.34	22.51	11.52
7'-3"	44.25	41.28	22.78	11.66
7'-4"	45.26	42.24	23.04	11.80
7'-5"	46.33	43.20	23.30	11.93
7'-6"	47.50	44.16	23.56	12.06
7'-7"	48.37	45.16	23.82	12.19
7'-8"	49.46	46.16	24.09	12.32
7'-9"	50.56	47.17	24.35	12.46
7'-10"	51.63	48.19	24.61	12.60
7'-11"	52.76	49.22	24.87	12.73
8'-0"	53.85	50.27	25.13	12.86
8'-1"	54.96	51.32	25.39	13.00
8'-2"	56.15	52.38	25.66	13.13
8'-3"	57.31	53.46	25.92	13.27
8'-4"	58.45	54.54	26.18	13.40
8'-5"	59.64	56.64	26.64	13.53
8'-6"	60.65	56.75	26.70	13.66
8'-7"	61.96	57.89	26.97	13.80
8'-8"	63.24	58.99	27.23	13.93
8'-9"	64.34	60.13	27.49	14.06
8'-10"	65.60	61.28	27.75	14.20
8'-11"	66.88	62.45	28.01	14.33
9'-0"	68.10	63.62	28.27	14.46
9'-1"	69.33	64.80	28.54	14.59
9'-2"	70.65	66.00	28.80	14.72
9'-3"	71.97	67.20	29.06	14.86
9'-4"	73.22	68.42	29.32	15.00
9'-5"	74.61	69.64	29.58	15.13
9'-6"	76.00	70.88	29.85	15.26
9'-7"	77.14	72.13	30.11	15.40
9'-8"	78.64	73.39	30.37	15.54
9'-9"	79.96	74.66	30.63	15.67
9'-10"	81.37	75.94	30.89	15.80
9'-11"	82.81	77.93	31.15	15.95



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I. GENERAL

7. Surface Area and Volume - Continued

AREAS AND VOLUMES - CYLINDERS

Diameter	Surface Area Sq. Ft. Per Linear Ft.	Volume Cu. Ft. Per Linear Ft.	Capacity Gals. Per Linear Ft.	Diameter	Surface Area Sq. Ft. Per Linear Ft.	Volume Cu. Ft. Per Linear Ft.	Capacity Gals. Per Linear Ft.
0'-6"	1.5708	0.1963	1.4688	29'-0"	91.1064	660.52	4941.0
1'-0"	3.1416	0.7854	5.8752	29'-6"	92.6772	683.49	5112.9
1'-6"	4.7124	1.7671	13.219	30'-0"	94.2480	706.86	5287.7
2'-0"	6.2832	3.1416	23.501	30'-6"	95.8188	730.62	5465.4
2'-6"	7.8540	4.9087	36.720	31'-0"	97.3896	744.77	5646.1
3'-0"	9.4248	7.0686	52.877	31'-6"	98.9604	779.31	5829.7
3'-6"	10.9956	9.6211	71.971	32'-0"	100.5312	804.25	6016.2
4'-0"	12.5664	12.566	94.003	32'-6"	102.1020	829.58	6205.7
4'-6"	14.1372	15.904	118.97	33'-0"	103.6728	855.30	6398.1
5'-0"	15.7080	19.635	146.88	33'-6"	105.2436	881.41	6593.4
5'-6"	17.2788	23.758	177.72	34'-0"	106.8144	907.92	6791.7
6'-0"	18.8496	28.274	211.51	34'-6"	108.3852	934.82	6992.9
6'-6"	20.4204	33.183	248.23	35'-0"	109.9560	962.11	7197.1
7'-0"	21.9912	38.485	287.88	35'-6"	111.5268	989.80	7404.2
7'-6"	23.5620	44.179	330.48	36'-0"	113.0976	1017.9	7614.2
8'-0"	25.1328	50.265	376.01	36'-6"	114.6684	1046.3	7827.2
8'-6"	26.7036	56.745	424.48	37'-0"	116.2392	1075.2	8043.1
9'-0"	28.2744	63.617	475.89	37'-6"	117.8100	1104.5	8262.0
9'-6"	29.8452	70.882	530.24	38'-0"	119.3808	1134.1	8483.8
10'-0"	31.4160	78.540	587.52	38'-6"	120.9516	1164.2	8708.5
10'-6"	32.9868	86.590	747.74	39'-0"	122.5224	1194.6	8936.2
11'-0"	34.5576	95.033	710.90	39'-6"	124.0932	1225.4	9166.8
11'-6"	36.1284	103.87	776.99	40'-0"	125.6640	1256.6	9400.3
12'-0"	37.6992	113.10	846.03	40'-6"	127.2348	1288.2	9636.8
12'-6"	39.2700	122.72	918.00	41'-0"	128.8056	1320.3	9876.2
13'-0"	40.8408	132.73	992.91	41'-6"	130.3764	1352.7	10119
13'-6"	42.4116	143.14	1070.8	42'-0"	131.9472	1385.4	10364
14'-0"	43.9824	153.94	1151.3	42'-6"	133.5180	1418.6	10612
14'-6"	45.5532	165.13	1235.3	43'-0"	135.0888	1452.2	10863
15'-0"	47.1240	176.71	1321.9	43'-6"	136.6586	1486.2	11117
15'-6"	48.6948	188.69	1411.5	44'-0"	138.2284	1520.5	11374
16'-0"	50.2656	201.06	1504.0	44'-6"	139.7992	1555.3	11634
16'-6"	51.8364	213.82	1599.5	45'-0"	141.3700	1590.4	11897
17'-0"	53.4072	226.98	1697.9	45'-6"	142.9408	1626.0	12163
17'-6"	54.9780	240.53	1799.3	46'-0"	144.5116	1661.9	12432
18'-0"	56.5488	254.47	1903.6	46'-6"	146.0824	1698.2	12704
18'-6"	58.1196	268.80	2010.8	47'-0"	147.6532	1734.9	12978
19'-0"	59.6904	283.53	2120.9	47'-6"	149.2240	1772.1	13256
19'-6"	61.2612	298.65	2234.0	48'-0"	150.7948	1809.6	13536
20'-0"	62.8320	314.16	2350.1	48'-6"	152.3656	1847.5	13820
20'-6"	64.4028	330.06	2469.0	49'-0"	153.9364	1885.7	14106
21'-0"	65.9736	346.36	2591.0	49'-6"	155.5072	1924.4	14396
21'-6"	67.5444	363.05	2715.8	50'-0"	157.0780	1963.5	14683
22'-0"	69.1152	380.13	2843.6	50'-6"	158.6488	2003.4	14974
22'-6"	70.6860	397.61	2974.3	51'-0"	160.2196	2043.8	15269
23'-0"	72.2568	415.48	3108.0	51'-6"	161.7904	2084.5	15567
23'-6"	73.8276	433.74	3244.6	52'-0"	163.3612	2125.6	15868
24'-0"	75.3984	452.39	3384.1	52'-6"	164.9320	2167.1	16172
24'-6"	76.9692	471.44	3526.6	53'-0"	166.5028	2208.9	16479
25'-0"	78.5400	490.87	3672.0	53'-6"	168.0736	2251.1	16789
25'-6"	80.1108	510.71	3820.3	54'-0"	169.6444	2293.7	17101
26'-0"	81.6816	530.93	3971.6	54'-6"	171.2152	2336.8	17416
26'-6"	83.2524	551.55	4125.8	55'-0"	172.7860	2380.2	17733
27'-0"	84.8232	572.56	4283.0	55'-6"	174.3568	2424.0	18052
27'-6"	86.3940	593.96	4443.1	56'-0"	175.9276	2468.1	18374
28'-0"	87.9648	615.75	4606.1	56'-6"	177.4984	2512.6	18699
28'-6"	89.5356	637.94	4772.1	57'-0"	179.0692	2557.4	19026
				57'-6"	180.6400	2602.6	19356
				58'-0"	182.2108	2648.1	19688
				58'-6"	183.7816	2693.9	20022
				59'-0"	185.3524	2740.0	20359
				59'-6"	186.9232	2786.4	20700
				60'-0"	188.4940	2833.1	21043
				60'-6"	190.0648	2880.1	21389
				61'-0"	191.6356	2927.4	21737
				61'-6"	193.2064	2975.0	22088
				62'-0"	194.7772	3022.8	22441
				62'-6"	196.3480	3070.9	22797
				63'-0"	197.9188	3119.3	23156
				63'-6"	199.4896	3168.4	23518
				64'-0"	201.0604	3217.0	23883
				64'-6"	202.6312	3266.3	24251
				65'-0"	204.2020	3315.9	24622
				65'-6"	205.7728	3365.8	24996
				66'-0"	207.3436	3416.0	25373
				66'-6"	208.9144	3466.5	25753
				67'-0"	210.4852	3517.3	26136
				67'-6"	212.0560	3568.4	26522
				68'-0"	213.6268	3619.7	26911
				68'-6"	215.1976	3671.3	27303
				69'-0"	216.7684	3723.1	27698
				69'-6"	218.3392	3775.2	28096
				70'-0"	219.9100	3827.5	28497
				70'-6"	221.4808	3880.0	28901
				71'-0"	223.0516	3932.7	29308
				71'-6"	224.6224	3985.7	29718
				72'-0"	226.1932	4038.9	30131
				72'-6"	227.7640	4092.4	30547
				73'-0"	229.3348	4146.1	30966
				73'-6"	230.9056	4199.9	31388
				74'-0"	232.4764	4254.0	31813
				74'-6"	234.0472	4308.3	32241
				75'-0"	235.6180	4362.9	32672
				75'-6"	237.1888	4417.7	33106
				76'-0"	238.7596	4472.8	33543
				76'-6"	240.3304	4528.1	33983
				77'-0"	241.9012	4583.6	34426
				77'-6"	243.4720	4639.3	34872
				78'-0"	245.0428	4695.2	35321
				78'-6"	246.6136	4751.4	35773
				79'-0"	248.1844	4807.8	36228
				79'-6"	249.7552	4864.5	36686
				80'-0"	251.3260	4921.3	37147
				80'-6"	252.8968	4978.4	37611
				81'-0"	254.4676	5035.7	38078
				81'-6"	256.0384	5093.3	38548
				82'-0"	257.6092	5151.1	39021
				82'-6"	259.1800	5209.2	39496
				83'-0"	260.7508	5267.5	39974
				83'-6"	262.3216	5326.0	40455
				84'-0"	263.8924	5384.7	40939
				84'-6"	265.4632	5443.7	41426
				85'-0"	267.0340	5502.9	41917
				85'-6"	268.6048	5562.3	42411
				86'-0"	270.1756	5621.9	42908
				86'-6"	271.7464	5681.7	43409
				87'-0"	273.3172	5741.8	43913
				87'-6"	274.8880	5802.1	44420
				88'-0"	276.4588	5862.6	44930
				88'-6"	278.0296	5923.3	45443
				89'-0"	279.6004	5984.2	45959
				89'-6"	281.1712	6045.3	46478
				90'-0"	282.7420	6106.6	47000
				90'-6"	284.3128	6168.1	47525
				91'-0"	285.8836	6229.8	48053
				91'-6"	287.4544	6291.7	48584
				92'-0"	289.0252	6353.8	49118
				92'-6"	290.5960	6416.1	49655
				93'-0"	292.1668	6478.6	50195
				93'-6"	293.7376	6541.3	50738
				94'-0"	295.3084	6604.2	51284
				94'-6"	296.8792	6667.3	51833
				95'-0"	298.4500	6730.6	52385
				95'-6"	299.9208	6794.1	52940
				96'-0"	301.4916	6857.8	53498
				96'-6"	303.0624	6921.7	54059
				97'-0"	304.6332	6985.8	54623
				97'-6"	306.2040	7050.1	55191
				98'-0"	307.7748	7114.6	55762
				98'-6"	309.30.		



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7. Surface Area and Volume - Continued

AREAS AND VOLUMES - SPHERES

Diameter	Surface Area in Sq. Ft.	Volume in Cu. Ft.	Total Capacity in Gallons	Diameter	Surface Area in Sq. Ft.	Volume in Cu. Ft.	Total Capacity in Gallons
0'-6"	.7854	.0654	.4892	29'-0"	2642.1	12770.0	95526
1'-0"	3.1416	.5236	3.917	29'-6"	2734.0	13442.0	100553
1'-6"	7.0686	1.7671	13.22	30'-0"	2827.4	14137.0	105752
2'-0"	12.566	4.1888	31.33	30'-6"	2922.5	14856.0	111131
2'-6"	19.635	8.1812	61.20	31'-0"	3019.1	15599.0	116639
3'-0"	28.274	14.137	105.8	31'-6"	3117.2	16366.0	122426
3'-6"	38.485	22.449	167.9	32'-0"	3217.0	17157.0	128343
4'-0"	50.265	33.510	250.7	32'-6"	3318.3	17974.0	134463
4'-6"	63.617	47.713	356.9	33'-0"	3421.2	18818.0	140760
5'-0"	78.540	65.450	489.6	33'-6"	3525.7	19685.0	147254
5'-6"	95.033	87.114	651.7	34'-0"	3631.7	20580.0	153949
6'-0"	113.10	113.10	846.1	34'-6"	3739.3	21501.0	160839
6'-6"	132.73	143.79	1076	35'-0"	3848.5	22449.0	167930
7'-0"	153.94	179.59	1343	35'-6"	3959.2	23425.0	175231
7'-6"	176.71	220.89	1652	36'-0"	4071.5	24429.0	182741
8'-0"	201.06	268.08	2005	36'-6"	4185.4	25461.0	190462
8'-6"	226.98	321.56	2405	37'-0"	4300.8	26522.0	198398
9'-0"	254.47	381.70	2855	37'-6"	4417.9	27612.0	206552
9'-6"	283.53	448.92	3358	38'-0"	4536.5	28731.0	214923
10'-0"	314.16	523.60	3917	38'-6"	4656.6	29880.0	223518
10'-6"	346.36	606.13	4534	39'-0"	4778.4	31059.0	232338
11'-0"	380.13	696.91	5213	39'-6"	4901.7	32269.0	241239
11'-6"	415.48	796.33	5957	40'-0"	5026.5	33510.0	250672
12'-0"	452.39	904.78	6768	40'-6"	5153.0	34783.0	260195
12'-6"	490.87	1022.7	7650	41'-0"	5281.0	36087.0	269950
13'-0"	530.93	1150.3	8605	41'-6"	5410.6	37423.0	279944
13'-6"	572.56	1288.2	9637	42'-0"	5541.8	38792.0	290184
14'-0"	615.75	1436.8	10748	42'-6"	5674.5	40194.0	300572
14'-6"	660.52	1596.3	11941	43'-0"	5808.8	41630.0	311414
15'-0"	706.86	1767.1	13219	43'-6"	5944.7	43099.0	322403
15'-6"	754.77	1949.8	14586	44'-0"	6082.1	44602.0	333646
16'-0"	804.25	2144.7	16044	44'-6"	6221.1	46140.0	345151
16'-6"	855.30	2352.1	17595	45'-0"	6361.7	47713.0	356918
17'-0"	907.92	2572.4	19243	45'-6"	6503.9	49321.0	368847
17'-6"	962.11	2806.2	20992	46'-0"	6647.6	50965.0	381245
18'-0"	1017.9	3053.6	22843	46'-6"	6792.9	52645.0	393312
18'-6"	1075.2	3315.2	24799	47'-0"	6939.8	54362.0	406656
19'-0"	1134.1	3591.4	26866	47'-6"	7083.2	56115.0	419759
19'-6"	1194.6	3882.4	29042	48'-0"	7238.2	57906.0	433167
20'-0"	1256.6	4188.8	31334	48'-6"	7389.8	59734.0	446841
20'-6"	1320.3	4510.9	33744	49'-0"	7543.0	61601.0	460808
21'-0"	1385.4	4849.0	36273	49'-6"	7697.7	63506.0	475058
21'-6"	1452.2	5203.7	38926	50'-0"	7854.0	65450.0	489500
22'-0"	1520.5	5575.3	41706	50'-6"	8013.0	67416.0	504155
22'-6"	1590.4	5964.1	44615	51'-0"	8174.0	69404.0	519024
23'-0"	1661.9	6370.6	47655	51'-6"	8337.0	71413.0	534109
23'-6"	1734.9	6795.2	50832	52'-0"	8502.0	73443.0	549406
24'-0"	1809.6	7238.2	54146	52'-6"	8669.0	75494.0	564916
24'-6"	1885.7	7700.1	57601	53'-0"	8838.0	77566.0	580640
25'-0"	1963.5	8181.2	61200	53'-6"	9009.0	79659.0	596579
25'-6"	2042.8	8682.0	64946	54'-0"	9182.0	81783.0	612734
26'-0"	2123.7	9202.8	68842	54'-6"	9357.0	83928.0	629106
26'-6"	2206.2	9744.0	72890	55'-0"	9534.0	86094.0	645696
27'-0"	2290.2	10306.0	77094	55'-6"	9713.0	88281.0	662504
27'-6"	2375.8	10889.0	81455	56'-0"	9894.0	90490.0	679530
28'-0"	2463.0	11494.0	85981	56'-6"	10077.0	92721.0	696774
28'-6"	2551.8	12121.0	90671	57'-0"	10262.0	94974.0	714246

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7. Surface Area and Volume - Continued

BARE AREA OF PIPE FITTINGS

(Including accompanying flanges in square feet and in equivalent length
of same size pipe standard weight fittings)

Pipe size In.	Flanged couplings		90° ells		Long radius ells		Tees		Crosses	
	Area Sq. Ft.	Pipe length Ft.	Area Sq. Ft.	Pipe length Ft.	Area Sq. Ft.	Pipe length Ft.	Area Sq. Ft.	Pipe length Ft.	Area Sq. Ft.	Pipe length Ft.
1	.32	.93	.79	2.31	.89	2.59	1.24	3.59	1.62	4.72
1½	.38	.88	.96	2.20	1.08	2.49	1.48	3.40	1.94	4.47
1½	.48	.95	1.17	2.35	1.34	2.68	1.82	3.64	2.38	4.78
2	.67	1.08	1.65	2.65	1.84	2.96	2.54	4.08	3.32	5.34
2½	.84	1.12	2.09	2.78	2.32	3.08	3.21	4.26	4.19	5.56
3	.95	1.03	2.38	2.60	2.68	2.93	3.66	3.99	4.77	5.70
3½	1.12	1.07	2.98	2.85	3.28	3.13	4.48	4.28	5.83	5.56
4	1.34	1.14	3.53	2.90	3.96	3.35	5.41	4.59	7.03	5.97
4½	1.47	1.13	3.95	3.01	4.43	3.38	6.07	4.63	7.87	6.01
5	1.62	1.11	4.44	3.05	5.00	3.43	6.81	4.67	8.82	6.06
6	1.82	1.05	5.13	2.95	5.99	3.45	7.84	4.53	10.08	5.81
7	2.17	1.05	6.17	3.09	7.38	3.70	9.37	4.69	12.00	6.01
8	2.41	1.07	6.98	3.09	8.56	3.79	10.55	4.67	13.44	5.96
9	3.00	1.19	8.71	3.46	10.57	4.20	13.18	5.23	16.78	6.66
10	3.43	1.22	10.18	3.61	12.35	4.38	15.41	5.47	19.58	6.95
12	4.41	1.32	13.08	3.92	16.35	4.90	19.67	5.89	24.87	7.45
14	5.59	1.47	16.38	4.47	20.17	5.47	24.81	6.78	31.48	8.60
16	6.69	1.60	20.17	4.82	25.41	6.07	30.32	7.23	38.34	9.15



SELECTION LIST OF INSULATION AND PROTECTIVE COVER FOR VARIOUS SERVICES

An insulation, its covering, and method of application should be selected to fulfill requirements of the service to which it is installed. The number of services and variations of requirements are many, thus no one insulation, nor one application system best suits all the different requirements of these many services. Thus each service requirements must be evaluated to determine their relative importance then on insulation selected whose properties will fulfill these requirements and further the method of application which should be used. As there are many services and variations of requirements within Union Carbide, it is necessary to have many material and application specifications from which to select the one (or more) which will fulfill a specific service and set of conditions.

Each particular service has primary requirements and secondary requirements. Thus for a particular service many insulations may fulfill the primary requirements (such as service temperature) but only one or two may fulfill some of the other requirements. Thus, proper selection of insulation materials becomes one of selecting a material whose properties fulfill the essential requirements, which, at least partly, fulfill most of the secondary requirements. Depending upon condition, a requirement which is critical for one service may not be critical in another service. Therefore, it is impossible to list which requirements are primary, or secondary or to arrive at any order of importance.

In some instances, due to the nature of the requirements, not a single material completely fulfills all that is desired and selection is limited to the one that has the least disadvantages. In other instances, two or more materials may be equally technically acceptable and final choice may be dictated by cost, availability or other non-technical factors.

To assist in the selection of proper insulation material and application specifications the following table has been prepared. Of course it is impossible to list each and every service and all variations of requirements existing within our plants in a single table, thus this table presents the services most common to Union Carbide operation. Nor is it possible to list all of the individual requirements connected with each of the services. Only the most significant are listed, yet a more significant requirement for a particular operation, and not considered in this listing, may be the most decisive for a particular use.

From a general standpoint the selection tables give the proper material and application recommended for that service. Where more than one specification may be used the one best suited, based on technical reasons, is present first. Where the word "or" is used between recommendations, it indicates equal acceptability.

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INDIVIDUAL INSULATION SPECIFICATION IDENTIFICATION AND SYMBOLS

SPECIFICATION NUMBER	INSULATION	OPERATING TEMPERATURE RANGE
10-H, 10-HSS	Cellular Glass (with glass fiber inner cushion blanket).	70F (21C) to 600F (316C)
10-J, 10-JSS	Cellular Glass	50F (10C) to 400F (204C)
10-JU, 10-JUSS	Cellular Glass - Underground	50F (10C) to 350F (177C)
10-L, 10-LSS	Cellular Glass (with glass fiber inner cushion blanket on equipment only)	-300F (-184C) to 400F (204C)
10-LSP	Cellular Glass	-40F (-40C) to 150F (66C)
10-OX	Cellular Glass (with heat treated fiber inner cushion blanket)	-300F (-184C) to Atmos.
12-H, 12-HSS	Rigid Urethane Foam	50F (10C) to 220F (104C)
14-J	Flexible Plastic Foam	50F (10C) to 180F (82C)
15-H	Fibrous Glass, Bonded	70F (21C) to 400F (204C)
19-H	Fibrous Glass Panels, Faced with Corrugated Aluminum	70F (21C) to 400F (204C)
19-J	Fibrous Glass Panels, Faced with Smooth Aluminum	70F (21C) to 400F (204C)
21-H, 21-HSS	Asbestos Fibers, Bonded	212F (100C) to 1000F (538C)
22-H, 22-HSS	Bonded Expanded Silica	40F (4C) to 1400F (760C)
23-H, 23-HSS	Calcium Silicate	212F (100C) to 1000F (538C)
25-H	High Temperature Calcium Silicate (inner layer), Calcium Silicate (outer layer)	750F (399C) to 1600F (871C)
31-H, 31-HSS	Reflective, Stainless Steel Cased Reflective Shields	33F (1C) to 1000F (538C)
32-HFP, 32-HFPSS	Bonded Expanded Silica (double layer-broken joint construction)	40F (4C) to 1400F (760C)
32-LFP, 32-L	Cellular Glass (inner layer), Bonded Expanded Silica (outer layer)	-300F (-184C) to 400F (204C)
37-H	Steel Underground Conduit - Insulation as Selected - Underground	40F (4C) to 750F (399C)
38-H	Molded Urethane Foam on Pipe in PVC Conduit - Underground	50F (10C) to 220F (4C)
39-H	Bituminous Fill - Underground	220F (104C) to 520F (271C)
40-J	Cork Filled PVA Mastic	34F (1C) to 180F (82C)
41-H	Sprayed Amosite Asbestos	70F (21C) to 700F (371C)
42-H	Sprayed Crocidolite Asbestos	700F (371C) to 1350F (732C)
43-H, 43-HSS	Sprayed Urethane Foam	50F (10C) to 250F (121C)

Letters In Specifications:

H indicates Ambient to high temperature service.
 J indicates Ambient or cyclic temperature service.
 L indicates Low temperature service.
 SS indicates suitable for application to stainless steel surface.

SP indicates for application to sphere.
 OX indicates for oxygen service.
 FP indicates suitable for Fire Protection.
 U indicates for underground service.

Metal Jackets

When metal jackets are specified add M to Spec. No. for stainless steel or MT for treated steel.

SELECTION OF INSULATION AND ITS PROTECTIVE COVER
FOR VARIOUS SERVICES AND OPERATING CONDITIONS

TABLE I EQUIPMENT

FOR APPLICATION WHERE OPERATING TEMPERATURES ARE BELOW AMBIENT						
SERVICE	OPERATING TEMP. RANGE	LOCATION	SPECIFICATION NUMBER	INSULATION	PROTECTIVE COVER	LIMITATIONS
						SPECIAL PROPERTIES
						COMMENTS
Process equipment except oxygen, acetylene and acetylene	50F (10C) down to -300F (-185C)	Indoors or outdoors	10-L, 10-LSS	Cellular glass (glass blanket inner layer cushion blanket)	Dynel reinforced Mastic	Good fire resistance for limited time. For extended time, fire protection use Spec. 32-LFP.
Oxygen equipment	50F (10C) down to -300F (-185C)	Indoors or outdoors	10-LOX, 10-LOXSS	Cellular glass (heat treated glass blanket inner layer cushion blanket)	Dynel reinforced Mastic	Good fire resistance for limited time. (For extended time fire protection use stainless steel jacket instead of Mastic)
Oxides, acetylene and other low temperature process equipment requiring extended time fire protection.	50F (10C) down to -300F (-185C)	Indoors or outdoors	32-LFP M or MT 32-LFP SS M or MT	Cellular glass and Expanded Silica, outer layer (glass blanket inner layer cushion blanket)	Metal jacket on cylindrical section. Dynel reinforced Mastic on heads and fittings.	Excellent resistance to vapor migration. Two hour fire protection.
Process equipment, low temperature with thawout up to 400F	400F (200C) Thawout down to -300F (-185C)	Indoors or outdoors	Use appropriate system above			Exercise special care in design and construction of expansion-contraction joints.
Water and process equipment, to prevent condensate drip.	Slightly below ambient	Indoors	40-J	PVA cork filled Mastic (color as specified)	None	Not suitable for conservation of refrigeration. Thickness 8" to 14".
						An insulating Mastic which retards condensate drip on vessels slightly below ambient temp.
						Applied by palm, trowel or spray to required thick. Surface must be dry at time of application and until mastic sets.

SELECTION OF INSULATION AND ITS PROTECTIVE COVER
FOR VARIOUS SERVICES AND OPERATING CONDITIONS
TABLE I EQUIPMENT

FOR APPLICATIONS WHERE OPERATING
TEMPERATURES ARE ABOVE AMBIENT

SERVICE	OPERATING TEMP. RANGE	LOCATION	SPECIFICATION NUMBER	INSULATION	PROTECTIVE COVER	LIMITATIONS	SPECIAL PROPERTIES	COMMENTS
Process and storage vessels except those containing reactive chemicals.	50F (10C) to 250F (121C)	Outdoors	43-H, 43-HSS	Sprayed urethane foam	Mastic	Short time resistance to external fire. Must be used in accordance with Fire Protection recommendations.	Light weight. Water resistant.	Spray application of insulation and mastic. Use proper safety precautions during spraying.
Process and utility equipment except those contain- ing reactive chemicals.	50F (10C) to 400F (205C)	Indoors or outdoors	15-H, 15-HM, 15-HMAT	Glass fiber	Glass cloth and PVA Coating in- doors. Metal or Dynel reinforced mastic outdoors.	Relatively soft. Will not withstand heavy mechanical abuse. Short time fire resistance.	Good flexibility. Will meet building code requirements on flame spread and smoke density.	Not easily shop fabricated. Limited sizes of molded glass fiber fittings are marketed.
Process and storage vessels, except those containing reactive chemicals.	50F (10C) to 400F (205C)	Outdoors	19-H, 19-J	Glass fiber panel with factory at- tached facing on side walls. 19-H expanded silica roof and heads. 19-H glass fiber roof insulation on roof.	Aluminum weather- barrier facing. 19-H is ribbed facing. 19-J is smooth facing.	Not suitable for vessels less than 120" OD in di- ameter. Short time fire resistance.	Light weight. Fast installation. Panels cover	19-H can be in- stalled by strap or studs. 19-J re- quires studs be welded to vessel wall.
Process and storage vessels or equipment. (Especially if highly toxic chemicals are involved)	50F (10C) to 350F (178C)	Indoors and outdoors	10-J, 10-JSS	Cellular glass	Dynel reinforced Mastic.	Will crack if sub- jected to rapid change of oper- ating temperature.	Excellent resistance to vapors and liquids. Will not become sat- urated by hazardous or toxic fumes or liquids. Good resis- tance to solar radi- ation.	Proper expansion and contraction joints are essential.
Process and storage vessels or equipment (where operating temperature is subject to rapid change).	50F (10C) to 600F (315C)	Indoors or outdoors	10-H, 10-HSS	Cellular glass and high temperature mineral fiber cushion blanket inner layer.	Dynel reinforced Mastic.	Inner mineral fiber inner layer is absorbent.	Most vapor and liquid resistant insulation system for rapid op- erating temperature change and temperature above 350F.	Proper expansion and contraction joints are essential.

SELECTION OF INSULATION AND ITS PROTECTIVE COVER
FOR VARIOUS SERVICES AND OPERATING CONDITIONS
TABLE I EQUIPMENT

FOR APPLICATIONS WHERE OPERATING
TEMPERATURES ARE ABOVE AMBIENT

SERVICE	OPERATING TEMP. RANGE	LOCATION	SPECIFICATION NUMBER	INSULATION	PROTECTIVE COVER	LIMITATIONS	SPECIAL PROPERTIES	COMMENTS
Steam, and process including acetylene oxide and other re- active chemical equipment. Also electric and steam traced vessels.	50F (10C) to 1400F (760C)	Indoors or outdoors	22-H, 22-HIM, or MT 22-HSS, 22-HSS M or MT	Expanded silica	Metal and/or Dynel reinforced Mastic depending upon size, shape and conditions.	Although it is silicone treated to obtain repellency, it can be saturated by some chemicals.	Water repellent. Max. resistance to external fire. This, and Spec. 32-H, are only spec's suitable for Ethylene Oxide.	Is more difficult to fabricate than calcium-silicate.
Steam, and process equipment.	212F (100C) to 1000F (529C)	Indoors or outdoors	23-H, 23-HIM, or MT 23-HSS, 23-HSM, or MT	Calcium silicate	Metal and/or Dynel reinforced Mastic depending upon size, shape and conditions.	Very absorbent. Subject to saturation by leaked or spilled liquids. Weather- barrier must be tight to prevent water damage.	Strong, can be cut and fabricated with ease. Max. resis- tance to external fire.	Must be protected from rain during installation.
Process equipment except stainless steel.	1000F (529C) to 1800F (982C)	Indoors or outdoors	25-H, 25-HIM or MT	High temperature calcium silicate inner layer, calcium silicate outer layer.	Metal and/or Dynel reinforced Mastic depending upon size, shape and conditions.	Very absorbent. Subject to saturation by leaked or spilled liquids. Weather- barrier must be tight to prevent water damage.	Strong, can be cut and fabricated with ease. Max. resis- tance to external fire.	Must be protected from rain during installation.
Process equipment, where absorbence cannot be tolerated or where quick removal and replace- ment is necessary.	35F (2C) to 1000F (529C)	Indoors or outdoors	31-H, 31-HSS	Prefabricated units consisting of stainless steel jacket enclosing aluminum or stainless steel reflective sheets.	Factory fabricated units to fit side walls, heads and trim.	Prefabricated as a system, thus must be ordered from the manufacturer to fit the particular equip- ment. Detail in- formation must be provided.	Advantageous for frequent removal and replacement. Desir- able where absorption of hazardous liquids or vapor cannot be tolerated.	For temperatures above 1000F. Units made of special alloys are obtainable.



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SELECTION OF INSULATION AND ITS PROTECTIVE COVER
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TABLE I EQUIPMENT

FOR APPLICATION WHERE OPERATING
TEMPERATURES ARE ABOVE AMBIENT

SERVICE	OPERATING TEMP. RANGE	LOCATION	SPECIFICATION NUMBER	INSULATION	PROTECTIVE COVER	LIMITATIONS	SPECIAL PROPERTIES	COMMENTS
Process equipment, for extended time fire protection.	Ambient to 1400F (760C)	Indoors or outdoors	32-HM or MT 32-HSS M or MT	Expanded silica	Metal jacket on cylindrical sections. Dynel reinforced mastic on valves and fittings.	Same as specifications 22-H, 22-HSS	Installed in double layer---broken joint construction.	Suitable for application on reactive chemicals equipment, including oxide and acetylene.
	70F (21C) to 700F (370C) 700F (370C) to 1350F (732C)	Indoors or outdoors Indoors or outdoors	41-H 41-H	Sprayed Amosite asbestos fibers Sprayed Crocidolite asbestos fibers	Dynel reinforced Mastic	Effective for insulation of large areas only. Do not use on small equipment.	Can be applied to any contour. Has sufficient extension-ability to move with metal expansion.	Depends upon surface adhesion. Surface must be properly cleaned or prepared before application.

SELECTION OF INSULATION AND ITS PROTECTIVE COVER
 FOR VARIOUS SERVICES AND OPERATING CONDITIONS
 TABLE II PIPE AND PIPE FITTINGS

SERVICE	OPERATING TEMP. RANGE	LOCATION	SPECIFICATION NUMBER	INSULATION	PROTECTIVE COVER	FOR APPLICATION WHERE OPERATING TEMPERATURES ARE BELOW AMBIENT	
						LIMITATIONS	SPECIAL PROPERTIES
Process lines except oxygen, oxide, and acetylene.	50F (10C) Down to -300F (-185C)	Indoors or outdoors	10-L, 10-LSS	Cellular glass	Dynel reinforced Mastic	Good fire resistance for limited time. For extended time fire protection use Spec. 32-LFP.	Excellent resistance to vapor migration.
Oxygen lines.	50F (10C) Down to -300F (-185C)	Indoors or outdoors	10-L OX, 10-L OXSS	Cellular glass	Dynel reinforced Mastic	Good fire resistance for limited time. For extended time fire protection use stain- less steel jacket instead of mastic.	Excellent resistance to vapor migration.
Oxides, acetylene and other low temp. process lines requir- ing extended time fire protection.	50F (10C) Down to -300F (-185C)	Indoors or outdoors	32-LFP M or MT 32-LFPSS M or MT	Cellular glass and expanded silica (outer layer).	Metal jacket on straight pipe, Dynel reinforced Mastic on valves and fittings.	Core must be taken that insulation is installed broken joint construction.	Excellent resistance to vapor migration. Two hour fire resistance.
Process lines, low temperature with thaw- out up to 400F.	400F (205C) Thaw- out down to -300F (-185C)	Indoors or outdoors	Use appropriate system above.				Exercise special care in design and construction of expansion-contraction joints.
Water and process lines, to prevent condensate drip.	Slightly Below ambient.	Indoors	40-J	PVA cork filled mastic.	None	Not suitable for conservation of refrigeration. Thick- ness $\frac{1}{8}$ " to $\frac{1}{4}$ ". Should be used only on pipes 3" NPS and larger.	An insulating mastic which retards con- densate drip from lines operating slightly below am- bient.
							Applied by palm, trowel or spray, surface must be dry at time of application and until mastic sets.

Metal on straight
pipe selected to be
suitable to resist
surrounding con-
tamination.

SELECTION OF INSULATION AND ITS PROTECTIVE COVER
FOR VARIOUS SERVICES AND OPERATING CONDITIONS
TABLE II PIPE AND PIPE FITTINGS

FOR APPLICATION WHERE OPERATING TEMPERATURES ARE ABOVE AMBIENT						
SERVICE	OPERATING TEMP. RANGE	LOCATION	SPECIFICATION NUMBER	INSULATION	PROTECTIVE COVER	LIMITATIONS
Water lines and instrument tubing to conserve heat or prevent condensate drip.	50F (10C) to 160F (71C)	Indoors or outdoors	14-J, 14-JSS	Flexible plastic foam	Vinyl paint	Poor fire resistance. Limited usage under building codes.
Process lines, for extended time fire protection.	Ambient to 1400F (760C)	Indoors or outdoors	32-HM or MT 32-HSS M or MT	Expanded silica	Metal jacket on straight pipe. Dynel reinforced mastic on valves and fittings.	Same as specification 22-H and 22-HSS
Underground process, hot water and low pressure steam.	50F (10C) to 230F (110C)	Underground	38-H	PVC conduit encased urethane foam insulated pipe. Factory made.	Rigid PVC high impact plastic conduit.	Not available for pipe sizes over 10" N.P.S.
Underground process, and steam lines.	Special glass fiber up to 400F (205C). Calcium silicate up to 1000F (529C)	Underground	37-H	Pipe and insulation (as specified).	Factory formed and coated steel conduit.	System designed by the manufacturer.
Underground process and traced lines	50F (10C) to 350F (173C)	Underground	10-JU	Cellular glass	Bituminous mastic with two layers of glass fabric.	Must be above height of water table and be provided with drainage for surface water.
Underground process and steam lines	225F (105C) to 520F (271C) depending on grade.	Underground	39-H	Granulated bitumen fill type.	None	Must be in soil of excellent drainage. Not recommended on slopes or pipes with down time or cycle temp.
						Heat causes material to form water barrier around pipe.
						Galvanic protection of impa tance.

NOTES (1) Where run of pipe is short between fittings, use Dynel reinforced mastic.

SPECIAL PROPERTIES

COMMENTS

For semi-flexible instrument tubing and air cond. unit run outs. Can be installed on tubing before tubing is bent and installed.

Suitable for application on reactive chemical lines, including oxide and acetylene. Installed in double layer-broken joint construction.

Fittings are factory insulated. Obtained as complete pipe and insulation system. Field installed by welding pipe together and sealing PVC conduit with special couplings.

Suitable for locations below ground water level. Field installed by welding pipe together and sealing conduit with special couplings.

Only system suitable for easy installation of tracing systems. Where temperatures exceed 350F special system is required.

Heat causes material to form water barrier around pipe. Galvanic protection of impa tance.

SELECTION OF INSULATION AND ITS PROTECTIVE COVER
FOR VARIOUS SERVICES AND OPERATING CONDITIONS
TABLE II PIPE AND PIPE FITTINGS

FOR APPLICATION WHERE OPERATING
TEMPERATURES ARE ABOVE AMBIENT

SERVICE	OPERATING TEMP. RANGE	LOCATION	SPECIFICATION NUMBER	INSULATION	PROTECTIVE COVER	LIMITATIONS	SPECIAL PROPERTIES	COMMENTS
Process lines	1000F (529C) to 1800 (982C)	Indoors or outdoors	25-HIA, 25-HMT	High temp. calcium-silicate inner layer. Calcium-silicate outer layer.	Metal jacket on straight pipe. Dynel reinforced Mastic on valves and fittings. (1)	Very absorbent. Subject to saturation by leaked or spilled liquids. Weather- barrier must be tight to prevent water damage.	Strong, can be cut or fabricated with ease. Max. resis- tance to external fires.	Metal on straight pipe selected to be suitable to resist surrounding con- tamination.
Process lines, where absorbance cannot be tolerated or where quick re- moval and replace- ment is necessary.	35F (2C) to 1000F (529C)	Indoors or outdoors	31-H, 31-HSS	Prefabricated units consisting of stainless steel jacket enclosing aluminum or stain- less steel reflective sheets.	Factory jacketed pipe and fittings.	Prefabricated as a system, thus must be ordered from manufacturer to fit the pipe system.	Advantageous for frequent removal and replacement. Desir- able where absorption of hazardous liquids or vapor cannot be tolerated.	For temperatures above 1000F units are obtainable.
Process lines, high pressure steam traced process lines.	212F (100C) to 1000F (529C)	Indoors or outdoors	21-HIM, 21-HMT 21-HSSM, 21-HSSMT	Asbestos fibers.	Metal jacket on straight pipe, Dynel reinforced Mastic on valves and fittings. (1)	Very absorbent. Subject to saturation by leaked or spilled liquids. Weather- barrier must be tight.	Excellent bridging properties. Resists fracturing.	Fitting covers re- quiring block must be prefabricated with calcium-silicate.
Water and process lines to retard freezing.	Atmospheric	Outdoors	10-L, 10-LSS	Cellular glass	Dynel reinforced Mastic	Insulation, without heat source, will only retard freezing.	Excellent resistance to vapor and water migration.	Easy to shop fabricate.
Water, steam, process lines and utilities in buildings.	50F (10C) to 400F (205C)	Indoors	15-II	Glass fiber	Factory applied jacket on straight pipe. Fabric rein- forced water emul- sion coatings on fittings (where exposed).	Relatively soft. Will not withstand heavy mechanical abuse. Short time fire re- sistance.	Good flexibility, easy handling. Will meet building code requirements on flame spread and smoke density.	In pipe chases, over suspended ceiling, etc., jacket required. Where exposed, selected required jacket must be specified.

SELECTION OF INSULATION AND ITS PROTECTIVE COVER
FOR VARIOUS SERVICES AND OPERATING CONDITIONS
TABLE II PIPE AND PIPE FITTINGS

FOR APPLICATIONS WHERE OPERATING TEMPERATURES ARE ABOVE AMBIENT								
PIPE	OPERATING TEMP. RANGE	LOCATION	SPECIFICATION NUMBER	INSULATION	PROTECTIVE COVER	LIMITATIONS	SPECIAL PROPERTIES	COMMENTS
Steam and process lines except reactive chemicals.	50F (10C) to 220F (115C)	Outdoors	12-HM, 12-HSS M	Rigid Urethane Foam	Metal jacket on straight pipe Dynel reinforced Mastic on valves and fittings.(1)	Short time resistance to external fire. Must be used in accordance with fire protection recommendations.	Light weight, water resistant.	Shop molded, PVC jacketed fitting covers may be used where available.
Steam and process, including acetylene, ethane, and other reactive chemical fittings. Electric and steam traced lines.	50F (10C) to 1400F (760C)	Indoors or outdoors	22-HM, or 22-HMT 22-HSSM or 22-HSSMT	Expanded silica	Metal jacket on straight pipe. Dynel reinforced Mastic on valves and fittings. (1)	Although it is silicone treated to obtain repellency it can be saturated by some chemicals.	Water repellent. Max. resistance to external fire. This, and Spec. 32-H, are only spec's. suitable for Ethylene Oxide service.	Metal on straight pipe selected to be suitable to resist surrounding contamination.
Steam, process, electric traced lines (especially if highly toxic chemicals are involved).	50F (10C) to 400F (205C)	Indoors or outdoors	10-J, 10-JSS	Cellular glass	Dynel reinforced Mastic.	Will crack if subjected to rapid change of operating temperature.	Excellent resistance to vapors and liquids. Will not become saturated by hazardous fumes or liquids.	Proper expansion and contraction joints are essential.
Steam, process, electric traced lines (where operating temperature is subject to rapid change).	50F (10C) to 600F (315C)	Indoors or outdoors	10-H, 10-HSS	Cellular glass and high temperature mineral fiber cushion inner layer.	Dynel reinforced Mastic.	Inner mineral fiber cushion insulation is absorbent.	Specially useful for electric or steam traced aluminum lines.	Proper expansion and contraction joints are essential.
Steam, process, and steam traced lines.	212F (100C) to 1000F (529C)	Indoors or outdoors	23-HM or 23-HMT 23-HSSM or 23-HSSMT	Calcium silicate.	Metal jacket on straight pipe. Dynel reinforced Mastic on valves and fittings.(1)	Very absorbent. Subject to saturation by leaked or spilled liquids. Weather-barrier must be tight to prevent water damage.	Strong, can be cut and fabricated with ease. Max. resistance to external fires.	Metal on straight pipe selected to be suitable to resist surrounding contamination.



INSULATION THICKNESS REQUIREMENTS

For any particular operating temperature there is no single correct thickness of insulation. The proper thickness depends upon many factors. The first of these factors of utmost importance is the function the insulation is to serve. Some of these functions are: (1) to conserve energy, (2) to maintain process temperature, (3) to protect equipment or piping from fire, (4) to maintain a safe surface temperature, (5) to maintain a surface temperature above dew point, (6) to limit heat transfer as required by process requirements, (7) to maintain stored or transit materials within given temperature range for a given temperature range for a given period of time.

Additional factors, other than function, which influence the correct thickness of insulation are: (1) ambient temperature and humidity, (2) investment cost of energy production equipment, (3) energy production cost, (4) insulation investment cost, (5) insulation maintenance cost, (6) amortization, (7) hours of operation, (8) desired life, (9) hazard of area, (10) location (indoors or outdoors), (11) condensation or freeze point of product, (12) conductivity of insulation, (13) emittance of surface coating or jacket over insulation, (14) size of pipe or equipment.

The possible combinations of only the most common services with the variables of climate and fuel and insulation costs of all the Group I plants require a considerable number of insulation thickness tables to fulfill the needs of engineering design and plant maintenance. The thickness of insulation must be determined by the function that it is to accomplish. The major functions of our use of insulation are:

1. Conservation of Energy
2. Control of Temperature - both internal and external
3. Control of Heat Loss or Gain
4. Protection of Personnel from Burns
5. Protection of Pipe and Equipment from Fire

In many applications the insulation serves more than one of these functions.

To assist in design, a series of tables has been developed to select the proper thickness of insulation. A service designation has been assigned to the various use or service function. In some instances, although a service designation has been provided for a particular service, tables have not been included, at present, because it is doubtful that use would warrant their calculation or because the need is special and requires individual consideration.

The service designation and a summary discussion of the use of each follows:



INSULATION THICKNESS REQUIREMENTS

Service Designation A - Air Condition Duct Insulation is for insulation of ducts outdoors or indoors. Tables are not included on the insulation thickness depends upon location - indoors or outdoors, temperature of air or gas in ducts, ambient temperatures, relative humidity, and emittance of exterior surface. The possible combinations of these many variables would require considerable number of tables and for the amount of ducts insulated it does not appear to warrant calculation of a set of tables. Material and Application Specification for Ducts are 17 RX, RY, and 18 FX, FY.

Service Designation B - Building Insulation is reserved for tables for recommended insulation thicknesses for floors, walls, and roofs of buildings. Tables have not been calculated as the number of possible combinations of building materials would make such tabulations unwarranted for the expected usage. Material and Application Specifications for Cellular Glass in Buildings is 10-B.

Service Designation C - Cold Pipe and Equipment Insulation Thicknesses are the bases for design of insulation of low temperature equipment and pipe. It is based on the fact that low temperature insulation will deteriorate approximately three times faster when its surface is wet than when the temperature of its surface is above the ambient dew point. Although surface temperature will be below dew point when ambient air is 100 percent relative humidity, the tables give the thickness of insulation which will be above most of the time so that mastics remain in good condition, maintenance can be performed, minimize fungus growth, and minimize rusting of steel. Differences in thicknesses for various plants are mainly due to differences in climatic conditions. Material and Application Specification is 10-L Cellular Glass. 10-J is also used where operation is cyclic. In this case the thicknesses are the greater as determined by comparison of Service Designations C and E.

Service Designation D - Insulation of Water Lines and Equipment to Prevent Drip is to be used when mastic is used on surfaces to prevent water drip from moisture condensation. In most instances it is used on overhead water lines, water storage tanks, and coal hoppers to prevent water drip. It should not be used for refrigerated pipe or equipment. Material and Application Specification is 40-J.

Service Designation E - Economic Insulation Thicknesses for Hot Pipe and Equipment is based on economics to obtain the optimum balance between cost of insulation and cost of heat. Thus cost of heat, cost of insulation, conductivity of insulation, temperature difference affect the thickness. The tables were calculated for the individual plant cost, installed insulation costs, and climatic conditions for most of the insulations commonly used. Of course selection of the insulation depends upon its properties as related to physical, chemical and thermal, and moisture conditions of the installation. Material and Application Specifications for the insulation selected are one of the following: 10-H, 10-J, 12-H, 15-H, 16-H, 19-H, 19-J, 21-H, 22-H, 25-H, or 41-H.



INSULATION THICKNESS REQUIREMENTS

Service Designation F - Insulation of Water Pipe to Retard Freezing

Insulation cannot prevent freezing of outdoor water lines of no flow. For water lines which do have some flow, a table is presented as to the minimum flow per 100 feet of pipe with water entering at 40F for various thicknesses of insulation. Material and Application Specification should be 10-L and 10-J.

Service Designation M - Insulation to Control Maximum Heat Loss

Process requirements may dictate that the equipment or piping system can tolerate only so much heat loss and still function properly. Although a service designation has been assigned to this insulation function, tables cannot be provided as the thicknesses to control heat losses within the limits must be calculated for the individual installation.

Service Designation N - Insulation to Control Maximum Heat Gain

Process requirements may dictate that the equipment or piping system can tolerate only so much heat gain and still function properly. Although a service designation has been assigned to this insulation function, tables cannot be provided as the thicknesses to control heat gains within the limits must be calculated for the individual installation.

Service Designation P - Fire Protection Insulation Thickness

Insulation thicknesses for fire protection of equipment and piping in hazardous locations are provided for low temperature, atmospheric, and high temperature installations. As the insulation may serve other functions other than for fire protection, tables are included not only for atmospheric operation temperature but low temperature and high temperature operation. Therefore, the tables will have a second service designation to serve as a guide to dual function the insulation is to serve.

Service Designation R - Reflective Insulation Thicknesses

The thermal resistance of reflective insulation is determined by the number of reflective shields. This insulation is supplied in completely finished units and the spacing of reflective sheets and its total thickness determine its total efficiency. For this reason, other than thickness, the shield spacing is provided in the tables. As number of shield or thicknesses in a unit is not a straight line cost factor, the tables provided have been taken into consideration the surface temperature, and economics, and may be used directly for Service Functions E, S, and T.

Service Designation S - Safe Surface Temperature Insulation Thicknesses

When insulation is used to provide safe surface temperature and when process heat is less valuable than heat provided by steam or Dowtherm, less thickness of insulation is required. However, safe surface temperatures are a function not only of



INSULATION THICKNESS REQUIREMENTS

Service Designation S - Safe Surface Temperature Insulation Thicknesses - Continued the insulation thickness and operating temperatures, but also the emittance of the outer surface. For this reason, tables are provided for safe surface temperatures based on operating temperatures and outer surface emittances of weather barriers commonly used. On high temperature installations excessively thick insulation may be required if weather barrier has low emittance. Although the table for safe surface temperature of low emittance weather barrier is provided, where the thicknesses exceed the thicknesses required for economics, a weather barrier of higher emittance should be specified.

Service Designation T - Traced Pipe and Equipment Insulation Thicknesses

Heat traced pipe and equipment are generally heat traced using steam or electric as source of heat. The steam heated tracing may supply the heat to the pipe by heating the annulus air space around the pipe. Where higher temperatures are required than can be obtained by a single tracer by this method, the steam tracer is thermally bonded to the process pipe or equipment with heat transfer cement. Tables for the design of these and the insulation thicknesses required are provided. The insulation thickness selected should be cross-checked with the economic thickness tables to determine that the optimum thickness of insulation is provided. However, the savings of tracer tubing or elimination of trap stations may warrant additional insulation than the thickness based on steam savings only.

Tables for design, and insulation thicknesses for electric tracing are also provided. Tables are based on electric tracer being bonded to process pipe with high conductive cement.

Service Designation U - Underground Insulation Thicknesses

Piping located underground requires factory-made conduits, field-made conduits or fill insulation. Various insulation can be supplied with the factory-made conduits, Specification No. 37-H, so in that particular specification the insulation material to be used must be selected as determined by operation requirements. The insulation thickness required of underground fill insulation, Specification No. 39-H, is given in the specification so no thickness table is included. Specification No. 39-H is recommended only where ground conditions are relatively dry and good drainage is possible.

An index of the service designation thickness tables follows.

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<u>Service Designation</u>	<u>Service or Use</u>	<u>Spec. No.</u>	<u>Table No.</u>	<u>Page</u>
A	Air Conditioning Duct Insulation Thickness	10-B	Not included	
B	Building Insulation Thicknesses	17	" "	
C	Cold Pipe and Equipment Insulation Thicknesses	10-L	C-1 to C-3	
D	Control of Water Drip From Surfaces	40-J	D-1	
E	Economic Insulation Thicknesses Steam, and Steam-Heated Processes	10-H 10-J 10-JSS 12-H 16-H 19-H 15-H 21-H 21-HSS 22-H 22-HSS 23-H 23-HSS 22-H 22-HSS 25-H 41-H 42-H	E1 to E-10 E11 to E-20 E-21 to E-24 E-25 to E-31 E-32, E-33 E-34 to E-43 E-44 to E-52 E-53	
	Dowtherm, and Dowtherm-Heated Processes (Not Calculated at Present)			
F	Insulation Thicknesses to Retard Freezing of Water Pipes	10-J 10-L	F-1	
M	Maximum Heat Loss from Equipment or Piping System		Not included	

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N	Maximum Heat Gain to Equipment or Piping System		Not included
P	Fire Protection Insulation Thicknesses		
PS	High Temperature Fire Protection and Safe Surface Temperature	32-H	PS-1, PS-2
PE	High Temperature Fire Protection and Economic Thickness	32-H	PE-3 to PE-12
PC	Low Temperature Fire Protection - Cold Service	32-L	PC-13 to PC-15
	Table of Thicknesses of Insulation Layers	32-L	P-16 to P-18
R	Reflective Insulation Thicknesses	13-H	R-1, R-2
S	Safety Insulation Thicknesses - Safe Surface Temperature	21-H 22-H 23-H 25-H	
	Emissivity of Surface 0.9 (Mastic Finishes)	21-H 22-H 23-H 25-H	S-1, S-2
	Emissivity of Surface 0.4 (Stainless Steel Jackets)	21-H 22-H 23-H 25-H	S-3, S-4
	Emissivity of Surface 0.05 (Aluminum Jacket)	21-H 22-H 23-H 25-H	S-5, S-6

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T	Heat Traced Piping and Equipment		
	Steam Heated	*	
	Pipe Spaced Tracer System (Air		
	Convection Annulus Space)	*	T-1 to T-7
	Pipe Cemented Tracer System		
	(Bonded with Heat Trans. Cement)	*	T-8 to T-14
U	Equipment Cemented Tracer System		
	(Bonded with Heat Trans. Cement)	*	T-15 to T-30
	Electric Traced Electrically Heated	*	
	Pipe Cemented Tracer System		
	(Bonded with Heat Trans. Cement)	*	T-31 to T-65
U	Underground Insulation Thicknesses		
	Urethane Conduit System	38-H	U-1, U-3
	Cellular Glass	10-U	U-4 to U-8
		10-USS	
	Steel Conduit	37-H	U-9 to U-13

* Specification selection may be based on other considerations other than the fact that pipe or equipment require heat tracing.



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INSULATION THICKNESS REQUIREMENTS

Service Designation C-2

CONDENSATION PREVENTION INSULATION THICKNESSES

PLANTS: MONTREAL C53, NIAGARA FALLS 516, OTTAWA

SPEC. NO'S: 1G-1 CELLULAR GLASS

SERVICE: LOW TEMPERATURE - OUTDOORS

SPEC. NO'S. 16-1 CELLULAR GLASS		SERVICE: LOW TEMPERATURE - OUTDOORS																												
		OPERATING TEMPERATURE ° C																												
NOM. PIPE SIZE	OPERATING TEMPERATURE ° F																													
	19	10	10	5	0	-1	-6	-11	-16	-21	-26	-31	-36	-41	-46	-51	-56	-61	-66	-71	-76	-81	-86	-91	-96	-101	-106	-111	-116	-121
1	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
3	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
6	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
8	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
10	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
12	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
14	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
16	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
18	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
20	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
22	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
24	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
26	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
28	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
30	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
36	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2					

OPERATING TEMPERATURE ° F

INSULATION THICKNESS REQUIREMENTS

Service Designation

INSULATION THICKNESSES FOR CONTROL OF WATER DRIP FROM SURFACE OF PIPE AND EQUIPMENT

SERVICE: PREVENTION OF WATER DRIP

**ALL PLANTS
40-J PVA INSULATING MASTIC**

PLANTS:
SPEC. NO.

PERCENT RELATIVE HUMIDITY, ABOVE WHICH CONDENSATION WILL OCCUR ON SURFACES																										
Pipe or Equipment Temperature		Insulated with 1" thickness of mastic Ambient Temperature ° C										Insulated with 3/8" thickness of mastic Ambient Temperature ° C														
C	F	7.2	10.0	12.8	15.6	18.3	21.1	23.9	26.7	29.4	32.2	35.0	37.8	7.2	10.0	12.8	15.6	18.3	21.1	23.9	26.7	29.4	32.2	35.0	37.8	
4.4	40	86	81	74	68	63	59	55	52	49	47	43	41	92	84	79	76	69	66	63	59	57	55	53	50	
7.2	45	91	82	75	69	64	60	57	54	50	50	48	45	92	85	80	74	70	67	64	61	58	56	53		
10.0	50		91		82	75	69	65	61	58	55	51	48		92		85	80	76	71	68	64	62	59	57	
12.8	55			91		83	77	71	66	62	59	54	52			92		86	80	76	72	69	66	63	60	
15.6	60				91		83	78	72	67	63	59	56				92		86	81	77	73	69	67	63	
18.3	65						92	84	78	73	68	64	60					92		92	87	82	78	73	70	
21.1	70							92	84	79	73	68	64						92		93	88	82	78	74	
23.9	75								92	86	79	74	69							93		93	90	82	79	
26.7	80									92	86	79	77								93		93	88	83	
29.4	85										92	86	80									93		93	88	
32.2	90											92	87										93	88	84	
35.0	95												92											93	93	
		45	50	55	60	65	70	75	80	85	90	95	100		45	50	55	60	65	70	75	80	85	90	95	100
		Ambient Temperature ° F												Ambient Temperature ° F												



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
PAGE 282
MAY, 1968

INSULATION THICKNESS REQUIREMENTS

Service Designation E-1
E-2

ECONOMIC INSULATION THICKNESSES

PLANTS: SILICONES - SISTERSVILLE PLANT
SPEC. NO'S: 10-H CELLULAR GLASS (FIBER GLASS INNER LAYER)
SERVICE: STEAM AND STEAM HEATED PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																
	60	80	100	120	140	160	180	200	220	240	260	280	300				
1	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	
2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	
3	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	
4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	
6	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	
8	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2 1/2	
10	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2 1/2	
12	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2 1/2	
14	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2 1/2	
16	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2 1/2	
18	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	3	
20	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	3 1/2	
22	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	3 1/2	
24	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	3 1/2	
26	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	3 1/2	
28	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	4	
30	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	4	
36	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	4	
EQUIP FLAT	1 1/2	2	2	2 1/2	3	3	3 1/2	3 1/2	3 1/2	4	4 1/2	4 1/2	4 1/2				4 1/2
	140	176	212	248	284	320	356	392	428	464	500	536	572				572
	175	211	247	283	319	355	391	427	463	499	535	571	607				607
OPERATING TEMPERATURE ° F																	

NOTE: Inner cushion of fiber glass not considered as part of specified thickness.

ECONOMIC INSULATION THICKNESSES

PLANTS: WHITING PLANT 517
SPEC. NO'S: 10-H CELLULAR GLASS (FIBER GLASS INNER LAYER)
SERVICE: STEAM AND STEAM HEATED PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE • C																
	60	80	100	120	140	160	180	200	220	240	260	280	300				
1	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2
2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2
3	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2
4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2
6	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2
8	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2
10	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2
12	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2
14	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2
16	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2
18	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2
20	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2
22	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2
24	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2
26	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2
28	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2
30	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2
36	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2
EQUIP FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2
	140	176	212	248	284	320	356	392	428	464	500	536	572				572
	175	211	247	283	319	355	391	427	463	499	535	571	607				607
OPERATING TEMPERATURE • F																	

NOTE: Inner cushion of fiber glass not considered as part of specified thickness.



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DE
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INSULATION THICKNESS REQUIREMENTS

Service Designation E-3
E-4

ECONOMIC INSULATION THICKNESSES

PLANTS: GULF COAST PLANTS - SEADRIFT-510, TEXAS CITY-515, TAFT-519,
BROWNSVILLE-526
SPEC. NO'S: 10-H CELLULAR GLASS SERVICE: STEAM AND STEAM HEATED
(FIBER GLASS INNER LAYER) PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																
	60	80	100	120	140	160	180	200	220	240	260	280	300				
1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
3/4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
1	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
1 1/4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
2 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
3	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
3 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
4 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
6	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
8	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
10	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
12	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
14	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
16	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
18	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
20	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
22	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
24	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
26	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
28	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
30	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
36	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
EQUIP FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
	140	176	212	248	284	320	356	392	428	464	500	536	572				
	10	10	10	10	10	10	10	10	10	10	10	10	10				
	175	211	247	283	319	355	391	427	463	499	535	571	607				
OPERATING TEMPERATURE ° F																	

NOTE: Inner cushion layer of glass fiber not considered as part of specified thickness.

ECONOMIC INSULATION THICKNESSES

PLANTS: TORRANCE PLANT 513
SPEC. NO'S: 10-H CELLULAR GLASS SERVICE: STEAM AND STEAM HEATED
(FIBER GLASS INNER LAYER) PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE °C																
	60	80	100	120	140	160	180	200	220	240	260	280	300				
1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
3/4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
1	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
1 1/4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
2 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
3	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
3 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
4 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
6	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
8	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
10	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
12	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
14	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
16	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
18	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
20	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
22	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
24	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
26	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
28	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
30	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
36	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
EQUIP FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
	140	176	212	248	284	320	356	392	428	464	500	536	572				
	10	10	10	10	10	10	10	10	10	10	10	10	10				
	175	211	247	283	319	355	391	427	463	499	535	571	607				
OPERATING TEMPERATURE ° F																	

NOTE: Inner cushion of fiber glass not considered as part of specified thickness.



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III INSULATION DESIGN

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INSULATION THICKNESS REQUIREMENTS

Service Designation E-5
E-6

ECONOMIC INSULATION THICKNESSES

PLANTS: KANAWHA VALLEY PLANTS - INSTITUTE-512, SOUTH CHARLESTON-514
SPEC. NO'S: 10-H CELLULAR GLASS SERVICE: STEAM AND STEAM HEATED
(FIBER GLASS INNER LAYER) PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																to			
	60	80	100	120	140	160	180	200	220	240	260	280	300	to	to	to	to	to	to	to
1	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
3	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
6	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
8	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
10	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
12	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
14	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
16	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
18	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
20	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
22	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
24	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
26	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
28	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
30	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
36	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
EQUIP FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
OPERATING TEMPERATURE ° F																	to			
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INSULATION THICKNESS REQUIREMENTS

Service Designation E-7

ECONOMIC INSULATION THICKNESSES

PLANTS: PONCE

SPEC. NO'S: 10-H CELLULAR GLASS
(FIBER GLASS INNER LAYER)

SERVICE: STEAM AND STEAM HEATED EQUIPMENT
AND PIPE

NOM PIPE SIZE	OPERATING TEMPERATURE ° C													
	60	80	100	120	140	160	180	200	220	240	260	280	300	
	to 79	to 99	to 119	to 139	to 159	to 179	to 199	to 219	to 239	to 259	to 279	to 299	to 319	
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	
¾	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	
2	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	
2½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	
3	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	
3½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	
4	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	
6	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	
8	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	
10	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3	
12	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	
14	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3	
16	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3	
18	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3	
20	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3	
22	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3	
24	1½	1½	1½	2	2	2½	2½	2½	2½	3	3	3½	3½	
26	1½	1½	1½	2	2	2½	2½	2½	2½	3	3	3½	3½	
28	1½	1½	1½	2	2	2½	2½	2½	2½	3	3	3½	3½	
30	1½	1½	1½	2	2	2½	2½	2½	2½	3	3	3½	3½	
36	1½	1½	1½	2	2	2½	2½	2½	2½	3	3	3½	3½	
EQUIP FLAT	1½	1½	2	2	2½	2½	3	3	3	3½	3½	3½	4	
	140	176	212	248	284	320	356	392	428	464	500	536	572	
	to 175	to 211	to 247	to 283	to 319	to 355	to 391	to 417	to 463	to 499	to 535	to 571	to 607	
	OPERATING TEMPERATURE ° F													

INSULATION THICKNESS REQUIREMENTS

Service Designation E-8

E-9

ECONOMIC INSULATION THICKNESSES

PLANTS: CARTERSVILLE PLANT - OTTAWA PLANT, PLASTICS DIVISION
SPEC. NO'S: 10-H CELLULAR GLASS SERVICE: STEAM AND STEAM HEATED
(FIBER GLASS INNER LAYER) PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C													
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	
1	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	
2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	
3	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	
4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	
5	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	
6	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	
8	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	
10	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	
12	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	
14	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	
16	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	
18	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	
20	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	
22	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	
24	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	
26	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	
28	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	
30	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	
32	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	
36	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	
EQUIP FLAT	1 1/2	1 1/2	2	2 1/2	2 1/2	2 1/2	3	3	3	3 1/2	4	4	4	
	140	176	212	248	284	320	356	392	428	464	500	536	572	
	to	to	to	to	to	to	to	to	to	to	to	to	to	
	175	211	247	283	319	355	391	427	463	499	535	571	607	
	to	to	to	to	to	to	to	to	to	to	to	to	to	
	OPERATING TEMPERATURE ° F													

Note: Inner layer of fiber glass not considered as part of specified thickness

ECONOMIC INSULATION THICKNESSES

PLANTS: BOUND BROOK PLANT - PLASTIC DIVISION
SPEC. NO'S: 10-H CELLULAR GLASS SERVICE: STEAM AND STEAM HEATED
(FIBER GLASS INNER LAYER) PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C													
	60	80	100	120	140	160	180	200	220	240	260	280	300	
1	10	10	10	10	10	10	10	10	10	10	10	10	10	
2	79	99	119	139	159	179	199	219	239	259	279	299	319	
3	11	11	11	11	11	11	11	11	11	11	11	11	11	
4	11	11	11	11	11	11	11	11	11	11	11	11	11	
5	11	11	11	11	11	11	11	11	11	11	11	11	11	
6	11	11	11	11	11	11	11	11	11	11	11	11	11	
8	11	11	11	11	11	11	11	11	11	11	11	11	11	
10	11	11	11	11	11	11	11	11	11	11	11	11	11	
12	11	11	11	11	11	11	11	11	11	11	11	11	11	
14	11	11	11	11	11	11	11	11	11	11	11	11	11	
16	11	11	11	11	11	11	11	11	11	11	11	11	11	
18	11	11	11	11	11	11	11	11	11	11	11	11	11	
20	11	11	11	11	11	11	11	11	11	11	11	11	11	
22	11	11	11	11	11	11	11	11	11	11	11	11	11	
24	11	11	11	11	11	11	11	11	11	11	11	11	11	
26	11	11	11	11	11	11	11	11	11	11	11	11	11	
28	11	11	11	11	11	11	11	11	11	11	11	11	11	
30	11	11	11	11	11	11	11	11	11	11	11	11	11	
36	11	11	11	11	11	11	11	11	11	11	11	11	11	
EQUIP	11	11	2	2	2	2	2	2	2	2	2	2	2	
FLAT	140	176	212	248	284	320	356	392	428	464	500	536	572	
	10	10	10	10	10	10	10	10	10	10	10	10	10	
	175	211	247	283	319	355	391	427	463	499	535	571	607	
	OPERATING TEMPERATURE ° F													

t4ote: Inner layer of fiber glass not considered as part of specified thickness.



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
PAGE 287
MAY, 1968

INSULATION THICKNESS REQUIREMENTS

Service Designation E-10

ECONOMIC INSULATION THICKNESSES

PLANTS: MARIETTA PLANT - PLASTICS DIVISION
SPEC. NO'S: 10-H CELLULAR GLASS SERVICE: STEAM AND STEAM HEATED
(FIBER GLASS INNER LAYER) PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C												
	60	80	100	120	140	160	180	200	220	240	260	280	300
	to 79	to 99	to 119	to 139	to 159	to 179	to 199	to 219	to 239	to 259	to 279	to 299	to 319
1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
3/4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
1	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
1 1/4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
2 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
3	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
3 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
6	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2
8	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2	2
10	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2	2	2
12	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2	2	2 1/2	2 1/2
14	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2	2	2 1/2	2 1/2	2 1/2
16	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2	2	2	2 1/2	2 1/2	2 1/2
18	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2	2	2	2 1/2	2 1/2	2 1/2
20	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2	2	2	2 1/2	2 1/2	2 1/2
22	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2	2	2	2 1/2	2 1/2	2 1/2
24	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2	2	2	2 1/2	2 1/2	2 1/2
26	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2	2	2	2 1/2	2 1/2	2 1/2
28	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2	2	2	2 1/2	2 1/2	2 1/2
30	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
36	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2
EQUIP FLAT	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2	3	3	3 1/2
	140	176	212	248	284	320	356	392	428	464	500	536	572
	to	to	to	to	to	to	to	to	to	to	to	to	to
	175	211	247	283	319	355	391	427	463	499	535	571	607
	OPERATING TEMPERATURE ° F												

Note: Inner layer of fiber glass not considered as part of specified thickness.

INSULATION THICKNESS REQUIREMENTS

Service Designation E-11
E-12

ECONOMIC INSULATION THICKNESSES

PLANTS: WHITING PLANT 517
SPEC. NO'S: 10-J, 10-J SS CELLULAR GLASS

NOM. PIPE SIZE	OPERATING TEMPERATURE ° C											
	60 to	80 to	100 to	120 to	140 to	160 to	180 to	200 to	220 to	240 to	260 to	280 to
1	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
3	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
6	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
8	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
10	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
12	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
14	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
16	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
18	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
20	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
22	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
24	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
26	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
28	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
30	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
36	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
EQUIP FLAT	1 1/2	2	2 1/2	3	3	3 1/2	3 1/2	3 1/2	4	4	4	4 1/2
	140	176	212	248	284	320	356	392	428	464	500	536
	to	to	to	to	to	to	to	to	to	to	to	to
	175	211	247	283	319	355	391	427	463	499	535	571

C O O L I N G TEMPERATURE ° F

ECONOMIC INSULATION THICKNESSES

PLANTS: TORRANCE PLANT 513
SPEC. NOS: 10-J, 10-J55 CELLULAR GLASS SERVICE: STEAM AND STEAM HEATED
PROCESS, PIPES AND
EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C											
	60	80	100	120	140	160	180	200	220	240	260	280
1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1	1
36	1	1	1	1	1	1	1	1	1	1	1	1
EQUIP FLAT	2	2	3	3	3	4	4	4	5	5	5	5
	140	176	212	248	284	320	356	392	428	464	500	536
	10	10	10	10	10	10	10	10	10	10	10	10
	175	211	247	283	319	355	391	427	463	499	535	571
	OPERATING TEMPERATURE ° F											

ECONOMIC INSULATION THICKNESSES

PLANTS: KANAWHA VALLEY PLANTS - INSTITUTE-512, SOUTH CHARLESTON-514
SPEC. NO'S: 10-J and 10-JSS CELLULAR GLASS SERVICE: STEAM AND STEAM HEATED
PROCESS PIPE AND EQUIPMENT

[illegible]

Service Designation E-
E-

ECONOMIC INSULATION THICKNESSES

PLANTS:	SILICONES - SISTERSVILLE PLANT	SERVICE:	STEAM AND STEAM HEATED PROCESS PIPE AND EQUIPMENT
REC. NO'S:	10-J and 10-JSS CELLULAR GLASS		

[illegible]

INSULATION THICKNESS REQUIREMENTS

Service Designation E-15
E-16

ECONOMIC INSULATION THICKNESSES

PLANTS: MONTREAL -053
SPEC. NO'S: 10-J, 10-JSS
CELLULAR GLASS SERVICE: STEAM AND STEAM HEATED
PROCESS LINES AND EQUIPMENT

NOM. PIPE SIZE	OPERATING TEMPERATURE ° C											
	60	80	100	120	140	160	180	200	220	240	260	280
1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
3	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
6	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
8	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
10	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
12	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
14	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
16	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
18	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
20	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
22	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
24	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
26	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
28	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
30	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
36	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
EQUIP FLAT	1 1/2	2	2 1/2	3	3	3 1/2	3 1/2	3 1/2	4	4	4	4 1/2
	140	176	212	248	284	320	356	392	428	464	500	536
	to	to	to	to	to	to	to	to	to	to	to	to
	175	211	247	283	319	355	391	427	463	499	535	571
	OPERATING TEMPERATURE ° F											

ECONOMIC INSULATION THICKNESSES

PLANTS: GULF COAST PLANTS - SEADRIFT-510, TEXAS CITY-515, TAFT-519, BROWNSVILLE-526
SPEC. NOS: 10-J and 10-JSS CELLULAR GLASS SERVICE: STEAM AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

PIPE SIZE	OPERATING TEMPERATURE ° C												EQUIP PLAT
	60	80	100	120	140	160	180	200	220	240	260	280	
1/2	11	11	11	11	11	11	11	11	11	11	11	11	
3/4	11	11	11	11	11	11	11	11	11	11	11	11	
1	11	11	11	11	11	11	11	11	11	11	11	11	
1 1/2	11	11	11	11	11	11	11	11	11	11	11	11	
2	11	11	11	11	11	11	11	11	11	11	11	11	
2 1/2	11	11	11	11	11	11	11	11	11	11	11	11	
3	11	11	11	11	11	11	11	11	11	11	11	11	
3 1/2	11	11	11	11	11	11	11	11	11	11	11	11	
4	11	11	11	11	11	11	11	11	11	11	11	11	
6	11	11	11	11	11	11	11	2	2	2	2	2	
8	11	11	11	11	11	11	11	2	2	2	2	2	
10	11	11	11	11	11	11	11	2	2	2	2	2	
12	11	11	11	11	11	11	2	2	2	2	2	2	
14	11	11	11	11	11	2	2	2	2	2	2	2	
16	11	11	11	11	11	2	2	2	2	2	2	2	
18	11	11	11	11	2	2	2	2	2	2	2	2	
20	11	11	11	11	2	2	2	2	2	2	2	2	
22	11	11	11	11	2	2	2	2	2	2	2	2	
24	11	11	11	11	2	2	2	2	2	2	2	2	
26	11	11	11	11	2	2	2	2	2	2	2	2	
28	11	11	11	11	2	2	2	2	2	2	2	2	
30	11	11	11	11	2	2	2	2	2	2	2	2	
36	11	11	11	11	2	2	2	2	2	2	2	2	
11	11	11	2	2	2	2 1/2	2 1/2	2 1/2	3	3	3	3 1/2	
140	176	212	248	284	320	356	392	428	464	500	536	536	
175	211	247	283	319	355	391	427	463	499	535	571	571	
OPERATING TEMPERATURE ° F													

INSULATION THICKNESS REQUIREMENTS

Service Designation E-17

ECONOMIC INSULATION THICKNESSES

PLANTS: PONCE
SPEC. NO'S: 10-J and 10-JSS CELLULAR GLASS

SERVICE: STEAM & STEAM
HEATED EQUIPMENT & PIPE

NOM PIPE SIZE	OPERATING TEMPERATURE ° C											
	60	80	100	120	140	160	180	200	220	240	260	280
	to 79	to 99	to 119	to 139	to 159	to 179	to 199	to 219	to 239	to 259	to 279	to 299
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
¾	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
2	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2
2½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
3	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2
3½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2
4	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2
6	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½
8	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½
10	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½	2½
12	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3
14	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3
16	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3
18	1½	1½	1½	2	2	2½	2½	2½	3	3	3	3
20	1½	1½	1½	2	2	2½	2½	2½	3	3	3	3
22	1½	1½	1½	2	2	2½	2½	2½	3	3	3	3
24	1½	1½	1½	2	2	2½	2½	2½	3	3	3	3½
26	1½	1½	1½	2	2	2½	2½	2½	3	3	3	3½
28	1½	1½	1½	2	2	2½	2½	2½	3	3	3	3½
30	1½	1½	2	2	2½	2½	2½	3	3	3	3½	3½
36	1½	1½	2	2	2½	2½	2½	3	3	3	3½	3½
EQUIP FLAT	1½	1½	2	2½	2½	3	3	3	3½	3½	3½	4
	140	176	212	248	284	320	356	392	428	464	500	536
	to	to	to	to	to	to	to	to	to	to	to	to
	175	211	247	283	319	355	391	427	463	499	535	571
	OPERATING TEMPERATURE ° F											

INSULATION THICKNESS REQUIREMENTS

Service Designation E-18
E-19

ECONOMIC INSULATION THICKNESSES

PLANT: CARTERSVILLE PLANT - OTTAWA PLANT, PLASTICS DIVISION
SPEC. NO'S: 10-J, 10-JSS
CELLULAR GLASS
SERVICE: STEAM AND STEAM HEATED
PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE • C											
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299
1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
3	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2	2	2
4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2	2	2
5	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2	2	2
6	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2 1/2	2 1/2	2 1/2
8	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2 1/2	2 1/2	2 1/2
10	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2 1/2	2 1/2	2 1/2
12	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2 1/2	2 1/2	2 1/2
14	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2 1/2	2 1/2	2 1/2
16	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2 1/2	2 1/2	2 1/2
18	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2 1/2	2 1/2	2 1/2
20	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2 1/2	2 1/2	2 1/2
22	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2 1/2	2 1/2	2 1/2
24	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2 1/2	2 1/2	2 1/2
26	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2 1/2	2 1/2	2 1/2
28	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2 1/2	2 1/2	2 1/2
30	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2 1/2	2 1/2	2 1/2
36	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2 1/2	2 1/2	2 1/2
EQUIP FLAT	1 1/2	2	2 1/2	3	3	3 1/2	3 1/2	4	4	4 1/2	4 1/2	4 1/2
	140	176	212	248	284	320	356	392	428	464	500	536
	to	to	to	to	to	to	to	to	to	to	to	to
	175	211	247	283	319	355	391	427	463	499	535	571
	OPERATING TEMPERATURE • F											

ECONOMIC INSULATION THICKNESSES

PLANTS: BOUND BROOK PLANT • PLASTICS DIVISION
SPEC. NOS: 10-J, 10-J 55 CELLULAR GLASS SERVICE; STEAM AND STEAM HEATED
PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE • C											
	60	80	100	120	140	160	180	200	220	240	260	280
1	11	11	11	11	11	11	11	11	11	11	11	11
2	11	11	11	11	11	11	11	11	11	11	11	11
3	11	11	11	11	11	11	11	11	11	11	11	11
4	11	11	11	11	11	11	11	11	11	11	11	11
6	11	11	11	11	11	11	11	11	11	11	11	11
8	11	11	11	11	11	11	11	11	11	11	11	11
10	11	11	11	11	11	11	11	11	11	11	11	11
12	11	11	11	11	11	11	11	11	11	11	11	11
14	11	11	11	11	11	11	11	11	11	11	11	11
16	11	11	11	11	11	11	11	11	11	11	11	11
18	11	11	11	11	11	11	11	11	11	11	11	11
20	11	11	11	11	11	11	11	11	11	11	11	11
22	11	11	11	11	11	11	11	11	11	11	11	11
24	11	11	11	11	11	11	11	11	11	11	11	11
26	11	11	11	11	11	11	11	11	11	11	11	11
28	11	11	11	11	11	11	11	11	11	11	11	11
30	11	11	11	11	11	11	11	11	11	11	11	11
36	11	11	11	11	11	11	11	11	11	11	11	11
EQUIP FLAT	11	11	2	2 1/2	2 1/2	2 1/2	3	3	3	3 1/2	3 1/2	3 1/2
	140	176	212	248	284	320	356	392	428	464	500	536
	175	211	247	283	319	355	391	427	463	499	535	571
	OPERATING TEMPERATURE • F											

INSULATION THICKNESS REQUIREMENTS

Service Designation E-20

ECONOMIC INSULATION THICKNESSES

PLANTS: MARJETTA PLANT - PLASTICS DIVISION

SPEC. NO'S: 10-J, 10-J SS CELLULAR GLASS SERVICE: STEAM AND STEAM HEATED
PROCESS PIPE AND EQUIPMENT

[illegible]

INSULATION THICKNESS REQUIREMENTS

Service Designation E-21
E-22

ECONOMIC INSULATION THICKNESSES

PLANTS: SILICONES-SISTERSVILLE, MONTREAL-053,
TORRANCE-513, NIAGARA FALLS-516, OTTAWA
SPEC. NO'S: 12-H URETHANE SERVICE: TRACED, LOW PRESS STEAM,
PROCESS-MODERATE SERVICE

NOM PIPE SIZE	OPERATING TEMPERATURE • C											
	20 to 39	40 59	60 79	80 99	100 to 119							
1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
1	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
1 1/4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
2 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
3	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
3 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
6	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
8	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
10	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
12	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
14	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
16	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
18	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
20	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
22	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
24	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
26	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
28	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
30	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
36	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
EQUIP	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
FLAT	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2							
	68	104	140	176	212							
	to	to	to	to	to							
	103	139	175	211	247							
	OPERATING TEMPERATURE • F											

ECONOMIC INSULATION THICKNESSES

PLANTS: KANAWHA VALLEY PLANTS AND GULF COAST PLANTS,
CARTERSVILLE, MARIETTA, BOUND BROOK
SPEC. NO'S: 12-H URETHANE SERVICE: TRACED, LOW PRESS, STEAM,
PROCESS-MODERATE SERVICE

NOM PIPE SIZE	OPERATING TEMPERATURE ° C							
	20	40	60	80	100			
1	1	1	1	1	1			
2	1	1	1	1	1			
3	1	1	1	1	1			
4	1	1	1	1	1			
6	1	1	1	1	1			
8	1	1	1	1	1			
10	1	1	1	1	1			
12	1	1	1	1	1			
14	1	1	1	1	1			
16	1	1	1	1	1			
18	1	1	1	1	1			
20	1	1	1	1	1			
22	1	1	1	1	1			
24	1	1	1	1	1			
26	1	1	1	1	1			
28	1	1	1	1	1			
30	1	1	1	1	1			
36	1	1	1	1	1			
EQUIP	1	1	1	1	1			
FLAT	1	1	1	1	1			
	68	104	140	176	212			
	10	10	10	10	10			
	103	139	175	211	247			
	OPERATING TEMPERATURE ° F							

INSULATION THICKNESS REQUIREMENTS

ECONOMIC INSULATION THICKNESSES

PLANTS: PONCE
SPEC. NOS: 12-H URETHANE
SERVICE: TRACED, LOW PRESSURE STEAM
PROCESS - MODERATE SERVICE

NOM PIPE SIZE	OPERATING TEMPERATURE °C							
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119			
1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2			
3/4	1	1	1	1	1			
1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4			
1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2			
2	2	2	2	2	2			
2 1/4	2 1/4	2 1/4	2 1/4	2 1/4	2 1/4			
3	3	3	3	3	3			
3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2			
4	4	4	4	4	4			
6	6	6	6	6	6			
8	8	8	8	8	8			
10	10	10	10	10	10			
12	12	12	12	12	12			
14	14	14	14	14	14			
16	16	16	16	16	16			
18	18	18	18	18	18			
20	20	20	20	20	20			
22	22	22	22	22	22			
24	24	24	24	24	24			
26	26	26	26	26	26			
28	28	28	28	28	28			
30	30	30	30	30	30			
36	36	36	36	36	36			
QUIP LAT	1 1/2	1 1/2	1 1/2	1 1/2	2			
38	104	140	176	212				
to	to	to	to	to				
103	139	175	211	247				
	OPERATING TEMPERATURE ° F							

ECONOMIC INSULATION THICKNESSES

PLANTS: WHITING PLANT-517
SPEC. NO.'S: 12-11 URETHANE SERVICE: TRACED, LOW PRESS STEAM,
PROCESS-MODERATE SERVICE

NOM PIPE SIZE	OPERATING TEMPERATURE ° C							
	20	40	60	80	100			
1	1	1	1	1	1			
1 1/2	1	1	1	1	1			
2	1	1	1	1	1			
2 1/2	1	1	1	1	1			
3	1	1	1	1	1			
3 1/2	1	1	1	1	1			
4	1	1	1	1	1			
6	1	1	1	1	1			
8	1	1	1	1	1			
10	1	1	1	1	1			
12	1	1	1	1	1			
14	1	1	1	1	1			
16	1	1	1	1	1			
18	1	1	1	1	1			
20	1	1	1	1	1			
22	1	1	1	1	1			
24	1	1	1	1	1			
26	1	1	1	1	1			
28	1	1	1	1	1			
30	1	1	1	1	1			
36	1	1	1	1	1			
EQUIP								
FLAT	1	1	1	1	2			
	68	104	140	176	212			
	10	10	10	10	10			
	103	139	175	211	247			
	OPERATING TEMPERATURE ° F							

INSULATION THICKNESS REQUIREMENTS

Service Designation E-2
E-2

ECONOMIC INSULATION THICKNESSES

PLANTS: WHITING PLANT-517 }
SPEC. NOS: 16-H FIBROUS GLASS }
 (LOW DENSITY) }
SERVICE: STEAM AND STEAM HEATED
PROCESS LINES, MILD SERVICE, INDOORS

NOM PIPE SIZE	OPERATING TEMPERATURE °C											
	60	80	100	120	140	160	180	to	to	to	to	to
	79	99	119	139	159	179	199					
1 1/2	1 1/2	1	1	1	1	1	1					
2	1 1/2	1	1	1	1	1	1					
3	1 1/2	1	1	1	1	1	1					
4	1 1/2	1	1	1	1	1	1					
6	1 1/2	1	1	1	1	1	1					
8	1 1/2	1	1	1	1	1 1/2	1 1/2					
10	1 1/2	1	1	1 1/2	1 1/2	1 1/2	1 1/2					
12	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2					
14	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2					
16	1 1/2	1 1/2	1 1/2	2	2	2	2					
18	1 1/2	1 1/2	2	2	2	2	2					
20	1 1/2	1 1/2	2	2	2	2	2					
22	1 1/2	1 1/2	2	2	2	2	2					
24	1 1/2	1 1/2	2	2	2	2	2 1/2					
26	1 1/2	1 1/2	2	2	2	2	2 1/2					
28	1 1/2	1 1/2	2	2	2	2	2 1/2					
30	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2					
36	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2					
EQUIP	1 1/2	2	2	2 1/2	2 1/2	2 1/2	3					
FLAT	140	176	212	248	284	320	356					
	to	to	to	to	to	to	to					
	175	211	247	283	319	355	391					
	OPERATING TEMPERATURE °F											

ECONOMIC INSULATION THICKNESSES

PLANTS: TORRANCE PLANT
SPEC. NO'S: 16-H FIBROUS GLASS (LOW DENSITY) SERVICE: STEAM AND STEAM
HEATED PROCESS LINES,
MILD SERVICE INDOORS

NOMINAL PIPE SIZE	OPERATING TEMPERATURE ° C										
	60	80	100	120	140	160	180				
1/2	1	1	1	1	1	1	1				
3/4	1	1	1	1	1	1	1				
1	1	1	1	1	1	1	1				
1 1/4	1	1	1	1	1	1	1				
1 1/2	1	1	1	1	1 1/2	1 1/2	1 1/2				
2	1	1	1	1	1 1/2	1 1/2	1 1/2				
2 1/2	1	1	1	1 1/2	1 1/2	1 1/2	1 1/2				
3	1	1	1	1 1/2	1 1/2	1 1/2	1 1/2				
3 1/2	1	1	1 1/2	1 1/2	1 1/2	2	2				
4	1	1	1 1/2	1 1/2	1 1/2	2	2				
6	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2				
8	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2				
10	1 1/2	1 1/2	2	2	2	2	2				
12	1 1/2	1 1/2	2	2	2	2	2				
14	1 1/2	1 1/2	2	2	2	2	2 1/2				
16	1 1/2	1 1/2	2	2	2	2	2 1/2				
18	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2				
20	1 1/2	1 1/2	2	2	2 1/2	2 1/2	2 1/2				
22	1 1/2	1 1/2	2	2	2 1/2	2 1/2	2 1/2				
24	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2				
26	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2				
28	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2				
30	1 1/2	2	2	2 1/2	2 1/2	2 1/2	3				
36	1 1/2	2	2	2 1/2	2 1/2	2 1/2	3				
EQUIP	1 1/2	2	2 1/2	3			3 1/2				
FLAT	140	176	212	248	284	320	356				
	10	10	10	10	10	10	10				
	175	211	247	283	319	355	391				
	OPERATING TEMPERATURE ° F										



PLANTS: PONCE
SPEC. NO'S: T-4-H FIBROUS GLASS (LOW DENSITY) SERVICE: STEAM & STEAM HEATED LINES, MILD SERVICE INDOORS



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INSULATION THICKNESS REQUIREMENTS

Service Designation E-38

ECONOMIC INSULATION THICKNESSES

PLANTS: TORRANCE PLANT 513
SPEC. NO'S: 15-H, 21-H, 21-HSS, 22-H, 22-HSS, 23-H, 23-HSS SERVICE: STEAM AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																								OPERATING TEMPERATURE ° F																							
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	560 to 579	580 to 599																					
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2																				
2	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																				
3	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																				
4	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																				
6	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																				
8	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																				
10	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																				
12	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																				
14	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																				
16	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																				
18	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																				
20	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																				
22	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																				
24	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																				
26	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																				
28	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																				
30	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																				
EQUIP FLAT	1	2	2	3	3	3	3	4	4	4	4	4	5	5	5	6	6	6	6	6	6	7	7	7	8	8	8	8																				
140	176	212	243	284	320	356	392	428	464	500	536	572	608	644	680	716	752	788	824	860	896	932	968	1004	1040	1076	1112	1148																				
175	211	247	283	319	355	391	427	463	499	535	571	607	643	679	715	751	787	823	859	895	931	967	1003	1039	1075	1111	1147	1183																				

Spec. 21-H Temp. Limit 540 C, 1000 F
Spec. 23-H Temp. Limit 400 C, 750 F
Spec. 15-H Temp. Limit 400 C, 750 F



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ECONOMIC INSULATION THICKNESSES

PLANIS: BOUND BROOK PLANT, PLASTICS DIVISION
SPEC. NOS: 15-H, 21-H, 21-HSS, 22-H, 22-HSS, 23-H, 23-HSS

SERVICE: STEAM AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

NOM. PIPE SIZE	OPERATING TEMPERATURE °C																											
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	560 to 579	580 to 599	
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
3/4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
1 1/4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
1 1/2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
2 1/2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
3 1/2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
36	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
EQUIP FLAT	1	1	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1																	

Spec. No. 21-H - Temp. limit 540C-1000F
Spec. No. 23-H - Temp. limit 400C-750F
Spec. No. 15-H - Temp. limit 400C-750F



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Service Designation E-43

ECONOMIC INSULATION THICKNESSES

PLANTS: MARIETTA PLANT - PLASTICS DIVISION
SPEC. NO'S: 15-H, 21-H, 21-HSS, 22-H, 22-HSS, 23-H, 23-HSS

SERVICE: STEAM AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE °C																									
	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420	440	460	480	500	520	540	560	580
1/2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3/4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1 1/4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1 1/2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2 1/2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3 1/2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4 1/2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
36	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
EQUIP	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
FLAT	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Spec. No. 21-H - Temp. limit 540C - 1000F
Spec. No. 23-H - Temp. limit 400C - 750F
Spec. No. 15-H - Temp. limit 400C - 750F

INSULATION THICKNESS REQUIREMENTS

Service Designation E-44

ECONOMIC INSULATION THICKNESSES

PLANTS: TORRANCE PLANT 513
22-H, 22-HSS EXPANDED SILICA, 25-H HIGH AND STD. CALCIUM SILICATE SERVICE: PROCESS PIPE AND EQUIPMENT
SPEC. NOS:

INCH PIPE SIZE	OPERATING TEMPERATURE ° C																								EQUIP FLAT	
	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	560 to 579	580 to 599	600 to 619	620 to 639	640 to 659	660 to 679	680 to 699	700 to 719	720 to 739	740 to 759	760 to 779	780 to 799	800 to 819	820 to 839	840 to 859		860 to 879
1	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
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1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
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1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
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1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
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1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3				

INSULATION THICKNESS REQUIREMENTS

Service Designation E-45

ECONOMIC INSULATION THICKNESSES

PLANTS:
WHITING PLANT 517
22-H, 22-HSS EXPANDED SILICA, 25-H HIGH AND STD. CALCIUM SILICATE
SPEC. NO'S:

[illegible]

INSULATION THICKNESS REQUIREMENTS

Service Designation E-46

ECONOMIC INSULATION THICKNESSES

PLANTS: GULF COAST PLANTS: SEADRIFT 510, TEXAS CITY 515, TAFT 519, BROWNSVILLE 526
SPEC. NOS: 22H, 22-HSS EXPANDED SILICA, 25-H HIGH AND STANDARD CALCIUM SILICATE
SERVICE: PROCESS PIPE AND EQUIPMENT

[illegible]

INSULATION THICKNESS REQUIREMENTS

ECONOMIC INSULATION THICKNESSES

PLANTS: MONTREAL 053, SILICONES-SISTERSVILLE
SPEC. NO'S: 22-H, 22-HSS EXPANDED SILICA, 25-H HI

SERVICE: PROCESS PIPE AND EQUIPMENT

[illegible]



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

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INSULATION THICKNESS REQUIREMENTS

Service Designation E-49

ECONOMIC INSULATION THICKNESSES

PLANTS: PONCE
SPEC. NO'S: 22-H, 22-HSS EXPANDED SILICA, 25-H HIGH & LOW CAL. SIL. SERVICE: PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE °C																								
	380	400	420	440	460	480	500	520	540	560	580	600	620	640	660	680	700	720	740	760	780	800	820	840	860
1	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2 1/2	2 1/2	2 1/2	2 1/2	3	3	3	3	3	3	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2
3/4	1 1/2	1 1/2	2	2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2	3	3	3	3	3	3	3	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2
1	2	2	2	2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2	3	3	3	3	3	3	3	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2
1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	3	3	3	3	3	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2
2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	3	3	3	3	3	3 1/2	3 1/2	3 1/2	4	4	4	4	4	4	4	4	4	4	4
2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	3	3	3	3	3 1/2	3 1/2	3 1/2	3 1/2	4	4	4	4	4	4	4	4	4	4	4
3	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	3	3	3	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	4	4	4	4	4	4	4	4	4	4	4
3 1/2	3	3	3	3	3	3	3	3 1/2	3 1/2	3 1/2	3 1/2	4	4	4	4	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2
4	3	3	3	3	3	3	3	3 1/2	3 1/2	3 1/2	3 1/2	4	4	4	4	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2
6	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	4	4	4	4	4	4	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2
8	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	4	4	4	4	4	4	4	4	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2
10	3 1/2	3 1/2	3 1/2	4	4	4	4	4	4 1/2	4 1/2	4 1/2	5	5	5	5	5	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2
12	3 1/2	3 1/2	3 1/2	4	4	4	4	4	4 1/2	4 1/2	5	5	5	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2
14	3 1/2	4	4	4	4	4	4 1/2	4 1/2	5	5	5	5	5 1/2	5 1/2	5 1/2	6	6	6	6	6	6	6	6	6	6
16	3 1/2	4	4	4	4 1/2	4 1/2	4 1/2	5	5	5	5 1/2	5 1/2	5 1/2	6	6	6	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2
18	4	4	4	4 1/2	4 1/2	4 1/2	5	5	5	5 1/2	5 1/2	5 1/2	5 1/2	6	6	6	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2
20	4	4	4	4 1/2	4 1/2	4 1/2	5	5	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	6	6	6	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2
22	4	4	4 1/2	4 1/2	4 1/2	4 1/2	5	5	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	6	6	6	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2
24	4	4	4 1/2	4 1/2	4 1/2	4 1/2	5	5	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	6	6	6	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2
26	4	4	4 1/2	4 1/2	4 1/2	4 1/2	5	5	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	6	6	6	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2
28	4	4	4 1/2	4 1/2	4 1/2	4 1/2	5	5	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	6	6	6	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2
30	4	4 1/2	4 1/2	5	5	5	5	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	6	6	6	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2
36	4	4 1/2	4 1/2	5	5	5	5	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	6	6	6	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2
EQUIP	OPERATING TEMPERATURE °F																								
FLAT	5	5	5 1/2	5 1/2	5 1/2	5 1/2	6	6	6 1/2	6 1/2	7	7	7	7	7 1/2	7 1/2	7 1/2	7 1/2	8	8	8	8 1/2	8 1/2	8 1/2	8 1/2
	716	752	788	824	860	896	932	968	1004	1040	1076	1112	1148	1184	1220	1256	1292	1328	1364	1400	1436	1472	1508	1544	1580
	751	787	823	859	895	931	967	1003	1039	1075	1111	1147	1183	1219	1255	1291	1327	1363	1399	1435	1471	1507	1543	1579	1616

INSULATION THICKNESS REQUIREMENTS

Service Designation E-50

ECONOMIC INSULATION THICKNESSES

PLANTS: BOUND BROOK PLANT, PLASTICS DIVISION
SPEC. NO'S: 22-H, 22-HSS EXPANDED SILICA, 25-H HIGH & STANDARD CALCIUM SILICATE

[illegible]

INSULATION THICKNESS REQUIREMENTS

Service Designation E-52

ECONOMIC INSULATION THICKNESSES

PLANTS	SPEC. NO'S	MARIETTA PLANT - PLASTICS DIVISION	SERVICE	PROCESS PIPE AND EQUIPMENT
		22-H, 22-HSS EXPANDED SILICA, 25-H HIGH AND STANDARD CALCIUM SILICATE		

[illegible]

INSULATION THICKNESS REQUIREMENTS

Service Designation E-55

ECONOMIC INSULATION THICKNESS

PLANTS: BROWNSVILLE 526 PONCE 293

SPEC. NO'S 21-H, 21-HSS, 22-H, 22-HSS, 23-H, 23-HSS

SERVICE: ELECTRIC HEATED PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE °C										OPERATING TEMPERATURE °F									
	0 to 19	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399
1/2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3/4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1 1/4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1 1/2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2 1/2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3 1/2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
6	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
8	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
10	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
12	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
14	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
16	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
18	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
20	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
22	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
24	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
26	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
28	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
30	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
36	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
EQUIP FLAT	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
32	68	104	140	176	212	248	284	320	356	392	428	463	500	536	572	608	644	680	716	752
67	103	139	175	211	247	283	319	355	391	427	463	500	536	572	608	644	680	716	752	788



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

INSULATION DESIGN
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APRIL 1970

INSULATION THICKNESS REQUIREMENTS

Service Designation E-5x

ECONOMIC INSULATION THICKNESS

PLANTS: SISTERSVILLE 380 WHITING 517 MONTREAL 503
SPEC. NO'S 21-H, 21-HSS, 22-H, 22-HSS, 23-H, 23-HSS

SERVICE: ELECTRIC HEATED PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE °C										OPERATING TEMPERATURE °F									
	0 to 19	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399
1/2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
3/4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
1	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
1 1/4	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
1 1/2	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
2	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
2 1/2	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
3	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
3 1/2	1.0	1.0	1.0	1.0	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
4	1.0	1.0	1.0	1.0	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
6	1.5	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
8	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
10	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
12	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
14	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
16	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
18	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
20	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
22	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
24	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
26	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
28	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
30	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
36	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
EQUIP. FLAT	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
32	68	104	140	176	212	248	284	320	356	392	428	464	500	536	572	608	644	680	716	752
67	103	139	175	211	247	283	319	355	391	427	463	499	535	571	607	643	679	715	751	787



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
PAGE 321
MAY, 1968

INSULATION THICKNESS REQUIREMENTS

Service Designation F-1

INSULATION THICKNESSES FOR FREEZE CONTROL OF OUTDOOR WATER LINES

PLANTS: ALL PLANTS
SPEC. NO'S: 10-L, 10-J

SERVICE: BASED ON WATER TEMPERATURE OF 40F(SC) AT ENTRY

NOM PIPE SIZE	MINIMUM FLOW OF WATER IN GALLONS PER HOUR, PER 100 LIN. FT. OF PIPE TO PREVENT FREEZING											
	1" Nominal Thick Insulation				1 1/2" Nominal Thick Insulation				2" Nominal Thick Insulation			
	Ambient Temperature ° F	Ambient Temperature ° C	Ambient Temperature ° F	Ambient Temperature ° C	Ambient Temperature ° F	Ambient Temperature ° C	Ambient Temperature ° F	Ambient Temperature ° C	Ambient Temperature ° F	Ambient Temperature ° C	Ambient Temperature ° F	Ambient Temperature ° C
1/2	30	20	10	0	-10	-20	-10	-20	-10	-20	-10	-20
3/4	1.91	2.87	3.81	4.76	5.73	6.65	1.45	2.18	2.91	3.64	4.25	5.09
1	2.25	3.46	4.59	5.78	6.93	8.05	1.70	2.55	3.40	4.25	5.10	5.93
1 1/4	2.52	3.62	4.90	5.95	7.22	8.40	1.91	2.87	3.81	4.77	5.72	6.68
1 1/2	3.08	4.67	6.15	7.75	9.34	11.0	2.12	3.18	4.24	5.28	6.34	7.40
2	3.27	4.85	6.33	7.90	9.70	11.0	2.42	3.63	4.83	6.05	7.25	8.46
2 1/2	3.69	5.68	7.35	9.25	11.2	13.0	2.71	4.04	5.40	6.72	8.08	9.40
3	4.23	6.35	8.48	10.6	12.7	14.9	3.19	4.19	5.80	7.00	8.38	9.77
3 1/2	5.07	7.58	0.3	12.7	15.2	17.9	3.59	5.38	7.20	8.98	10.8	12.6
4	5.83	8.61	10.5	13.6	16.0	20.1	3.69	5.64	7.38	9.25	10.9	12.7
6	6.23	9.40	12.4	15.2	18.8	21.5	4.38	6.70	8.78	10.9	13.2	15.3
8	6.92	10.2	13.9	17.1	20.4	24.0	6.30	9.58	13.5	16.0	19.2	22.4
10							7.45	10.4	14.9	18.8	22.8	26.7
12							8.91	13.7	17.9	22.5	26.7	31.5
14							10.2	15.5	20.8	26.2	31.0	35.8
16							11.9	18.0	23.6	29.3	35.5	41.7
18							13.9	20.8	27.7	33.5	42.0	49.0
20							15.3	23.1	31.1	38.9	46.5	55.2
22							16.7	25.0	34.2	42.5	50.2	59.3
24							18.2	27.3	37.1	46.0	55.2	64.3
26							20.6	30.1	41.0	51.3	61.0	71.7
28							21.9	32.5	43.7	55.1	65.5	76.9
30							23.3	35.0	47.2	59.2	70.5	82.5
32							25.1	36.8	49.0	62.7	74.7	87.8
34							28.3	42.0	56.6	71.3	85.8	102.0
36							30	20	10	0	-10	-20
	Ambient Temperature ° F	Ambient Temperature ° C	Ambient Temperature ° F	Ambient Temperature ° C	Ambient Temperature ° F	Ambient Temperature ° C	Ambient Temperature ° F	Ambient Temperature ° C	Ambient Temperature ° F	Ambient Temperature ° C	Ambient Temperature ° F	Ambient Temperature ° C

EXAMPLE: If outdoor line is 50 feet long, one-half of flow listed above is required.
If line is 200 feet, twice the flow listed above is required.

INSULATION THICKNESS REQUIREMENTS

FIRE PROTECTION INSULATION THICKNESSES HIGH TEMPERATURE SERVICE

SERVICE: FIRE PROTECTION AND SAFE SURFACE TEMPERATURE - MASTIC OR JACKETS OF 0.9 EMITTANCE

PLANTS:	ALL PLANTS
SPEC. NO'S:	32-H

NOM PIPE SIZE	OPERATING TEMPERATURE °C																											
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
8	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
10	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
12	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½
14	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
16	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
18	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
20	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
22	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
24	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
26	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
28	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
30	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
36	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
EQUIP FLAT	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
58	104	140	176	212	248	284	320	356	392	428	464	500	536	572	608	644	680	716	752	788	824	860	896	932	968	1004	1040	
103	139	175	211	247	283	319	355	391	427	463	499	535	571	607	643	679	715	751	787	823	859	895	931	967	1003	1039	1075	
OPERATING TEMPERATURE °F																												

NOTE: For temperatures above those listed, use thickness chart for safe surface temperatures - mastics or jackets of 0.9 emittance.



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
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Service Designation

INSULATION THICKNESS REQUIREMENTS

FIRE PROTECTION INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: ALL PLANTS
SPEC. NO'S: 32-H

SERVICE: FIRE PROTECTION AND SAFE SURFACE TEMPERATURE - STAINLESS STEEL JACKETS

NOM PIPE SIZE	OPERATING TEMPERATURE °C																												OPERATING TEMPERATURE °F																											
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	EQUIP PLAT																												
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2		2	2	2																									
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
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1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
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1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
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1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
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1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
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1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
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1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																																							

NOTE: For temperatures above those listed, use thickness chart for safe surface temperatures - stainless steel jackets.



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
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INSULATION THICKNESS REQUIREMENTS

Service Designation PE-4

FIRE PROTECTION INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: WHITING PLANT 517
SPEC. NO'S: 32-H EXPANDED SILICA

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																							
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
8	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
10	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
12	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
14	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
16	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
18	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
20	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
22	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
24	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
26	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
28	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
30	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
36	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
EQUIP FLAT	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

OPERATING TEMPERATURE ° F



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INSULATION THICKNESS REQUIREMENTS

Service Designation PE-10

FIRE PROTECTION INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: BOUND BROOK PLANT - PLASTICS DIVISION
PEC. NO'S: 32-H EXPANDED SILICA
SERVICE: FIRE PROTECTION AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

PIPE SIZE	OPERATING TEMPERATURE °C																												OPERATING TEMPERATURE °F																											
	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420	440	460	480	500	520	540	to	to																											
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	to	to																										
3/4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	to	to																										
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	to	to																										
1 1/4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	to	to																									
1 1/2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	to	to																									
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	to	to																									
2 1/4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	to	to																									
3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	to	to																									
3 1/2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	to	to																									
4	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	to	to																									
5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	to	to																									
5 1/2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	to	to																									
6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	to	to																									
10	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	to	to																									
12	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	to	to																									
14	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	to	to																									
16	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	to	to																									
18	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	to	to																									
20	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	to	to																									
22	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	to	to																									
24	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	to	to																									
26	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	to	to																									
28	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	to	to																									
30	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	to	to																									
36	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	to	to																									
QUIP	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	to	to																									
AT	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	to	to																									
28	104	140	176	212	248	284	320	356	392	428	464	500	536	572	608	644	680	716	752	788	824	860	896	932	968	1004	1040	1076	1112	to	to																									
103	159	175	211	247	283	319	355	391	427	463	499	535	571	607	643	679	715	751	787	823	859	895	931	967	1003	1039	1075	1111	1147	to	to																									



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
PAGE 333
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INSULATION THICKNESS REQUIREMENTS

Service Designation PE-12

FIRE PROTECTION INSULATION THICKNESSES HIGH TEMPERATURE SERVICE

PLANTS: MARIETTA PLANT - PLASTICS DIVISION
SPEC. NO'S: 32-H EXPANDED SILICA
SERVICE: FIRE PROTECTION AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE °C																				
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	
1/4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3/4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1 1/4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1 1/2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2 1/2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3 1/2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2
6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
8	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
10	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
12	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
14	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
16	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
18	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
22	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
24	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
26	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
28	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
30	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
36	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
EQUIP FLAT	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
68	104	140	176	212	248	284	320	356	392	428	464	500	536	572	608	644	680	716	752	788	824
to 103	139	175	211	247	283	319	355	391	427	463	499	535	571	607	643	679	715	751	787	823	859

OPERATING TEMPERATURE °F

INSULATION THICKNESS REQUIREMENTS

**FIRE PROTECTION INSULATION THICKNESSES
LOW TEMPERATURE SERVICE**

PLANTS. ALL PLANTS
SPEC. NO'S: 32-L CELLULAR GLASS - EXPANDED SILICA

SERVICE: INDOORS - AIR CONDITIONED BUILDING (75F-60%R, H.)

NOM. PIPE SIZE	OPERATING TEMPERATURE °C																													
	19	9	4	-1	-6	-11	-16	-21	-26	-31	-36	-41	-46	-51	-56	-61	-66	-71	-76	-81	-86	-91	-96	-101	-106	-111	-116	-121		
1	10	5	0	-5	10	-15	-20	-25	-30	-35	-40	-45	-50	-55	-60	-65	-70	-75	-80	-85	-90	-95	-100	-105	-110	-115	-120	-125		
2	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½		
3	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½		
4	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½		
6	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½		
8	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½		
10	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½		
12	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½		
14	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½		
16	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½		
18	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½		
20	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½		
22	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½		
24	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½		
26	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½		
28	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½		
30	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½		
32	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½		
34	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½		
36	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½		
EQUIP.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3			
FLAT	67	47	40	31	22	13	4	-5	-14	-23	-32	-41	-50	-59	-68	-77	-85	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185		
50	40	30	20	10	0	10	20	30	40	50	60	70	80	90	100	110	120													
50	41	32	23	14	5	-4	-13	-22	-31	-40	-49	-58	-67	-76	-85	-94	-103	-112	-121	-130	-139	-148	-157	-166	-175	-184	-193	-202		
	OPERATING TEMPERATURE °F																													

INSULATION THICKNESS REQUIREMENTS

Service Designation PC-14

FIRE PROTECTION INSULATION THICKNESSES LOW TEMPERATURE SERVICE

PLANTS: MONTREAL 053, NIAGARA FALLS 516 , OTTAWA
SPEC. NO'S: 32-L CELLULAR GLASS - EXPANDED SILICA
SERVICE: FIRE PROTECTION AND LOW TEMPERATURE SERVICE - OUTDOORS

[illegible]



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

INSULATION THICKNESS REQUIREMENTS

Service Designation P-16

SIZES OF INSULATION LAYERS TO OBTAIN SPECIFIED THICKNESS
SPECIFICATION 32L, LOW TEMPERATURE
FIRE PROTECTION

NOM PIPE SIZE	SPECIFIED THICKNESSES											
	2 1/2		3		3 1/2		4		4 1/2		5	
	1st Layer Foamglas	2nd Layer Careytemp	1st Layer Foamglas	2nd Layer Careytemp	1st Layer Foamglas	2nd Layer Careytemp	1st Layer Foamglas	2nd Layer Careytemp	1st Layer Foamglas	2nd Layer Careytemp	1st Layer Foamglas	2nd Layer Careytemp
1	1 1/2 x 1 1/2	3 1/2 x 1	1 1/2 x 2	4 x 1	1 1/2 x 2 1/2	5 x 1	1 x 2 1/2	6 x 1 1/2	1 1/2 x 3	6 x 1 1/2	1 1/2 x 1 1/2	3 1/2 x 2
1 1/2	3/4 x 1 1/2	3 1/2 x 1	3/4 x 2	4 1/2 x 1	3/4 x 2 1/2	5 x 1	1 x 3	6 x 1 1/2	3/4 x 3	6 x 1 1/2	3/4 x 1 1/2	3 1/2 x 2
1	1 x 1 1/2	4 x 1	1 x 2	5 x 1	1 1/2 x 2 1/2	5 x 1	1 1/2 x 2 1/2	6 x 1 1/2	1 x 3	7 x 1 1/2	1 x 1 1/2	4 x 2
1 1/2	1 1/2 x 1 1/2	4 x 1	1 1/2 x 2	5 x 1	1 1/2 x 2 1/2	5 x 1	1 1/2 x 2 1/2	6 x 1 1/2	1 1/2 x 3	7 x 1 1/2	1 1/2 x 1 1/2	4 x 2
2	1 1/2 x 1 1/2	4 1/2 x 1	1 1/2 x 2	5 x 1	1 1/2 x 2 1/2	5 x 1	1 1/2 x 2 1/2	6 x 1 1/2	1 1/2 x 3	7 x 1 1/2	1 1/2 x 1 1/2	4 1/2 x 2
2 1/2	2 x 1 1/2	5 x 1	2 1/2 x 1 1/2	6 x 1 1/2	2 x 2 1/2	6 x 1 1/2	2 1/2 x 2 1/2	7 x 1 1/2	2 x 3	8 x 1 1/2	2 1/2 x 1 1/2	5 x 2
3	3 x 1 1/2	6 x 1 1/2	3 x 1 1/2	6 x 1 1/2	3 x 2	7 x 1 1/2	3 x 2 1/2	8 x 1 1/2	3 x 3	9 x 1 1/2	3 x 1 1/2	6 x 2
3 1/2	3 1/2 x 1 1/2	7 x 1 1/2	3 1/2 x 1 1/2	7 x 1 1/2	3 1/2 x 2	8 x 1 1/2	3 1/2 x 2 1/2	9 x 1 1/2	3 1/2 x 3	10 x 1 1/2	3 1/2 x 1 1/2	7 x 2
4	4 x 1 1/2	7 x 1 1/2	4 x 1 1/2	7 x 1 1/2	4 x 2	8 x 1 1/2	4 x 2 1/2	9 x 1 1/2	4 x 3	10 x 1 1/2	4 x 1 1/2	7 x 2
6	6 x 1 1/2	9 x 1 1/2	6 x 1 1/2	10 x 1 1/2	6 x 2	10 x 1 1/2	6 x 2 1/2	11 x 1 1/2	6 x 3	12 x 1 1/2	6 x 1 1/2	9 x 2
8	8 x 1 1/2	11 x 1 1/2	8 x 1 1/2	12 x 1 1/2	8 x 2	12 x 1 1/2	8 x 2 1/2	14 x 1 1/2	8 x 3	15 x 1 1/2	8 x 1 1/2	11 x 2
10	10 x 1 1/2	14 x 1 1/2	10 x 2	15 x 1 1/2	10 x 2	15 x 1 1/2	10 x 2 1/2	16 x 1 1/2	10 x 3	17 x 1 1/2	10 x 1 1/2	14 x 2
12	12 x 1 1/2	16 x 1 1/2	12 x 2	17 x 1 1/2	12 x 2	17 x 1 1/2	12 x 2 1/2	18 x 1 1/2	12 x 3	19 x 1 1/2	12 x 1 1/2	16 x 2
14	14 x 1 1/2	17 x 1 1/2	14 x 2	18 x 1 1/2	14 x 2	18 x 1 1/2	14 x 2 1/2	19 x 1 1/2	14 x 3	20 x 1 1/2	14 x 1 1/2	17 x 2
16	16 x 1 1/2	19 x 1 1/2	16 x 2	20 x 1 1/2	16 x 2	20 x 1 1/2	16 x 2 1/2	21 x 1 1/2	16 x 3	22 x 1 1/2	16 x 1 1/2	19 x 2
18	18 x 1 1/2	21 x 1 1/2	18 x 2	22 x 1 1/2	18 x 2	22 x 1 1/2	18 x 2 1/2	23 x 1 1/2	18 x 3	24 x 1 1/2	18 x 1 1/2	21 x 2
20	20 x 1 1/2	23 x 1 1/2	20 x 2	24 x 1 1/2	20 x 2	24 x 1 1/2	20 x 2 1/2	25 x 1 1/2	20 x 3	26 x 1 1/2	20 x 1 1/2	23 x 2
22	22 x 1 1/2	25 x 1 1/2	22 x 2	26 x 1 1/2	22 x 2	26 x 1 1/2	22 x 2 1/2	27 x 1 1/2	22 x 3	28 x 1 1/2	22 x 1 1/2	25 x 2
24	24 x 1 1/2	27 x 1 1/2	24 x 2	28 x 1 1/2	24 x 2	28 x 1 1/2	24 x 2 1/2	29 x 1 1/2	24 x 3	30 x 1 1/2	24 x 1 1/2	27 x 2
26	26 x 1 1/2	29 x 1 1/2	26 x 2	30 x 1 1/2	26 x 2	30 x 1 1/2	26 x 2 1/2	31 x 1 1/2	26 x 3	32 x 1 1/2	26 x 1 1/2	29 x 2
28	28 x 1 1/2	31 x 1 1/2	28 x 2	32 x 1 1/2	28 x 2	32 x 1 1/2	28 x 2 1/2	33 x 1 1/2	28 x 3	34 x 1 1/2	28 x 1 1/2	31 x 2
30	30 x 1 1/2	33 x 1 1/2	30 x 2	34 x 1 1/2	30 x 2	34 x 1 1/2	30 x 2 1/2	35 x 1 1/2	30 x 3	36 x 1 1/2	30 x 1 1/2	33 x 2
36	36 x 1 1/2	39 x 1 1/2	36 x 2	40 x 1 1/2	36 x 2	40 x 1 1/2	36 x 2 1/2	39 x 1 1/2	36 x 3	42 x 1 1/2	36 x 1 1/2	39 x 2
EQUIP FLAT	1 1/2	1 1/2	2	1 1/2	2 1/2	1 1/2	2 1/2	1 1/2	3	1 1/2	1 1/2	2

NOTE: The above tables are provided to show the multiple layers required for fire protection of low temperature insulated pipe.

EXAMPLE: When total thickness of 4" thickness on a 3" NPS was required, the inner layer cellular glass would be 3" NPS pipe size 2 1/2" thick. The outer layer Careytemp would be 8" NPS pipe size 1 1/2" thick.



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INSULATION THICKNESS REQUIREMENTS

Service Designation P-17

SIZES OF INSULATION LAYERS TO OBTAIN SPECIFIED THICKNESS
SPECIFICATION 32-L LOW TEMPERATURE
FIRE PROTECTION

NOM. PIPE SIZE	SPECIFIED THICKNESSES											
	5 $\frac{1}{2}$			6			6 $\frac{1}{2}$			7		
	1st Layer Foamglas	2nd Layer Foamglas	3rd Layer Careytemp	1st Layer Foamglas	2nd Layer Foamglas	3rd Layer Careytemp	1st Layer Foamglas	2nd Layer Foamglas	3rd Layer Careytemp	1st Layer Foamglas	2nd Layer Foamglas	3rd Layer Careytemp
1	1 $\frac{1}{2}$ x 2	4 x 2	8 x 1 $\frac{1}{2}$	1 $\frac{1}{2}$ x 2	4 x 2 $\frac{1}{2}$	9 x 1 $\frac{1}{2}$	1 $\frac{1}{2}$ x 2 $\frac{1}{2}$	5 x 2 $\frac{1}{2}$	10 x 1 $\frac{1}{2}$	1 $\frac{1}{2}$ x 2 $\frac{1}{2}$	5 x 3	11 x 1 $\frac{1}{2}$
2	3/4 x 2	4 $\frac{1}{2}$ x 2	9 x 1 $\frac{1}{2}$	3/4 x 2	4 $\frac{1}{2}$ x 2 $\frac{1}{2}$	10 x 1 $\frac{1}{2}$	3/4 x 2 $\frac{1}{2}$	5 x 2 $\frac{1}{2}$	10 x 1 $\frac{1}{2}$	3/4 x 3	5 x 3	11 x 1 $\frac{1}{2}$
3	1 x 2	5 x 2	9 x 1 $\frac{1}{2}$	1 x 2	5 x 2 $\frac{1}{2}$	10 x 1 $\frac{1}{2}$	1 x 2 $\frac{1}{2}$	6 x 2 $\frac{1}{2}$	11 x 1 $\frac{1}{2}$	1 x 3	6 x 3	12 x 1 $\frac{1}{2}$
4	1 $\frac{1}{2}$ x 2	5 x 2	9 x 1 $\frac{1}{2}$	1 $\frac{1}{2}$ x 2	5 x 2 $\frac{1}{2}$	10 x 1 $\frac{1}{2}$	1 $\frac{1}{2}$ x 2 $\frac{1}{2}$	6 x 2 $\frac{1}{2}$	11 x 1 $\frac{1}{2}$	1 $\frac{1}{2}$ x 3	7 x 3	14 x 1 $\frac{1}{2}$
6	1 $\frac{1}{2}$ x 2	5 x 2	9 x 1 $\frac{1}{2}$	1 $\frac{1}{2}$ x 2	5 x 2 $\frac{1}{2}$	10 x 1 $\frac{1}{2}$	1 $\frac{1}{2}$ x 2 $\frac{1}{2}$	6 x 2 $\frac{1}{2}$	11 x 1 $\frac{1}{2}$	1 $\frac{1}{2}$ x 3	7 x 3	14 x 1 $\frac{1}{2}$
8	2 x 2	6 x 2	10 x 1 $\frac{1}{2}$	2 x 2	6 x 2 $\frac{1}{2}$	11 x 1 $\frac{1}{2}$	2 x 2 $\frac{1}{2}$	7 x 2 $\frac{1}{2}$	12 x 1 $\frac{1}{2}$	2 x 3	8 x 3	15 x 1 $\frac{1}{2}$
10	2 $\frac{1}{2}$ x 2	6 x 2	10 x 1 $\frac{1}{2}$	2 $\frac{1}{2}$ x 2	6 x 2 $\frac{1}{2}$	11 x 1 $\frac{1}{2}$	2 $\frac{1}{2}$ x 2 $\frac{1}{2}$	7 x 2 $\frac{1}{2}$	12 x 1 $\frac{1}{2}$	2 $\frac{1}{2}$ x 3	8 x 3	15 x 1 $\frac{1}{2}$
12	3 x 2	7 x 2	11 x 1 $\frac{1}{2}$	3 x 2	7 x 2 $\frac{1}{2}$	12 x 1 $\frac{1}{2}$	3 x 2 $\frac{1}{2}$	8 x 2 $\frac{1}{2}$	14 x 1 $\frac{1}{2}$	3 x 3	9 x 3	16 x 1 $\frac{1}{2}$
14	3 $\frac{1}{2}$ x 2	8 x 2	12 x 1 $\frac{1}{2}$	3 $\frac{1}{2}$ x 2	8 x 2 $\frac{1}{2}$	14 x 1 $\frac{1}{2}$	3 $\frac{1}{2}$ x 2 $\frac{1}{2}$	9 x 2 $\frac{1}{2}$	15 x 1 $\frac{1}{2}$	3 $\frac{1}{2}$ x 3	10 x 3	17 x 1 $\frac{1}{2}$
16	4 x 2	8 x 2	12 x 1 $\frac{1}{2}$	4 x 2	8 x 2 $\frac{1}{2}$	14 x 1 $\frac{1}{2}$	4 x 2 $\frac{1}{2}$	9 x 2 $\frac{1}{2}$	15 x 1 $\frac{1}{2}$	4 x 3	10 x 3	17 x 1 $\frac{1}{2}$
18	6 x 2	10 x 2	15 x 1 $\frac{1}{2}$	6 x 2	10 x 2 $\frac{1}{2}$	16 x 1 $\frac{1}{2}$	6 x 2 $\frac{1}{2}$	11 x 2 $\frac{1}{2}$	17 x 1 $\frac{1}{2}$	6 x 3	12 x 3	19 x 1 $\frac{1}{2}$
20	8 x 2	12 x 2	17 x 1 $\frac{1}{2}$	8 x 2	12 x 2 $\frac{1}{2}$	18 x 1 $\frac{1}{2}$	8 x 2 $\frac{1}{2}$	14 x 2 $\frac{1}{2}$	19 x 1 $\frac{1}{2}$	8 x 3	15 x 3	21 x 1 $\frac{1}{2}$
22	10 x 2	15 x 2	19 x 1 $\frac{1}{2}$	10 x 2	15 x 2 $\frac{1}{2}$	20 x 1 $\frac{1}{2}$	10 x 2 $\frac{1}{2}$	16 x 2 $\frac{1}{2}$	21 x 1 $\frac{1}{2}$	10 x 3	17 x 3	23 x 1 $\frac{1}{2}$
24	12 x 2	17 x 2	21 x 1 $\frac{1}{2}$	12 x 2	17 x 2 $\frac{1}{2}$	22 x 1 $\frac{1}{2}$	12 x 2 $\frac{1}{2}$	18 x 2 $\frac{1}{2}$	23 x 1 $\frac{1}{2}$	12 x 3	19 x 3	25 x 1 $\frac{1}{2}$
26	14 x 2	18 x 2	22 x 1 $\frac{1}{2}$	14 x 2	18 x 2 $\frac{1}{2}$	23 x 1 $\frac{1}{2}$	14 x 2 $\frac{1}{2}$	19 x 2 $\frac{1}{2}$	24 x 1 $\frac{1}{2}$	14 x 3	20 x 3	26 x 1 $\frac{1}{2}$
28	16 x 2	20 x 2	24 x 1 $\frac{1}{2}$	16 x 2	20 x 2 $\frac{1}{2}$	25 x 1 $\frac{1}{2}$	16 x 2 $\frac{1}{2}$	21 x 2 $\frac{1}{2}$	26 x 1 $\frac{1}{2}$	16 x 3	22 x 3	28 x 1 $\frac{1}{2}$
30	18 x 2	22 x 2	26 x 1 $\frac{1}{2}$	18 x 2	22 x 2 $\frac{1}{2}$	27 x 1 $\frac{1}{2}$	18 x 2 $\frac{1}{2}$	23 x 2 $\frac{1}{2}$	28 x 1 $\frac{1}{2}$	18 x 3	24 x 3	30 x 1 $\frac{1}{2}$
32	20 x 2	24 x 2	28 x 1 $\frac{1}{2}$	20 x 2	24 x 2 $\frac{1}{2}$	29 x 1 $\frac{1}{2}$	20 x 2 $\frac{1}{2}$	25 x 2 $\frac{1}{2}$	30 x 1 $\frac{1}{2}$	20 x 3	26 x 3	32 x 1 $\frac{1}{2}$
34	22 x 2	26 x 2	30 x 1 $\frac{1}{2}$	22 x 2	26 x 2 $\frac{1}{2}$	31 x 1 $\frac{1}{2}$	22 x 2 $\frac{1}{2}$	27 x 2 $\frac{1}{2}$	32 x 1 $\frac{1}{2}$	22 x 3	28 x 3	34 x 1 $\frac{1}{2}$
36	24 x 2	28 x 2	32 x 1 $\frac{1}{2}$	24 x 2	28 x 2 $\frac{1}{2}$	33 x 1 $\frac{1}{2}$	24 x 2 $\frac{1}{2}$	29 x 2 $\frac{1}{2}$	34 x 1 $\frac{1}{2}$	24 x 3	30 x 3	36 x 1 $\frac{1}{2}$
38	26 x 2	30 x 2	34 x 1 $\frac{1}{2}$	26 x 2	30 x 2 $\frac{1}{2}$	35 x 1 $\frac{1}{2}$	26 x 2 $\frac{1}{2}$	31 x 2 $\frac{1}{2}$	36 x 1 $\frac{1}{2}$	26 x 3	32 x 3	38 x 1 $\frac{1}{2}$
40	28 x 2	32 x 2	36 x 1 $\frac{1}{2}$	28 x 2	32 x 2 $\frac{1}{2}$	37 x 1 $\frac{1}{2}$	28 x 2 $\frac{1}{2}$	33 x 2 $\frac{1}{2}$	38 x 1 $\frac{1}{2}$	28 x 3	34 x 3	40 x 1 $\frac{1}{2}$
42	30 x 2	34 x 2	38 x 1 $\frac{1}{2}$	30 x 2	34 x 2 $\frac{1}{2}$	41 x 1 $\frac{1}{2}$	30 x 2 $\frac{1}{2}$	35 x 2 $\frac{1}{2}$	40 x 1 $\frac{1}{2}$	30 x 3	36 x 3	42 x 1 $\frac{1}{2}$
44	36 x 2	40 x 2	44 x 1 $\frac{1}{2}$	36 x 2	40 x 2 $\frac{1}{2}$	45 x 1 $\frac{1}{2}$	36 x 2 $\frac{1}{2}$	41 x 2 $\frac{1}{2}$	46 x 1 $\frac{1}{2}$	36 x 3	42 x 3	48 x 1 $\frac{1}{2}$
EQUIP. FLAT 2	2	2	1 $\frac{1}{2}$	2 $\frac{1}{2}$	2 $\frac{1}{2}$	1 $\frac{1}{2}$	2 $\frac{1}{2}$	2 $\frac{1}{2}$	1 $\frac{1}{2}$	3	3	1 $\frac{1}{2}$



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INSULATION THICKNESS REQUIREMENTS

Service Designation P-18

SIZES OF INSULATION LAYERS TO OBTAIN SPECIFIED THICKNESS
SPECIFICATION 32-L, LOW TEMPERATURE
FIRE PROTECTION

NOM PIPE SIZE	SPECIFIED THICKNESSES											
	8			8½			9			9½		
	1st Layer Foamglas	2nd Layer Foamglas	3rd Layer Careytemp	1st Layer Foamglas	2nd Layer Foamglas	3rd Layer Careytemp	1st Layer Foamglas	2nd Layer Foamglas	3rd Layer Careytemp	1st Layer Foamglas	2nd Layer Foamglas	3rd Layer Careytemp
1	1 x 3	6 x 3½	14 x 1½	1 x 3½	7 x 3½	15 x 1½	1 x 3½	7 x 4	16 x 1½	1 x 4	9 x 4	18 x 1½
3/4	3/4 x 3	6 x 3½	14 x 1½	3/4 x 3½	8 x 3½	16 x 1½	3/4 x 3½	8 x 4	17 x 1½	3/4 x 4	9 x 4	18 x 1½
1	1 x 3	7 x 3½	15 x 1½	1 x 3½	8 x 3½	16 x 1½	1 x 3½	8 x 4	17 x 1½	1 x 4	9 x 4	18 x 1½
1½	1½ x 3	7 x 3½	15 x 1½	1½ x 3½	8 x 3½	16 x 1½	1½ x 3½	8 x 4	17 x 1½	1½ x 4	9 x 4	18 x 1½
1½	1½ x 3	7 x 3½	15 x 1½	1½ x 3½	8 x 3½	16 x 1½	1½ x 3½	8 x 4	17 x 1½	1½ x 4	9 x 4	18 x 1½
2	2 x 3	8 x 3½	16 x 1½	2 x 3½	9 x 3½	17 x 1½	2 x 3½	9 x 4	18 x 1½	2 x 4	10 x 4	19 x 1½
2½	2½ x 3	8 x 3½	16 x 1½	2½ x 3½	9 x 3½	17 x 1½	2½ x 3½	9 x 4	18 x 1½	2½ x 4	10 x 4	19 x 1½
3	3 x 3	9 x 3½	17 x 1½	3 x 3½	10 x 3½	18 x 1½	3 x 3½	10 x 4	19 x 1½	3 x 4	11 x 4	20 x 1½
3½	3½ x 3	10 x 3½	18 x 1½	3½ x 3½	11 x 3½	19 x 1½	3½ x 3½	11 x 4	20 x 1½	3½ x 4	12 x 4	21 x 1½
4	4 x 3	10 x 3½	18 x 1½	4 x 3½	11 x 3½	19 x 1½	4 x 3½	11 x 4	20 x 1½	4 x 4	12 x 4	21 x 1½
6	6 x 3	12 x 3½	20 x 1½	6 x 3½	14 x 3½	21 x 1½	6 x 3½	14 x 4	22 x 1½	6 x 4	15 x 4	23 x 1½
8	8 x 3	15 x 3½	22 x 1½	8 x 3½	16 x 3½	23 x 1½	8 x 3½	16 x 4	24 x 1½	8 x 4	17 x 4	25 x 1½
10	10 x 3	17 x 3½	24 x 1½	10 x 3½	18 x 3½	25 x 1½	10 x 3½	18 x 4	26 x 1½	10 x 4	19 x 4	27 x 1½
12	12 x 3	19 x 3½	26 x 1½	12 x 3½	20 x 3½	27 x 1½	12 x 3½	20 x 4	28 x 1½	12 x 4	21 x 4	29 x 1½
14	14 x 3	20 x 3½	27 x 1½	14 x 3½	21 x 3½	28 x 1½	14 x 3½	21 x 4	29 x 1½	14 x 4	22 x 4	30 x 1½
16	16 x 3	22 x 3½	29 x 1½	16 x 3½	23 x 3½	30 x 1½	16 x 3½	23 x 4	31 x 1½	16 x 4	24 x 4	32 x 1½
18	18 x 3	24 x 3½	31 x 1½	18 x 3½	25 x 3½	32 x 1½	18 x 3½	25 x 4	33 x 1½	18 x 4	26 x 4	34 x 1½
20	20 x 3	26 x 3½	33 x 1½	20 x 3½	27 x 3½	34 x 1½	20 x 3½	27 x 4	35 x 1½	20 x 4	28 x 4	36 x 1½
22	22 x 3	28 x 3½	35 x 1½	22 x 3½	29 x 3½	36 x 1½	22 x 3½	29 x 4	37 x 1½	22 x 4	30 x 4	38 x 1½
24	24 x 3	30 x 3½	37 x 1½	24 x 3½	31 x 3½	38 x 1½	24 x 3½	31 x 4	39 x 1½	24 x 4	32 x 4	40 x 1½
26	26 x 3	32 x 3½	39 x 1½	26 x 3½	33 x 3½	40 x 1½	26 x 3½	33 x 4	41 x 1½	26 x 4	34 x 4	42 x 1½
28	28 x 3	34 x 3½	41 x 1½	28 x 3½	35 x 3½	42 x 1½	28 x 3½	35 x 4	43 x 1½	28 x 4	36 x 4	44 x 1½
30	30 x 3	36 x 3½	43 x 1½	30 x 3½	37 x 3½	44 x 1½	30 x 3½	37 x 4	45 x 1½	30 x 4	38 x 4	46 x 1½
36	36 x 3	42 x 3½	49 x 1½	36 x 3½	43 x 3½	50 x 1½	36 x 3½	43 x 4	51 x 1½	36 x 4	44 x 4	52 x 1½
EQUIP FLAT	3	3½	1½	3½	3½	1½	3½	4	1½	4	4	1½

INSULATION THICKNESS REQUIREMENTS

Service Designation R-1

REFLECTIVE INSULATION THICKNESSES
1/2 INCH SPACING

SEADRIFT-510, INSTITUTE-512, TORRANCE-513, S. CHARLESTON-514, TAFT-519, BROWNSVILLE-526, BOUND BROCK, MARIETTA, CARTERSVILLE, PONCE
PLANTS:
SPEC. NO'S: 31-H
SERVICE PROCESS: NON-ABSORBANT INSULATION REQUIRED

[illegible]

INSULATION THICKNESS REQUIREMENTS

Service Designation R-2

REFLECTIVE INSULATION THICKNESSES
3/8 INCH SPACING

PLANTS: WHITING-517, MONTREAL-053, OTTAWA
SPEC. NO'S: 31-H

SERVICE PROCESS: NON-ABSORBANT INSULATION REQUIRED

OPERATING TEMPERATURE °C

[illegible]

INSULATION THICKNESS REQUIREMENTS

Service Designation S-1

SAFETY INSULATION THICKNESSES

OUTER COVERING: MASTIC OR JACKET WITH EMISSIVITY 0.9

PLANTS: ALL PLANTS
SPEC. NO'S: 21-H, 22-H, 23-H, 25-H

[illegible]

INSULATION THICKNESS REQUIREMENTS

SAFETY INSULATION THICKNESSES

PLANTS: ALL PLANTS
SPEC. NO'S: 21-H, 22-H, 23-H, 25-H
OUTER COVERING: MASTIC OR JACKET
WITH EMISSIVITY 0.90

NOM PIPE SIZE		OPERATING TEMPERATURE ° C													
		600 to 619	620 to 639	640 to 659	660 to 679	680 to 699	700 to 719	720 to 739	740 to 759	760 to 779	780 to 799	800 to 819	820 to 839	840 to 859	860
1	1	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½
2	1	2	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	3
3	1½	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3	3
4	2	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3	3½
5	2	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3	3½
6	2	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3	3½
8	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4
10	3½	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4
12	4	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4
14	6	3	3	3½	3½	3½	3½	3½	3½	4	4	4	4	4½	4½
16	8	3	3	3½	3½	3½	3½	4	4	4	4	4½	4½	4½	4½
18	10	3	3½	3½	3½	3½	4	4	4	4	4½	4½	4½	5	5
20	12	3½	3½	3½	3½	4	4	4	4	4½	4½	4½	5	5	5
22	14	3½	3½	3½	4	4	4	4	4	4½	4½	5	5	5	5½
24	16	3½	3½	4	4	4	4	4	4	4½	5	5	5	5½	5½
26	18	3½	3½	4	4	4	4	4	4	4½	5	5	5	5½	5½
28	20	3½	3½	4	4	4	4	4	4	4½	5	5	5	5½	5½
30	22	3½	3½	4	4	4	4	4	4	4½	5	5	5	5½	5½
36	24	3½	4	4	4	4	4	4	4	4½	5	5	5	5½	6
36	26	3½	4	4	4	4	4	4	4	4½	5	5	5	5½	6
36	28	3½	4	4	4	4	4	4	4	4½	5	5	5	5½	6
36	30	3½	4	4	4	4	4	4	4	4½	5	5	5	5½	6
36	36	3½	4	4	4	4	4	4	4	4½	5	5	5	5½	6
EQUIP FLAT		4	4	4½	4½	5	5	5	5	5½	6	6	6½	6½	6½
		1112	1148	1184	1220	1256	1292	1328	1364	1400	1436	1472	1508	1544	1580
		to	to	to	to	to	to	to	to	to	to	to	to	to	to
		1147	1183	1219	1255	1291	1327	1363	1399	1435	1471	1507	1543	1579	1616
OPERATING TEMPERATURE ° F															

INSULATION THICKNESS REQUIREMENTS

Service Designation S-3

SAFETY INSULATION THICKNESSES

OUTER COVERING: STAINLESS STEEL JACKET EMISSIVITY 0.40

PLANTS: ALL PLANTS
SPEC. NO's: 21-H, 22-H, 23-H, 25-H

[illegible]



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INSULATION THICKNESS REQUIREMENTS

Service Designation T-1

SPACED STEAM TRACER SYSTEM AND DEFINITION OF SYMBOLS - Continued

DEFINITIONS OF SYMBOLS

T_1 = Minimum temperature ($^{\circ}\text{F}$) that the tracer will maintain in the process line, based on an ambient temperature of -20°F . The calculations are based on static conditions, i. e., no fluid flow, and are independent of the viscosity, density, and thermal conductivity of the process fluid.

T_2 = Same as T_1 except based on an ambient temperature of 30°F .

T_3 = Same as T_1 except based on an ambient temperature of 50°F .

Approximate process line temperatures for other ambient temperatures may be determined by interpolation or extrapolation based on temperatures T_1 and T_3 . If the upper temperature limit of the process line is critical, the effect of solar radiation should be investigated, since it was not considered in calculating the temperatures given in the table.

L_1 = Maximum length (feet) of straight run of tracer, based on an ambient temperature of -20°F . It is applicable at all plant locations except 513 and 526.

L_2 = Same as L_1 , except based on an ambient temperature of 30°F . It is applicable at Plant Locations 513 and 526.

L_1 and L_2 represent total lengths of tracers, including all branches, and apply to straight runs only. In utilizing them in actual tracer layouts, the following limitations and requirements shall be considered:

1. Lengths shall be reduced as necessary to compensate for friction losses caused by bends, tees, valves, and other constrictions.
2. In general, all low points and pockets in tracers shall be trapped. However, under certain conditions, installation of traps at these points may be impracticable. If so, the length of the tracer shall be reduced sufficiently to offset pressure drop caused by the condensate head.
3. Steam tracer feed lines shall be sized properly so that pressure drop will not require a reduction in the tracer length.
4. Traps shall be installed at the ends of all tracers, including ends of all branches, and at all other condensate removal points.



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Service Designation T-1

SPACED STEAM TRACER SYSTEM AND DEFINITION OF SYMBOLS

NOTE:

The tabulated data on this Standard applies to steam tracing systems in which the tracer is separated from the process line by spacers, using air as the heat-conductive medium, as detailed and specified on Standard P-140. Insulation sizes and assembly dimensions are given on Standard P-140A.

This Standard provides steam tracing data based on static conditions only. Information compiled is based on heat loss from the insulation and does not provide for addition of any heat to the material in the process line.

Data in these tables can be used for selection of tracers and insulation thickness under two general conditions, as follows:

1. Where temperature to be maintained in the process line determines selection of insulation thickness, tracer size and steam pressure.

When temperature to be maintained completely determines selection, the most economical selection of insulation thickness and tracer size is above the heavy line. Where temperature requirements permit, combinations above the heavy line should be used. Where temperature requirements dictate combinations below the heavy line, and a choice is possible, it is more economical to use the larger size tracer than to increase the insulation thickness.

2. Where operating temperature determines insulation thickness, and temperature to be maintained during down time determines selection of tracer size and steam pressure.

When operating temperature dictates the insulation thickness, this thickness may be greater than necessary for most economical selection of insulation thickness and tracer size. However, under these conditions the applicable tracer data can be obtained from the table, based on the predetermined insulation thickness and temperature to be maintained during down time.

Under either condition, the final selection of tracer size, i. e. , 3/8 inch or 5/8 inch, may be influenced by physical requirements as to length of tracer that can be run between traps.



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INSULATION THICKNESS REQUIREMENTS

Service Designation T-2

STEAM TRACING DATA SPACED TRACER SYSTEM

			15 psig (250 F) STEAM																			
INSULATION THICKNESS	TRACER SIZE (OD)	SEE NOTE 1 BELOW	PROCESS LINE NOMINAL PIPE SIZE (APPLICABLE OD SIZES LISTED UNDER NOMINAL IPS)																			
			3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	
			1/2 OD 3/4 OD 1 OD	1/2 OD 3/4 OD 1 OD	1/2 OD 3/4 OD 1 OD	1/2 OD 3/4 OD 1 OD	1/2 OD 3/4 OD 1 OD	1/2 OD 3/4 OD 1 OD	1/2 OD 3/4 OD 1 OD	1/2 OD 3/4 OD 1 OD	1/2 OD 3/4 OD 1 OD	1/2 OD 3/4 OD 1 OD	1/2 OD 3/4 OD 1 OD	1/2 OD 3/4 OD 1 OD	1/2 OD 3/4 OD 1 OD	1/2 OD 3/4 OD 1 OD	1/2 OD 3/4 OD 1 OD	1/2 OD 3/4 OD 1 OD	1/2 OD 3/4 OD 1 OD	1/2 OD 3/4 OD 1 OD	1/2 OD 3/4 OD 1 OD	1/2 OD 3/4 OD 1 OD
1	3/8	T ₁	90	90	100	90	90	82	72	73	61	51										
		L ₁	81	81	84	81	81	78	75	76	72	70										
		T ₂	120	120	128	120	120	113	105	106	96	88										
	L ₂	93	93	97	93	93	90	86	87	83	80											
	T ₃	132	132	139	132	132	125	118	119	110	103											
	5/8	T ₁	125	125	134	125	116	112	105	107	93	81										
L ₁		198	198	209	198	189	185	179	181	170	162											
T ₂		148	148	156	148	140	137	132	133	122	112											
L ₂	227	227	239	227	216	212	206	207	195	185												
T ₃	157	157	164	157	150	147	142	144	134	125												
1 1/2	3/8	T ₁	103	103	111	103	103	100	85	84	74	64	50	41	34	26	23	19	16	13	9	
		L ₁	86	86	89	86	86	84	79	79	76	73	70	67	66	64	64	63	63	62	61	
		T ₂	130	130	137	130	130	128	116	115	106	98	87	79	74	67	65	62	59	57	53	
	L ₂	98	98	102	98	98	97	91	91	87	84	80	77	76	74	73	73	72	71	70		
	T ₃	141	141	147	141	141	139	128	127	119	112	102	95	90	84	82	79	77	74	71		
	5/8	T ₁	137	137	145	137	134	131	119	118	107	96	80	68	60	48	45	40	35	31	25	
L ₁		212	212	223	212	209	205	192	191	181	172	161	154	149	144	142	140	138	137	134		
T ₂		158	158	165	158	156	153	143	143	133	124	111	102	95	86	83	79	75	72	66		
L ₂	243	243	256	243	239	235	220	219	208	197	185	177	171	165	163	160	158	157	154			
T ₃	166	166	172	166	164	162	153	152	144	135	124	115	109	101	98	94	91	88	83			
2	3/8	T ₁	112	112	124	112	112	108	95	93	84	74	60	52	42	34	31	27	23	20	15	
		L ₁	89	89	95	89	89	88	83	82	79	76	72	70	68	66	65	65	64	63	62	
		T ₂	138	138	147	138	139	134	124	122	114	106	95	88	81	74	72	68	63	62	58	
	L ₂	102	102	109	102	102	100	95	94	90	87	83	80	78	76	75	74	73	73	72		
	T ₃	148	148	157	148	148	145	135	134	127	119	109	103	96	90	88	84	82	79	76		
	5/8	T ₁	146	146	157	146	142	140	129	127	118	107	91	82	70	59	56	50	45	41	33	
L ₁		224	224	242	224	219	215	203	201	191	181	169	162	155	149	147	144	142	141	138		
T ₂		165	165	174	165	162	160	151	150	142	133	121	113	103	94	92	87	83	79	73		
L ₂	257	257	277	257	251	247	232	230	219	207	193	186	178	171	169	166	163	162	158			
T ₃	173	173	181	173	170	168	160	159	152	144	132	125	117	108	106	102	98	95	89			
2 1/2	3/8	T ₁	119	119	130	119	119	113	103	100	92	83	68	59	50	41	38	33	29	26	20	
		L ₁	92	92	98	92	92	90	85	81	78	74	72	70	68	67	66	65	64	63		
		T ₂	143	143	152	143	143	140	130	128	121	114	101	94	87	79	77	73	70	67	63	
	L ₂	106	106	112	106	106	104	96	97	93	90	85	82	80	77	77	76	75	74	73		
	T ₃	153	153	161	153	153	150	141	139	133	126	115	109	102	95	93	89	86	84	80		
	5/8	T ₁	152	152	162	152	148	146	137	135	126	117	100	91	79	68	65	59	53	49	41	
L ₁		234	234	251	234	228	224	212	209	199	190	176	168	161	154	152	149	146	145	141		
T ₂		170	170	178	170	167	165	158	156	149	141	128	120	111	102	99	94	90	86	80		
L ₂	268	268	286	268	261	257	243	240	228	217	201	193	184	177	174	171	168	166	162			
T ₃	178	178	185	178	175	173	166	164	158	151	139	132	123	115	113	108	104	101	95			
3	3/8	T ₁	124	124	134	124	124	120	109	107	99	89	76	66	56	47	44	39	35	31	25	
		L ₁	95	95	101	95	95	93	88	87	84	81	76	74	71	69	68	67	66	66	64	
		T ₂	148	148	156	148	148	144	135	133	127	119	108	100	92	85	82	78	75	72	67	
	L ₂	109	109	115	109	109	107	101	100	96	93	88	84	82	79	78	77	76	75	74		
	T ₃	157	157	164	157	157	153	145	144	138	131	121	113	106	100	98	94	91	88	83		
	5/8	T ₁	157	157	166	157	153	151	143	141	133	124	110	98	87	76	73	66	61	56	48	
L ₁		242	242	259	242	235	232	220	217	207	197	183	174	166	159	157	153	150	148	144		
T ₂		175	175	182	175	171	169	163	161	155	147	136	126	117	108	105	100	96	92	85		
L ₂	275	278	297	278	270	266	252	249	238	225	210	199	190	182	180	175	172	170	166			
T ₃	181	181	188	181	179	177	171	169	163	156	146	137	129	121	118	114	110	106	100			



STANDARD

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SECTION III
INSULATION DESIGN

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-3

STEAM TRACING DATA
SPACED TRACER SYSTEM

			25 psig (267 F) STEAM																			
INSULATION THICKNESS	TRACER SIZE (OD)	SEE NOTE 1 BELOW	PROCESS LINE NOMINAL PIPE SIZE (APPLICABLE OD SIZES LISTED UNDER NOMINAL IPS)																			
			3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	
			1/2 OD 3/4 OF	1/2 OD 3/4 OF	1 OD 1 1/4 OF	1 OD 1 1/4 OF	1 1/4 OD 2 OF	1 1/2 OD 2 OF	2 OD 2 1/4 OF	2 1/2 OD 3 OF	3 OD 3 1/2 OF	4 OD 4 1/2 OF	6 OD 6 1/2 OF	8 OD 8 1/2 OF	10 OD 10 1/2 OF	12 OD 12 1/2 OF						
1	3/8	T ₁	97	97	108	97	97	88	78	79	67	56										
		L ₁	101	101	105	101	101	97	94	94	90	87										
		T ₂	127	127	135	127	127	119	111	112	101	92										
	5/8	L ₂	115	115	120	115	115	111	107	107	103	99										
		T ₃	139	139	146	139	139	132	124	125	115	107										
		L ₃	134	134	144	134	124	120	113	115	100	87										
1 1/2	3/8	L ₁	244	244	258	244	233	228	221	223	210	200										
		T ₂	157	157	165	157	149	146	140	141	129	119										
		L ₂	277	277	293	277	265	259	251	253	238	227										
	5/8	T ₃	166	166	174	166	159	156	150	152	141	131										
		L ₁	111	111	120	111	111	108	92	91	80	69	55	44	38	28	26	22	18	15	11	
		L ₁	107	107	111	107	107	105	99	98	94	91	87	84	82	80	80	79	78	77	76	
2	3/8	T ₂	138	138	145	138	138	135	122	122	112	103	92	83	77	70	68	64	62	59	55	
		L ₂	121	121	126	121	121	120	112	112	107	103	99	96	94	91	91	90	89	88	87	
		T ₃	149	149	156	149	149	146	135	134	125	117	106	99	93	87	85	81	79	77	73	
	5/8	T ₁	147	147	156	147	144	141	128	127	115	103	86	74	65	53	49	44	39	35	25	
		L ₁	262	262	275	262	258	253	237	236	223	212	199	190	184	177	176	173	170	171	167	
		T ₂	168	168	175	166	166	163	152	151	141	131	118	107	100	90	87	82	78	75	69	
2 1/2	3/8	L ₂	298	298	313	298	293	289	270	268	254	241	226	216	210	202	200	196	193	194	190	
		T ₃	176	176	183	176	174	172	162	161	152	143	130	121	114	105	102	98	94	91	86	
		L ₁	120	120	133	120	120	116	102	100	90	80	65	56	46	37	34	30	26	22	17	
	5/8	L ₁	111	111	119	111	111	109	103	102	98	94	90	87	85	82	82	81	80	79	78	
		T ₂	146	146	156	146	146	142	131	129	121	112	100	93	85	77	75	71	68	65	60	
		L ₂	127	127	135	127	127	124	117	116	112	107	102	99	96	94	93	92	91	90	88	
3	3/8	T ₃	156	156	166	156	156	153	142	141	133	125	114	108	100	93	91	87	84	82	75	
		L ₁	157	157	168	157	152	150	139	137	126	115	98	88	76	64	61	54	49	44	37	
		L ₁	277	277	298	277	270	266	250	248	235	223	208	200	192	184	182	178	175	176	172	
	5/8	T ₂	176	176	185	176	172	170	161	159	151	141	128	119	109	95	96	91	87	83	77	
		L ₂	315	315	339	315	307	302	284	281	267	253	237	228	218	209	207	203	199	200	195	
		T ₃	183	183	192	183	180	179	170	168	161	152	139	132	122	113	111	106	102	99	93	
3 1/2	3/8	T ₁	128	128	139	128	128	123	110	108	99	89	73	64	54	45	42	37	32	29	23	
		L ₁	115	115	122	115	115	113	106	105	101	98	92	90	87	84	83	82	81	80	79	
		T ₂	152	152	161	152	152	148	138	135	128	120	107	99	91	83	81	77	73	70	65	
	5/8	L ₂	131	131	139	131	131	129	121	120	115	111	105	102	99	96	95	93	92	91	90	
		T ₃	162	162	170	162	162	158	148	147	140	132	121	114	106	99	97	93	89	87	82	
		L ₁	163	163	174	163	159	157	147	144	135	125	109	98	86	74	70	64	58	53	45	
4	3/8	L ₁	289	289	310	289	291	277	261	258	246	234	217	208	198	190	188	184	180	180	176	
		T ₂	181	181	190	181	178	176	168	166	158	150	136	127	117	107	104	99	94	90	83	
		L ₂	328	328	352	328	319	314	297	293	279	266	246	236	225	216	213	209	205	205	200	
	5/8	T ₃	189	189	196	189	185	183	176	174	167	160	147	139	130	121	118	113	109	105	99	
		L ₁	134	134	144	134	134	129	117	115	107	96	82	71	61	51	48	43	36	34	25	
		L ₁	119	119	125	119	119	116	110	109	105	101	95	92	89	86	85	84	83	82	80	
4 1/2	3/8	T ₂	157	157	165	157	157	153	143	141	134	126	114	105	97	89	86	82	78	75	70	
		L ₂	135	135	142	135	135	132	125	123	119	114	108	104	101	98	97	95	94	93	91	
		T ₃	166	166	174	166	166	162	153	152	146	138	127	119	111	104	102	98	94	91	86	
	5/8	T ₁	169	169	178	169	164	162	153	151	143	133	118	106	94	82	78	72	66	61	52	
		L ₁	299	299	320	299	290	286	271	268	256	243	226	214	205	196	193	189	185	185	180	
		T ₂	186	186	193	186	182	180	173	171	165	156	144	134	124	114	111	106	101	97	89	
5	3/8	L ₂	340	340	363	340	330	325	308	304	291	276	257	244	232	223	220	215	210	210	205	
		T ₃	193	193	200	193	189	188	181	179	173	165	154	145	136	127	124	119	115	111	104	
		L ₁	134	134	144	134	134	129	117	115	107	96	82	71	61	51	48	43	36	34	25	
	5/8	L ₁	119	119	125	119	119	116	110	109	105	101	95	92	89	86	85	84	83	82	80	
		T ₂	157	157	165	157	157	153	143	141	134	126	114	105	97	89	86	82	78	75	70	
		L ₂	135	135	142	135	135	132	125	123	119	114	108	104	101	98	97	95	94	93	91	

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-4

STEAM TRACING DATA
SPACED TRACER SYSTEM

			35 psig (281 F) STEAM																			
INSULATION THICKNESS	TRACER SIZE (OD)	SEE NOTE 1 BELOW	PROCESS LINE NOMINAL PIPE SIZE (APPLICABLE OD SIZES LISTED UNDER NOMINAL IPS)																			
			3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	
			1/2 OD 3/4 OD 1 OD	3/4 OD 1 OD 1 1/4 OD	1 OD 1 1/4 OD 1 1/2 OD	1 1/4 OD 1 1/2 OD 1 3/4 OD	1 1/2 OD 1 3/4 OD 2 OD	1 3/4 OD 2 OD 2 1/4 OD	2 OD 2 1/4 OD 2 3/4 OD	2 1/4 OD 2 3/4 OD 3 OD	2 3/4 OD 3 OD 3 1/2 OD	3 OD 3 1/2 OD 4 OD	3 1/2 OD 4 OD 5 OD	4 OD 5 OD 6 OD	5 OD 6 OD 8 OD	6 OD 8 OD 10 OD	8 OD 10 OD 12 OD					
1	3/8	T ₁	103	103	114	103	103	93	83	84	71	59										
		L ₁	117	117	122	117	117	113	109	110	105	101										
		T ₂	133	133	142	133	133	125	115	117	106	96										
	L ₂	133	133	138	133	133	128	123	124	118	114											
	T ₃	144	144	153	144	144	137	129	130	120	111											
	5/8	T ₁	141	141	152	141	131	127	119	121	106	93										
L ₁		287	287	302	287	273	263	260	262	246	234											
T ₂		165	165	173	165	156	152	146	148	135	124											
L ₂	323	323	341	323	309	303	293	295	278	264												
T ₃	174	174	182	174	166	163	157	158	147	136												
1 1/2	3/8	T ₁	117	117	127	117	117	114	97	96	85	73	58	48	40	31	28	24	20	17	12	
		L ₁	124	124	129	124	124	122	115	115	110	106	101	98	96	93	93	92	91	90	89	
		T ₂	144	144	152	144	144	142	128	127	117	108	95	86	80	72	70	66	63	61	57	
	L ₂	140	140	146	140	140	138	130	129	124	119	114	110	108	105	105	104	103	102	100		
	T ₃	155	155	162	155	155	153	140	139	130	121	110	102	96	89	87	84	81	78	74		
	5/8	T ₁	155	155	164	155	152	149	135	134	122	109	92	78	69	56	53	47	42	37	30	
L ₁		307	307	323	307	302	297	278	277	262	249	233	223	216	208	206	203	200	198	195		
T ₂		176	176	184	176	174	171	159	159	148	137	123	112	104	94	91	86	81	78	72		
L ₂	347	347	365	347	341	336	314	313	296	281	264	252	244	235	233	229	225	224	220			
T ₃	184	184	191	184	182	180	169	168	159	149	135	125	118	108	106	101	97	94	88			
2	3/8	T ₁	127	127	141	127	127	123	108	106	96	84	69	60	50	40	37	32	28	24	19	
		L ₁	129	129	138	129	129	127	120	119	114	110	104	101	98	96	95	94	93	92	90	
		T ₂	153	153	164	153	153	149	137	135	126	117	104	97	88	80	77	73	70	67	62	
	L ₂	146	146	155	146	146	143	135	134	129	124	118	115	111	108	107	106	105	104	102		
	T ₃	163	163	173	163	163	159	148	147	139	130	118	111	103	96	94	90	87	84	80		
	5/8	T ₁	165	165	177	165	161	158	146	144	133	121	104	93	81	68	65	58	52	48	40	
L ₁		325	325	350	325	317	312	294	291	276	262	244	235	225	216	214	209	206	204	200		
T ₂		184	184	195	184	181	178	169	167	158	148	133	125	114	104	100	95	90	86	80		
L ₂	367	367	395	367	358	352	331	328	312	296	276	265	254	244	241	236	232	231	225			
T ₃	192	192	201	192	189	187	178	176	168	158	145	137	127	118	115	110	105	102	96			
2 1/2	3/8	T ₁	135	135	147	135	135	130	117	114	105	95	78	68	58	48	45	39	35	31	25	
		L ₁	134	134	142	134	134	131	124	122	118	114	107	104	101	98	97	96	94	93	92	
		T ₂	159	159	169	159	159	155	144	142	134	125	112	104	95	86	84	80	76	72	67	
	L ₂	151	151	160	151	151	148	140	138	133	128	121	118	114	111	110	108	107	105	104		
	T ₃	169	169	178	169	169	165	155	153	145	138	125	118	110	102	100	96	92	89	84		
	5/8	T ₁	172	172	183	172	168	165	155	152	143	132	114	103	91	78	75	68	62	57	48	
L ₁		339	339	364	339	330	325	307	303	288	275	254	244	233	223	220	216	212	210	205		
T ₂		190	190	199	190	186	184	176	174	166	151	142	133	122	112	109	103	98	94	87		
L ₂	383	383	410	383	372	367	346	342	325	310	287	275	263	252	249	243	239	237	231			
T ₃	197	197	206	197	194	192	184	182	175	167	153	145	135	125	122	117	113	109	102			
3	3/8	T ₁	141	141	152	141	141	136	124	121	113	102	87	76	65	55	52	46	41	37	30	
		L ₁	138	138	146	138	138	135	127	126	122	117	111	107	103	100	99	97	96	95	93	
		T ₂	164	164	174	164	164	160	150	148	141	132	119	110	101	92	90	85	81	78	72	
	L ₂	156	156	165	156	156	152	144	143	138	132	125	120	116	113	112	110	109	107	105		
	T ₃	174	174	182	174	174	170	160	158	152	144	132	123	115	107	105	101	97	94	89		
	5/8	T ₁	178	178	188	178	173	171	162	160	151	140	125	112	99	87	83	76	70	65	56	
L ₁		351	351	375	351	341	336	318	314	301	285	266	252	240	230	227	222	217	215	203		
T ₂		195	195	203	195	191	189	181	180	173	163	151	140	129	119	116	110	105	101	93		
L ₂	396	396	424	396	385	379	359	355	339	321	300	284	271	260	256	250	245	243	236			
T ₃	202	202	209	202	198	196	189	188	181	173	161	151	141	132	129	124	119	115	108			



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INSULATION THICKNESS REQUIREMENTS

Service Designation T-5

STEAM TRACING DATA SPACED TRACER SYSTEM

			50 psig (298 F) STEAM																		
INSULATION THICKNESS	TRACER SIZE (OD)	SEE NOTE 1 BELOW	PROCESS LINE NOMINAL PIPE SIZE (APPLICABLE OD SIZES LISTED UNDER NOMINAL IPS)																		
			3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
			1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	
1	3/8	T ₁	110	110	121	110	110	100	88	90	76	64									
		L ₁	139	139	145	139	139	134	129	130	124	120									
		T ₂	139	139	149	139	139	131	121	122	110	100									
	5/8	L ₂	156	156	162	156	156	150	145	145	139	134									
		T ₃	151	151	160	151	151	143	134	135	124	115									
		L ₁	150	150	161	150	139	135	127	129	113	99									
1 1/2	3/8	L ₂	338	338	357	338	323	317	307	309	291	277									
		T ₂	173	173	183	173	164	160	154	155	142	130									
		L ₂	390	390	400	380	362	355	344	347	326	310									
	5/8	T ₃	182	182	191	182	174	170	164	166	153	142									
		L ₁	124	124	134	124	124	121	104	103	90	78	63	51	44	34	31	26	22	19	14
		L ₂	146	146	152	146	146	145	136	135	130	125	119	116	113	110	110	108	107	106	105
2	3/8	T ₂	152	152	160	152	152	149	135	133	123	113	99	90	83	75	73	69	66	63	58
		L ₂	164	164	171	164	164	162	152	152	146	140	134	130	127	124	123	122	120	119	118
		T ₃	162	162	170	162	162	160	146	145	136	126	114	105	99	92	90	86	83	80	76
	5/8	L ₁	165	165	174	165	161	158	144	143	129	116	97	83	74	60	57	50	45	40	33
		L ₂	363	363	382	363	357	351	329	327	310	294	276	264	256	246	244	239	236	234	230
		T ₃	186	186	194	186	183	180	168	167	156	144	129	117	109	98	95	89	85	81	74
2 1/2	3/8	L ₂	407	407	428	407	401	394	369	367	347	330	309	296	287	276	273	268	265	263	258
		T ₃	194	194	201	194	191	189	177	177	166	156	141	131	123	113	110	105	101	97	91
		L ₁	135	135	149	135	135	130	115	113	102	90	74	64	53	43	40	35	30	27	21
	5/8	L ₂	153	153	163	153	153	150	141	140	135	130	123	120	116	113	112	111	109	108	107
		T ₂	161	161	172	161	161	157	144	142	133	123	109	101	92	83	81	76	72	69	64
		L ₂	172	172	182	172	172	168	159	157	151	145	138	134	130	127	126	124	123	122	120
3	3/8	T ₃	171	171	182	171	171	167	155	153	145	136	123	116	107	99	97	93	89	86	82
		L ₁	175	175	188	175	171	168	155	153	142	129	111	100	86	73	69	62	56	51	43
		L ₂	384	384	414	384	374	369	347	343	326	309	289	278	266	255	252	247	243	241	236
	5/8	T ₂	194	194	205	194	190	188	178	176	166	155	140	131	119	108	105	99	94	90	83
		L ₂	430	430	464	430	420	413	389	385	366	347	324	311	293	256	283	277	273	271	265
		T ₃	202	202	212	202	198	196	186	185	176	166	152	143	133	122	119	114	109	105	99
3 1/2	3/8	L ₁	143	143	156	143	143	138	124	121	111	101	83	73	62	51	48	43	38	34	27
		L ₂	158	158	168	158	158	155	146	145	139	134	127	123	119	116	115	113	112	110	109
		T ₂	167	167	178	167	167	163	151	149	140	132	117	108	99	99	97	93	79	75	70
	5/8	L ₂	178	178	188	178	178	174	164	162	156	151	142	138	134	130	129	127	125	124	122
		T ₃	177	177	187	177	177	173	162	160	152	144	130	122	114	106	103	99	95	92	87
		L ₁	133	133	144	133	133	130	118	116	107	97	81	71	60	50	40	35	30	27	21
4	3/8	L ₂	400	400	430	400	389	384	362	357	341	324	301	288	275	264	260	255	250	248	242
		T ₂	201	201	210	201	196	194	185	183	174	165	149	139	128	117	114	108	102	98	90
		L ₂	449	449	482	449	437	430	406	401	382	364	337	323	308	296	292	286	281	278	271
	5/8	T ₃	208	208	217	208	204	202	193	191	183	175	160	151	141	131	128	122	117	113	106
		L ₁	150	150	161	150	150	144	131	129	120	109	93	81	70	59	56	50	45	40	33
		L ₂	163	163	172	163	163	159	151	149	144	138	131	126	122	119	117	115	114	112	110
4 1/2	3/8	T ₂	173	173	183	173	173	168	157	155	148	138	125	115	105	96	94	89	84	81	75
		L ₂	183	183	193	183	183	178	169	167	161	155	147	141	137	132	131	129	127	126	124
		T ₃	192	192	191	182	182	178	168	166	159	150	138	128	120	111	109	104	100	97	91
	5/8	L ₁	188	188	199	188	184	181	171	169	160	149	132	119	106	93	89	81	75	69	60
		L ₂	415	415	444	415	403	397	376	372	353	336	314	297	284	272	268	262	257	254	247
		T ₃	206	206	214	206	201	199	191	189	182	172	158	147	136	125	122	115	110	105	97
5	3/8	L ₂	465	465	497	465	451	445	422	417	398	377	352	334	318	305	301	294	288	285	277
		T ₃	212	212	220	212	208	207	199	197	190	181	169	158	148	138	135	129	124	119	112
		L ₁	150	150	161	150	150	144	131	129	120	109	93	81	70	59	56	50	45	40	33
	5/8	L ₂	163	163	172	163	163	159	151	149	144	138	131	126	122	119	117	115	114	112	110
		T ₂	173	173	183	173	173	168	157	155	148	138	125	115	105	96	94	89	84	81	75
		L ₂	183	183	193	183	183	178	169	167	161	155	147	141	137	132	131	129	127	126	124



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INSULATION THICKNESS REQUIREMENTS

Service Designation T-6

STEAM TRACING DATA SPACED TRACER SYSTEM

			75 psig (320 F) STEAM																		
INSULATION THICKNESS	TRACER SIZE (OD)	SEE NOTE 1 BELOW	PROCESS LINE NOMINAL PIPE SIZE (APPLICABLE OD SIZES LISTED UNDER NOMINAL IPS)																		
			3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
			1.00 1.50 2.00	1.00 1.50 2.00	1.00 1.50 2.00	1.00 1.50 2.00	1.00 1.50 2.00	2.00 2.50 3.00	2.50 3.00 3.50	3.00 3.50 4.00	4.00 4.50 5.00	5.00 5.50 6.00	6.00 6.50 7.00	7.00 7.50 8.00	8.00 8.50 9.00	9.00 9.50 10.00	10.00 10.50 11.00	11.00 11.50 12.00	12.00 12.50 13.00	13.00 13.50 14.00	14.00 14.50 15.00
1	3/8	T ₁	119	119	131	119	119	108	96	98	83	70									
		L ₁	168	168	175	168	168	162	156	157	150	145									
		T ₂	149	149	159	149	149	139	129	130	117	106									
	L ₂	187	187	195	187	187	180	174	175	167	161										
	T ₃	160	160	170	160	160	152	142	143	131	121										
	5/8	T ₁	162	162	175	162	151	146	137	139	122	107									
L ₁		410	410	432	410	391	383	371	374	352	335										
T ₂		186	186	196	186	176	171	164	166	151	138										
L ₂	456	456	481	456	435	426	413	416	392	373											
T ₃	195	195	204	195	186	182	175	177	163	151											
1 1/2	3/8	T ₁	135	135	146	135	135	131	113	112	98	85	69	56	48	38	35	30	25	22	16
		L ₁	177	177	185	177	177	175	164	164	157	151	144	140	137	134	133	131	130	129	127
		T ₂	162	162	171	162	162	159	143	142	131	120	106	95	88	79	77	72	69	66	61
	L ₂	197	197	205	197	197	195	183	182	175	168	161	156	153	149	148	146	145	143	142	
	T ₃	173	173	181	173	173	170	155	154	144	134	120	111	104	96	93	89	86	83	79	
	5/8	T ₁	178	178	188	178	175	171	156	154	140	126	106	91	80	66	62	56	50	45	37
L ₁		440	440	462	440	433	425	398	396	375	356	334	319	310	298	295	290	286	284	278	
T ₂		199	199	208	199	196	193	180	179	167	154	137	125	116	104	100	94	89	85	78	
L ₂	489	489	514	489	481	473	443	441	417	396	371	355	344	331	328	322	318	316	310		
T ₃	207	207	215	207	204	201	189	188	177	166	150	138	130	118	115	110	105	101	95		
2	3/8	T ₁	147	147	162	147	147	141	125	123	111	98	81	70	59	48	44	39	34	30	24
		L ₁	195	185	197	185	185	182	171	170	163	157	149	145	141	137	136	134	133	131	129
		T ₂	172	172	185	172	172	168	153	152	141	131	116	107	97	88	85	80	76	73	67
	L ₂	206	206	219	206	206	202	190	189	182	175	166	161	157	152	151	149	147	146	144	
	T ₃	182	182	194	182	182	178	165	163	154	144	130	122	112	104	101	97	93	90	85	
	5/8	T ₁	189	189	203	189	184	181	168	166	153	140	120	108	94	80	76	68	62	56	47
L ₁		465	465	501	465	453	446	420	416	395	374	350	336	322	309	305	299	294	292	286	
T ₂		208	208	220	208	204	202	190	188	178	166	150	139	127	115	111	105	100	95	87	
L ₂	517	517	557	517	504	496	467	462	439	416	389	374	358	344	340	333	327	325	318		
T ₃	216	216	227	216	212	210	199	197	188	177	161	152	140	129	126	120	115	111	103		
2 1/2	3/8	T ₁	155	155	169	155	155	150	135	132	121	109	91	80	68	57	53	47	42	38	31
		L ₁	192	192	203	192	192	187	177	175	169	163	154	149	144	140	139	137	135	134	131
		T ₂	179	179	191	179	179	175	162	159	150	140	124	115	105	95	92	87	83	79	73
	L ₂	213	213	226	213	213	208	197	195	188	181	171	166	160	156	154	152	150	149	146	
	T ₃	189	189	200	189	189	185	173	170	162	153	138	129	120	111	108	103	99	96	90	
	5/8	T ₁	197	197	210	197	192	189	178	175	164	152	132	119	105	91	87	79	72	67	57
L ₁		485	485	520	485	471	464	439	433	412	393	364	349	333	319	315	308	303	300	293	
T ₂		215	215	226	215	211	208	198	196	187	177	159	149	137	125	121	114	109	104	96	
L ₂	539	539	578	539	524	516	488	481	459	437	405	388	370	355	351	343	337	334	325		
T ₃	222	222	232	222	218	216	207	205	196	187	170	161	149	138	135	129	123	119	111		
3	3/8	T ₁	162	162	175	162	162	156	142	140	130	118	101	88	76	65	61	55	49	45	37
		L ₁	197	197	209	197	197	193	182	181	174	167	159	153	147	143	142	139	138	136	133
		T ₂	185	185	196	185	185	180	166	166	158	148	133	122	112	102	99	94	89	85	78
	L ₂	219	219	232	219	219	214	203	201	194	186	176	170	164	159	158	155	153	151	148	
	T ₃	194	194	204	194	194	190	179	177	169	159	146	136	126	117	114	109	105	101	95	
	5/8	T ₁	204	204	215	204	198	196	185	183	173	161	144	129	115	101	97	89	82	76	66
L ₁		502	502	537	502	487	481	455	450	430	407	380	360	343	329	325	317	311	307	299	
T ₂		221	221	230	221	216	214	205	203	195	184	169	157	145	133	130	123	117	112	103	
L ₂	558	558	597	558	542	534	506	500	478	453	422	400	382	366	361	353	346	342	333		
T ₃	227	227	236	227	223	221	213	211	203	194	180	168	157	146	143	136	131	126	118		



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STEAM TRACING DATA SPACED TRACER SYSTEM

			200 psig (388 F) STEAM																		
INSULATION THICKNESS	TRACER SIZE (OD)	SEE NOTE 1 BELOW	PROCESS LINE NOMINAL PIPE SIZE (APPLICABLE OD SIZES LISTED UNDER NOMINAL IPS)																		
			3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
			1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	
1	3/8	T ₁	147	147	161	147	147	134	119	121	103	88									
		L ₁	273	273	284	273	273	263	253	255	244	235									
		T ₂	176	176	189	176	176	165	152	154	138	124									
	L ₂	298	298	310	298	298	287	277	278	266	257										
	T ₃	188	188	200	188	188	177	165	167	152	139										
	5/8	T ₁	198	198	213	198	185	179	169	171	151	132									
L ₁	665	665	702	665	635	622	603	607	572	544											
T ₂	222	222	234	222	210	204	195	197	180	164											
L ₂	726	726	766	726	693	679	658	663	624	594											
T ₃	231	231	243	231	219	214	206	206	191	176											
1 1/2	3/8	T ₁	166	166	178	166	166	161	139	138	122	106	86	72	62	49	45	39	34	30	23
		L ₁	288	288	300	288	288	284	267	266	255	246	235	227	223	217	216	213	211	209	207
		T ₂	193	193	204	193	193	189	169	168	154	141	123	110	102	90	87	82	78	74	68
	L ₂	314	314	327	314	314	310	291	290	279	268	256	248	243	237	235	233	230	228	226	
	T ₃	204	204	214	204	204	200	182	180	167	154	138	126	118	107	104	99	95	92	86	
	5/8	T ₁	217	217	230	217	213	209	190	189	172	154	131	113	100	83	79	71	64	58	48
L ₁	714	714	750	714	702	690	646	643	609	578	542	518	503	484	479	470	464	461	452		
T ₂	238	238	249	238	234	230	214	213	198	183	162	147	135	121	117	109	103	98	89		
L ₂	779	779	819	779	766	753	706	702	664	631	592	565	549	528	523	513	506	503	493		
T ₃	246	246	257	246	243	239	224	223	209	194	175	160	150	136	132	125	119	114	106		
2	3/8	T ₁	179	179	197	179	179	173	153	151	137	121	101	88	74	61	57	51	45	40	32
		L ₁	301	301	320	301	301	295	278	276	265	255	242	236	229	222	221	218	215	213	210
		T ₂	205	205	221	205	205	199	182	180	167	154	136	125	113	101	98	92	87	83	76
	L ₂	328	328	349	328	328	322	303	301	289	278	265	257	250	243	241	238	235	233	229	
	T ₃	215	215	230	215	215	210	194	191	180	167	150	140	128	117	114	108	104	100	93	
	5/8	T ₁	231	231	247	231	225	221	205	202	188	171	148	134	116	100	94	86	78	71	61
L ₁	754	754	813	754	736	724	681	675	641	608	568	546	522	502	496	486	478	474	463		
T ₂	250	250	264	250	245	241	227	225	212	198	177	165	150	135	130	123	118	110	101		
L ₂	823	823	887	823	803	790	744	735	700	663	619	596	570	547	541	531	522	517	506		
T ₃	257	257	271	257	253	249	236	234	222	208	199	177	163	149	145	137	131	126	117		
2 1/2	3/8	T ₁	190	190	206	190	190	183	163	162	149	135	113	100	85	72	68	61	54	49	41
		L ₁	311	311	330	311	311	304	289	285	274	264	250	242	234	227	226	222	219	217	214
		T ₂	214	214	228	214	214	208	192	189	178	166	146	135	122	111	107	101	95	91	83
	L ₂	339	339	360	339	339	332	314	311	299	288	272	264	256	248	246	242	239	237	233	
	T ₃	224	224	237	224	224	218	203	200	190	178	160	149	137	126	123	117	112	107	100	
	5/8	T ₁	240	240	255	240	234	231	217	213	200	186	162	147	130	113	108	99	91	84	72
L ₁	787	787	844	787	765	754	712	702	669	637	591	566	541	518	512	501	492	487	475		
T ₂	258	258	271	258	253	250	238	234	223	211	189	176	161	147	142	134	127	121	111		
L ₂	858	858	921	858	835	823	777	767	731	696	645	613	590	566	559	547	537	531	518		
T ₃	265	264	278	265	260	257	246	243	232	221	200	188	174	160	156	148	142	136	126		
3	3/8	T ₁	198	198	213	198	198	191	173	171	160	143	125	110	95	82	77	70	63	57	48
		L ₁	320	320	338	320	320	313	296	293	283	272	258	248	239	232	230	226	223	221	217
		T ₂	221	221	234	221	221	215	201	198	188	175	157	144	131	119	115	109	103	98	90
	L ₂	349	349	369	349	349	341	323	320	309	296	281	270	261	253	251	247	244	241	237	
	T ₃	230	230	243	230	230	225	211	208	199	187	170	157	145	134	130	124	119	114	106	
	5/8	T ₁	248	248	261	248	241	236	226	223	211	197	176	158	142	125	120	110	102	95	82
L ₁	815	815	871	815	791	780	739	730	698	661	617	585	558	534	527	515	505	499	485		
T ₂	265	265	276	265	259	257	246	243	233	220	202	186	172	157	153	144	137	131	120		
L ₂	889	889	951	889	863	851	806	797	761	721	673	638	608	583	575	562	551	545	530		
T ₃	272	272	283	272	266	264	253	251	242	229	212	198	184	170	166	158	151	145	133		



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Service Designation T-8

HEAT TRANSFER CEMENT BONDED STEAM TRACING SYSTEMS AND DEFINITIONS OF SYMBOLS

NOTE:

The tabulated data on this Standard applies to steam tracing systems using heat transfer cement as the heat-conductive medium, as detailed and specified on Standard P-140. Insulation sizes and assembly dimensions are given on Standard P-140A.

This Standard provides steam tracing data based on static conditions only. Information compiled is based on heat loss from the insulation and does not provide for addition of any heat to the material in the process line.

This Standard is for use where required temperatures are higher than those that can be maintained with air as the heat-conductive medium.

Data in these tables can be used for selection of tracers under two general conditions, as follows:

1. Where temperature to be maintained in the process line determines selection of insulation thickness, tracer size and steam pressure.

When temperature to be maintained completely determines selection, frequently the most economical selection is the combination using only one tracer and the thickness of insulation which is consistent with "Economic Thickness of Insulation." In some instances it may be desirable to have two tracers for use in coldest weather so that one can be turned off in mild weather to prevent overheating. Where a choice is possible, it is more economical to use the larger size tracer than to increase the insulation thickness.

2. Where operating temperature determines insulation thickness, and temperature to be maintained during down time determines selection of tracer size and steam pressure.

When operating temperature dictates the insulation thickness, this thickness may be greater than necessary for most economical selection of insulation thickness and tracer size. However, under these conditions the applicable tracer data can be obtained from the table, based on the predetermined insulation thickness and temperature to be maintained during down time.

Under either of the conditions, the final selection of tracer size, i. e., 3/8 inch or 5/8 inch, may be influenced by physical requirements as to length of tracer that can be run between traps.



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HEAT TRANSFER CEMENT BONDED STEAM TRACING SYSTEMS AND DEFINITIONS OF SYMBOLS - Continued

DEFINITIONS OF SYMBOLS

T = Minimum temperature ($^{\circ}\text{F}$) that the tracer will maintain in the process line, based on an ambient temperature of -20°F . The calculations are based on static conditions, i. e., no fluid flow, and are independent of the viscosity, density, and thermal conductivity of the process fluid.

Higher ambient temperatures will result in slightly higher process line temperatures.

If the upper temperature limit of the process line is critical, the effect of solar radiation should be investigated, since it was not considered in calculating the temperatures given in the table.

L_1 = Maximum length (feet) of straight run of tracer, based on an ambient temperature of -20°F . It is applicable at all plant locations except 513 and 526.

L_2 = Same as L_1 , except based on an ambient temperature of 30°F . It is applicable at Plant Locations 513 and 526.

L_1 and L_2 represent total lengths of tracers, including all branches, and apply to straight runs only. In utilizing them in actual tracer layouts, the following limitations and requirements shall be considered:

1. Lengths shall be reduced as necessary to compensate for friction losses caused by bends, tees, valves, and other constrictions.
2. In general, all low points and pockets in tracers shall be trapped. However, under certain conditions, installation of traps at these points may be impracticable. If so, the length of the tracer shall be reduced sufficiently to offset pressure drop caused by the condensate head.
3. Steam tracer feed lines shall be sized properly so that pressure drop will not require a reduction in the tracer length.
4. Traps shall be installed at the ends of all tracers, including ends of branches, and at all other condensate removal points.



INSULATION THICKNESS REQUIREMENTS

Service Designation T-9

STEAM TRACING DATA
TRACER BONDED TO PIPE WITH HEAT TRANSFER CEMENT

				15 psig (250 F) STEAM																					
INSULATION THICKNESS	TRACER SIZE (OD)	NUMBER OF TRACERS	SEE NOTE 1 BELOW	PROCESS LINE NOMINAL PIPE SIZE (APPLICABLE OD. SIZES LISTED UNDER NOMINAL IPS)																					
				3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24			
1	3/8	1	T L ₁ L ₂	240 78 90	237 75 86	232 66 75	229 63 72	224 57 65	223 56 64	218 51 59	212 46 53	210 46 53	203 42 48												
		2	T L ₁ L ₂		248 117 134	245 102 117	243 97 111	240 87 100	239 85 98	235 78 89	232 70 80	231 70 80	226 62 72												
	5/8	1	T L ₁ L ₂	248 208 239	245 195 224	242 175 200	239 168 192	235 152 174	234 149 171	229 134 154	228 133 152	222 118 135	215 103 119												
		2	T L ₁ L ₂				249 262 301	246 236 270	245 231 265	242 207 237	241 204 234	238 180 206	234 157 180												
1 1/2	3/8	1	T L ₁ L ₂	241 83 95	238 80 92	235 74 85	231 68 78	227 62 71	226 61 70	224 59 67	217 52 59	215 50 58	209 46 52	191 36 42	181 33 38	172 31 35	160 28 32	156 27 31	149 26 30	142 25 28	136 24 27	125 22 26			
		2	T L ₁ L ₂		248 126 144	246 115 132	244 105 121	241 96 110	240 94 108	238 90 103	235 87 98	233 87 98	229 79 91	218 61 71	211 55 65	206 50 60	197 45 55	194 43 53	189 38 48	183 36 46	178 34 44	169 32 42			
	5/8	1	T L ₁ L ₂	249 231 265	246 210 241	243 190 218	240 163 199	238 174 196	237 171 196	232 149 167	231 145 160	226 131 153	221 116 133	212 101 116	205 90 103	198 83 95	189 75 86	185 72 83	179 68 78	173 65 74	168 62 71	158 58 66			
		2	T L ₁ L ₂				249 288 320	247 272 312	246 267 306	244 225 257	242 201 231	240 177 203	236 152 175	231 135 155	227 123 141	222 109 125	217 105 121	214 98 113	210 93 107	206 88 101	203 83 93	196 78 88	191 71 81		
2	3/8	1	T L ₁ L ₂	242 88 101	239 85 97	236 76 87	234 75 86	230 66 75	228 66 75	226 62 72	221 56 64	219 54 62	213 49 56	198 40 45	190 36 42	181 33 38	170 30 35	167 29 34	160 28 33	154 27 32	148 26 31	137 24 29			
		2	T L ₁ L ₂		248 133 152	246 119 136	244 116 133	242 103 118	241 101 116	239 96 110	236 85 97	235 82 95	231 74 85	222 67 77	218 59 67	211 54 61	204 48 55	202 43 50	197 39 45	192 37 43	188 35 41	179 33 39			
	5/8	1	T L ₁ L ₂	249 238 273	246 229 263	243 203 233	240 156 212	238 182 209	234 161 184	233 156 179	229 142 163	224 127 145	221 111 127	212 101 116	205 91 104	197 82 94	194 75 91	188 68 86	183 65 82	178 62 78	169 58 72				
		2	T L ₁ L ₂				249 308 354	247 289 332	246 285 327	244 250 297	243 219 277	241 194 252	238 168 223	234 152 193	230 136 175	226 121 156	221 109 134	220 103 126	216 98 118	213 93 112	210 88 103	203 81 98	200 78 93		
2 1/2	3/8	1	T L ₁ L ₂	242 91 105	240 89 102	237 80 92	235 75 89	231 69 80	230 66 79	228 65 75	223 57 68	221 55 66	216 50 60	203 42 49	196 39 45	188 35 41	178 32 37	175 30 36	169 28 34	163 27 33	157 26 31	147 24 29			
		2	T L ₁ L ₂		249 139 159	246 125 144	245 121 139	242 108 124	242 107 123	240 90 116	237 88 104	236 80 100	233 73 89	225 63 77	221 58 70	215 52 64	209 47 59	207 45 54	203 43 52	199 40 49	195 38 46	187 35 44			
	5/8	1	T L ₁ L ₂	249 250 256	246 239 274	244 213 244	242 207 237	240 195 223	239 192 220	236 171 196	234 165 190	231 152 174	227 137 157	220 119 137	215 109 124	209 98 112	202 89 102	200 86 98	195 81 93	190 77 88	186 73 84	178 68 78			
		2	T L ₁ L ₂				249 323 373	247 305 349	246 300 344	244 266 305	243 257 295	242 235 270	239 211 242	236 182 208	233 165 189	229 148 169	225 132 152	223 123 146	220 119 137	217 113 129	214 107 123	209 98 112			
3	3/8	1	T L ₁ L ₂	242 95 108	240 92 105	237 83 96	235 81 93	231 73 84	230 72 83	228 69 79	223 62 71	221 60 69	216 55 63	203 46 52	196 41 47	188 38 43	178 34 39	175 33 38	169 32 36	163 30 35	157 29 33	147 27 31			
		2	T L ₁ L ₂		249 144 165	247 130 150	245 126 145	242 113 130	242 109 129	241 106 122	238 95 109	237 93 106	235 84 97	229 79 91	223 69 79	219 61 71	213 55 64	211 50 58	207 46 54	204 43 51	200 40 47	193 38 44			
	5/8	1	T L ₁ L ₂	249 250 297	247 242 284	244 213 254	242 207 237	240 195 233	239 192 230	236 171 206	234 165 195	231 152 167	227 137 147	220 119 132	215 109 120	209 98 109	202 89 105	200 86 99	195 81 94	190 77 90	186 73 83	178 68 83			
		2	T L ₁ L ₂				249 339 389	247 318 365	245 314 360	243 281 322	242 272 312	241 251 287	238 225 258	237 217 226	233 197 202	229 176 181	224 158 163	218 142 157	213 137 148	207 129 139	200 122 132	196 115 121	184 105 112		

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**STEAM TRACING DATA
TRACER BONDED TO PIPE WITH HEAT TRANSFER CEMENT**

				25 psig (267F) STEAM																			
				PROCESS LINE NOMINAL PIPE SIZE (APPLICABLE OD SIZES LISTED UNDER NOMINAL IPS)																			
				3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	
INSULATION THICKNESS	TRACER SIZE (OD)	NUMBER OF TRACERS	SEE NOTE ¹ BELOW																				
1	3/8	1	T ₁ L ₂	257 97 111	253 93 106	248 82 93	245 78 89	240 71 80	238 69 79	233 64 72	226 58 66	225 58 66	217 52 59										
		2	T ₁ L ₂		265 146 166	262 127 144	259 120 137	256 108 123	255 106 121	251 97 110	248 87 99	246 87 99	242 87 88										
	5/8	1	T ₁ L ₂	265 260 295	262 243 276	258 217 247	255 209 237	251 189 215	250 185 211	245 167 190	244 165 188	238 147 167	230 129 146										
		2	T ₁ L ₂				266 327 371	263 294 334	262 283 327	259 257 293	258 253 289	254 224 255	250 195 222										
1 1/2	3/8	1	T ₁ L ₂	257 104 118	253 100 114	251 92 104	247 85 96	243 77 88	242 76 87	239 73 83	232 64 72	230 63 72	223 57 65	205 45 52	193 41 47	184 38 43	172 35 39	167 34 38	159 32 37	152 31 35	146 30 34	134 29 32	
		2	T ₁ L ₂		265 156 173	263 143 163	260 131 149	258 119 134	256 117 133	254 98 111	249 95 108	242 86 98	236 76 88	227 67 76	219 59 68	212 55 62	202 49 56	198 47 54	192 44 51	186 42 48	180 40 46	169 37 42	
	5/8	1	T ₁ L ₂	265 286 327	262 262 297	259 237 269	257 228 259	254 217 246	253 213 243	249 186 211	246 161 206	242 163 185	236 145 164	227 126 143	219 112 129	212 104 118	202 93 106	198 90 102	192 85 97	186 81 92	180 77 88	169 72 82	
		2	T ₁ L ₂				266 358 407	264 339 385	263 333 378	260 298 327	259 280 318	256 251 285	253 220 251	247 190 216	242 168 191	232 153 174	226 136 155	221 123 149	219 131 139	216 123 132	211 116 125	209 110 115	
2	3/8	1	T ₁ L ₂	258 109 124	256 106 120	252 95 108	250 83 94	245 82 93	244 79 93	241 69 99	236 67 77	234 66 77	228 61 70	212 49 56	204 45 52	194 41 48	183 38 43	179 37 42	171 35 40	165 33 38	158 32 36	147 30 34	
		2	T ₁ L ₂		265 166 188	263 148 168	261 134 144	258 128 145	257 126 143	256 120 136	252 106 120	251 103 117	247 93 105	238 83 96	233 76 88	226 68 81	218 61 76	216 59 71	210 56 68	206 53 65	201 50 61	192 48 58	
	5/8	1	T ₁ L ₂	266 297 337	263 286 325	260 253 287	258 245 278	255 220 262	254 200 238	250 194 221	248 177 201	245 160 180	240 157 173	232 143 159	226 129 143	219 116 132	210 107 122	207 99 112	201 93 106	196 89 101	191 85 96	181 79 89	
		2	T ₁ L ₂				266 436	264 410	263 403	261 373	257 342	254 311	247 273	242 242	236 238	230 216	226 192	219 172	210 166	207 155	201 146	196 139	181 127
2 1/2	3/8	1	T ₁ L ₂	259 114 130	256 110 126	253 100 110	251 97 110	247 87 99	246 86 98	243 82 93	238 74 81	236 71 80	231 66 74	217 53 60	210 49 55	201 44 50	191 40 46	187 39 45	181 37 42	174 36 41	169 34 39	158 32 36	
		2	T ₁ L ₂		256 173 197	263 151 172	261 135 154	259 133 152	255 126 141	254 113 129	252 109 124	249 100 113	241 90 100	236 79 92	230 72 85	224 65 74	221 58 66	217 56 64	212 53 61	208 50 58	200 48 55		
	5/8	1	T ₁ L ₂	266 311 353	263 298 338	260 265 302	258 257 293	256 242 275	255 230 262	252 213 242	250 206 234	247 189 215	243 171 194	236 156 180	230 143 169	221 133 154	216 121 142	214 111 132	209 107 122	204 101 115	199 96 104	190 91 96	
		2	T ₁ L ₂				266 460	264 431	263 425	261 377	257 342	254 311	247 273	242 242	236 238	230 216	226 192	219 172	210 166	207 155	201 146	196 139	181 127
3	3/8	1	T ₁ L ₂	259 118 134	257 114 120	254 104 116	252 101 115	248 91 104	247 86 103	245 86 97	240 77 86	239 75 86	234 69 78	222 57 65	214 51 59	206 47 53	197 43 49	194 42 47	186 40 45	182 38 43	177 36 41	167 34 39	
		2	T ₁ L ₂		265 179 204	263 163 185	262 157 178	260 141 161	259 140 159	257 132 150	255 119 135	253 115 131	251 97 119	244 86 97	239 77 87	234 69 79	229 63 71	226 57 69	222 52 61	218 49 58	214 47 54	207 45 54	
	5/8	1	T ₁ L ₂	266 322 366	263 308 350	261 277 314	259 269 305	257 253 287	256 224 255	253 218 247	251 201 229	249 181 206	247 160 184	243 141 163	239 130 154	234 118 143	229 114 139	225 108 134	221 104 130	219 101 127	214 98 111	205 90 103	
		2	T ₁ L ₂				266 423	264 396	264 391	262 359	261 312	259 280	257 245	253 219	250 197	247 177	243 171	241 160	239 151	236 144	233 131	229 123	228 116



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INSULATION THICKNESS REQUIREMENTS

Service Designation T-11

STEAM TRACING DATA TRACER BONDED TO PIPE WITH HEAT TRANSFER CEMENT

				35 psig (281 F) STEAM																		
INSULATION THICKNESS	TRACER SIZE (OD)	NUMBER OF TRACERS	SEE NOTE 1 BELOW	PROCESS LINE NOMINAL PIPE SIZE (APPLICABLE OD SIZES LISTED UNDER NOMINAL IPS)																		
				3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
1	3/8	1	T ₁ L ₂	270 113 128	267 109 123	261 95 108	258 91 102	252 82 93	251 81 91	245 74 84	238 67 76	237 67 76	229 61 68									
		2	T ₁ L ₂		279 170 192	276 148 167	273 140 158	270 126 142	268 124 140	265 112 127	261 102 115	259 101 114	254 90 102									
	5/8	1	T ₁ L ₂	279 302 341	276 282 319	272 233 285	269 243 274	264 220 248	263 215 248	258 194 219	256 192 217	250 170 192	242 150 169									
		2	T ₁ L ₂					280 380 429	277 342 386	273 334 377	271 299 334	268 260 294	263 226 257									
1 1/2	3/8	1	T ₁ L ₂	271 121 136	268 116 131	264 107 121	260 98 111	256 90 102	254 89 100	252 85 96	244 75 84	242 73 83	235 66 75	215 53 60	204 48 54	194 44 50	181 40 46	176 39 44	168 37 42	161 36 41	154 35 39	141 33 37
		2	T ₁ L ₂		279 182 205	277 166 193	274 152 172	271 138 156	268 130 154	266 117 147	262 114 128	258 100 113	246 88 98	238 78 88	232 70 82	222 64 72	219 57 64	213 55 62	207 52 58	201 49 55	191 47 53	178 43 49
	5/8	1	T ₁ L ₂	279 335 378	276 304 343	273 275 311	270 265 300	267 252 284	266 232 280	262 216 244	259 233 239	255 206 214	248 184 190	239 160 165	230 146 148	223 132 136	213 119 122	209 115 118	202 103 112	196 99 106	190 91 102	178 84 94
		2	T ₁ L ₂					280 416 470	273 393 444	277 387 426	274 334 377	272 325 367	270 291 329	266 256 289	260 221 249	255 195 220	250 178 201	244 158 179	241 152 172	237 143 161	233 135 152	228 128 144
2	3/8	1	T ₁ L ₂	272 127 144	269 123 139	265 110 125	263 108 122	258 96 109	257 95 107	254 91 102	248 81 89	246 78 81	240 71 75	223 58 65	215 53 60	204 48 54	192 44 50	188 43 48	181 41 46	174 39 44	167 37 42	155 35 39
		2	T ₁ L ₂		279 193 217	277 172 194	275 168 190	272 149 168	271 139 166	269 117 157	266 113 139	264 108 135	260 95 122	250 85 96	245 78 88	238 70 79	230 63 71	227 58 66	222 54 61	217 51 58	212 49 54	202 47 54
	5/8	1	T ₁ L ₂	279 345 389	277 332 375	274 294 331	271 294 321	269 265 302	267 264 298	263 233 263	262 226 233	258 206 232	252 184 207	244 160 181	238 146 163	230 132 149	222 119 134	218 115 130	212 103 122	207 99 116	191 91 111	178 84 103
		2	T ₁ L ₂					290 446 504	273 419 473	277 412 466	274 318 355	272 282 335	270 243 309	268 263 316	263 259 275	259 221 249	255 221 222	249 198 198	247 191 191	243 169 179	240 159 169	236 150 160
2 1/2	3/8	1	T ₁ L ₂	272 133 150	270 128 145	266 116 131	264 110 128	260 108 115	259 95 113	256 93 108	251 86 97	249 83 94	244 75 86	229 62 70	221 57 64	211 51 58	201 47 53	197 46 52	190 44 49	184 43 47	178 41 45	167 37 42
		2	T ₁ L ₂		279 201 227	277 181 205	275 167 198	273 157 177	272 147 175	270 131 166	267 127 148	266 121 143	262 116 131	254 92 104	249 84 95	243 75 83	236 68 77	233 66 74	229 62 70	225 59 66	224 58 63	219 56 63
	5/8	1	T ₁ L ₂	290 361 408	277 336 390	274 308 348	272 299 338	269 282 318	268 278 314	265 248 280	263 210 270	260 220 249	256 199 225	248 172 195	243 157 177	236 142 160	229 129 145	225 124 140	220 117 132	215 111 126	210 106 122	201 98 111
		2	T ₁ L ₂					290 470 531	278 441 498	277 435 491	275 386 435	274 372 420	272 340 384	260 306 346	263 238 297	258 214 260	253 192 241	251 185 216	248 173 209	245 163 195	241 155 184	237 144 175
3	3/8	1	T ₁ L ₂	273 137 155	270 133 150	267 121 137	265 117 132	261 106 120	260 99 113	255 90 102	253 85 99	251 80 90	246 66 75	234 60 68	226 55 62	217 50 56	208 49 55	204 46 52	195 44 49	192 43 47	186 42 45	176 39 42
		2	T ₁ L ₂		279 209 235	277 189 213	275 176 196	273 164 185	272 162 183	271 154 175	269 138 156	267 134 152	264 122 138	256 112 131	251 99 101	246 93 98	240 83 87	238 79 82	233 70 76	230 66 71	225 63 68	218 60 65
	5/8	1	T ₁ L ₂	290 375 423	277 335 404	274 321 363	272 294 332	269 282 328	268 284 329	265 253 296	263 234 284	260 210 238	256 199 210	248 172 199	243 157 171	236 142 155	229 129 141	225 124 135	220 117 130	215 111 124	210 106 118	201 98 115
		2	T ₁ L ₂					290 535 599	278 523 599	277 494 567	275 444 516	274 416 467	272 385 435	260 325 375	263 295 343	258 253 299	246 206 236	240 199 224	233 186 219	230 186 216	225 176 209	218 163 199

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STEAM TRACING DATA
TRACER BONDED TO PIPE WITH HEAT TRANSFER CEMENT

				50 psig (298F) STEAM																		
INSULATION THICKNESS	TRACER SIZE (OD)	NUMBER OF TRACERS	SEE NOTE 1 BELOW	PROCESS LINE NOMINAL PIPE SIZE (APPLICABLE OD SIZES LISTED UNDER NOMINAL IPS)																		
				3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
				L ₁	L ₂	L ₁	L ₂	L ₁	L ₂	L ₁	L ₂	L ₁	L ₂	L ₁	L ₂	L ₁	L ₂	L ₁	L ₂	L ₁	L ₂	L ₁
1	3/8	1	T _{L₁} L ₂	235 134 150	282 128 144	276 113 126	273 107 120	267 97 109	265 96 107	259 87 98	252 80 97	251 79 89	242 72 80									
		2	T _{L₁} L ₂		295 201 225	292 175 196	289 165 185	285 149 167	284 146 164	290 133 149	276 120 135	274 119 134	269 107 120									
	5/8	1	T _{L₁} L ₂	295 357 400	292 333 374	287 299 335	284 287 321	280 259 291	278 255 285	277 229 257	271 227 255	265 201 236	256 177 199									
		2	T _{L₁} L ₂				296 449 503	293 403 452	291 395 443	288 354 396	287 350 392	283 308 345	278 268 300									
1 1/2	3/8	1	T _{L₁} L ₂	286 143 160	283 137 154	280 126 142	275 116 130	270 106 119	269 105 115	266 101 113	258 88 99	256 86 97	249 78 88	228 63 70	216 57 63	206 53 59	192 48 54	187 46 52	178 44 50	170 42 48	163 41 46	150 38 43
		2	T _{L₁} L ₂		295 215 241	292 197 220	290 180 202	287 164 183	285 161 181	283 154 173	279 134 151	277 118 147	273 92 132	260 82 103	252 75 92	245 67 84	236 65 75	232 61 73	225 58 69	219 56 65	213 54 62	202 51 58
	5/8	1	T _{L₁} L ₂	295 395 443	292 359 403	286 325 364	286 258 334	283 253 329	281 253 286	276 249 279	274 249 251	269 221 221	263 194 173	253 173 160	244 154 143	236 142 139	225 126 131	221 117 123	214 111 123	207 106 119	201 99 111	189 99 111
		2	T _{L₁} L ₂				296 492 531	294 465 521	292 457 512	290 385 443	288 384 431	285 344 396	281 303 339	275 261 293	270 231 259	263 211 236	258 187 210	253 169 202	251 159 178	246 159 170	242 151 165	233 138 155
	3/8	1	T _{L₁} L ₂	237 150 169	255 145 163	280 131 146	278 125 129	273 114 123	272 107 126	269 95 107	262 93 104	260 83 95	254 68 76	236 63 70	227 58 64	216 53 59	204 48 54	199 46 52	191 44 50	184 42 48	177 41 46	165 38 43
		2	T _{L₁} L ₂		295 225 255	293 203 226	291 198 225	288 176 197	287 173 194	284 165 183	281 145 163	277 141 158	273 128 143	267 103 113	258 92 103	252 83 93	243 74 83	240 67 80	235 64 76	229 61 72	224 58 68	214 56 65
	5/8	1	T _{L₁} L ₂	295 407 437	293 392 440	289 347 399	287 336 376	283 316 353	278 312 350	277 275 309	273 267 299	267 243 273	258 217 243	252 189 212	244 173 194	234 156 175	223 140 157	221 129 152	215 129 144	213 122 137	210 116 131	203 105 121
		2	T _{L₁} L ₂				296 527 591	294 495 555	293 457 546	290 427 479	289 414 464	287 373 421	283 333 372	278 267 292	274 251 281	269 233 261	264 208 233	261 200 224	257 187 210	253 177 198	250 163 189	242 154 172
2 1/2	3/8	1	T _{L₁} L ₂	258 137 176	265 135 170	262 134 154	279 123 135	273 120 133	274 113 133	271 101 126	265 98 113	263 90 110	258 73 101	242 67 82	232 64 75	224 59 68	213 54 62	209 50 58	202 48 55	195 46 53	188 44 50	177 43 49
		2	T _{L₁} L ₂		295 267 267	293 214 240	291 208 233	286 183 206	287 183 206	285 174 193	281 155 174	277 137 168	273 121 154	267 99 122	258 91 111	252 81 100	243 75 90	240 68 87	235 63 82	229 61 79	224 58 73	214 56 65
	5/8	1	T _{L₁} L ₂	295 427 478	293 209 458	290 364 409	287 353 393	283 323 368	284 293 329	280 253 293	278 260 317	275 235 292	270 203 264	262 186 228	257 166 208	249 152 189	241 132 165	238 126 155	233 122 148	227 116 141	222 113 130	212 106 120
		2	T _{L₁} L ₂				296 556 623	294 521 584	293 513 576	291 455 511	289 439 493	287 402 451	285 362 405	280 311 349	277 292 316	272 252 281	266 226 254	263 218 245	260 205 229	256 193 219	253 183 206	249 168 198
3	3/8	1	T _{L₁} L ₂	286 162 182	286 137 176	282 143 160	280 129 155	276 123 141	273 118 139	268 106 132	266 103 119	260 95 116	247 78 106	239 71 88	230 65 79	220 59 72	216 54 64	210 50 61	203 47 58	197 44 54	186 41 50	
		2	T _{L₁} L ₂		295 216 276	293 223 250	291 216 242	289 194 218	285 192 215	286 181 204	283 163 183	282 158 178	279 144 162	271 118 132	266 105 119	260 97 107	254 88 97	252 80 93	247 74 88	243 71 83	238 68 79	230 65 73
	5/8	1	T _{L₁} L ₂	296 443 496	293 223 474	290 380 426	287 347 414	283 317 389	284 299 365	280 277 345	278 277 335	275 279 310	270 247 279	262 226 272	257 208 272	249 182 221	241 152 176	238 166 196	233 158 181	227 151 179	222 143 171	212 134 160
		2	T _{L₁} L ₂				296 651	294 611	293 602	291 559	290 521	289 485	287 442	286 384	283 337	282 301	279 244	275 224	273 223	271 208	269 200	266 197



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INSULATION THICKNESS REQUIREMENTS

Service Designation T-13

STEAM TRACING DATA

TRACER BONDED TO PIPE WITH HEAT TRANSFER CEMENT

INSULATION THICKNESS	TRACER SIZE (OD)	NUMBER OF TRACERS	SEE NOTE ¹ BELOW	75 psig (320F) STEAM																					
				PROCESS LINE NOMINAL PIPE SIZE																					
				(APPLICABLE OD SIZES LISTED UNDER NOMINAL IPS)																					
				3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24			
1	3/8	1	T L ₁ L ₂	308 162 180	304 155 173	298 136 152	294 130 144	288 118 131	266 116 129	279 106 118	272 97 107	270 98 107	261 98 107												
		2	T L ₁ L ₂		318 243 270	314 211 235	311 200 223	307 180 200	306 177 197	302 161 179	297 145 162	296 145 161	290 129 144												
	5/8	1	T L ₁ L ₂	318 431 480	314 404 449	310 361 402	306 347 386	301 314 349	300 308 343	294 278 309	292 275 306	285 244 271	276 214 238												
		2	T L ₁ L ₂					319 543 604	316 488 543	314 478 531	311 428 478	309 423 471	305 372 414	300 324 361											
1 1/2	3/8	1	T L ₁ L ₂	309 173 192	306 166 185	301 153 170	297 141 157	292 129 143	290 127 141	287 122 135	279 107 119	276 105 117	268 95 106	246 76 84	233 68 76	222 64 71	207 58 64	193 54 60	184 51 57	176 50 55	162 47 52				
		2	T L ₁ L ₂		318 260 289	315 238 265	312 218 242	309 198 220	308 195 217	305 187 207	298 163 191	296 159 177	290 143 159	283 111 124	273 99 110	263 91 101	255 88 91	243 82 88	239 78 82	231 75 78	224 70 75	217 62 69	205 59 66		
	5/8	1	T L ₁ L ₂	318 478 532	315 435 483	311 393 437	308 379 422	305 355 401	303 309 343	298 301 335	296 271 301	290 240 267	283 209 233	273 187 208	263 172 192	255 155 172	243 150 167	239 141 157	231 135 150	224 129 143	217 120 133	205 109 120			
		2	T L ₁ L ₂					319 595 662	316 562 625	315 553 615	312 478 531	310 465 517	307 417 463	303 366 407	297 316 351	291 279 310	285 255 284	278 226 252	275 218 242	270 204 227	265 193 214	261 183 204	252 168 186		
2	3/8	1	T L ₁ L ₂	310 182 202	307 176 195	302 158 176	300 135 153	294 138 151	293 136 144	290 130 142	283 115 125	281 112 121	274 102 114	255 82 92	245 76 84	235 69 77	220 63 70	215 58 65	207 53 60	199 50 56	192 47 53	178 40 46			
		2	T L ₁ L ₂		318 275 306	315 246 274	313 240 267	310 213 233	309 210 221	307 199 216	303 176 190	301 171 182	297 154 172	285 122 136	279 111 124	271 100 111	262 90 97	259 87 91	253 82 86	247 77 81	242 74 78	231 68 72	219 60 66		
	5/8	1	T L ₁ L ₂	318 493 548	315 475 528	312 420 467	309 406 452	306 383 426	305 378 420	300 333 370	298 323 359	294 263 327	288 229 292	279 209 235	273 188 210	263 170 189	253 164 183	249 155 173	242 148 164	236 141 157	230 131 145	219 119 131			
		2	T L ₁ L ₂					319 639 709	317 599 666	315 590 655	313 517 575	311 501 557	309 454 505	305 403 448	300 348 387	295 315 351	290 282 313	284 251 279	282 242 269	277 227 252	273 214 238	269 203 226	261 186 207		
2 1/2	3/8	1	T L ₁ L ₂	310 190 211	307 184 204	303 166 185	301 152 162	296 145 160	295 144 152	292 136 146	286 123 136	284 119 132	278 109 121	261 88 98	252 81 90	241 74 82	230 67 75	226 65 73	218 62 69	210 59 66	203 56 64	191 53 59			
		2	T L ₁ L ₂		318 298 320	316 259 298	314 251 279	311 225 250	310 222 247	308 210 234	304 188 209	303 182 202	299 166 194	289 132 146	283 120 133	277 108 120	269 97 108	266 94 105	261 89 99	255 84 93	250 80 89	241 74 82	231 68 76		
	5/8	1	T L ₁ L ₂	318 516 574	316 495 550	312 441 490	310 429 476	307 403 448	306 395 442	302 354 394	300 342 381	296 315 350	291 291 316	283 247 274	277 225 250	269 203 226	260 184 204	257 178 198	251 168 187	245 159 177	240 152 169	229 141 157			
		2	T L ₁ L ₂					319 672 748	317 630 701	316 621 691	313 551 613	312 532 591	310 487 541	307 438 487	302 376 418	298 341 379	294 305 340	288 274 305	286 264 294	283 248 275	279 234 260	275 227 252	268 203 226		
3	3/8	1	T L ₁ L ₂	311 196 219	308 190 211	304 173 192	302 168 187	298 152 169	294 142 158	289 129 143	286 125 139	281 115 127	267 95 105	258 86 95	248 78 87	237 72 80	224 66 73	219 63 70	213 60 67	201 56 63	191 53 59				
		2	T L ₁ L ₂		318 298 332	316 270 300	314 261 290	311 235 261	310 232 255	308 220 244	305 198 220	304 192 214	292 175 194	287 142 158	281 128 142	274 115 128	271 104 116	266 99 112	262 96 106	257 93 100	252 90 95	247 86 91	238 79 88		
	5/8	1	T L ₁ L ₂	318 535 595	316 512 569	313 450 511	310 447 497	308 420 467	307 415 462	303 381 415	301 402 437	298 372 402	294 335 366	287 266 296	280 241 266	273 219 241	266 211 236	263 206 231	257 199 224	252 189 214	247 181 206	238 167 191			
		2	T L ₁ L ₂					319 702 791	317 658 732	316 649 722	314 581 646	313 562 625	311 519 577	309 465 517	304 408 454	300 364 405	296 327 363	292 295 329	290 284 316	286 267 296	283 252 280	279 239 266	275 219 243		



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INSULATION THICKNESS REQUIREMENTS

Service Designation T-14

**STEAM TRACING DATA
TRACER BONDED TO PIPE WITH HEAT TRANSFER CEMENT**

				200 psig (388 F) STEAM																			
INSULATION THICKNESS	TRACER SIZE (OD)	NUMBER OF TRACERS	SEE NOTE 1 BELOW	PROCESS LINE NOMINAL PIPE SIZE (APPLICABLE OD SIZES LISTED UNDER NOMINAL IPS)																			
				3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	
				T _{L1}	T _{L2}	T _{L1}	T _{L2}	T _{L1}	T _{L2}	T _{L1}	T _{L2}	T _{L1}	T _{L2}	T _{L1}	T _{L2}	T _{L1}	T _{L2}	T _{L1}	T _{L2}	T _{L1}	T _{L2}	T _{L1}	T _{L2}
1	3/8	1	T _{L1}	372	368	361	356	348	346	338	329	328	316										
		T _{L2}	263	252	221	211	191	188	172	157	156	141											
	5/8	1	T _{L1}	385	380	375	371	365	363	356	354	346	335										
		T _{L2}	287	275	242	230	208	205	188	171	170	154											
1 1/2	3/8	1	T _{L1}	374	370	365	359	353	351	347	338	335	325	299	283	270	252	246	235	224	215	198	
		T _{L2}	280	270	248	229	209	206	198	174	170	154	123	111	104	94	92	87	84	81	76		
	5/8	1	T _{L1}	385	381	376	373	369	367	361	358	352	343	331	319	309	295	290	281	272	264	249	
		T _{L2}	287	277	255	236	216	213	205	181	177	161	130	118	111	101	99	95	91	88	83		
2	3/8	1	T _{L1}	373	371	366	363	356	355	351	343	340	332	309	297	283	267	262	252	242	233	217	
		T _{L2}	295	285	257	251	224	221	211	187	182	166	134	123	112	102	99	95	90	87	82		
	5/8	1	T _{L1}	385	382	379	375	374	371	366	364	359	346	338	329	318	314	307	300	293	281		
		T _{L2}	295	285	257	251	224	221	211	187	182	166	134	123	112	102	99	95	90	87	82		
2 1/2	3/8	1	T _{L1}	375	372	367	364	359	357	353	347	344	337	316	306	293	279	274	265	256	248	232	
		T _{L2}	308	298	270	262	236	233	221	199	193	177	143	132	120	110	107	101	97	93	87		
	5/8	1	T _{L1}	385	382	378	375	372	370	365	363	359	353	343	333	326	316	312	304	297	291	278	
		T _{L2}	308	298	270	262	236	233	221	199	193	177	143	132	120	110	107	101	97	93	87		
3	3/8	1	T _{L1}	376	373	368	366	360	359	356	349	347	340	323	312	301	288	284	275	267	259	245	
		T _{L2}	318	309	281	272	246	244	231	209	204	186	154	139	127	116	113	107	102	98	92		
	5/8	1	T _{L1}	385	382	378	375	372	371	367	365	361	356	347	340	331	322	319	312	306	300	288	
		T _{L2}	318	309	281	272	246	244	231	209	204	186	154	139	127	116	113	107	102	98	92		

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-15
T-16
T-17TEMPERATURE MAINTENANCE IN CEMENTED STEAM TRACED STORAGE VESSELS
TRACER BONDED TO VESSEL WITH HEAT TRANSFER CEMENT1" THICK SPEC. NO. 22-H, 23-H
-20°F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	132	154	185	208	217	220
25	140	168	205	230	240	244
50	150	186	227	256	268	274
100	65	210	257	288	302	311
150	175	226	275	311	328	337
200	185	241	289	331	347	357

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 1/2" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	140	165	195	214	220	223
25	150	183	215	238	244	245
50	162	202	238	265	273	276
100	180	227	271	298	310	314
150	195	245	290	323	336	341
200	205	259	306	342	356	362

1" THICK SPEC. NO. 22-H, 23-H
0° F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	135	160	191	212	219	222
25	144	178	211	235	243	245
50	155	197	233	262	272	275
100	174	221	266	293	307	312
150	185	239	284	318	332	339
200	195	253	298	338	352	360

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 1/2" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	144	171	200	217	222	224
25	155	190	221	241	245	246
50	170	211	244	268	275	278
100	192	237	277	302	312	316
150	206	255	298	328	339	343
200	217	269	316	347	360	365

1" THICK SPEC. NO. 22-H, 23-H
30° F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	145	171	205	217	222	223
25	155	190	221	242	245	245
50	172	210	245	269	275	278
100	193	238	278	303	313	316
150	208	257	298	329	340	343
200	221	270	316	349	360	364

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 1/2" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	153	183	207	220	223	
25	168	203	230	245	245	
50	185	225	255	275	277	
100	210	255	288	310	316	
150	227	274	312	337	343	
200	241	287	341	357	365	

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Service Designation T-18

T-19

T-20

**TEMPERATURE MAINTENANCE IN CEMENTED STEAM TRACED STORAGE VESSELS
TRACER BONDED TO VESSEL WITH HEAT TRANSFER CEMENT**1" THICK SPEC. NO. 22-H, 23-H
50° F AMBIENT TEMPERATURE**TEMPERATURE MAINTAINED ° F**

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	150	181	205	219	223	225
25	163	202	227	243	245	248
50	180	223	252	272	277	282
100	203	252	284	308	314	320
150	218	271	306	334	342	347
200	232	284	326	353	363	370

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 1/2" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	162	192	213	222	225	227
25	180	212	236	245	248	250
50	199	235	263	275	281	285
100	222	267	295	313	319	324
150	240	286	320	340	346	351
200	255	301	340	361	368	375

1-1/2" THICK SPEC. 22-H, 23-H
-20° F AMBIENT TEMPERATURE**TEMPERATURE MAINTAINED ° F**

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	32	168	197	217	223	225
25	150	190	220	243	250	251
50	165	212	245	269	275	276
100	187	235	277	304	315	318
150	200	254	299	332	343	348
200	215	272	317	349	362	369

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 1/2" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	145	181	206	222	225	227
25	168	203	230	248	251	253
50	184	225	255	275	276	278
100	205	251	288	312	318	320
150	220	271	312	340	348	350
200	242	288	330	358	368	372

1-1/2" THICK SPEC. 22-H, 23-H
0° F AMBIENT TEMPERATURE**TEMPERATURE MAINTAINED ° F**

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	140	175	202	219	224	226
25	163	196	225	246	251	252
50	180	218	250	272	276	277
100	202	242	283	308	317	319
150	217	262	306	336	346	349
200	240	280	324	354	366	370

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 1/2" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	150	186	210	223	225	227
25	173	208	234	250	252	253
50	190	232	260	275	277	278
100	212	260	293	315	318	321
150	227	282	319	343	348	350
200	250	298	336	362	370	373

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INSULATION THICKNESS REQUIREMENTS

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T-22
T-23TEMPERATURE MAINTENANCE IN CEMENTED STEAM TRACED STORAGE VESSELS
TRACER BONDED TO VESSEL WITH HEAT TRANSFER CEMENT1- $\frac{1}{2}$ " THICK SPEC. 22-H, 23-H
30° F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	155	185	210	223	225	227
25	176	208	233	249	251	253
50	194	230	260	266	277	279
100	215	260	293	314	320	320
150	232	280	318	343	350	350
200	253	297	335	362	370	374

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With $\frac{1}{2}$ " O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	167	191	215	225	227	
25	190	218	240	250	253	
50	211	243	267	277	279	
100	234	275	302	318	320	
150	252	296	328	347	350	
200	271	314	347	368	373	

1- $\frac{1}{2}$ " THICK SPEC. 22-H, 23-H
50° F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	160	192	213	224	227	229
25	182	215	238	250	252	255
50	201	238	265	276	277	280
100	224	268	299	317	320	324
150	241	290	325	346	349	351
200	260	312	342	366	371	374

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With $\frac{1}{2}$ " O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	175	202	219	225	229	230
25	196	225	245	252	255	255
50	217	250	272	277	280	281
100	242	282	312	318	323	324
150	262	305	335	348	351	351
200	280	322	353	370	374	375

2" THICK SPEC. 22-H, 23-H
-20° F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	155	187	208	223	228	229
25	170	207	232	248	254	256
50	190	229	257	276	280	281
100	220	260	290	312	318	320
150	235	277	316	337	343	346
200	255	293	333	358	366	370

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With $\frac{1}{2}$ " O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	170	196	215	227	229	230
25	184	218	239	253	255	257
50	209	241	267	278	280	282
100	235	272	300	316	320	322
150	250	294	326	342	346	350
200	268	310	344	364	369	373

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Service Designation T-24
T-25
T-26TEMPERATURE MAINTENANCE IN CEMENTED STEAM TRACED STORAGE VESSELS
TRACER BONDED TO VESSEL WITH HEAT TRANSFER CEMENT2" THICK SPEC. 22-H, 23-H
0° F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	160	190	212	225	228	229
25	175	210	235	250	255	256
50	200	233	265	277	280	282
100	225	263	294	314	318	320
150	240	282	321	338	345	347
200	260	297	338	361	367	371

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 1/2" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	175	199	217	227	229	230
25	190	222	242	254	256	257
50	215	245	270	279	282	283
100	242	277	303	317	320	323
150	258	298	329	342	347	351
200	274	316	348	366	370	375

2" THICK SPEC. 22-H, 23-H
30° F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	172	196	215	227	229	230
25	186	217	241	253	255	257
50	211	242	268	280	280	283
100	239	273	300	317	320	323
150	255	296	327	342	347	350
200	272	311	346	365	370	373

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 1/2" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	182	205	221	229	230	
25	200	227	246	255	257	
50	224	253	274	280	283	
100	253	285	308	320	322	
150	272	311	334	345	350	
200	287	327	354	369	373	

2" THICK SPEC. 22-H, 23-H
50° F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	177	201	218	228	229	230
25	195	223	243	254	256	257
50	217	247	271	279	282	284
100	245	280	305	318	321	324
150	262	303	330	343	348	352
200	278	320	350	367	371	375

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 1/2" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	187	208	223	229	229	232
25	208	232	249	256	257	259
50	230	257	276	280	282	286
100	260	290	312	320	321	326
150	278	316	337	346	348	354
200	294	333	358	370	372	377

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T-28**TEMPERATURE MAINTENANCE IN CEMENTED STEAM TRACED STORAGE VESSELS
TRACER BONDED TO VESSEL WITH HEAT TRANSFER CEMENT**3" THICK SPEC. 22-H, 23-H
30° F AMBIENT TEMPERATURE**TEMPERATURE MAINTAINED ° F**

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	192	206	221	230	230	232
25	204	224	245	260	260	262
50	231	255	276	285	287	288
100	261	287	313	325	327	329
150	280	312	338	350	353	355
200	298	330	356	372	375	378
250	322	345	374	390	392	395

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 1/2" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	197	212	226	230	232	
25	210	232	252	260	262	
50	240	264	280	286	288	
100	271	299	317	325	329	
150	293	325	343	351	355	
200	310	342	362	373	378	
250	325	358	380	391	395	

3" THICK SPEC. 22-H, 23-H
50° F AMBIENT TEMPERATURE**TEMPERATURE MAINTAINED ° F**

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	194	209	223	230	231	232
25	208	227	248	259	260	262
50	235	259	277	286	287	289
100	263	292	314	325	327	329
150	281	317	340	350	353	356
200	300	335	358	372	376	379
250	315	350	375	389	392	395

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 1/2" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	199	215	227	231	232	234
25	214	235	255	260	262	264
50	245	267	282	287	288	291
100	272	303	319	326	329	330
150	295	330	345	352	356	358
200	312	346	365	374	379	381
250	326	362	383	391	395	397

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T-30**TEMPERATURE MAINTENANCE IN CEMENTED STEAM TRACED STORAGE VESSELS
TRACER BONDED TO PIPE WITH HEAT TRANSFER CEMENT**3" THICK SPEC. 22-H, 23-H
-20° F AMBIENT TEMPERATURE**TEMPERATURE MAINTAINED ° F**

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	185	201	217	228	230	231
25	200	217	238	257	260	260
50	220	249	270	283	286	287
100	255	277	307	321	325	327
150	270	300	333	347	351	353
200	290	318	350	367	373	375
250	302	332	366	385	390	392

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 1/2" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	191	207	222	230	231	232
25	206	225	246	260	260	261
50	227	257	276	285	287	289
100	260	289	313	325	327	329
150	276	315	339	350	353	355
200	296	331	357	372	375	378
250	310	347	374	390	392	395

3" THICK SPEC. 22-H, 23-H
0° F AMBIENT TEMPERATURE**TEMPERATURE MAINTAINED ° F**

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	187	203	218	229	230	232
25	202	220	240	258	260	260
50	222	251	272	284	287	287
100	257	280	309	322	325	328
150	272	305	335	348	352	354
200	292	322	353	369	373	376
250	304	336	370	387	390	393

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 1/2" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	194	210	223	230	231	232
25	208	228	248	260	260	262
50	234	260	277	286	287	289
100	264	293	315	325	327	330
150	282	320	340	351	353	357
200	300	336	359	372	376	380
250	315	352	376	390	392	395



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
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INSULATION THICKNESS REQUIREMENTS

Service Designation T-32

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT
PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

1-1/2" NOMINAL INSULATION THICKNESS											PIPE SIZE											AMBIENT AIR TEMP -20.0 F (-28.3 C)			
CABLE TEMP DEG F		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24					
4C	PIPE TEMP	56.1	55.8	55.0	46.3	53.6	53.2	51.3	51.1	49.3	47.0	42.8	39.1	35.7	32.4	30.9	28.4	26.7	24.8	21.6					
	MAX. W. F/FT	2.8	2.9	3.3	3.7	3.9	4.1	5.0	5.2	6.2	7.3	9.0	10.4	11.5	13.0	13.6	14.6	15.4	16.4	18.2					
	MIN. W. F/FT	2.6	2.8	3.1	3.5	3.7	3.8	4.6	4.8	5.8	6.6	8.2	9.7	11.0	12.4	13.0	14.1	15.0	15.8	17.3					
4C	PIPE TEMP	75.0	74.6	73.7	72.7	71.6	71.3	69.1	68.7	66.4	63.5	58.3	53.6	49.3	45.1	43.3	40.4	38.1	35.6	31.7					
	MAX. W. F/FT	3.5	3.7	4.2	4.8	5.0	5.2	6.4	6.7	7.9	9.2	11.4	13.2	14.5	16.4	17.2	18.7	19.9	21.0	22.9					
	MIN. W. F/FT	3.4	3.6	4.0	4.5	4.7	4.9	5.9	6.2	7.2	8.3	10.4	12.2	13.9	15.6	16.4	17.8	18.9	19.9	21.7					
10C	PIPE TEMP	93.8	93.3	92.2	91.0	90.0	89.4	86.7	86.2	83.4	79.9	73.6	67.9	62.8	57.7	55.4	52.2	49.4	46.4	41.7					
	MAX. W. F/FT	4.4	4.6	5.2	5.9	6.2	6.4	7.8	8.2	9.6	11.3	13.9	16.0	17.6	19.9	20.8	22.6	24.1	25.3	27.7					
	MIN. W. F/FT	4.1	4.3	4.9	5.5	5.8	6.0	7.2	7.5	8.7	10.2	12.6	14.8	16.8	18.9	19.8	21.5	22.9	24.0	26.2					
12C	PIPE TEMP	112.6	112.1	110.7	109.3	108.1	107.4	104.2	103.6	100.4	96.2	88.8	82.2	76.2	70.2	67.8	63.8	60.5	57.1	51.6					
	MAX. W. F/FT	5.2	5.4	6.2	7.0	7.4	7.6	9.3	9.7	11.4	13.4	16.4	18.9	20.8	23.4	24.5	26.6	28.3	29.8	32.5					
	MIN. W. F/FT	4.9	5.1	5.8	6.5	6.9	7.1	8.5	8.9	10.4	12.0	14.9	17.5	19.8	22.3	23.3	25.2	26.9	28.2	30.8					
14C	PIPE TEMP	131.3	130.7	129.1	127.5	126.1	125.3	121.6	121.0	117.2	112.4	103.9	96.4	89.4	82.6	80.0	75.3	71.6	67.7	61.4					
	MAX. W. F/FT	6.1	6.4	7.2	8.2	8.6	8.9	10.9	11.3	13.3	15.6	19.0	21.8	24.0	27.1	28.2	30.7	32.6	34.2	37.3					
	MIN. W. F/FT	5.8	6.0	6.8	7.6	8.0	8.3	10.0	10.4	12.0	14.0	17.2	20.2	22.9	25.7	26.8	29.1	30.9	32.4	35.4					
16C	PIPE TEMP	148.9	148.4	147.5	146.4	145.0	144.2	138.9	138.3	134.0	128.5	119.0	110.4	102.6	94.8	92.0	86.7	82.5	78.2	71.2					
	MAX. W. F/FT	7.0	7.4	8.3	9.4	9.9	10.2	12.5	12.9	15.2	17.8	21.7	24.6	27.5	30.7	32.0	34.6	37.0	38.4	42.3					
	MIN. W. F/FT	6.6	6.9	7.8	8.7	9.2	9.5	11.4	11.8	13.7	15.9	19.6	22.9	25.9	29.2	30.4	32.9	35.0	36.7	40.0					
18C	PIPE TEMP	168.6	167.9	165.9	163.7	161.9	161.0	156.2	155.5	150.7	144.5	133.9	124.4	115.7	107.0	103.9	98.0	93.4	88.6	80.8					
	MAX. W. F/FT	8.0	8.4	9.4	10.7	11.2	11.5	14.1	14.6	17.2	20.1	24.4	27.9	30.6	34.5	35.8	38.9	41.4	43.4	47.2					
	MIN. W. F/FT	7.5	7.9	8.8	9.9	10.4	10.7	12.9	13.4	15.5	17.9	22.0	25.7	29.1	32.7	34.0	36.8	39.1	41.0	44.7					
20C	PIPE TEMP	187.1	186.4	184.1	181.7	179.8	178.8	173.4	172.6	167.3	160.5	148.7	138.2	128.7	119.0	115.7	109.2	104.2	98.9	90.4					
	MAX. W. F/FT	9.0	9.4	10.6	12.0	12.4	12.9	15.8	16.3	19.2	22.4	27.2	31.0	33.9	38.3	39.7	43.1	45.8	48.0	52.2					
	MIN. W. F/FT	8.5	8.9	9.9	11.1	11.7	11.9	14.4	14.9	17.3	20.0	24.4	28.6	32.3	36.3	37.6	40.8	43.3	45.4	49.4					
22C	PIPE TEMP	205.6	204.9	202.4	199.6	197.5	196.5	190.5	189.7	183.6	176.3	163.5	152.0	141.6	131.0	127.4	120.4	114.8	109.1	99.9					
	MAX. W. F/FT	10.0	10.4	11.8	13.3	14.0	14.3	17.6	18.1	21.3	24.8	30.0	34.2	37.4	42.1	43.7	47.4	50.3	52.7	57.3					
	MIN. W. F/FT	9.4	9.8	11.0	12.3	12.9	13.2	16.0	16.5	19.1	22.1	27.0	31.4	35.5	39.9	41.3	44.8	47.6	49.8	54.1					
24C	PIPE TEMP	224.1	223.3	220.5	217.5	215.2	214.1	207.5	206.7	200.3	192.1	178.1	165.4	154.3	142.8	139.1	131.4	125.4	119.3	109.3					
	MAX. W. F/FT	11.1	11.5	13.0	14.7	15.4	15.8	19.4	19.9	23.4	27.3	32.9	37.5	40.8	46.0	47.7	51.7	54.9	57.4	62.4					
	MIN. W. F/FT	10.4	10.8	12.1	13.6	14.3	14.6	17.6	18.1	20.9	24.2	29.5	34.6	38.8	43.8	45.1	48.9	51.8	54.3	58.9					
26C	PIPE TEMP	242.5	241.4	238.6	235.3	232.9	231.7	224.5	223.6	216.7	207.8	197.7	179.2	167.0	154.5	150.6	142.3	135.9	129.3	118.6					
	MAX. W. F/FT	12.2	12.7	14.3	16.2	16.9	17.3	21.2	21.6	25.6	29.8	35.9	40.8	44.4	50.0	51.7	56.1	59.5	62.2	67.4					
	MIN. W. F/FT	11.5	11.9	13.3	15.2	15.6	15.9	19.2	19.6	22.9	26.4	32.1	37.4	42.1	47.3	48.9	53.0	56.3	58.7	63.8					
28C	PIPE TEMP	260.8	260.0	256.7	253.1	250.4	249.2	241.4	240.5	233.0	223.4	207.2	192.7	179.4	166.2	162.1	153.2	146.4	139.3	127.9					
	MAX. W. F/FT	13.4	13.9	15.6	17.7	18.4	18.8	23.1	23.7	27.8	32.4	38.9	44.1	47.9	54.0	55.8	60.5	64.1	67.2	72.8					
	MIN. W. F/FT	12.5	12.9	14.5	16.2	17.0	17.3	20.9	21.5	24.8	28.7	34.7	40.4	45.5	51.0	52.7	57.1	60.5	63.3	68.6					
30C	PIPE TEMP	279.1	278.7	274.7	270.8	268.0	266.7	258.2	257.3	249.7	238.9	221.6	208.1	192.2	177.7	173.5	164.0	156.7	149.2	137.0					
	MAX. W. F/FT	14.6	15.0	17.0	19.2	20.0	20.4	25.1	25.6	30.1	35.0	42.0	47.5	51.6	58.1	59.9	65.0	68.6	72.0	78.0					
	MIN. W. F/FT	13.6	14.0	15.7	17.6	18.4	18.7	22.6	23.3	26.8	30.9	37.4	43.5	48.9	54.6	56.6	61.3	64.9	67.9	73.6					
35C	PIPE TEMP	324.7	323.7	319.5	314.8	310.1	307.0	299.0	298.6	289.6	277.4	257.2	239.2	223.1	208.2	201.5	190.5	182.2	173.5	159.7					
	MAX. W. F/FT	17.7	18.2	20.5	23.0	24.0	24.4	30.1	30.7	36.0	41.8	49.4	56.3	60.4	68.5	70.5	76.4	80.8	84.4	91.3					
	MIN. W. F/FT	16.5	16.9	19.1	21.2	22.1	22.4	27.0	27.6	31.9	36.8	44.3	51.3	57.6	64.6	66.5	71.9	76.1	79.5	86.0					
40C	PIPE TEMP	370.0	368.9	364.0	359.5	354.8	353.2	341.4	340.4	329.5	315.5	292.4	271.6	253.4	234.1	229.1	216.6	207.1	197.4	181.8					
	MAX. W. F/FT	21.0	21.4	24.3	27.4	28.4	28.8	35.5	36.0	42.2	48.9	58.1	65.3	70.4	79.2	81.3	88.0	93.1	97.1	104.9					
	MIN. W. F/FT	19.5	20.0	22.3	25.0	26.0	26.3	31.7	32.5	37.2	42.8	51.4	59.6	64.5	74.5	76.6	82.8	87.5	91.3	98.7					
45C	PIPE TEMP	415.0	413.9	408.2	403.9	397.7	396.1	382.4	381.4	364.0	353.1	327.1	303.9	283.3	261.6	256.2	242.1	231.7	220.9	203.6					
	MAX. W. F/FT	24.5	25.1	28.2	31.9	32.9	33.3	41.1	41.6	48.7	56.3	66.6	74.7	80.2	90.2	92.4	100.0	105.4	110.1	118.8					
	MIN. W. F/FT	22.7	23.2	25.8	28.9	30.0	30.3	36.5	37.3	42.9	49.1	58.8	67.7	73.7	84.7	86.9	93.9	99.1	103.3	111.5					
50C	PIPE TEMP	454.8	453.4	447.2	443.0	436.6	435.0	423.1	422.2	408.2	390.4	361.4	335.6	312.4	289.6	282.8	267.3	255.8	244.0	225.0					
	MAX. W. F/FT	28.2	28.7	32.4	36.4	37.4	37.8	46.9	47.4	55.4	64.0	75.5	84.3	90.1	101.4	103.4	112.2	118.4	123.3	132.8					
	MIN. W. F/FT	26.0	26.4	29.5	33.0	34.0	34.3	41.5	42.4	48.5	55.6	66.3	76.3	83.1	95.1	97.5	105.2	111.0	115.6	124.6					
55C	PIPE TEMP	504.3	503.1	495.9	491.9	484.8	483.2	473.4	472.5	457.3	437.3	395.4	366.9	341.8	315.1	309.1	292.0	279.5	266.6	246.0					
	MAX. W. F/FT	32.1	32.7	36.8	41.5	42.6	42.9	53.0	53.4	62.4	72.0	84.5	94.2	100.6	112.9	114.4	124.6	131.4	136.7	147.1					
	MIN. W. F/FT	29.5	30.0	33.4	37.3	38.4	38.7	46.7	47.6	54.4	62.2	74.0	85.0	94.6	105.8	108.2	118.7	125.0	129.6	139.3					
60C	PIPE TEMP	548.7	547.4	539.5	535.5	528.0	526.0	503.7	502.8	485.7	464.0	429.0	397.6	370.5	341.3	334.9	316.4	302.9	289.0	266.7					
	MAX. W. F/FT	36.2	36.7	41.4	46.4	47.7	48.0	59.3	59.6	69.6															



STANDARD

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INSULATION DESIGN
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INSULATION THICKNESS REQUIREMENTS

Service Designation T-33

ELECTRIC HEAT TRACING -
MI CABLE - BONDED TO PIPE WITH HEAT TRANSFER CEMENT
PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

2" NOMINAL INSULATION THICKNESS		PIPE SIZE																AMBIENT AIR TEMP-20.0 F (-28.9 C)			
CABLE TEMP DEG F		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	
4C	PIPE TEMP	56.2	56.0	55.6	54.8	54.1	53.7	52.3	51.9	50.3	46.3	44.5	41.4	38.2	35.2	33.9	31.7	30.5	28.1	25.0	
	PAR.W /FT	2.6	2.8	2.8	3.3	3.6	3.7	4.5	4.7	5.5	6.4	7.9	8.8	10.2	11.5	12.1	13.1	14.1	14.8	16.3	
	PI.N.W /FT	2.5	2.6	2.7	3.2	3.4	3.5	4.2	4.4	5.1	5.9	7.4	8.5	9.8	11.0	11.6	12.6	13.5	14.2	15.7	
6C	PIPE TEMP	75.2	74.9	74.4	73.3	72.4	72.0	70.1	69.7	67.7	65.1	60.4	56.5	52.5	48.7	47.1	44.4	42.2	39.9	36.0	
	PAR.W /FT	3.4	3.5	3.6	4.3	4.6	4.8	5.7	6.0	6.8	8.1	10.0	11.2	12.9	14.5	15.2	16.6	17.7	18.7	20.5	
	PI.N.W /FT	3.2	3.4	3.5	4.0	4.3	4.5	5.3	5.6	6.4	7.5	9.3	10.8	12.4	13.9	14.6	15.9	17.0	17.9	19.7	
10C	PIPE TEMP	94.0	93.4	93.2	91.8	90.7	90.2	87.9	87.4	85.1	81.9	76.2	71.5	66.7	62.1	60.2	57.0	54.3	51.5	46.9	
	PAR.W /FT	4.1	4.3	4.4	5.2	5.6	5.8	7.0	7.3	8.5	9.9	12.1	13.6	15.6	17.6	18.4	20.0	21.4	22.6	24.8	
	PI.N.W /FT	3.9	4.1	4.2	4.9	5.3	5.5	6.5	6.8	7.9	9.1	11.3	13.1	15.0	16.9	17.7	19.2	20.5	21.6	23.7	
12C	PIPE TEMP	112.9	112.4	111.8	110.2	109.0	108.4	105.7	105.0	102.3	98.6	91.9	86.5	80.8	75.4	73.2	69.5	66.4	63.1	57.8	
	PAR.W /FT	4.5	5.7	5.3	6.2	6.7	6.9	8.3	8.7	10.0	11.7	14.3	16.0	18.4	20.7	21.6	23.5	25.1	26.5	29.1	
	PI.N.W /FT	4.7	4.9	5.0	5.9	6.3	6.5	7.7	8.1	9.3	10.8	13.3	15.4	17.7	19.9	20.8	22.6	24.1	25.4	27.9	
14C	PIPE TEMP	131.4	131.1	130.5	128.6	127.2	126.5	123.3	122.6	119.5	115.2	107.5	101.3	94.8	88.5	86.2	81.9	78.3	74.6	68.5	
	PAR.W /FT	5.8	6.7	6.1	7.3	7.8	8.0	9.6	10.1	11.6	13.5	16.8	18.5	21.2	23.9	24.9	27.1	28.9	30.5	33.4	
	PI.N.W /FT	5.5	5.7	5.9	6.8	7.4	7.6	9.0	9.4	10.8	12.5	15.4	17.8	20.4	22.9	23.9	26.0	27.7	29.2	32.0	
16C	PIPE TEMP	150.4	149.8	149.1	146.9	145.3	144.6	141.0	140.2	136.6	131.8	123.1	116.1	108.7	101.6	99.0	94.2	90.2	86.0	79.2	
	PAR.W /FT	6.6	8.7	7.0	8.3	8.9	9.2	11.0	11.5	13.3	15.5	18.8	21.0	24.0	27.1	28.2	30.7	32.8	34.5	37.8	
	PI.N.W /FT	6.3	6.4	6.7	7.9	8.4	8.7	10.2	10.8	12.3	14.2	17.5	20.2	23.1	26.0	27.1	29.4	31.4	33.0	36.2	
18C	PIPE TEMP	169.1	168.4	167.7	165.2	163.4	162.6	158.5	157.6	153.7	148.2	138.6	130.7	122.5	114.6	111.8	106.4	102.0	97.3	89.8	
	PAR.W /FT	7.5	7.9	8.0	9.4	10.1	10.4	12.4	13.0	15.0	17.4	21.2	23.5	26.9	30.4	31.6	34.4	36.7	38.4	42.4	
	PI.N.W /FT	7.2	7.4	7.6	8.9	9.5	9.8	11.6	12.1	13.8	16.0	19.7	22.7	25.9	29.1	30.3	32.9	35.1	36.9	40.4	
20C	PIPE TEMP	187.7	187.0	186.2	183.4	181.6	180.5	176.0	175.1	170.7	164.4	154.0	145.3	136.3	127.5	124.5	118.5	113.7	108.6	100.3	
	PAR.W /FT	8.5	8.7	8.9	10.4	11.1	11.4	13.9	14.5	16.7	19.4	23.6	26.1	29.9	33.7	35.2	38.1	40.4	42.7	46.7	
	PI.N.W /FT	8.0	8.3	8.5	9.9	10.7	10.9	12.9	13.5	15.4	17.8	21.9	25.2	28.7	32.3	33.6	36.5	38.6	40.8	44.7	
22C	PIPE TEMP	206.3	205.4	204.7	201.6	199.3	198.6	193.4	192.4	187.6	180.9	169.3	159.8	149.9	140.3	137.1	130.5	125.3	119.7	110.7	
	PAR.W /FT	9.5	9.9	9.9	11.8	12.4	12.9	15.4	16.1	18.5	21.5	26.0	28.8	32.9	37.1	38.5	41.8	44.6	46.8	51.2	
	PI.N.W /FT	8.9	9.3	9.4	11.0	11.8	12.1	14.3	15.0	17.0	19.7	24.1	27.7	31.6	35.5	36.9	40.0	42.6	44.8	49.0	
24C	PIPE TEMP	224.8	224.1	223.1	219.7	217.3	216.3	209.7	208.4	197.2	184.5	174.2	163.5	153.0	143.6	140.5	134.6	128.8	123.0	112.1	
	PAR.W /FT	10.5	10.9	10.9	13.0	13.7	14.1	17.0	17.6	20.3	23.4	28.5	31.5	35.4	40.5	42.0	45.4	48.4	51.4	55.8	
	PI.N.W /FT	9.5	10.7	10.4	12.2	13.0	13.3	15.7	16.4	18.7	21.6	26.4	30.3	34.5	38.8	40.2	43.6	46.4	48.6	53.3	
26C	PIPE TEMP	243.3	242.5	241.5	237.8	235.1	234.1	228.1	227.0	221.2	213.3	199.6	188.6	177.0	165.7	162.1	154.4	148.2	141.8	131.4	
	PAR.W /FT	11.5	11.9	12.0	14.2	15.2	15.5	18.6	19.3	22.2	25.7	31.0	34.2	39.0	44.0	45.5	49.5	52.6	55.3	60.4	
	PI.N.W /FT	10.9	11.7	11.3	13.3	14.2	14.5	17.2	17.9	20.6	23.5	28.7	32.9	37.4	42.1	43.6	47.3	50.3	52.8	57.7	
28C	PIPE TEMP	261.8	261.0	259.9	255.8	252.9	251.9	245.3	244.1	238.0	229.5	214.7	202.8	190.4	178.2	174.4	166.2	159.6	152.8	141.6	
	PAR.W /FT	12.6	13.0	13.0	15.3	16.5	16.8	20.2	20.9	24.1	27.9	33.4	37.0	42.1	47.5	49.1	53.4	56.8	59.4	65.0	
	PI.N.W /FT	11.8	12.7	12.3	14.5	15.5	15.7	18.7	19.4	22.1	25.3	31.0	35.5	40.4	45.4	47.0	51.0	54.2	56.9	62.1	
30C	PIPE TEMP	280.2	279.7	278.2	273.7	270.7	269.6	262.5	261.3	254.6	245.5	229.7	217.0	203.7	190.7	186.7	177.9	170.9	163.6	151.7	
	PAR.W /FT	13.7	14.1	14.1	16.6	17.9	18.2	21.9	22.7	26.0	30.1	36.2	39.8	45.3	51.0	52.7	57.3	60.9	63.9	69.7	
	PI.N.W /FT	12.9	13.7	13.4	15.7	16.8	17.0	20.2	21.0	23.8	27.5	33.4	38.2	43.4	48.8	50.4	54.7	58.1	61.0	66.5	
35C	PIPE TEMP	326.0	325.1	323.8	318.5	314.9	313.6	305.2	303.8	296.0	285.3	266.9	252.2	236.7	221.4	217.0	206.4	198.6	190.4	176.7	
	PAR.W /FT	16.6	17.0	17.0	20.2	21.5	21.8	26.2	27.1	31.1	35.9	42.9	47.0	53.4	60.1	62.0	67.3	71.5	74.9	81.6	
	PI.N.W /FT	15.5	16.0	16.0	18.9	20.1	20.3	24.1	25.0	28.4	32.8	39.5	45.1	51.1	57.4	59.2	64.2	68.2	71.5	77.8	
40C	PIPE TEMP	371.5	370.6	369.2	362.9	358.6	357.4	347.6	346.1	337.1	324.7	303.7	286.8	269.2	251.7	246.9	235.3	226.2	216.7	201.3	
	PAR.W /FT	19.6	20.1	20.0	23.9	25.3	25.6	30.8	31.7	36.3	41.8	49.9	54.5	61.8	69.5	71.5	77.6	82.3	86.2	93.7	
	PI.N.W /FT	18.4	18.4	18.9	22.2	23.6	23.8	28.2	29.2	33.1	38.0	45.8	52.2	59.1	68.2	69.2	73.9	76.4	80.1	89.3	
45C	PIPE TEMP	416.8	415.4	414.3	407.1	402.4	401.0	389.6	388.1	377.3	363.8	340.0	321.0	301.3	281.5	276.4	263.3	253.2	242.7	225.5	
	PAR.W /FT	22.9	23.4	23.2	27.7	29.4	29.6	35.3	36.3	41.8	48.1	57.1	62.2	70.4	79.1	81.3	88.1	93.3	97.7	106.1	
	PI.N.W /FT	21.4	21.6	21.8	25.7	27.2	27.4	32.5	33.6	38.0	43.5	52.4	59.5	67.2	75.3	77.4	83.8	88.8	92.9	100.9	
50C	PIPE TEMP	461.9	460.9	459.2	451.0	445.8	444.2	431.4	429.7	419.3	402.5	374.0	354.9	332.9	310.9	305.4	290.9	279.8	268.2	249.4	
	PAR.W /FT	26.4	26.8	26.6	31.7	33.4	33.7	40.5	41.6	47.9	55.4	66.4	70.1	80.8	91.2	93.4	100.4	104.6	109.4	118.7	
	PI.N.W /FT	24.5	25.0	24.9	29.3	31.0	31.2	36.9	38.1	43.0	49.2	59.1	67.0	75.4	84.6	86.8	93.9	99.5	104.0	112.8	
55C	PIPE TEMP	506.0	505.7	504.0	494.7	489.0	487.3	472.9	471.2	458.4	440.9	411.6	388.3	364.1	339.9	334.0	318.1	304.3	293.3	272.8	
	PAR.W /FT	30.0	30.4	30.1	35.9	37.7	38.0	45.7	46.8	53.4	61.3	72.3	78.2	88.2	99.0	101.4	109.8	116.1	121.3	131.4	
	PI.N.W /FT	27.6	28.7	28.1	33.0	34.9	35.1	41.5	42.8	48.2	55.1	66.0	74.7	84.1	94.0	96.4	104.2	110.3	115.2	124.8	
60C	PIPE TEMP	551.5	550.4	548.6	538.2	531.9	530.1	514.2	512.3	498.3	479.0	446.9	421.3	395.0	368.5	362.2	344.9	331.8	318.1	295.9	
	PAR.W /FT	33.7	34.7	34.7	40.2	42.2	42.5	51.0	52.2	59.5	68.2	80.2	86.5	97.5	109.2	111.8	120.9	127.8	133.5	144.4	
	PI.N.W /FT	31.2	31.7	31.4	36.9	38.9	39.1	46.2	47.6	53.6	61.2	73.0	82.4	92.8	103.7	106.2	114.7	121.3	126.6	137.0	
65C	PIPE TEMP	596.0	594.9	593.0	581.6	574.7	572.8	555.3	553.3	538.0	514.9	481.9	454.1	425.5	396.8	390.1	371.4	357.2	342.5	318.7	
	PAR.W /FT	37.6	38.7	37.5	44.7	46.8	47.1	56.5	57.7	65.4	75.3	86.3	95.0	104.9	119.7	122.4	132.4	138.5			



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III INSULATION DESIGN

PAGE 373

MAY, 1968

INSULATION THICKNESS REQUIREMENTS

Service Designation T-34

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

2-1/2" NOMINAL INSULATION THICKNESS		PIPE SIZE																AMBIENT AIR TEMP -20.0 F (-28.9 C)			
CABLE TEMP DEG F		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	
80	PIPE TEMP	56.3	56.7	55.9	55.1	54.4	54.1	52.8	52.4	51.1	49.3	45.8	43.0	40.1	37.4	36.2	34.2	32.5	30.8	27.8	
	MAX W / FT	2.4	2.4	2.6	3.1	3.3	3.5	4.1	4.3	4.9	5.7	7.1	8.0	9.2	10.4	10.9	11.9	12.7	13.6	14.9	
	MIN W / FT	2.3	2.4	2.6	2.9	3.2	3.3	3.9	4.1	4.7	5.4	6.7	7.8	8.9	10.0	10.5	11.5	12.3	13.0	14.4	
100	PIPE TEMP	75.5	75.7	74.7	73.7	72.9	72.5	70.9	70.4	68.7	66.5	62.0	58.6	54.9	51.5	50.0	47.6	45.5	43.2	39.6	
	MAX W / FT	3.1	3.7	3.4	3.9	4.2	4.4	5.2	5.5	6.3	7.2	8.9	10.1	11.6	13.1	13.7	14.9	16.0	16.9	18.7	
	MIN W / FT	3.0	3.1	3.2	3.8	4.1	4.2	4.9	5.2	5.9	6.8	8.5	9.8	11.3	12.7	13.3	14.4	15.5	16.3	18.0	
120	PIPE TEMP	94.4	94.1	93.5	92.3	91.3	90.8	88.3	88.3	86.2	83.6	78.2	74.1	69.7	65.5	63.8	60.8	58.3	55.6	51.2	
	MAX W / FT	3.8	4.7	4.1	4.8	5.2	5.4	6.3	6.7	7.6	8.7	10.8	12.2	14.0	15.8	16.6	18.1	19.3	20.6	22.5	
	MIN W / FT	3.6	3.6	4.0	4.6	5.0	5.1	6.0	6.3	7.2	8.2	10.3	11.9	13.6	15.3	16.0	17.5	18.7	19.7	21.8	
140	PIPE TEMP	113.3	112.9	112.3	110.9	109.7	109.1	106.8	106.1	103.7	100.6	94.3	89.5	84.3	79.4	77.4	74.0	71.0	67.9	62.8	
	MAX W / FT	4.5	4.7	4.9	5.7	6.2	6.4	7.5	7.9	9.0	10.3	12.8	14.4	16.5	18.6	19.5	21.2	22.7	24.0	26.4	
	MIN W / FT	4.3	4.5	4.7	5.5	5.9	6.1	7.1	7.5	8.5	9.7	12.2	14.0	16.0	18.0	18.8	20.5	21.9	23.2	25.5	
160	PIPE TEMP	132.2	131.9	131.0	129.4	128.0	127.4	124.6	123.9	121.2	117.5	110.3	104.8	98.9	93.2	91.0	87.0	83.7	80.2	74.3	
	MAX W / FT	5.3	5.4	5.7	6.7	7.2	7.4	8.7	9.2	10.5	12.0	14.8	16.6	19.1	21.5	22.4	24.4	26.1	27.4	30.4	
	MIN W / FT	5.1	5.3	5.5	6.4	6.9	7.1	8.2	8.7	9.9	11.3	14.1	16.1	18.5	20.8	21.7	23.6	25.2	26.6	29.3	
180	PIPE TEMP	151.0	150.4	149.7	147.8	146.2	145.6	142.4	141.6	138.5	134.4	126.2	120.0	113.4	106.9	104.6	100.0	96.3	92.3	85.7	
	MAX W / FT	6.1	6.3	6.5	7.6	8.2	8.5	10.0	10.5	12.0	13.6	16.8	18.9	21.6	24.4	25.4	27.7	29.6	31.2	34.4	
	MIN W / FT	5.8	6.1	6.3	7.3	7.9	8.1	9.4	9.9	11.2	12.8	16.0	18.3	20.9	23.6	24.6	26.7	28.5	30.1	33.1	
200	PIPE TEMP	169.8	169.3	168.4	166.2	164.4	163.7	160.2	159.3	155.8	151.3	142.1	135.2	127.8	120.6	118.0	113.0	108.8	104.6	97.1	
	MAX W / FT	6.9	7.2	7.4	8.7	9.3	9.5	11.3	11.8	13.5	15.3	18.9	21.2	24.2	27.3	28.4	31.0	33.1	34.9	38.4	
	MIN W / FT	6.6	6.9	7.1	8.2	8.9	9.1	10.6	11.2	12.7	14.4	17.9	20.5	23.5	26.4	27.5	29.9	31.9	33.7	37.0	
220	PIPE TEMP	188.5	188.0	187.0	184.6	182.6	181.8	177.9	176.9	173.1	168.0	157.9	150.3	142.1	134.1	131.4	125.8	121.2	116.4	108.4	
	MAX W / FT	7.7	8.2	8.3	9.7	10.4	10.7	12.6	13.2	15.3	17.1	21.0	23.5	26.9	30.3	31.5	34.3	36.6	38.6	42.5	
	MIN W / FT	7.4	7.7	7.9	9.2	9.9	10.1	11.9	12.5	14.7	16.1	19.9	22.4	26.0	29.2	30.4	33.1	35.3	37.2	40.9	
240	PIPE TEMP	207.2	206.6	205.6	202.9	200.7	199.5	195.9	195.5	190.3	184.7	173.7	165.3	156.4	147.6	144.6	138.6	133.6	128.3	119.6	
	MAX W / FT	8.6	8.9	9.2	10.8	11.6	11.8	13.9	14.6	16.9	18.9	23.1	25.9	29.6	33.3	34.6	37.7	40.2	42.4	46.6	
	MIN W / FT	8.2	8.5	8.8	10.2	11.0	11.2	13.1	13.8	15.6	17.7	22.0	25.1	28.6	32.2	33.4	36.3	38.8	40.8	44.8	
260	PIPE TEMP	225.9	225.4	224.1	221.1	218.8	217.9	213.1	212.0	207.4	201.3	189.3	180.3	170.5	161.0	157.9	151.2	145.8	140.1	130.7	
	MAX W / FT	9.5	9.8	10.1	11.9	12.7	13.0	15.3	16.0	18.2	20.7	25.3	28.3	32.3	36.4	37.7	41.1	43.8	46.2	50.7	
	MIN W / FT	9.1	9.4	9.7	11.2	12.1	12.3	14.4	15.1	17.1	19.4	24.0	27.4	31.2	35.1	36.4	39.6	42.2	44.7	48.8	
280	PIPE TEMP	244.5	243.9	242.7	239.4	236.8	235.9	230.6	229.5	224.5	217.9	204.9	195.2	184.6	174.3	171.0	163.9	158.0	151.9	141.8	
	MAX W / FT	10.5	10.9	11.1	13.0	13.9	14.2	16.7	17.5	19.9	22.5	27.5	30.7	35.0	39.5	40.9	44.5	47.5	50.0	54.9	
	MIN W / FT	10.0	10.3	10.6	12.3	13.2	13.4	15.7	16.5	18.6	21.1	26.1	29.8	33.9	38.1	39.5	42.9	45.7	48.2	52.8	
300	PIPE TEMP	263.1	262.4	261.1	257.5	254.8	253.8	248.1	246.9	241.6	234.6	220.4	210.0	198.7	187.6	184.1	176.4	170.2	163.6	152.6	
	MAX W / FT	11.4	11.8	12.1	14.1	15.1	15.4	18.2	19.0	21.5	24.4	29.8	33.2	37.8	42.2	43.6	47.4	50.2	52.7	58.1	
	MIN W / FT	10.9	11.2	11.5	13.4	14.4	14.6	17.1	17.9	20.1	22.9	28.2	32.2	36.6	41.1	42.6	46.2	49.3	51.9	56.9	
320	PIPE TEMP	281.6	280.9	279.6	275.7	272.7	271.7	265.6	264.2	258.5	250.9	235.9	224.7	212.6	200.7	197.0	188.8	182.2	175.2	163.7	
	MAX W / FT	12.4	12.8	13.1	15.3	16.4	16.7	19.7	20.5	23.3	26.4	32.1	35.7	40.7	45.8	47.4	51.5	54.9	57.8	63.3	
	MIN W / FT	11.8	12.1	12.5	14.5	15.5	15.8	18.4	19.3	21.7	24.7	30.4	34.6	39.3	44.1	45.7	49.6	52.9	55.6	60.9	
340	PIPE TEMP	327.8	327.0	325.5	320.8	317.4	316.2	309.9	307.4	300.7	291.0	276.3	261.3	247.2	233.3	229.7	219.7	212.0	203.9	190.7	
	MAX W / FT	15.0	15.4	15.7	18.4	19.7	19.9	23.5	24.3	27.7	31.3	38.0	42.2	47.9	53.9	55.7	60.5	64.4	67.7	73.1	
	MIN W / FT	14.2	14.6	14.9	17.4	18.6	18.8	22.0	23.0	25.8	29.3	35.9	40.8	46.3	51.9	53.6	58.2	62.0	65.1	71.3	
360	PIPE TEMP	373.8	372.9	371.2	365.7	361.7	360.5	352.0	350.3	342.6	337.3	312.2	297.4	281.3	265.4	260.9	250.0	241.4	232.3	217.3	
	MAX W / FT	17.7	18.1	18.5	21.7	23.1	23.3	27.6	28.6	32.3	36.5	44.1	48.9	55.4	62.3	64.2	69.7	74.2	77.9	85.1	
	MIN W / FT	16.8	17.2	17.5	20.4	21.8	22.0	25.7	26.9	30.1	34.1	41.7	47.2	53.4	59.9	61.8	67.3	71.3	74.9	81.8	
380	PIPE TEMP	419.5	418.6	416.7	410.4	405.9	404.5	394.8	393.0	384.2	377.5	349.8	333.1	315.0	297.1	292.1	278.0	270.3	260.1	243.5	
	MAX W / FT	20.6	21.0	21.4	25.1	26.7	26.9	31.8	32.0	37.2	41.9	50.5	55.7	63.1	70.9	73.0	79.2	84.1	88.3	96.3	
	MIN W / FT	19.5	19.9	20.3	23.6	25.1	25.4	29.6	30.9	34.5	39.0	47.6	53.8	60.8	68.1	70.2	76.1	80.8	84.8	92.5	
400	PIPE TEMP	465.0	464.1	462.0	454.8	449.8	448.3	437.3	435.3	425.5	412.3	387.0	368.4	348.4	328.3	323.0	309.5	298.8	287.6	269.1	
	MAX W / FT	23.7	24.1	24.4	28.7	30.4	30.7	36.2	37.5	42.2	47.5	57.0	62.4	71.0	79.7	81.9	88.8	94.3	98.9	107.8	
	MIN W / FT	22.4	22.7	23.1	26.9	28.6	28.8	33.6	35.9	39.1	44.1	53.7	60.6	68.4	76.5	78.5	85.3	90.5	94.9	103.4	
420	PIPE TEMP	510.4	509.4	507.1	499.1	493.4	491.9	479.6	477.4	466.5	451.9	423.9	403.1	381.3	359.2	353.5	338.6	327.0	314.7	294.7	
	MAX W / FT	26.9	27.3	27.6	32.4	34.3	34.5	40.7	42.1	47.4	53.3	63.8	70.1	79.1	88.7	91.1	98.7	104.7	109.7	119.4	
	MIN W / FT	25.3	25.7	26.1	30.3	32.2	32.4	37.8	39.3	43.8	49.4	60.0	67.6	76.1	85.1	87.4	94.6	100.4	105.2	114.5	
440	PIPE TEMP	555.4	554.4	552.1	543.1	536.9	535.3	521.6	519.3	507.3	491.2	460.4	437.9	413.8	389.7	383.6	367.4	354.8	341.5	319.8	
	MAX W / FT	30.2	30.6	30.9	36.2	38.3	38.6	45.5	46.9	52.8	59.3	70.7	77.8	87.4	97.4	100.5	108.8	115.3	120.7	131.3	
	MIN W / FT	28.4	28.8	29.2	33.8	35.9	36.1	42.0	43.7	48.7	54.8	66.4	74.7	8							



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
PAGE 374
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INSULATION THICKNESS REQUIREMENTS

Service Designation T-35

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

3" NOMINAL INSULATION THICKNESS			AMBIENT AIR TEMP -200 F (-289 C)																	
CABLE TEMP DEG F		PIPE SIZE																		
		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
60	PIPE TEMP	56.6	56.4	56.0	55.4	54.7	54.4	53.2	52.9	51.7	50.0	46.9	44.3	41.7	39.2	36.1	34.7	33.0	30.1	
	MAX.W /FT	2.3	2.4	2.5	2.9	3.1	3.2	3.8	4.0	4.5	5.2	6.3	7.3	8.4	9.5	10.0	10.9	11.7	12.3	13.7
	MIN.W /FT	2.2	2.3	2.4	2.8	3.0	3.1	3.6	3.8	4.3	5.0	6.2	7.2	8.2	9.2	9.7	10.6	11.3	12.0	13.3
80	PIPE TEMP	75.7	75.4	75.0	74.1	73.3	72.9	71.4	71.0	69.5	67.4	63.5	60.2	56.9	53.7	52.4	50.1	46.1	44.0	42.5
	MAX.W /FT	2.9	3.0	3.2	3.7	4.0	4.1	4.8	5.0	5.7	6.6	8.0	9.3	10.6	12.0	12.5	13.7	14.7	15.5	17.2
	MIN.W /FT	2.8	2.9	3.1	3.5	3.8	4.0	4.6	4.9	5.5	6.3	7.8	9.0	10.4	11.6	12.2	13.3	14.2	15.1	16.7
100	PIPE TEMP	94.7	94.4	93.8	92.7	91.8	91.3	89.5	89.0	87.3	84.7	80.0	76.1	72.0	68.2	66.6	63.9	61.5	59.0	54.8
	MAX.W /FT	3.6	3.7	3.9	4.5	4.9	5.0	5.9	6.1	7.0	8.0	9.7	11.2	12.9	14.5	15.2	16.5	17.7	18.7	20.7
	MIN.W /FT	3.4	3.6	3.8	4.3	4.7	4.8	5.6	5.9	6.7	7.7	9.5	10.9	12.5	14.1	14.7	16.1	17.2	18.2	20.1
120	PIPE TEMP	113.7	113.3	112.7	111.4	110.2	109.7	107.4	107.0	105.0	101.9	96.4	91.9	87.1	82.6	80.8	77.6	74.8	71.9	67.6
	MAX.W /FT	4.2	4.4	4.6	5.3	5.8	6.0	6.9	7.3	8.2	9.5	11.4	13.2	15.1	17.0	17.8	19.4	20.8	22.0	24.3
	MIN.W /FT	4.1	4.3	4.5	5.1	5.6	5.7	6.6	7.0	7.9	9.1	11.2	12.9	14.7	16.6	17.3	18.9	20.2	21.4	23.6
140	PIPE TEMP	132.6	132.2	131.5	130.0	128.6	128.1	125.4	125.0	122.6	119.1	112.8	107.6	102.1	96.9	94.9	91.2	88.1	84.7	79.1
	MAX.W /FT	5.0	5.2	5.4	6.2	6.7	6.9	8.1	8.4	9.5	11.0	13.2	15.2	17.4	19.6	20.5	22.3	23.9	25.3	28.0
	MIN.W /FT	4.8	5.0	5.2	6.0	6.5	6.6	7.7	8.1	9.1	10.5	12.9	14.9	17.0	19.1	19.9	21.7	23.2	24.5	27.1
160	PIPE TEMP	151.5	151.0	150.2	148.5	147.0	146.4	143.4	142.9	140.2	136.2	129.1	123.2	117.1	111.2	109.0	104.8	101.2	97.4	91.1
	MAX.W /FT	5.7	5.9	6.2	7.1	7.7	7.9	9.2	9.6	10.8	12.5	15.0	17.3	19.6	22.3	23.2	25.3	27.1	28.6	31.6
	MIN.W /FT	5.5	5.7	5.9	6.8	7.4	7.6	8.8	9.2	10.4	11.9	14.4	16.9	19.2	21.6	22.5	24.6	26.3	27.8	30.6
180	PIPE TEMP	170.3	169.9	169.0	167.0	165.3	164.6	161.5	160.7	157.7	153.3	145.3	138.8	131.9	125.3	123.0	118.3	114.3	110.1	103.1
	MAX.W /FT	6.5	6.7	7.0	8.1	8.7	8.9	10.4	10.8	12.2	14.0	16.8	19.4	22.1	24.9	26.0	28.5	30.3	32.0	35.3
	MIN.W /FT	6.2	6.5	6.7	7.7	8.4	8.6	9.9	10.4	11.6	13.4	16.4	18.9	21.5	24.2	25.2	27.5	29.4	31.0	34.2
200	PIPE TEMP	189.1	188.4	187.7	185.5	183.6	182.9	179.3	178.5	175.2	170.3	161.5	154.3	146.7	139.4	136.9	131.7	127.4	122.7	115.1
	MAX.W /FT	7.2	7.4	7.8	9.0	9.7	9.9	11.6	12.1	13.6	15.6	18.7	21.5	24.5	27.6	28.7	31.3	33.5	35.4	39.0
	MIN.W /FT	7.0	7.3	7.5	8.6	9.4	9.5	11.0	11.6	13.0	14.9	18.2	21.0	23.9	26.8	27.9	30.4	32.5	34.3	37.6
220	PIPE TEMP	207.9	207.4	206.3	203.9	201.8	201.1	197.1	196.3	192.6	187.2	177.6	169.7	161.5	153.5	150.7	145.0	140.3	135.3	126.9
	MAX.W /FT	8.1	8.3	8.6	10.0	10.8	11.0	12.8	13.4	15.0	17.2	20.6	23.7	27.0	30.4	31.6	34.4	36.8	38.8	42.8
	MIN.W /FT	7.8	8.0	8.3	9.6	10.4	10.5	12.2	12.8	14.3	16.4	20.0	23.1	26.2	29.5	30.6	33.4	35.6	37.6	41.5
240	PIPE TEMP	226.7	226.1	224.9	222.2	220.3	219.2	214.9	214.0	210.0	204.1	193.7	185.1	176.1	167.4	164.5	158.3	153.2	147.7	138.7
	MAX.W /FT	8.9	9.2	9.5	11.0	11.9	12.1	14.1	14.7	16.5	18.9	22.5	25.9	29.5	33.2	34.4	37.5	40.1	42.3	46.6
	MIN.W /FT	8.6	8.9	9.2	10.5	11.4	11.6	13.4	14.0	15.7	18.0	21.4	25.2	29.6	33.2	34.4	37.6	40.0	42.0	45.1
260	PIPE TEMP	245.4	244.9	243.5	240.6	238.1	237.3	232.4	231.6	227.3	220.9	209.4	190.7	181.3	170.1	171.5	166.0	160.1	150.4	
	MAX.W /FT	9.8	10.1	10.4	12.1	13.0	13.2	15.4	16.0	17.9	20.5	24.4	28.1	32.6	36.0	37.3	40.6	43.4	45.4	50.4
	MIN.W /FT	9.4	9.7	10.0	11.5	12.4	12.6	14.6	15.3	17.1	19.6	23.6	27.3	31.1	34.9	36.2	39.4	42.1	44.4	48.6
280	PIPE TEMP	264.0	263.4	262.1	258.9	256.2	255.4	250.3	249.2	244.6	237.7	225.6	215.6	205.2	195.1	191.8	184.6	178.7	172.5	162.1
	MAX.W /FT	10.7	11.0	11.3	13.1	14.1	14.3	16.7	17.3	19.4	22.3	26.4	30.3	34.5	38.8	40.3	43.8	46.8	49.5	54.3
	MIN.W /FT	10.2	10.5	10.9	12.5	13.5	13.7	15.9	16.6	18.6	21.5	25.6	29.5	33.5	37.7	39.0	42.5	45.3	47.8	52.6
300	PIPE TEMP	282.7	282.0	280.6	277.1	274.3	273.4	267.9	266.8	261.9	254.4	241.4	230.8	219.7	208.8	205.3	197.7	191.6	184.7	173.6
	MAX.W /FT	11.6	11.9	12.2	14.2	15.1	15.3	18.1	18.7	21.0	24.0	28.5	32.6	37.1	41.7	43.2	47.0	50.2	52.9	58.2
	MIN.W /FT	11.1	11.4	11.8	13.6	14.6	14.8	17.1	17.9	19.9	22.9	27.7	31.8	36.0	40.5	41.9	45.6	48.6	51.2	56.3
320	PIPE TEMP	324.1	323.4	322.0	317.6	314.3	313.3	311.7	310.5	304.7	296.0	280.8	268.4	255.5	242.6	238.9	230.0	222.8	215.1	202.1
	MAX.W /FT	14.0	14.3	14.7	17.0	18.1	18.3	21.6	22.3	25.4	28.5	33.7	38.5	43.7	49.1	50.8	55.2	58.9	62.6	68.1
	MIN.W /FT	13.4	13.7	14.1	16.3	17.5	17.7	20.4	21.3	23.7	27.1	32.4	37.4	42.6	47.6	49.2	53.5	57.0	60.5	65.9
340	PIPE TEMP	375.3	374.5	372.7	367.9	364.0	362.9	355.3	354.0	347.3	337.2	319.8	305.6	290.9	276.3	272.0	261.9	253.7	245.0	230.5
	MAX.W /FT	16.5	16.9	17.3	20.0	21.4	21.6	25.2	26.1	29.1	33.2	39.0	44.6	50.5	56.7	58.6	63.6	67.8	71.4	78.7
	MIN.W /FT	15.8	16.1	16.5	19.1	20.5	20.7	23.9	24.8	27.6	31.5	38.0	43.3	49.0	54.7	56.7	61.6	65.6	69.0	75.6
360	PIPE TEMP	421.3	420.4	418.5	412.9	409.3	408.3	398.6	397.2	389.6	378.2	358.5	342.5	326.0	309.5	304.6	293.4	284.2	274.5	258.4
	MAX.W /FT	19.2	19.5	20.0	22.6	24.0	24.2	28.1	29.1	32.0	36.8	43.6	50.9	57.5	64.5	66.5	72.3	76.9	80.9	88.6
	MIN.W /FT	18.3	18.6	19.1	21.6	23.0	23.2	26.4	27.4	30.3	34.1	40.9	48.4	55.9	62.4	64.4	69.4	74.3	78.2	85.6
380	PIPE TEMP	467.1	466.1	464.1	457.7	452.8	451.5	441.7	440.1	431.6	418.8	396.8	379.0	360.6	342.2	337.1	324.5	314.4	303.6	285.8
	MAX.W /FT	22.0	22.3	22.8	26.0	27.4	27.6	31.6	32.6	36.1	41.4	48.4	56.3	64.7	72.6	74.7	81.1	86.2	90.6	99.1
	MIN.W /FT	20.9	21.2	21.6	24.8	26.2	26.4	30.2	31.2	34.6	39.9	46.9	54.8	63.2	71.1	73.3	79.3	84.3	88.5	95.7
400	PIPE TEMP	512.8	512.0	510.5	503.9	500.0	498.4	487.4	485.8	475.4	459.1	434.2	415.1	394.8	374.6	369.1	355.2	344.1	332.3	312.9
	MAX.W /FT	24.5	24.7	25.2	28.6	30.0	30.2	34.2	35.2	38.6	44.0	51.6	60.3	69.2	78.1	80.2	87.1	92.1	96.5	109.8
	MIN.W /FT	23.7	24.0	24.4	27.8	29.2	29.4	33.4	34.4	37.8	43.2	50.8	59.5	68.4	77.3	79.4	86.3	91.3	95.7	109.0
420	PIPE TEMP	558.3	557.4	556.7	549.8	545.8	544.3	532.7	531.3	519.0	499.2	472.5	451.0	428.8	406.6	400.7	386.6	375.5	363.7	343.6
	MAX.W /FT	27.4	27.8	28.4	31.8	33.2	33.4	37.4	38.4	41.8	47.2	55.8	64.7	73.6	82.5	84.6	91.5	96.5	101.0	120.8
	MIN.W /FT	26.5	26.8	27.4	30.8	32.2	32.4	36.4	37.4	40.8	46.2	54.8	63.7	72.6	81.5	83.6	90.5	95.5	100.0	116.4
440	PIPE TEMP	603.7	602.7	601.9	594.1	589.5	587.9	575.7	574.3	561.9	539.1	509.4	486.5	462.4	438.3	432.0	416.6	404.8	392.9	373.0
	MAX.W /FT	31.1	31.4	31.9	35.2	36.6	36.8	40.8	41.8	45.2	50.6									



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
PAGE 375
MAY 1968

INSULATION THICKNESS REQUIREMENTS

Service Designation T-36

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

3-1/2" NOMINAL INSULATION THICKNESS		PIPE SIZE																AMBIENT AIR TEMP -20.0 F (-28.9 C)			
CABLE TEMP DEG F		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	
CC	PIPE TEMP	51.8	56.5	56.2	59.6	59.0	59.7	59.6	59.3	59.2	59.6	47.8	45.4	42.9	40.6	39.6	37.9	36.4	34.8	32.1	
	PAR.W /FT	2.2	2.3	2.4	2.7	2.9	3.0	3.5	3.7	4.2	4.8	5.9	6.8	7.8	8.8	9.2	10.1	10.8	11.6	12.7	
	PIA.W /FT	2.1	2.7	2.3	2.6	2.9	3.0	3.4	3.6	4.1	4.7	5.8	6.7	7.6	8.6	9.0	9.8	10.5	11.2	12.4	
EC	PIPE TEMP	75.9	75.4	75.2	76.3	73.6	73.2	71.9	71.4	70.1	68.1	64.6	61.6	58.5	55.4	54.3	52.2	50.3	48.3	45.0	
	PAR.W /FT	2.8	2.9	3.0	3.5	3.6	3.9	4.5	4.7	5.3	6.1	7.4	8.6	9.8	11.1	11.6	12.7	13.6	14.4	16.0	
	PIA.W /FT	2.7	2.9	3.0	3.4	3.6	3.8	4.3	4.6	5.2	5.9	7.3	8.4	9.6	10.8	11.3	12.5	13.2	14.0	15.6	
1CC	PIPE TEMP	94.5	94.4	94.1	93.1	92.2	91.8	90.1	89.6	88.0	85.6	81.3	77.7	74.0	70.4	69.0	66.4	64.2	61.8	57.7	
	PAR.W /FT	3.4	3.4	3.7	4.3	4.6	4.7	5.4	5.6	6.5	7.4	9.0	10.4	11.9	13.4	14.0	15.3	16.4	17.4	19.3	
	PIA.W /FT	3.3	3.4	3.6	4.1	4.5	4.6	5.3	5.6	6.3	7.2	8.8	10.2	11.6	13.1	13.7	14.9	16.0	16.9	18.4	
12C	PIPE TEMP	113.5	113.4	113.0	111.6	110.7	110.3	108.3	107.7	105.8	103.0	98.0	93.8	89.4	85.2	83.6	80.6	78.0	75.2	70.5	
	PAR.W /FT	4.0	4.7	4.4	5.1	5.4	5.6	6.4	6.8	7.7	8.8	10.6	12.2	14.0	15.7	16.5	17.9	19.2	20.4	22.6	
	PIA.W /FT	3.9	4.1	4.3	4.9	5.3	5.4	6.2	6.6	7.4	8.5	10.4	12.0	13.7	15.4	16.1	17.5	18.8	19.9	22.0	
14C	PIPE TEMP	132.5	132.4	131.8	130.4	129.2	128.7	126.5	125.7	123.4	120.3	114.6	109.8	104.8	100.0	98.1	94.7	91.7	88.5	83.1	
	PAR.W /FT	4.7	4.9	5.1	5.9	6.3	6.5	7.5	7.9	8.9	10.2	12.2	14.1	16.1	18.1	18.9	20.6	22.1	23.6	25.9	
	PIA.W /FT	4.6	4.7	5.0	5.7	6.1	6.3	7.2	7.7	8.6	9.8	12.0	13.8	15.8	17.7	18.5	20.1	21.6	22.8	25.3	
16C	PIPE TEMP	151.4	151.4	150.6	149.0	147.8	147.1	144.6	143.7	141.3	137.6	131.2	125.7	120.1	114.6	112.6	108.7	105.3	101.7	95.7	
	PAR.W /FT	5.4	5.4	5.9	6.7	7.2	7.4	8.5	9.0	10.1	11.6	13.9	16.0	18.3	20.6	21.4	23.4	25.0	26.5	29.3	
	PIA.W /FT	5.2	5.4	5.7	6.5	7.0	7.2	8.2	8.8	9.7	11.2	13.4	15.7	17.9	20.1	20.9	22.8	24.4	25.8	28.6	
18C	PIPE TEMP	170.7	170.5	169.4	167.6	166.1	165.5	162.6	161.7	159.0	154.9	147.7	141.6	135.3	129.2	127.0	122.6	118.9	114.9	108.2	
	PAR.W /FT	6.1	6.3	6.6	7.6	8.2	8.3	9.6	10.2	11.4	13.0	15.6	17.9	20.5	23.0	24.0	26.1	28.0	29.6	32.8	
	PIA.W /FT	5.9	6.1	6.4	7.3	7.9	8.1	9.3	9.9	11.0	12.6	15.3	17.6	20.0	22.4	23.4	25.5	27.3	28.8	31.9	
20C	PIPE TEMP	189.4	189.1	188.2	186.2	184.4	183.8	180.6	179.6	176.4	172.1	164.1	157.4	150.5	143.8	141.4	136.5	132.5	128.1	120.7	
	PAR.W /FT	6.8	7.1	7.4	8.5	9.1	9.3	10.7	11.3	12.6	14.4	17.3	19.9	22.7	25.5	26.5	28.9	31.0	32.8	36.2	
	PIA.W /FT	6.7	6.9	7.2	8.2	8.8	9.0	10.3	11.0	12.2	14.0	16.9	19.5	22.2	24.9	25.9	28.2	30.2	31.9	35.2	
22C	PIPE TEMP	208.4	208.0	206.9	204.7	202.8	202.1	198.6	197.5	194.2	189.2	180.5	173.2	165.4	158.2	155.6	150.4	145.9	141.1	133.1	
	PAR.W /FT	7.4	7.6	7.9	9.1	9.8	9.9	11.4	12.1	13.4	15.4	18.6	21.4	24.3	27.3	28.4	31.8	34.0	35.9	39.7	
	PIA.W /FT	7.4	7.6	7.9	9.1	9.8	9.9	11.4	12.1	13.4	15.4	18.6	21.4	24.3	27.3	28.4	31.8	34.0	35.9	39.7	
24C	PIPE TEMP	227.2	226.7	225.6	223.1	221.1	220.3	216.5	215.3	211.8	206.3	196.9	188.9	180.7	172.6	169.4	164.1	159.3	154.1	145.4	
	PAR.W /FT	8.1	8.4	8.7	10.0	10.7	10.9	12.5	13.3	14.7	16.9	20.4	23.4	26.6	29.8	31.0	34.9	37.0	38.1	42.1	
	PIA.W /FT	8.1	8.4	8.7	10.0	10.7	10.9	12.5	13.3	14.7	16.9	20.4	23.4	26.6	29.8	31.0	34.9	37.0	38.1	42.1	
26C	PIPE TEMP	246.2	245.4	244.2	241.5	239.3	238.5	234.3	233.1	229.3	223.4	213.1	204.6	195.7	186.9	184.0	177.6	172.6	167.0	157.7	
	PAR.W /FT	9.2	9.4	9.6	11.1	12.1	12.3	14.2	15.0	16.6	19.0	22.6	26.0	29.5	33.2	34.4	37.5	40.1	42.4	46.8	
	PIA.W /FT	9.0	9.2	9.5	10.9	11.7	11.9	13.7	14.5	16.0	18.3	21.1	25.4	28.8	32.3	33.6	36.5	39.0	41.2	45.5	
28C	PIPE TEMP	264.7	264.2	262.9	259.6	257.5	256.7	252.2	250.4	246.7	240.3	229.4	220.1	210.6	201.7	198.1	191.4	185.9	179.9	169.9	
	PAR.W /FT	10.1	10.5	10.7	12.3	13.2	13.4	15.4	16.2	18.0	20.6	24.5	28.1	31.9	35.8	37.2	40.6	43.2	45.7	50.4	
	PIA.W /FT	9.7	10.0	10.4	12.0	12.7	12.9	14.8	15.7	17.4	19.9	23.9	27.4	31.1	34.9	36.2	39.4	42.1	44.6	49.0	
30C	PIPE TEMP	283.4	282.4	281.5	278.3	275.7	274.9	270.0	268.6	264.1	257.3	245.5	235.6	225.4	215.3	212.1	205.0	199.0	192.6	182.6	
	PAR.W /FT	10.5	11.7	11.6	13.5	14.2	14.4	16.4	17.5	19.5	22.2	26.3	30.2	34.3	38.5	39.9	43.4	46.4	49.0	54.0	
	PIA.W /FT	10.5	10.9	11.2	12.9	13.6	13.8	15.8	16.9	18.7	21.4	25.7	29.5	33.4	37.5	38.6	42.3	45.1	47.6	52.5	
35C	PIPE TEMP	330.1	329.6	327.8	324.0	321.0	320.0	314.2	312.7	307.5	299.4	285.7	274.2	262.3	250.5	246.8	238.6	231.7	224.3	212.0	
	PAR.W /FT	13.1	13.6	13.9	16.0	17.0	17.2	19.9	20.6	23.1	26.3	31.1	35.6	40.3	45.3	46.6	51.0	54.4	57.6	63.2	
	PIA.W /FT	12.7	13.0	13.4	15.4	16.5	16.6	19.1	20.1	22.2	25.4	30.4	34.7	39.3	44.1	45.4	49.6	52.9	55.6	61.4	
40C	PIPE TEMP	376.5	375.4	373.9	369.5	366.0	365.0	358.3	356.5	350.5	341.2	325.5	312.3	298.7	285.2	281.2	271.7	263.9	255.4	241.7	
	PAR.W /FT	15.5	15.9	16.3	18.8	20.0	20.1	23.2	24.3	26.8	30.6	36.1	41.2	46.6	52.3	54.0	58.7	62.6	66.0	72.6	
	PIA.W /FT	14.9	15.2	15.6	18.0	19.3	19.4	22.2	23.5	25.9	29.5	35.3	40.2	45.4	50.9	52.6	57.1	60.9	64.2	70.5	
45C	PIPE TEMP	422.7	422.4	419.9	414.8	410.9	409.8	402.0	400.1	393.3	382.7	364.9	350.1	334.6	319.4	315.1	304.5	295.8	286.4	270.9	
	PAR.W /FT	16.0	16.7	17.1	20.0	21.2	21.3	24.6	25.7	28.3	32.0	38.5	44.2	50.1	56.1	58.1	63.4	67.2	71.1	78.2	
	PIA.W /FT	17.3	17.6	18.2	20.8	22.2	22.3	25.6	26.9	29.7	33.7	40.3	46.8	53.1	59.7	61.7	67.0	70.7	74.4	81.9	
50C	PIPE TEMP	468.8	468.7	465.0	458.0	455.5	454.3	445.6	443.6	435.8	423.9	404.1	387.5	370.5	353.5	348.7	336.9	327.2	316.9	299.8	
	PAR.W /FT	20.4	20.9	21.5	24.5	25.8	25.9	29.4	30.7	33.4	38.2	45.4	51.6	58.1	64.6	67.0	72.7	77.4	81.4	89.3	
	PIA.W /FT	19.8	20.1	20.7	23.7	25.2	25.4	29.0	30.5	33.6	38.2	45.4	51.6	58.1	64.6	67.0	72.7	77.4	81.4	89.3	
55C	PIPE TEMP	514.7	513.4	511.4	504.9	500.0	498.7	488.4	486.5	478.1	464.9	442.9	424.7	405.9	387.1	381.8	368.9	358.3	347.0	328.3	
	PAR.W /FT	23.3	23.7	24.3	27.9	29.3	29.7	34.1	35.6	39.3	44.5	52.0	59.1	66.6	74.5	76.7	83.2	88.5	93.1	102.0	
	PIA.W /FT	22.4	22.7	23.4	26.7	28.4	28.5	32.6	34.2	37.6	42.7	50.7	57.5	64.6	72.3	74.5	80.7	85.9	90.3	98.9	
60C	PIPE TEMP	560.4	559.4	556.9	549.7	544.2	542.8	532.1	529.5	520.1	505.8	481.5	461.5	440.9	420.4	414.7	400.5	389.0	376.7	356.4	
	PAR.W /FT	25.2	25.5	26.1	30.1	31.6	31.8	36.1	37.7	41.7	47.4	56.2	63.6	71.5	79.4	82.1	88.4	93.7	97.5	107.5	
	PIA.W /FT	25.1	25.4	26.1	30.1	31.6	31.8	36.1	37.7	41.7											



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
PAGE 376
MAY, 1968

INSULATION THICKNESS REQUIREMENTS

Service Designation T-37

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT
PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

4" NOMINAL INSULATION THICKNESS			PIPE SIZE																AMBIENT AIR TEMP -20.0 F (-28.9 C)			
CABLE TEMP DEG F			3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	
40	PIPE TEMP	56.9	56.7	56.3	55.7	55.0	54.7	53.9	53.5	52.6	51.2	48.5	46.3	44.0	41.8	40.9	39.3	37.9	36.3	33.8		
	MAX W / FT	2.1	2.7	2.3	2.6	2.9	3.0	3.3	3.6	4.0	4.5	5.5	6.4	7.3	8.2	9.6	9.4	10.1	10.7	11.9		
	MIN W / FT	2.0	2.1	2.2	2.5	2.9	3.0	3.2	3.5	3.9	4.4	5.4	6.3	7.2	8.0	9.4	9.2	9.9	10.5	11.6		
80	PIPE TEMP	78.0	75.7	75.3	74.6	73.6	73.2	72.3	71.8	70.6	68.8	65.5	62.7	59.8	57.1	55.9	53.9	52.2	50.3	47.1		
	MAX W / FT	2.6	2.9	2.9	3.3	3.8	3.9	4.2	4.5	5.0	5.7	7.0	8.1	9.2	10.3	10.8	11.6	12.7	13.4	14.9		
	MIN W / FT	2.6	2.7	2.8	3.2	3.6	3.8	4.1	4.4	4.9	5.6	6.8	7.9	9.0	10.1	10.6	11.6	12.4	13.1	14.4		
100	PIPE TEMP	95.1	94.8	94.3	93.4	92.2	91.8	90.6	90.0	88.6	86.4	82.4	79.1	75.6	72.3	70.9	68.5	66.4	64.1	60.3		
	MAX W / FT	3.2	3.4	3.5	4.0	4.6	4.7	5.2	5.5	6.0	6.9	8.4	9.7	11.1	12.5	13.1	14.3	15.3	16.2	18.0		
	MIN W / FT	3.2	3.3	3.5	3.9	4.5	4.6	5.0	5.4	6.0	6.8	8.3	9.6	10.9	12.2	12.8	13.9	15.0	15.9	17.6		
120	PIPE TEMP	114.1	113.9	113.2	112.1	110.7	110.3	108.4	104.2	104.0	99.3	95.4	91.3	87.4	85.9	83.1	80.6	77.9	73.5			
	MAX W / FT	3.9	4.0	4.2	4.8	5.4	5.6	6.1	6.5	7.2	8.1	9.9	11.5	13.1	14.7	15.3	16.7	17.9	19.0	21.1		
	MIN W / FT	3.8	3.9	4.1	4.7	5.3	5.4	5.9	6.3	7.0	8.0	9.8	11.2	12.8	14.4	15.0	16.4	17.6	18.6	20.6		
140	PIPE TEMP	133.1	132.8	132.1	130.8	129.2	128.7	127.1	126.4	124.4	121.5	116.1	111.6	107.1	102.5	100.4	97.5	94.7	91.7	86.6		
	MAX W / FT	4.5	4.7	4.9	5.6	6.3	6.5	7.1	7.5	8.3	9.4	11.5	13.2	15.1	16.9	17.7	19.2	20.6	21.9	24.3		
	MIN W / FT	4.4	4.6	4.8	5.4	6.1	6.3	6.9	7.3	8.1	9.2	11.3	13.0	14.8	16.6	17.3	18.8	20.2	21.4	23.7		
160	PIPE TEMP	152.1	151.7	151.0	149.5	147.6	147.1	145.3	144.5	142.2	139.0	132.9	127.8	122.6	117.5	115.6	112.0	104.8	105.4	99.6		
	MAX W / FT	5.2	5.3	5.6	6.4	7.2	7.4	8.1	8.5	9.5	10.7	13.0	15.0	17.1	19.2	20.0	21.6	23.3	24.7	27.4		
	MIN W / FT	5.0	5.2	5.4	6.2	7.0	7.2	7.8	8.4	9.2	10.5	12.8	14.7	16.7	18.8	19.6	21.3	22.8	24.2	26.8		
180	PIPE TEMP	171.1	170.7	169.8	168.2	166.1	165.5	163.4	162.5	160.1	156.4	149.6	144.0	138.2	132.5	130.4	126.3	122.8	119.0	112.6		
	MAX W / FT	5.8	6.0	6.3	7.2	8.2	8.3	9.1	9.6	10.7	12.0	14.6	16.8	19.1	21.4	22.3	24.3	26.1	27.6	30.6		
	MIN W / FT	5.7	5.9	6.1	7.0	7.9	8.1	8.8	9.4	10.4	11.8	14.3	16.5	18.7	21.0	21.9	23.8	25.5	27.0	29.9		
200	PIPE TEMP	190.0	189.6	188.7	186.8	184.4	183.8	181.5	180.6	177.8	173.8	166.3	160.1	154.6	148.4	146.1	140.6	136.7	132.5	125.5		
	MAX W / FT	6.6	6.8	7.0	8.0	9.1	9.3	10.1	10.7	11.9	13.3	16.2	18.6	21.2	23.8	24.7	26.9	28.9	30.6	33.9		
	MIN W / FT	6.4	6.6	6.9	7.8	8.8	9.0	9.8	10.5	11.6	13.1	15.9	18.2	20.7	23.3	24.2	26.3	28.2	29.9	33.1		
220	PIPE TEMP	208.9	208.4	207.4	205.4	202.8	202.1	199.6	198.5	195.5	191.1	182.9	176.1	169.1	162.2	159.8	154.8	150.6	146.0	138.4		
	MAX W / FT	7.3	7.5	7.8	8.9	10.1	10.3	11.2	11.8	13.1	14.7	17.8	20.5	23.5	26.1	27.2	29.6	31.7	33.5	37.1		
	MIN W / FT	7.1	7.3	7.6	8.6	9.8	10.0	10.9	11.5	12.7	14.4	17.5	20.1	22.8	25.5	26.6	28.9	30.9	32.7	36.2		
240	PIPE TEMP	227.7	227.2	226.2	223.9	221.1	220.3	217.6	216.5	213.2	208.4	199.5	192.1	184.4	177.0	174.4	169.0	164.4	159.5	151.2		
	MAX W / FT	8.0	8.1	8.4	9.8	11.1	11.3	12.3	13.0	14.3	16.1	19.5	22.3	25.4	28.5	29.6	32.2	34.5	36.5	40.4		
	MIN W / FT	7.8	8.0	8.3	9.5	10.7	10.9	11.9	12.7	14.0	15.8	19.1	21.7	24.9	27.9	28.9	31.5	33.7	35.7	39.4		
260	PIPE TEMP	246.5	246.0	244.9	242.4	239.3	238.5	235.6	234.4	230.3	225.6	216.0	208.0	199.7	191.6	188.9	183.1	178.2	172.8	163.9		
	MAX W / FT	8.8	9.0	9.3	10.7	12.1	12.3	13.4	14.1	15.6	17.5	21.2	24.3	27.5	30.9	32.1	34.9	37.2	39.5	43.7		
	MIN W / FT	8.6	8.8	9.1	10.4	11.7	11.9	13.0	13.8	15.2	17.2	20.8	23.8	27.0	30.2	31.4	34.1	36.5	38.6	42.7		
280	PIPE TEMP	265.3	264.9	263.6	260.9	257.5	256.7	253.5	252.7	248.4	242.8	232.5	223.9	215.0	206.3	203.3	197.1	191.8	186.1	176.6		
	MAX W / FT	9.6	9.8	10.2	11.6	13.2	13.4	14.5	15.3	16.9	19.8	23.8	27.1	30.7	34.3	35.4	38.7	40.9	43.2	47.1		
	MIN W / FT	9.3	9.6	9.9	11.3	12.7	12.9	14.1	14.9	16.4	18.8	22.4	25.7	29.1	32.6	33.8	36.8	39.3	41.6	45.9		
300	PIPE TEMP	284.1	283.6	282.2	279.3	275.7	274.9	271.4	270.1	266.0	260.0	249.9	239.7	230.2	220.8	217.7	211.1	205.4	199.3	189.7		
	MAX W / FT	10.4	10.6	11.0	12.6	14.2	14.4	15.7	16.5	18.7	20.4	24.6	28.2	31.9	35.8	37.1	40.4	42.2	45.7	50.5		
	MIN W / FT	10.1	10.3	10.7	12.2	13.8	14.0	15.2	16.1	17.7	20.0	24.1	27.6	31.3	35.0	36.3	39.5	42.2	44.6	49.2		
320	PIPE TEMP	303.8	303.3	301.8	298.3	294.0	293.2	288.4	286.9	282.6	275.6	264.9	254.7	244.2	233.8	230.7	223.1	217.4	211.5	201.6		
	MAX W / FT	12.5	12.8	13.2	15.0	17.0	17.2	18.7	19.6	21.8	24.2	29.1	33.2	37.6	42.2	43.6	46.9	50.7	53.6	59.1		
	MIN W / FT	12.1	12.4	12.8	14.6	16.5	16.8	18.1	19.1	21.0	23.7	28.5	32.5	36.8	41.2	42.6	46.3	49.5	52.2	57.6		
340	PIPE TEMP	322.7	322.2	320.7	317.2	312.8	312.0	307.0	305.3	300.9	293.8	282.9	272.7	262.2	251.8	248.7	241.1	235.4	229.5	219.6		
	MAX W / FT	14.7	15.0	15.4	17.6	20.0	20.2	21.9	22.9	25.2	28.1	33.7	38.4	43.5	48.2	50.3	54.6	59.4	62.6	67.9		
	MIN W / FT	14.3	14.6	15.0	17.1	19.3	19.4	21.1	22.3	24.5	27.6	33.0	37.6	42.5	47.5	49.1	53.4	56.9	60.1	66.2		
360	PIPE TEMP	341.6	341.1	339.6	336.1	331.7	330.9	325.7	324.0	319.5	312.4	301.5	291.3	280.8	270.4	267.3	260.7	255.0	249.1	239.2		
	MAX W / FT	16.6	16.9	17.3	19.7	22.2	22.4	24.3	25.4	28.0	31.0	36.5	41.2	46.3	51.4	53.5	58.8	64.6	68.7	74.9		
	MIN W / FT	16.0	16.3	16.7	19.1	21.6	21.8	23.7	24.8	27.4	30.4	35.9	40.6	45.7	50.8	52.9	57.2	61.6	64.9	71.9		
380	PIPE TEMP	360.5	360.0	358.5	355.0	350.6	349.8	344.5	342.8	338.3	331.2	320.3	310.1	300.0	289.6	286.5	280.9	275.2	269.3	259.4		
	MAX W / FT	18.6	18.9	19.3	21.8	24.4	24.6	26.7	27.8	30.4	33.4	38.9	43.6	48.7	53.8	55.9	61.2	67.0	71.1	78.1		
	MIN W / FT	18.0	18.3	18.7	21.2	23.8	24.0	26.1	27.2	29.8	32.8	38.3	43.0	48.1	53.2	55.3	59.6	64.0	67.3	74.3		
400	PIPE TEMP	379.4	378.9	377.4	373.9	369.5	368.7	363.4	361.7	357.2	350.1	339.2	329.0	318.8	308.6	305.5	299.9	294.2	288.3	278.4		
	MAX W / FT	20.6	20.9	21.3	23.8	26.4	26.6	28.7	29.8	32.4	35.4	40.9	45.6	50.7	55.8	57.9	63.2	69.0	73.1	80.1		
	MIN W / FT	20.0	20.3	20.7	23.2	25.8	26.0	28.1	29.2	31.8	34.8	40.3	45.0	50.1	55.2	57.3	61.6	66.0	69.3	76.3		
420	PIPE TEMP	398.3	397.8	396.3	392.8	388.4	387.6	382.3	380.6	376.1	369.0	358.1	347.9	337.7	327.5	324.4	318.9	313.2	307.3	297.4		
	MAX W / FT	22.1	22.4	22.8	25.3	27.9	28.1	30.2	31.3													

INSULATION THICKNESS REQUIREMENTS

Service Designation T-38

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT
PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

1" NOMINAL INSULATION THICKNESS		AMBIENT AIR TEMP 0 F (-17.8 C)																			
CABLE TEMP DEG F		PIPE SIZE																			
		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	
60	PIPE TEMP	54.5	56.2	55.8	55.1	54.3	53.8	52.6	52.5	50.8	48.8										
	PIPE IN FET	2.4	2.7	2.9	3.3	3.7	3.9	4.5	4.5	5.5	6.4										
	PIPE IN FET	2.4	2.5	2.7	3.0	3.4	3.5	4.0	4.1	4.9	5.7										
80	PIPE TEMP	75.3	74.8	74.3	73.3	72.2	71.6	70.0	69.8	67.5	64.8										
	PIPE IN FET	3.5	3.8	4.0	4.5	5.1	5.3	6.2	6.2	7.6	8.7										
	PIPE IN FET	3.3	3.5	3.7	4.1	4.6	4.8	5.5	5.6	6.6	7.7										
100	PIPE TEMP	93.9	93.4	92.7	91.5	89.9	89.3	87.2	87.1	84.1	80.7										
	PIPE IN FET	4.5	4.8	5.1	5.8	6.5	6.8	7.9	7.9	9.4	11.4										
	PIPE IN FET	4.2	4.4	4.7	5.3	5.9	6.2	7.0	7.1	8.4	9.8										
120	PIPE TEMP	112.5	111.9	111.0	109.5	107.6	106.8	104.3	104.2	100.6	96.5										
	PIPE IN FET	5.6	5.9	6.2	7.1	8.0	8.4	9.7	9.7	11.8	13.9										
	PIPE IN FET	5.2	5.4	5.7	6.5	7.3	7.5	8.6	8.7	10.3	12.0										
140	PIPE TEMP	130.9	130.3	129.2	127.4	125.2	124.3	121.3	121.2	117.0	112.1										
	PIPE IN FET	6.7	7.1	7.5	8.5	9.6	10.0	11.5	11.5	14.0	16.5										
	PIPE IN FET	6.2	6.5	6.8	7.7	8.7	9.0	10.2	10.3	12.2	14.2										
160	PIPE TEMP	149.3	148.6	147.4	145.3	142.7	141.7	138.2	138.1	133.3	127.7										
	PIPE IN FET	7.9	8.3	8.7	10.0	11.2	11.7	13.5	13.4	16.3	19.2										
	PIPE IN FET	7.2	7.6	8.0	9.0	10.1	10.5	11.9	12.0	14.2	16.5										
180	PIPE TEMP	167.7	166.9	165.5	163.1	160.2	159.0	155.0	155.0	149.5	143.1										
	PIPE IN FET	9.1	9.6	10.0	11.5	13.0	13.4	15.5	15.4	18.7	22.0										
	PIPE IN FET	8.3	8.7	9.2	10.4	11.6	12.0	13.6	13.7	16.2	18.8										
200	PIPE TEMP	186.0	185.0	183.5	180.8	177.5	176.2	171.7	171.7	165.6	158.4										
	PIPE IN FET	10.3	10.9	11.4	13.0	14.7	15.3	17.6	17.4	21.2	24.9										
	PIPE IN FET	9.5	9.9	10.4	11.8	13.2	13.6	15.4	15.5	18.3	21.2										
220	PIPE TEMP	204.2	203.2	201.5	198.4	194.7	193.4	188.4	188.4	181.6	173.6										
	PIPE IN FET	11.7	12.3	12.8	14.7	16.6	17.1	19.7	19.5	23.7	27.8										
	PIPE IN FET	10.7	11.2	11.7	13.2	14.8	15.2	17.3	17.3	20.4	23.7										
240	PIPE TEMP	222.3	221.2	219.4	216.0	211.9	210.4	204.9	205.0	197.5	188.7										
	PIPE IN FET	13.1	13.7	14.3	16.4	18.5	19.1	22.0	21.6	26.3	30.9										
	PIPE IN FET	11.9	12.4	13.0	14.7	16.4	16.9	19.2	19.2	22.6	26.2										
260	PIPE TEMP	240.3	239.2	237.2	233.4	229.0	227.4	221.3	221.5	213.3	203.7										
	PIPE IN FET	14.5	15.2	15.8	18.1	20.4	21.0	24.3	23.8	29.6	34.0										
	PIPE IN FET	13.2	13.7	14.3	16.2	18.1	18.6	21.1	21.1	24.8	28.7										
280	PIPE TEMP	258.3	257.1	255.0	250.8	245.9	244.3	237.7	238.0	229.0	218.6										
	PIPE IN FET	16.0	16.7	17.4	19.9	22.5	23.1	26.6	26.1	31.7	37.2										
	PIPE IN FET	14.5	15.1	15.7	17.8	19.9	20.3	23.1	23.0	27.1	31.3										
300	PIPE TEMP	276.3	275.0	272.7	268.2	262.9	261.1	253.9	254.3	244.7	233.4										
	PIPE IN FET	17.5	18.3	19.0	21.8	24.6	25.2	29.0	28.7	34.5	40.6										
	PIPE IN FET	15.9	16.5	17.2	19.4	21.7	22.1	25.1	25.0	29.4	34.0										
350	PIPE TEMP	320.8	319.4	316.7	311.2	304.8	302.9	294.2	294.9	283.6	270.0										
	PIPE IN FET	21.6	22.5	23.3	26.7	30.0	30.7	35.4	34.5	41.8	48.9										
	PIPE IN FET	19.5	20.1	20.9	23.7	26.3	26.8	30.4	30.2	35.4	40.8										
400	PIPE TEMP	364.9	363.4	360.3	353.8	346.3	344.2	334.0	335.1	321.6	306.1										
	PIPE IN FET	26.1	26.9	27.9	32.0	35.9	36.6	42.1	40.9	49.5	57.9										
	PIPE IN FET	23.4	24.1	24.9	28.2	31.3	31.8	36.0	35.6	41.7	47.9										
450	PIPE TEMP	408.6	407.0	403.5	396.0	387.4	385.1	373.4	374.9	359.5	341.8										
	PIPE IN FET	30.8	31.7	32.8	37.5	42.1	42.6	49.2	47.6	57.6	67.2										
	PIPE IN FET	27.4	28.2	29.1	32.9	36.4	36.9	41.7	41.2	48.2	55.3										
500	PIPE TEMP	452.0	450.3	446.5	437.8	428.1	425.7	412.4	414.3	396.9	377.0										
	PIPE IN FET	35.8	36.8	37.9	43.4	48.6	49.1	56.7	54.5	66.1	76.9										
	PIPE IN FET	31.8	32.5	33.5	37.8	41.8	42.3	47.7	47.0	54.9	62.8										
550	PIPE TEMP	495.1	493.3	489.1	479.4	468.5	465.9	451.1	453.4	434.0	411.8										
	PIPE IN FET	41.7	42.2	43.3	49.6	55.4	56.1	64.6	61.8	74.8	87.0										
	PIPE IN FET	38.3	37.0	38.0	42.9	47.4	47.9	53.9	52.9	61.8	70.6										
600	PIPE TEMP	537.9	536.1	531.5	520.7	508.6	505.9	489.4	492.2	470.8	446.4										
	PIPE IN FET	46.8	47.8	48.5	56.0	62.5	63.2	72.5	69.3	81.9	97.4										
	PIPE IN FET	41.0	41.8	42.8	48.2	53.2	53.6	60.3	59.1	68.8	78.6										
650	PIPE TEMP	580.5	578.6	573.7	561.8	548.5	545.6	527.5	530.8	507.3	480.6										
	PIPE IN FET	52.6	53.7	54.8	62.7	69.9	70.5	80.8	77.1	91.1	108.2										
	PIPE IN FET	45.9	46.7	47.7	53.7	59.1	59.5	66.9	65.4	76.1	88.7										
700	PIPE TEMP	622.9	620.9	615.7	602.6	588.1	585.1	565.4	569.2	543.6	514.6										
	PIPE IN FET	58.6	59.8	60.9	69.6	77.5	78.1	89.5	85.1	102.9	119.3										
	PIPE IN FET	51.0	51.8	52.8	59.3	65.2	65.6	73.6	71.9	83.5	95.0										
750	PIPE TEMP	665.1	663.1	657.6	643.4	627.7	624.5	603.2	607.5	579.7	548.4										
	PIPE IN FET	65.2	66.3	67.3	76.8	85.5	86.0	98.5	93.3	112.9	130.7										
	PIPE IN FET	56.3	57.1	58.0	65.2	71.5	71.9	80.5	78.5	91.2	103.6										
800	PIPE TEMP	707.3	705.3	699.4	684.0	667.1	663.8	640.8	645.6	615.8	582.1										
	PIPE IN FET	72.0	73.1	74.0	84.4	93.8	94.3	107.8	101.9	123.3	142.5										
	PIPE IN FET	61.8	62.6	63.5	71.2	78.0	78.3	87.7	85.3	99.0	112.3										
850	PIPE TEMP	749.4	747.3	741.1	724.5	706.4	703.0	678.3	683.6	651.7	615.7										
	PIPE IN FET	79.2	80.3	81.1	92.3	102.4	102.9	117.5	110.7	134.1	154.8										
	PIPE IN FET	67.6	68.4	69.2	77.5	84.8	85.0	95.1	92.4	107.1	121.3										
900	PIPE TEMP	791.4	789.3	782.8	765.1	745.7	742.1	715.8	721.5	687.6	649.3										
	PIPE IN FET	87.0	88.1	88.6	100.7	111.6	112.0	127.8	120.0	145.4	167.7										
	PIPE IN FET	73.8	74.5	75.3	84.1	91.9	92.1	102.8	99.7	115.5	130.6										
950	PIPE TEMP	833.5	831.3	824.4	805.5	784.9	781.3	753.3	759.4	723.4	682.8										
	PIPE IN FET	95.4	96.5	96.7	109.8	121.4	121.4	138.9	129.8	157.5	181.3										
	PIPE IN FET	80.5	81.2	81.7	91.2	99.4	99.5	111.0	107.3	124.3	140.9										



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
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SECTION III
INSULATION DESIGN
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INSULATION THICKNESS REQUIREMENTS

Service Designation T-39

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT
PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

1-1/2" NOMINAL INSULATION THICKNESS		PIPE SIZE																AMBIENT AIR TEMP ° F (-17.8 C)		
CABLE TEMP DEG F		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
60	PIPE TEMP	57.0	56.8	56.3	55.7	55.2	54.9	53.6	53.3	51.9	50.2	47.1	44.2	41.6	39.1	36.0	34.3	34.9	33.4	31.0
	PAR.W /FT	2.1	2.2	2.5	2.8	3.0	3.1	3.8	3.9	4.7	5.5	6.8	7.9	8.7	9.8	10.3	11.2	11.9	12.6	13.8
	PIA.W /FT	2.0	2.1	2.4	2.6	2.8	2.9	3.5	3.7	4.3	5.0	6.2	7.3	8.3	9.3	9.8	10.6	11.3	11.9	13.0
80	PIPE TEMP	75.9	75.6	74.9	74.1	73.4	73.0	71.5	70.9	69.1	66.7	62.5	58.7	55.3	51.9	50.5	48.1	46.2	44.3	41.1
	PAR.W /FT	2.8	3.0	3.4	3.8	4.1	4.2	5.2	5.4	6.4	7.4	9.2	10.6	11.7	13.2	13.9	15.1	16.1	16.9	18.5
	PIA.W /FT	2.7	2.9	3.2	3.6	3.8	3.9	4.7	5.0	5.8	6.7	8.3	9.8	11.2	12.6	13.2	14.3	15.2	16.0	17.5
100	PIPE TEMP	94.8	94.4	93.5	92.5	91.6	91.1	88.9	88.4	86.1	83.1	77.9	73.1	68.8	64.5	62.8	59.9	57.5	55.1	51.1
	PAR.W /FT	3.7	3.9	4.4	4.9	5.2	5.4	6.4	6.8	8.1	9.5	11.7	13.4	14.8	16.7	17.5	19.0	20.2	21.3	23.2
	PIA.W /FT	3.5	3.6	4.1	4.6	4.8	5.0	6.0	6.3	7.3	8.5	10.5	12.6	14.1	15.9	16.6	18.0	19.2	20.1	22.0
120	PIPE TEMP	113.6	113.2	112.0	110.8	109.7	109.1	106.4	105.9	103.1	99.5	93.1	87.4	82.2	77.0	75.0	71.5	68.7	65.7	61.0
	PAR.W /FT	4.5	4.7	5.3	6.0	6.4	6.6	8.1	8.3	9.9	11.6	14.2	16.3	17.9	20.3	21.1	23.0	24.5	25.7	28.0
	PIA.W /FT	4.2	4.5	5.0	5.6	5.9	6.1	7.4	7.7	8.9	10.4	12.8	15.1	17.1	19.2	20.1	21.8	23.0	24.2	26.5
140	PIPE TEMP	132.3	131.8	130.5	129.0	127.8	127.1	123.8	123.3	120.0	115.7	108.3	101.6	95.5	89.4	87.1	83.0	79.7	76.3	70.8
	PAR.W /FT	5.4	5.6	6.4	7.2	7.6	7.8	9.4	9.9	11.7	13.7	16.8	19.2	21.1	23.9	24.9	27.0	28.7	30.2	32.9
	PIA.W /FT	5.1	5.3	6.0	6.7	7.1	7.3	8.8	9.1	10.6	12.3	15.1	17.8	20.1	22.6	23.6	25.6	27.2	28.6	31.1
160	PIPE TEMP	151.0	150.5	148.9	147.1	145.7	145.0	141.2	140.6	136.8	131.8	123.3	115.6	108.7	101.7	99.2	94.4	90.7	86.8	80.6
	PAR.W /FT	6.3	6.4	7.4	8.4	8.8	9.1	11.2	11.5	13.6	15.9	19.4	22.2	24.9	27.5	28.6	31.1	33.1	34.7	37.8
	PIA.W /FT	5.9	6.2	6.9	7.8	8.2	8.5	10.2	10.6	12.3	14.2	17.5	20.5	23.2	26.1	27.2	29.5	31.3	32.6	35.2
180	PIPE TEMP	169.6	169.0	167.2	165.2	163.6	162.8	158.4	157.8	153.5	147.9	138.3	129.6	121.8	113.8	111.1	105.7	101.5	97.2	90.2
	PAR.W /FT	7.2	7.4	8.6	9.7	10.1	10.4	12.8	13.2	15.6	18.2	22.1	25.3	27.7	31.3	32.5	35.3	37.5	39.3	42.8
	PIA.W /FT	6.8	7.1	8.0	8.9	9.4	9.7	11.7	12.1	14.0	16.2	19.9	23.3	26.3	29.6	30.8	33.4	35.5	37.2	40.6
200	PIPE TEMP	188.2	187.6	185.5	183.2	181.5	180.6	175.7	175.0	170.1	163.9	153.1	143.5	134.8	125.9	122.9	117.0	112.3	107.5	99.7
	PAR.W /FT	8.2	8.4	9.7	11.0	11.5	11.8	14.5	14.9	17.4	20.5	24.9	28.4	31.1	35.1	36.4	39.5	41.9	44.0	47.4
	PIA.W /FT	7.7	8.0	9.0	10.1	10.7	10.9	13.2	13.6	15.8	18.3	22.4	26.1	29.5	33.2	34.6	37.3	39.6	41.5	45.2
220	PIPE TEMP	206.7	206.1	203.7	201.2	199.3	198.3	192.8	192.0	186.7	179.7	167.9	157.2	147.6	137.8	134.6	128.1	123.0	117.7	109.2
	PAR.W /FT	9.3	9.6	10.9	12.3	12.9	13.2	16.2	16.7	19.6	22.9	27.7	31.6	34.5	38.9	40.3	43.8	46.5	48.7	52.3
	PIA.W /FT	8.7	9.0	10.1	11.4	11.9	12.2	14.7	15.2	17.6	20.4	24.9	29.0	32.7	36.8	38.1	41.3	43.9	45.9	49.9
240	PIPE TEMP	225.2	224.5	221.9	219.1	217.0	216.0	209.8	209.1	203.1	195.5	182.6	170.9	160.4	149.6	146.3	139.1	133.6	127.8	118.6
	PAR.W /FT	10.3	10.7	12.1	13.7	14.3	14.6	18.0	18.5	21.7	25.3	30.6	34.8	38.0	42.8	44.3	48.1	51.0	53.6	58.0
	PIA.W /FT	9.7	10.0	11.2	12.6	13.2	13.5	16.3	16.8	19.4	22.5	27.4	31.9	36.0	40.5	41.9	45.4	48.1	50.4	54.7
260	PIPE TEMP	243.6	242.9	240.1	237.0	234.7	233.6	226.8	226.0	219.6	211.2	197.1	184.5	173.1	161.4	157.8	150.0	144.1	137.9	127.9
	PAR.W /FT	11.4	11.8	13.4	15.1	15.8	16.1	19.8	20.3	23.9	27.8	33.4	38.1	41.5	46.8	48.3	52.5	55.4	58.2	63.2
	PIA.W /FT	10.7	11.1	12.4	13.9	14.6	14.9	17.9	18.5	21.3	24.7	30.0	34.9	39.3	43.7	45.2	49.5	52.5	54.9	59.6
280	PIPE TEMP	262.0	261.2	258.1	254.8	252.3	251.1	243.7	242.9	235.9	226.9	211.6	198.0	185.7	173.0	169.3	160.9	154.5	147.8	137.1
	PAR.W /FT	12.5	13.0	14.7	16.6	17.3	17.6	21.7	22.2	26.1	30.4	36.6	41.5	45.0	50.8	52.4	56.9	60.3	63.1	68.4
	PIA.W /FT	11.7	12.1	13.6	15.2	15.9	16.2	19.6	20.2	23.3	26.9	32.6	37.9	42.7	48.0	49.5	53.6	56.8	59.4	64.5
300	PIPE TEMP	280.3	279.5	276.2	272.5	269.8	268.6	260.6	259.7	252.2	242.4	226.1	211.4	198.3	184.6	180.6	171.7	164.8	157.7	146.3
	PAR.W /FT	13.7	14.2	16.0	18.1	18.8	19.2	23.7	24.2	28.2	33.0	39.6	44.9	49.7	54.9	56.4	61.3	65.0	67.9	73.9
	PIA.W /FT	12.8	13.2	14.8	16.6	17.3	17.6	21.3	21.9	25.2	29.2	35.3	41.0	46.1	51.8	53.4	57.8	61.2	64.0	69.4
350	PIPE TEMP	326.0	325.0	321.0	316.6	313.5	312.1	302.4	301.5	292.5	281.0	261.7	244.6	229.2	213.1	208.7	198.2	190.2	182.1	168.9
	PAR.W /FT	16.8	17.3	19.5	22.0	22.9	23.2	28.7	29.2	34.2	39.8	47.5	53.6	57.9	65.3	67.1	72.7	77.0	80.4	87.0
	PIA.W /FT	15.6	16.1	17.9	20.1	21.0	21.3	25.7	26.4	30.3	35.0	42.2	48.8	54.8	61.5	63.3	68.4	72.4	75.6	81.8
400	PIPE TEMP	371.3	370.3	365.6	360.3	356.8	355.3	343.9	343.0	332.5	319.1	297.0	277.6	259.6	241.0	236.3	226.2	215.2	205.9	191.0
	PAR.W /FT	20.1	20.6	23.2	26.2	27.1	27.5	34.0	34.5	40.4	46.8	55.7	62.6	67.5	76.0	78.0	84.4	89.2	93.1	100.4
	PIA.W /FT	18.6	19.1	21.3	23.9	24.8	25.1	30.3	31.0	35.0	41.0	49.2	56.9	63.7	71.4	73.4	79.3	83.8	87.5	94.5
450	PIPE TEMP	416.4	415.3	409.9	403.8	399.8	398.2	385.0	384.1	372.1	358.8	331.8	309.4	289.5	268.5	263.4	249.8	239.8	229.4	212.8
	PAR.W /FT	23.6	24.1	27.2	30.7	31.6	32.0	39.5	40.0	46.2	54.2	64.2	71.9	77.3	86.9	89.1	96.4	101.8	105.4	114.4
	PIA.W /FT	21.6	22.3	24.8	27.8	28.8	29.1	35.1	35.9	41.1	47.2	56.5	65.2	72.9	81.6	83.7	90.4	95.5	99.2	107.6
500	PIPE TEMP	461.2	460.1	453.9	447.0	442.5	440.8	425.8	424.9	411.4	394.2	366.2	341.2	319.0	295.5	290.0	275.0	263.9	252.4	234.1
	PAR.W /FT	27.3	27.8	31.3	35.3	36.3	36.7	45.3	45.8	53.5	61.9	73.0	81.5	87.4	98.2	100.4	108.6	114.5	119.3	128.5
	PIA.W /FT	25.1	25.6	28.5	31.9	33.0	33.3	40.1	40.9	46.8	53.7	64.0	73.7	82.2	92.0	94.2	101.7	107.3	111.8	120.5
550	PIPE TEMP	505.8	504.6	497.7	489.9	485.0	483.2	468.3	465.4	450.4	431.2	400.2	372.5	348.1	322.1	316.3	299.7	287.6	275.1	255.1
	PAR.W /FT	31.1	31.7	35.6	40.2	41.2	41.5	51.3	51.7	60.4	69.8	82.0	91.4	97.7	109.7	112.0	121.0	127.6	132.7	142.9
	PIA.W /FT	28.6	29.1	32.3	36.1	37.3	37.6	45.2	46.1	52.7	60.3	71.7	82.4	91.8	102.6	105.0	113.2	119.3	124.2	133.7
600	PIPE TEMP	550.2	549.0	541.3	532.6	527.3	525.3	508.6	505.7	489.1	467.9	433.9	403.5	376.8	348.3	342.2	324.1	310.9	297.4	275.8
	PAR.W /FT	35.2	35.7	40.1	45.2	46.3	46.6	57.6	57.9	67.9	77.9	91.3	101.5	108.2	121.4	123.8	133.7	140.8	146.4	157.



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INSULATION THICKNESS REQUIREMENTS

Service Designation T-40

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT
PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

2" NOMINAL INSULATION THICKNESS		PIPE SIZE																AMBIENT AIR TEMP ° F (-17.8 C)		
CABLE TEMP DEG F		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
40	PIPE TEMP	57.2	56.9	56.7	56.1	55.5	55.3	54.2	53.9	52.7	51.2	48.3	46.0	43.6	41.3	40.3	38.7	37.4	35.9	33.6
	PARALLEL / FT	2.0	2.1	2.1	2.5	2.7	2.8	3.4	3.5	4.1	4.8	5.9	6.7	7.7	8.7	9.1	9.9	10.6	11.2	12.3
	PISTON / FT	1.9	2.0	2.0	2.4	2.6	2.7	3.2	3.3	3.8	4.5	5.5	6.4	7.4	8.3	8.7	9.5	10.2	10.7	11.8
80	PIPE TEMP	76.1	75.8	75.5	74.6	73.9	73.6	72.1	71.7	70.1	68.1	64.2	61.1	57.9	54.8	53.5	51.4	49.6	47.7	44.6
	PARALLEL / FT	2.7	2.8	2.9	3.4	3.7	3.8	4.6	4.8	5.6	6.5	8.0	9.0	10.3	11.7	12.2	13.3	14.2	15.0	16.5
	PISTON / FT	2.6	2.7	2.8	3.2	3.5	3.6	4.3	4.5	5.2	6.0	7.5	8.7	10.0	11.2	11.7	12.8	13.7	14.4	15.8
100	PIPE TEMP	95.0	94.7	94.3	93.1	92.2	91.5	89.9	89.4	87.5	84.9	80.1	76.2	72.1	68.2	66.7	64.0	61.7	59.6	55.5
	PARALLEL / FT	3.5	3.6	3.7	4.4	4.7	4.9	5.8	6.1	7.1	8.3	10.1	11.4	13.1	14.7	15.4	16.8	17.9	18.9	20.8
	PISTON / FT	3.3	3.5	3.5	4.1	4.5	4.6	5.4	5.7	6.6	7.6	9.5	11.0	12.6	14.1	14.8	16.1	17.2	18.1	19.9
120	PIPE TEMP	113.9	113.5	113.0	111.6	110.5	110.0	107.7	107.1	104.8	101.6	95.8	91.1	86.2	81.5	79.7	76.5	73.8	71.0	66.4
	PARALLEL / FT	4.2	4.5	4.5	5.4	5.9	6.1	7.1	7.5	8.6	10.1	12.3	13.8	15.8	17.4	18.1	20.3	21.7	22.8	25.1
	PISTON / FT	4.0	4.2	4.3	5.1	5.4	5.6	6.6	7.0	8.0	9.3	11.5	13.3	15.2	17.1	17.9	19.5	20.8	21.9	24.0
140	PIPE TEMP	132.6	132.2	131.7	130.0	128.7	128.1	125.4	124.7	122.0	118.2	111.5	106.0	100.2	94.7	92.7	88.9	85.7	82.5	77.1
	PARALLEL / FT	5.1	5.3	5.4	6.4	6.8	7.1	8.5	8.8	10.2	11.9	14.6	16.2	18.6	21.0	21.9	23.9	25.5	26.8	29.4
	PISTON / FT	4.8	5.0	5.1	6.0	6.5	6.7	7.9	8.3	9.5	11.0	13.6	15.6	17.9	20.2	21.0	22.9	24.4	25.7	28.1
160	PIPE TEMP	151.4	150.9	150.3	148.3	146.9	146.2	143.0	142.3	139.1	134.8	127.0	120.7	114.1	107.8	105.5	101.2	97.6	93.9	87.8
	PARALLEL / FT	5.9	6.2	6.3	7.4	8.0	8.2	9.8	10.2	11.9	13.8	16.8	18.7	21.5	24.2	25.2	27.5	29.3	30.8	33.8
	PISTON / FT	5.6	5.9	6.0	7.0	7.5	7.7	9.1	9.6	11.0	12.7	15.7	18.1	20.6	23.2	24.2	26.3	28.0	29.5	32.3
180	PIPE TEMP	170.1	169.6	168.9	166.6	165.0	164.3	160.6	159.8	156.2	151.3	142.5	135.4	128.0	120.8	118.3	113.4	109.4	105.2	98.4
	PARALLEL / FT	6.8	7.1	7.2	8.5	9.1	9.4	11.3	11.7	13.6	15.8	19.2	21.3	24.4	27.5	28.6	31.1	33.2	34.9	38.2
	PISTON / FT	6.5	6.7	6.8	8.0	8.6	8.8	10.5	11.0	12.5	14.5	17.8	20.5	23.4	26.4	27.4	29.8	31.7	33.4	36.6
200	PIPE TEMP	188.7	188.2	187.4	184.9	183.0	182.2	178.1	177.2	173.2	167.7	157.9	150.0	141.7	133.7	131.0	125.5	121.1	116.4	108.9
	PARALLEL / FT	7.8	8.1	8.1	9.7	10.3	10.6	12.7	13.2	15.3	17.7	21.5	23.9	27.3	30.8	32.0	34.8	37.1	39.0	42.7
	PISTON / FT	7.3	7.6	7.7	9.1	9.7	10.0	11.8	12.3	14.1	16.3	20.0	23.0	26.2	29.5	30.7	33.5	35.5	37.3	40.8
220	PIPE TEMP	207.4	206.7	205.9	203.0	201.0	200.2	195.5	194.6	190.1	184.0	173.2	164.5	155.4	146.5	143.6	137.5	132.7	127.6	119.3
	PARALLEL / FT	8.7	9.0	9.1	10.8	11.6	11.8	14.2	14.8	17.1	19.8	24.0	26.5	30.3	34.2	35.5	38.6	41.1	43.2	47.2
	PISTON / FT	8.2	8.5	8.7	10.2	10.9	11.1	13.2	13.8	15.7	18.1	22.2	25.5	29.1	32.7	34.0	36.9	39.3	41.3	45.1
240	PIPE TEMP	225.9	225.2	224.4	221.2	218.9	218.0	212.9	211.9	207.0	200.3	188.5	179.0	169.0	159.2	156.1	149.5	144.2	138.7	129.6
	PARALLEL / FT	9.7	10.1	10.1	12.0	12.8	13.1	15.8	16.4	18.9	21.9	26.4	29.2	33.4	37.6	39.0	42.4	45.1	47.4	51.8
	PISTON / FT	9.2	9.5	9.6	11.3	12.1	12.3	14.6	15.2	17.3	20.0	24.5	28.1	32.0	36.0	37.3	40.5	43.1	45.3	49.5
260	PIPE TEMP	244.4	243.7	242.8	239.3	236.8	235.9	230.2	229.2	223.8	216.5	203.7	193.3	182.5	171.9	168.6	161.4	155.6	149.7	139.9
	PARALLEL / FT	10.7	11.1	11.2	13.3	14.1	14.4	17.3	18.0	20.7	24.0	29.0	31.9	36.4	41.1	42.5	46.2	49.2	51.7	56.4
	PISTON / FT	10.1	10.4	10.6	12.4	13.3	13.5	16.0	16.7	19.0	21.9	26.8	30.7	34.9	39.3	40.7	44.2	47.0	49.3	53.9
280	PIPE TEMP	262.9	262.2	261.1	257.3	254.6	253.6	247.5	246.4	240.6	232.6	218.8	207.6	195.9	184.4	180.9	173.2	167.0	160.6	150.1
	PARALLEL / FT	11.8	12.2	12.2	14.5	15.5	15.8	19.0	19.6	22.6	26.2	31.5	34.7	39.6	44.6	46.1	50.1	53.3	56.0	61.1
	PISTON / FT	11.1	11.4	11.6	13.6	14.5	14.8	17.5	18.2	20.9	23.9	29.1	33.3	37.9	42.6	44.1	47.9	50.9	53.6	58.5
300	PIPE TEMP	281.5	280.5	279.5	275.3	272.4	271.4	265.7	263.5	257.3	248.7	233.8	221.8	209.2	196.9	193.2	184.9	178.3	171.4	160.2
	PARALLEL / FT	12.9	13.3	13.3	15.8	16.8	17.1	20.6	21.3	24.5	28.4	34.1	37.5	42.7	48.1	49.7	54.0	57.4	60.3	65.8
	PISTON / FT	12.1	12.5	12.6	14.8	15.8	16.0	19.0	19.6	22.5	25.9	31.5	36.0	40.9	46.0	47.5	51.6	54.8	57.5	62.7
350	PIPE TEMP	327.2	326.3	325.1	320.0	316.7	315.5	307.4	306.2	298.7	288.5	271.0	257.0	242.2	227.7	223.5	213.8	206.2	198.2	185.2
	PARALLEL / FT	15.7	16.2	16.1	19.2	20.4	20.7	24.9	25.7	29.5	34.1	40.8	44.7	50.8	57.2	59.0	64.1	67.4	70.7	77.7
	PISTON / FT	14.8	15.1	15.2	17.9	19.1	19.3	22.9	23.8	28.0	33.0	37.6	42.9	48.6	54.6	56.3	61.1	64.8	68.0	74.0
400	PIPE TEMP	372.8	371.9	370.5	364.5	360.6	359.3	349.9	348.5	339.9	328.0	307.6	291.7	274.8	258.0	253.2	242.3	233.6	224.5	209.8
	PARALLEL / FT	18.8	19.2	19.2	22.8	24.2	24.5	29.4	30.3	34.8	40.1	47.8	52.1	59.2	66.6	68.5	74.3	78.8	82.6	89.8
	PISTON / FT	17.6	18.0	18.0	21.2	22.5	22.8	26.9	28.0	31.6	36.3	43.9	50.0	56.6	63.5	65.5	70.8	75.1	78.6	85.5
450	PIPE TEMP	418.1	417.2	415.7	408.8	404.3	402.9	392.0	390.5	380.7	367.1	344.2	325.9	306.9	287.8	282.9	270.3	260.6	250.4	234.0
	PARALLEL / FT	22.0	22.5	22.3	26.6	28.1	28.4	34.7	35.1	40.2	46.3	55.0	59.8	67.7	76.1	78.2	84.8	89.9	94.1	102.2
	PISTON / FT	20.9	21.0	21.0	24.6	26.1	26.4	31.2	32.3	36.5	41.8	50.4	57.2	64.7	72.5	74.5	80.7	85.5	89.5	97.1
500	PIPE TEMP	463.3	462.3	460.7	452.7	447.7	446.2	433.8	432.2	421.2	405.9	380.3	359.8	338.5	317.3	312.0	297.9	287.1	275.9	257.8
	PARALLEL / FT	25.4	25.9	25.6	30.6	32.2	32.5	39.1	40.1	45.9	52.7	62.4	67.7	76.5	86.0	88.2	95.5	101.2	105.8	114.7
	PISTON / FT	23.7	24.1	24.0	28.2	29.9	30.1	35.6	36.8	41.5	47.5	57.0	64.7	73.0	81.8	83.9	90.8	96.1	100.5	109.0
550	PIPE TEMP	508.2	507.2	505.5	496.5	491.0	489.3	475.4	473.7	461.4	444.4	418.0	393.3	369.8	346.3	340.6	325.1	313.3	301.1	281.2
	PARALLEL / FT	29.0	29.5	29.1	34.7	36.5	36.8	44.2	45.3	51.7	59.4	70.1	75.8	85.5	96.0	98.4	106.5	112.7	117.7	127.5
	PISTON / FT	28.9	29.3	29.2	32.0	33.8	34.0	40.1	41.4	46.7	53.4	63.9	72.4	81.5	91.2	93.5	101.1	107.0	111.7	121.0
600	PIPE TEMP	553.0	551.9	550.1	540.1	534.0	532.2	516.8	515.0	501.3	482.6	451.4	426.4	400.7	374.9	368.9	352.0	339.2	325.9	304.3
	PARALLEL / FT	32.7	33.2	32.7	39.0	40.9	41.2	49.5	50.6	57.8	66.2	77.9	84.1	94.8	106.2	108.8	117.6	124.4	129.9	140.5
	PISTON / FT	30.3																		



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
PAGE 380
MAY, 1968

INSULATION THICKNESS REQUIREMENTS

Service Designation T-41

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT
PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

2-1/2" NOMINAL INSULATION THICKNESS		PIPE SIZE																AMBIENT AIR TEMP ° F (-17.8 ° C)			
CABLE TEMP DEG F		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	
60	PIPE TEMP	57.3	57.1	56.9	56.3	55.8	55.4	54.6	54.3	53.3	52.0	49.3	47.2	45.0	43.0	42.1	40.4	39.3	38.0	35.8	
	MAX W / FT	1.8	1.9	2.0	2.3	2.5	2.6	3.1	3.2	3.7	4.3	5.3	6.0	6.9	7.8	8.2	8.9	9.3	10.1	11.2	
	MIN W / FT	1.8	1.8	1.9	2.2	2.4	2.5	2.9	3.1	3.5	4.0	5.1	5.9	6.7	7.6	7.9	8.6	9.3	9.8	10.6	
80	PIPE TEMP	74.4	74.1	73.8	73.0	72.3	71.0	72.7	72.3	70.9	69.2	65.6	62.8	59.9	57.1	55.9	53.9	52.3	50.5	47.5	
	MAX W / FT	2.5	2.6	2.7	3.2	3.4	3.5	4.2	4.4	5.0	5.8	7.2	8.1	9.3	10.5	11.0	12.0	12.9	13.6	15.0	
	MIN W / FT	2.4	2.5	2.6	3.0	3.3	3.4	3.9	4.2	4.8	5.4	6.8	7.9	9.0	10.2	10.7	11.6	12.4	13.1	14.5	
100	PIPE TEMP	95.3	95.0	94.6	93.6	92.7	92.3	90.7	90.2	88.5	86.3	81.7	78.3	74.6	71.1	69.7	67.2	65.1	62.9	59.7	
	MAX W / FT	3.2	3.3	3.5	4.0	4.3	4.5	5.3	5.6	6.4	7.3	9.1	10.2	11.8	13.3	13.9	15.1	16.2	17.1	18.4	
	MIN W / FT	3.0	3.2	3.3	3.8	4.2	4.3	5.0	5.3	6.0	6.9	8.6	9.9	11.4	12.8	13.4	14.6	15.6	16.5	18.2	
120	PIPE TEMP	114.3	113.9	113.4	112.1	111.1	110.7	108.6	108.0	106.0	103.3	97.9	93.7	89.3	85.0	83.4	80.4	77.8	75.2	70.7	
	MAX W / FT	3.9	4.1	4.2	4.9	5.3	5.5	6.5	6.8	7.8	8.9	11.0	12.4	14.2	16.1	16.8	18.3	19.6	20.7	22.4	
	MIN W / FT	3.7	3.9	4.1	4.7	5.1	5.2	6.1	6.5	7.3	8.4	10.5	12.0	13.8	15.5	16.2	17.7	18.9	19.9	22.0	
140	PIPE TEMP	133.1	132.8	132.1	130.7	129.4	128.9	126.5	125.8	123.5	120.3	113.9	109.1	103.9	98.8	97.0	93.4	90.5	87.4	82.3	
	MAX W / FT	4.6	4.9	5.0	5.9	6.3	6.5	7.7	8.1	9.2	10.5	13.0	14.6	16.8	18.9	19.7	21.5	23.0	24.3	26.7	
	MIN W / FT	4.5	4.6	4.8	5.6	6.0	6.2	7.2	7.7	8.7	9.9	12.4	14.2	16.2	18.3	19.0	20.7	22.2	23.4	25.8	
160	PIPE TEMP	152.0	151.6	150.9	149.1	147.7	147.1	144.3	143.6	140.8	137.2	129.9	124.3	118.4	112.6	110.5	106.5	103.1	99.5	93.7	
	MAX W / FT	5.4	5.7	5.8	6.8	7.4	7.5	8.9	9.4	10.7	12.2	15.0	16.9	19.3	21.8	22.7	24.7	26.4	27.9	30.7	
	MIN W / FT	5.2	5.4	5.6	6.5	7.0	7.2	8.4	8.9	10.0	11.5	14.3	16.4	18.7	21.0	21.9	23.9	25.5	26.9	29.6	
180	PIPE TEMP	170.8	170.3	169.5	167.5	165.9	165.3	162.1	161.3	158.2	154.0	145.8	139.5	132.8	126.2	123.9	119.4	115.6	111.6	105.6	
	MAX W / FT	6.2	6.5	6.7	7.8	8.4	8.6	10.2	10.7	12.2	13.9	17.1	19.2	21.9	24.7	25.7	28.0	29.9	31.6	34.7	
	MIN W / FT	6.0	6.2	6.4	7.4	8.0	8.2	9.6	10.1	11.4	13.0	16.2	18.6	21.2	23.9	24.8	27.0	28.9	30.4	33.5	
200	PIPE TEMP	189.5	189.0	188.2	185.9	184.1	183.4	179.4	178.9	175.4	170.8	161.4	154.6	147.1	139.8	137.3	132.2	128.0	123.6	116.3	
	MAX W / FT	7.1	7.3	7.4	8.6	9.2	9.3	11.0	11.5	13.0	14.7	18.0	20.5	23.5	26.7	27.6	30.2	32.3	34.0	38.0	
	MIN W / FT	6.8	7.0	7.2	8.4	9.1	9.2	10.9	11.4	12.9	14.7	18.2	20.8	23.8	26.7	27.8	30.2	32.3	34.0	37.4	
220	PIPE TEMP	208.3	207.7	206.8	204.2	202.3	201.5	197.5	196.5	192.7	187.5	177.3	169.7	161.4	153.3	150.6	145.0	140.4	135.5	127.5	
	MAX W / FT	7.9	8.2	8.4	9.9	10.6	10.9	12.8	13.4	15.3	17.4	21.3	23.8	27.2	30.7	31.9	34.7	37.0	39.0	42.9	
	MIN W / FT	7.6	7.8	8.1	9.4	10.1	10.3	12.1	12.7	14.5	16.3	20.2	23.1	26.3	29.6	30.8	33.5	35.7	37.6	41.3	
240	PIPE TEMP	226.9	226.4	225.3	222.5	220.4	219.6	215.1	214.1	209.8	204.2	193.0	184.6	175.6	166.7	163.8	157.7	152.7	147.4	138.6	
	MAX W / FT	8.8	9.1	9.4	11.0	11.8	12.0	14.2	14.9	16.9	19.2	23.5	26.2	30.0	33.8	35.0	38.1	40.7	42.8	47.0	
	MIN W / FT	8.4	8.7	9.0	10.6	11.2	11.4	13.3	14.0	15.8	18.0	22.3	25.4	29.0	32.6	33.8	36.7	39.2	41.5	45.1	
260	PIPE TEMP	245.6	245.0	243.8	240.8	238.4	237.6	232.4	231.5	226.9	220.8	208.6	199.5	189.7	180.0	176.9	170.3	164.9	159.1	149.7	
	MAX W / FT	9.6	10.1	10.3	12.1	13.0	13.2	15.6	16.3	18.5	21.0	25.7	28.7	32.7	36.9	38.2	41.6	44.7	47.7	51.7	
	MIN W / FT	9.3	9.6	9.9	11.5	12.3	12.5	14.7	15.4	17.3	19.7	24.4	27.8	31.6	35.5	36.8	40.0	42.7	44.9	49.3	
280	PIPE TEMP	264.2	263.5	262.3	259.0	256.4	255.5	250.1	249.0	244.0	237.3	224.2	214.3	203.7	193.3	190.0	182.8	177.0	170.8	160.7	
	MAX W / FT	10.7	11.0	11.3	13.2	14.2	14.4	17.1	17.8	20.2	22.9	28.3	31.2	35.5	40.0	41.4	45.0	48.0	50.6	55.4	
	MIN W / FT	10.2	10.5	10.8	12.5	13.5	13.7	16.0	16.8	18.7	21.5	26.5	30.2	34.3	38.6	39.9	43.4	46.2	48.7	53.3	
300	PIPE TEMP	282.7	282.1	280.8	277.1	274.3	273.4	267.6	266.3	261.0	253.8	239.6	229.1	217.7	206.4	203.0	195.2	189.0	182.4	171.6	
	MAX W / FT	11.7	12.0	12.3	14.4	15.4	15.7	18.5	19.3	21.9	24.8	30.2	33.7	38.3	43.2	44.7	48.4	51.8	54.5	59.7	
	MIN W / FT	11.1	11.4	11.7	13.6	14.6	14.8	17.4	18.2	20.5	23.2	28.6	32.6	37.0	41.6	43.0	46.8	49.8	52.4	57.4	
350	PIPE TEMP	326.9	326.2	324.7	322.3	319.0	318.0	311.0	309.4	303.2	296.7	278.0	265.7	252.3	239.0	235.2	226.1	218.8	211.1	198.5	
	MAX W / FT	14.2	14.6	14.9	17.5	18.7	18.9	22.3	23.2	26.3	29.8	36.1	40.1	45.6	51.5	53.0	57.6	61.3	64.6	70.5	
	MIN W / FT	13.5	13.8	14.2	16.5	17.7	17.9	20.9	21.9	24.9	28.5	34.2	38.8	44.0	49.4	51.0	55.4	58.9	61.9	67.8	
400	PIPE TEMP	374.9	374.2	372.5	367.3	363.4	362.3	354.1	352.5	345.2	335.3	316.0	301.8	286.5	271.2	266.9	256.5	248.2	239.4	225.1	
	MAX W / FT	17.0	17.3	17.6	20.7	22.1	22.3	26.4	27.4	30.9	34.9	42.2	46.8	53.0	59.6	61.5	66.8	71.0	74.6	81.5	
	MIN W / FT	16.1	16.4	16.8	19.5	20.8	21.0	24.6	25.7	28.8	32.6	39.9	45.2	51.1	57.4	59.1	64.2	68.2	71.7	78.3	
450	PIPE TEMP	420.7	419.9	418.0	412.0	407.4	406.4	397.0	395.2	386.8	375.5	353.7	337.4	320.2	302.9	298.2	286.4	277.1	267.3	251.5	
	MAX W / FT	19.6	20.2	20.5	24.1	25.6	25.9	30.5	31.7	35.7	40.3	48.6	53.4	60.7	68.2	70.2	74.8	79.1	83.0	92.7	
	MIN W / FT	18.7	19.1	19.5	22.6	24.1	24.3	28.4	29.7	33.2	37.5	45.8	51.7	58.5	65.5	67.5	73.2	77.7	81.6	89.0	
500	PIPE TEMP	466.3	465.4	463.4	456.5	451.4	450.2	439.5	437.6	428.2	415.4	390.9	372.9	353.5	334.2	329.0	316.0	305.7	294.8	277.1	
	MAX W / FT	22.9	23.3	23.5	27.6	29.3	29.6	34.9	36.1	40.7	45.9	55.1	60.7	68.6	77.0	79.2	85.8	91.2	95.6	104.2	
	MIN W / FT	21.6	21.9	22.3	25.9	27.6	27.8	32.6	33.8	37.7	42.6	51.8	58.5	66.0	73.9	76.0	82.4	87.4	91.7	99.9	
550	PIPE TEMP	511.7	510.8	508.5	500.8	495.3	493.8	481.9	479.8	469.3	455.1	427.9	407.9	386.5	365.1	359.6	345.1	333.8	322.0	302.5	
	MAX W / FT	26.0	26.4	26.7	31.3	33.2	33.4	39.6	40.8	45.9	51.6	61.8	67.9	76.7	86.0	88.3	95.7	101.5	106.4	115.8	
	MIN W / FT	24.5	24.8	25.2	29.3	31.2	31.4	36.5	38.0	42.4	47.8	58.1	65.4	73.7	82.5	84.7	91.7	97.3	101.9	111.0	
600	PIPE TEMP	556.9	556.0	553.5	544.9	538.9	537.3	524.0	521.8	510.1	494.5	464.5	442.6	419.1	395.6	389.7	373.9	361.7	348.7	327.6	
	MAX W / FT	29.3	29.7	30.0	35.1	37.2	37.4	44.1	45.5	51.2	57.5	68.7	75.4	85.0	95.2	97.6	105.7	112.1	117.4	127.6	
	MIN W / FT	27.5	27.9	28.3	32.8	34.9	35.0	40.8	42.4	47.2											



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
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INSULATION THICKNESS REQUIREMENTS

Service Designation T-42

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT
PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

3" NOMINAL INSULATION THICKNESS			PIPE SIZE																AMBIENT AIR TEMP ° F (-178 C)			
CABLE TEMP DEG F			3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	
40	PIPE TEMP	57.5	57.3	57.0	56.5	56.0	55.8	56.9	56.7	53.8	52.5	50.2	48.2	46.2	44.3	43.5	42.1	40.9	39.6	37.5		
	MAX W / FT	1.7	1.8	1.9	2.2	2.4	2.4	2.8	3.0	3.4	3.9	4.8	5.5	6.3	7.1	7.5	8.2	8.8	9.3	10.3		
	MIN W / FT	1.7	1.7	1.8	2.1	2.3	2.4	2.7	2.9	3.2	3.8	4.6	5.4	6.2	6.9	7.3	7.9	8.5	9.0	10.0		
80	PIPE TEMP	76.5	76.3	76.0	75.2	74.6	74.3	73.1	72.8	71.6	69.9	66.7	64.1	61.4	58.9	57.4	56.0	54.4	52.7	49.9		
	MAX W / FT	2.3	2.4	2.6	3.0	3.2	3.3	3.9	4.1	4.6	5.3	6.4	7.4	8.5	9.6	10.1	11.0	11.8	12.5	13.8		
	MIN W / FT	2.3	2.4	2.5	2.8	3.1	3.2	3.7	3.9	4.4	5.1	6.3	7.3	8.3	9.3	9.8	10.7	11.4	12.1	13.4		
100	PIPE TEMP	95.6	95.3	94.8	93.9	93.1	92.8	91.2	90.5	89.4	87.2	83.3	80.0	76.4	73.4	72.1	69.8	67.8	65.7	62.7		
	MAX W / FT	3.0	3.1	3.3	3.8	4.1	4.2	4.9	5.1	5.8	6.7	8.1	9.4	10.8	12.1	12.7	13.8	14.8	15.7	17.4		
	MIN W / FT	2.9	3.0	3.2	3.6	3.9	4.0	4.7	4.9	5.6	6.4	7.9	9.2	10.5	11.8	12.3	13.4	14.4	15.2	16.8		
120	PIPE TEMP	114.5	114.2	113.7	112.6	111.4	111.2	109.3	108.9	107.1	104.5	99.7	95.8	91.7	87.8	86.3	83.5	81.1	78.6	74.4		
	MAX W / FT	3.7	3.8	4.0	4.6	5.0	5.1	6.0	6.3	7.1	8.1	9.8	11.4	13.0	14.7	15.3	16.7	17.9	18.9	20.9		
	MIN W / FT	3.5	3.7	3.8	4.4	4.8	4.9	5.7	6.0	6.8	7.8	9.6	11.1	12.7	14.3	14.9	16.2	17.4	18.4	20.3		
140	PIPE TEMP	133.5	133.1	132.5	131.2	130.0	129.5	127.3	126.8	124.7	121.6	116.1	111.5	106.7	102.2	100.4	97.1	94.4	91.4	86.5		
	MAX W / FT	4.4	4.5	4.7	5.5	5.9	6.1	7.1	7.4	8.4	9.6	11.6	13.4	15.3	17.2	18.0	19.6	21.0	22.2	24.6		
	MIN W / FT	4.2	4.4	4.6	5.3	5.7	5.8	6.8	7.1	8.0	9.2	11.3	13.0	14.9	16.8	17.5	19.2	20.4	21.6	23.8		
160	PIPE TEMP	152.4	152.0	151.3	149.7	148.4	147.9	145.3	144.7	142.3	138.8	132.4	127.2	121.7	116.4	114.5	110.7	107.6	104.2	98.5		
	MAX W / FT	5.1	5.2	5.5	6.4	6.9	7.0	8.2	8.6	9.7	11.1	13.4	15.4	17.6	19.9	20.7	22.6	24.2	25.6	28.2		
	MIN W / FT	4.9	5.1	5.3	6.1	6.6	6.8	7.8	8.2	9.2	10.6	13.0	15.0	17.2	19.3	20.1	21.9	23.4	24.8	27.4		
180	PIPE TEMP	171.3	170.8	170.0	168.3	166.7	166.1	163.3	162.6	159.9	155.9	148.7	142.7	136.6	130.6	128.5	124.2	120.7	116.9	110.5		
	MAX W / FT	5.8	6.1	6.3	7.3	7.9	8.0	9.4	9.8	11.0	12.7	15.2	17.5	20.0	22.5	23.5	25.6	27.4	28.9	31.9		
	MIN W / FT	5.6	5.8	6.1	7.0	7.6	7.7	8.9	9.4	10.5	12.1	14.8	17.1	19.5	21.9	22.8	24.8	26.5	28.0	30.9		
200	PIPE TEMP	190.1	189.6	188.8	186.7	185.0	184.4	181.1	180.4	177.4	172.9	164.9	158.3	151.4	144.7	142.4	137.6	133.7	129.5	122.5		
	MAX W / FT	6.6	6.8	7.1	8.2	8.9	9.1	10.6	11.0	12.4	14.2	17.0	19.6	22.4	25.2	26.2	28.6	30.6	32.3	35.6		
	MIN W / FT	6.4	6.6	6.8	7.9	8.5	8.7	10.1	10.6	11.8	13.6	16.6	19.1	21.8	24.5	25.5	27.7	29.7	31.3	34.5		
220	PIPE TEMP	208.9	208.4	207.4	205.2	203.3	202.6	199.0	198.2	194.8	189.8	181.0	173.7	166.1	158.7	156.2	151.0	146.8	142.0	134.1		
	MAX W / FT	7.4	7.7	7.9	9.2	9.9	10.1	11.8	12.3	13.8	15.8	18.9	21.8	24.9	28.0	29.1	31.7	33.9	35.8	39.4		
	MIN W / FT	7.1	7.4	7.6	8.8	9.5	9.7	11.2	11.8	13.2	15.1	18.5	21.2	24.2	27.2	28.2	30.7	32.8	34.6	38.2		
240	PIPE TEMP	227.6	227.1	226.1	223.6	221.5	220.7	216.7	215.9	212.2	206.7	197.0	189.1	180.8	172.7	170.0	164.2	159.5	154.5	146.1		
	MAX W / FT	8.2	8.5	8.8	10.2	11.0	11.2	13.1	13.6	15.2	17.5	20.8	24.0	27.3	30.8	31.9	34.8	37.2	39.2	43.2		
	MIN W / FT	7.9	8.2	8.5	9.8	10.5	10.7	12.4	13.0	14.5	16.7	20.3	23.3	26.6	29.9	31.0	33.7	36.0	38.0	41.8		
260	PIPE TEMP	246.4	245.8	244.3	241.9	239.6	238.9	234.5	233.6	229.6	223.6	213.0	204.4	195.4	186.5	183.7	177.4	172.3	166.8	157.8		
	MAX W / FT	9.1	9.4	9.7	11.2	12.1	12.3	14.3	14.9	16.7	19.2	22.8	26.2	29.8	33.6	34.8	37.9	40.5	42.7	47.1		
	MIN W / FT	8.7	9.0	9.3	10.7	11.4	11.6	13.6	14.3	15.9	18.3	22.2	25.5	29.0	32.6	33.8	36.8	39.2	41.4	45.6		
280	PIPE TEMP	265.0	264.5	263.7	260.2	257.7	256.9	252.2	251.2	246.9	240.4	229.0	219.6	209.9	200.3	197.3	190.6	185.1	179.2	169.4		
	MAX W / FT	10.0	10.3	10.6	12.3	13.2	13.4	15.6	16.2	18.2	20.9	24.8	28.4	32.4	36.4	37.8	41.1	43.6	45.8	50.9		
	MIN W / FT	9.6	9.8	10.2	11.7	12.7	12.8	14.9	15.5	17.3	19.9	24.1	27.7	31.5	35.3	36.6	39.8	42.5	44.8	49.3		
300	PIPE TEMP	283.7	283.1	281.8	278.5	275.8	275.0	269.8	268.8	264.1	257.1	244.9	234.8	224.4	214.1	210.8	203.6	197.7	191.4	181.0		
	MAX W / FT	10.9	11.2	11.5	13.4	14.3	14.6	17.0	17.6	19.7	22.6	26.8	30.7	35.0	39.3	40.7	44.3	47.3	49.9	54.8		
	MIN W / FT	10.4	10.7	11.1	12.8	13.7	13.9	16.1	16.8	18.8	21.5	26.1	29.9	34.0	38.1	39.3	42.9	45.8	48.3	53.1		
350	PIPE TEMP	336.2	335.5	334.0	329.0	325.8	325.0	313.7	312.6	307.0	298.7	284.3	272.5	260.2	248.1	244.4	236.0	229.1	221.7	209.6		
	MAX W / FT	13.2	13.5	13.8	15.8	16.7	17.3	20.5	21.2	23.7	27.1	32.0	36.6	41.5	46.7	48.1	52.5	56.0	59.0	64.8		
	MIN W / FT	12.7	13.0	13.4	15.4	16.4	16.8	19.4	20.2	22.5	25.7	31.1	35.6	40.3	45.2	46.6	50.8	54.2	57.1	62.6		
400	PIPE TEMP	376.4	375.7	374.0	369.3	365.6	364.8	357.3	356.1	349.7	340.0	323.4	309.8	295.7	281.7	277.6	267.9	260.0	251.7	237.8		
	MAX W / FT	15.7	16.1	16.5	19.1	20.5	20.7	24.1	24.9	27.8	31.7	37.3	42.6	48.3	54.3	56.0	60.9	64.9	68.3	74.9		
	MIN W / FT	15.0	15.3	15.8	18.2	19.5	19.7	22.8	23.7	26.3	30.1	36.3	41.4	46.9	52.6	54.3	58.9	62.7	66.0	72.6		
450	PIPE TEMP	422.5	421.3	419.8	414.4	410.2	409.0	400.7	399.3	392.0	381.0	362.1	346.7	330.7	314.8	310.3	299.4	290.6	282.2	265.7		
	MAX W / FT	18.4	18.7	19.1	22.2	23.7	23.9	27.9	28.8	32.3	36.8	42.9	48.9	55.3	62.1	64.0	69.5	74.0	77.8	85.2		
	MIN W / FT	17.5	17.8	18.3	21.1	22.6	22.8	26.3	27.4	30.3	34.7	41.7	47.5	53.6	60.1	61.9	67.5	71.5	75.2	82.3		
500	PIPE TEMP	468.3	467.6	465.4	459.3	454.5	453.3	443.8	442.3	434.1	421.7	400.4	383.2	365.4	347.6	342.7	330.5	320.7	310.3	293.1		
	MAX W / FT	21.2	21.5	21.9	25.5	27.2	27.3	31.9	32.8	36.5	41.6	48.6	55.3	62.5	70.1	72.2	78.3	83.3	87.4	95.8		
	MIN W / FT	20.2	20.5	21.0	24.2	25.9	26.0	30.0	31.2	34.5	39.4	47.2	53.7	60.5	67.7	69.8	75.7	80.5	84.5	92.4		
550	PIPE TEMP	514.0	513.2	510.8	503.9	498.7	497.3	486.7	485.1	475.9	462.1	438.5	419.4	399.7	380.0	374.7	361.3	350.5	339.0	320.2		
	MAX W / FT	24.1	24.4	24.9	28.8	30.7	30.9	36.0	37.0	41.1	46.8	54.5	61.9	69.9	78.3	80.5	87.3	92.4	97.5	106.5		
	MIN W / FT	22.9	23.2	23.7	27.3	29.2	29.4	33.8	35.1	38.8	44.2	52.9	60.0	67.6	75.6	77.8	84.3	89.6	94.0	102.7		
600	PIPE TEMP	559.6	558.8	556.2	548.4	542.6	541.2	529.4	527.6	517.5	502.3	478.2	455.3	433.7	412.1	406.4	391.7	379.4	367.4	347.0		
	MAX W / FT	27.1	27.4	27.9	32.3	34.4	34.6	40.2	41.3	45.												



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INSULATION THICKNESS REQUIREMENTS

Service Designation T-43

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT
PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

3-1/2" NOMINAL INSULATION THICKNESS			PIPE SIZE																AMBIENT AIR TEMP °F (-17.8 C)		
CABLE TEMP DEG F			3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
40	PIPE TEMP	57.6	57.4	57.1	56.7	56.2	56.0	55.2	54.9	54.1	52.9	50.8	49.0	47.2	45.4	44.6	43.4	42.2	41.0	39.3	
	MAX.W /FT	1.6	1.7	1.8	2.1	2.2	2.3	2.6	2.8	3.2	3.6	4.4	5.1	5.9	6.6	6.9	7.6	8.1	8.6	9.6	
	MIN.W /FT	1.6	1.7	1.7	2.0	2.2	2.2	2.4	2.7	3.1	3.5	4.3	5.0	5.7	6.5	6.8	7.4	7.9	8.4	9.3	
80	PIPE TEMP	76.7	76.5	76.1	75.5	74.9	74.6	73.5	73.1	72.1	70.5	67.6	65.2	62.7	60.4	59.4	57.7	56.2	54.6	51.9	
	MAX.W /FT	2.2	2.3	2.4	2.8	3.0	3.1	3.6	3.8	4.3	4.9	6.0	6.9	7.9	8.9	9.3	10.2	10.9	11.6	12.8	
	MIN.W /FT	2.2	2.3	2.4	2.7	2.9	3.0	3.5	3.7	4.1	4.8	5.8	6.8	7.7	8.7	9.1	9.9	10.6	11.3	12.5	
100	PIPE TEMP	95.7	95.5	95.1	94.2	93.5	93.1	91.8	91.3	90.0	88.0	84.4	81.4	78.3	75.3	74.1	71.9	70.1	68.0	64.7	
	MAX.W /FT	2.8	3.0	3.1	3.6	3.8	3.9	4.5	4.8	5.4	6.2	7.5	8.7	10.0	11.2	11.7	12.8	13.7	14.5	16.1	
	MIN.W /FT	2.8	2.9	3.0	3.4	3.7	3.8	4.4	4.7	5.2	6.0	7.4	8.5	9.7	10.9	11.4	12.5	13.4	14.2	15.7	
120	PIPE TEMP	114.8	114.5	114.0	112.9	112.0	111.6	110.0	109.4	107.8	105.4	101.1	97.5	93.7	90.1	88.7	86.1	83.8	81.4	77.4	
	MAX.W /FT	3.5	3.6	3.8	4.3	4.7	4.8	5.5	5.9	6.6	7.5	9.1	10.5	12.0	13.5	14.2	15.4	16.5	17.5	19.4	
	MIN.W /FT	3.4	3.5	3.7	4.2	4.5	4.7	5.4	5.7	6.4	7.3	8.9	10.3	11.8	13.2	13.8	15.1	16.1	17.1	18.9	
140	PIPE TEMP	133.8	133.4	132.8	131.6	130.5	130.1	128.1	127.5	125.4	122.7	117.7	113.5	109.1	104.8	103.2	100.2	97.6	94.8	90.1	
	MAX.W /FT	4.1	4.3	4.5	5.2	5.5	5.7	6.6	7.0	7.8	8.9	10.7	12.4	14.2	15.9	16.6	18.1	19.4	20.6	22.8	
	MIN.W /FT	4.0	4.2	4.4	5.0	5.4	5.5	6.3	6.7	7.5	8.6	10.5	12.1	13.8	15.5	16.2	17.7	18.9	20.0	22.2	
160	PIPE TEMP	152.7	152.4	151.7	150.2	149.0	148.5	146.2	145.5	143.3	140.1	134.3	129.4	124.4	119.5	117.7	114.2	111.2	108.0	102.6	
	MAX.W /FT	4.8	5.0	5.2	6.0	6.4	6.6	7.6	8.1	9.0	10.3	12.4	14.3	16.3	18.3	19.1	20.9	22.3	23.6	26.2	
	MIN.W /FT	4.7	4.8	5.1	5.8	6.3	6.4	7.3	7.8	8.7	10.0	12.1	14.0	15.9	17.9	18.7	20.3	21.6	23.0	25.5	
180	PIPE TEMP	171.6	171.2	170.5	168.8	167.4	166.9	164.3	163.5	161.0	157.3	150.8	145.3	139.7	134.1	132.1	128.2	124.8	121.2	115.2	
	MAX.W /FT	5.5	5.7	6.0	6.9	7.4	7.5	8.7	9.2	10.2	11.7	14.1	16.2	18.5	20.8	21.7	23.6	25.3	26.8	29.6	
	MIN.W /FT	5.4	5.5	5.8	6.6	7.1	7.3	8.4	8.9	9.9	11.3	13.8	15.9	18.1	20.3	21.1	23.0	24.6	26.1	28.8	
200	PIPE TEMP	190.5	190.1	189.2	187.4	185.8	185.2	182.3	181.4	178.7	174.5	167.3	161.2	154.8	148.7	146.5	142.1	138.4	134.3	127.4	
	MAX.W /FT	6.3	6.5	6.7	7.7	8.3	8.5	9.8	10.3	11.5	13.2	15.6	18.2	20.7	23.3	24.2	26.4	28.3	29.9	33.1	
	MIN.W /FT	6.1	6.3	6.5	7.5	8.1	8.2	9.4	10.0	11.1	12.7	15.4	17.8	20.2	22.7	23.6	25.7	27.5	29.1	32.2	
220	PIPE TEMP	209.4	208.9	208.0	205.9	204.2	203.5	200.3	199.3	196.3	191.7	183.7	177.0	170.0	163.1	160.8	155.9	151.8	147.4	140.0	
	MAX.W /FT	7.0	7.2	7.5	8.7	9.3	9.4	10.9	11.5	12.8	14.6	17.5	20.2	23.0	25.8	26.8	28.8	31.3	33.1	36.6	
	MIN.W /FT	6.8	7.0	7.3	8.4	9.0	9.1	10.5	11.1	12.4	14.2	17.1	19.7	22.4	25.2	26.2	28.5	30.5	32.2	35.6	
240	PIPE TEMP	228.2	227.7	226.7	224.4	222.5	221.8	218.2	217.2	213.9	208.8	200.0	192.7	185.0	177.5	175.0	169.7	165.2	160.4	152.3	
	MAX.W /FT	7.8	8.0	8.3	9.6	10.3	10.4	12.1	12.7	14.2	16.2	19.3	22.2	25.2	28.4	29.5	32.1	34.3	36.3	40.1	
	MIN.W /FT	7.5	7.8	8.1	9.3	9.9	10.1	11.6	12.3	13.6	15.6	18.9	21.7	24.6	27.7	28.7	31.3	33.4	35.3	39.0	
260	PIPE TEMP	247.0	246.5	245.3	242.8	240.7	240.0	236.1	235.0	231.4	225.9	216.3	208.3	200.0	191.8	189.1	183.3	178.5	173.3	164.6	
	MAX.W /FT	8.4	8.6	8.9	10.2	11.3	11.5	13.2	13.9	15.5	17.7	21.1	24.2	27.5	31.0	32.1	34.6	37.4	39.5	43.4	
	MIN.W /FT	8.3	8.5	8.8	10.0	10.9	11.1	12.7	13.5	14.9	17.1	20.6	23.7	26.9	30.2	31.3	34.1	36.4	38.5	42.4	
280	PIPE TEMP	265.7	265.2	264.0	261.2	259.0	258.2	254.0	252.8	248.8	242.9	232.6	223.9	214.9	206.1	203.2	197.0	191.7	186.1	176.8	
	MAX.W /FT	9.4	9.7	10.0	11.5	12.3	12.5	14.4	15.2	16.8	19.3	22.9	26.3	29.9	33.4	34.8	37.9	40.5	42.8	47.2	
	MIN.W /FT	9.1	9.3	9.7	11.1	11.9	12.1	13.9	14.7	16.3	18.6	22.4	25.7	29.2	32.7	33.9	36.9	39.4	41.6	45.9	
300	PIPE TEMP	284.4	283.9	282.6	279.4	277.2	276.4	271.8	270.5	264.3	259.8	248.7	239.4	229.8	220.3	217.2	210.5	204.9	198.9	188.9	
	MAX.W /FT	10.3	10.5	10.9	12.5	13.4	13.6	15.7	16.5	18.3	20.8	24.8	28.4	32.3	36.3	37.4	40.9	43.7	46.1	50.9	
	MIN.W /FT	9.9	10.1	10.5	12.1	12.9	13.1	15.1	15.9	17.6	20.1	24.2	27.7	31.5	35.3	36.6	39.8	42.5	44.9	49.6	
350	PIPE TEMP	331.1	330.5	329.0	325.4	322.5	321.6	316.1	314.6	309.6	302.0	288.9	278.0	266.7	255.5	252.0	244.1	237.6	230.6	218.9	
	MAX.W /FT	12.5	12.7	13.2	15.2	16.1	16.3	18.8	19.8	21.9	24.9	29.5	33.8	38.3	43.0	44.5	48.4	51.7	54.6	60.1	
	MIN.W /FT	12.0	12.3	12.7	14.6	15.6	15.8	18.1	19.1	21.1	24.1	28.9	33.0	37.4	41.9	43.3	47.1	50.3	53.0	58.4	
400	PIPE TEMP	377.5	376.9	375.2	370.9	367.6	366.6	360.1	358.5	352.7	343.8	328.8	316.2	303.2	290.2	286.4	277.3	269.8	261.8	248.5	
	MAX.W /FT	14.8	15.1	15.6	17.9	19.2	19.2	22.2	23.2	25.7	29.2	34.5	39.4	44.6	50.2	51.7	56.2	59.9	63.2	69.3	
	MIN.W /FT	14.3	14.5	15.0	17.2	18.4	18.5	21.2	22.4	24.7	28.2	33.7	38.4	43.4	48.7	50.3	54.6	58.2	61.6	67.5	
450	PIPE TEMP	423.8	423.1	421.2	416.3	412.5	411.4	404.0	402.1	395.5	385.4	368.3	354.0	339.3	324.6	320.3	310.1	301.7	292.7	277.8	
	MAX.W /FT	17.3	17.6	18.1	20.8	22.1	22.3	25.6	26.8	29.7	33.7	39.6	45.2	51.1	57.2	59.0	64.1	68.4	72.0	79.1	
	MIN.W /FT	16.6	16.9	17.4	20.0	21.3	21.4	24.5	25.8	28.5	32.4	38.7	44.0	49.7	55.6	57.4	62.3	66.4	69.7	76.8	
500	PIPE TEMP	469.9	469.2	467.0	461.4	457.1	456.0	447.6	445.5	438.1	426.7	407.5	391.5	375.0	358.6	353.9	342.5	333.2	323.2	306.6	
	MAX.W /FT	19.9	20.2	20.7	23.8	25.2	25.4	29.2	30.6	33.8	38.3	44.9	51.1	57.7	64.6	66.6	72.3	77.0	81.0	88.9	
	MIN.W /FT	19.1	19.4	20.0	22.8	24.3	24.5	28.0	29.4	32.4	36.8	43.8	49.8	56.1	62.7	64.7	70.2	74.7	78.6	86.7	
550	PIPE TEMP	515.9	515.1	512.7	506.4	501.6	500.4	490.9	488.6	480.4	467.7	446.4	428.7	410.4	392.2	387.1	374.6	364.3	353.3	335.1	
	MAX.W /FT	22.6	22.9	23.4	27.0	28.5	28.7	33.0	34.4	38.0	43.0	50.4	57.2	64.5	72.1	74.3	80.4	85.8	90.2	98.9	
	MIN.W /FT	21.6	21.9	22.6	25.8	27.4	27.6	31.5	33.1	36.4	41.3	49.1	55.7	62.7	70.0	72.2	78.2	83.2	87.5	95.8	
600	PIPE TEMP	561.7	560.9	558.2	551.2	545.9	544.6	534.1	531.6	522.6	508.5	485.0	465.5	445.5	425.5	420.0	406.2	395.0	383.1	363.3	
	MAX.W /FT	25.4	25.7	26.3	30.2	31.9	32.1	36.9	38.5	42.4	47.9	56.0	63								



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
PAGE 383
MAY, 1968

INSULATION THICKNESS REQUIREMENTS

Service Designation T-44

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT
PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

4" NOMINAL INSULATION THICKNESS		AMBIENT AIR TEMP ° F (-17.8 C)																		
CABLE TEMP DEG F		PIPE SIZE																		
		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
40	PIPE TEMP	57.4	57.5	57.2	56.8	56.2	56.0	55.4	55.1	54.4	53.4	51.4	49.7	47.9	46.3	45.6	44.4	43.4	42.2	40.3
	MAX W / FT	1.4	1.4	1.7	1.9	2.2	2.3	2.5	2.7	3.0	3.4	4.1	4.8	5.5	6.2	6.5	7.1	7.6	8.0	8.9
	MIN W / FT	1.5	1.6	1.7	1.9	2.2	2.2	2.4	2.6	2.9	3.3	4.1	4.7	5.4	6.0	6.3	6.9	7.4	7.9	8.7
80	PIPE TEMP	74.0	74.6	74.3	73.6	74.9	74.6	73.8	73.4	72.5	71.0	68.4	66.1	63.8	61.6	60.7	59.1	57.7	56.2	53.4
	MAX W / FT	2.1	2.2	2.3	2.6	3.0	3.1	3.4	3.6	4.0	4.5	5.6	6.5	7.4	8.3	8.7	9.5	10.2	10.8	12.0
	MIN W / FT	2.1	2.2	2.3	2.6	2.9	3.0	3.3	3.5	3.9	4.5	5.5	6.3	7.2	8.1	8.5	9.3	9.9	10.5	11.7
100	PIPE TEMP	95.9	95.7	95.2	94.5	93.5	93.1	92.1	91.7	90.4	88.7	85.3	82.5	79.4	76.8	75.7	73.7	71.9	70.0	66.8
	MAX W / FT	2.7	2.8	3.0	3.4	3.8	3.9	4.3	4.6	5.1	5.7	7.0	8.1	9.3	10.4	10.9	11.9	12.8	13.6	15.1
	MIN W / FT	2.6	2.8	2.9	3.3	3.7	3.8	4.2	4.5	5.0	5.7	6.9	8.0	9.1	10.2	10.7	11.7	12.5	13.3	14.7
120	PIPE TEMP	114.9	114.7	114.2	113.2	112.0	111.6	110.4	109.9	108.4	106.3	102.2	98.4	95.3	92.0	90.7	88.3	86.1	83.8	80.0
	MAX W / FT	3.3	3.5	3.6	4.1	4.7	4.8	5.2	5.6	6.2	7.0	8.5	9.9	11.2	12.4	13.2	14.4	15.4	16.4	18.2
	MIN W / FT	3.2	3.4	3.5	4.0	4.5	4.7	5.1	5.4	6.0	6.9	8.4	9.7	11.0	12.4	12.9	14.1	15.1	16.0	17.7
140	PIPE TEMP	134.0	133.7	133.1	132.0	130.5	130.1	128.7	128.0	126.3	123.8	119.1	115.1	111.0	107.1	105.6	102.7	100.3	97.6	93.1
	MAX W / FT	3.9	4.1	4.3	4.9	5.5	5.7	6.2	6.6	7.3	8.2	10.1	11.6	13.2	14.8	15.5	16.9	18.1	19.2	21.3
	MIN W / FT	3.9	4.0	4.2	4.8	5.4	5.5	6.0	6.4	7.1	8.1	9.9	11.4	13.0	14.5	15.2	16.5	17.7	18.8	20.8
160	PIPE TEMP	153.0	152.4	152.0	150.7	149.0	148.5	146.9	146.2	144.2	141.3	135.9	131.3	126.7	122.1	120.4	117.2	114.3	111.3	106.1
	MAX W / FT	4.6	4.6	5.0	5.7	6.4	6.6	7.2	7.6	8.5	9.5	11.6	13.4	15.2	17.1	17.8	19.4	20.8	22.1	24.5
	MIN W / FT	4.5	4.6	4.8	5.5	6.3	6.4	7.0	7.4	8.2	9.4	11.4	13.1	14.9	16.7	17.4	19.0	20.4	21.6	23.9
180	PIPE TEMP	171.9	171.6	170.8	169.3	167.4	166.9	165.0	164.2	162.0	158.7	152.6	147.5	142.2	137.1	135.2	131.5	128.3	124.9	119.1
	MAX W / FT	5.3	5.5	5.7	6.5	7.4	7.5	8.2	8.7	9.6	10.8	13.2	15.1	17.2	19.4	20.2	22.0	23.6	25.0	27.7
	MIN W / FT	5.1	5.3	5.5	6.3	7.1	7.3	8.0	8.5	9.4	10.6	12.7	14.9	16.9	19.0	19.7	21.5	23.0	24.4	27.0
200	PIPE TEMP	190.9	190.5	189.7	188.0	185.2	185.2	183.1	182.3	179.8	176.1	169.3	163.4	157.7	152.0	149.9	145.8	142.3	138.4	132.0
	MAX W / FT	6.0	6.2	6.4	7.3	8.3	8.5	9.2	9.8	10.8	12.1	14.8	17.0	19.3	21.7	22.6	24.6	26.3	27.9	30.9
	MIN W / FT	5.8	6.0	6.2	7.1	8.1	8.2	9.0	9.5	10.5	11.9	14.5	16.6	18.9	21.2	22.1	24.0	25.7	27.2	30.2
220	PIPE TEMP	209.8	209.4	208.5	206.6	204.2	203.5	201.2	200.3	197.5	193.5	185.9	179.6	173.1	166.8	164.6	160.0	156.1	151.9	144.9
	MAX W / FT	6.7	6.9	7.1	8.2	9.3	9.4	10.3	10.9	12.0	13.5	16.4	18.8	21.4	24.0	25.0	27.2	29.2	30.9	34.2
	MIN W / FT	6.5	6.7	7.0	7.9	9.0	9.1	10.0	10.6	11.7	13.3	16.1	18.5	21.0	23.5	24.4	26.6	28.5	30.1	33.3
240	PIPE TEMP	228.6	228.2	227.2	225.1	222.5	221.8	219.3	218.2	215.2	210.8	202.5	195.6	188.5	181.6	179.2	174.2	170.0	165.4	157.7
	MAX W / FT	7.4	7.6	7.9	9.0	10.3	10.4	11.4	12.0	13.3	14.9	18.0	20.7	23.5	26.4	27.4	29.9	32.0	33.9	37.5
	MIN W / FT	7.2	7.4	7.7	8.8	9.9	10.1	11.0	11.7	12.9	14.6	17.7	20.3	23.0	25.8	26.8	29.2	31.2	33.1	36.8
260	PIPE TEMP	247.5	247.0	246.0	243.6	240.7	240.0	237.3	236.2	232.9	228.0	219.0	211.6	203.8	196.3	193.7	188.3	183.7	178.4	170.4
	MAX W / FT	8.2	8.4	8.7	9.9	11.3	11.5	12.5	13.1	14.5	16.3	19.7	22.6	25.7	28.8	29.9	32.6	34.9	36.9	40.8
	MIN W / FT	8.0	8.2	8.5	9.7	10.9	11.1	12.1	12.8	14.6	16.5	19.3	22.2	25.1	28.2	29.2	31.8	34.0	36.0	39.8
280	PIPE TEMP	266.3	265.8	264.7	262.1	259.0	258.2	255.2	254.0	250.5	245.7	235.5	227.4	219.1	210.9	208.2	202.3	197.4	192.0	183.0
	MAX W / FT	9.0	9.2	9.5	10.9	12.3	12.5	13.6	14.3	15.8	17.7	21.4	24.5	27.9	31.3	32.4	35.3	37.8	39.9	44.1
	MIN W / FT	8.7	8.9	9.3	10.6	11.9	12.1	13.2	14.0	15.4	17.4	21.0	24.0	27.3	30.6	31.7	34.5	36.9	39.0	43.1
300	PIPE TEMP	285.1	284.5	283.3	280.6	277.2	276.4	273.1	271.9	268.0	262.3	251.9	243.2	234.3	225.5	222.6	216.3	211.0	205.2	195.4
	MAX W / FT	9.8	10.0	10.3	11.8	13.4	13.6	14.7	15.3	17.1	19.2	23.2	26.5	30.1	33.7	35.0	38.1	40.7	43.0	47.5
	MIN W / FT	9.5	9.7	10.1	11.5	12.9	13.1	14.3	15.1	16.7	18.8	22.7	26.0	29.4	33.0	34.2	37.2	39.7	42.0	46.6
350	PIPE TEMP	331.9	331.3	329.9	326.6	322.5	321.6	317.7	316.3	311.8	305.0	292.7	282.5	272.0	261.6	258.3	250.9	244.7	238.0	226.9
	MAX W / FT	11.9	12.1	12.5	14.2	16.1	16.3	17.7	18.6	20.5	22.9	27.4	31.5	35.7	40.1	41.5	45.1	48.2	50.9	56.7
	MIN W / FT	11.5	11.7	12.1	13.8	15.6	15.8	17.2	18.2	19.9	22.5	27.1	30.9	34.9	39.1	40.5	44.0	47.0	49.6	54.1
400	PIPE TEMP	378.5	377.9	376.2	372.6	368.6	367.2	362.1	360.5	355.2	347.4	333.2	321.5	309.4	297.3	293.7	285.2	278.1	271.4	257.7
	MAX W / FT	14.1	14.3	14.7	16.8	19.0	19.2	20.8	21.9	24.1	26.8	32.2	36.7	41.6	46.6	48.1	52.3	55.9	59.0	65.0
	MIN W / FT	13.6	13.9	14.3	16.3	18.4	18.5	20.2	21.3	23.4	26.3	31.6	36.0	40.6	45.4	47.0	51.4	54.5	57.5	63.3
450	PIPE TEMP	424.9	424.3	422.4	418.0	412.5	411.4	406.3	404.4	398.4	389.5	373.4	360.1	346.4	332.7	328.8	319.0	311.1	302.4	288.1
	MAX W / FT	16.4	16.7	17.1	19.5	22.1	22.3	24.1	25.2	27.8	30.9	37.0	42.1	47.6	53.2	55.0	59.7	63.7	67.2	74.0
	MIN W / FT	15.9	16.1	16.6	18.9	21.3	21.4	23.3	24.6	26.9	30.3	36.2	41.2	46.5	52.0	53.8	58.2	62.1	65.5	72.0
500	PIPE TEMP	471.2	470.5	468.5	463.6	457.1	456.0	450.2	448.1	441.4	431.3	413.3	398.3	383.0	367.7	363.2	352.5	343.7	334.1	318.7
	MAX W / FT	18.8	19.1	19.6	22.3	25.4	25.6	28.0	29.1	32.4	35.1	41.9	47.7	53.7	60.1	62.0	67.3	71.8	75.6	83.1
	MIN W / FT	18.2	18.5	19.0	21.6	24.3	24.5	26.5	28.0	30.6	34.4	41.0	46.6	52.5	58.6	60.5	65.6	69.9	73.7	80.9
550	PIPE TEMP	517.3	516.6	514.3	508.6	501.6	500.4	493.9	491.6	484.1	472.9	452.8	436.3	419.3	402.4	397.5	385.6	375.9	365.4	347.9
	MAX W / FT	21.4	21.7	22.2	25.3	28.5	28.7	31.0	32.4	35.5	39.4	47.0	53.4	60.1	67.1	69.2	75.1	80.0	84.2	92.5
	MIN W / FT	20.7	20.9	21.5	24.4	27.6	27.8	29.9	31.5	34.6	38.6	46.0	52.1	58.7	65.4	67.5	73.1	77.9	82.0	90.0
600	PIPE TEMP	563.3	562.6	560.1	553.7	545.9	544.6	537.4	534.9	526.7	514.3	492.1	474.0	455.3	436.7	431.4	418.5	407.8	396.3	377.2
	MAX W / FT	24.0	24.3	24.8	28.3	31.9	32.1	34.6	36.1	39.6	43.9	52.2	59.2	66.6	74.3	76.6	83.0	88.4	93.0	102.0
	MIN W / FT	23.2	23.5	24.1	27.3	30.7	30.8	33.4	35.1	38.3	43.0	51.1	57.8	65.0	72.4	74.6	80.8	86.0	90.5	99.2
650	PIPE TEMP	609.2	608.4	605.7	598.1	589.7	588.7	580.8	578.1	56										



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
PAGE 384
MAY, 1968

INSULATION THICKNESS REQUIREMENTS

Service Designation T-45

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT
PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

1" NOMINAL INSULATION THICKNESS		PIPE SIZE																				AMBIENT AIR TEMP 30.0 F (-1.1 C)			
CABLE TEMP DEG F		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24					
40	PIPE TEMP	58.2	58.1	57.9	57.5	57.1	56.9	56.3	56.2	55.3	54.3														
	PAR.W /FT	1.3	1.4	1.5	1.7	1.9	2.0	2.3	2.3	2.8	3.3														
	PI.N.W /FT	1.2	1.3	1.4	1.5	1.7	1.8	2.0	2.1	2.5	2.9														
80	PIPE TEMP	77.0	76.7	76.4	75.8	75.0	74.7	73.6	73.6	72.1	70.4														
	PAR.W /FT	2.2	2.4	2.5	2.9	3.2	3.4	3.9	3.9	4.8	5.7														
	PI.N.W /FT	2.1	2.2	2.3	2.6	2.9	3.1	3.5	3.5	4.2	4.9														
100	PIPE TEMP	95.6	95.3	94.8	93.9	92.9	92.4	90.9	90.8	88.8	86.3														
	PAR.W /FT	3.2	3.4	3.6	4.1	4.6	4.9	5.6	5.6	6.8	8.1														
	PI.N.W /FT	3.0	3.2	3.3	3.7	4.2	4.4	5.0	5.0	6.0	7.0														
120	PIPE TEMP	114.2	113.8	113.1	112.0	110.6	110.0	108.1	108.0	105.3	102.1														
	PAR.W /FT	4.2	4.5	4.7	5.4	6.1	6.4	7.4	7.3	9.0	10.6														
	PI.N.W /FT	3.9	4.1	4.4	4.9	5.5	5.7	6.5	6.6	7.8	9.1														
140	PIPE TEMP	132.8	132.2	131.4	130.0	128.2	127.5	125.1	125.1	121.7	117.8														
	PAR.W /FT	5.3	5.6	5.9	6.8	7.7	8.0	9.2	9.2	11.2	13.2														
	PI.N.W /FT	4.9	5.2	5.4	6.1	6.9	7.1	8.1	8.2	9.7	11.3														
160	PIPE TEMP	151.2	150.6	149.4	147.9	145.8	144.9	142.1	142.0	138.1	133.4														
	PAR.W /FT	6.5	6.8	7.2	8.2	9.3	9.6	11.1	11.0	13.4	15.9														
	PI.N.W /FT	6.0	6.3	6.6	7.4	8.3	8.6	9.8	9.8	11.7	13.6														
180	PIPE TEMP	169.6	168.9	167.8	165.7	163.2	162.3	158.9	158.9	154.3	148.8														
	PAR.W /FT	7.7	8.1	8.5	9.7	11.0	11.4	13.1	13.0	15.8	18.6														
	PI.N.W /FT	7.0	7.4	7.7	8.8	9.8	10.1	11.5	11.5	13.7	15.9														
200	PIPE TEMP	187.9	187.1	185.8	183.5	180.6	179.6	175.7	175.7	170.4	164.2														
	PAR.W /FT	8.9	9.4	9.8	11.2	12.7	13.1	15.2	15.0	18.2	21.5														
	PI.N.W /FT	8.2	8.5	8.9	10.1	11.3	11.7	13.3	13.3	15.7	18.3														
220	PIPE TEMP	206.1	205.3	203.8	201.1	197.9	196.8	192.4	192.4	186.5	179.4														
	PAR.W /FT	10.2	10.7	11.2	12.8	14.5	15.0	17.3	17.0	20.7	24.4														
	PI.N.W /FT	9.3	9.8	10.2	11.5	12.9	13.3	15.1	15.1	17.8	20.7														
240	PIPE TEMP	224.3	223.4	221.8	218.7	215.1	213.9	208.9	209.1	202.4	194.6														
	PAR.W /FT	11.6	12.1	12.7	14.5	16.4	16.9	19.5	19.2	23.3	27.4														
	PI.N.W /FT	10.6	11.0	11.5	13.0	14.5	14.9	17.0	16.9	20.0	23.2														
260	PIPE TEMP	242.4	241.4	239.6	236.2	232.2	230.9	225.4	225.6	218.3	209.6														
	PAR.W /FT	13.0	13.6	14.2	16.2	18.3	18.8	21.7	21.3	25.9	30.5														
	PI.N.W /FT	11.8	12.3	12.8	14.5	16.2	16.6	18.9	18.0	22.2	25.7														
280	PIPE TEMP	260.4	259.4	257.4	253.7	249.3	247.8	241.8	242.1	234.0	224.6														
	PAR.W /FT	14.5	15.1	15.7	18.0	20.3	20.9	24.1	23.8	28.7	33.6														
	PI.N.W /FT	13.1	13.6	14.2	16.1	17.9	18.3	20.8	20.7	24.4	28.3														
300	PIPE TEMP	278.4	277.3	275.2	271.0	266.2	264.7	258.1	258.5	249.7	239.4														
	PAR.W /FT	16.0	16.6	17.2	19.9	22.4	22.9	26.5	25.9	31.4	36.9														
	PI.N.W /FT	14.5	15.0	15.6	17.7	19.7	20.1	22.9	22.7	26.7	30.9														
350	PIPE TEMP	323.0	321.7	319.3	314.2	308.3	306.5	298.5	299.2	288.5	278.2														
	PAR.W /FT	20.0	20.7	21.5	24.7	27.4	28.4	32.7	31.9	38.7	45.3														
	PI.N.W /FT	18.0	18.6	19.3	21.8	24.3	24.8	28.1	27.8	32.7	37.7														
400	PIPE TEMP	367.2	365.8	363.0	356.9	349.9	348.0	338.5	339.5	326.9	312.4														
	PAR.W /FT	24.4	25.2	26.0	29.9	33.6	34.2	39.4	38.2	46.3	54.1														
	PI.N.W /FT	21.8	22.4	23.2	26.5	29.2	29.6	33.5	33.1	38.9	44.7														
450	PIPE TEMP	411.0	409.5	406.3	399.2	391.1	389.0	378.0	379.4	364.9	348.2														
	PAR.W /FT	29.0	29.9	30.8	35.3	39.7	40.3	46.4	44.8	54.3	63.4														
	PI.N.W /FT	25.8	26.5	27.3	30.9	34.3	34.7	39.3	38.7	45.3	52.0														
500	PIPE TEMP	454.6	453.0	449.4	441.2	431.9	429.7	417.1	418.9	402.4	383.5														
	PAR.W /FT	34.0	34.9	35.5	41.1	46.1	46.7	53.7	51.7	62.6	73.0														
	PI.N.W /FT	30.1	30.8	31.6	35.8	39.6	40.0	45.2	44.4	51.9	59.5														
550	PIPE TEMP	497.8	496.1	492.1	482.9	472.5	470.1	455.9	458.2	439.6	418.5														
	PAR.W /FT	37.2	40.2	41.2	47.2	52.8	53.4	61.4	58.8	71.3	83.0														
	PI.N.W /FT	34.5	35.2	36.2	40.8	45.1	45.5	51.3	50.3	58.8	67.2														
600	PIPE TEMP	540.7	538.9	534.7	524.3	512.7	510.2	494.4	497.1	476.6	453.2														
	PAR.W /FT	44.7	45.7	46.7	53.5	59.8	60.4	69.3	66.2	80.3	93.3														
	PI.N.W /FT	39.2	39.6	40.8	46.0	50.8	51.2	57.6	56.4	65.8	75.1														
650	PIPE TEMP	583.4	581.8	577.0	565.5	552.7	550.0	532.7	535.9	513.2	487.6														
	PAR.W /FT	50.5	51.5	52.6	60.1	67.1	67.7	77.6	73.9	89.5	103.9														
	PI.N.W /FT	44.0	44.7	45.7	51.4	56.6	57.0	64.1	62.7	73.0	83.2														
700	PIPE TEMP	625.9	624.1	619.1	606.5	592.5	589.7	570.7	574.4	549.7	521.7														
	PAR.W /FT	58.6	57.6	58.4	67.0	74.6	75.2	86.1	81.8	97.1	114.9														
	PI.N.W /FT	49.0	49.8	50.7	57.0	62.7	63.0	70.8	69.1	80.3	91.4														
750	PIPE TEMP	668.1	666.4	661.1	647.3	632.2	629.2	608.6	612.8	586.0	555.7														
	PAR.W /FT	63.0	64.0	64.9	74.1	82.5	83.0	95.0	90.0	109.0	126.3														
	PI.N.W /FT	54.3	55.0	55.5	62.8	68.9	69.2	77.6	75.7	87.9	99.9														
800	PIPE TEMP	710.5	708.6	703.0	688.1	671.7	668.6	646.3	651.0	622.1	589.5														
	PAR.W /FT	69.7	70.7	71.6	81.6	90.7	91.1	104.3	98.4	117.3	138.0														
	PI.N.W /FT	59.7	60.5	61.4	68.8	75.4	75.7	84.7	82.4	95.7	108.6														
850	PIPE TEMP	752.7	750.8	744.8	728.7	711.2	707.9	684.0	689.1	658.2	623.3														
	PAR.W /FT	76.8	77.9	78.6	89.5	99.3	99.7	114.0	107.2	130.0	150.2														
	PI.N.W /FT	65.5	66.2	67.0	75.1	82.1	82.3	92.1	89.4	103.7	117.5														
900	PIPE TEMP	794.9	792.9	786.5	769.3	750.5	747.1	721.6	727.2	694.2	656.9														
	PAR.W /FT	84.6	85.6	86.1	97.7	108.4	108.8	124.2	116.5	141.3	163.1														
	PI.N.W /FT</																								



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III INSULATION DESIGN

PAGE 385

MAY, 1968

INSULATION THICKNESS REQUIREMENTS

Service Designation T-46

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

1-1/2" NOMINAL INSULATION THICKNESS			PIPE SIZE																AMBIENT AIR TEMP 30.0 F (-1.1 C)			
CABLE TEMP DEG F			3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	
40	PIPE TEMP	58.5	58.4	58.1	57.8	57.6	57.4	56.7	56.6	55.9	55.0	53.5	52.0	50.7	49.4	48.9	48.0	47.3	46.5	45.3		
	MAX W / FT	1.1	1.1	1.3	1.4	1.5	1.6	1.9	2.0	2.4	2.8	3.4	4.0	4.4	5.0	5.2	5.7	6.1	6.4	7.0		
	MIN W / FT	1.0	1.1	1.2	1.3	1.4	1.5	1.8	1.8	2.2	2.5	3.1	3.7	4.2	4.7	5.0	5.4	5.7	6.0	6.6		
80	PIPE TEMP	77.4	77.2	76.8	76.3	75.8	75.6	74.5	74.3	73.1	71.6	68.9	66.4	64.4	62.2	61.3	59.8	58.7	57.4	55.4		
	MAX W / FT	1.8	1.9	2.2	2.4	2.6	2.7	3.3	3.4	4.0	4.7	5.8	6.7	7.4	8.4	8.4	9.5	10.2	10.7	11.7		
	MIN W / FT	1.7	1.8	2.0	2.3	2.4	2.5	3.0	3.1	3.6	4.2	5.3	6.2	7.1	8.0	8.3	9.0	9.6	10.1	11.1		
100	PIPE TEMP	96.3	96.1	95.4	94.7	94.1	93.7	92.1	91.8	90.2	88.1	84.3	81.0	77.9	74.8	73.7	71.6	69.9	68.2	65.4		
	MAX W / FT	2.6	2.7	3.1	3.5	3.7	3.8	4.7	4.8	5.7	6.7	8.3	9.5	10.5	11.9	12.4	13.5	14.3	15.1	16.5		
	MIN W / FT	2.5	2.6	2.9	3.2	3.4	3.5	4.3	4.5	5.2	6.0	7.5	8.8	10.0	11.3	11.7	12.8	13.6	14.3	15.6		
120	PIPE TEMP	115.1	114.8	113.9	113.0	112.2	111.8	109.7	109.3	107.2	104.4	99.4	95.3	91.3	87.4	85.9	83.2	81.1	78.9	75.3		
	MAX W / FT	3.4	3.6	4.1	4.6	4.8	5.0	6.1	6.3	7.5	8.8	10.6	12.4	13.6	15.4	16.0	17.4	18.6	19.5	21.3		
	MIN W / FT	3.2	3.4	3.8	4.3	4.5	4.8	5.6	5.8	6.8	7.9	9.7	11.4	13.0	14.6	15.2	16.5	17.6	18.5	20.1		
140	PIPE TEMP	133.9	133.5	132.4	131.2	130.3	129.8	127.1	126.7	124.1	120.7	114.8	109.5	104.6	99.7	98.0	94.7	92.1	89.4	85.1		
	MAX W / FT	4.3	4.5	5.1	5.7	6.0	6.2	7.4	7.6	9.3	10.9	13.3	15.3	16.8	19.0	19.8	21.5	22.9	24.0	26.2		
	MIN W / FT	4.0	4.2	4.7	5.3	5.6	5.8	7.0	7.2	8.4	9.8	12.0	14.1	16.0	18.0	18.7	20.3	21.6	22.7	24.7		
160	PIPE TEMP	152.6	152.2	150.9	149.4	148.3	147.7	144.5	144.1	140.9	136.9	129.9	123.6	117.8	112.0	110.0	106.1	103.1	99.9	94.8		
	MAX W / FT	5.2	5.4	6.1	6.9	7.3	7.5	9.2	9.5	11.2	13.1	16.0	18.3	20.0	22.7	23.5	25.6	27.2	28.5	31.1		
	MIN W / FT	4.9	5.1	5.7	6.4	6.7	6.9	8.4	8.7	10.1	11.7	14.4	16.8	19.1	21.5	22.3	24.2	25.7	27.0	29.4		
180	PIPE TEMP	171.3	170.8	169.2	167.6	166.2	165.6	161.9	161.3	157.7	153.0	144.9	137.6	131.0	124.2	122.0	117.4	113.9	110.3	104.4		
	MAX W / FT	6.1	6.4	7.2	8.1	8.5	8.8	10.8	11.1	13.1	15.3	18.7	21.3	23.6	26.4	27.4	29.8	31.6	33.1	36.1		
	MIN W / FT	5.7	6.0	6.7	7.5	7.9	8.1	9.8	10.2	11.8	13.7	16.8	19.6	22.2	25.0	25.9	28.1	29.9	31.3	34.1		
200	PIPE TEMP	189.9	189.3	187.6	185.6	184.1	183.4	178.1	178.5	174.3	169.0	159.7	151.5	144.0	136.2	133.8	128.6	124.7	120.6	113.9		
	MAX W / FT	7.1	7.4	8.3	9.4	9.9	10.1	12.5	12.8	15.1	17.6	21.4	24.4	26.7	30.2	31.3	34.0	36.1	37.8	41.1		
	MIN W / FT	6.6	6.9	7.7	8.7	9.1	9.4	11.3	11.7	13.5	15.7	19.2	22.4	25.4	28.6	29.6	32.1	34.1	35.7	38.8		
220	PIPE TEMP	208.4	207.8	205.8	203.6	201.9	201.1	196.3	195.6	190.9	184.9	174.5	165.2	156.9	148.2	145.5	139.8	135.3	130.7	123.4		
	MAX W / FT	8.1	8.4	9.5	10.7	11.2	11.5	14.2	14.5	17.1	20.0	24.2	27.8	30.1	34.0	35.2	38.2	40.8	42.5	46.2		
	MIN W / FT	7.6	7.9	8.8	9.9	10.4	10.6	12.8	13.3	15.3	17.8	21.7	25.3	28.6	32.2	33.3	36.1	38.3	40.1	43.6		
240	PIPE TEMP	226.9	226.3	224.1	221.6	219.7	218.8	213.4	212.7	207.7	200.7	189.2	178.9	169.7	160.0	157.1	150.8	145.9	140.8	132.7		
	MAX W / FT	9.1	9.5	10.7	12.1	12.6	12.9	15.9	16.3	19.2	22.4	27.1	30.8	33.6	37.9	39.2	42.6	45.2	47.3	51.3		
	MIN W / FT	8.5	8.8	9.9	11.1	11.7	11.9	14.4	14.9	17.2	19.9	24.2	28.2	31.8	35.8	37.0	40.1	42.6	44.6	48.4		
260	PIPE TEMP	245.4	244.7	242.2	239.4	237.4	236.5	230.4	229.7	223.9	216.5	203.9	192.6	182.4	171.8	168.7	161.7	156.4	150.9	142.0		
	MAX W / FT	10.2	10.6	11.9	13.5	14.1	14.4	17.7	18.1	21.3	24.9	30.0	34.1	37.1	41.9	43.2	46.9	49.8	52.1	56.5		
	MIN W / FT	9.5	9.9	11.0	12.4	13.0	13.2	16.0	16.5	19.0	22.0	26.8	31.2	35.1	39.5	40.8	44.2	46.9	49.1	53.2		
280	PIPE TEMP	263.8	263.1	260.3	257.3	255.1	254.0	247.4	246.6	240.3	232.1	218.4	206.1	195.0	183.4	180.1	172.6	166.8	160.8	151.2		
	MAX W / FT	11.3	11.7	13.2	14.9	15.6	15.9	19.6	20.0	23.5	27.4	33.0	37.4	40.7	45.3	47.3	51.4	54.4	56.9	61.8		
	MIN W / FT	10.8	10.9	12.2	13.7	14.3	14.6	17.6	18.2	21.0	24.2	29.4	34.2	38.5	43.3	44.7	48.6	51.3	53.6	58.1		
300	PIPE TEMP	282.2	281.4	278.4	275.0	272.6	271.6	264.2	263.5	256.6	247.7	232.8	219.5	207.5	195.0	191.5	183.3	177.1	170.7	160.3		
	MAX W / FT	12.5	12.9	14.5	16.4	17.1	17.4	21.5	21.9	25.8	30.0	36.0	40.8	44.3	50.0	51.5	55.8	59.2	61.8	67.0		
	MIN W / FT	11.6	12.0	13.4	15.1	15.7	16.0	19.3	19.9	22.9	26.5	32.1	37.3	41.9	47.1	48.5	52.6	55.7	58.2	63.1		
350	PIPE TEMP	327.9	327.0	323.3	319.2	316.4	315.1	308.2	305.4	297.1	286.4	268.6	252.7	238.5	223.5	219.6	209.8	202.5	195.0	182.8		
	MAX W / FT	15.5	15.9	18.0	20.3	21.1	21.4	26.5	26.9	31.8	36.7	43.9	49.5	53.5	60.4	62.0	67.2	71.2	74.4	80.3		
	MIN W / FT	14.4	14.8	16.8	19.3	19.3	19.6	23.7	24.3	28.0	32.2	38.9	45.1	50.6	56.8	58.4	63.2	66.9	69.8	75.5		
400	PIPE TEMP	373.3	372.4	368.0	363.1	359.8	358.4	347.7	344.6	337.1	324.6	303.9	285.4	268.9	251.5	247.1	235.9	227.5	218.8	204.9		
	MAX W / FT	18.7	19.2	21.4	24.5	25.3	25.6	31.7	32.1	37.7	43.7	52.0	58.5	63.1	71.0	72.9	78.9	83.4	87.4	94.0		
	MIN W / FT	17.4	17.8	19.8	22.2	23.1	23.4	28.2	28.9	33.2	38.2	45.9	53.1	59.5	67.4	69.5	74.1	78.3	81.7	88.2		
450	PIPE TEMP	418.4	417.4	412.4	406.6	402.9	401.4	389.0	388.1	374.9	342.4	338.8	317.7	298.9	279.0	274.3	261.5	252.0	242.3	226.6		
	MAX W / FT	22.1	22.4	24.5	28.4	29.7	30.0	37.2	37.4	44.0	51.0	60.6	67.8	72.8	82.0	84.0	90.9	96.0	100.0	107.9		
	MIN W / FT	20.5	20.9	23.3	26.1	27.1	27.3	33.0	33.3	38.6	44.4	53.2	61.3	68.6	78.9	80.8	85.1	89.9	93.7	101.1		
500	PIPE TEMP	463.3	462.3	456.5	449.9	445.7	444.1	429.9	429.0	416.3	399.9	373.3	349.5	328.5	306.1	301.0	286.6	276.1	265.3	247.9		
	MAX W / FT	25.8	26.3	29.4	33.4	34.3	34.7	42.9	43.3	50.6	58.6	69.1	77.3	82.9	93.2	95.3	103.0	108.7	113.2	122.0		
	MIN W / FT	23.7	24.2	26.5	30.1	31.2	31.4	37.9	38.3	46.3	54.8	66.6	75.9	81.7	92.3	94.3	98.6	101.7	106.0	114.2		
550	PIPE TEMP	508.0	506.9	500.3	492.9	488.3	486.6	470.5	469.7	455.3	437.0	407.5	381.0	357.6	332.7	327.3	311.4	299.8	287.9	268.9		
	MAX W / FT	29.6	30.1	33.8	38.2	39.1	39.5	48.4	48.8	57.5	66.4	78.1	87.1	93.1	104.7	106.9	115.5	121.8	126.7	136.1		
	MIN W / FT	27.2	27.6	30.7	34.3	35.4	35.7	43.0	43.8	50.1	57.3	68.2	78.5	87.5	97.9	100.0	107.9	113.8	118.4	127.5		
600	PIPE TEMP	552.5	551.4	544.0	535.8	530.7	528.8	510.9	510.1	494.2	473.9	441.3	412.1	386.4	359.0	353.2	335.8	323.2	310.3	289.5		
	MAX W / FT	33.5	34.1	38.3	43.2	44.1	44.4	54.0	54.5	63.3	72.5	84.6	94									



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
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INSULATION THICKNESS REQUIREMENTS

Service Designation T-47

ELECTRIC HEAT TRACING

MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

2" NOMINAL INSULATION THICKNESS		PIPE SIZE																AMBIENT AIR TEMP 30.0 F (-1.1 C)		
CABLE TEMP DEG F		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
60	PIPE TEMP	58.0	58.5	58.3	58.0	57.7	57.6	57.0	56.9	56.3	55.5	54.1	52.9	51.7	50.5	50.1	49.2	48.6	47.9	46.7
	MAX W / FT	1.0	1.1	1.1	1.3	1.4	1.4	1.7	1.8	2.1	2.4	3.0	3.4	3.9	4.4	4.6	5.0	5.4	5.7	6.2
	MIN W / FT	1.0	1.0	1.0	1.2	1.3	1.3	1.6	1.7	1.9	2.2	2.8	3.2	3.7	4.2	4.4	4.8	5.1	5.4	6.0
80	PIPE TEMP	77.5	77.4	77.2	76.6	76.2	75.9	75.0	74.2	73.8	72.5	70.1	68.1	66.0	64.1	63.3	61.9	60.8	59.6	57.7
	MAX W / FT	1.7	1.8	1.8	2.2	2.3	2.4	2.9	3.0	3.5	4.1	5.1	5.7	6.5	7.4	7.7	8.4	9.0	9.5	10.4
	MIN W / FT	1.6	1.7	1.8	2.0	2.2	2.3	2.7	2.8	3.3	3.8	4.7	5.5	6.3	7.1	7.4	8.1	8.6	9.1	10.0
100	PIPE TEMP	96.5	96.2	96.0	95.1	94.5	94.2	92.9	92.5	91.2	89.3	85.9	83.2	80.3	77.5	76.5	74.5	73.0	71.3	68.6
	MAX W / FT	2.4	2.6	2.6	3.1	3.3	3.4	4.1	4.3	5.0	5.8	7.2	8.0	9.2	10.4	10.9	11.9	12.7	13.4	14.7
	MIN W / FT	2.3	2.4	2.5	2.9	3.1	3.2	3.8	4.0	4.6	5.4	6.7	7.7	8.9	10.0	10.4	11.4	12.1	12.8	14.1
120	PIPE TEMP	115.3	115.0	114.7	113.6	112.8	112.4	110.7	110.3	108.5	106.1	101.7	98.1	94.4	90.8	89.5	87.0	85.0	82.9	79.4
	MAX W / FT	3.2	3.4	3.4	4.1	4.4	4.5	5.4	5.6	6.5	7.6	9.3	10.4	12.0	13.5	14.1	15.4	16.4	17.3	19.0
	MIN W / FT	3.1	3.2	3.3	3.8	4.1	4.2	5.0	5.3	6.1	7.0	8.7	10.0	11.5	13.0	13.5	14.7	15.7	16.6	18.2
140	PIPE TEMP	134.2	133.8	133.4	132.1	131.1	130.6	128.4	127.9	125.7	122.7	117.4	113.0	108.4	104.0	102.5	99.4	97.0	94.4	90.1
	MAX W / FT	4.0	4.2	4.3	5.1	5.4	5.6	6.7	7.0	8.1	9.5	11.6	12.9	14.8	16.7	17.4	18.9	20.2	21.3	23.1
	MIN W / FT	3.8	4.0	4.1	4.8	5.1	5.3	6.2	6.6	7.5	8.7	10.7	12.4	14.2	16.0	16.7	18.1	19.3	20.4	22.3
160	PIPE TEMP	152.9	152.5	152.0	150.4	149.2	148.7	146.1	145.5	142.9	139.3	133.0	127.8	122.4	117.2	115.3	111.7	108.8	105.8	100.8
	MAX W / FT	4.9	5.1	5.1	6.1	6.5	6.7	8.1	8.4	9.7	11.3	13.8	15.4	17.6	19.9	20.7	22.5	24.0	25.3	27.7
	MIN W / FT	4.6	4.8	4.9	5.7	6.2	6.3	7.5	7.9	9.0	10.4	12.8	14.8	16.9	19.1	19.8	21.6	23.0	24.2	26.5
180	PIPE TEMP	171.7	171.2	170.7	168.8	167.4	166.8	163.7	163.0	160.0	155.8	148.5	142.5	136.3	130.2	128.1	124.0	120.6	117.1	111.4
	MAX W / FT	5.7	6.0	6.0	7.2	7.7	7.9	9.5	9.9	11.4	13.3	16.1	17.9	20.5	23.2	24.1	26.2	27.9	29.4	32.2
	MIN W / FT	5.4	5.7	5.7	6.8	7.2	7.4	8.8	9.2	10.5	12.2	15.0	17.2	19.7	22.2	23.1	25.1	26.7	28.1	30.8
200	PIPE TEMP	190.3	189.9	189.2	187.0	185.4	184.8	181.2	180.5	177.0	172.3	163.9	157.1	150.0	143.1	140.8	136.1	132.3	128.3	121.8
	MAX W / FT	6.7	6.9	7.0	8.3	8.9	9.1	10.9	11.4	13.1	15.2	18.5	20.5	23.5	26.5	27.5	29.9	31.9	33.5	36.7
	MIN W / FT	6.3	6.5	6.6	7.8	8.3	8.5	10.1	10.6	12.1	14.0	17.1	19.7	22.5	25.4	26.3	28.6	30.5	32.0	35.0
220	PIPE TEMP	209.0	208.4	207.7	205.2	203.5	202.7	198.7	197.9	194.0	188.6	179.3	171.7	163.7	155.9	153.4	148.1	143.9	139.5	132.2
	MAX W / FT	7.6	7.9	7.9	9.4	10.1	10.3	12.4	12.9	14.9	17.2	20.9	23.1	26.6	29.9	30.9	33.7	35.4	37.7	41.7
	MIN W / FT	7.2	7.4	7.5	8.9	9.5	9.7	11.5	12.0	13.7	15.8	19.4	22.2	25.4	28.6	29.6	32.2	34.2	36.0	39.3
240	PIPE TEMP	227.6	227.0	226.2	223.4	221.4	220.7	216.1	215.3	210.9	204.9	194.5	186.1	177.3	168.6	165.9	160.1	155.4	150.5	142.4
	MAX W / FT	8.6	8.9	8.9	10.6	11.3	11.6	13.9	14.4	16.7	19.3	23.4	25.8	29.5	33.3	34.4	37.5	39.9	41.9	45.8
	MIN W / FT	8.1	8.4	8.5	9.9	10.6	10.8	12.9	13.4	15.3	17.7	21.6	24.8	28.3	31.8	32.9	35.8	38.1	40.0	43.7
260	PIPE TEMP	246.1	245.5	244.7	241.5	239.3	238.5	233.4	232.5	227.8	221.2	209.7	200.5	190.8	181.3	178.4	171.9	166.8	161.5	152.8
	MAX W / FT	9.6	9.9	9.9	11.8	12.6	12.8	15.5	16.0	18.5	21.4	25.9	28.5	32.5	36.7	38.0	41.3	43.9	46.2	50.4
	MIN W / FT	9.0	9.3	9.4	11.1	11.8	12.0	14.3	14.7	16.9	19.6	23.9	27.4	31.2	35.1	36.3	39.4	41.9	44.0	48.1
280	PIPE TEMP	264.6	264.0	263.1	259.6	257.2	256.3	250.7	249.8	244.5	237.3	224.9	214.8	204.3	193.8	190.7	183.7	178.2	172.4	163.0
	MAX W / FT	10.6	10.9	11.0	13.1	13.9	14.2	17.1	17.7	20.4	23.6	28.4	31.3	35.7	40.2	41.6	45.2	48.1	50.5	55.1
	MIN W / FT	10.0	10.3	10.4	12.2	13.0	13.3	15.7	16.4	18.6	21.5	26.2	30.0	34.2	38.4	39.7	43.1	45.8	48.1	52.5
300	PIPE TEMP	283.1	282.4	281.4	277.6	275.0	274.1	268.0	267.0	261.3	253.4	239.9	229.0	217.6	206.3	203.0	195.4	189.5	183.2	173.1
	MAX W / FT	11.7	12.0	12.1	14.4	15.3	15.5	18.7	19.3	22.3	25.8	31.0	34.1	38.8	43.8	45.2	49.1	52.2	54.8	59.8
	MIN W / FT	11.0	11.3	11.4	13.4	14.3	14.5	17.2	17.9	20.4	23.5	28.6	32.7	37.2	41.8	43.2	46.9	49.8	52.2	57.0
350	PIPE TEMP	329.0	328.2	327.1	322.4	319.3	318.3	310.8	309.7	302.8	293.4	277.2	264.2	250.6	237.1	233.4	224.4	217.3	210.0	198.0
	MAX W / FT	14.5	14.9	14.8	17.7	18.8	19.1	23.0	23.7	27.2	31.4	37.8	41.2	46.9	52.8	54.6	59.1	62.8	65.8	71.7
	MIN W / FT	13.6	13.9	14.0	16.5	17.5	17.8	21.1	21.9	24.8	28.6	34.6	39.5	45.4	50.4	51.9	56.3	59.8	62.7	68.3
400	PIPE TEMP	374.7	373.8	372.6	367.0	363.4	362.2	353.4	352.1	344.0	333.0	314.1	299.0	283.2	267.5	263.3	252.8	244.7	236.3	222.4
	MAX W / FT	17.5	17.9	17.8	21.2	22.5	22.8	27.4	28.2	32.4	37.4	44.5	48.4	55.2	62.2	63.9	69.4	73.4	77.1	83.9
	MIN W / FT	16.4	16.7	16.7	19.7	20.9	21.2	25.1	26.0	29.4	33.8	40.9	44.6	52.7	59.2	60.9	66.0	70.0	73.4	79.8
450	PIPE TEMP	420.1	419.2	417.9	411.3	407.2	405.9	395.8	394.2	384.9	372.2	350.6	333.4	315.4	297.4	292.8	280.9	271.8	262.2	246.8
	MAX W / FT	20.7	21.1	21.0	25.0	26.4	26.6	32.1	33.0	37.8	43.5	51.7	56.3	63.7	71.7	73.6	79.9	84.7	88.4	96.2
	MIN W / FT	19.3	19.7	19.6	23.1	24.5	24.7	29.3	30.3	34.2	39.3	47.3	53.8	60.8	68.2	70.1	75.9	80.5	84.2	91.4
500	PIPE TEMP	465.3	464.4	463.0	455.4	450.7	449.3	437.5	436.0	425.4	411.1	386.8	367.3	347.1	326.9	321.9	308.6	298.4	287.7	270.5
	MAX W / FT	24.0	24.5	24.2	28.9	30.4	30.7	37.0	37.9	43.4	49.9	59.1	64.1	72.5	81.5	83.6	90.6	95.9	100.3	108.8
	MIN W / FT	22.3	22.7	22.6	26.7	28.2	28.4	33.6	34.7	39.2	44.9	54.0	61.3	69.1	77.5	79.5	86.0	91.5	95.2	103.3
550	PIPE TEMP	510.4	509.4	507.8	499.3	494.0	492.5	479.2	477.6	465.8	449.7	422.6	400.9	378.5	356.0	350.6	335.8	324.6	312.9	294.0
	MAX W / FT	27.5	28.0	27.6	32.9	34.7	34.9	42.0	43.0	49.2	56.5	68.7	72.1	81.5	91.5	93.7	101.5	107.4	112.2	121.6
	MIN W / FT	25.5	25.9	25.8	30.3	32.0	32.2	38.1	39.3	45.3	52.7	63.0	68.9	77.6	86.9	89.0	96.3	101.9	106.4	115.9
600	PIPE TEMP	555.2	554.1	552.5	542.9	537.1	535.4	520.7	519.0	505.9	488.0	458.1	434.1	409.5	384.7	379.0	362.7	350.5	337.7	317.1
	MAX W / FT	31.2	31.7	31.2	37.2	39.0	39.3	47.2	48.3	55.2	63.2	76.4	80.4	90.6	101.7	104.3	112.6	119.1	124.3	134.6
	MIN W / FT	28.9	29.3	29.0	34.1	36.0	36.2	42.7	43.1	49.6	56.6	67.7	72.7	82.6	92.6	94.8	1020			

**STANDARD**CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITEDSECTION III
INSULATION DESIGN
PAGE 387
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INSULATION THICKNESS REQUIREMENTS

Service Designation T-48

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

2-1/2" NOMINAL INSULATION THICKNESS		AMBIENT AIR TEMP 30.0 F (-1.1 C)																		
CABLE TEMP DEG F		PIPE SIZE																		
		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
40	PIPE TEMP	58.6	58.6	58.4	58.1	57.9	57.8	57.3	57.1	56.6	56.0	54.6	53.6	52.5	51.4	51.0	50.2	49.6	48.9	47.8
	MAX. W / FT	0.9	1.0	1.0	1.2	1.3	1.3	1.5	1.6	1.9	2.1	2.7	3.0	3.5	3.9	4.1	4.5	4.8	5.1	5.6
	MIN. W / FT	0.9	0.9	1.0	1.1	1.2	1.3	1.5	1.6	1.8	2.0	2.6	2.9	3.4	3.8	4.0	4.4	4.7	4.9	5.4
80	PIPE TEMP	77.7	77.5	77.3	76.8	76.4	76.2	75.4	75.1	74.3	73.2	70.9	69.2	67.3	65.5	64.8	63.6	62.5	61.4	59.5
	MAX. W / FT	1.6	1.6	1.7	2.0	2.2	2.2	2.6	2.8	3.2	3.6	4.5	5.1	5.9	6.6	6.9	7.6	8.1	8.6	9.5
	MIN. W / FT	1.5	1.6	1.6	1.9	2.1	2.1	2.5	2.6	3.0	3.4	4.3	5.0	5.7	6.4	6.7	7.3	7.8	8.3	9.1
100	PIPE TEMP	96.7	96.5	96.2	95.9	94.6	94.6	93.4	93.1	91.9	90.3	87.1	84.7	82.1	79.6	78.6	76.8	75.4	73.8	71.2
	MAX. W / FT	2.2	2.4	2.4	2.8	3.1	3.2	3.7	3.9	4.5	5.2	6.4	7.2	8.3	9.4	9.8	10.7	11.4	12.1	13.3
	MIN. W / FT	2.2	2.3	2.3	2.7	2.9	3.0	3.5	3.7	4.3	4.9	6.1	7.0	8.0	9.1	9.5	10.3	11.0	11.7	12.7
120	PIPE TEMP	115.7	115.4	115.0	114.1	113.3	112.9	111.4	111.0	109.4	107.4	103.3	100.1	96.8	93.5	92.3	90.0	88.1	86.1	82.8
	MAX. W / FT	2.9	3.1	3.2	3.7	4.0	4.1	4.9	5.1	5.9	6.7	8.3	9.4	10.8	12.2	12.7	13.8	14.8	15.6	17.2
	MIN. W / FT	2.8	3.0	3.1	3.6	3.8	3.9	4.6	4.9	5.5	6.3	7.9	9.1	10.4	11.7	12.3	13.4	14.3	15.1	16.6
140	PIPE TEMP	134.6	134.3	133.8	132.6	131.6	131.2	129.3	128.8	126.9	124.4	119.3	115.5	111.4	107.4	105.9	103.1	100.8	98.3	95.3
	MAX. W / FT	3.7	3.8	4.0	4.6	5.0	5.1	6.1	6.4	7.3	8.3	10.3	11.6	13.3	15.0	15.6	17.0	18.2	19.2	21.2
	MIN. W / FT	3.5	3.7	3.8	4.4	4.8	4.9	5.7	6.1	6.9	7.8	9.8	11.2	12.9	14.5	15.1	16.4	17.6	18.5	20.4
160	PIPE TEMP	153.4	153.1	152.5	151.1	149.9	149.5	147.2	146.6	144.3	141.3	135.3	130.8	125.9	121.1	119.5	116.1	113.4	110.5	105.7
	MAX. W / FT	4.4	4.6	4.8	5.6	6.0	6.2	7.3	7.7	8.7	10.0	12.3	13.8	15.8	17.9	18.6	20.3	21.7	22.9	25.2
	MIN. W / FT	4.3	4.4	4.6	5.3	5.7	5.9	6.9	7.3	8.2	9.4	11.7	13.4	15.3	17.3	18.0	19.6	20.9	22.0	24.7
180	PIPE TEMP	172.3	171.9	171.2	169.5	168.2	167.7	165.0	164.3	161.7	158.2	151.2	146.0	140.3	134.8	132.9	129.0	125.9	122.5	117.0
	MAX. W / FT	5.2	5.4	5.6	6.6	7.1	7.2	8.6	9.0	10.2	11.7	14.3	16.1	18.4	20.8	21.6	23.6	25.2	26.5	29.2
	MIN. W / FT	5.0	5.2	5.4	6.2	6.7	6.9	8.1	8.5	9.6	11.0	13.6	15.6	17.8	20.1	20.9	22.7	24.3	25.6	28.1
200	PIPE TEMP	191.0	190.6	189.9	187.9	186.4	185.8	182.7	182.0	179.0	175.0	167.1	161.1	154.7	148.4	146.3	141.9	138.3	134.5	128.1
	MAX. W / FT	6.1	6.3	6.5	7.6	8.1	8.3	9.8	10.3	11.7	13.6	16.6	18.4	21.1	23.8	24.7	26.9	28.7	30.3	33.1
	MIN. W / FT	5.8	6.0	6.2	7.2	7.8	7.9	9.3	9.8	11.0	12.6	15.6	17.8	20.4	22.9	23.8	25.9	27.7	29.2	32.0
220	PIPE TEMP	209.8	209.3	208.5	206.3	204.6	203.9	200.4	199.6	196.2	191.7	182.9	176.2	169.0	161.9	159.6	154.7	150.7	146.4	139.5
	MAX. W / FT	6.9	7.1	7.3	8.6	9.2	9.4	11.2	11.7	13.3	15.1	18.6	20.8	23.7	26.8	27.8	30.2	32.3	34.0	37.4
	MIN. W / FT	6.6	6.8	7.0	8.2	8.8	9.0	10.5	11.0	12.5	14.2	17.6	20.1	22.9	25.8	26.8	29.1	31.1	32.8	36.0
240	PIPE TEMP	228.5	228.0	227.1	224.6	222.7	222.0	218.0	217.1	213.4	208.4	198.6	191.2	183.2	175.3	172.8	167.3	162.9	158.3	150.6
	MAX. W / FT	7.8	8.0	8.2	9.7	10.4	10.6	12.6	13.1	14.9	16.9	20.7	23.2	26.4	29.8	30.9	33.7	35.9	37.8	41.5
	MIN. W / FT	7.4	7.7	7.9	9.2	9.9	10.0	11.8	12.4	13.9	15.9	19.6	22.4	25.5	28.7	29.8	32.4	34.6	36.4	40.0
260	PIPE TEMP	247.2	246.6	245.6	242.9	240.8	240.0	235.4	234.7	230.5	225.0	214.2	206.1	197.3	188.6	185.9	180.0	175.1	170.0	161.6
	MAX. W / FT	8.7	9.0	9.2	10.8	11.6	11.8	13.9	14.5	16.5	18.8	22.9	25.6	29.2	32.9	34.1	37.1	39.6	41.7	45.7
	MIN. W / FT	8.3	8.5	8.8	10.2	11.0	11.1	13.1	13.7	15.6	17.6	21.7	24.8	28.2	31.7	32.9	35.7	38.1	40.1	44.0
280	PIPE TEMP	265.8	265.2	264.1	261.1	258.6	258.0	253.2	252.1	247.4	241.6	229.8	220.9	211.3	201.9	199.0	192.5	187.2	181.7	172.6
	MAX. W / FT	9.6	9.9	10.1	11.9	12.7	13.0	15.3	16.0	18.2	20.6	25.2	28.1	32.0	36.0	37.3	40.4	43.3	45.9	48.9
	MIN. W / FT	9.2	9.4	9.7	11.3	12.1	12.3	14.4	15.1	17.0	19.3	23.6	27.1	30.9	34.7	35.9	39.1	41.6	43.8	48.0
300	PIPE TEMP	284.4	283.8	282.6	279.3	276.8	275.9	270.6	269.5	264.7	258.1	245.3	235.7	225.3	215.1	212.0	204.9	199.3	193.3	183.5
	MAX. W / FT	10.6	10.9	11.1	13.1	14.0	14.2	16.8	17.5	19.9	22.5	27.4	30.6	34.8	39.2	40.5	44.1	47.0	49.5	54.7
	MIN. W / FT	10.1	10.3	10.6	12.3	13.2	13.4	15.7	16.5	18.5	21.1	26.0	29.6	33.6	37.8	39.1	42.6	45.2	47.6	52.1
350	PIPE TEMP	330.7	330.0	328.6	324.6	321.5	320.6	314.1	312.9	307.0	299.1	283.7	272.3	260.0	247.7	244.1	235.8	229.1	221.4	210.4
	MAX. W / FT	13.1	13.4	13.7	16.1	17.2	17.4	20.6	21.4	24.2	27.4	33.3	37.0	42.0	47.3	48.8	53.1	56.5	59.4	65.0
	MIN. W / FT	12.4	12.7	13.0	15.2	16.2	16.4	19.2	20.1	22.8	25.6	31.5	35.7	40.5	45.5	47.0	51.0	54.3	57.1	62.5
400	PIPE TEMP	376.7	376.0	374.5	369.6	366.0	365.0	357.3	355.9	349.0	339.8	321.8	308.5	294.2	279.9	275.9	266.2	258.5	250.3	237.0
	MAX. W / FT	15.8	16.1	16.4	19.2	20.5	20.7	24.5	25.5	28.8	32.5	39.1	43.6	49.6	55.6	57.3	62.3	66.2	69.6	76.0
	MIN. W / FT	14.9	15.2	15.6	18.1	19.4	19.5	22.9	23.9	26.7	30.3	37.1	42.1	47.7	53.5	55.1	59.6	63.6	66.8	73.0
450	PIPE TEMP	422.6	421.8	420.1	414.4	410.3	409.1	400.3	398.6	390.7	380.1	359.5	344.4	328.0	311.6	307.2	296.2	287.4	278.2	263.1
	MAX. W / FT	18.6	18.9	19.2	22.6	24.0	24.2	28.7	29.7	33.5	37.8	45.6	50.4	57.1	64.2	66.0	71.7	76.2	80.0	87.3
	MIN. W / FT	17.6	17.9	18.2	21.2	22.6	22.8	26.8	27.8	31.1	35.2	43.0	48.6	55.0	61.6	63.5	68.8	73.1	76.7	83.7
500	PIPE TEMP	488.2	487.4	485.5	478.9	474.3	473.0	461.2	459.2	451.2	432.2	420.1	396.9	379.8	361.4	354.0	342.8	331.0	318.7	288.7
	MAX. W / FT	21.6	21.9	22.2	26.1	27.7	27.9	33.0	34.1	38.5	43.3	52.1	57.4	66.9	72.9	75.0	81.3	86.4	90.4	98.7
	MIN. W / FT	20.3	20.7	21.0	24.4	26.0	26.2	30.6	31.9	35.6	40.2	49.0	55.3	62.5	70.0	72.0	78.0	82.8	86.8	96.6
550	PIPE TEMP	513.7	512.8	510.7	503.3	498.1	496.8	485.4	483.4	473.4	459.9	435.7	414.9	394.5	374.0	368.8	355.0	344.2	332.9	314.4
	MAX. W / FT	24.7	25.1	25.3	29.7	31.5	31.7	37.4	38.7	43.6	49.0	58.7	64.6	73.0	81.9	84.1	91.1	96.7	101.3	110.1
	MIN. W / FT	23.2	23.6	23.9	27.8	29.6	29.7	34.7	36.1	40.2	45.4	55.2	62.2	70.1	78.5	80.6	87.3	92.6	97.1	105.7
600	PIPE TEMP	559.0	558.1	555.8	547.5	541.8	540.3	527.6	525.5	514.3	499.4	470.7	449.7	427.2	404.6	399.0	383.9	372.1	359.7	339.5
	MAX. W / FT	27.9	28.3	28.5	33.5	35.4	35.6	42.0	43.4	48.8	54.9	65.6	72.0	81.2	91.0	93.4	101.1	107.2	112.3	122.1
	MIN. W / FT	26.2	26.6	26.9	31.3	33.2	33.4	38.9	40.4	45.0	50.7	61.5	69.3	78.0	87.2	89.5	96.8	102.6	107.5	116.4
650	PIPE TEMP	604.2	603.2	600.7	591.5	585.2	583.6	569.6	567.3	555.1	538.6	507.2	484.2	459.6	434.9	428.9	412.4	399.6	386.2	364.4
	MAX. W / FT	31.3	31.7	31.9	37.4	39.3	39.5	45.9	47.7	54.0	60.9	72.6	79.5	89.8	100.3	102.8	111.3	117.0	121.5	131.1
	MIN. W / FT	29.3	29.7	30.0	34.4	37.0	37.1	43.2	44.9	49.9	56.2	68.0	74.5	84.0	94.0	96.5	104.5	110.		



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
PAGE 388
MAY, 1968

INSULATION THICKNESS REQUIREMENTS

Service Designation T-49

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT
PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

3" NOMINAL INSULATION THICKNESS			AMBIENT AIR TEMP 30.0 F (-1.1 C)																	
CABLE TEMP DEG F		PIPE SIZE																		
		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
40	PIPE TEMP	58.7	58.6	58.5	58.2	58.0	57.9	57.4	57.3	56.9	56.2	55.0	54.1	53.1	52.1	51.7	51.0	50.4	49.8	48.7
	MAX W / FT	0.9	0.9	0.9	1.1	1.2	1.2	1.4	1.5	1.7	2.0	2.4	2.8	3.2	3.6	3.8	4.1	4.4	4.7	5.2
	MIN W / FT	0.8	0.9	0.9	1.1	1.1	1.2	1.4	1.5	1.6	1.9	2.3	2.7	3.1	3.5	3.7	4.0	4.3	4.5	5.0
80	PIPE TEMP	77.8	77.7	77.5	77.0	76.6	76.4	75.7	75.5	74.7	73.6	71.7	70.0	68.3	66.7	66.0	64.9	63.9	62.8	61.0
	MAX W / FT	1.5	1.5	1.4	1.9	2.0	2.1	2.4	2.6	2.9	3.3	4.0	4.7	5.4	6.1	6.3	6.9	7.4	7.9	8.7
	MIN W / FT	1.4	1.5	1.4	1.8	1.9	2.0	2.3	2.5	2.8	3.2	3.9	4.6	5.2	5.9	6.2	6.7	7.2	7.6	8.4
100	PIPE TEMP	96.9	96.7	96.4	95.7	95.1	94.9	93.8	93.5	92.5	91.0	88.2	85.9	83.5	81.2	80.3	78.7	77.3	75.8	73.3
	MAX W / FT	2.1	2.2	2.3	2.7	2.9	3.0	3.5	3.6	4.1	4.7	5.7	6.6	7.6	8.5	8.9	9.8	10.5	11.1	12.2
	MIN W / FT	2.0	2.1	2.2	2.6	2.8	2.8	3.3	3.5	3.9	4.5	5.6	6.5	7.4	8.3	8.7	9.5	10.1	10.7	11.9
120	PIPE TEMP	115.9	115.6	115.2	114.4	113.6	113.3	111.9	111.4	110.2	108.3	104.7	101.7	98.6	95.7	94.5	92.4	90.6	88.7	85.5
	MAX W / FT	2.8	2.9	3.0	3.5	3.8	3.9	4.5	4.7	5.3	6.1	7.4	8.6	9.8	11.1	11.6	12.6	13.5	14.3	15.8
	MIN W / FT	2.7	2.8	2.9	3.3	3.6	3.7	4.3	4.5	5.1	5.9	7.2	8.4	9.6	10.8	11.2	12.3	13.1	13.9	15.3
140	PIPE TEMP	134.8	134.6	134.1	133.0	132.1	131.7	130.0	129.6	127.9	125.5	121.1	117.4	113.7	110.0	108.7	106.1	103.9	101.5	97.6
	MAX W / FT	3.5	3.6	3.7	4.3	4.7	4.8	5.4	5.6	6.4	7.3	8.9	10.3	11.8	13.3	13.8	15.1	16.1	17.1	18.9
	MIN W / FT	3.3	3.5	3.6	4.2	4.5	4.6	5.4	5.6	6.3	7.3	8.9	10.3	11.8	13.3	13.8	15.1	16.1	17.1	18.9
160	PIPE TEMP	153.8	153.5	152.9	151.6	150.5	150.1	148.0	147.5	145.5	142.6	137.4	133.1	128.6	124.3	122.7	119.6	117.1	114.3	109.7
	MAX W / FT	4.2	4.3	4.5	5.2	5.4	5.8	6.7	7.0	7.9	9.1	10.9	12.6	14.4	16.3	17.0	18.5	19.8	20.9	23.1
	MIN W / FT	4.0	4.2	4.3	5.0	5.4	5.5	6.4	6.7	7.6	8.7	10.7	12.3	14.1	15.8	16.5	17.9	19.2	20.3	22.4
180	PIPE TEMP	172.7	172.3	171.7	170.2	168.9	168.4	166.0	165.4	163.1	159.7	153.7	148.7	143.5	138.5	136.7	133.1	130.2	127.0	121.7
	MAX W / FT	4.9	5.1	5.3	6.1	6.4	6.7	7.9	8.2	9.2	10.6	12.7	14.7	16.8	18.9	19.7	21.5	23.0	24.3	26.8
	MIN W / FT	4.7	4.9	5.1	5.9	6.3	6.5	7.5	7.9	8.8	10.2	12.4	14.3	16.3	18.4	19.1	20.8	22.3	23.5	26.0
200	PIPE TEMP	191.5	191.1	190.4	188.7	187.2	186.7	183.9	183.2	180.7	176.8	169.9	164.3	158.4	152.6	150.6	146.6	143.2	139.6	133.6
	MAX W / FT	5.7	5.9	6.1	7.0	7.6	7.7	9.1	9.4	10.6	12.2	14.6	16.8	19.2	21.6	22.5	24.5	26.2	27.7	30.5
	MIN W / FT	5.5	5.6	5.8	6.7	7.3	7.4	8.6	9.0	10.1	11.6	14.2	16.4	18.7	21.0	21.8	23.8	25.4	26.8	29.6
220	PIPE TEMP	210.3	209.9	209.1	207.1	205.5	204.9	201.7	201.0	198.1	193.8	186.1	179.7	173.1	166.6	164.5	159.9	156.1	152.1	145.4
	MAX W / FT	6.4	6.7	6.9	8.0	8.6	8.8	10.3	10.7	12.0	13.8	16.5	19.0	21.6	24.4	25.3	27.6	29.5	31.1	34.3
	MIN W / FT	6.2	6.4	6.6	7.7	8.3	8.4	9.8	10.2	11.4	13.2	16.0	18.5	21.0	23.7	24.6	26.7	28.6	30.2	33.2
240	PIPE TEMP	229.1	228.7	227.8	225.5	223.7	223.1	219.5	218.8	215.6	210.7	202.2	195.1	187.8	180.6	178.2	173.2	169.0	164.6	157.2
	MAX W / FT	7.3	7.5	7.7	9.0	9.7	9.8	11.5	12.0	13.4	15.4	18.4	21.1	24.1	27.1	28.2	30.7	32.8	34.6	38.1
	MIN W / FT	7.0	7.2	7.4	8.6	9.3	9.4	10.9	11.4	12.8	14.7	17.9	20.6	23.4	26.3	27.3	29.7	31.8	33.5	36.9
260	PIPE TEMP	247.9	247.4	246.4	243.9	241.9	241.2	237.3	236.5	232.9	227.6	218.2	210.4	202.4	194.5	191.9	186.4	181.8	176.9	168.9
	MAX W / FT	8.1	8.3	8.6	10.0	10.7	10.9	12.8	13.3	14.9	17.1	20.3	23.3	26.4	30.0	31.1	33.8	36.1	38.1	42.0
	MIN W / FT	7.8	8.0	8.3	9.6	10.3	10.5	12.1	12.7	14.2	16.3	19.8	22.7	25.8	29.1	30.1	32.8	35.0	36.9	40.6
280	PIPE TEMP	266.6	266.1	265.0	262.3	260.0	259.3	255.0	254.1	250.3	244.4	234.1	225.7	217.0	208.3	205.6	199.5	194.6	189.3	180.5
	MAX W / FT	9.0	9.2	9.5	11.0	11.9	12.0	14.1	14.4	16.2	18.8	22.3	25.6	29.1	32.8	33.9	37.0	39.5	41.7	45.9
	MIN W / FT	8.8	9.0	9.3	10.5	11.4	11.5	13.4	14.0	15.6	17.9	21.7	24.9	28.3	31.8	32.9	35.8	38.3	40.3	44.4
300	PIPE TEMP	285.2	284.7	283.5	280.6	278.1	277.4	272.7	271.8	267.5	261.2	250.0	240.9	231.6	222.0	219.1	212.6	207.2	201.5	192.0
	MAX W / FT	9.8	10.1	10.4	12.1	13.0	13.2	15.4	15.9	17.9	20.5	24.3	27.9	31.7	35.7	36.9	40.2	42.9	45.3	49.8
	MIN W / FT	9.4	9.7	10.0	11.5	12.4	12.6	14.6	15.2	17.0	19.5	23.6	27.1	30.8	34.6	35.8	38.9	41.5	43.8	48.1
350	PIPE TEMP	331.8	331.2	329.4	326.1	323.2	322.4	316.7	315.6	310.5	302.9	289.5	278.7	267.3	256.1	252.7	244.9	238.6	231.8	220.6
	MAX W / FT	12.2	12.4	12.8	14.8	15.9	16.1	18.8	19.5	21.8	24.9	29.4	33.7	38.3	43.1	44.5	48.4	51.6	54.6	59.7
	MIN W / FT	11.6	11.9	12.3	14.2	15.2	15.4	17.8	18.6	20.7	23.7	28.6	32.7	37.1	41.7	43.1	46.8	49.9	52.8	57.7
400	PIPE TEMP	378.1	377.5	375.9	371.5	368.1	367.1	360.4	359.2	353.2	344.2	328.7	316.0	302.8	289.7	286.0	276.9	269.4	261.8	248.9
	MAX W / FT	14.4	14.9	15.3	17.8	19.0	19.2	22.4	23.1	25.8	29.5	34.8	39.7	45.0	50.6	52.2	56.8	60.5	63.7	69.8
	MIN W / FT	14.0	14.2	14.7	16.9	18.1	18.3	21.2	22.1	24.5	28.3	33.8	38.6	43.7	49.0	50.5	54.9	58.5	61.5	67.5
450	PIPE TEMP	424.2	423.3	421.7	416.6	412.7	411.6	403.8	402.5	395.6	385.3	367.5	353.0	338.0	323.0	318.8	308.4	300.1	291.3	276.7
	MAX W / FT	17.2	17.5	17.9	20.8	22.2	22.4	26.2	27.0	30.1	34.3	40.3	45.9	52.0	58.4	60.2	65.4	69.6	73.2	80.2
	MIN W / FT	16.4	16.7	17.2	19.8	21.2	21.4	24.7	25.7	28.5	32.5	39.1	44.6	50.4	56.5	58.2	63.2	67.2	70.7	77.4
500	PIPE TEMP	470.2	469.4	467.4	461.6	457.1	455.9	447.0	445.6	437.8	426.1	405.9	389.6	372.7	355.8	351.2	339.6	330.3	320.4	304.2
	MAX W / FT	20.0	20.3	20.7	24.0	25.4	25.8	30.1	31.0	34.3	39.3	46.0	52.3	59.1	66.3	68.3	74.1	78.9	82.9	90.7
	MIN W / FT	19.0	19.3	19.8	22.8	24.4	24.5	28.3	29.4	32.4	37.2	44.6	50.7	57.3	64.1	66.0	71.6	76.1	80.0	87.5
550	PIPE TEMP	515.9	515.2	512.5	506.3	501.3	500.1	490.0	488.4	479.7	468.6	444.1	425.9	407.1	388.3	383.3	370.4	360.2	349.3	331.3
	MAX W / FT	22.8	23.1	23.4	27.4	29.1	29.3	34.1	35.1	39.0	44.4	51.8	58.9	66.5	74.5	76.6	83.1	88.3	92.8	101.4
	MIN W / FT	21.7	22.0	22.5	25.9	27.7	27.8	32.1	33.3	36.8	41.9	50.3	57.1	64.3	71.9	74.0	80.2	85.2	89.5	97.6
600	PIPE TEMP	561.6	560.7	558.2	550.9	545.4	544.0	532.8	531.1	521.4	506.8	481.9	461.9	441.2	420.5	415.1	400.9	389.7	377.7	358.1
	MAX W / FT	25.8	26.1	26.4	30.8	32.8	32.9	38.3	39.3	43.7	49.7	57.8	65.4	74.0	82.8	85.1	92.2	98.0	102.9	112.1
	MIN W / FT	24.5	24.8	25.3	29.1	31.1	31.2	36.0	37.3	41.2	46.9	56.1	63.5	71.5	79.9	82.1	89.0	94.5	99.1	108.2
650	PIPE TEMP	607.0	606.2	603.5	595.4	589.2	587.8	575.4	573.5	562.9	546.9	519.5	497.6	475.0	452.3	446.5	431.1	418.8	405.4	386.6
	MAX W / FT	28.9	29.2	29.7	34.6	36.5	36.7	42.4	43.4	47.8	54.6	64.0	72.5	81.6	91.3	93.8	101.4	107.8	113.1	121.3
	MIN W / FT	27.4	27.7	28.2	32.5	34.6	34.7	40.0	41.4	45.7	51.9	62.0	70.2	78.9	88.0	90.4	97.9	103.9	108.9	118.6
700	PIPE TEMP	652.4	651.5	648.4	639.7	633.0	631.													



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
PAGE 389
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INSULATION THICKNESS REQUIREMENTS

Service Designation T-50

ELECTRIC HEAT TRACING

MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

3-1/2" NOMINAL INSULATION THICKNESS		PIPE SIZE																AMBIENT AIR TEMP 30.0 °F (-1.1 °C)			
CABLE TEMP °C	°F	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	
40	PIPE TEMP	58.8	58.7	58.4	58.3	58.1	58.0	57.6	57.4	57.0	56.4	55.4	54.5	53.5	52.6	52.3	51.9	51.1	50.5	49.4	
	MAX. W / FT	0.8	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.4	1.8	2.2	2.6	3.0	3.3	3.5	3.8	4.1	4.3	4.8	
	MIN. W / FT	0.8	0.8	0.9	1.0	1.1	1.1	1.3	1.4	1.5	1.8	2.2	2.5	2.9	3.2	3.4	3.7	4.0	4.2	4.7	
80	PIPE TEMP	77.9	77.8	77.4	77.1	76.8	76.4	75.9	75.7	75.0	74.0	72.2	70.7	69.1	67.6	67.0	66.0	65.0	64.0	62.3	
	MAX. W / FT	1.4	1.5	1.5	1.8	1.9	2.0	2.3	2.4	2.7	3.1	3.7	4.3	5.0	5.4	5.9	6.4	6.9	7.3	8.1	
	MIN. W / FT	1.4	1.4	1.5	1.7	1.8	1.9	2.2	2.3	2.6	3.0	3.7	4.2	4.9	5.5	5.7	6.2	6.7	7.1	7.9	
100	PIPE TEMP	97.0	96.8	96.5	95.9	95.4	95.2	94.2	93.9	92.9	91.5	89.0	86.9	84.7	82.6	81.7	80.2	78.9	77.5	75.1	
	MAX. W / FT	2.0	2.1	2.2	2.5	2.7	2.8	3.2	3.4	3.8	4.4	5.3	6.1	7.0	7.9	8.3	9.0	9.7	10.2	11.4	
	MIN. W / FT	1.9	2.0	2.1	2.4	2.6	2.7	3.1	3.3	3.7	4.2	5.2	6.0	6.9	7.7	8.1	8.8	9.4	10.0	11.1	
120	PIPE TEMP	116.0	115.8	115.4	114.7	114.0	113.7	112.4	112.0	110.8	109.0	105.7	103.0	100.1	97.4	96.4	94.4	92.7	90.9	87.9	
	MAX. W / FT	2.6	2.7	2.9	3.3	3.5	3.6	4.2	4.4	5.0	5.7	6.9	8.0	9.1	10.2	10.7	11.7	12.5	13.2	14.7	
	MIN. W / FT	2.5	2.6	2.8	3.2	3.4	3.5	4.0	4.3	4.8	5.5	6.7	7.8	8.9	10.0	10.4	11.4	12.2	12.9	14.3	
140	PIPE TEMP	135.1	134.8	134.3	133.4	132.5	132.2	130.6	130.1	128.6	126.4	122.4	119.0	115.5	112.2	110.9	108.5	106.4	104.2	100.5	
	MAX. W / FT	3.3	3.4	3.5	4.1	4.4	4.5	5.2	5.5	6.2	7.0	8.5	9.8	11.2	12.4	13.2	14.3	15.4	16.3	18.0	
	MIN. W / FT	3.2	3.3	3.4	3.9	4.3	4.4	5.0	5.3	5.9	6.8	8.3	9.6	10.9	12.3	12.8	14.0	15.0	15.9	17.6	
160	PIPE TEMP	154.0	153.8	153.2	152.0	151.0	150.6	148.7	148.2	146.4	143.7	139.0	135.0	130.9	126.9	125.4	122.5	120.1	117.5	113.1	
	MAX. W / FT	3.9	4.1	4.3	4.9	5.3	5.4	6.2	6.6	7.4	8.4	10.1	11.7	13.3	15.0	15.7	17.1	18.3	19.4	21.4	
	MIN. W / FT	3.8	4.0	4.1	4.7	5.1	5.2	6.0	6.4	7.1	8.2	9.9	11.4	13.0	14.7	15.3	16.6	17.8	18.9	20.9	
180	PIPE TEMP	173.0	172.7	172.0	170.6	169.5	169.0	166.8	166.2	164.1	161.0	155.5	150.9	146.1	141.5	139.8	136.5	133.7	130.6	125.6	
	MAX. W / FT	4.6	4.8	5.0	5.7	6.2	6.3	7.3	7.7	8.6	9.8	11.8	13.6	15.5	17.5	18.2	19.8	21.2	22.5	24.9	
	MIN. W / FT	4.5	4.6	4.8	5.6	6.0	6.1	7.0	7.5	8.3	9.5	11.6	13.3	15.2	17.0	17.7	19.3	20.7	21.9	24.2	
200	PIPE TEMP	191.9	191.5	190.8	189.2	187.4	186.9	184.1	183.4	181.8	178.2	172.0	166.8	161.3	156.0	154.2	150.4	147.2	143.8	138.0	
	MAX. W / FT	5.4	5.5	5.7	6.6	7.1	7.2	8.4	8.8	9.8	11.3	13.5	15.6	17.7	20.0	20.7	22.4	23.6	24.8	28.3	
	MIN. W / FT	5.2	5.3	5.6	6.4	6.9	7.0	8.1	8.5	9.5	10.9	13.2	15.2	17.3	19.5	20.2	22.0	23.6	24.9	27.5	
220	PIPE TEMP	210.8	210.4	209.6	207.8	206.2	205.7	202.9	202.1	199.4	195.4	188.4	182.6	176.5	170.5	168.5	164.2	160.7	156.8	150.4	
	MAX. W / FT	6.1	6.3	6.5	7.5	8.1	8.2	9.5	10.0	11.1	12.7	15.2	17.5	20.0	22.5	23.3	25.4	27.2	28.8	31.8	
	MIN. W / FT	5.9	6.1	6.3	7.3	7.8	7.9	9.1	9.7	10.7	12.3	14.9	17.1	19.5	21.9	22.6	24.8	26.5	28.0	30.9	
240	PIPE TEMP	229.6	229.2	228.3	226.3	224.6	224.0	220.8	219.9	217.0	212.5	204.8	198.3	191.6	186.9	182.7	178.0	174.0	169.8	162.7	
	MAX. W / FT	6.9	7.0	7.3	8.4	9.0	9.2	10.6	11.2	12.5	14.2	17.0	19.5	22.2	25.0	26.0	28.3	30.3	32.0	35.1	
	MIN. W / FT	6.6	6.8	7.1	8.1	8.7	8.9	10.2	10.8	12.0	13.8	16.6	19.1	21.7	24.4	25.3	27.6	29.5	31.1	34.4	
260	PIPE TEMP	248.4	248.0	247.0	244.7	242.9	242.3	238.8	237.8	234.5	229.6	221.1	214.0	206.6	199.3	196.9	191.7	187.4	182.7	175.0	
	MAX. W / FT	7.6	7.8	8.1	9.4	10.0	10.2	11.8	12.4	13.8	15.8	18.8	21.6	24.5	27.6	28.6	31.2	33.4	35.3	38.9	
	MIN. W / FT	7.4	7.6	7.9	9.0	9.7	9.9	11.3	12.0	13.3	15.2	18.4	21.1	23.9	26.9	27.9	30.4	32.3	34.3	37.2	
280	PIPE TEMP	267.2	266.7	265.6	263.2	261.1	260.5	256.6	255.6	252.0	246.6	237.4	229.6	221.5	213.5	211.0	205.3	200.6	195.6	187.1	
	MAX. W / FT	8.4	8.7	9.0	10.3	11.1	11.2	13.0	13.6	15.2	17.3	20.6	23.6	26.9	30.2	31.3	34.1	36.5	38.5	42.5	
	MIN. W / FT	8.2	8.4	8.7	10.0	10.7	10.8	12.5	13.2	14.6	16.7	20.1	23.1	26.2	29.4	30.5	33.2	35.6	37.5	41.3	
300	PIPE TEMP	285.9	285.5	284.3	281.6	279.4	278.7	274.5	273.3	269.5	263.6	253.6	245.1	236.6	227.7	225.0	218.9	213.4	208.3	199.3	
	MAX. W / FT	9.3	9.5	9.8	11.3	12.1	12.3	14.2	14.9	16.6	18.9	22.4	25.7	29.3	32.9	34.1	37.1	39.6	41.8	46.1	
	MIN. W / FT	9.0	9.2	9.5	10.9	11.7	11.9	13.6	14.4	15.9	18.2	21.9	25.1	28.5	32.0	33.2	36.1	38.5	40.7	44.8	
350	PIPE TEMP	332.7	332.1	330.7	327.4	324.7	323.9	318.9	317.5	312.9	305.9	293.8	283.8	273.3	262.9	259.8	252.5	246.5	240.0	229.3	
	MAX. W / FT	11.4	11.7	12.1	13.9	14.8	15.0	17.3	18.2	20.2	22.9	27.2	31.1	35.3	39.6	41.0	44.4	46.7	50.3	55.4	
	MIN. W / FT	11.0	11.3	11.7	13.4	14.3	14.5	16.8	17.5	19.4	22.1	26.6	30.4	34.6	38.6	39.9	43.4	45.8	48.8	53.8	
400	PIPE TEMP	379.2	378.6	377.0	373.0	369.9	369.0	363.0	361.4	356.1	347.8	333.8	322.0	309.9	298.2	294.2	285.7	278.8	271.3	258.9	
	MAX. W / FT	13.7	14.0	14.4	16.6	17.7	17.8	20.6	21.4	23.9	27.2	32.1	36.7	41.5	46.6	48.2	52.4	55.9	58.9	64.8	
	MIN. W / FT	13.2	13.5	13.9	16.0	17.1	17.2	19.7	20.8	22.9	26.2	31.3	35.8	40.4	45.3	46.8	50.9	54.3	57.2	62.9	
450	PIPE TEMP	425.5	424.9	423.0	418.4	414.9	413.9	408.9	405.1	399.0	389.4	373.3	359.9	346.0	332.2	328.2	318.5	310.6	302.2	288.1	
	MAX. W / FT	16.2	16.4	16.5	19.5	20.7	20.8	23.8	24.5	27.0	31.0	37.2	42.4	47.9	53.8	55.5	60.3	64.3	67.7	74.4	
	MIN. W / FT	15.8	16.0	16.3	18.7	19.9	20.1	23.0	23.7	26.2	30.4	36.3	41.3	46.7	52.3	53.9	58.5	62.4	65.7	72.1	
500	PIPE TEMP	471.7	471.0	468.9	463.7	459.6	458.5	452.6	448.6	441.8	430.8	412.6	397.5	381.9	366.3	361.9	351.0	342.2	332.7	317.0	
	MAX. W / FT	18.7	19.0	19.5	22.5	23.8	24.0	27.6	28.8	31.9	36.1	42.4	48.3	54.5	61.1	63.0	68.4	72.9	76.7	84.1	
	MIN. W / FT	18.0	18.2	18.8	21.5	22.9	23.1	26.4	27.7	30.5	34.7	41.4	47.0	53.1	59.3	61.2	66.6	70.7	74.4	81.6	
550	PIPE TEMP	517.7	517.0	514.7	508.7	504.2	503.0	494.0	491.8	484.0	471.9	451.6	434.8	417.4	400.0	395.2	383.1	373.4	362.9	345.6	
	MAX. W / FT	21.4	21.7	22.2	25.5	27.0	27.2	31.3	32.7	36.1	40.8	47.8	54.3	61.3	68.6	70.7	74.7	79.1	83.2	91.7	
	MIN. W / FT	20.5	20.8	21.4	24.4	26.0	26.1	29.9	31.4	34.5	39.2	46.6	52.9	59.6	66.6	68.6	74.4	79.1	83.2	91.7	
600	PIPE TEMP	567.5	567.0	564.2	553.6	548.6	547.3	537.3	534.9	526.2	512.8	490.3	471.7	452.6	433.4	428.2	416.9	404.2	392.7	373.8	
	MAX. W / FT	24.2	24.5	25.0	28.8	30.4	30.5	35.1	36.6	40.4	45.7	53.4	60.6	68.2	76.3	78.5	85.1	90.4	95.2	104.7	
	MIN. W / FT	23.1	23.4	24.1	27.5	29.2	29.3	33.5	35.2	38.6	43.8	52.0	58.9	66.3	74.0	76.2	82.5	87.8	92.2	102.9	
650	PIPE TEMP	609.2	608.5	605.7	598.3	592.8	591.4	580.4	577.8	568.3	553.4	528.8	508.4	487.5	466.5	460.8	446.4	434.7	422.1	401.7	
	MAX. W / FT	27.0	27.1	27.4	32.1	33.9	34.0	39.1	40.7	44.9	50.6	59.1	66.9	75.3	84.1	86.5	93.8	99.7	104.7	114.5	
	MIN. W / FT	25.9	26.1	26.6	30.6	32.5	32.6	37.2	39.0	42.8	48.5	57.5	65.1	73.1	81.8	83.9	90.8	96.5	101.6		



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
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INSULATION THICKNESS REQUIREMENTS

Service Designation T-51

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT
PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

4" NOMINAL INSULATION THICKNESS			PIPE SIZE																AMBIENT AIR TEMP 300 F (-11 C)			
CABLE TEMP DEG F			3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	
40	PIPE TEMP	58.8	58.7	58.6	58.4	58.1	58.0	57.7	57.4	57.2	56.7	55.7	54.8	53.9	53.1	52.8	52.2	51.4	51.1	50.1		
	MAX W / FT	0.8	0.8	0.8	1.0	1.1	1.1	1.2	1.3	1.3	1.5	1.7	2.1	2.4	2.8	3.1	3.3	3.5	3.8	4.0	4.5	
	MIN W / FT	0.8	0.8	0.8	1.0	1.1	1.1	1.2	1.3	1.3	1.5	1.7	2.0	2.4	2.7	3.0	3.2	3.5	3.7	4.0	4.4	
80	PIPE TEMP	78.0	77.9	77.7	77.3	76.8	76.6	76.1	75.9	75.3	74.4	72.7	71.3	69.8	68.4	67.9	66.9	66.0	64.8	63.4		
	MAX W / FT	1.3	1.4	1.4	1.5	1.7	1.9	2.0	2.1	2.3	2.5	2.9	3.5	4.1	4.6	5.2	5.5	6.0	6.4	6.8	7.5	
	MIN W / FT	1.3	1.4	1.4	1.6	1.8	1.9	2.1	2.2	2.5	2.8	3.4	4.0	4.5	5.1	5.3	5.8	6.3	6.6	7.4		
100	PIPE TEMP	97.1	96.9	96.6	96.1	95.4	95.2	94.5	94.1	93.3	92.0	89.7	87.7	85.6	83.7	82.9	81.5	80.2	78.9	76.6		
	MAX W / FT	1.9	2.0	2.1	2.4	2.7	2.8	3.0	3.2	3.6	4.0	5.0	5.7	6.5	7.4	7.7	8.4	9.0	9.6	10.6		
	MIN W / FT	1.9	1.9	2.0	2.3	2.6	2.7	3.0	3.2	3.5	4.0	4.9	5.6	6.4	7.2	7.5	8.2	8.8	9.3	10.4		
120	PIPE TEMP	116.2	116.0	115.6	114.9	114.0	113.7	112.8	112.4	111.3	109.6	106.6	104.0	101.4	98.9	97.9	96.0	94.4	92.7	89.8		
	MAX W / FT	2.5	2.6	2.7	3.1	3.5	3.6	4.0	4.2	4.7	5.3	6.4	7.4	8.5	9.5	10.0	10.9	11.6	12.4	13.7		
	MIN W / FT	2.4	2.5	2.7	3.0	3.4	3.5	3.8	4.1	4.6	5.2	6.3	7.3	8.3	9.3	9.7	10.6	11.4	12.1	13.4		
140	PIPE TEMP	135.2	135.0	134.6	133.7	132.5	132.2	131.0	130.6	129.2	127.2	123.4	120.3	117.1	114.0	112.8	110.5	108.4	106.5	102.9		
	MAX W / FT	3.1	3.2	3.4	3.9	4.4	4.5	4.9	5.2	5.8	6.5	7.9	9.2	10.5	11.7	12.3	13.4	14.3	15.2	16.9		
	MIN W / FT	3.0	3.2	3.3	3.8	4.3	4.4	4.8	5.1	5.6	6.4	7.8	9.0	10.2	11.5	12.0	13.1	14.0	14.8	16.5		
160	PIPE TEMP	154.3	154.0	153.5	152.4	151.0	150.6	149.3	148.7	147.1	144.7	140.3	136.6	132.7	129.0	127.6	125.0	122.4	120.1	115.9		
	MAX W / FT	3.8	3.9	4.0	4.6	5.3	5.4	5.9	6.2	6.9	7.8	9.5	10.9	12.4	14.0	14.6	15.9	17.0	18.1	20.6		
	MIN W / FT	3.7	3.8	4.0	4.5	5.1	5.2	5.7	6.1	6.7	7.6	9.3	10.7	12.2	13.7	14.3	15.5	16.7	17.6	19.6		
180	PIPE TEMP	173.3	173.0	172.3	171.1	169.5	169.0	167.5	166.8	164.9	162.2	157.0	152.7	148.3	144.0	142.4	139.3	136.7	133.8	128.9		
	MAX W / FT	4.4	4.6	4.7	5.4	6.2	6.3	6.9	7.3	8.1	9.1	11.0	12.7	14.5	16.3	16.9	18.5	19.8	21.0	23.2		
	MIN W / FT	4.3	4.4	4.6	5.3	6.0	6.1	6.7	7.1	7.9	8.9	10.8	12.5	14.2	15.9	16.6	18.0	19.3	20.5	22.7		
200	PIPE TEMP	192.2	191.9	191.2	189.7	187.9	187.4	185.6	184.9	182.7	179.6	173.7	168.9	163.8	158.9	157.2	153.6	150.6	147.3	141.8		
	MAX W / FT	5.1	5.3	5.5	6.2	7.1	7.2	7.9	8.3	9.2	10.4	12.6	14.5	16.5	18.4	19.3	21.1	22.6	23.9	26.5		
	MIN W / FT	5.0	5.1	5.3	6.1	6.9	7.0	7.7	8.1	9.0	10.2	12.4	14.2	16.2	18.2	18.9	20.6	22.0	23.3	25.8		
220	PIPE TEMP	211.1	210.8	210.0	208.3	206.2	205.7	203.7	202.9	200.5	197.0	190.4	184.9	179.3	173.7	171.8	167.8	164.5	160.8	154.7		
	MAX W / FT	5.8	6.0	6.2	7.1	8.1	8.2	8.9	9.4	10.4	11.7	14.2	16.4	18.6	20.9	21.7	23.7	25.4	26.8	29.7		
	MIN W / FT	5.7	5.8	6.0	6.9	7.8	7.9	8.7	9.2	10.2	11.5	14.0	16.0	18.2	20.5	21.3	23.1	24.8	26.2	29.0		
240	PIPE TEMP	230.0	229.8	228.8	226.9	224.6	224.0	221.8	220.9	218.2	214.3	207.0	200.9	194.7	188.5	186.4	182.0	178.3	174.2	167.4		
	MAX W / FT	6.5	6.7	6.9	7.9	9.0	9.2	10.0	10.5	11.7	13.1	15.9	18.2	20.7	23.3	24.2	26.3	28.2	29.8	33.0		
	MIN W / FT	6.4	6.5	6.8	7.7	8.7	8.9	9.7	10.3	11.4	12.9	15.6	17.9	20.3	22.8	23.6	25.7	27.5	29.1	32.2		
260	PIPE TEMP	248.9	248.5	247.5	245.5	242.9	242.3	239.8	238.8	235.9	231.5	223.5	216.9	210.0	203.2	201.0	196.1	192.0	187.6	180.2		
	MAX W / FT	7.3	7.5	7.7	8.8	10.0	10.2	11.1	11.7	12.9	14.5	17.5	20.1	22.9	25.7	26.7	29.0	31.1	32.9	36.4		
	MIN W / FT	7.1	7.3	7.5	8.6	9.7	9.9	10.8	11.4	12.6	14.2	17.2	19.7	22.4	25.1	26.1	28.4	30.3	32.1	35.5		
280	PIPE TEMP	267.7	267.3	266.3	264.0	261.1	260.5	257.8	256.7	253.5	248.8	240.0	232.8	225.3	217.9	215.4	210.1	205.7	200.9	192.8		
	MAX W / FT	8.0	8.2	8.5	9.7	11.1	11.2	12.2	12.8	14.2	15.9	19.2	22.1	25.0	28.1	29.2	31.8	34.0	35.9	39.7		
	MIN W / FT	7.8	8.0	8.3	9.5	10.7	10.8	11.8	12.5	13.8	15.6	18.9	21.6	24.5	27.5	28.5	31.0	33.2	35.1	38.7		
300	PIPE TEMP	286.5	286.1	285.0	282.5	279.4	278.7	275.7	274.6	271.1	265.9	256.5	248.6	240.5	232.4	229.8	224.1	219.3	214.1	205.4		
	MAX W / FT	8.8	9.0	9.3	10.7	12.1	12.3	13.3	14.0	15.5	17.3	21.0	24.0	27.2	30.6	31.7	34.5	36.9	39.0	43.1		
	MIN W / FT	8.6	8.8	9.1	10.4	11.7	11.9	12.9	13.7	15.1	17.0	20.6	23.5	26.7	29.9	31.0	33.7	36.0	38.3	42.0		
350	PIPE TEMP	333.4	332.9	331.6	328.9	324.7	323.9	320.4	319.1	314.9	308.7	297.4	288.0	278.2	268.6	265.6	258.8	253.1	246.9	236.6		
	MAX W / FT	10.9	11.1	11.4	13.1	14.8	15.0	16.3	17.1	18.9	21.1	25.4	29.0	32.9	36.9	38.2	41.5	44.4	46.9	51.7		
	MIN W / FT	10.6	10.8	11.1	12.7	14.3	14.5	15.8	16.7	18.3	20.7	24.9	28.4	32.1	36.0	37.3	40.5	43.3	45.7	50.4		
400	PIPE TEMP	360.0	359.5	358.0	354.9	349.9	349.0	344.8	343.3	338.4	331.1	317.9	307.0	295.7	284.4	281.0	273.1	266.5	259.3	247.4		
	MAX W / FT	12.6	12.9	13.3	15.1	17.1	17.2	18.7	19.8	21.7	24.5	29.3	33.5	37.8	42.3	43.7	47.5	50.7	53.5	59.0		
450	PIPE TEMP	426.5	425.9	424.2	420.0	414.9	413.9	409.0	407.3	401.7	393.3	378.2	365.6	352.7	339.9	336.0	327.0	319.5	311.4	297.9		
	MAX W / FT	15.3	15.6	16.0	18.3	20.7	20.8	22.6	23.6	25.0	27.6	32.0	36.7	41.5	46.7	50.0	51.6	54.1	56.9	63.1		
	MIN W / FT	14.9	15.1	15.4	17.7	19.9	20.1	21.8	23.0	25.2	28.4	34.0	38.7	43.6	48.8	50.4	52.9	55.6	58.5	67.1		
500	PIPE TEMP	472.9	472.2	470.3	465.5	459.6	458.5	453.0	451.1	444.7	435.2	418.1	404.0	389.4	375.0	370.7	360.5	352.1	343.1	328.0		
	MAX W / FT	17.7	18.0	18.4	21.0	23.8	24.0	25.9	27.1	29.8	33.1	39.6	45.0	50.8	56.8	58.4	63.7	67.9	71.6	78.7		
	MIN W / FT	17.2	17.6	17.9	20.4	22.9	23.1	25.0	26.4	28.9	32.5	38.7	44.0	49.6	55.4	57.2	62.0	66.1	69.7	76.6		
550	PIPE TEMP	519.0	518.4	516.2	510.9	504.2	503.0	498.6	496.7	487.5	476.9	457.8	442.0	425.9	409.7	405.1	393.8	384.5	374.4	357.7		
	MAX W / FT	20.3	20.5	21.0	23.9	27.0	27.2	29.4	30.7	33.7	37.4	44.6	50.7	57.1	63.8	65.8	71.4	76.1	80.1	88.0		
	MIN W / FT	19.6	19.8	20.4	23.1	26.0	26.1	28.3	29.6	32.6	36.7	43.7	49.5	55.7	62.2	64.3	69.5	74.1	78.0	85.6		
600	PIPE TEMP	565.1	564.4	562.0	556.0	548.6	547.3	540.4	538.0	530.2	518.3	497.2	479.8	461.9	444.1	439.1	426.6	416.4	405.4	387.1		
	MAX W / FT	22.9	23.1	23.6	26.9	30.4	30.5	32.9	34.4	37.7	41.8	49.8	56.5	63.5	71.0	73.1	79.3	84.4	88.9	97.5		
	MIN W / FT	22.1	22.3	22.9	26.0	29.2	29.3	31.8	33.4	36.5	41.0	48.7	55.2	62.0	69.1	71.2</						

INSULATION THICKNESS REQUIREMENTS

Service Designation T-52

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT
PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

1" NOMINAL INSULATION THICKNESS		PIPE SIZE																AMBIENT AIR TEMP 60.0 F (15.6 C)		
CABLE TEMP DEG F		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
80	PIPE TEMP	78.8	78.7	78.5	78.3	78.0	77.8	77.4	77.4	76.8	76.1									
	PAR.W / FT	0.9	1.0	1.0	1.2	1.3	1.4	1.6	1.6	1.9	2.3									
	FIN.W / FT	0.8	0.9	0.9	1.1	1.2	1.4	1.6	1.4	1.7	2.0									
100	PIPE TEMP	87.5	87.3	87.0	86.5	85.8	85.6	84.7	84.7	83.5	82.1									
	PAR.W / FT	1.9	2.0	2.1	2.4	2.7	2.8	3.3	3.2	4.0	4.7									
	FIN.W / FT	1.7	1.8	1.9	2.2	2.4	2.5	2.9	2.9	3.5	4.0									
120	PIPE TEMP	114.1	115.4	115.4	114.6	113.6	113.2	111.9	111.9	110.1	107.9									
	PAR.W / FT	2.9	3.1	3.2	3.7	4.1	4.3	5.0	5.0	6.1	7.2									
	FIN.W / FT	2.7	2.8	2.9	3.3	3.7	3.9	4.4	4.4	5.3	6.2									
140	PIPE TEMP	134.6	134.3	133.7	132.6	131.3	130.8	129.0	129.0	126.5	123.6									
	PAR.W / FT	3.9	4.2	4.4	5.0	5.7	5.9	6.8	6.8	8.2	9.7									
	FIN.W / FT	3.6	3.8	4.0	4.5	5.1	5.3	6.0	6.0	7.2	8.3									
160	PIPE TEMP	153.1	152.7	151.9	150.6	148.9	148.3	146.0	146.0	142.9	139.3									
	PAR.W / FT	5.1	5.3	5.6	6.4	7.2	7.5	8.7	8.6	10.5	12.4									
	FIN.W / FT	4.7	4.9	5.1	5.8	6.5	6.7	7.6	7.7	9.1	10.6									
180	PIPE TEMP	171.5	171.0	170.1	168.4	166.4	165.7	162.9	162.9	159.2	156.8									
	PAR.W / FT	6.2	6.6	6.9	7.9	8.9	9.2	10.6	10.5	12.8	15.1									
	FIN.W / FT	5.7	6.0	6.3	7.1	7.9	8.2	9.3	9.3	11.1	12.9									
200	PIPE TEMP	189.9	189.3	188.2	186.2	183.8	183.0	179.7	179.8	175.3	170.1									
	PAR.W / FT	7.5	7.8	8.2	9.4	10.6	11.0	12.7	12.5	15.2	17.9									
	FIN.W / FT	6.8	7.1	7.5	8.4	9.5	9.7	11.1	11.1	13.1	15.2									
220	PIPE TEMP	208.2	207.4	206.2	203.9	201.2	200.2	196.4	196.5	191.4	185.4									
	PAR.W / FT	8.7	9.2	9.6	11.0	12.4	12.8	14.8	14.5	17.7	20.8									
	FIN.W / FT	8.0	8.3	8.7	9.8	11.0	11.3	12.9	12.9	15.2	17.6									
240	PIPE TEMP	226.4	225.6	224.2	221.5	218.4	217.3	213.0	213.2	207.4	200.6									
	PAR.W / FT	10.1	10.5	11.0	12.6	14.2	14.7	16.9	16.6	20.2	23.8									
	FIN.W / FT	9.2	9.5	10.0	11.3	12.6	12.9	14.7	14.7	17.3	20.1									
260	PIPE TEMP	244.5	243.6	242.1	239.1	235.6	234.4	229.6	229.8	223.3	215.7									
	PAR.W / FT	11.5	12.0	12.5	14.3	16.1	16.6	19.2	18.8	22.9	26.9									
	FIN.W / FT	10.4	10.8	11.3	12.8	14.3	14.6	16.6	16.5	19.5	22.6									
280	PIPE TEMP	262.6	261.6	259.9	256.6	252.6	251.4	246.0	246.3	239.1	230.7									
	PAR.W / FT	12.9	13.4	14.0	16.1	18.1	18.6	21.5	21.0	25.5	30.0									
	FIN.W / FT	11.7	12.1	12.6	14.3	16.0	16.3	18.5	18.4	21.7	25.2									
300	PIPE TEMP	280.6	279.6	277.7	274.0	269.6	268.3	262.4	262.8	254.8	245.6									
	PAR.W / FT	14.4	15.0	15.6	17.9	20.1	20.6	23.8	23.3	28.3	33.2									
	FIN.W / FT	13.0	13.5	14.0	15.9	17.7	18.1	20.5	20.4	24.0	27.8									
350	PIPE TEMP	325.3	324.1	321.9	317.2	311.8	310.3	302.9	303.6	293.8	282.4									
	PAR.W / FT	18.3	19.0	19.7	22.6	25.5	26.0	30.0	29.2	35.5	41.6									
	FIN.W / FT	16.5	17.0	17.6	20.0	22.2	22.6	25.7	25.4	29.9	34.5									
400	PIPE TEMP	369.6	368.3	365.7	360.0	353.5	351.8	343.0	344.0	332.3	318.8									
	PAR.W / FT	22.6	23.4	24.1	27.7	31.1	31.7	36.6	35.4	43.0	50.3									
	FIN.W / FT	20.2	20.8	21.5	24.3	27.0	27.4	31.1	30.7	36.0	41.5									
450	PIPE TEMP	413.5	412.2	409.2	402.5	394.9	393.0	382.6	384.0	370.4	354.7									
	PAR.W / FT	27.2	28.0	28.9	33.1	37.2	37.8	43.5	41.9	50.9	58.9									
	FIN.W / FT	24.2	24.8	25.6	28.9	32.1	32.5	36.7	36.2	42.4	48.7									
500	PIPE TEMP	457.2	455.7	452.7	444.6	435.9	433.8	421.9	423.7	408.0	390.2									
	PAR.W / FT	32.1	32.9	33.8	38.8	43.5	44.1	50.7	48.7	59.1	69.0									
	FIN.W / FT	28.4	29.0	29.8	33.7	37.3	37.7	42.6	41.8	48.9	56.1									
550	PIPE TEMP	500.5	498.9	495.2	486.4	476.5	474.3	460.8	463.0	445.4	425.3									
	PAR.W / FT	37.2	38.1	39.1	44.8	50.1	50.7	58.3	55.8	67.7	78.9									
	FIN.W / FT	32.7	33.4	34.3	38.7	42.7	43.1	48.6	47.7	55.7	63.7									
600	PIPE TEMP	543.5	541.9	537.8	527.9	516.9	514.5	499.5	502.1	482.5	460.1									
	PAR.W / FT	42.7	43.6	44.5	51.0	57.0	57.6	66.1	63.1	76.6	89.1									
	FIN.W / FT	37.3	38.0	38.5	43.8	48.3	48.7	54.9	53.7	62.6	71.6									
650	PIPE TEMP	586.4	584.7	580.3	569.3	557.0	554.5	537.9	541.0	519.3	496.6									
	PAR.W / FT	48.4	49.3	50.3	57.5	64.2	64.7	74.3	70.7	85.7	99.6									
	FIN.W / FT	42.1	42.8	43.7	49.2	54.1	54.5	61.3	59.9	69.8	79.6									
700	PIPE TEMP	627.0	627.2	622.5	610.4	597.0	594.3	576.0	579.7	555.9	529.0									
	PAR.W / FT	54.3	55.3	56.2	64.3	71.6	72.2	82.7	78.5	95.2	110.5									
	FIN.W / FT	47.0	47.7	48.6	54.7	60.1	60.5	67.9	66.2	77.1	87.8									
750	PIPE TEMP	671.5	669.7	664.6	651.4	636.8	633.9	614.0	618.1	592.3	561.1									
	PAR.W / FT	60.6	61.6	62.5	71.3	79.4	79.9	91.5	86.6	105.0	121.7									
	FIN.W / FT	52.2	52.9	53.8	60.4	66.3	66.6	74.7	72.7	84.6	96.2									
800	PIPE TEMP	713.8	712.0	706.6	692.2	676.4	673.4	651.9	656.5	628.6	597.0									
	PAR.W / FT	67.3	68.3	69.1	78.8	87.5	88.0	100.7	95.0	115.2	133.4									
	FIN.W / FT	57.7	58.4	59.2	66.4	72.7	73.0	81.7	79.5	92.3	104.8									
850	PIPE TEMP	756.1	754.2	748.5	733.0	716.0	712.8	689.7	694.7	664.7	630.9									
	PAR.W / FT	74.4	75.4	76.0	86.6	96.1	96.5	110.4	103.8	125.5	145.6									
	FIN.W / FT	63.4	64.1	64.8	72.6	79.4	79.6	89.1	86.4	100.3	113.7									
900	PIPE TEMP	798.3	796.4	790.3	773.6	755.4	752.1	727.3	732.8	700.8	666.7									
	PAR.W / FT	82.1	83.1	83.5	95.0	105.2	105.6	120.6	113.0	137.2	158.4									
	FIN.W / FT	69.5	70.2	70.8	79.2	86.5	86.6	96.8	93.7	108.7	123.0									
950	PIPE TEMP	840.5	838.5	832.1	814.2	794.8	791.3	764.9	770.8	736.7	698.7									
	PAR.W / FT	90.6	91.6	91.7	104.1	113.1	113.4	131.7	122.8	149.3	172.1									
	FIN.W / FT	76.2	76.9	77.3	86.2	94.0	94.1	104.9	101.3	117.5	132.8									



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
PAGE 392
MAY, 1968

INSULATION THICKNESS REQUIREMENTS

Service Designation T-53

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT
PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

1-1/2" NOMINAL INSULATION THICKNESS		AMBIENT AIR TEMP 60.0 F (15.6 C)																		
CABLE TEMP DEG F		PIPE SIZE																		
		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	20	24	
80	PIPE TEMP	79.0	78.9	78.7	78.5	78.3	78.2	77.8	77.7	77.2	76.6	75.5	74.6	73.7	72.8	72.4	71.8	71.4	70.9	70.0
	MAX.W /FT	0.7	0.8	0.8	1.0	1.0	1.1	1.3	1.4	1.6	1.9	2.4	2.7	3.0	3.4	3.6	3.9	4.1	4.3	4.7
	MIN.W /FT	0.7	0.7	0.8	0.9	1.0	1.0	1.2	1.3	1.5	1.7	2.1	2.5	2.9	3.2	3.4	3.7	3.9	4.1	4.5
100	PIPE TEMP	97.9	97.7	97.3	96.9	96.6	96.4	95.4	95.3	94.3	93.1	90.9	89.0	87.2	85.4	84.8	83.6	82.6	81.6	80.0
	MAX.W /FT	1.5	1.6	1.8	2.0	2.1	2.2	2.7	2.8	3.3	3.9	4.8	5.5	6.1	6.9	7.2	7.8	8.3	8.7	9.5
	MIN.W /FT	1.4	1.5	1.7	1.9	2.0	2.0	2.5	2.6	3.0	3.5	4.3	5.1	5.8	6.5	6.8	7.4	7.9	8.3	9.0
120	PIPE TEMP	116.7	116.5	115.9	115.3	114.7	114.5	113.0	112.8	111.4	109.5	106.3	103.3	100.6	97.9	97.0	95.2	93.7	92.2	89.8
	MAX.W /FT	2.3	2.4	2.7	3.1	3.3	3.4	4.1	4.3	5.1	5.9	7.3	8.4	9.2	10.4	10.8	11.8	12.5	13.2	14.4
	MIN.W /FT	2.2	2.3	2.6	2.9	3.0	3.1	3.8	3.9	4.6	5.3	6.6	7.7	8.7	9.9	10.3	11.2	11.9	12.5	13.6
140	PIPE TEMP	135.5	135.2	134.4	133.6	132.9	132.5	130.5	130.2	128.3	125.8	121.5	117.5	114.0	110.3	109.1	106.7	104.8	102.8	99.6
	MAX.W /FT	3.1	3.3	3.7	4.2	4.4	4.6	5.6	5.8	6.8	8.0	9.8	11.3	12.4	14.0	14.6	15.8	16.8	17.7	19.3
	MIN.W /FT	3.0	3.1	3.5	3.9	4.1	4.2	5.1	5.3	6.2	7.2	8.8	10.4	11.8	13.3	13.8	15.0	15.9	16.7	18.2
160	PIPE TEMP	154.2	153.9	152.9	151.8	150.9	150.4	148.0	147.6	145.2	142.0	136.6	131.7	127.2	122.6	121.1	118.1	115.7	113.2	109.2
	MAX.W /FT	4.0	4.2	4.8	5.4	5.6	5.8	7.1	7.4	8.7	10.2	12.4	14.2	15.6	17.7	18.3	20.0	21.2	22.2	24.2
	MIN.W /FT	3.8	4.0	4.4	5.0	5.2	5.4	6.5	6.7	7.8	9.1	11.2	13.1	14.8	16.7	17.4	18.8	20.0	21.0	22.9
180	PIPE TEMP	172.9	172.5	171.3	169.9	168.9	168.3	165.3	164.9	162.0	158.1	151.6	145.7	140.3	134.8	133.0	129.4	126.5	123.6	118.8
	MAX.W /FT	4.9	5.1	5.8	6.6	6.9	7.1	8.7	9.0	10.4	12.4	15.1	17.3	18.9	21.4	22.2	24.1	25.6	26.9	29.7
	MIN.W /FT	4.6	4.8	5.4	6.1	6.4	6.6	7.9	8.2	9.5	11.1	13.6	15.9	18.0	20.2	21.0	22.8	24.2	25.3	27.6
200	PIPE TEMP	191.6	191.1	189.7	188.0	186.8	186.2	182.6	182.1	178.7	174.2	166.5	159.6	153.3	146.8	144.8	140.6	137.2	133.8	128.1
	MAX.W /FT	5.9	6.1	6.9	7.8	8.2	8.4	10.4	10.7	12.6	14.7	17.9	20.4	22.3	25.2	26.1	28.3	30.1	31.5	34.1
	MIN.W /FT	5.5	5.7	6.4	7.2	7.6	7.8	9.4	9.7	11.3	13.1	16.0	18.7	21.1	23.4	24.8	26.7	28.4	29.7	32.3
220	PIPE TEMP	210.2	209.7	208.0	206.1	204.6	204.0	199.8	199.3	195.3	190.1	181.3	173.4	166.2	158.8	156.6	151.7	147.9	144.0	137.7
	MAX.W /FT	6.9	7.1	8.1	9.1	9.5	9.8	12.1	12.4	14.6	17.0	20.7	23.5	25.7	29.0	30.0	32.6	34.6	36.3	39.4
	MIN.W /FT	6.4	6.7	7.5	8.4	8.8	9.0	10.9	11.3	13.0	15.1	18.5	21.6	24.3	27.4	28.3	30.7	32.6	34.2	37.1
240	PIPE TEMP	228.7	228.2	226.2	224.0	222.4	221.7	216.9	216.4	211.8	206.0	196.0	187.1	179.0	170.6	168.2	162.7	158.4	154.1	147.1
	MAX.W /FT	7.9	8.2	9.3	10.3	10.9	11.2	13.8	14.1	16.6	19.4	23.5	26.7	29.1	32.9	34.0	36.9	39.2	41.0	44.5
	MIN.W /FT	7.4	7.6	8.6	9.6	10.1	10.3	12.5	12.9	14.9	17.2	21.0	24.5	27.6	31.1	32.1	34.8	36.9	38.6	41.9
260	PIPE TEMP	247.2	246.6	244.4	242.0	240.2	239.4	234.0	233.4	228.3	221.8	210.7	200.7	191.8	182.4	179.7	173.6	168.9	164.1	156.3
	MAX.W /FT	9.0	9.3	10.5	11.9	12.4	12.6	15.6	15.9	18.8	21.9	26.4	30.0	32.6	36.9	38.1	41.3	43.8	45.8	49.7
	MIN.W /FT	8.4	8.6	9.7	10.9	11.4	11.6	14.0	14.5	16.7	19.4	23.5	27.4	30.9	34.8	35.9	38.9	41.2	43.1	46.8
280	PIPE TEMP	265.6	265.0	262.5	259.8	257.9	257.0	251.0	250.4	244.7	237.5	225.3	214.3	204.4	194.0	191.2	184.4	179.3	174.0	165.5
	MAX.W /FT	10.0	10.4	11.7	13.3	13.8	14.1	17.4	17.8	20.9	24.4	29.4	33.3	36.2	40.9	42.2	45.8	48.5	50.7	55.3
	MIN.W /FT	9.4	9.7	10.8	12.2	12.7	13.0	15.7	16.1	18.6	21.5	26.1	30.4	34.2	38.5	39.7	43.0	45.6	47.7	51.7
300	PIPE TEMP	284.0	283.4	280.8	277.6	275.5	274.5	267.9	267.3	261.1	253.1	239.7	227.7	216.9	205.6	202.6	195.2	189.6	183.8	176.4
	MAX.W /FT	11.2	11.5	13.0	14.7	15.3	15.6	19.3	19.7	23.1	27.0	32.4	36.7	39.8	45.0	46.3	50.2	53.2	55.6	60.3
	MIN.W /FT	10.4	10.7	12.0	13.5	14.1	14.3	17.3	17.8	20.5	23.7	28.8	33.5	37.6	42.3	43.6	47.2	50.0	52.3	56.6
350	PIPE TEMP	329.8	329.0	325.7	321.9	319.3	318.2	310.0	309.3	301.7	291.9	275.6	261.0	247.9	234.1	230.6	221.7	215.0	208.1	197.0
	MAX.W /FT	14.1	14.5	16.4	18.6	19.2	19.5	24.2	24.6	28.9	33.6	40.2	45.3	49.0	55.3	56.8	61.6	65.2	68.1	73.7
	MIN.W /FT	13.2	13.5	15.1	16.9	17.6	17.9	21.6	22.2	25.5	29.5	35.5	41.2	46.3	52.0	53.5	57.9	61.2	63.9	69.1
400	PIPE TEMP	375.3	374.4	370.4	365.8	362.8	361.6	351.7	350.9	341.8	330.2	311.0	293.8	278.4	262.2	258.2	247.7	239.9	231.9	219.0
	MAX.W /FT	17.3	17.7	20.0	22.4	23.4	23.7	29.3	29.8	34.9	40.5	48.3	54.3	58.5	66.0	67.7	73.3	77.5	80.9	87.4
	MIN.W /FT	16.1	16.4	18.3	20.6	21.4	21.6	26.1	26.7	30.7	35.4	42.5	49.2	55.2	61.9	63.5	68.7	72.6	75.8	81.9
450	PIPE TEMP	420.5	419.4	414.9	409.5	406.4	404.4	393.0	392.2	381.7	368.1	346.0	326.1	308.5	289.7	285.3	273.3	264.5	255.3	240.7
	MAX.W /FT	20.7	21.1	23.6	26.9	27.7	28.1	34.7	35.1	41.2	47.8	56.6	63.5	68.3	76.9	78.8	85.2	90.0	93.4	101.2
	MIN.W /FT	19.1	19.5	21.7	24.6	25.3	25.5	30.8	31.5	36.1	41.5	49.7	57.4	64.2	72.9	73.9	79.8	84.3	87.8	94.8
500	PIPE TEMP	465.5	464.6	459.1	452.9	449.0	447.4	434.0	433.2	421.2	405.7	380.6	358.1	338.1	316.8	312.1	298.5	288.6	278.4	262.0
	MAX.W /FT	24.2	24.7	27.8	31.4	32.3	32.6	40.4	40.8	47.7	55.2	65.3	73.0	78.1	88.1	90.1	97.5	102.8	106.1	115.4
	MIN.W /FT	22.3	22.7	25.3	28.4	29.3	29.6	35.7	36.4	41.7	47.8	57.1	65.8	73.5	82.4	84.3	91.1	96.1	100.1	107.6
550	PIPE TEMP	510.3	509.3	503.0	496.0	491.6	490.0	476.8	474.0	460.4	443.0	414.9	389.7	367.4	343.5	338.5	323.4	312.3	301.0	283.5
	MAX.W /FT	28.0	28.5	32.0	36.2	37.1	37.3	46.2	46.6	54.5	63.0	74.1	82.7	88.5	99.5	101.6	109.6	115.8	120.5	129.7
	MIN.W /FT	25.7	26.1	29.0	32.5	33.5	33.8	40.7	41.4	47.5	54.3	64.7	74.4	83.0	93.0	95.0	102.5	108.1	112.5	121.1
600	PIPE TEMP	556.9	555.8	548.4	538.9	534.1	532.4	515.2	514.5	497.3	480.0	448.8	420.9	396.2	369.9	364.5	347.8	335.7	323.6	303.6
	MAX.W /FT	31.9	32.4	36.4	41.1	42.0	42.3	52.3	52.6	61.5	71.0	83.3	92.7	98.9	111.2	113.4	122.5	129.0	136.2	144.7
	MIN.W /FT	29.2	29.6	32.9	36.4	37.9	38.1	45.9	46.7	53.3	61.0	72.4	83.2	92.7	103.7	105.9	114.1	120.3	125.1	134.5
650	PIPE TEMP	599.3	598.2	590.4	581.7	576.4	574.5	555.5	554.8	538.1	516.7	482.5	451.8	424.8	395.9	390.2	372.0	358.8	345.4	324.0
	MAX.W /FT	36.0	36.5	41.0	46.2	47.1	47.4	58.6	58.8	68.7	79.2	92.6	102.9	109.6	123.1	125.3	135.3	142.3	148.1	159.0
	MIN.W /FT	32.8	33.3	36.9	41.2	42.4	42.6	51.2	52.0	59.3	67.8	80.3	92.2	102.6	114.6	116.9	126.0	132.6	137.9	148.1
700	PIPE TEMP	643.6	642.4	633.8	624.2	618.5	616.5	595.6	594.9	576.6	553.2									



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
PAGE 393
MAY, 1968

INSULATION THICKNESS REQUIREMENTS

Service Designation T-54

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

2" NOMINAL INSULATION THICKNESS		PIPE SIZE																AMBIENT AIR TEMP 60.0 F (15.6 C)			
CABLE TEMP DEG F		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	
60	PIPE TEMP	79.0	78.9	78.9	78.6	78.4	78.4	78.0	77.9	77.5	77.0	76.0	75.2	74.3	73.6	73.2	72.7	72.2	71.8	71.0	
	PARALLEL FET	0.7	0.7	0.7	0.9	0.9	1.0	1.2	1.2	1.4	1.7	2.0	2.3	2.6	3.0	3.1	3.4	3.6	3.8	4.2	
	PERIN FET	0.7	0.7	0.7	0.8	0.9	0.9	1.1	1.2	1.3	1.5	1.9	2.2	2.5	2.9	3.0	3.3	3.5	3.7	4.0	
100	PIPE TEMP	97.9	97.8	97.7	97.2	96.8	96.7	95.9	95.7	94.9	93.8	91.9	90.3	88.6	87.0	86.4	85.3	84.4	83.4	81.9	
	PARALLEL FET	1.4	1.5	1.5	1.8	1.9	2.0	2.4	2.5	2.9	3.4	4.1	4.6	5.3	6.0	6.3	6.9	7.3	7.7	8.5	
	PERIN FET	1.3	1.4	1.4	1.7	1.8	1.9	2.2	2.3	2.7	3.1	3.9	4.5	5.1	5.8	6.0	6.6	7.0	7.4	8.1	
120	PIPE TEMP	116.9	116.7	116.4	115.7	115.2	114.9	113.7	113.4	112.2	110.6	107.7	105.3	102.8	100.3	99.5	97.8	96.4	94.0	92.7	
	PARALLEL FET	2.2	2.3	2.3	2.7	2.9	3.0	3.6	3.8	4.4	5.1	6.1	7.0	8.1	9.1	9.5	10.4	11.1	11.7	12.8	
	PERIN FET	2.1	2.2	2.2	2.6	2.8	2.9	3.4	3.6	4.1	4.7	5.9	6.8	7.8	8.8	9.1	9.9	10.6	11.2	12.2	
140	PIPE TEMP	135.7	135.5	135.1	134.2	133.4	133.1	131.5	131.1	129.5	127.3	123.4	120.2	116.8	113.5	112.4	110.2	108.4	106.5	103.4	
	PARALLEL FET	3.0	3.1	3.1	3.7	4.0	4.1	4.9	5.2	6.0	7.0	8.5	9.5	10.9	12.3	12.8	13.9	14.9	15.7	17.2	
	PERIN FET	2.8	2.9	3.0	3.5	3.8	3.9	4.6	4.8	5.5	6.4	7.9	9.1	10.4	11.8	12.2	13.3	14.2	15.0	16.4	
160	PIPE TEMP	154.5	154.2	153.8	152.6	151.6	151.2	149.2	148.7	146.7	143.9	139.0	135.0	130.8	126.7	125.3	122.5	120.2	117.8	114.0	
	PARALLEL FET	3.8	4.0	4.0	4.7	5.1	5.2	6.3	6.5	7.6	8.8	10.7	12.0	13.7	15.5	16.1	17.5	18.7	19.7	21.6	
	PERIN FET	3.6	3.7	3.8	4.5	4.8	4.9	5.8	6.1	7.0	8.1	10.0	11.5	13.2	14.8	15.4	16.8	17.9	18.8	20.4	
180	PIPE TEMP	173.3	172.9	172.5	170.9	169.8	169.3	166.8	166.3	163.8	160.5	154.5	149.7	144.6	139.7	138.1	134.7	132.0	129.1	124.5	
	PARALLEL FET	4.6	4.8	4.9	5.8	6.2	6.4	7.7	8.0	9.2	10.7	13.1	14.5	16.4	18.4	19.5	21.2	22.6	23.8	26.0	
	PERIN FET	4.4	4.6	4.6	5.5	5.8	6.0	7.1	7.4	8.5	9.8	12.1	13.9	15.9	18.0	18.6	20.3	21.6	22.7	24.9	
200	PIPE TEMP	192.0	191.6	191.2	189.2	187.9	187.4	184.6	183.8	180.9	177.0	170.0	164.4	158.4	152.6	150.8	146.8	143.7	140.4	135.0	
	PARALLEL FET	5.5	5.8	5.8	6.9	7.4	7.5	9.1	9.4	10.9	12.7	15.4	17.1	19.5	22.2	22.9	24.9	26.5	27.9	30.5	
	PERIN FET	5.2	5.4	5.5	6.5	6.9	7.1	8.4	8.8	10.0	11.6	14.3	16.4	18.7	21.1	21.9	23.8	25.3	26.6	29.1	
220	PIPE TEMP	210.8	210.2	209.6	207.5	205.9	205.4	201.9	201.2	197.9	193.4	185.4	178.9	172.1	165.4	163.4	158.8	155.2	151.5	145.4	
	PARALLEL FET	6.5	6.7	6.7	8.0	8.4	8.4	8.7	10.5	10.9	12.8	14.7	17.4	19.7	22.5	23.6	25.5	26.5	28.1	31.1	
	PERIN FET	6.1	6.3	6.4	7.5	8.0	8.2	9.7	10.2	11.6	13.4	16.5	18.9	21.6	24.3	25.2	27.4	29.1	30.6	33.5	
240	PIPE TEMP	229.2	228.8	228.1	225.7	223.9	223.3	219.3	218.6	214.9	209.7	200.7	193.4	185.7	178.2	175.9	170.8	166.8	162.5	155.7	
	PARALLEL FET	7.4	7.7	7.7	9.2	9.8	10.0	12.0	12.5	14.4	16.7	20.2	22.3	25.5	28.8	29.8	32.5	34.4	36.3	39.7	
	PERIN FET	7.0	7.2	7.3	8.6	9.2	9.4	11.1	11.6	13.2	15.3	18.7	21.5	24.5	28.6	29.5	31.0	33.0	34.6	37.8	
260	PIPE TEMP	247.6	247.3	246.6	243.8	241.9	241.2	236.7	235.9	231.7	225.9	215.9	207.8	199.3	190.8	188.3	182.7	178.2	173.5	165.9	
	PARALLEL FET	8.4	8.7	8.7	10.4	11.1	11.3	13.6	14.1	16.2	19.8	22.7	25.0	28.4	32.3	33.4	36.4	38.6	40.7	44.3	
	PERIN FET	7.9	8.2	8.2	9.7	10.4	10.5	12.5	13.1	14.9	17.2	21.0	24.0	27.4	30.8	31.9	34.6	36.8	38.7	42.7	
280	PIPE TEMP	266.3	265.8	265.2	261.9	259.8	259.0	254.0	253.2	248.6	242.1	231.1	222.1	212.7	203.4	200.7	194.4	189.5	184.4	176.1	
	PARALLEL FET	9.4	9.7	9.7	11.6	12.4	12.6	15.2	15.7	18.1	20.9	25.2	27.8	31.7	35.7	37.0	40.2	42.7	45.9	49.0	
	PERIN FET	8.9	9.1	9.2	10.8	11.6	11.8	14.0	14.5	16.5	19.1	23.3	26.7	30.4	34.2	35.3	38.3	40.7	42.8	46.6	
300	PIPE TEMP	284.8	284.2	283.4	280.0	277.6	276.8	271.3	270.4	265.3	258.3	246.1	236.3	226.1	215.9	213.0	206.2	200.8	195.2	186.1	
	PARALLEL FET	10.5	10.8	10.8	12.9	13.7	13.9	16.8	17.3	20.0	23.1	27.8	30.6	34.8	39.3	40.6	44.1	46.9	49.2	53.7	
	PERIN FET	9.8	10.1	10.2	12.0	12.8	13.0	15.4	16.1	18.2	21.0	25.6	29.3	33.4	37.3	38.7	42.1	44.7	46.9	51.1	
350	PIPE TEMP	336.8	336.2	335.2	324.9	322.0	321.1	314.3	313.2	307.0	298.3	283.5	271.4	259.2	246.7	243.4	235.1	228.7	222.0	211.1	
	PARALLEL FET	13.2	13.6	13.6	16.2	17.1	17.4	21.0	21.6	24.9	28.7	34.4	37.7	42.9	48.4	49.8	54.0	57.5	60.3	65.6	
	PERIN FET	12.4	12.7	12.7	15.0	16.0	16.2	19.2	20.0	22.6	26.1	31.6	36.1	41.0	46.1	47.5	51.9	54.7	57.5	62.4	
400	PIPE TEMP	376.6	375.8	374.7	364.5	361.2	360.1	354.9	353.7	348.3	338.0	320.5	306.5	291.8	277.1	273.3	263.6	256.1	248.3	235.4	
	PARALLEL FET	16.2	16.6	16.6	19.6	20.6	21.0	25.4	26.0	30.0	34.6	41.3	45.1	51.2	57.1	58.4	64.4	68.1	71.5	77.8	
	PERIN FET	15.1	15.4	15.5	18.2	19.3	19.6	23.2	24.0	27.2	31.3	37.8	43.1	48.9	54.9	56.5	61.2	64.9	68.0	73.9	
450	PIPE TEMP	422.1	421.3	420.1	413.9	410.0	408.8	399.2	397.9	389.3	377.3	357.1	340.9	324.0	307.1	302.9	291.7	283.1	274.2	259.7	
	PARALLEL FET	19.3	19.7	19.5	23.3	24.6	24.9	30.0	30.8	35.3	40.7	48.4	52.6	59.7	67.2	69.0	74.8	79.3	83.0	90.7	
	PERIN FET	18.0	18.3	18.3	21.6	22.9	23.1	27.3	28.3	32.0	36.7	44.6	50.3	56.9	63.6	65.6	71.1	75.3	78.8	85.6	
500	PIPE TEMP	487.4	486.5	485.2	478.1	473.7	472.3	461.2	459.9	450.0	436.3	416.3	393.4	375.0	355.9	350.7	336.7	325.0	314.4	294.7	
	PARALLEL FET	21.9	22.0	21.9	25.7	27.2	27.4	32.8	33.6	39.4	45.8	55.7	60.4	68.4	78.9	81.5	87.4	91.9	95.4	102.7	
	PERIN FET	21.0	21.4	21.3	25.1	26.5	26.7	31.6	32.7	36.7	42.3	50.8	57.7	65.2	73.1	75.0	81.1	85.9	89.9	97.5	
550	PIPE TEMP	512.5	511.4	510.2	502.0	497.1	495.6	483.0	481.5	470.4	455.0	429.3	408.7	387.3	365.8	360.8	346.7	334.0	324.3	302.1	
	PARALLEL FET	26.0	26.5	26.1	31.2	32.8	33.0	39.8	40.7	46.6	53.5	63.2	68.4	77.3	88.9	91.0	96.8	102.0	106.6	115.5	
	PERIN FET	24.1	24.5	24.4	28.7	30.3	30.5	36.0	37.2	41.9	48.0	57.6	65.3	73.6	82.4	84.5	91.4	96.7	101.1	109.5	
600	PIPE TEMP	557.4	556.5	555.5	545.8	540.2	538.7	524.6	523.0	510.6	493.5	464.9	442.0	418.5	394.7	389.2	373.3	362.0	350.8	320.1	
	PARALLEL FET	29.7	30.1	29.6	35.1	37.1	37.3	44.9	45.9	52.5	60.2	70.9	76.4	86.4	97.0	99.3	105.5	111.7	117.4	128.4	
	PERIN FET	27.4	27.8	27.6	32.4	34.2	34.4	40.6	41.6	47.1	53.9	64.5	71.0	82.2	92.0	94.2	100.4	107.7	112.4	121.7	
650	PIPE TEMP	602.2	601.2	600.5	589.4	583.3	581.6	566.0	564.2	550.5	531.7	500.3	475.0	449.3	423.2	417.4	400.4	387.6	374.3	352.3	
	PARALLEL FET	33.4	33.9	33.7	39.6	41.6	41.8	50.2	51.3	58.6	67.1	78.8	85.0	95.7	107.4	109.8	116.8	123.5	131.0	141.6	
	PERIN FET	30.8	31.2	31.0	36.3	38.2	38.4	45.3	46.7	52.5	59.4	71.5	80.9	91.0</							



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
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INSULATION THICKNESS REQUIREMENTS

Service Designation T-55

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

2-1/2" NOMINAL INSULATION THICKNESS		PIPE SIZE																AMBIENT AIR TEMP 600 F (156 C)			
CABLE TEMP DEG F		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	
80	PIPE TEMP	79.1	79.0	78.9	78.7	78.5	78.3	78.1	78.0	77.7	77.2	76.3	75.6	74.9	74.2	73.9	73.4	72.9	72.5	71.7	
	MAX W / FT	0.6	0.7	0.7	0.8	0.9	0.9	1.0	1.1	1.3	1.5	1.8	2.1	2.4	2.7	2.8	3.1	3.3	3.5	3.6	
	MIN W / FT	0.6	0.6	0.7	0.8	0.8	0.9	1.0	1.1	1.2	1.4	1.7	2.0	2.3	2.6	2.7	3.0	3.2	3.3	3.7	
100	PIPE TEMP	98.1	98.0	97.8	97.4	97.0	96.9	96.2	96.0	95.3	94.4	92.6	91.2	89.7	88.2	87.7	86.6	85.8	84.9	83.4	
	MAX W / FT	1.3	1.4	1.4	1.6	1.8	1.8	2.2	2.3	2.6	3.0	3.7	4.2	4.8	5.4	5.7	6.2	6.6	7.0	7.7	
	MIN W / FT	1.2	1.3	1.4	1.6	1.7	1.7	2.0	2.2	2.5	2.8	3.5	4.1	4.6	5.2	5.5	6.0	6.4	6.7	7.4	
120	PIPE TEMP	117.1	116.9	116.6	116.0	115.5	115.3	114.2	113.9	112.9	111.5	108.7	106.6	104.4	102.2	101.4	99.8	98.5	97.2	94.7	
	MAX W / FT	2.0	2.1	2.1	2.5	2.7	2.8	3.3	3.5	4.0	4.5	5.6	6.3	7.3	8.2	8.5	9.3	9.6	10.5	11.6	
	MIN W / FT	1.9	2.0	2.1	2.4	2.6	2.7	3.1	3.3	3.7	4.3	5.3	6.1	7.0	7.9	8.3	9.0	9.6	10.2	11.2	
140	PIPE TEMP	136.0	135.8	135.4	134.6	133.9	133.6	132.1	131.8	130.4	128.5	124.8	122.0	119.0	116.0	115.0	112.9	111.2	109.4	106.4	
	MAX W / FT	2.7	2.8	2.9	3.4	3.7	3.8	4.5	4.7	5.4	6.1	7.4	8.5	9.8	11.0	11.5	12.5	13.4	14.1	15.6	
	MIN W / FT	2.6	2.7	2.8	3.2	3.5	3.6	4.2	4.4	5.0	5.8	7.2	8.3	9.4	10.6	11.1	12.1	12.9	13.6	15.0	
160	PIPE TEMP	154.9	154.6	154.2	153.1	152.2	151.8	150.0	149.6	147.8	145.5	140.8	137.3	133.5	129.8	128.5	125.9	123.8	121.5	117.8	
	MAX W / FT	3.5	3.6	3.7	4.3	4.7	4.8	5.7	6.0	6.8	7.7	9.6	10.7	12.3	13.9	14.4	15.8	16.8	17.8	19.6	
	MIN W / FT	3.3	3.4	3.6	4.1	4.5	4.6	5.3	5.6	6.4	7.3	9.1	10.4	11.9	13.4	13.9	15.2	16.2	17.1	18.8	
180	PIPE TEMP	173.7	173.4	172.9	171.6	170.5	170.1	167.9	167.3	165.2	162.4	156.8	152.5	148.0	143.5	142.0	138.8	136.3	133.6	129.1	
	MAX W / FT	4.2	4.4	4.5	5.3	5.7	5.8	6.9	7.2	8.3	9.4	11.6	13.0	14.9	16.8	17.5	19.0	20.3	21.5	23.6	
	MIN W / FT	4.0	4.2	4.3	5.0	5.4	5.5	6.5	6.9	7.7	8.8	11.0	12.6	14.4	16.2	16.9	18.4	19.6	20.7	22.7	
200	PIPE TEMP	192.6	192.2	191.6	190.0	188.7	188.2	185.4	185.0	182.5	179.2	172.6	167.7	162.3	157.1	155.3	151.7	148.7	145.6	140.4	
	MAX W / FT	5.0	5.2	5.4	6.3	6.8	6.9	8.2	8.6	9.6	11.1	13.7	15.3	17.5	19.8	20.5	22.4	23.9	25.2	27.7	
	MIN W / FT	4.8	5.0	5.1	6.0	6.4	6.6	7.7	8.1	9.1	10.4	13.0	14.8	16.9	19.1	19.8	21.5	23.0	24.2	26.6	
220	PIPE TEMP	211.3	210.9	210.3	208.4	206.9	206.4	203.4	202.7	199.8	196.0	188.4	182.8	176.6	170.6	168.6	164.5	161.1	157.5	151.5	
	MAX W / FT	5.9	6.1	6.2	7.3	7.9	8.0	9.5	9.9	11.3	12.9	15.8	17.7	20.2	22.8	23.6	25.7	27.5	28.9	31.8	
	MIN W / FT	5.6	5.8	6.0	6.9	7.5	7.6	8.9	9.4	10.6	12.1	15.0	17.1	19.5	22.0	22.8	24.8	26.4	27.9	30.6	
240	PIPE TEMP	230.1	229.6	228.9	226.7	225.1	224.5	221.0	220.3	217.0	212.7	204.2	197.8	190.8	184.0	181.9	177.1	173.3	169.3	162.6	
	MAX W / FT	6.7	6.9	7.1	8.4	9.0	9.1	10.8	11.3	12.9	14.6	17.9	20.0	22.9	25.6	26.7	29.1	31.1	32.7	35.9	
	MIN W / FT	6.4	6.6	6.8	7.9	8.5	8.6	10.2	10.7	12.2	13.7	17.0	19.4	22.1	24.9	25.8	28.0	29.9	31.5	34.6	
260	PIPE TEMP	248.7	248.3	247.4	245.0	243.2	242.5	238.7	237.8	234.2	229.4	219.8	212.7	205.0	197.4	195.0	189.7	185.5	181.0	173.7	
	MAX W / FT	7.6	7.8	8.0	9.4	10.1	10.3	12.2	12.7	14.5	16.4	20.1	22.5	25.6	28.9	29.9	32.6	34.7	36.6	40.1	
	MIN W / FT	7.3	7.5	7.7	8.9	9.6	9.8	11.4	12.0	13.5	15.4	19.0	21.7	24.7	27.8	28.8	31.4	33.4	35.2	38.6	
280	PIPE TEMP	267.4	266.9	266.0	263.5	261.2	260.5	256.2	255.3	251.3	245.9	235.4	227.6	219.1	210.6	208.1	202.3	197.6	192.7	184.6	
	MAX W / FT	8.5	8.8	9.0	10.5	11.3	11.5	13.6	14.2	16.3	18.3	22.3	24.9	28.4	32.0	33.1	36.1	38.4	40.5	44.4	
	MIN W / FT	8.1	8.3	8.4	10.0	10.7	10.9	12.7	13.4	15.0	17.1	21.1	24.1	27.4	30.8	31.9	34.7	37.0	38.9	42.6	
300	PIPE TEMP	286.0	285.5	284.5	281.5	279.2	278.5	273.7	272.7	268.4	262.5	251.0	242.6	233.1	223.6	221.1	214.7	209.7	204.3	195.5	
	MAX W / FT	9.5	9.7	9.9	11.7	12.5	12.7	15.0	15.7	17.8	20.2	24.9	27.6	31.2	35.2	36.4	39.6	42.2	44.6	48.6	
	MIN W / FT	9.0	9.2	9.5	11.0	11.8	12.0	14.1	14.8	16.6	18.9	23.3	26.5	30.1	33.9	35.0	38.1	40.6	42.7	46.7	
350	PIPE TEMP	332.4	331.8	330.6	326.8	324.1	323.2	317.3	316.1	310.8	303.6	289.5	279.1	267.7	256.5	253.3	245.6	239.5	233.0	222.4	
	MAX W / FT	11.9	12.2	12.4	14.6	15.4	15.6	18.8	19.5	22.1	25.0	30.4	33.8	38.4	43.3	44.6	48.6	51.7	54.3	59.5	
	MIN W / FT	11.3	11.6	11.8	13.8	14.6	14.8	17.5	18.3	20.6	23.6	28.7	32.6	37.0	41.6	42.9	46.7	49.7	52.2	57.1	
400	PIPE TEMP	378.5	377.9	376.4	371.4	368.6	367.7	360.6	359.3	352.9	344.3	327.7	315.4	302.0	288.7	285.1	276.0	268.9	261.3	249.0	
	MAX W / FT	14.4	14.9	15.1	17.8	18.9	19.1	22.7	23.5	26.6	30.1	36.4	40.3	45.8	51.6	53.1	57.7	61.4	64.5	70.3	
	MIN W / FT	13.6	14.1	14.4	16.7	17.9	18.0	21.1	22.1	24.7	28.0	34.3	38.9	44.1	49.6	51.1	55.4	58.9	61.9	67.6	
450	PIPE TEMP	426.4	425.7	424.1	418.0	415.0	414.9	405.4	402.1	394.7	384.8	365.5	351.3	335.9	320.6	316.5	308.1	297.9	289.3	275.1	
	MAX W / FT	17.3	17.7	17.9	21.1	22.4	22.6	26.7	27.7	31.3	35.3	42.6	47.1	53.4	60.1	61.4	66.4	71.3	74.9	81.7	
	MIN W / FT	16.4	16.7	17.0	19.8	21.1	21.3	24.9	25.9	29.0	32.8	40.2	45.6	51.6	57.7	59.4	64.6	68.4	71.8	78.3	
500	PIPE TEMP	476.2	475.4	474.6	468.4	465.1	465.9	454.4	450.7	443.6	433.0	408.8	394.4	378.5	362.0	357.5	347.5	338.4	329.5	314.6	
	MAX W / FT	20.3	20.7	20.9	24.5	25.8	26.0	30.2	31.0	34.2	38.2	46.1	51.1	58.2	65.0	67.0	72.7	77.5	81.5	88.6	
	MIN W / FT	19.1	19.4	19.7	23.0	24.3	24.5	28.4	29.3	32.5	36.5	44.1	50.1	57.1	64.0	67.0	73.5	78.1	81.9	89.2	
550	PIPE TEMP	515.7	514.9	513.9	507.9	504.0	504.7	489.7	485.9	477.6	466.7	440.1	422.0	402.6	383.1	378.2	365.0	354.8	344.3	326.4	
	MAX W / FT	21.3	21.7	21.9	25.8	27.1	27.3	31.4	32.4	35.4	39.4	48.4	53.7	61.2	69.2	71.7	78.5	83.5	87.2	94.8	
	MIN W / FT	20.0	20.3	20.6	24.3	25.6	25.8	29.7	30.7	33.7	37.7	46.7	52.3	59.9	67.9	70.4	77.5	82.8	87.9	94.2	
600	PIPE TEMP	561.1	560.2	559.0	552.2	548.7	549.3	531.2	529.2	518.4	504.4	477.0	458.9	435.4	413.8	408.5	394.0	382.7	370.9	351.6	
	MAX W / FT	24.5	24.9	25.1	29.1	30.4	30.6	34.6	35.6	38.6	42.6	52.6	58.6	67.6	77.6	80.0	86.4	91.4	95.4	102.4	
	MIN W / FT	23.9	24.2	24.5	28.7	30.0	30.3	34.0	35.0	38.0	42.0	52.0	58.0	67.0	77.0	80.1	86.5	91.5	95.5	102.5	
650	PIPE TEMP	604.3	603.4	602.3	595.3	591.3	592.4	573.3	571.2	559.5	543.7	513.6	491.5	468.0	444.3	438.5	422.7	410.4	397.5	376.5	
	MAX W / FT	29.4	30.2	30.4	34.4	35.7	35.9	40.7	41.7	44.7	48.7	58.7	64.7	74.7	84.7	87.0	94.4	99.4	103.4	110.4	
	MIN W / FT	28.0	28.3	28.6	32.6	33.9	34.2	38.9	39.9	42.9	46.9	56.9	62.9	72.9	82.9	86.1	93.5	98.			



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CHEMICALS AND PLASTICS OPERATIONS DIVISION
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SECTION III
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INSULATION THICKNESS REQUIREMENTS

Service Designation T-56

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT
PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

3" NOMINAL INSULATION THICKNESS			PIPE SIZE																AMBIENT AIR TEMP 600 F (36 C)			
CABLE TEMP DEG F			3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	
80	PIPE TEMP	79.1	79.1	79.0	78.8	78.6	78.5	78.2	78.2	77.9	77.4	76.4	76.0	75.3	74.4	74.4	73.9	73.5	73.1	72.3		
	PAR.W /FT	0.4	0.4	0.7	0.8	0.8	0.8	1.0	1.0	1.2	1.3	1.6	1.9	2.2	2.4	2.6	2.8	3.0	3.2	3.5		
	PIA.W /FT	0.8	0.8	0.8	0.7	0.8	0.8	0.9	1.0	1.1	1.3	1.6	1.8	2.1	2.4	2.6	2.8	3.0	3.2	3.4		
100	PIPE TEMP	98.2	98.1	97.9	97.5	97.2	97.1	96.4	96.3	95.7	94.8	93.2	91.9	90.5	89.2	88.7	87.7	86.9	86.0	84.6		
	PAR.W /FT	1.2	1.3	1.3	1.5	1.7	1.7	2.0	2.1	2.4	2.7	3.3	3.8	4.4	4.9	5.2	5.6	6.0	6.4	7.1		
	PIA.W /FT	1.2	1.2	1.3	1.5	1.6	1.6	1.9	2.0	2.3	2.6	3.2	3.7	4.3	4.8	5.0	5.5	5.9	6.2	6.8		
120	PIPE TEMP	117.2	117.1	116.8	116.2	115.7	115.5	114.6	114.5	113.4	112.1	109.7	107.7	105.6	103.6	102.9	101.4	100.2	98.9	96.8		
	PAR.W /FT	1.9	1.9	2.0	2.3	2.5	2.5	3.0	3.2	3.6	4.1	5.0	5.8	6.6	7.5	7.8	8.5	9.1	9.6	10.7		
	PIA.W /FT	1.8	1.9	2.0	2.2	2.4	2.5	2.9	3.1	3.4	4.0	4.9	5.6	6.4	7.3	7.6	8.2	8.8	9.3	10.3		
140	PIPE TEMP	136.2	136.0	135.7	134.9	134.2	133.9	132.7	132.4	131.1	129.3	126.1	123.5	120.7	118.0	117.0	115.1	113.5	111.8	108.9		
	PAR.W /FT	2.5	2.6	2.7	3.2	3.4	3.5	4.1	4.3	4.8	5.6	6.7	7.8	8.9	10.0	10.5	11.4	12.2	12.9	14.3		
	PIA.W /FT	2.4	2.5	2.6	3.0	3.3	3.4	3.9	4.1	4.6	5.3	6.6	7.6	8.7	9.7	10.2	11.1	11.8	12.5	13.8		
160	PIPE TEMP	155.2	154.9	154.5	153.5	152.6	152.3	150.7	150.3	148.8	146.5	142.5	139.1	135.7	132.3	131.1	128.7	126.7	124.5	121.0		
	PAR.W /FT	3.2	3.4	3.5	4.0	4.4	4.5	5.2	5.4	6.1	7.1	8.5	9.8	11.2	12.7	13.2	14.4	15.4	16.4	17.9		
	PIA.W /FT	3.1	3.2	3.4	3.9	4.2	4.3	5.0	5.2	5.9	6.8	8.3	9.6	10.9	12.3	12.8	13.9	14.9	15.7	17.4		
180	PIPE TEMP	174.1	173.8	173.3	172.1	171.0	170.6	168.7	168.2	166.4	163.7	158.8	154.8	150.6	146.5	145.1	142.2	139.8	137.2	132.9		
	PAR.W /FT	4.0	4.1	4.2	4.9	5.3	5.4	6.4	6.6	7.5	8.6	10.3	11.9	13.6	15.3	15.9	17.4	18.6	19.6	21.7		
	PIA.W /FT	3.8	3.9	4.1	4.7	5.1	5.2	6.1	6.4	7.1	8.2	10.0	11.6	13.2	14.9	15.4	16.8	18.0	19.0	21.0		
200	PIPE TEMP	193.0	192.6	192.0	190.6	189.4	188.9	186.6	186.1	183.9	180.7	175.0	170.3	165.4	160.6	159.0	155.6	152.8	149.8	144.8		
	PAR.W /FT	4.7	4.9	5.0	5.8	6.3	6.4	7.5	7.8	8.8	10.1	12.1	14.0	16.0	18.0	18.7	20.4	21.8	23.0	25.4		
	PIA.W /FT	4.5	4.7	4.8	5.6	6.1	6.2	7.2	7.5	8.4	9.7	11.8	13.6	15.5	17.5	18.1	19.8	21.1	22.3	24.6		
220	PIPE TEMP	211.8	211.5	210.8	209.1	207.7	207.2	204.5	203.9	201.4	197.7	191.2	185.8	180.2	174.6	172.8	168.9	165.7	162.3	156.6		
	PAR.W /FT	5.5	5.6	5.8	6.8	7.3	7.4	8.7	9.1	10.2	11.7	14.0	16.1	18.4	20.7	21.5	23.4	25.1	26.5	29.2		
	PIA.W /FT	5.3	5.4	5.6	6.5	7.0	7.1	8.3	8.7	9.7	11.2	13.6	15.7	17.9	20.1	20.9	22.7	24.3	25.6	28.7		
240	PIPE TEMP	230.6	230.2	229.4	227.5	225.9	225.4	222.3	221.7	218.9	214.7	207.3	201.2	194.9	188.6	186.6	182.2	178.6	174.8	168.4		
	PAR.W /FT	6.3	6.5	6.7	7.8	8.3	8.5	9.9	10.3	11.6	13.3	15.9	18.3	20.8	23.4	24.4	26.5	28.4	29.9	33.0		
	PIA.W /FT	6.0	6.2	6.4	7.4	8.0	8.1	9.4	9.9	11.0	12.7	15.5	17.8	20.2	22.8	23.6	25.7	27.5	29.0	31.9		
260	PIPE TEMP	249.4	249.0	248.1	245.9	244.1	243.6	240.1	239.4	236.3	231.6	223.4	216.6	209.5	202.5	200.3	195.4	191.4	187.1	180.1		
	PAR.W /FT	7.1	7.3	7.5	8.7	9.4	9.6	11.2	11.6	13.0	15.0	17.8	20.5	23.3	26.3	27.2	29.7	31.7	33.5	36.8		
	PIA.W /FT	6.8	7.0	7.2	8.4	9.0	9.2	10.6	11.1	12.4	14.2	17.3	19.9	22.7	25.5	26.6	28.6	30.7	32.4	35.6		
280	PIPE TEMP	268.1	267.7	266.7	264.3	262.3	261.7	257.9	257.1	253.7	248.5	239.1	231.9	224.1	216.4	214.0	208.6	204.2	199.5	191.7		
	PAR.W /FT	7.9	8.1	8.4	9.8	10.5	10.7	12.5	12.9	14.5	16.6	19.8	22.7	25.9	29.1	30.2	32.9	35.1	37.0	40.7		
	PIA.W /FT	7.6	7.8	8.1	9.3	10.1	10.2	11.8	12.4	13.8	15.8	19.2	22.1	25.1	28.2	29.2	31.8	34.0	35.8	39.4		
300	PIPE TEMP	286.8	286.3	285.3	282.6	280.5	279.8	275.6	274.8	271.0	265.3	255.3	247.1	238.4	230.1	227.5	221.6	216.8	211.7	203.2		
	PAR.W /FT	8.8	9.0	9.3	10.8	11.6	11.8	13.6	14.3	16.0	18.3	21.8	25.0	28.4	32.0	33.1	36.1	38.5	40.6	44.6		
	PIA.W /FT	8.4	8.6	8.9	10.5	11.1	11.3	13.1	13.6	15.2	17.4	21.2	24.3	27.6	31.0	32.1	34.9	37.2	39.3	43.2		
350	PIPE TEMP	333.4	332.9	331.6	328.3	325.6	324.8	319.6	318.7	314.0	307.0	296.8	288.9	274.5	264.2	261.2	254.0	248.2	242.0	231.8		
	PAR.W /FT	11.1	11.3	11.6	13.5	14.5	14.7	17.1	17.7	19.9	22.7	26.9	30.8	35.0	39.3	40.6	44.2	47.2	49.7	54.6		
	PIA.W /FT	10.6	10.8	11.2	12.9	13.9	14.0	16.2	16.9	18.8	21.6	26.1	29.9	33.9	38.1	39.4	42.8	45.6	48.0	52.7		
400	PIPE TEMP	379.8	379.2	377.7	373.7	370.5	369.7	363.4	362.3	356.8	348.5	334.1	322.3	310.1	297.9	294.4	288.0	279.2	270.0	260.0		
	PAR.W /FT	13.5	13.8	14.1	16.4	17.5	17.7	20.7	21.4	23.9	27.3	32.1	36.7	41.7	46.9	48.6	52.6	56.1	59.0	64.7		
	PIA.W /FT	12.9	13.1	13.5	15.6	16.7	16.9	19.6	20.4	22.6	25.9	31.2	35.7	40.4	45.3	46.8	50.8	54.2	57.0	62.5		
450	PIPE TEMP	426.0	425.4	423.7	418.9	415.3	414.3	406.9	405.7	399.3	389.6	372.9	359.4	345.3	331.2	327.3	317.6	309.8	301.6	287.9		
	PAR.W /FT	16.0	16.2	16.7	19.4	20.7	20.9	24.0	24.2	28.1	32.0	37.6	42.9	48.4	54.6	56.3	61.1	65.1	68.5	75.0		
	PIA.W /FT	15.3	15.6	16.0	18.0	19.1	19.3	22.0	22.9	26.5	30.3	36.5	41.8	47.1	52.8	54.4	59.1	62.9	66.1	72.4		
500	PIPE TEMP	472.0	471.3	469.4	463.9	459.7	458.6	450.2	448.9	441.6	430.5	411.5	396.1	380.1	364.2	359.8	348.9	340.1	330.8	315.4		
	PAR.W /FT	18.7	19.0	19.4	22.6	24.1	24.2	28.3	28.3	32.4	36.9	43.2	49.3	55.7	62.4	64.9	69.9	74.4	78.2	85.5		
	PIA.W /FT	17.8	18.1	18.6	21.4	22.9	23.0	26.6	27.6	31.6	36.9	42.0	47.8	53.9	60.4	62.2	67.5	71.8	75.4	82.5		
550	PIPE TEMP	517.8	517.1	515.0	508.8	504.0	502.8	493.3	491.8	483.6	471.1	449.7	432.5	414.7	396.8	392.0	379.8	370.0	359.6	342.6		
	PAR.W /FT	21.5	21.9	22.3	25.8	27.5	27.7	32.3	32.3	36.9	42.0	49.0	55.8	63.0	70.6	72.6	78.8	83.8	88.0	96.2		
	PIA.W /FT	20.5	20.8	21.2	24.5	26.1	26.3	30.3	31.5	36.6	42.7	49.6	56.0	63.9	71.7	73.7	79.9	84.9	89.2	97.7		
600	PIPE TEMP	583.5	582.8	580.4	573.4	568.1	566.8	556.5	554.5	545.8	529.8	507.7	488.4	468.9	449.4	444.0	429.9	419.3	408.2	389.2		
	PAR.W /FT	24.5	24.8	25.2	29.3	31.1	31.2	36.4	37.4	42.6	49.2	57.0	64.4	72.4	80.4	82.4	89.1	94.1	98.1	107.1		
	PIA.W /FT	23.2	23.5	24.0	27.7	29.5	29.6	34.2	35.4	39.1	45.5	53.5	60.5	68.1	76.1	78.2	84.8	90.0	94.5	103.1		
650	PIPE TEMP	609.1	608.3	605.7	597.9	592.1	590.7	579.8	577.1	567.0	551.4	525.4	504.4	482.7	461.0	455.4	440.6	428.9	416.4	396.0		
	PAR.W /FT	27.5	27.8	28.3	32.8	34.8	34.9	40.7	41.7	46.3	52.6	61.1	69.3	78.0	87.7	89						



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
PAGE 396
MAY, 1968

INSULATION THICKNESS REQUIREMENTS

Service Designation T-57

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT
PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

3-1/2" NOMINAL INSULATION THICKNESS		PIPE SIZE																AMBIENT AIR TEMP 600 F (156 C)		
CABLE TEMP DEG F		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
80	PIPE TEMP	79.1	79.1	79.0	78.8	78.7	78.6	78.3	78.3	78.0	77.6	76.9	76.3	75.6	75.0	74.8	74.3	74.0	73.5	72.9
	MAX. W / FT	0.6	0.6	0.6	0.7	0.8	0.8	0.9	1.0	1.1	1.2	1.5	1.8	2.0	2.3	2.4	2.6	2.8	2.9	3.1
	MIN. W / FT	0.6	0.6	0.6	0.7	0.7	0.8	0.9	0.9	1.1	1.2	1.5	1.7	2.0	2.2	2.3	2.5	2.7	2.9	3.1
100	PIPE TEMP	98.3	98.2	98.0	97.6	97.3	97.2	96.7	96.5	95.9	95.1	93.7	92.4	91.2	89.9	89.5	88.6	87.8	87.0	85.6
	MAX. W / FT	1.2	1.2	1.3	1.4	1.6	1.6	1.8	2.0	2.2	2.5	3.1	3.5	4.0	4.6	4.8	5.2	5.6	5.9	6.5
	MIN. W / FT	1.1	1.2	1.2	1.4	1.5	1.6	1.8	1.9	2.1	2.4	3.0	3.5	4.0	4.4	4.6	5.1	5.4	5.8	6.4
120	PIPE TEMP	117.3	117.2	116.9	116.4	115.9	115.8	114.6	114.6	113.8	112.6	110.4	108.6	106.6	104.8	104.1	102.8	101.6	100.4	98.4
	MAX. W / FT	1.8	1.8	1.9	2.2	2.4	2.4	2.8	3.0	3.3	3.8	4.6	5.3	6.1	6.9	7.2	7.8	8.4	8.9	9.7
	MIN. W / FT	1.7	1.8	1.9	2.1	2.3	2.4	2.7	2.7	3.2	3.7	4.5	5.2	6.0	6.7	7.0	7.6	8.2	8.7	9.6
140	PIPE TEMP	136.4	136.2	135.8	135.1	134.5	134.3	133.1	132.8	131.7	130.0	127.1	124.6	122.1	119.6	118.7	116.9	115.4	113.7	111.0
	MAX. W / FT	2.4	2.5	2.6	3.0	3.2	3.3	3.8	4.0	4.5	5.2	6.2	7.2	8.2	9.3	9.7	10.5	11.3	11.9	13.2
	MIN. W / FT	2.3	2.4	2.5	2.9	3.1	3.2	3.7	3.9	4.4	5.0	6.1	7.0	8.0	9.0	9.4	10.3	11.0	11.6	12.9
160	PIPE TEMP	155.4	155.2	154.7	153.8	153.0	152.7	151.3	150.8	149.4	147.6	143.7	140.6	137.6	134.3	133.2	130.9	129.0	127.0	123.6
	MAX. W / FT	3.1	3.2	3.3	3.8	4.1	4.2	4.8	5.1	5.7	6.5	7.9	9.1	10.4	11.7	12.1	13.3	14.2	15.0	16.6
	MIN. W / FT	3.0	3.1	3.2	3.7	4.0	4.0	4.7	4.9	5.5	6.3	7.7	8.9	10.1	11.4	11.8	12.9	13.8	14.6	16.2
180	PIPE TEMP	174.3	174.1	173.6	172.4	171.5	171.2	169.4	168.9	167.2	164.7	160.3	156.5	152.7	148.9	147.6	144.9	142.6	140.2	136.1
	MAX. W / FT	3.7	3.9	4.0	4.6	5.0	5.1	5.9	6.2	6.9	7.9	9.5	11.0	12.5	14.1	14.7	16.0	17.1	17.9	20.1
	MIN. W / FT	3.6	3.7	3.9	4.5	4.8	4.9	5.7	6.0	6.7	7.7	9.3	10.7	12.2	13.8	14.3	15.6	16.7	17.7	19.5
200	PIPE TEMP	193.3	193.0	192.4	191.1	189.9	189.5	187.5	186.8	184.9	181.9	176.8	172.6	167.9	163.5	162.0	158.8	156.2	153.3	148.5
	MAX. W / FT	4.4	4.6	4.8	5.5	5.9	6.0	6.9	7.3	8.2	9.4	11.2	12.9	14.7	16.6	17.2	18.8	20.1	21.3	23.5
	MIN. W / FT	4.3	4.4	4.6	5.3	5.7	5.8	6.7	7.1	7.9	9.0	11.0	12.6	14.4	16.2	16.8	18.3	19.6	20.7	22.9
220	PIPE TEMP	212.2	211.9	211.2	209.6	208.3	207.9	205.5	204.8	202.4	199.1	193.2	188.2	183.1	178.0	176.3	172.6	169.6	166.3	160.9
	MAX. W / FT	5.2	5.3	5.5	6.4	6.8	6.9	8.0	8.5	9.5	10.8	12.9	14.9	17.0	19.1	19.8	21.6	23.1	24.5	27.0
	MIN. W / FT	5.0	5.1	5.4	6.2	6.6	6.7	7.7	8.2	9.1	10.4	12.7	14.5	16.6	18.6	19.3	21.0	22.5	23.8	26.1
240	PIPE TEMP	231.0	230.7	229.9	228.2	226.7	226.2	223.5	222.7	220.2	216.3	209.6	204.0	198.1	192.4	190.5	186.4	183.0	179.1	173.2
	MAX. W / FT	5.9	6.1	6.3	7.3	7.8	7.9	9.2	9.6	10.8	12.3	14.7	16.9	19.2	21.6	22.5	24.5	26.2	27.7	30.6
	MIN. W / FT	5.7	5.9	6.1	7.0	7.5	7.7	8.8	9.3	10.4	11.9	14.4	16.5	18.8	21.1	21.9	23.8	25.5	26.9	29.7
260	PIPE TEMP	249.9	249.5	248.6	246.6	245.0	244.4	240.5	239.7	233.4	225.9	219.7	213.2	206.7	200.1	198.3	192.2	187.9	183.2	176.5
	MAX. W / FT	6.7	6.9	7.1	8.2	8.8	8.9	10.3	10.8	12.1	13.8	16.5	18.9	21.5	24.2	25.1	27.4	29.3	30.9	34.1
	MIN. W / FT	6.5	6.6	6.9	7.9	8.5	8.6	9.9	10.5	11.8	13.3	16.1	18.5	21.0	23.6	24.5	26.8	28.5	30.1	33.7
280	PIPE TEMP	268.7	268.3	267.3	265.1	263.3	262.7	259.3	258.4	255.2	250.5	242.2	235.3	228.1	221.0	218.8	213.7	209.6	205.1	197.6
	MAX. W / FT	7.5	7.7	7.9	9.2	9.8	9.9	11.5	12.1	13.4	15.3	18.3	21.0	23.8	26.8	27.8	30.3	32.4	34.2	37.7
	MIN. W / FT	7.2	7.4	7.7	8.8	9.5	9.6	11.0	11.7	12.9	14.8	17.9	20.5	23.3	26.1	27.1	29.5	31.5	33.2	36.7
300	PIPE TEMP	287.4	287.0	286.0	283.5	281.6	280.9	277.2	276.1	272.7	267.5	258.5	250.9	243.0	235.2	232.8	227.3	222.8	217.9	209.7
	MAX. W / FT	8.3	8.5	8.8	10.1	10.8	11.0	12.7	13.3	14.8	16.9	20.1	23.1	26.2	29.5	30.5	33.2	35.2	37.5	41.4
	MIN. W / FT	8.0	8.2	8.5	9.6	10.5	10.6	12.2	12.9	14.2	16.3	19.6	22.5	25.5	28.7	29.7	32.3	34.5	36.5	40.2
350	PIPE TEMP	334.2	333.7	332.5	329.4	327.0	326.3	321.6	320.4	314.2	309.8	298.8	289.6	280.0	270.5	267.6	261.0	255.5	249.5	239.7
	MAX. W / FT	10.4	10.6	11.0	12.7	13.5	13.6	15.8	16.5	18.8	20.9	24.8	28.4	32.2	36.2	37.5	40.8	43.5	46.9	50.6
	MIN. W / FT	10.0	10.2	10.6	12.2	13.0	13.2	15.1	16.0	17.6	20.2	24.2	27.7	31.4	35.2	36.4	39.6	42.3	45.6	49.1
400	PIPE TEMP	380.8	380.3	378.8	375.1	372.3	371.4	365.9	364.6	359.5	351.8	338.8	327.9	318.6	305.6	302.1	294.2	286.9	280.9	269.4
	MAX. W / FT	12.7	12.9	13.3	15.3	16.3	16.5	19.0	19.9	22.1	25.1	29.7	33.9	38.4	43.2	44.6	48.5	51.7	54.5	60.0
	MIN. W / FT	12.2	12.4	12.8	14.7	15.7	15.9	18.2	19.2	21.2	24.2	29.0	33.1	37.4	41.9	43.3	47.1	50.2	52.9	58.2
450	PIPE TEMP	427.2	426.6	424.9	420.6	417.3	416.4	409.4	408.2	402.4	393.5	378.5	365.9	352.9	339.9	336.2	327.1	319.7	311.8	299.7
	MAX. W / FT	15.1	15.3	15.7	18.1	19.3	19.6	22.4	23.4	25.9	29.5	34.7	39.6	44.8	50.3	51.9	56.4	60.1	63.3	69.9
	MIN. W / FT	14.5	14.7	15.2	17.4	18.6	18.7	21.4	22.6	24.9	28.3	33.9	38.6	43.6	48.8	50.4	54.7	58.3	61.6	67.5
500	PIPE TEMP	473.4	472.8	470.9	465.9	462.1	461.1	453.6	451.7	445.2	435.0	417.8	403.6	388.8	374.1	369.9	359.7	351.3	342.4	327.6
	MAX. W / FT	17.6	17.8	18.3	21.1	22.3	22.5	25.9	27.1	29.9	34.0	39.9	45.4	51.3	57.6	59.3	64.4	68.7	72.3	79.1
	MIN. W / FT	16.9	17.1	17.6	20.2	21.5	21.6	24.8	26.1	28.7	32.8	38.9	44.3	49.9	55.9	57.6	62.5	66.6	70.1	76.2
550	PIPE TEMP	519.5	518.8	516.7	511.0	506.7	505.6	497.1	495.1	487.7	476.2	456.9	440.9	424.6	407.9	403.3	391.9	382.6	372.6	356.2
	MAX. W / FT	20.2	20.5	21.0	24.1	25.5	25.7	29.6	30.9	34.1	38.4	45.3	51.5	58.1	65.0	67.0	72.7	77.4	81.4	89.3
	MIN. W / FT	19.4	19.6	20.2	23.1	24.6	24.7	28.2	29.7	32.6	37.1	44.1	50.1	56.4	63.1	65.0	70.5	75.0	78.9	86.3
600	PIPE TEMP	565.4	564.7	562.3	556.0	551.2	550.0	540.5	538.2	530.0	517.1	495.7	478.0	459.7	441.4	436.4	423.8	413.5	402.6	384.5
	MAX. W / FT	22.9	23.2	23.7	27.3	28.9	29.0	33.3	34.8	38.4	43.4	50.8	57.6	64.9	72.6	74.8	81.1	86.3	90.7	98.2
	MIN. W / FT	22.0	22.2	22.8	26.1	27.7	27.8	31.8	33.4	36.7	41.6	49.4	56.1	63.1	70.5	72.5	78.6	83.8	87.9	96.2
650	PIPE TEMP	611.2	610.5	607.8	600.8	595.5	594.2	583.6	581.2	572.1	557.9	534.3	514.8	494.7	474.6	469.2	455.3	444.1	432.2	412.5
	MAX. W / FT	25.8	26.0	26.6	30.4	32.3	32.4	37.2	38.8	42.8	48.3	56.4	63.9	71.9	80.4	82.7	89.7	95.4	100.2	108.6
	MIN. W / FT	24.6	24.9	25.6	29.2	31.0	31.1	35.5	37.2	40.8	46.3	54.9	62.2	69.9	78.0	80.				



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
PAGE 397
MAY, 1968

INSULATION THICKNESS REQUIREMENTS

Service Designation T-58

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT
PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

4" NOMINAL INSULATION THICKNESS		PIPE SIZE																AMBIENT AIR TEMP 60.0 °F (15.6 °C)			
CABLE TEMP DEG F		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	
80	PIPE TEMP	79.2	79.1	79.0	78.9	78.7	78.6	78.4	78.3	78.1	77.7	77.0	76.5	75.9	75.3	75.1	74.7	74.3	74.0	73.1	
	PARALLEL / FT	0.5	0.6	0.6	0.7	0.8	0.8	0.9	0.9	1.0	1.2	1.4	1.6	1.9	2.1	2.2	2.4	2.6	2.7	3.0	
	PISTON / FT	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.1	1.4	1.6	1.8	2.1	2.2	2.4	2.5	2.7	3.1	
100	PIPE TEMP	98.3	98.2	98.1	97.7	97.3	97.2	96.8	96.6	96.1	95.4	94.0	92.9	91.7	90.6	90.2	89.3	88.6	87.8	86.5	
	PARALLEL / FT	1.1	1.1	1.2	1.4	1.6	1.6	1.7	1.9	2.1	2.3	2.9	3.3	3.8	4.4	4.6	4.8	5.2	5.5	6.1	
	PISTON / FT	1.1	1.1	1.2	1.3	1.5	1.6	1.7	1.8	2.0	2.3	2.8	3.2	3.7	4.2	4.3	4.7	5.1	5.4	6.0	
120	PIPE TEMP	117.4	117.3	117.1	116.6	115.9	115.8	114.9	114.9	114.1	113.0	111.0	109.3	107.5	105.8	105.1	103.9	102.8	101.7	99.7	
	PARALLEL / FT	1.7	1.8	1.8	2.1	2.4	2.4	2.7	2.8	3.1	3.5	4.3	5.0	5.7	6.4	6.7	7.1	7.8	8.3	9.2	
	PISTON / FT	1.6	1.7	1.8	2.0	2.3	2.4	2.6	2.8	3.1	3.5	4.3	4.9	5.6	6.3	6.6	7.1	7.7	8.1	9.0	
140	PIPE TEMP	136.5	136.3	136.0	135.4	134.5	134.3	133.1	132.1	130.6	127.9	125.6	123.2	120.9	120.1	118.4	117.0	115.4	115.4	112.9	
	PARALLEL / FT	2.3	2.4	2.5	2.8	3.2	3.3	3.6	3.8	4.2	4.8	5.8	6.7	7.7	8.6	9.0	9.8	10.5	11.1	12.4	
	PISTON / FT	2.2	2.3	2.4	2.8	3.1	3.2	3.5	3.7	4.1	4.7	5.7	6.6	7.5	8.4	8.8	9.6	10.3	10.9	12.4	
160	PIPE TEMP	155.6	155.3	154.9	154.1	153.0	152.7	151.7	151.2	150.0	148.1	144.7	141.8	138.8	136.0	134.9	132.8	131.0	129.1	125.8	
	PARALLEL / FT	2.9	3.0	3.1	3.6	4.1	4.2	4.6	4.8	5.4	6.0	7.4	8.5	9.7	10.9	11.3	12.3	13.2	14.0	15.5	
	PISTON / FT	2.8	2.9	3.1	3.5	4.0	4.0	4.4	4.7	5.2	5.9	7.2	8.3	9.5	10.6	11.1	12.1	12.9	13.7	15.2	
180	PIPE TEMP	174.6	174.3	173.8	172.8	171.5	171.2	169.9	169.4	167.9	165.6	161.5	158.0	154.4	150.9	149.7	147.2	145.0	142.7	138.8	
	PARALLEL / FT	3.6	3.7	3.8	4.4	5.0	5.1	5.5	5.9	6.5	7.3	8.9	10.2	11.7	13.1	13.7	14.8	16.0	16.9	18.9	
	PISTON / FT	3.5	3.6	3.7	4.3	4.8	4.9	5.4	5.7	6.3	7.2	8.7	10.0	11.4	12.8	13.4	14.6	15.6	16.8	18.3	
200	PIPE TEMP	193.5	193.3	192.7	191.5	189.9	189.5	188.1	187.5	185.7	183.1	178.2	174.2	170.0	165.9	164.4	161.5	159.0	156.3	151.7	
	PARALLEL / FT	4.2	4.4	4.5	5.2	5.9	6.0	6.5	6.9	7.7	8.6	10.5	12.1	13.7	15.4	16.0	17.5	18.7	19.8	22.0	
	PISTON / FT	4.1	4.2	4.4	5.0	5.7	5.8	6.4	6.7	7.5	8.5	10.3	11.8	13.4	15.1	15.7	17.1	18.3	19.4	21.4	
220	PIPE TEMP	212.5	212.2	211.5	210.1	208.3	207.9	206.2	205.5	203.5	200.5	196.9	190.2	185.4	180.7	179.1	175.7	172.9	169.7	164.5	
	PARALLEL / FT	4.9	5.1	5.2	6.0	6.8	6.9	7.6	8.0	8.9	9.9	12.1	13.9	15.8	17.8	18.5	20.1	21.5	22.8	25.7	
	PISTON / FT	4.8	4.9	5.1	5.8	6.6	6.7	7.4	7.8	8.8	9.8	11.9	13.6	15.5	17.4	18.0	19.6	21.0	22.3	24.6	
240	PIPE TEMP	231.4	231.1	230.3	228.7	226.7	226.2	224.3	223.5	221.2	217.8	211.5	206.3	200.8	195.5	193.7	189.9	186.7	183.2	177.1	
	PARALLEL / FT	5.6	5.8	6.0	6.8	7.8	7.9	8.6	9.1	10.1	11.3	13.7	15.7	17.9	20.1	20.9	22.8	24.4	25.8	28.5	
	PISTON / FT	5.5	5.6	5.8	6.7	7.5	7.7	8.4	8.9	9.8	11.1	13.4	15.4	17.5	19.7	20.4	22.2	23.8	25.2	27.6	
260	PIPE TEMP	250.3	249.9	249.1	247.3	245.0	244.5	242.3	241.5	238.9	235.1	228.1	222.2	216.2	210.2	208.3	204.0	200.4	196.5	190.0	
	PARALLEL / FT	6.4	6.5	6.7	7.7	8.8	8.9	9.7	10.2	11.3	12.7	15.4	17.4	20.0	22.5	23.4	25.5	27.2	28.6	31.9	
	PISTON / FT	6.2	6.3	6.6	7.5	8.5	8.6	9.4	10.0	11.0	12.5	15.1	17.3	19.6	22.0	22.8	24.9	26.6	28.1	31.1	
280	PIPE TEMP	269.1	268.8	267.9	265.8	263.3	262.7	260.3	259.4	256.6	252.3	246.6	238.1	231.5	224.9	222.7	218.1	214.1	209.8	202.7	
	PARALLEL / FT	7.1	7.3	7.5	8.6	9.8	9.9	10.8	11.4	12.6	14.1	17.0	19.6	22.2	25.0	25.9	28.2	30.1	31.9	35.2	
	PISTON / FT	6.9	7.1	7.3	8.4	9.5	9.6	10.5	11.1	12.2	13.8	16.7	19.2	21.7	24.4	25.3	27.5	29.4	31.1	34.4	
300	PIPE TEMP	288.0	287.6	286.6	284.3	281.6	280.9	278.3	277.3	274.2	269.5	261.1	254.0	246.7	239.5	237.2	232.0	227.7	223.1	215.3	
	PARALLEL / FT	7.9	8.1	8.3	9.5	10.8	11.0	11.9	12.5	13.9	15.5	18.8	21.5	24.4	27.4	28.4	30.9	33.1	35.0	38.6	
	PISTON / FT	7.7	7.8	8.1	9.2	10.5	10.6	11.6	12.2	13.5	15.2	18.4	21.1	23.9	26.8	27.7	30.2	32.3	34.1	37.7	
350	PIPE TEMP	334.9	334.4	333.2	330.5	327.0	326.3	323.0	321.8	318.0	312.4	302.0	293.4	286.5	279.5	273.0	266.7	261.5	255.9	246.5	
	PARALLEL / FT	9.9	10.1	10.4	11.9	13.5	13.6	14.8	15.6	17.2	19.2	23.1	26.5	30.0	33.7	34.8	37.9	40.5	42.8	47.2	
	PISTON / FT	9.6	9.8	10.1	11.5	13.0	13.2	14.4	15.2	16.7	18.6	22.7	25.9	29.3	32.9	34.0	37.0	39.5	41.7	46.0	
400	PIPE TEMP	381.6	381.1	379.7	376.4	372.3	371.4	367.6	366.1	361.4	354.9	342.6	332.5	322.0	311.6	308.4	301.1	295.0	288.3	277.3	
	PARALLEL / FT	12.0	12.2	12.4	14.0	16.3	16.5	17.8	18.7	20.6	23.0	27.7	31.6	35.8	40.1	41.5	45.1	48.2	50.8	56.0	
	PISTON / FT	11.7	11.9	12.2	13.9	15.7	15.9	17.3	18.2	20.0	22.6	27.1	30.9	35.0	39.1	40.5	44.0	46.9	49.5	54.0	
450	PIPE TEMP	428.2	427.4	426.0	422.1	417.3	416.4	411.8	410.2	405.0	397.1	383.0	371.3	359.2	347.1	343.5	335.1	328.0	320.4	307.8	
	PARALLEL / FT	14.3	14.5	14.5	17.0	19.3	19.4	21.0	22.0	24.2	27.0	32.4	36.9	41.7	46.7	48.2	52.5	56.0	58.4	65.7	
	PISTON / FT	13.8	14.0	14.5	16.5	18.6	18.7	20.3	21.4	23.5	26.5	31.7	36.1	40.7	45.6	47.1	51.1	54.5	57.5	63.1	
500	PIPE TEMP	474.5	474.0	472.2	467.7	462.1	461.1	455.9	454.1	448.1	439.1	423.0	409.7	396.0	382.3	378.3	368.7	360.8	352.2	337.9	
	PARALLEL / FT	16.4	16.9	17.3	19.7	22.3	22.5	24.3	25.5	28.0	31.1	37.2	42.4	47.8	53.5	55.2	60.0	64.0	67.4	74.1	
	PISTON / FT	16.1	16.3	16.8	19.1	21.5	21.6	23.5	24.6	27.1	30.5	36.6	41.6	46.7	52.2	53.8	58.6	62.5	65.6	72.1	
550	PIPE TEMP	520.8	520.2	518.2	513.0	506.7	505.6	499.8	497.7	491.0	480.9	467.8	452.5	437.1	422.7	418.7	402.0	393.2	383.6	367.4	
	PARALLEL / FT	19.1	19.4	19.7	22.6	25.5	25.7	27.7	29.0	31.8	35.6	42.2	48.0	54.1	60.5	62.3	67.7	72.1	76.0	83.4	
	PISTON / FT	18.5	18.7	19.2	21.8	24.6	24.7	26.8	28.2	30.8	34.7	41.3	46.9	52.7	58.9	60.7	65.9	70.2	73.9	81.2	
600	PIPE TEMP	566.9	566.2	564.0	558.3	551.2	550.0	543.5	541.2	533.7	522.4	502.3	485.7	468.7	451.7	446.9	435.0	425.2	414.7	397.3	
	PARALLEL / FT	21.2	21.7	22.4	25.6	28.9	29.0	31.3	32.7	35.8	39.7	47.3	53.7	60.5	67.4	69.4	75.5	80.4	84.7	92.9	
	PISTON / FT	20.9	21.2	21.7	24.7	27.7	27.8	30.2	31.7	34.7	38.9	46.3	52.5	59.0	65.8	67.8	73.5	78.2	82.3	90.3	
650	PIPE TEMP	612.9	612.2	609.7	603.3	595.5	594.2	587.0	584.5	576.2	563.7	541.5	523.3	504.6	485.9	480.7	467.7	457.0	445.5	426.5	
	PARALLEL / FT	24.4	24.8	25.1	28.6	32.3	32.4	34.9	36.5	39.9	44.3	52.6	59.6	67.0	74.8	77.0	83.7	88.9	93.5	102.5	
	PISTON / FT	23.5	23.7	24.3	27.6	31.0	31.1	33.6	35.4	38.6	43.3	51.6	58.2	65.3	72.8	75.0	81.2	86.6	90.9	99.	



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
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SECTION III
INSULATION DESIGN
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INSULATION THICKNESS REQUIREMENTS

Service Designation T-59

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT
PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

1" NOMINAL INSULATION THICKNESS		AMBIENT AIR TEMP 90.0 F (32.2 C)															
CABLE TEMP DEG F		PIPE SIZE															
		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16
100	PIPE TEMP	55.4	99.3	99.2	99.1	98.9	98.5	98.7	98.7	98.3	98.0						
	MAX. W / FT	C-5	C-5	C-5	C-4	C-7	C-7	C-8	C-8	C-8	C-9						
	MIN. W / FT	C-4	C-5	C-5	C-6	C-6	C-6	C-7	C-7	C-7	C-8						
120	PIPE TEMP	110.6	117.9	117.6	117.2	116.8	116.4	115.9	115.9	115.0	113.9						
	MAX. W / FT	1.5	1.6	1.6	1.9	2.1	2.2	2.5	2.5	3.1	3.7						
	MIN. W / FT	1.4	1.4	1.5	1.7	1.9	2.0	2.2	2.3	2.7	3.1						
140	PIPE TEMP	136.6	136.4	136.0	135.3	134.5	134.2	133.0	133.0	131.5	129.4						
	MAX. W / FT	2.5	2.7	2.8	3.2	3.6	3.7	4.3	4.3	5.2	6.2						
	MIN. W / FT	2.3	2.4	2.5	2.9	3.2	3.3	3.8	3.8	4.5	5.3						
160	PIPE TEMP	155.1	154.8	154.3	153.3	152.1	151.7	150.1	150.1	147.9	145.3						
	MAX. W / FT	3.4	3.8	4.0	4.6	5.2	5.3	6.2	6.2	7.5	8.8						
	MIN. W / FT	3.3	3.5	3.6	4.1	4.6	4.8	5.6	5.6	6.4	7.5						
180	PIPE TEMP	173.6	173.2	172.5	171.2	169.7	169.1	167.0	167.0	164.2	160.8						
	MAX. W / FT	4.4	5.0	5.2	6.0	6.8	7.0	8.1	8.0	9.4	11.5						
	MIN. W / FT	4.4	4.6	4.8	5.4	6.0	6.2	7.1	7.1	8.4	9.8						
200	PIPE TEMP	191.9	191.4	190.4	189.0	187.1	186.4	183.8	183.9	180.4	176.2						
	MAX. W / FT	5.0	5.7	6.0	7.0	8.0	8.3	10.1	10.0	12.1	14.3						
	MIN. W / FT	5.4	5.7	5.9	6.7	7.5	7.7	8.8	8.8	10.4	12.1						
220	PIPE TEMP	210.2	209.7	208.7	206.6	204.5	203.7	200.6	200.7	196.5	191.6						
	MAX. W / FT	7.2	7.5	7.9	9.0	10.2	10.5	12.2	12.0	14.6	17.2						
	MIN. W / FT	6.6	6.8	7.1	8.1	9.1	9.3	10.6	10.6	12.5	14.5						
240	PIPE TEMP	228.5	227.8	226.7	224.4	221.8	220.5	217.3	217.4	212.5	206.8						
	MAX. W / FT	8.5	8.9	9.3	10.7	12.0	12.4	14.3	14.0	17.1	20.2						
	MIN. W / FT	7.7	8.1	8.4	9.5	10.6	10.6	12.4	12.4	14.6	16.9						
260	PIPE TEMP	246.6	245.9	244.6	242.0	239.0	238.0	233.8	234.1	228.5	221.9						
	MAX. W / FT	9.9	10.3	10.7	12.3	13.9	14.3	16.5	16.2	19.7	23.2						
	MIN. W / FT	9.0	9.3	9.7	11.0	12.3	12.6	14.3	14.2	16.8	19.4						
280	PIPE TEMP	264.7	264.0	262.5	259.5	256.1	255.0	250.3	250.6	244.3	236.9						
	MAX. W / FT	11.3	11.8	12.2	14.0	15.8	16.3	18.8	18.3	22.3	26.3						
	MIN. W / FT	10.2	10.6	11.0	12.5	13.9	14.2	16.2	16.1	19.0	22.0						
300	PIPE TEMP	282.8	281.5	280.3	277.0	273.1	272.0	266.7	267.1	260.1	251.9						
	MAX. W / FT	12.8	13.3	13.8	15.8	17.8	18.2	21.1	20.6	25.1	29.5						
	MIN. W / FT	11.5	11.9	12.4	14.0	15.7	16.0	18.2	18.0	21.2	24.6						
350	PIPE TEMP	327.4	326.6	324.6	320.3	315.4	314.0	307.4	308.0	295.1	288.8						
	MAX. W / FT	16.6	17.2	17.9	20.5	23.1	23.4	27.2	26.4	32.1	37.7						
	MIN. W / FT	14.9	15.4	16.0	18.1	20.1	20.5	23.3	23.0	27.3	31.2						
400	PIPE TEMP	372.0	370.9	368.5	363.3	357.3	355.7	347.6	348.5	337.8	329.3						
	MAX. W / FT	20.8	21.5	22.2	25.5	28.7	29.2	33.7	32.5	39.6	46.4						
	MIN. W / FT	18.8	19.1	19.8	22.4	24.9	25.2	28.4	28.2	33.1	38.1						
450	PIPE TEMP	416.3	414.8	412.1	405.8	398.7	397.0	387.3	388.7	376.0	361.3						
	MAX. W / FT	25.3	26.1	26.8	30.8	34.6	35.1	40.5	39.0	47.4	55.5						
	MIN. W / FT	22.5	23.1	23.8	26.9	29.8	30.2	34.2	33.6	39.4	45.3						
500	PIPE TEMP	459.8	458.4	455.3	448.1	439.9	437.9	426.7	428.5	413.8	396.9						
	MAX. W / FT	30.1	30.9	31.7	36.4	40.8	41.4	47.7	45.7	55.6	64.9						
	MIN. W / FT	28.6	29.2	29.9	31.6	35.0	35.4	39.9	39.2	45.9	52.6						
550	PIPE TEMP	503.2	501.8	498.3	490.0	480.7	478.5	465.8	468.0	451.3	432.2						
	MAX. W / FT	35.2	36.0	36.9	42.3	47.3	47.6	55.1	52.7	64.0	74.7						
	MIN. W / FT	30.5	31.5	32.1	36.5	40.3	40.7	45.9	45.0	52.6	60.2						
600	PIPE TEMP	546.4	544.5	541.1	531.7	521.2	518.5	504.6	507.2	489.5	467.2						
	MAX. W / FT	40.5	41.4	42.3	48.4	54.1	54.7	62.9	59.9	72.6	84.8						
	MIN. W / FT	35.4	36.1	36.9	41.6	45.9	46.2	52.1	50.9	59.5	68.0						
650	PIPE TEMP	589.4	587.8	583.6	573.1	561.4	559.0	543.1	546.2	525.4	501.8						
	MAX. W / FT	46.1	47.0	47.9	54.8	61.2	61.7	70.9	67.4	81.8	95.2						
	MIN. W / FT	40.1	40.8	41.6	46.9	51.4	51.9	58.4	57.1	66.5	75.9						
700	PIPE TEMP	632.1	630.4	626.0	614.3	601.5	598.4	581.4	585.0	562.2	536.3						
	MAX. W / FT	52.1	53.1	53.8	61.5	68.6	69.1	79.3	75.1	91.2	106.0						
	MIN. W / FT	45.0	45.7	46.5	52.3	57.5	57.8	65.0	63.3	73.7	84.0						
750	PIPE TEMP	674.7	673.0	668.2	655.4	641.4	638.7	619.6	623.6	598.7	570.5						
	MAX. W / FT	58.3	59.2	60.0	68.5	76.3	76.8	88.0	83.2	101.0	117.1						
	MIN. W / FT	50.2	50.8	51.6	58.0	63.7	63.9	71.7	69.8	81.2	92.4						
800	PIPE TEMP	717.2	715.4	710.2	696.4	681.2	678.3	657.5	662.0	635.1	604.4						
	MAX. W / FT	64.9	65.8	66.5	75.9	84.4	84.8	97.1	91.5	111.1	128.8						
	MIN. W / FT	55.6	56.2	57.0	63.9	70.0	70.3	78.7	76.5	88.9	101.0						
850	PIPE TEMP	754.5	752.7	747.2	732.2	716.8	713.8	695.4	700.3	671.3	638.4						
	MAX. W / FT	72.0	72.9	73.5	83.7	92.9	93.3	106.7	100.2	121.8	140.9						
	MIN. W / FT	61.3	61.9	62.6	70.1	76.7	76.6	86.0	83.4	96.9	109.9						
900	PIPE TEMP	801.8	800.0	794.1	777.9	760.3	757.1	733.1	738.5	707.4	672.4						
	MAX. W / FT	78.7	79.4	80.0	91.0	101.0	101.4	117.0	109.4	133.0	153.7						
	MIN. W / FT	67.4	68.1	68.6	76.7	83.6	83.6	93.7	90.7	105.2	119.2						
950	PIPE TEMP	844.0	842.1	835.9	818.6	799.7	796.4	770.7	776.5	743.4	706.1						
	MAX. W / FT	84.2	85.1	85.1	96.2	106.2	106.2	124.1	119.3	145.2	167.4						
	MIN. W / FT	74.1	74.7	75.1	83.7	91.3	91.4	101.9	98.3	114.1	128.9						



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
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INSULATION THICKNESS REQUIREMENTS

Service Designation T-60

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT
PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

1-1/2" NOMINAL INSULATION THICKNESS		PIPE SIZE																				AMBIENT AIR TEMP 90.0 F (32.2 C)	
CABLE TEMP DEG F		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24			
100	PIPE TEMP	99.5	99.4	99.3	99.2	99.1	99.1	98.8	98.6	98.3	97.7	97.2	96.8	96.3	96.1	95.8	95.6	95.3	95.1	94.9			
	PAR. W FFI	0.4	0.4	0.5	0.5	0.5	0.4	0.7	0.7	0.8	1.0	1.2	1.4	1.5	1.7	1.8	2.0	2.1	2.2	2.4			
	MIN. W FFI	0.4	0.4	0.4	0.5	0.5	0.5	0.4	0.7	0.8	0.9	1.1	1.3	1.5	1.7	1.7	1.9	2.0	2.1	2.3			
120	PIPE TEMP	118.3	118.2	117.9	117.6	117.3	117.2	116.5	116.4	115.6	114.7	113.0	111.5	110.2	108.8	108.3	107.4	106.7	105.9	104.7			
	PAR. W FFI	1.2	1.2	1.4	1.6	1.7	1.7	2.1	2.2	2.6	3.0	3.7	4.2	4.7	5.3	5.5	6.0	6.4	6.7	7.3			
	MIN. W FFI	1.1	1.2	1.3	1.5	1.5	1.6	1.9	2.0	2.3	2.7	3.3	3.9	4.4	5.0	5.2	5.7	6.0	6.3	6.9			
140	PIPE TEMP	137.1	137.0	136.5	135.9	135.5	135.2	134.0	133.8	132.6	131.0	128.3	125.8	123.5	121.2	120.4	118.9	117.7	116.6	115.4			
	PAR. W FFI	2.0	2.1	2.4	2.7	2.8	2.9	3.6	3.7	4.3	5.1	6.2	7.1	7.8	8.9	9.2	10.0	10.7	11.2	12.2			
	MIN. W FFI	1.9	2.0	2.2	2.5	2.6	2.7	3.2	3.4	3.9	4.5	5.4	6.4	7.4	8.4	8.7	9.5	10.1	10.6	11.5			
160	PIPE TEMP	155.9	155.7	155.0	154.2	153.6	153.2	151.5	151.2	149.5	147.3	143.4	139.9	136.7	133.5	132.6	130.3	128.6	126.9	124.1			
	PAR. W FFI	2.9	3.0	3.4	3.8	4.0	4.1	5.1	5.2	6.2	7.2	8.8	10.1	11.1	12.6	13.0	14.2	15.1	15.8	17.2			
	MIN. W FFI	2.7	2.8	3.1	3.5	3.7	3.8	4.6	4.8	5.5	6.4	7.9	9.3	10.5	11.9	12.3	13.4	14.2	14.9	16.2			
180	PIPE TEMP	174.6	174.3	173.4	172.4	171.6	171.2	168.9	168.6	166.3	163.4	158.4	153.9	149.9	145.6	144.6	141.6	139.4	137.2	133.6			
	PAR. W FFI	3.7	3.9	4.4	5.0	5.2	5.4	6.4	6.8	8.1	9.4	11.5	13.1	14.4	16.3	16.9	18.3	19.5	20.4	22.2			
	MIN. W FFI	3.5	3.7	4.1	4.6	4.9	5.0	6.0	6.2	7.2	8.4	10.3	12.0	13.6	15.4	15.9	17.3	18.4	19.2	20.9			
200	PIPE TEMP	193.3	193.0	191.8	190.5	189.5	189.0	186.2	185.8	183.1	179.5	173.4	167.9	162.9	157.7	156.1	152.7	150.1	147.4	143.0			
	PAR. W FFI	4.7	4.9	5.5	6.2	6.5	6.7	8.3	8.5	10.0	11.7	14.2	16.2	17.7	20.1	20.8	22.6	24.0	25.1	27.3			
	MIN. W FFI	4.4	4.6	5.1	5.8	6.0	6.2	7.5	7.7	8.9	10.4	12.7	14.9	16.8	19.0	19.6	21.3	22.6	23.8	25.7			
220	PIPE TEMP	211.9	211.5	210.1	208.6	207.4	206.8	203.4	203.0	199.7	195.5	188.2	181.7	175.8	169.6	167.9	163.8	160.7	157.5	152.4			
	PAR. W FFI	5.7	5.9	6.6	7.5	7.8	8.0	9.9	10.2	12.0	14.0	17.0	19.4	21.1	23.9	24.7	26.9	28.5	29.8	32.4			
	MIN. W FFI	5.3	5.5	6.1	6.9	7.3	7.4	9.0	9.3	10.7	12.4	15.2	17.7	20.0	22.6	23.3	25.3	26.8	28.1	30.5			
240	PIPE TEMP	230.5	230.0	228.4	226.6	225.2	224.8	220.4	220.0	216.3	211.4	203.0	195.4	188.6	181.5	179.5	174.8	171.2	167.6	161.7			
	PAR. W FFI	6.7	6.9	7.8	8.8	9.2	9.4	11.4	11.9	14.0	16.4	19.8	22.6	24.6	27.8	28.7	31.1	32.1	34.8	37.6			
	MIN. W FFI	6.2	6.4	7.2	8.1	8.5	8.7	10.5	10.8	12.5	14.5	17.7	20.6	23.6	26.2	27.1	29.3	31.1	32.6	35.3			
260	PIPE TEMP	249.0	248.5	246.6	244.5	243.0	242.3	237.7	237.2	232.8	227.2	217.7	209.1	201.3	193.2	191.0	185.7	181.7	177.6	170.9			
	PAR. W FFI	7.7	8.0	9.0	10.2	10.6	10.8	13.4	13.7	16.1	18.8	22.7	25.8	28.1	31.8	32.7	35.6	37.7	39.5	42.8			
	MIN. W FFI	7.2	7.4	8.3	9.3	9.8	10.0	12.3	12.6	14.3	16.6	20.2	23.6	26.6	29.9	30.8	33.4	35.5	37.1	40.2			
280	PIPE TEMP	267.5	266.9	264.8	262.4	260.7	259.5	254.7	254.2	249.3	242.9	232.2	222.6	214.0	204.9	202.5	196.5	192.1	187.5	180.1			
	PAR. W FFI	8.8	9.0	10.2	11.6	12.1	12.3	15.2	15.5	18.3	21.3	25.7	29.1	31.6	35.8	36.8	40.0	42.4	44.3	48.1			
	MIN. W FFI	8.2	8.4	9.4	10.6	11.1	11.3	13.7	14.1	16.2	18.8	22.4	26.5	29.9	33.7	34.7	37.6	39.4	41.6	45.1			
300	PIPE TEMP	285.9	285.3	282.9	280.2	278.4	277.5	271.7	271.1	265.7	258.6	246.8	236.1	226.6	216.5	213.8	207.3	202.3	197.3	189.1			
	PAR. W FFI	9.9	10.2	11.5	13.0	13.5	13.8	17.1	17.4	20.5	23.9	28.7	32.5	35.9	40.0	40.5	44.1	46.3	49.3	53.4			
	MIN. W FFI	9.2	9.5	10.6	11.9	12.4	12.6	15.3	15.7	18.1	21.0	25.4	29.6	33.3	37.5	38.6	41.8	44.2	48.2	50.1			
350	PIPE TEMP	331.7	331.1	328.0	324.6	322.3	321.3	313.8	313.2	307.4	297.4	282.7	269.5	257.6	245.0	241.9	233.8	227.7	221.5	211.5			
	PAR. W FFI	12.8	13.1	14.8	16.8	17.4	17.7	21.9	22.2	26.1	30.4	36.4	41.1	46.4	50.2	51.5	55.9	59.1	61.6	66.8			
	MIN. W FFI	11.9	12.2	13.6	15.3	15.9	16.1	19.5	20.0	23.1	28.4	32.1	37.3	41.9	47.1	48.4	52.4	55.4	57.9	62.6			
400	PIPE TEMP	377.3	376.4	372.8	368.7	365.9	364.8	355.6	355.0	346.4	335.9	318.2	302.3	288.2	273.1	269.5	259.8	252.7	245.3	235.5			
	PAR. W FFI	15.9	16.3	18.4	20.8	21.3	21.8	27.0	27.3	32.1	37.3	44.4	50.0	53.9	60.9	62.4	67.6	71.4	74.5	80.3			
	MIN. W FFI	14.7	15.1	16.8	18.9	19.6	19.8	24.0	24.5	28.2	32.5	39.1	45.3	50.8	57.0	58.5	63.3	66.9	69.8	75.3			
450	PIPE TEMP	422.3	421.8	417.4	412.4	409.2	407.4	397.1	396.4	386.5	373.9	353.3	334.8	316.3	300.7	296.7	285.4	277.2	268.7	255.1			
	PAR. W FFI	16.2	16.6	18.8	21.2	21.8	22.3	28.4	28.7	33.6	39.4	46.4	52.7	59.2	63.6	67.6	73.8	77.5	80.5	86.4			
	MIN. W FFI	15.7	16.1	18.2	20.6	21.3	21.7	26.6	27.1	31.8	37.6	44.6	51.9	58.2	64.6	66.1	71.3	74.8	77.8	83.3			
500	PIPE TEMP	467.7	466.6	461.7	455.9	452.2	450.8	438.2	437.5	426.2	411.6	388.0	366.8	346.0	327.8	323.5	310.7	301.3	291.7	276.4			
	PAR. W FFI	22.7	23.2	26.1	29.5	30.3	30.5	37.9	38.2	45.7	51.8	61.3	68.6	73.6	82.9	84.7	91.6	96.7	100.7	108.6			
	MIN. W FFI	20.5	21.3	23.7	26.5	27.4	27.7	33.4	34.1	39.0	46.8	53.6	61.8	69.1	77.2	79.2	85.6	90.3	94.0	101.3			
550	PIPE TEMP	512.6	511.7	505.8	499.1	495.0	493.5	479.1	478.4	465.5	449.0	422.4	396.5	377.3	356.6	349.9	335.5	325.1	314.4	297.1			
	PAR. W FFI	26.4	26.8	30.2	34.1	34.9	35.2	43.6	43.9	51.4	59.5	70.1	78.3	83.7	94.3	96.2	104.0	109.7	114.2	122.9			
	MIN. W FFI	24.2	24.6	27.4	30.6	31.6	31.8	38.4	39.1	46.7	54.2	64.1	72.3	78.5	88.0	89.9	97.0	102.3	106.5	114.6			
600	PIPE TEMP	557.3	556.3	549.6	542.2	537.6	536.0	519.7	519.0	504.6	486.2	456.5	429.8	406.3	381.1	376.0	360.1	348.6	336.8	318.0			
	PAR. W FFI	30.2	30.7	34.5	38.9	39.8	40.1	49.4	49.9	58.3	67.4	79.1	88.2	94.1	105.9	107.9	116.6	122.9	127.6	137.4			
	MIN. W FFI	27.7	28.1	31.2	34.8	35.9	36.1	43.5	44.2	50.5	57.8	68.8	79.1	88.2	98.7	100.7	108.6	114.6	119.0	128.0			
650	PIPE TEMP	601.8	600.7	593.3	585.0	580.0	578.2	560.1	559.4	546.4	523.0	490.3	460.9	434.9	407.2	401.7	384.3	371.7	358.9	338.3			
	PAR. W FFI	34.3	34.7	39.0	44.0	44.8	45.1	55.8	56.4	65.5	75.5	88.4	98.3	104.7	117.7	119.9	129.5	136.3	141.7	152.2			
	MIN. W FFI	31.3	31.7	35.1	39.2	40.3	40.5	48.7	49.5	56.5	64.6	76.6	86.0	96.0	107.5	111.7	120.4	126.6	131.6	141.6			
700	PIPE TEMP	644.1	643.1	636.8	627.6	622.2	620																



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
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INSULATION THICKNESS REQUIREMENTS

Service Designation T-61

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

2" NOMINAL INSULATION THICKNESS		PIPE SIZE																AMBIENT AIR TEMP 90°F (32.2°C)		
CABLE TEMP DEG F		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
100	PIPE TEMP	99.5	99.4	99.4	99.3	99.2	99.2	99.0	98.9	98.7	98.4	97.9	97.5	97.1	96.7	96.6	96.3	96.0	95.8	95.4
	PAR.W / FT	C.4	C.4	C.4	0.5	0.5	0.5	0.6	0.6	0.7	0.9	1.1	1.2	1.4	1.5	1.6	1.7	1.9	2.0	2.1
	PI.N.W / FT	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8	1.0	1.1	1.3	1.5	1.5	1.7	1.8	1.9	2.1
120	PIPE TEMP	110.4	110.3	110.2	110.1	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	109.6	108.8	108.1	107.3	106.2
	PAR.W / FT	1.1	1.2	1.2	1.4	1.5	1.5	1.8	1.8	1.9	2.2	2.6	3.2	3.6	4.1	4.6	4.8	5.3	5.6	6.5
	PI.N.W / FT	1.0	1.1	1.1	1.3	1.4	1.4	1.7	1.7	1.6	2.1	2.4	3.0	3.4	3.9	4.4	4.6	5.0	5.4	6.2
140	PIPE TEMP	137.3	137.1	136.9	136.7	136.5	136.4	136.4	136.4	136.4	136.4	136.4	136.4	136.4	136.4	136.4	136.4	136.4	136.4	136.4
	PAR.W / FT	1.9	2.0	2.0	2.4	2.5	2.5	3.1	3.1	3.0	3.6	4.4	5.4	6.0	6.9	7.4	8.1	8.8	9.4	10.4
	PI.N.W / FT	1.8	1.9	1.9	2.2	2.4	2.4	2.9	2.9	2.8	3.5	4.0	5.0	5.8	6.6	7.5	7.7	8.4	9.0	10.4
160	PIPE TEMP	156.1	155.9	155.6	155.4	155.1	155.0	155.0	155.0	155.0	155.0	155.0	155.0	155.0	155.0	155.0	155.0	155.0	155.0	155.0
	PAR.W / FT	2.7	2.8	2.8	3.4	3.6	3.6	4.4	4.4	4.3	5.2	6.2	7.4	8.5	9.3	10.5	11.4	12.4	13.3	14.0
	PI.N.W / FT	2.5	2.6	2.7	3.2	3.4	3.5	4.2	4.2	4.1	4.9	5.7	7.1	8.1	9.3	10.5	10.9	11.9	12.7	13.3
180	PIPE TEMP	174.9	174.6	174.3	173.9	173.5	173.4	173.4	173.4	173.4	173.4	173.4	173.4	173.4	173.4	173.4	173.4	173.4	173.4	173.4
	PAR.W / FT	3.5	3.7	3.7	4.4	4.7	4.7	5.6	5.6	5.5	6.6	7.8	9.0	10.0	11.2	12.4	14.4	16.4	17.2	18.0
	PI.N.W / FT	3.3	3.5	3.5	4.1	4.4	4.5	5.4	5.4	5.3	6.4	7.5	9.2	10.6	12.1	13.6	14.1	15.4	16.4	17.2
200	PIPE TEMP	193.4	193.3	192.9	192.4	192.0	191.9	191.9	191.9	191.9	191.9	191.9	191.9	191.9	191.9	191.9	191.9	191.9	191.9	191.9
	PAR.W / FT	4.4	4.6	4.6	5.5	5.9	5.9	6.9	6.9	6.8	8.1	9.4	10.4	12.0	12.8	13.0	14.6	15.6	16.2	16.8
	PI.N.W / FT	4.2	4.3	4.4	5.1	5.5	5.6	6.7	6.7	6.6	8.0	9.2	10.3	11.9	12.6	12.8	14.4	15.4	16.0	16.6
220	PIPE TEMP	212.3	211.9	211.5	209.7	208.5	208.4	208.4	208.4	208.4	208.4	208.4	208.4	208.4	208.4	208.4	208.4	208.4	208.4	208.4
	PAR.W / FT	5.3	5.5	5.5	6.6	7.0	7.0	8.2	8.2	8.1	9.5	10.8	12.1	14.0	14.8	15.0	16.8	17.8	18.4	19.0
	PI.N.W / FT	5.0	5.2	5.2	6.2	6.6	6.7	8.0	8.0	7.9	9.3	10.5	11.8	13.5	14.3	14.5	16.4	17.4	18.0	18.6
240	PIPE TEMP	231.0	230.5	230.0	227.9	226.5	226.4	226.4	226.4	226.4	226.4	226.4	226.4	226.4	226.4	226.4	226.4	226.4	226.4	226.4
	PAR.W / FT	6.2	6.5	6.5	7.7	8.2	8.2	9.4	9.4	9.3	10.8	12.2	14.0	15.0	16.0	16.2	18.2	19.2	19.8	20.4
	PI.N.W / FT	5.9	6.1	6.1	7.2	7.7	7.8	9.0	9.0	8.9	10.4	11.8	13.6	14.6	15.6	15.8	17.8	18.8	19.4	20.0
260	PIPE TEMP	249.5	249.1	248.5	246.1	244.5	244.4	244.4	244.4	244.4	244.4	244.4	244.4	244.4	244.4	244.4	244.4	244.4	244.4	244.4
	PAR.W / FT	7.2	7.4	7.5	8.9	9.5	9.5	10.7	10.7	10.6	12.2	13.6	15.4	16.4	17.4	17.6	19.6	20.6	21.2	21.8
	PI.N.W / FT	6.8	7.0	7.1	8.3	8.9	9.0	10.3	10.3	10.2	11.7	13.1	14.9	16.0	17.0	17.2	19.2	20.2	20.8	21.4
280	PIPE TEMP	268.1	267.6	267.0	264.2	262.4	262.3	262.3	262.3	262.3	262.3	262.3	262.3	262.3	262.3	262.3	262.3	262.3	262.3	262.3
	PAR.W / FT	8.2	8.5	8.5	10.1	10.8	10.8	12.2	12.2	12.1	13.7	15.1	17.0	18.0	19.0	19.2	21.2	22.2	22.8	23.4
	PI.N.W / FT	7.7	7.9	8.0	9.4	10.1	10.2	11.6	11.6	11.5	13.0	14.4	16.2	17.3	18.3	18.5	20.5	21.5	22.1	22.7
300	PIPE TEMP	286.6	286.1	285.4	282.3	280.3	280.2	280.2	280.2	280.2	280.2	280.2	280.2	280.2	280.2	280.2	280.2	280.2	280.2	280.2
	PAR.W / FT	9.2	9.5	9.5	11.4	12.1	12.1	13.5	13.5	13.4	15.0	16.4	18.4	19.4	20.4	20.6	22.6	23.6	24.2	24.8
	PI.N.W / FT	8.7	8.9	9.0	10.6	11.3	11.4	12.7	12.7	12.6	14.1	15.5	17.4	18.5	19.5	19.7	21.7	22.7	23.3	23.9
320	PIPE TEMP	322.7	322.1	321.2	327.3	324.6	324.5	324.5	324.5	324.5	324.5	324.5	324.5	324.5	324.5	324.5	324.5	324.5	324.5	324.5
	PAR.W / FT	11.9	12.3	12.2	14.4	15.5	15.5	17.0	17.0	16.9	18.5	20.0	22.0	23.0	24.0	24.2	26.2	27.2	27.8	28.4
	PI.N.W / FT	11.2	11.5	11.5	13.6	14.4	14.4	15.9	15.9	15.8	17.4	18.5	20.4	21.5	22.5	22.7	24.7	25.7	26.3	26.9
340	PIPE TEMP	370.5	370.0	369.0	372.1	369.0	368.9	368.9	368.9	368.9	368.9	368.9	368.9	368.9	368.9	368.9	368.9	368.9	368.9	368.9
	PAR.W / FT	14.8	15.2	15.1	18.0	19.1	19.1	20.6	20.6	20.5	22.1	23.6	25.6	26.6	27.6	27.8	29.8	30.8	31.4	32.0
	PI.N.W / FT	13.9	14.2	14.2	16.7	17.7	17.7	19.2	19.2	19.1	20.7	21.8	23.7	24.8	25.8	26.0	28.0	29.0	29.6	30.2
360	PIPE TEMP	424.2	423.4	422.3	416.6	413.0	412.8	412.8	412.8	412.8	412.8	412.8	412.8	412.8	412.8	412.8	412.8	412.8	412.8	412.8
	PAR.W / FT	17.9	18.3	18.1	21.6	22.8	22.8	24.3	24.3	24.2	25.8	27.3	29.3	30.3	31.3	31.5	33.5	34.5	35.1	35.7
	PI.N.W / FT	16.7	17.0	17.0	20.0	21.2	21.2	22.7	22.7	22.6	24.1	25.2	27.1	28.2	29.2	29.4	31.4	32.4	33.0	33.6
380	PIPE TEMP	465.5	464.7	463.5	460.6	456.7	456.5	456.5	456.5	456.5	456.5	456.5	456.5	456.5	456.5	456.5	456.5	456.5	456.5	456.5
	PAR.W / FT	21.1	21.5	21.3	25.4	26.6	26.6	28.1	28.1	28.0	29.6	31.1	33.1	34.1	35.1	35.3	37.3	38.3	38.9	39.5
	PI.N.W / FT	19.4	20.0	19.9	23.4	24.6	24.6	26.1	26.1	26.0	27.5	28.6	30.5	31.6	32.6	32.8	34.8	35.8	36.4	37.0
400	PIPE TEMP	514.7	513.9	512.5	509.8	505.2	505.0	505.0	505.0	505.0	505.0	505.0	505.0	505.0	505.0	505.0	505.0	505.0	505.0	505.0
	PAR.W / FT	26.5	26.9	26.6	30.9	32.1	32.1	33.6	33.6	33.5	35.1	36.6	38.6	39.6	40.6	40.8	42.8	43.8	44.4	45.0
	PI.N.W / FT	24.7	25.1	25.0	28.9	29.9	29.9	31.4	31.4	31.3	32.9	34.0	35.9	37.0	38.0	38.2	40.2	41.2	41.8	42.4
420	PIPE TEMP	555.7	554.8	553.4	549.7	545.0	544.8	544.8	544.8	544.8	544.8	544.8	544.8	544.8	544.8	544.8	544.8	544.8	544.8	544.8
	PAR.W / FT	28.1	28.5	28.2	32.5	33.7	33.7	35.2	35.2	35.1	36.7	38.2	40.2	41.2	42.2	42.4	44.4	45.4	46.0	46.6
	PI.N.W / FT	26.0	26.3	26.3	30.7	31.7	31.7	33.2	33.2	33.1	34.7	35.8	37.7	38.8	39.8	40.0	42.0	43.0	43.6	44.2
440	PIPE TEMP	604.5	603.5	602.1	597.4	592.6	592.4	592.4	592.4	592.4	592.4	592.4	592.4	592.4	592.4	592.4	592.4	592.4	592.4	592.4
	PAR.W / FT	31.8	32.2	31.9	37.7	38.9	38.9	40.4	40.4	40.3	41.9	43.4	45.4	46.4	47.4	47.6	49.6	50.6	51.2	51.8
	PI.N.W / FT	29.3	29.7	29.6	34.1	35.1	35.1	36.6	36.6	36.5	38.1	39.2	41.1	42.2	43.2	43.4	45.4	46.4	47.0	47.6
460	PIPE TEMP	645.2	644.2	642.8	637.9	633.0	632.8	632.8	632.8	632.8	632.8	632.8	632.8	632.8	632.8	632.8	632.8	632.8	632.8	632.8
	PAR.W / FT	35.7	36.1	35.8	41.7	42.9	42.9	44.4	44.4	44.3	45.9	47.4	49.4	50.4	51.4	51.6	53.6	54.6	55.2	55.8
	PI.N.W / FT	32.8	33.2	33.1	37.6	38.6	38.6	40.1	40.1	40.0	41.6	42.7	44.6	45.7	46.7	46.9	48.9	49.9	50.5	51.1
480	PIPE TEMP	685.8																		



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESI
PAGE 401
MAY, 1968

INSULATION THICKNESS REQUIREMENTS

Service Designation T-62

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

2-1/2" NOMINAL INSULATION THICKNESS										PIPE SIZE												AMBIENT AIR TEMP 90.0 F (32.2 C)	
CABLE TEMP DEG F		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24			
100	PIPE TEMP	99.5	99.5	99.4	99.3	99.2	99.1	99.0	98.8	98.6	98.4	98.1	97.8	97.4	97.0	96.6	96.4	96.2	95.8	95.8			
	PAR.W /FT	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.1	1.2	1.4	1.4	1.4	1.7	1.8	1.9			
	PIR.W /FT	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	1.5	1.6	1.7			
120	PIPE TEMP	110.5	110.4	110.3	110.0	110.7	110.6	110.4	110.4	110.4	110.4	110.3	110.2	110.1	110.0	109.8	109.1	108.5	107.3	107.3			
	PAR.W /FT	1.0	1.1	1.1	1.3	1.4	1.4	1.7	1.8	2.0	2.3	2.6	3.2	3.7	4.1	4.3	4.7	5.0	5.3	5.9			
	PIR.W /FT	1.0	1.0	1.0	1.2	1.3	1.3	1.6	1.7	1.9	2.2	2.7	3.1	3.6	4.0	4.2	4.5	4.9	5.1	5.7			
140	PIPE TEMP	137.5	137.3	137.1	136.6	136.1	135.5	135.0	134.8	133.9	132.8	130.4	128.6	126.7	124.8	124.2	122.9	121.8	120.7	118.8			
	PAR.W /FT	1.7	1.8	1.8	2.2	2.3	2.4	2.8	3.0	3.4	3.9	4.8	5.9	6.2	7.0	7.3	7.9	8.5	8.9	9.4			
	PIR.W /FT	1.6	1.7	1.8	2.1	2.2	2.3	2.7	2.8	3.2	3.6	4.5	5.2	6.0	6.7	7.0	7.6	8.2	8.6	9.5			
160	PIPE TEMP	156.4	156.2	155.9	155.1	154.5	154.2	153.0	152.6	151.4	149.7	146.4	144.0	141.3	138.6	137.7	135.9	134.4	132.8	130.2			
	PAR.W /FT	2.4	2.5	2.6	3.1	3.3	3.4	4.0	4.2	4.8	5.5	6.8	7.6	8.7	9.8	10.2	11.2	11.9	12.6	13.8			
	PIR.W /FT	2.3	2.4	2.5	2.9	3.2	3.2	3.8	4.0	4.5	5.2	6.4	7.4	8.4	9.5	9.9	10.7	11.5	12.1	13.3			
180	PIPE TEMP	175.3	175.0	174.6	173.6	172.8	172.5	170.8	170.4	168.8	166.7	162.4	159.2	155.7	152.3	151.2	148.8	146.9	144.8	141.5			
	PAR.W /FT	3.2	3.3	3.4	4.0	4.3	4.4	5.2	5.5	6.3	7.1	8.8	9.9	11.3	12.4	13.2	14.4	15.4	16.3	17.9			
	PIR.W /FT	3.1	3.2	3.3	3.8	4.1	4.2	4.9	5.2	5.9	6.7	8.3	9.5	10.9	12.3	12.8	13.9	14.8	15.7	17.2			
200	PIPE TEMP	194.1	193.8	193.3	192.1	191.1	190.1	188.6	188.1	186.2	183.5	178.3	174.4	170.1	165.9	164.6	161.6	159.3	156.8	152.7			
	PAR.W /FT	4.0	4.1	4.2	5.0	5.4	5.5	6.5	6.8	7.7	8.8	10.8	12.2	13.9	15.7	16.3	17.8	19.0	20.0	22.0			
	PIR.W /FT	3.8	3.9	4.1	4.7	5.1	5.2	6.1	6.4	7.3	8.3	10.3	11.8	13.4	15.1	15.7	17.1	18.3	19.2	21.1			
220	PIPE TEMP	212.9	212.6	212.0	210.5	209.3	208.8	206.4	205.8	203.5	200.3	194.1	189.5	184.4	179.4	177.9	174.4	171.6	168.7	163.8			
	PAR.W /FT	4.8	5.0	5.1	6.0	6.4	6.4	7.8	8.1	9.3	10.6	12.9	14.5	16.6	18.7	19.4	21.1	22.6	23.8	26.1			
	PIR.W /FT	4.6	4.7	4.9	5.7	6.1	6.2	7.3	7.7	8.7	9.9	12.3	14.0	16.0	18.0	18.7	20.3	21.7	22.9	25.1			
240	PIPE TEMP	231.6	231.3	230.8	228.8	227.4	227.0	224.1	223.4	220.7	217.1	209.9	204.5	198.6	192.9	191.1	187.1	183.9	180.5	174.9			
	PAR.W /FT	5.7	5.8	6.0	7.0	7.5	7.7	9.1	9.5	10.8	12.3	15.1	16.9	19.3	21.4	22.5	24.5	26.2	27.6	30.3			
	PIR.W /FT	5.4	5.6	5.7	6.7	7.2	7.3	8.5	9.0	10.3	11.5	14.3	16.3	18.6	21.0	21.7	23.6	25.2	26.5	29.1			
260	PIPE TEMP	250.4	250.0	249.2	247.2	245.4	245.0	241.7	241.0	237.9	233.7	225.6	219.4	212.8	206.2	204.2	199.7	196.1	192.2	185.9			
	PAR.W /FT	6.5	6.7	6.9	8.1	8.7	8.8	10.5	10.9	12.4	14.1	17.3	19.3	22.0	24.8	25.7	28.0	29.8	31.4	34.5			
	PIR.W /FT	6.2	6.4	6.6	7.7	8.2	8.4	9.8	10.3	11.6	13.2	16.3	18.6	21.2	23.9	24.7	26.9	28.4	29.7	33.1			
280	PIPE TEMP	269.0	268.6	267.8	265.4	263.7	263.1	259.3	258.5	255.0	250.4	241.2	234.3	226.9	219.5	217.3	212.3	208.2	203.9	196.9			
	PAR.W /FT	7.4	7.6	7.8	9.2	9.8	10.0	11.8	12.4	14.0	15.9	19.5	21.7	24.8	27.9	28.9	31.5	33.5	35.3	38.7			
	PIR.W /FT	7.1	7.3	7.4	8.7	9.3	9.5	11.1	11.6	13.1	14.9	18.4	21.0	23.9	26.9	27.6	30.2	32.2	33.9	37.2			
300	PIPE TEMP	287.7	287.2	286.3	283.7	281.7	281.1	276.9	276.0	272.1	266.9	256.7	249.1	240.9	232.7	230.3	224.7	220.2	215.5	207.7			
	PAR.W /FT	8.3	8.4	8.7	10.3	11.0	11.2	13.3	13.8	15.7	17.8	21.7	24.2	27.6	31.1	32.0	34.7	36.7	38.4	43.0			
	PIR.W /FT	7.9	8.1	8.3	9.7	10.4	10.6	12.4	13.0	14.9	16.6	20.5	23.4	26.6	29.9	30.9	33.6	35.6	37.7	41.3			
350	PIPE TEMP	334.1	333.6	332.5	329.1	326.6	325.5	320.5	319.5	314.6	308.1	295.4	285.9	275.7	265.4	262.6	255.6	250.1	244.2	234.8			
	PAR.W /FT	10.4	11.0	11.2	13.2	14.1	14.3	16.8	17.4	20.0	22.4	27.3	30.5	34.7	39.4	40.4	43.9	46.4	48.2	53.8			
	PIR.W /FT	10.2	10.4	10.7	12.5	13.3	13.5	15.8	16.5	19.0	21.1	25.9	29.5	33.5	37.6	38.6	42.2	44.9	47.2	51.6			
400	PIPE TEMP	380.3	379.7	378.4	374.3	371.3	370.4	363.9	362.7	356.8	348.9	333.6	322.3	310.0	297.7	294.4	286.1	279.5	272.5	261.2			
	PAR.W /FT	13.3	13.6	13.8	16.3	17.4	17.5	20.8	21.6	24.4	27.6	33.5	37.1	42.1	47.4	48.4	53.1	56.5	59.3	64.9			
	PIR.W /FT	12.8	12.9	13.1	15.3	16.4	16.5	19.4	20.2	22.7	25.7	31.5	35.8	40.5	45.5	46.5	50.9	54.2	56.9	62.2			
450	PIPE TEMP	424.3	423.7	422.4	418.2	415.7	414.7	407.0	405.6	398.7	389.5	371.5	358.3	344.0	329.6	325.9	318.1	310.5	300.5	287.3			
	PAR.W /FT	16.1	16.4	16.6	19.5	20.6	20.9	24.0	24.8	27.7	31.0	37.8	42.1	47.4	52.5	53.5	58.9	62.7	66.1	71.1			
	PIR.W /FT	15.2	15.4	15.7	18.3	19.4	19.7	22.1	22.9	25.9	30.3	37.3	42.2	47.8	53.4	54.4	59.9	63.6	66.4	72.9			
500	PIPE TEMP	472.1	471.4	469.7	464.0	459.9	458.0	449.9	448.3	440.4	429.7	409.1	393.9	377.6	361.2	357.0	349.4	339.7	328.1	313.2			
	PAR.W /FT	18.5	18.8	19.0	22.0	23.1	23.4	26.8	27.6	30.7	34.9	42.1	46.1	51.4	56.4	57.4	63.9	68.0	71.4	77.5			
	PIR.W /FT	17.5	17.8	18.0	21.0	22.1	22.4	25.8	26.6	29.7	33.9	41.1	45.1	50.4	55.4	56.4	61.9	65.8	69.2	75.3			
550	PIPE TEMP	517.7	517.1	515.1	508.5	502.9	502.7	492.5	490.8	481.8	469.7	446.4	429.2	410.9	392.3	387.7	379.3	368.5	355.4	338.7			
	PAR.W /FT	22.0	22.3	22.5	25.4	26.6	26.9	30.3	31.1	34.5	38.8	45.7	50.5	57.8	62.3	63.3	70.9	75.4	78.8	85.0			
	PIR.W /FT	20.7	21.0	21.3	24.2	25.4	25.7	29.1	29.9	33.3	37.6	44.5	49.3	56.6	61.1	62.1	68.7	73.2	76.6	82.8			
600	PIPE TEMP	563.2	562.4	560.3	552.5	547.7	546.6	536.9	535.0	524.9	509.4	483.4	464.1	443.8	423.2	418.1	409.3	397.6	382.3	363.9			
	PAR.W /FT	25.1	25.4	25.6	30.1	31.2	31.5	34.9	35.7	39.1	44.4	52.3	57.1	64.4	68.9	69.9	77.5	82.0	85.4	91.6			
	PIR.W /FT	23.8	24.1	24.4	28.1	29.2	29.5	32.9	33.7	37.1	42.4	49.3	54.1	61.4	65.9	66.9	73.5	78.0	81.4	87.6			
650	PIPE TEMP	608.5	607.7	605.4	597.1	591.3	589.5	577.3	575.0	563.9	548.9	520.1	499.0	476.4	453.7	448.2	439.1	427.3	412.0	393.7			
	PAR.W /FT	28.4	28.7	28.9	33.9	35.0	35.3	38.7	39.5	42.9	48.2	56.1	60.9	68.2	72.7	73.7	81.3	85.8	89.2	95.4			
	PIR.W /FT	26.8	27.1	27.4	31.6	32.7	33.0	36.4	37.2	40.6	45.9	52.8	57.6	64.9	69.4	70.4	77.0	81.5	84.9	91.1			
700	PIPE TEMP	657.7	657.0	654.3	645.1	639.4	637.3	625.1	622.8	611.0	594.7	565.8	542.4	518.9	495.4	490.9	481.8	469.9	454.6	435.5			
	PAR.W /FT	31.8	32.1	32.3	37.4	38.5	38.8	42.2	43.0	46.4	51.7	59.6	64.4	71.7	76.2	77.2	84.8	89.3	92.7	98.9			
	PIR.W /FT	29.7	30.0	30.3	34.5	35.6	35.9	39.3	40.1	43.5	48.8	55.7	60.5	67.8	72.3	73.3	80.9	85.4	88.8	95.0			
750	PIPE TEMP	698																					



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III INSULATION DESIGN

PAGE 402

MAY, 1968

INSULATION THICKNESS REQUIREMENTS

Service Designation T-63

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

3" NOMINAL INSULATION THICKNESS		AMBIENT AIR TEMP 90°F (32.2°C)																		
CABLE TEMP DEG F		PIPE SIZE																		
		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
100	PIPE TEMP	99.5	99.5	99.5	99.4	99.3	99.3	99.1	99.1	98.9	98.7	98.3	97.9	97.4	97.3	97.1	96.9	96.7	96.5	96.1
	MAX W / FT	0.2	0.2	0.2	0.4	0.4	0.4	0.5	0.5	0.6	0.7	0.8	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.8
	MIN W / FT	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.1	1.2	1.3	1.4	1.5	1.6	1.7
120	PIPE TEMP	110.4	110.5	110.4	110.1	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	109.4	108.3
	MAX W / FT	0.9	1.0	1.0	1.2	1.3	1.3	1.5	1.6	1.8	2.1	2.5	2.9	3.3	3.8	4.3	4.8	5.4	6.0	6.6
	MIN W / FT	0.9	0.9	1.0	1.1	1.2	1.3	1.5	1.5	1.7	2.0	2.5	2.8	3.3	3.7	4.2	4.8	5.4	6.0	6.6
140	PIPE TEMP	137.4	137.5	137.3	136.8	136.3	136.2	135.4	135.2	134.4	133.3	131.2	129.6	127.8	126.1	125.5	124.3	123.3	122.2	120.4
	MAX W / FT	1.8	1.7	1.7	2.0	2.2	2.2	2.6	2.7	3.1	3.5	4.2	4.9	5.6	6.3	6.6	7.2	7.7	8.2	9.0
	MIN W / FT	1.5	1.6	1.7	1.9	2.1	2.1	2.5	2.6	2.9	3.4	4.1	4.8	5.5	6.2	6.4	7.0	7.5	7.9	8.7
160	PIPE TEMP	156.4	156.4	156.1	155.4	154.8	154.6	153.4	153.2	152.1	150.5	147.6	145.3	142.8	140.4	139.6	137.8	136.4	134.9	132.7
	MAX W / FT	2.3	2.4	2.5	2.9	3.1	3.2	3.7	3.8	4.3	5.0	6.0	6.9	7.9	9.0	9.3	10.2	10.9	11.5	12.4
	MIN W / FT	2.2	2.3	2.4	2.7	3.0	3.0	3.5	3.7	4.1	4.8	5.9	6.8	7.7	8.7	9.0	9.9	10.5	11.1	12.3
180	PIPE TEMP	175.5	175.3	174.9	174.0	173.2	172.9	171.4	171.1	169.7	167.6	163.9	160.9	157.7	154.6	153.6	151.4	149.5	147.6	144.4
	MAX W / FT	3.0	3.1	3.2	3.7	4.0	4.1	4.8	5.0	5.6	6.5	7.8	9.0	10.3	11.6	12.1	13.2	14.9	16.4	16.4
	MIN W / FT	2.9	3.0	3.1	3.6	3.9	3.9	4.6	4.8	5.4	6.2	7.6	8.8	10.0	11.3	11.7	12.7	13.6	14.4	15.9
200	PIPE TEMP	194.4	194.2	193.7	192.5	191.6	191.2	189.4	189.0	187.3	184.7	180.2	176.4	172.6	168.7	167.5	164.8	162.5	160.2	156.2
	MAX W / FT	3.7	3.9	4.0	4.6	5.0	5.1	6.0	6.2	7.0	8.0	9.6	11.1	12.7	14.3	14.8	16.2	17.3	18.3	20.2
	MIN W / FT	3.6	3.7	3.8	4.4	4.8	4.9	5.7	5.9	6.7	7.7	9.4	10.8	12.3	13.9	14.4	15.7	16.4	17.7	19.5
220	PIPE TEMP	213.3	213.0	212.4	211.0	209.9	209.5	207.3	206.8	204.4	201.8	196.4	191.9	187.3	182.8	181.3	178.1	175.5	172.7	168.0
	MAX W / FT	4.5	4.6	4.8	5.6	6.0	6.1	7.1	7.4	8.4	9.6	11.5	13.2	15.1	17.0	17.7	19.1	20.6	21.7	23.9
	MIN W / FT	4.3	4.4	4.6	5.3	5.7	5.8	6.8	7.1	7.9	9.1	11.2	12.9	14.7	16.5	17.1	18.6	19.9	21.0	23.2
240	PIPE TEMP	232.1	231.8	231.1	229.5	228.2	227.7	225.2	224.6	222.3	218.7	212.5	207.4	202.0	196.8	195.1	191.4	188.4	185.1	179.8
	MAX W / FT	5.3	5.4	5.6	6.5	7.0	7.1	8.3	8.7	9.7	11.2	13.4	15.4	17.5	19.8	20.5	22.3	23.9	25.2	27.8
	MIN W / FT	5.1	5.2	5.4	6.2	6.7	6.8	7.9	8.3	9.3	10.7	13.0	15.0	17.0	19.2	19.9	21.6	23.1	24.4	28.8
260	PIPE TEMP	250.4	250.4	249.8	248.0	246.4	245.9	242.4	242.4	239.7	235.7	228.6	222.4	216.7	210.7	208.8	204.4	201.2	197.5	191.4
	MAX W / FT	6.1	6.2	6.4	7.5	8.1	8.2	9.6	9.9	11.2	12.8	15.3	17.6	20.0	22.4	23.6	25.5	27.2	28.7	31.6
	MIN W / FT	5.8	6.0	6.2	7.2	7.7	7.8	9.1	9.5	10.6	12.2	14.9	17.1	19.4	21.9	22.7	24.7	26.3	27.9	30.6
280	PIPE TEMP	269.7	269.3	268.5	266.3	264.6	264.1	260.7	260.1	257.1	252.4	244.6	238.1	231.3	224.5	222.5	217.8	214.9	209.8	203.1
	MAX W / FT	6.9	7.1	7.3	8.5	9.1	9.2	10.8	11.2	12.6	14.5	17.2	19.8	22.5	25.4	26.3	28.6	30.4	32.1	35.5
	MIN W / FT	6.8	6.9	7.0	8.1	8.7	8.8	10.3	10.7	12.0	13.8	16.8	19.2	21.9	24.6	25.5	27.7	29.6	31.2	34.3
300	PIPE TEMP	288.4	288.0	287.1	284.7	282.8	282.2	278.5	277.8	274.4	269.6	260.6	253.3	245.8	238.3	236.1	230.8	226.6	222.1	214.6
	MAX W / FT	7.6	7.8	8.1	9.5	10.2	10.4	12.1	12.6	14.1	16.2	19.2	22.0	25.1	28.3	29.2	31.8	34.0	35.8	39.4
	MIN W / FT	7.4	7.6	7.8	9.1	9.8	9.9	11.5	12.0	13.5	15.4	18.7	21.4	24.3	27.6	28.3	30.8	32.9	34.7	38.1
350	PIPE TEMP	335.1	334.6	333.5	330.4	328.0	327.3	322.6	321.8	317.6	311.2	300.2	291.2	281.8	272.5	269.7	263.3	258.0	252.4	243.2
	MAX W / FT	10.0	10.2	10.5	12.2	13.1	13.2	15.5	16.0	17.9	20.5	24.3	27.8	31.6	35.6	36.7	40.0	42.7	44.9	49.6
	MIN W / FT	9.8	9.9	10.1	11.6	12.5	12.6	14.6	15.1	17.0	19.5	23.6	27.0	30.6	34.4	35.6	38.7	41.2	43.4	47.7
400	PIPE TEMP	381.5	381.0	379.6	376.4	373.0	372.2	366.5	365.5	360.4	352.8	339.5	328.7	317.5	306.2	303.0	295.3	289.0	282.4	271.4
	MAX W / FT	12.0	12.4	12.9	15.0	16.1	16.2	19.0	19.6	21.9	25.0	29.5	33.7	38.3	43.1	44.0	47.3	50.2	54.2	59.5
	MIN W / FT	11.8	12.0	12.4	14.3	15.3	15.5	17.9	18.7	20.7	23.7	28.7	32.8	37.1	41.7	42.6	45.9	48.6	52.4	57.8
450	PIPE TEMP	427.8	427.2	425.6	421.2	417.6	416.6	410.1	409.0	403.0	394.0	378.5	365.9	352.8	339.6	336.0	327.0	319.7	312.0	299.3
	MAX W / FT	14.0	14.4	14.8	17.0	18.2	18.4	21.3	21.8	24.0	27.7	32.9	38.9	45.2	50.8	52.6	56.0	59.8	63.7	70.8
	MIN W / FT	13.7	14.1	14.5	16.5	17.6	17.8	20.5	21.2	23.4	27.1	32.1	38.1	44.3	49.9	51.6	55.0	58.8	62.5	67.3
500	PIPE TEMP	473.8	473.2	471.5	466.3	462.6	461.6	453.5	452.2	445.4	435.0	417.1	402.7	387.7	372.6	368.6	358.3	350.3	341.3	326.6
	MAX W / FT	16.2	16.6	17.0	20.0	21.4	21.6	24.9	25.4	27.8	32.3	38.4	45.5	52.8	59.6	62.4	66.8	71.4	76.0	83.5
	MIN W / FT	16.0	16.4	16.8	19.8	21.2	21.4	24.7	25.2	27.6	32.1	38.2	45.3	52.6	59.4	62.2	66.6	71.2	75.8	83.0
550	PIPE TEMP	519.8	519.2	517.5	511.2	506.8	505.8	496.8	495.2	487.5	475.7	455.5	439.2	422.3	405.3	400.9	389.3	380.0	370.2	356.1
	MAX W / FT	18.3	18.7	19.1	22.2	23.6	23.8	27.1	27.6	30.0	34.5	41.6	49.7	57.8	65.8	68.8	73.8	79.2	84.8	93.8
	MIN W / FT	18.1	18.5	18.9	21.9	23.3	23.5	26.8	27.3	29.7	34.2	41.3	49.4	57.5	65.7	68.5	72.9	78.3	83.2	87.6
600	PIPE TEMP	565.5	564.8	563.0	556.0	551.0	549.7	539.8	538.1	529.4	516.2	493.5	475.4	456.6	437.7	432.8	419.5	409.7	398.6	381.0
	MAX W / FT	20.3	20.7	21.1	24.2	25.6	25.8	29.1	29.6	32.0	36.5	43.6	51.7	59.8	67.9	70.8	75.8	81.2	86.8	95.8
	MIN W / FT	20.2	20.6	21.0	24.0	25.4	25.6	28.9	29.4	31.8	36.3	43.4	51.5	59.6	67.7	70.5	74.9	79.5	84.1	93.0
650	PIPE TEMP	611.1	610.4	608.6	600.5	595.0	593.7	582.6	580.7	571.1	558.4	531.3	511.1	490.4	469.8	464.5	450.3	439.1	427.1	407.6
	MAX W / FT	22.2	22.6	23.0	26.1	27.5	27.7	31.0	31.5	33.9	38.4	45.5	53.6	61.7	69.8	72.6	77.6	83.0	88.6	98.6
	MIN W / FT	22.0	22.4	22.8	25.8	27.2	27.4	30.7	31.2	33.6	38.1	45.2	53.3	61.4	69.5	72.3	76.7	81.3	85.9	95.9
700	PIPE TEMP	656.6	655.8	653.9	644.8	638.9	637.4	625.0	623.2	612.8	598.4	568.9	547.0	524.3	501.6	495.8	480.6	468.4	455.2	434.0
	MAX W / FT	24.3	24.7	25.1	28.2	29.6	29.8	33.1	33.6	36.0	40.5	47.6	55.7	63.8	71.9	74.7	79.7	85.1	90.6	100.6
	MIN W / FT	24.1	24.5	24.9	27.9	29.3	29.5	32.8	33.3	35.7	40.2	47.3	55.4	63.5	71.6	74.4	78.8	83.4	88.0	98.0
750	PIPE TEMP	701.2	701.2	699.3	689.1	682.6	681.1	667.6	665.5	653.9	638.6	608.2	584.4	559.8	533.1	526.9	510.2	496.0	480.3	460.1
	MAX W / FT	26.3	26.8	27.2	30.2	31.6	31.8	35.1	35.6	38.0	42.5	49.6	57.7	65.8	73.9	76.7	81.7	87.1	92.7	102.7
	MIN W / FT	26.1	26.5	26.9	29.9	31.3	31.5	34.8	35.3	37.7	42.2	49.3	57.4	65.5	73.6	76.4	80.8	85.4	90.0	100.0
800	PIPE TEMP	747.3	746.4	744.5	734.4	727.5	725.9	712.5	710.6	699.0	684.6	654.2	629.8							

INSULATION THICKNESS REQUIREMENTS

Service Designation T-64

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT
PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

3-1/2" NOMINAL INSULATION THICKNESS		PIPE SIZE																AMBIENT AIR TEMP 90.0 F (32.2 C)		
CABLE TEMP DEG F		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
100	PIPE TEMP	99.6	95.5	90.5	84.4	76.3	69.1	63.2	58.1	53.6	49.4	45.4	41.6	38.1	34.7	31.4	28.2	25.1	22.1	19.1
	PARALLEL FEET	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.9	1.0	1.2	1.2	1.3	1.4	1.5
	PISTON FEET	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.9	1.0	1.2	1.2	1.3	1.4	1.5
120	PIPE TEMP	110.7	110.6	110.5	110.2	117.5	117.5	117.4	117.3	116.9	116.3	115.2	114.2	113.3	112.3	112.0	111.3	110.7	110.1	109.1
	PARALLEL FEET	0.5	0.5	1.0	1.1	1.2	1.2	1.4	1.5	1.7	1.9	2.3	2.7	3.1	3.5	3.6	4.0	4.3	4.5	5.0
	PISTON FEET	0.5	0.5	0.5	1.1	1.2	1.2	1.4	1.5	1.6	1.9	2.3	2.6	3.0	3.4	3.5	3.9	4.1	4.4	4.9
140	PIPE TEMP	137.7	137.6	137.4	136.9	136.5	136.4	135.7	135.4	134.7	133.7	131.8	130.3	129.7	127.1	126.5	125.4	124.5	123.4	121.7
	PARALLEL FEET	1.5	1.6	1.6	1.9	2.0	2.1	2.4	2.5	2.8	3.3	3.9	4.5	5.2	5.9	6.1	6.7	7.1	7.5	8.4
	PISTON FEET	1.5	1.5	1.6	1.8	1.9	2.0	2.3	2.5	2.7	3.2	3.8	4.4	5.1	5.7	5.9	6.5	6.9	7.3	8.1
160	PIPE TEMP	152.7	152.6	152.3	151.6	151.1	150.5	150.3	150.5	152.5	151.1	148.5	146.3	144.0	141.8	141.0	139.9	138.1	136.7	134.3
	PARALLEL FEET	2.2	2.2	2.3	2.7	2.7	2.7	3.4	3.6	4.0	4.6	5.4	6.2	7.3	8.3	8.6	9.4	10.0	10.6	11.8
	PISTON FEET	2.1	2.2	2.3	2.6	2.6	2.6	3.3	3.5	3.9	4.5	5.4	6.3	7.1	8.0	8.4	9.1	9.8	10.3	11.4
180	PIPE TEMP	175.7	175.2	175.1	174.3	173.4	173.3	172.0	171.6	170.3	168.4	165.1	162.2	159.3	156.5	155.5	153.6	151.7	149.9	146.8
	PARALLEL FEET	2.8	2.8	3.0	3.5	3.6	3.8	4.4	4.7	5.2	6.0	7.2	8.3	9.5	10.7	11.1	12.1	13.0	13.7	15.2
	PISTON FEET	2.7	2.8	3.0	3.4	3.4	3.6	4.3	4.5	5.1	5.8	7.1	8.1	9.3	10.4	10.8	11.6	12.6	13.4	14.8
200	PIPE TEMP	194.7	194.5	194.0	192.9	192.0	191.7	190.1	189.6	188.0	185.7	181.6	178.1	174.5	171.0	169.8	167.3	165.2	163.0	159.2
	PARALLEL FEET	3.5	3.5	3.6	4.2	4.2	4.4	5.0	5.2	5.8	7.0	8.4	9.7	11.2	12.7	13.2	13.7	14.9	16.0	16.9
	PISTON FEET	3.4	3.5	3.7	4.2	4.2	4.5	5.0	5.3	5.8	6.2	7.2	8.7	10.0	11.4	12.8	13.3	14.5	15.5	16.6
220	PIPE TEMP	213.6	213.3	212.6	211.5	210.5	210.1	208.1	207.5	205.7	202.9	198.1	194.0	189.7	185.5	184.1	181.2	178.7	176.0	171.5
	PARALLEL FEET	4.2	4.4	4.5	5.2	5.6	5.7	6.6	6.9	7.7	8.9	10.7	12.2	13.9	15.7	16.3	17.7	19.0	20.1	22.2
	PISTON FEET	4.1	4.2	4.4	5.0	5.4	5.5	6.3	6.7	7.5	8.6	10.4	11.9	13.6	15.3	15.8	17.3	18.5	19.5	21.6
240	PIPE TEMP	232.5	232.2	231.5	230.1	228.0	228.4	226.1	225.5	223.3	220.1	214.5	209.7	204.8	200.0	198.4	194.9	192.1	189.0	183.8
	PARALLEL FEET	5.0	5.1	5.3	6.1	6.5	6.4	7.7	8.1	9.0	10.3	12.1	14.2	16.2	18.2	18.6	20.6	22.0	23.3	25.7
	PISTON FEET	4.8	4.9	5.1	5.9	6.3	6.4	7.6	7.8	8.7	10.0	12.1	14.2	16.2	18.2	18.7	20.6	21.4	22.6	25.0
260	PIPE TEMP	251.3	251.0	250.3	248.6	247.2	246.7	244.1	243.4	240.9	237.2	230.0	225.4	219.9	214.3	212.6	208.6	205.4	201.9	196.1
	PARALLEL FEET	5.7	5.9	6.1	7.0	7.5	7.4	8.8	9.3	10.3	11.8	14.1	16.2	18.5	20.8	21.3	23.5	25.1	26.5	29.3
	PISTON FEET	5.5	5.7	5.9	6.8	7.3	7.4	8.5	9.0	10.0	11.4	13.8	15.8	18.0	20.2	21.0	22.8	24.4	25.8	28.6
280	PIPE TEMP	270.2	269.8	269.0	267.1	265.5	265.0	262.0	261.2	258.5	254.3	247.1	241.1	234.8	228.6	226.7	222.3	218.7	214.7	208.2
	PARALLEL FEET	6.5	6.7	6.9	8.0	8.5	8.4	10.0	10.5	11.7	13.3	15.9	18.3	20.8	23.4	23.9	26.2	27.8	29.4	32.9
	PISTON FEET	6.3	6.4	6.7	7.7	8.2	8.1	9.6	10.1	11.2	12.9	15.5	17.8	20.2	22.8	23.6	25.7	27.4	29.3	31.9
300	PIPE TEMP	289.0	288.6	287.7	285.5	283.8	283.2	279.5	278.0	274.0	271.3	263.4	256.7	249.9	242.9	240.7	235.9	231.9	227.5	220.4
	PARALLEL FEET	7.3	7.5	7.7	8.9	9.5	9.4	11.2	11.7	13.0	14.9	17.7	20.3	23.1	26.0	26.9	29.3	31.4	33.1	36.5
	PISTON FEET	7.0	7.2	7.5	8.6	9.2	9.1	10.7	11.3	12.5	14.4	17.3	19.8	22.5	25.3	26.2	28.6	30.5	32.2	35.5
320	PIPE TEMP	308.0	307.4	306.2	303.5	301.7	301.0	297.4	295.8	291.5	287.3	278.4	271.7	264.9	257.8	255.6	249.5	245.4	240.9	232.7
	PARALLEL FEET	8.0	8.2	8.4	9.6	10.2	10.1	12.0	12.5	14.0	16.0	18.9	21.6	24.5	27.5	28.4	30.9	32.8	34.5	38.7
	PISTON FEET	7.8	8.0	8.2	9.4	10.0	9.9	11.6	12.1	13.4	15.4	18.2	21.0	23.8	26.6	27.5	29.9	31.8	33.5	37.6
340	PIPE TEMP	327.0	326.4	325.0	321.8	319.9	319.2	315.4	313.8	309.3	305.0	295.0	288.3	281.5	274.6	272.4	265.3	261.2	256.7	247.5
	PARALLEL FEET	8.8	9.0	9.2	10.4	11.0	10.9	12.8	13.3	14.8	16.8	19.7	22.4	25.3	28.3	29.2	31.7	33.6	35.3	39.9
	PISTON FEET	8.6	8.8	9.0	10.2	10.8	10.7	12.4	12.9	14.2	16.2	19.0	21.8	24.6	27.4	28.3	30.7	32.6	34.3	38.6
360	PIPE TEMP	346.0	345.4	343.8	340.4	338.5	337.8	333.9	332.3	327.7	323.4	313.4	306.7	299.9	293.0	290.8	282.7	278.6	274.1	264.9
	PARALLEL FEET	9.6	9.8	10.0	11.2	11.8	11.7	13.6	14.1	15.6	17.6	20.5	23.2	26.1	29.1	30.0	32.5	34.4	36.1	40.9
	PISTON FEET	9.4	9.6	9.8	11.0	11.6	11.5	13.2	13.7	15.0	17.0	19.8	22.6	25.4	28.2	29.1	31.5	33.4	35.1	39.4
380	PIPE TEMP	365.0	364.4	362.8	359.2	357.3	356.6	352.5	350.9	346.3	342.0	332.0	325.3	318.5	311.6	309.4	300.3	296.2	291.7	282.5
	PARALLEL FEET	10.4	10.6	10.8	12.0	12.6	12.5	14.4	14.9	16.4	18.4	21.3	24.0	26.9	29.9	30.8	33.3	35.2	36.9	41.7
	PISTON FEET	10.2	10.4	10.6	11.8	12.4	12.3	14.0	14.5	15.8	17.8	20.6	23.4	26.2	29.0	29.9	32.3	34.2	35.9	40.1
400	PIPE TEMP	384.0	383.4	381.8	378.0	376.1	375.4	371.1	369.5	364.9	360.6	350.6	343.9	337.1	330.2	328.0	318.9	314.8	310.3	301.1
	PARALLEL FEET	11.2	11.4	11.6	12.8	13.4	13.3	15.2	15.7	17.2	19.2	22.1	24.8	27.7	30.7	31.6	34.1	36.0	37.7	42.5
	PISTON FEET	11.0	11.2	11.4	12.6	13.2	13.1	14.8	15.3	16.6	18.6	21.4	24.2	27.0	30.0	30.9	33.3	35.2	36.9	41.1
420	PIPE TEMP	403.0	402.4	400.8	396.8	394.9	394.2	390.0	388.4	383.8	379.4	369.4	362.7	355.9	349.0	346.8	337.7	333.6	329.1	319.9
	PARALLEL FEET	12.0	12.2	12.4	13.6	14.2	14.1	16.0	16.5	18.0	20.0	22.9	25.6	28.5	31.5	32.4	34.9	36.8	38.5	43.3
	PISTON FEET	11.8	12.0	12.2	13.4	14.0	13.9	15.6	16.1	17.4	19.4	22.2	25.0	27.8	30.6	31.5	33.9	35.8	37.5	41.7
440	PIPE TEMP	422.0	421.4	419.8	415.6	413.7	413.0	408.7	407.1	402.5	398.1	388.1	381.4	374.6	367.7	365.5	356.5	352.4	347.9	338.7
	PARALLEL FEET	12.8	13.0	13.2	14.4	15.0	14.9	16.8	17.3	18.8	20.8	23.7	26.4	29.3	32.3	33.2	35.7	37.6	39.3	44.1
	PISTON FEET	12.6	12.8	13.0	14.2	14.8	14.7	16.4	16.9	18.2	20.2	23.0	25.8	28.6	31.4	32.3	34.7	36.6	38.3	42.5
460	PIPE TEMP	441.0	440.4	438.8	434.4	432.5	431.8	427.5	425.9	421.3	416.9	406.9	400.2	393.4	386.5	384.3	375.3	371.2	366.7	357.5
	PARALLEL FEET	13.6	13.8	14.0	15.2	15.8	15.7	17.6	18.1	19.6	21.6	24.5	27.2	30.1	33.1	34.0	36.5	38.4	40.1	44.9
	PISTON FEET	13.4	13.6	13.8	15.0	15.6	15.5	17.2	17.7	19.0	21.0	23.8	26.6	29.4	32.2	33.1	35.5	37.4	39.1	43.3
480	PIPE TEMP	460.0	459.4	457.8	453.2	451.3	450.6	446.3	444.7	439.9	435.5	425.5	418.8	412.0	405.1	402.9	393.9	389.8	385.3	376.1
	PARALLEL FEET	14.4	14.6	14.8	16.0	16.6	16.5	18.4	18.9	20.4	22.4	25.3	28.0	30.9	33.9	34.8	37.3	39.2	40.9	45.7
	PISTON FEET	14.2	14.4	14.6	15.8	16.4	16.3	18.0	18.5	19.8	21.8	24.6	27.4	30.2	33.0	33.9	36.3	38.2	39.9	44.1
500	PIPE TEMP	479.0	478.4	476.8	472.0	470.1	469.4	465.1	463.5	458.7	454.3	444.3	437.6	430.8	423.9	421.7	412.7	408.6	404.1	394.9
	PARALLEL FEET	15.2	15.4	15.6	16.8	17.4	17.3	19.2	19.7	21.2	23.2	26.1	28.8	31.7	34.7	35.6	38.1	40.0	41.7	46.5
	PISTON FEET	15.0	15.2	15.4	16.6	17.2	17.1	18.8	19.3	20.6	22.6	25.4	28.2	31.0	33.8	34.7	37.1	39.0	40.7	44.9
520	PIPE TEMP	498.0	497.4	495.8	490.8	488.9	488.2	483.9	482.3	477.5	473.1	463.1	456.4	449.6	442.7	440.5	431.5			



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SECTION III
INSULATION DESIGN
PAGE 404
MAY, 1968

INSULATION THICKNESS REQUIREMENTS

Service Designation T-65

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT
PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

4" NOMINAL INSULATION THICKNESS			PIPE SIZE																AMBIENT AIR TEMP 90.0 F (32.2 C)			
CABLE TEMP DEG F			3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24	
100	PIPE TEMP	99.6	99.6	99.5	99.4	99.3	99.3	99.2	99.1	99.0	98.8	98.5	98.2	97.9	97.6	97.5	97.3	97.1	96.9	96.6		
	PARALL /FT	C-3	C-3	C-3	C-3	C-4	C-4	C-4	C-5	C-5	C-5	C-6	C-6	C-6	C-6	C-6	C-6	C-6	C-6	C-6		
	PISTON /FT	C-3	C-3	C-3	C-3	C-4	C-4	C-4	C-5	C-5	C-5	C-6	C-6	C-6	C-6	C-6	C-6	C-6	C-6	C-6		
120	PIPE TEMP	110.7	110.6	110.5	110.3	110.9	110.5	110.4	110.3	110.2	110.1	109.9	109.6	109.3	109.0	108.7	108.5	108.3	108.1	107.8		
	PARALL /FT	C-3	C-3	C-3	C-3	C-4	C-4	C-4	C-5	C-5	C-5	C-6	C-6	C-6	C-6	C-6	C-6	C-6	C-6	C-6		
	PISTON /FT	C-3	C-3	C-3	C-3	C-4	C-4	C-4	C-5	C-5	C-5	C-6	C-6	C-6	C-6	C-6	C-6	C-6	C-6	C-6		
140	PIPE TEMP	137.6	137.7	137.5	137.1	136.5	136.4	136.5	136.5	136.5	136.5	136.5	136.5	136.5	136.5	136.5	136.5	136.5	136.5	136.5		
	PARALL /FT	1-4	1-5	1-6	1-8	2-0	2-1	2-3	2-4	2-7	3-0	3-7	4-2	4-8	5-4	5-7	6-2	6-6	7-0	7-6		
	PISTON /FT	1-4	1-5	1-5	1-7	2-0	2-0	2-2	2-3	2-6	3-0	3-6	4-2	4-7	5-3	5-5	6-0	6-5	6-9	7-6		
160	PIPE TEMP	156.9	156.7	156.4	155.8	155.1	154.9	154.1	153.8	152.9	151.6	149.2	147.2	145.1	143.0	142.3	140.8	139.5	138.2	136.9		
	PARALL /FT	2-1	2-1	2-2	2-5	2-5	2-5	3-2	3-4	3-8	4-3	5-2	6-0	6-8	7-7	8-0	8-7	9-3	9-9	11-0		
	PISTON /FT	2-0	2-1	2-2	2-5	2-8	2-5	3-1	3-3	3-7	4-2	5-1	5-9	6-7	7-5	7-8	8-5	9-1	9-7	10-7		
180	PIPE TEMP	175.5	175.7	175.3	174.6	173.8	173.3	172.4	172.0	170.8	169.1	166.0	163.4	160.7	158.0	157.1	155.2	153.5	151.8	149.8		
	PARALL /FT	2-7	2-8	2-9	3-3	3-8	3-8	4-2	4-4	4-9	5-5	6-7	7-8	8-8	9-9	10-3	11-3	12-1	12-8	13-2		
	PISTON /FT	2-6	2-7	2-8	3-2	3-8	3-7	4-1	4-3	4-8	5-4	6-6	7-6	8-7	9-7	10-1	11-0	11-8	12-5	13-8		
200	PIPE TEMP	194.9	194.7	194.2	193.3	192.0	191.7	190.5	190.1	188.7	186.6	182.7	179.5	176.2	172.9	171.8	169.5	167.5	165.3	161.7		
	PARALL /FT	3-4	3-5	3-6	4-1	4-7	4-8	5-2	5-5	6-1	6-8	8-1	9-4	10-9	12-2	12-7	13-9	14-9	15-7	17-4		
	PISTON /FT	3-3	3-4	3-5	4-0	4-5	4-8	5-0	5-3	5-9	6-7	8-1	9-4	10-7	12-0	12-4	13-6	14-5	15-4	17-0		
220	PIPE TEMP	213.8	213.6	213.1	211.9	210.5	210.1	208.7	208.1	206.5	204.0	199.4	195.6	191.7	187.8	186.5	183.7	181.3	178.4	174.5		
	PARALL /FT	4-0	4-1	4-3	4-9	5-6	5-7	6-2	6-5	7-3	8-1	9-9	11-4	13-0	14-6	15-1	16-5	17-7	18-7	20-7		
	PISTON /FT	3-9	4-0	4-2	4-8	5-4	5-5	6-0	6-4	7-1	8-0	9-7	11-2	12-7	14-2	14-8	16-1	17-2	18-2	20-2		
240	PIPE TEMP	232.8	232.5	231.9	230.8	229.6	228.4	226.8	226.2	224.2	221.4	216.1	211.7	207.1	202.4	201.1	197.9	195.2	192.2	187.3		
	PARALL /FT	4-7	4-8	5-0	5-7	6-5	6-6	7-2	7-6	8-5	9-5	11-5	13-2	15-1	16-9	17-4	19-2	20-5	21-7	24-0		
	PISTON /FT	4-6	4-7	4-9	5-6	6-3	6-4	7-0	7-4	8-2	9-3	11-3	13-0	14-7	16-5	17-2	18-7	20-0	21-2	23-4		
260	PIPE TEMP	251.7	251.4	250.7	249.1	247.2	246.7	244.9	244.2	241.9	238.7	232.7	227.6	222.5	217.3	215.7	212.0	208.9	205.6	200.0		
	PARALL /FT	5-4	5-6	5-8	6-6	7-5	7-6	8-3	8-7	9-7	10-9	13-2	15-1	17-2	19-3	20-0	21-6	23-4	24-7	27-3		
	PISTON /FT	5-3	5-4	5-6	6-4	7-3	7-4	8-1	8-5	9-4	10-7	12-9	14-8	16-8	18-9	19-6	21-3	22-8	24-1	26-7		
280	PIPE TEMP	270.6	270.2	269.5	267.7	265.5	265.0	262.9	262.1	259.6	256.0	249.2	243.6	237.8	232.0	230.2	226.1	222.6	218.9	212.7		
	PARALL /FT	6-2	6-3	6-5	7-5	8-5	8-6	9-4	9-9	10-9	12-2	14-8	17-0	19-3	21-7	22-5	24-5	26-3	27-8	30-7		
	PISTON /FT	6-0	6-1	6-4	7-3	8-2	8-3	9-1	9-6	10-6	12-0	14-5	16-7	18-9	21-2	22-0	24-0	25-8	27-1	29-9		
300	PIPE TEMP	289.4	289.1	288.2	286.2	283.8	283.2	280.9	280.0	277.3	273.2	265.7	259.5	253.0	246.6	244.6	240.1	236.1	232.1	225.2		
	PARALL /FT	6-9	7-1	7-3	8-4	9-5	9-6	10-5	11-0	12-2	13-7	16-5	18-9	21-5	24-2	25-0	27-3	29-2	30-9	34-1		
	PISTON /FT	6-7	6-9	7-1	8-1	9-2	9-3	10-2	10-8	11-9	13-6	16-2	18-6	21-0	23-6	24-5	26-8	28-5	30-1	33-2		
320	PIPE TEMP	308.4	308.0	307.0	304.8	302.3	301.7	300.0	299.0	296.0	291.9	286.7	280.9	274.9	268.9	266.9	262.1	258.1	254.1	247.5		
	PARALL /FT	6-9	7-1	7-3	8-4	9-5	9-6	10-5	11-0	12-2	13-7	16-5	18-9	21-5	24-2	25-0	27-3	29-2	30-9	34-1		
	PISTON /FT	6-8	6-9	7-1	8-1	9-2	9-3	10-2	10-8	11-9	13-6	16-2	18-6	21-0	23-6	24-5	26-8	28-5	30-1	33-2		
340	PIPE TEMP	327.2	326.7	325.5	323.0	320.3	319.7	317.9	316.9	313.9	309.7	304.5	298.9	293.3	287.7	285.7	280.9	276.9	272.9	265.7		
	PARALL /FT	11-0	11-2	11-5	12-2	13-0	13-1	13-7	14-1	15-3	17-0	19-3	21-9	24-6	27-3	28-1	30-4	32-3	34-0	37-7		
	PISTON /FT	10-9	11-0	11-2	12-0	12-8	12-9	13-6	14-0	15-2	16-9	19-2	21-8	24-4	27-0	27-8	30-1	32-0	33-7	37-4		
360	PIPE TEMP	383.2	382.7	381.5	378.4	375.5	374.9	373.0	371.9	368.9	364.7	359.5	353.9	348.3	342.7	340.7	336.1	332.1	328.1	320.7		
	PARALL /FT	13-0	13-2	13-5	14-2	15-0	15-1	15-7	16-1	17-3	19-0	21-3	23-9	26-6	29-3	30-1	32-4	34-3	36-0	40-7		
	PISTON /FT	12-9	13-0	13-2	14-0	14-8	14-9	15-6	16-0	17-2	18-9	21-2	23-8	26-4	29-0	29-8	32-1	34-0	35-7	39-4		
400	PIPE TEMP	429.8	429.3	428.0	424.2	420.3	419.7	417.8	416.7	413.2	408.3	401.0	393.9	386.9	379.9	377.9	373.3	369.3	365.3	357.9		
	PARALL /FT	13-2	13-4	13-6	14-3	15-1	15-2	15-8	16-2	17-4	19-1	21-4	24-0	26-7	29-4	30-2	32-5	34-4	36-1	40-8		
	PISTON /FT	13-0	13-2	13-4	14-1	14-9	15-0	15-7	16-1	17-3	19-0	21-3	23-9	26-5	29-1	29-9	32-2	34-1	35-8	39-5		
440	PIPE TEMP	476.3	475.7	474.0	469.2	465.3	464.7	462.8	461.7	458.2	453.3	446.0	438.9	431.9	424.9	422.9	418.3	414.3	410.3	402.9		
	PARALL /FT	15-3	15-5	15-8	16-5	17-3	17-4	17-9	18-3	19-5	21-2	23-5	25-9	28-6	31-3	32-1	34-4	36-3	38-0	42-7		
	PISTON /FT	15-0	15-2	15-4	16-1	16-9	17-0	17-7	18-1	19-3	21-0	23-3	25-9	28-5	31-1	31-9	34-2	36-1	37-8	41-5		
480	PIPE TEMP	522.6	522.0	520.1	515.3	511.3	510.7	508.8	507.7	504.2	499.3	492.0	484.9	477.9	470.9	468.9	464.3	460.3	456.3	448.9		
	PARALL /FT	16-0	16-2	16-4	17-1	17-9	18-0	18-5	18-9	20-1	21-8	24-1	26-5	29-2	31-9	32-7	35-0	36-9	38-6	43-3		
	PISTON /FT	15-9	16-0	16-2	16-9	17-7	17-8	18-3	18-7	20-0	21-7	24-0	26-6	29-2	31-8	32-6	34-9	36-8	38-5	42-2		
520	PIPE TEMP	569.7	569.1	567.2	562.4	558.5	557.9	556.0	554.9	551.4	546.5	540.0	532.9	525.9	518.9	516.9	512.3	508.3	504.3	496.9		
	PARALL /FT	16-3	16-5	16-8	17-5	18-3	18-4	18-9	19-3	20-5	22-2	24-5	26-9	29-6	32-3	33-1	35-4	37-3	39-0	43-7		
	PISTON /FT	16-2	16-3	16-5	17-2	18-0	18-1	18-6	19-0	20-2	21-9	24-2	26-8	29-4	32-0	32-8	35-1	37-0	38-7	42-4		
560	PIPE TEMP	616.8	616.1	614.2	609.4	605.5	604.9	603.0	601.9	598.4	593.5	586.0	578.9	571.9	564.9	562.9	558.3	554.3	550.3	542.9		
	PARALL /FT	17-1	17-3	17-6	18-3	19-1	19-2	19-7	20-1	21-3	23-0	25-3	27-7	30-4	33-1	33-9	36-2	38-1	39-8	44-5		
	PISTON /FT	17-0	17-1																			

INSULATION THICKNESS REQUIREMENTS

Service Designation U-1
U-2

UNDERGROUND INSULATION THICKNESSES HIGH TEMPERATURE SERVICE

PLANTS: SILICONES, SISTERSVILLE, MONTREAL 053, TORRANCE 513,
NIAGARA FALLS 516

SPEC. NO'S: 38-H URETHANE FOAM SERVICE: PROCESS AND LOW
PVA JACKET PRESSURE STEAM

NOM PIPE SIZE	OPERATING TEMPERATURE ° C							
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119			
1 1/2	1	1	1	1	1			
2	1	1	1	1	1			
3	1	1	1	1	1			
4	1	1	1	1	1			
5	1	1	1	1	1			
6	1	1	1	1	1			
8	1	1	1	1	1			
10	1	1	1	1	1			
12	1	1	1	1	1			
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247			
	OPERATING TEMPERATURE ° F							

UNDERGROUND INSULATION THICKNESSES HIGH TEMPERATURE SERVICE

PLANTS
KAWAHA VALLEY PLANTS, GULF COAST
PLANTS, AND WHITING PLANT
SPEC. NO'S 38-H URETHANE FOAM -
PVC-JACKET SERVICE: PROCESS AND LOW
PRESSURE STEAM LINES

NOM. PIPE SIZE	OPERATING TEMPERATURE ° C							OPERATING TEMPERATURE ° F
	20	40	60	80	100			
1	1	1	1	1	1			
2	1	1	1	1	1			
3	1	1	1	1	1			
4	1	1	1	1	1			
5	1	1	1	1	1			
6	1	1	1	1	1			
8	1	1	1	1	1			
10	1	1	1	1	1			
	68	104	140	176	212			
	160	132	175	211	247			

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INSULATION THICKNESS REQUIREMENTS

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UNDERGROUND INSULATION THICKNESSES
HIGH TEMPERATURE SERVICEPLANTS: PONCE
SPEC. NO'S: 38-H URETHANE FOAM PVC JACKET SERVICE: PROCESS & LOW PRESSURE
STEAM

NOM PIPE SIZE	OPERATING TEMPERATURE °C				
	20	40	60	80	100
	to	to	to	to	to
	39	59	79	99	119
1½	1	1	1	1	1
3/4	1	1	1	1	1
1	1	1	1	1	1
1½	1	1	1	1	1
1½	1	1	1	1	1
2	1	1	1	1	1
2½	1	1	1	1	1
3	1	1	1	1	1
3½	1	1	1	1	1
4	1	1	1	1	1
6	1	1	1	1	2
8	1	1	1	2	2
10	1	1	1		
	68	104	140	176	212
	to	to	to	to	to
	103	139	175	211	247
OPERATING TEMPERATURE °F					

Note Maximum size conduit jacket 12" ID



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
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INSULATION THICKNESS REQUIREMENTS

Service Designation U-4
U-5

UNDERGROUND INSULATION THICKNESSES HIGH TEMPERATURE SERVICE

PLANTS: GULF COAST PLANTS - SEADRIFT 510, TEXAS CITY 515,
TAFT 519, BROWNSVILLE 526
SPEC. NO'S: 10-U and 10-USS SERVICE: STEAM AND PROCESS PIPE -
CELLULAR GLASS UNDERGROUND

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259					
1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
3/4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
1	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
2 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
3	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
3 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
6	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
8	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
10	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
12	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
14	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
16	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
18	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
20	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
22	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
24	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
26	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
28	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
30	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
36	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
												OPERATING TEMPERATURE ° F					
68	104	140	176	212	248	284	320	356	392	428	464						
to	to	to	to	to	to	to	to	to	to	to	to	to	to	to	to	to	to
103	139	175	211	247	283	319	355	391	427	463	499						

UNDERGROUND INSULATION THICKNESSES HIGH TEMPERATURE SERVICE

PLANTS: KANAWHA VALLEY PLANTS - INSTITUTE 512, S. CHAS. 514
SPEC. NO'S: 10-U and 10-USS SERVICE: STEAM AND PROCESS LINES
CELLULAR GLASS UNDERGROUND

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259					
1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
3/4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
1	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
2 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
3	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
3 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
6	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
8	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
10	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
12	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
14	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
16	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
18	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
20	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
22	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
24	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
26	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
28	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
30	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
36	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
68	104	140	176	212	248	284	320	356	392	428	464						
103	139	175	211	247	283	319	355	391	427	463	499						
												OPERATING TEMPERATURE ° F					

INSULATION THICKNESS REQUIREMENTS

Service Designation U-6
U-7

UNDERGROUND INSULATION THICKNESSES HIGH TEMPERATURE SERVICE

PLANTS: TORRANCE PLANT 513
SPEC. NO'S: 10-U and 10-U55
SERVICE: STEAM AND PROCESS PIPE -
CELLULAR GLASS UNDERGROUND

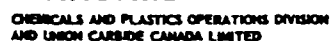
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UNDERGROUND INSULATION THICKNESSES HIGH TEMPERATURE SERVICE

PLANTS: WHITING PLANT, SILICONE PLANT-SISTERSVILLE,
ALOTREAL 053, NIAGARA FALLS 516
SPEC. NO.'s 10-U and 10-USS CELLULAR GLASS SERVICE: STEAM AND PROCESS
PIPE - UNDERGROUND

NOM. PIPE SIZE	OPERATING TEMPERATURE °C																							
	20	40	60	80	100	120	140	160	180	200	220	240	30	50	70	90	110	130	150	170	190	210	230	250
1	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
2	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
3	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
4	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
5	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
6	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
8	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
10	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
12	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
14	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
16	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
18	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
20	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
22	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
24	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
26	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
28	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
30	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
36	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
68	104	140	176	212	248	284	320	356	392	428	464		10	10	10	10	10	10	10	10	10	10	10	10
103	137	175	211	247	283	319	355	391	427	463	499		10	10	10	10	10	10	10	10	10	10	10	10

OPERATING TEMPERATURE ° F



INSULATION THICKNESS REQUIREMENTS

UNDERGROUND INSULATION THICKNESSES HIGH TEMPERATURE SERVICE

PLANTS: PONCE
SPEC. NO'S: 10-U and 10-USS CELLULAR GLASS SERVICE: STEAM AND
PROCESS PIPE-UNDERGROUND

NOM PIPE SIZE	OPERATING TEMPERATURE ° C											
	20	40	60	80	100	120	140	160	180	200	220	240
	to 39	to 59	to 79	to 99	to 119	to 139	to 159	to 179	to 199	to 219	to 239	to 259
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
¾	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
2	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
2½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
3	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2
3½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2
4	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2
6	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½
8	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½
10	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½	3
12	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3
14	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3
16	1½	1½	1½	1½	2	2	2½	2½	2½	3	3	3
18	1½	1½	1½	1½	2	2	2½	2½	2½	3	3	3
20	1½	1½	1½	1½	2	2	2½	2½	2½	3	3	3
22	1½	1½	1½	1½	2	2	2½	2½	2½	3	3	3
24	1½	1½	1½	1½	2	2	2½	2½	2½	3	3	3
26	1½	1½	1½	1½	2	2	2½	2½	2½	3	3	3
28	1½	1½	1½	1½	2	2½	2½	2½	3	3	3	3½
30	1½	1½	1½	2	2	2½	2½	2½	3	3	3	3½
36	1½	1½	1½	2	2	2½	2½	2½	3	3	3	3½
	68	104	140	176	212	248	284	320	356	392	428	464
	to 103	to 139	to 175	to 211	to 247	to 283	to 319	to 355	to 391	to 427	to 463	to 499
	OPERATING TEMPERATURE ° F											

INSULATION THICKNESS REQUIREMENTS

Service Designation U-10

UNDERGROUND INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: WHITING PLANT 517, SILICONE PLANT-SISTERSVILLE, MONTREAL 053, NIAGARA FALLS 516
SPEC. NO'S: 37-H SERVICE: STEAM AND PROCESS PIPE - UNDERGROUND

[illegible]

NOTE: Largest standard size of conduit is 18" ID

INSULATION THICKNESS REQUIREMENTS

Service Designation U-12

UNDERGROUND INSULATION THICKNESSES HIGH TEMPERATURE SERVICE

PLANTS: GULF COAST PLANTS - SEADRIFT 510, TEXAS CITY 515, TAFT 519, BROWNSVILLE 526
SPEC. NO'S: SERVICE: STEAM AND PROCESS PIPE - UNDERGROUND

[illegible]



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INSULATION THICKNESS REQUIREMENTS

Service Designation U-13

UNDERGROUND INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE
SERVICE: STEAM AND PROCESS PIPE - UNDERGROUND

PLANTS: PONCE
SPEC. NO'S: 37-H

NOM. PIPE SIZE	OPERATING TEMPERATURE °C																												OPERATING TEMPERATURE °F																											
	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	350	360	400	420	440	460	480	500	520	540																													
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2																											
3/4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2																											
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2																											
1 1/4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2																											
1 1/2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2																											
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2																											
2 1/2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2																											
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2																											
3 1/2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2																											
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2																											
6	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2 1/2	2 1/2	2 1/2	2 1/2																											
8	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2 1/2	2 1/2	2 1/2	2 1/2																											
10	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2 1/2	2 1/2	2 1/2	2 1/2																											
12	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2 1/2	2 1/2	2 1/2	2 1/2																											
14	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2 1/2	2 1/2	2 1/2	2 1/2																											
EQUIP FLAT																																																								
58	104	140	176	212	248	284	320	356	392	428	464	500	536	572	608	644	680	716	752	788	824	860	896	932	968	1004																														
103	159	175	211	247	283	319	355	391	427	463	499	535	571	607	643	679	715	751	787	823	859	895	931	967	1003	1039																														

Note: Largest standard size of conduit is 18" ID



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SHORT FORM JOB SHEETS

The short form job sheets included in this section do not constitute a part of Insulation Design. They are included to serve requests for a short single page instruction sheet for individual field applications. These sheets are presented so that copies of them could be made to serve that need.

For this reason the first part of the sheet was layed out as a form which could be filled in to direct work on a specific individual piece of equipment, pipe or duct to be insulated. The required information could be entered on the form by construction or maintenance engineer or designer and directed through correct channels to procure materials and their field application.

The List of Materials was given so that it would not be necessary, for each case, to refer back to the "Thermal Insulation Manual - Volume I Specifications". It would serve both as a list for procurement and a check list by the applicator to determine that material required was available at the point of installation. It is suggested that sheets, given the field applicator, the numbers referring to "MATERIAL SPECIFICATION" be removed and that individual store room numbers for each item be inserted.

Preparation was listed so that important preinsulation preparations such as to see that correct insulation supports are available and that proper surface preparation is not overlooked.

Where heat tracers are required, these too must be properly installed before application of insulation.

References to proper "MANUALS" or "ENGINEERING STANDARDS" are given so that in case of question the individual is directed to the proper information for answers.

Application is listed in brief form to assist and guide the applicator. The condensed brief form specification only points out what is to be done in very broad manner. Applicators with firm knowledge and experience of the individual specification could follow these directions with little reference to THERMAL INSULATION MANUAL - VOLUME I, SPECIFICATIONS. Where specific detailed information is needed, the proper references are provided.

A listing of the Short Form Job Sheets provided in this section follows.

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<u>Specification Number</u>	<u>Insulation Material</u>	<u>Operating Temperature °F</u>	<u>Type of Service</u>
10-H & HSS	Cellular glass	50 to 600	Equip & Piping
10-J & JSS	Cellular glass	50 to 400	Equip & Piping
10-JU & JUSS	Cellular glass	50 to 350	Underground piping
10-L & LSS	Cellular glass	-250 to 400	Equip & piping
10-LSP	Cellular glass	-40 to 150	Spheres
10-LOX	Cellular glass	-250 to Atmos	Oxygen equip & piping
12-H & HSS	Rigid urethane foam	50 to 250	Equip & piping
14-J	Flexible plastic foam	32 to 180	Equip & piping
15-H	Heavy density fibrous glass	70 to 750	Equip & piping
16-H	Low density fibrous glass	70 to 350	Equip & piping
17-RX	Rigid fibrous glass	60 to 150	Exterior of A. C. ducts
17-RY	Rigid fibrous glass	60 to 150	Interior of A. C. ducts
18-FX	Flexible fibrous glass	60 to 150	Exterior of A. C. ducts
18-FY	Flexible fibrous glass	60 to 150	Interior of A. C. ducts
19-H	Mineral wool with facing	60 to 450	Large diameter vessels
19-J	Fibrous glass with facing	60 to 350	Large diameter vessels
21-H & HSS	Asbestos fibers	70 to 1000	Piping
22-H & HSS	Bonded expanded silica	70F to 1600	Equip & piping
22-HSP & HSPSS	Bonded expanded silica	70F to 500	Spheres
23-H & HSS	Calcium silicate(regular)	70 to 950	Equip & piping

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<u>Specification Number</u>	<u>Insulation Material</u>	<u>Operating Temperature °F</u>	<u>Type of Service</u>
25-H	Calcium silicate (high temp.)	750 to 1600	Equip & piping
31-H & HSS	Stainless cased-reflective	33 to 1000	Equip & piping
32-HFP & HFPSS	Bonded expanded silica	40 to 1600	Fire protection, equip & piping
32-LFP & LFPSS	Cellular glass & bonded expanded silica	-250 to 400	Fire protection equip & piping
37-H	Metal conduit - insul as selected	40 to 750	Underground piping
38-H	Urethane foam, PVC jacket pipe system	50 to 250	Underground piping
39-H	Bituminous fill	220 to 550	Underground piping
40-J	Cork filled PVA mastic	34 to 180	Equip & piping
41-H	Sprayed asbestos fibers	70 to 700	Equip
42-H	Sprayed asbestos fibers	70 to 1350	Equip
43-H & HSS	Sprayed urethane foam	50 to 250	Equip

Note: SS in specification number indicates suitable for use on stainless steel surface.



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MAY, 1968SPECIFICATION NO. 10-H, 10-HSS, CELLULAR GLASS(High Temperature Service
Max. 600F)EQUIPMENT INSULATION

	<u>VESSEL OR COLUMN</u>	<u>DUCT OR FLAT SURFACE</u>
PLANT _____	ITEM NO. _____ METAL _____	TOP AND BOTTOM: _____
UNIT _____	BODY: Dia. _____ LENGTH _____	WIDTH _____
WORK ORDER _____	HEADS _____ SHAPE _____	LENGTH _____
ACCOUNT NO. _____	VESSEL FLANGES _____	SIDES: _____
DATE _____	MANHOLES _____	WIDTH _____
	NOZZLES _____	LENGTH _____
	SKIRT OR LEGS _____	
	INSULATION THICKNESS " _____	

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIAL SPECIFICATIONS

Cellular Glass	Spec. 10.	Strapping Tape	VII. A. 33.
Cushioning Material		High Temperature	
Equipment above 350F	VII. A. 1.	Fabricating Cement	VII. A. 91.
Equipment at 350F and below	VII. A. 2.	Heat Resistant Sealer	VII. A. 42.
Insulating Cement	VII. A. 6.	Non Setting Sealer	VII. A. 88.
Equipment Insulation Strap	VII. A. 11.	Mastic (Caulking)	VII. A. 45.
Clips for Equipment Strap	VII. A. 12.	Weather Barrier	
Stainless Steel Wire	VII. A. 17.	Mastic, color as specified,	
Welding Pins	VII. A. 19.	Trowel Grade,	
Stainless Steel Pins	VII. A. 20.	Designation WC	VII. B. 1. a.
Stainless Steel Skewers	VII. A. 21.	Mastic, color as specified,	
Strap Anchor Clips	VII. A. 24.	Spray Grade,	
Staples	VII. A. 25.	Designation WB	VII. B. 1. a.
		Reinforcing Cloth	VII. B. 1. b.

Note: For 10-HSS (on stainless steel equipment), use only Cushioning Material
VII. A. 1.PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
GENERAL SPECIFICATIONSSurface:Surface shall be clean and dry and, where required, steel or stainless steel shall
be coated in accordance with "COATING MANUAL".

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MAY, 1968PREPARATION: Continued

(10-H, 10-HSS Equip. Contd)

Insulation Supports:

Welded (vendor installed where possible) as per Standards EQ-64. Bolted on as per Standards IS-31, 31A, 36, 42.

Tracing: (Where Required)

Heat Transfer Cement, Materials, MATERIAL SPECIFICATIONS VII. C. Application, GENERAL SPECIFICATIONS XIII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL, VOLUME 1", SPECIFICATIONS NO. 10-H, 10-HSS

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather Barrier</u>
Curved Side Walls	Curved block (single layer to 2 1/2" thick, double above). 1" cushion blanket under curved blocks	Strap for Wire for Blanket	Mastic
Heads	Preformed block 2" cushion blanket under curved block as shown in Figure 10-H. 1	Strap and Wire	Mastic
Vessel Flanges	Preformed covers as shown in Figure 10-H. 3	Strap, Skewers, Wire	Mastic and Stainless Steel
Nozzles	Preformed covers as shown in Figure 10-H. 6	Strap, Skewers, Wire	Mastic
Legs - Channel	Block down to fire proofing as shown in Figure 10-H. 10	Strap Wire	Mastic
Legs - Concrete Filled	Not insulated		
Flat Surfaces	Block and insulating cement as shown in Figure 10-H. 2	Pins, Pin Clips	Mastic
Skirts & Cradles	Not insulated unless required for fire protection		

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MAY, 1968SPECIFICATION NO. 10-H, 10-HSS, CELLULAR GLASS(High Temperature Service
Max 600F)PIPING INSULATIONPIPE

	<u>LINE NO.</u>	<u>SIZE</u>	<u>LOCATION</u>	<u>METAL</u>	<u>INSUL THK "</u>
PLANT _____	_____	_____	_____	_____	_____
UNIT _____	_____	_____	_____	_____	_____
WORK ORDER _____	_____	_____	_____	_____	_____
ACCOUNT NO. _____	_____	_____	_____	_____	_____
DATE _____	_____	_____	_____	_____	_____
WEATHER BARRIER: STRAIGHT PIPE _____ FITTINGS _____ MASTIC _____					

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIAL SPECIFICATIONS

Cellular Glass Insulation	Spec. 10.	Strapping Tape	VII. A. 33.
Cushioning Material		High Temperature Fabri-	
Piping above 350F	VII. A. 3.	cation Cement	VII. A. 34.
Piping 350F and below	VII. A. 4.	Heat Resistant Sealer	VII. A. 42.
Insulating Cement	VII. A. 6.	Non Setting Sealer	VII. A. 88.
Pipe Insulation Support	VII. A. 9.	Mastic (Caulking)	VII. A. 45.
Pipe Insulation Strap	VII. A. 13.	Weather Barrier: As Specified	
Clips for Pipe Strap	VII. A. 14.	Mastic, color as specified,	
Stainless Steel Wire	VII. A. 17.	Trowel Grade,	
Stainless Steel Skewers	VII. A. 21.	Designation WC	VII. B. 1. a.
		Reinforcing Cloth	VII. B. 1. b.
		Stainless Steel Jacket,	
		Designation M	VII. B. 2.
		Treated Steel Jacket,	
		Designation MT	VII. B. 3.

Note: For 10-HSS(on Stainless Steel Piping) Use Only Cushion Material VII. A. 1.

PREPARATION: As specified in "THERMAL INSULATION MANUAL, VOLUME 1",
GENERAL SPECIFICATIONSSurface:Steel shall be clean and dry. Stainless steel shall be coated as per "COATING
MANUAL".Insulation Supports:

Vertical pipe, over 4" NPS, as shown in Figure 10-H-18.

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MAY, 1968**PREPARATION:** Continued

(10-H, 10-HSS Piping, Contd)

Tracing: (Where Required)

Steam, installed per Standard P-140, P-140A. Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

Electric, installed per Standard EL-43. Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

Heat Transfer Cement, Materials. MATERIAL SPECIFICATIONS VII. C.
Application, GENERAL SPECIFICATIONS XIII. B.**APPLICATION:** Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION 10-H, HSS

<u>Component</u>	<u>Type and Form Of Insulation</u>	<u>Securement</u>	<u>Weather-Barrier</u>
Straight Pipe	Cushion blanket under all sectional pipe and fitting insulation. Sectional insulation (single layer to 2 1/2" thick. Double layer 3" thick and above.	<u>For All Pipe and Fittings</u> Wire for blanket Wire for inner layers Strap for all other	Mastic or Steel Jacket
Insulation Expansion Joints	Install: Up to 2 1/2" thick one each 60 ft, 3" to 5" thick one every 45 ft, 5 1/2" to 7 1/2" one every 30 ft	Strap	Mastic and Stainless Steel Sleeves
Gate and Globe Valves	Preformed as per "UCC Fab. Manual"* as shown in Figure 10-H-16	Strap	Mastic
Ball & Plug Valves	Field cut from sectional covering	Strap	Mastic
Flanged Fittings	Preformed as per "UCC Fab. Manual"* as shown in Figure 10-H-15	Strap	Mastic
Welded Ells	Preformed as per "UCC Fab. Manual"* as shown in Figure 10-H-12	Strap	Mastic
Screwed Fittings	Preformed as per "UCC Fab. Manual"*	Strap	Mastic

* Or ASTM Recommended Practice C-450, Latest Revision.

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MAY, 1968SPECIFICATION NO. 10-J, 10-JSS, CELLULAR GLASS(Moderate Temperature Service,
Max. 400F)EQUIPMENT INSULATION

	<u>VESSEL OR COLUMN</u>	<u>DUCT OR FLAT SURFACE</u>
PLANT _____	ITEM NO. _____ METAL _____	TOP AND BOTTOM:
UNIT _____	BODY: Dia. _____ LENGTH _____	WIDTH _____
WORK ORDER _____	HEADS _____ SHAPE _____	LENGTH _____
ACCOUNT NO. _____	VESSEL FLANGES _____	SIDES:
DATE _____	MANHOLES _____	WIDTH _____
	NOZZLES _____	LENGTH _____
	SKIRT OR LEGS _____	
WEATHER BARRIER _____	INSULATION THICKNESS " _____	

(MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIAL SPECIFICATIONS

Cellular Glass	Spec. 10.	High and Low Temperature	
Equipment Insulation Strap	VII. A. 11.	Anti-Abrasive Coating	VII. A. 40.
Clips for Equipment Strap	VII. A. 12.	Mastic (Caulking)	VII. A. 45.
Stainless Steel Wire	VII. A. 17.	Weather Barrier, as specified	
Welding Pins	VII. A. 19.	Mastic, color as specified,	
Stainless Steel Pins	VII. A. 20.	Trowel Grade,	
Stainless Steel Skewers	VII. A. 21.	Designation WC	VII. B. 1. a.
Strap Anchor Clip	VII. A. 24.	Mastic, color as specified,	
Strapping Tape	VII. A. 33.	Spray Grade,	
Insulating Cement	VII. A. 6.	Designation WB	VII. B. 1. a.
Moderate Temperature		Reinforcing Cloth	VII. B. 1. b.
Fabrication Cement	VII. A. 35.	Stainless Steel Jacket,	
Heat Resistant Sealer	VII. A. 42.	Designation M	VII. B. 2.
Glass Wool Metal Mesh Blanket	VII. A. 86.	Treated Steel Jacket,	
Non Setting Sealer	VII. A. 88.	Designation MT	VII. B. 3.

(PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
GENERAL SPECIFICATIONS

Surface:

(Surface shall be clean and dry. Steel or stainless steel, where required, shall be coated in accordance with "COATINGS MANUAL".

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MAY, 1968PREPARATION: Continued

(10-J, 10-JSS Equip, Contd)

Insulation Supports:

Welded (vendor installed where possible) as per Standards EQ-64. Bolted as per Standards EQ-67, 68, 69.

Tracing: (Where Required)

Heat Transfer Cement, Materials - MATERIAL SPECIFICATIONS VII. C. Application, GENERAL SPECIFICATIONS XIII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION NO. 10-J, 10-JSS

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather Barrier</u>
Curved Side Walls	Curved block (single layer to 2 1/2" thick, double above)	Strap	Mastic or Steel Jacket
Heads	Preformed block as shown in Figure 10-J. 1	Strap, Wire	Mastic
Vessel Flanges	Preformed covers, as shown in Figure 10-J. 3	Strap, Skewers, Wire	Mastic
Nozzles	Preformed covers, as shown in Figure 10-J. 6	Strap, Skewers, Wire	Mastic
Legs-Channel	Block down to fire proofing as shown in Figure 10-J-8	Strap, Wire	Mastic
Legs-Concrete Filled	Not insulated		
Flat Surfaces	Block and insulating cement as shown in Figure 10-J. 2	Pin, Pin Clips, Wire, Netting	Mastic
Skirts & Cradles	Not insulated unless required for fire protection		



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SPECIFICATION NO. 10-J, 10-JSS, CELLULAR GLASS

(Moderate Temperature Service
Max 400F)

PIPING INSULATION

	<u>PIPE</u>				
	<u>LINE NO.</u>	<u>SIZE</u>	<u>LOCATION</u>	<u>METAL</u>	<u>INSUL THK "</u>
PLANT _____	_____	_____	_____	_____	_____
UNIT _____	_____	_____	_____	_____	_____
WORK ORDER _____	_____	_____	_____	_____	_____
ACCOUNT NO. _____	_____	_____	_____	_____	_____
DATE _____	_____	_____	_____	_____	_____
WEATHER BARRIER: STRAIGHT PIPE _____	FITTINGS _____	MASTIC _____			

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
MATERIAL SPECIFICATIONS

Cellular Glass	Spec. 10.	Strapping Tape	VII. A. 33.
Insulating Cement	VII. A. 6.	Moderate Temperature	
Pipe Insulation Support	VII. A. 9.	Fabrication Cement	VII. A. 33.
Pipe Insulation Strap	VII. A. 12.	Heat-Resistant Sealer	VII. A. 42.
Clips for Pipe Strap	VII. A. 13.	Glass Wool Metal Mesh	
Stainless Steel Wire	VII. A. 17.	Blanket	VII. A. 86
Welding Pins	VII. A. 10.	Non-Setting Sealer	VII. A. 88.
Stainless Steel Pins	VII. A. 20.	High & Low Temperature	
Stainless Steel Skewers	VII. A. 21.	Anti Abrasive Coating	VII. A. 40.
		Mastic (Caulking)	VII. A. 45.
		Weather Barrier: As specified	
		Mastic, Color as specified	VII. B. 1. a.
		Reinforcing Cloth	VII. B. 1. b.
		Stainless Steel Jacket,	
		Designation M	VII. B. 2.
		Treated Steel Jacket,	
		Designation MT	VII. B. 3.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
GENERAL SPECIFICATIONS

Surface:

Steel shall be clean and dry. Stainless steel shall be coated as per "COATING MANUAL".

Insulation Supports:

Vertical pipes over 1" NPS as shown in Figure 10-J-16.

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MAY, 1968PREPARATION: Continued

(10-J, 10-JSS, Piping, Contd)

Tracing:

Steam, installed as per Standard P-140, P-140A. Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

Electric, installed as per Standard EL-43. Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

Heat Transfer Cement, Materials - MATERIAL SPECIFICATIONS VII. C.
Application, GENERAL SPECIFICATIONS XIII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION 10-J, 10-JSS

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather-Barrier</u>
Straight Pipe	Sectional insulation single layer to 2 1/2" thick, double layer 3" thick and above	Inner layer-wire; single and outer layer strap	Mastic or Steel Jacket
Insulation Expansion Joints	Install: Up to 2 1/2" thick one each 60 ft, 3" to 5" thick - one each 30 ft. As shown in Figures 10-J-15 and 10-J-16	Strap	Mastic and Stainless Steel Sleeves
Gate & Globe Valves	Preformed as per UCC Fab. Manual*, as shown in Figure 10-J-14	Strap	Mastic
Ball & Plug Valves	Field cut from sectional covering	Strap	Mastic
Flanged Fittings	Preformed as per UCC Fab. Manual*, as shown in Figure 10-J-13	Strap	Mastic
Welded Fittings	Preformed as per UCC Fab. Manual*, as shown in Figure 10-J-10	Strap	Mastic
Screwed Fittings	Preformed as per UCC Fab. Manual*	Strap	Mastic

* Or ASTM Recommended Practice C-450, Latest Revision



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SPECIFICATION NO. 10-JU, 10-JUSS, CELLULAR GLASS

(Moderate Temperature
Service Max. 350F)

UNDERGROUND PIPING

	<u>LINE NO.</u>	<u>SIZE</u>	<u>LOCATION</u>	<u>METAL</u>	<u>INSUL. THK</u>
PLANT _____	_____	_____	_____	_____	_____
UNIT _____	_____	_____	_____	_____	_____
WORK ORDER _____	_____	_____	_____	_____	_____
ACCOUNT NO. _____	_____	_____	_____	_____	_____
DATE _____	_____	_____	_____	_____	_____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
MATERIAL SPECIFICATIONS

Cellular Glass	Spec. 10	High Temperature Fab-	
Pipe Insulation Strap	VII. A. 13.	rication Cement	VII. A. 3
Clips for Insulation Strap	VII. A. 14.	Joint Sealer	VII. A. 8
Stainless Steel Wire	VII. A. 17.	Reinforcing Cloth	VII. A. 8
Anti-Abrasive Coating (for stainless steel)	VII. A. 40.	Water - Barrier Coating	VII. A. 7
Anti-Abrasive Coating	VII. A. 39.	Concrete support Pad (field poured)	
		Carbon Pipe Slides for Support Pads	Std. P. -2

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
GENERAL SPECIFICATIONS

Surface:

Steel shall be clean and dry. Stainless steel shall be coated as per "COATING MANUAL".

Tracing: (Where Required)

Steam, installed as per Standards P-140, P-140A. Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

Electric installed as per Standard EL-43. Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

Heat Transfer Cement, Materials, MATERIAL SPECIFICATION VII. A.
Application, GENERAL SPECIFICATIONS XIII. B.

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(10-JU, 10-JUSS, Contd)

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL VOLUME 1", SPECIFICATION NO. 10-J, 10-JSS

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Water-Barrier</u>
Straight Pipe	Sectional insulation (single layer to 2 1/2" thick, double layer 3" thick and above	Wire inner layers, strap single and outer layers	Mastic* Mastic*
Elbow and Tee	Oversize sectional pipe insulation	Strap	
Expansion Chamber	Construction as shown in Figures 10-JU-3, 4, 5, & 6		
*Water-Barrier	Application as given in Spec. No. 10-J, 10-JSS B. 2. b.		

Cathodic Protection:

Where required, cathodic protection shall be installed as specified by Mechanical and Electrical Groups, and in accordance with STANDARD SPECIFICATIONS B. 2. 60 and STANDARDS EL-75, 76 and 77. Details shall be coordinated so that the purpose of each system is retained. Special attention is required at electrical isolating joints.

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MAY, 1968SPECIFICATION NO. 10-L, 10-LSS, CELLULAR GLASS

(Low Temperature Service)

EQUIPMENT INSULATION

	<u>VESSEL OR COLUMN</u>	<u>DUCT OR FLAT SURFACE</u>
PLANT _____	ITEM NO. _____ METAL _____	TOP AND BOTTOM:
UNIT _____	BODY: Dia. _____ LENGTH _____	WIDTH _____
WORK ORDER _____	HEADS _____ SHAPE _____	LENGTH _____
ACCOUNT NO. _____	VESSEL FLANGES _____	SIDES:
DATE _____	MANHOLES _____	WIDTH _____
	NOZZLES _____	LENGTH _____
	SKIRT OR LEGS _____	

WEATHER BARRIER Mastic INSULATION THICKNESS " _____MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIAL SPECIFICATIONS

Cellular Glass Insulation	Spec. 10.	Mastic	VII. A. 45.
Cushioning Material		Lap Sealer	VII. A. 46.
Equipment operating above 350F	VII. A. 1.	Non Setting Sealer	VII. A. 88.
Equipment operating at 350F and below	VII. A. 2.	Joint Sealer	VII. A. 43.
Equipment Insulation Strap	VII. A. 11.	Modified Asphalt Sealer	VII. A. 116.
Clips for Equipment Strap	VII. A. 12.	Mastic (Caulking)	VII. A. 45.
Stainless Steel Wire	VII. A. 17.	Weather Barrier Mastic, (color as specified)	
Welding Pins	VII. A. 19.	Trowel Grade,	
Stainless Steel Skewers	VII. A. 21.	Designation WC	VII. B. 1. a.
Strap Anchor Clip	VII. A. 24.	Spray Grade,	
Fabrication Cement	VII. A. 36.	Designation WB	VII. B. 1. a.
		Reinforcing Cloth	VII. B. 1. b.

Note: For 10-LSS (on stainless steel equipment) use only Cushioning Material VII. A. 1
Do not use Joint Sealer VII. A. 43. Do use Joint Sealer VII. A. 116.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
GENERAL SPECIFICATIONSSurface:

Steel shall be clean and dry. Stainless steel shall be coated, if so required, as per "COATINGS MANUAL".

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(10-L, 10-LSS, Equip, Conts)

Insulation Supports:

Welded (vendor installed where possible) as per Standard EQ-64. Bolted on as per Standards EQ-67, 68, 69.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL, VOLUME 1", SPECIFICATION NO. 10-L, 10-LSS

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather Barrier</u>
Curved Side Walls	Curved block (single layer to 2 1/2" thick, double above) 1" cushion blanket under curved blocks	Strap	Mastic
Heads	Preformed block, 1" cushion blanket under block as shown in Figure 10-L. 2	Strap and Wire	Mastic
Vessel Flanges	Preformed covers as shown in Figure 10-L. 3.	Strap, Skewers, Mastic Wire	
Nozzles	Preformed covers as shown in Figure 10-L. 5	Strap, Skewers, Mastic Wire	
Legs - Channel	Block down to fire proofing as shown in Figure 10-L. 9	Strap, Wire	Mastic
Legs - Concrete Filled	Block down 4 times specified thickness with 1/2 specified thickness insulation	Strap, Wire	Mastic
Skirts & Cradles	Block down 4 times specified thickness with 1/2 specified thickness insulation as shown in Figures 10-L. 10, 11 & 12	Strap, Wire	Mastic
Flat Surfaces	Block up to 2 1/2" to surface with adhesive	Adhesive	Mastic

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MAY, 1968SPECIFICATION NO. 10-L, 10-LSS, CELLULAR GLASS

(Low Temperature Service)

PIPING INSULATION

	<u>PIPE</u>				
	<u>LINE NO.</u>	<u>SIZE</u>	<u>LOCATION</u>	<u>METAL</u>	<u>INSUL THICK"</u>
PLANT _____	_____	_____	_____	_____	_____
UNIT _____	_____	_____	_____	_____	_____
WORK ORDER _____	_____	_____	_____	_____	_____
ACCOUNT NO. _____	_____	_____	_____	_____	_____
DATE _____	_____	_____	_____	_____	_____

WEATHER BARRIER: MasticMATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
MATERIAL SPECIFICATIONS

Cellular Glass Insulation	Spec. 10.	Joint Sealer	VII. A. 43.
Pipe Insulation Support	VII. A. 9.	Mastic	VII. A. 45.
Pipe Insulation Strap	VII. A. 13.	Lap Sealer	VII. A. 46.
Clips for Pipe Strap	VII. A. 14.	Curved Wood Block	
Stainless Steel Wire	VII. A. 17.	Insulation Support	VII. A. 87.
Welding Pins	VII. A. 19.	Non Setting Sealer	VII. A. 88.
Stainless Steel Skewers	VII. A. 21.	Modified Asphalt Sealer	VII. A. 116.
Strapping Tape	VII. A. 33.	Mastic (Caulking)	VII. A. 45.
Fabrication Cement	VII. A. 36.	Weather-Barrier Mastic	
		(color as specified)	
		Trowel Grade, Designation WC VII, B. 1. a	
		Reinforcing Cloth	VII. B. 1. b.

Note: For 10-LSS (on stainless steel piping) do not use joint sealer VII. A. 43.
Do use modified asphalt sealer VII. A. 116.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
GENERAL SPECIFICATIONS

Surface:

Steel shall be clean and dry. Stainless steel shall be coated, if so required, as per "COATINGS MANUAL".

Insulation Support:

Vertical pipes over 4" NPS as shown in Figure 10-L-20.

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MAY, 1968PREPARATION: Continued

(10-L, 10-LSS, Piping, Contd)

Pipe Supports:

Horizontal piping, supported by insulation in cradles, as per Standard P-82.
At bottom of vertical risers curved wood block (VII. A. 87) must be inserted
between cradle and pipe to support pipe load.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL
VOLUME 1", SPECIFICATION NO. 10-L, 10-LSS

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather-Barrier</u>
Straight Pipe	Sectional insulation (single layer up to 2 1/2" thick, double layer 3" thick and above)	Inner layers Tape Single and outer layer up to 4 1/2" OD Tape, above strap	Mastic
Insulation Expansion	Up to 2 1/2" thick insulation 1 for each 60'	Strap	Mastic
Contraction Joints	3" to 5" thick insulation 1 for each 45', 5 1/2 and above 1 each 30' as shown in Figures 10-L-19 & 20		
Gate and Globe Valves	Preformed as per UCC Fab. Manual* as shown in Figure 10-L-17	Strap	Mastic
Ball & Plug Valves	Preformed as per UCC Fab. Manual*	Strap	Mastic
Flanged Fittings	Preformed as per UCC Fab. Manual,* as shown in Figure 10-L-16.	Strap	Mastic
Welded Fittings	Preformed as per UCC Fab. Manual, * as shown in Figure 10-L-13, 14	Strap	Mastic
Screwed Fittings	Preformed as per UCC Fab. Manual*	Strap	Mastic
Hanger Rods	Insulated as shown in Figure 10-L-8	Strap & Tape	Mastic

* Or ASTM Recommended Practice C-450, latest revision.



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SPECIFICATION NO. 10-LSP, CELLULAR GLASS (Insulation for
Sphere Minus 40F to 15

SPHERE INSULATION

SPHERE

PLANT _____ ITEM NO. _____
UNIT _____ BODY: DIA. _____
WORK ORDER _____ MANHOLES _____
ACCOUNT NO. _____ NOZZLES _____
DATE _____ PROJECTIONS _____
LEGS _____

WEATHER BARRIER: Mastic INSULATION THICKNESS " _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
MATERIAL SPECIFICATIONS

Cellular Glass Insulation	Spec. 10.	Water Sealer	VII. A. 116.
Nylon Strap	VII. A. 114.	Fireproofing Insulation	Spec. 22.
Crimp Clip, for Nylon Strap	VII. A. 115.	Mastic (Caulking)	VII A. 45.
Pipe Insulation Strap	VII. A. 13.	Non Setting Sealer	VII A. 88.
Clips for Pipe Strap	VII. A. 14.	Cushioning Material	VII. A. 2.
Stainless Steel Wire	VII. A. 17.	Stainless Steel Wire	VII. A. 117.
Insulation Adhesive (two part)	VII. A. 105.	Weather-Barrier Mastic,	
Joint Sealer	VII. A. 43	color as specified	
		Trowel Grade,	
		Designation WC	VII. B. 1. a.
		Spray Grade	
		Designation WB	VII. B. 1. a.
		Reinforcing Cloth	VII. B. 1. b.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
SPECIFICATION NO. 10-LSP

Surface:

Steel sphere shall be cleaned and coated with Dimetecote No. 3 or 4, in accordance with "COATING MANUAL"

Insulation Supports:

Shall be provided as shown on drawings. One to be located at equator. One to be approximately 30° below and another to be approximately 30° above equator.
Bottom support to be slotted for band attachment.

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(10-LSP, Sphere, Contd)

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL VOLUME 1", SPECIFICATION NO. 10-LSP

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather-Barrier</u>
Body	Insulation shall be shop fabricated, geodesically shaped to fit sphere body. Bottom section of insulation shall be adhered to sphere with insulation adhesive and nylon bands. Midsection and upper section shall be secured to sphere by adhesive only. Edges and ends of blocks vapor sealed, as shown in Figure 10-LSP-1	Adhesive and Nylon Bands	Mastic
Insulation Supports	Preformed cellular glass blocks fit over insulation sealed as shown in Figure 10-LSP-2	Insulation Adhesive	Mastic
Nozzles & Manholes	Preformed cellular glass covers installed as shown in Figures 10-LSP-3, 4	Wire and Strap	Mastic
Legs - Concrete Filled	Preformed cellular glass down 4 times specified thickness with 1/2 specified thickness as shown in Figure 10-LSP-5	Strap	Mastic
Legs - Not filled	Preformed cellular glass down 4 times specified thickness with 1/2 specified thickness. Below this preformed expanded silica insulation to fire proofing or base as shown in Figure 10-LSP-5	Strap	Mastic
Tie Rods	2" thick sec. expanded silica as per Spec. No. 22-H	Strap	Steel Jacket

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MAY, 1968SPECIFICATION NO. 10-OX, CELLULAR GLASS (Low Temperature
Oxygen Service)EQUIPMENT INSULATIONVESSEL OR COLUMN

PLANT _____ ITEM NO. _____ METAL _____
UNIT _____ BODY: Dia. _____ LENGTH _____
WORK ORDER _____ HEADS _____ SHAPE _____
ACCOUNT NO. _____ VESSEL FLANGES _____
DATE _____ MANHOLES _____
NOZZLES _____
SKIRT OR LEGS _____

WEATHER BARRIER: Mastic INSULATION THICKNESS" _____MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIAL SPECIFICATIONS

Cellular Glass Insulation	Spec. 10.	Neoprene - 1/16" thick U.S.	
Cushion Material for		Rubber No. M-8891, or	
Equipment and Pipe	VII. A. 1.	Hercules No. 765-N, or	
Equipment Insulation Strap	VII. A. 11.	approved equal	
Clips for Equipment Strap	VII. A. 13.	Weather Barrier Mastic,	
Stainless Steel Wire	VII. A. 17.	color as specified,	
Strap Anchor Clip	VII. A. 24.	Trowel Grade,	
Anti-Abrasive Coating	VII. A. 39.	Designation WC	VII. B. 1.
Fabrication Cement	VII. A. 34.	Spray Grade,	
Stainless Steel Skewers	VII. A. 21	Designation WB	VII. B. 1.
Welding Pins	VII. A. 19.	Reinforcing Cloth	VII. B. 1.
Adhesive Cement	VII. A. 47.		
Joint Sealer - Vimasco			
Lax-Seal F or approved equal			

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
GENERAL SPECIFICATIONSSurface:

Surface shall be clean and dry

Insulation Supports:Welded (vendor installed where possible) as per Standards EQ-64. Bolted as per
Standards EQ-67, 68, 69.

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(10-OX Equip., Contd)

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL -
VOLUME 1", SPECIFICATION NO. 10-OX

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather Barrier</u>
*Curved Side Walls	Curved block (single layer to 2 1/2" thick, double above) 1" cushion blanket compressed to 1/2" under curved blocks	Strap	Mastic
*Vessel Head	Preformed block, 2" cushion blanket compressed to 1" on top head, 1" cushion blanket compressed to 1/2" on bottom head	Strap and Wire	Mastic
*Inner layer blocks on side walls and heads given a coat of anti-abrasive coating and allowed to dry before application. Outer layer edges and ends of blocks vapor sealed as applied.			
Vessel Flanges	Preformed covers as shown in Figure 10-OX. 3	Strap, Skewers, Wire	Mastic
Nozzles	Preformed covers as shown in Figure 10-OX. 5	Strap, Skewers, Wire	Mastic
Legs-Channel	Block down to fireproofing as shown in Figure 10-OX. 9	Strap, Wire	Mastic
Skirts & Cradles & Supports	Block down 4 times specified thickness with 1/2 specified thickness as shown in Figure 10-OX. 10, 11, 12	Strap, Wire	Mastic



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SPECIFICATION NO. 10-OX, CELLULAR GLASS

(Low Temperature Oxygen Service)

PIPING INSULATION

	<u>PIPE</u>				
	<u>LINE NO.</u>	<u>SIZE</u>	<u>LOCATION</u>	<u>METAL</u>	<u>INSUL THK</u>
PLANT _____	_____	_____	_____	_____	_____
UNIT _____	_____	_____	_____	_____	_____
WORK ORDER _____	_____	_____	_____	_____	_____
ACCOUNT NO. _____	_____	_____	_____	_____	_____
DATE _____	_____	_____	_____	_____	_____

WEATHER BARRIER: Mastic

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
MATERIAL SPECIFICATIONS

Cellular Glass Insulation	Spec. 10.	Fabrication Cement	VII. A. 34
Cushioning Material	VII. A. 1.	Adhesive Cement	VII. A. 47
Pipe Insulation Strap	VII. A. 12.	Joint Sealer, Vimasco Lax-	
Clips for Pipe Strap	VII. A. 14.	Seal F, or approved equal	
Stainless Steel Wire	VII. A. 17.	Neoprene 1/16" thick	
Stainless Steel Skewers	VII. A. 21.	U. S. Rubber No. M-8891,	
Pipe Insulation Support as shown in Figure 10-OX-18		Hercules No. 765-N, or approved equal	
Anti-Abrasive Coating	VII. A. 39.	Weather-Barrier Mastic (color as specified)	
		Trowel Grade,	
		Designation WC	VII. B. 1.
		Reinforcing Cloth	VII. B. 1.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
GENERAL SPECIFICATIONS

Surface:

Surface shall be clean

Insulation Support:

Insulation support, for vertical pipe, shall be fabricated of Everdur and installed as shown in Figure 10-OX-8.

Pipe Supports:

Horizontal piping, supported by insulation in cradles, shall be as per Standard P-8.

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(10-OX Piping, . Contd)

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL VOLUME 1", SPECIFICATION NO. 10-OX

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather-Barrier</u>
Straight Pipe	Sectional insulation (single layer up to 2 1/2" thick, double layer 3" thick and above, 1" cushion blanket, compressed to 1/2", secured with wire shall be applied prior to application of sectional insulation.	Wire, Strap	Mastic
Insulation Expansion - Contraction Joints	Shall be installed in both horizontal and vertical straight run piping at 10' intervals and shall be constructed of cushioning material between butt ends of section insulation as shown in Figures 10-OX. 19, 20	Strap, Skewers	Neoprene
Gate & Globe Valves	Preformed as per UCC Fab. Manual*, installed as shown in Figure 10-OX. 17	Strap	Mastic
Flanged Fittings	Preformed as per UCC Fab. Manual*, 1" installed as shown in Figures 10-OX. 15, 16	Strap	Mastic
Welded Fittings	Preformed as per UCC Fab. Manual*, 1" cushion blanket, compress to 1/2 under fitting cover installed as shown in Figure 10-OX. 13, 14	Strap, Wire	Mastic
Hanger Rods	Installed as shown in Figure 10-OX. 23	Strap	Mastic

*Or ASTM Recommended Practice C-450, latest revision.



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SPECIFICATION NO. 12-H, 12-HSS, RIGID URETHANE FOAM

(Moderate Temperature
50F to 250F)

EQUIPMENT INSULATION

	<u>VESSEL OR COLUMN</u>	<u>DUCT OR FLAT SURFACE</u>
PLANT _____	ITEM NO. _____ METAL _____	TOP AND BOTTOM: _____
UNIT _____	BODY: Dia. _____ LENGTH _____	WIDTH _____
WORK ORDER _____	HEADS _____ SHAPE _____	LENGTH _____
ACCOUNT NO. _____	VESSEL FLANGES _____	SIDES: _____
DATE _____	MANHOLES _____	WIDTH _____
	SKIRT OR LEGS _____	LENGTH _____
	INSULATION THICKNESS " _____	

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIAL SPECIFICATIONS

Rigid Urethane Foam Insulation	Spec. 12.	Contact Adhesive (Standard)	VII. A. 65.
Insulating Cement	VII. A. 6.	Contact Adhesive	
Equipment Insulation Strap	VII. A. 11.	(high temperature)	VII. A. 66.
Clips for Equipment Strap	VII. A. 12.	Mastic (Caulking)	VII. A. 45.
Stainless steel Wire	VII. A. 17.	Weather Barrier Mastic,	
Welding Pins	VII. A. 19.	(color as specified)	
Stainless Steel Pins	VII. A. 20.	Trowel Grade,	
Welding Pin Insulation Fasteners	VII. A. 22.	Designation WC	VII. 1. B. a
Cork Filled Polyvinyl Acetate		Spray Grade,	
Mastic	Spec. 40.	Designation WB	VII. 1. B. a.
Strapping Tape	VII. A. 33.	Reinforcing Cloth	VII. 1. B. b.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
GENERAL SPECIFICATIONS

Surface:

Steel shall be clean and dry and coated in accordance with "COATING MANUAL".
Stainless steel shall be coated in accordance with "COATING MANUAL".

Insulation Supports:

Welded (vendor installed where possible) as per Standards EQ-64. Bolted on as
per Standards EQ-67, 68, 69.

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(12-H, 12-HSS, Equip, Contd)

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL, VOLUME 1," SPECIFICATION NO. 12-H, 12-HSS

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather Barrier</u>
Curved Side Walls	Curved block as shown in Figures 12-H. 1, 2	Strap	Mastic
Heads	Preformed block to fit head as shown in Figures 12-H. 1, 2	Strap, Wire	Mastic
Vessel Flanges	Preformed covers as shown in Figure 12-H. 4	Strap, Skewers, Wire	Mastic and Stainless Steel Sleeves
Nozzles	Preformed covers as shown in Figure 12-H-B	Strap, Skewers, Wire	Mastic
Legs	Do not insulate		
Skirts & Cradles	Outside of skirt down 4 times thickness of insulation, as shown in Figure 12-H. 9	Strap	Mastic
Flat Surfaces	Block, secured with pins and pin clips for temperature above 180F, secured to surface with adhesive temperatures 50F to 18F	Pins, Pin Clips, Adhesives	Mastic

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MAY, 1968SPECIFICATION NO. 12-H, 12-HSS, RIGID URETHANE FOAM(Moderate Temperature Service
50 F to 250F)PIPING INSULATIONPIPE

	<u>LINE NO.</u>	<u>SIZE</u>	<u>LOCATION</u>	<u>METAL</u>	<u>INSUL THK"</u>
PLANT _____	_____	_____	_____	_____	_____
UNIT _____	_____	_____	_____	_____	_____
WORK ORDER _____	_____	_____	_____	_____	_____
ACCOUNT NO. _____	_____	_____	_____	_____	_____
DATE _____	_____	_____	_____	_____	_____
WEATHER BARRIER: _____					

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
MATERIAL SPECIFICATIONS

Rigid Urethane Foam Insulation	Spec. 12.	Contact Adhesive(Standard)	VII. A. 65.
Insulating Cement	VII. A. 6.	Contact Adhesive (High	
Pipe Insulation Support	VII. A. 9.	Temperature)	VII. A. 66.
Stainless Steel Wire	VII. A. 17.	Weather-Barrier, as specified	
Cork Filled Polyvinyl Acetate		Mastic, color as specified	
Mastic	Spec. 40.	Trowel Grade,	
Mastic (Caulking)	VII. A. 45.	Designation WC	VII. B. 1. a.
Strapping Tape	VII. A. 33.	Reinforcing Cloth	VII. B. 1. b.
		Stainless Steel Jacket,	
		Designation M	VII. B. 2.
		Treated Steel Jacket,	
		Designation MT	VII. B. 3.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
GENERAL SPECIFICATIONSSurface:Steel shall be clean and dry and coated in accordance with "COATING MANUAL".
Stainless steel shall be coated in accordance with "COATING MANUAL".APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL
VOLUME 1", SPECIFICATION NO. 12-H, 12-HSS

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather-Barrier</u>
Straight Pipe	Sectional insulation	Tape	Mastic or Steel

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(12-H, 12-HSS, Piping, Contd)

Gate and Globe Valves	Preformed as per UCC Fab. Manual*, installed as shown in Figure 12-H-12	Tape, Wire	Mastic
Ball and Plug Valves	Field fabricated of sectional insulation	Tape	Mastic
Flanged Fittings	Preformed as per UCC Fab. Manual*, installed as shown in Figures 12-H-10, 11	Tape	Mastic
Screwed and Welded Fittings	1" NPS and less - insulating cement, 1 1/2" to 3" NPS field fabricated, or preformed 3 1/2" NPS and above shall be preformed in accordance with UCC Fab. Manual*	Tape, Wire	Mastic

* Or ASTM Recommended Practice C-450, latest revision.

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MAY, 1968SPECIFICATION NO. 14-J, PREFORMED FLEXIBLE PLASTIC FOAM(Moderate Temperature
33F to 180F)PIPING INSULATIONPIPE

	<u>LINE NO.</u>	<u>SIZE</u>	<u>LOCATION</u>	<u>METAL</u>	<u>INSUL THK"</u>
PLANT _____	_____	_____	_____	_____	_____
UNIT _____	_____	_____	_____	_____	_____
WORK ORDER _____	_____	_____	_____	_____	_____
ACCOUNT NO. _____	_____	_____	_____	_____	_____
DATE _____	_____	_____	_____	_____	_____

MATERIALS: As specified in "THERMAL INSULATION MANUAL, VOLUME 1"
MATERIAL SPECIFICATIONS

Cellular Glass Insulation	Spec. 14.	Flexible Sealer	VII. A. 68.
Contact Adhesive (Standard)	VII. A. 65.	PVA Finish Coating	
Contact Adhesive (High Temp.)	VII. A. 66.	(Color as specified)	VII. A. 69
Vinyl Finish	VII. A. 67.	Weather-Barrier Mastic	
Strapping Tape	VII. A. 89	(Color as specified)	
Mastic (Caulking)	VII. A. 45.	Trowel Grade,	
		Designation WC	VII. B. 1. a.
		Reinforcing Cloth	VII. B. 1. b.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
SPECIFICATION NO. 14-JSurface:

Steel shall be clean and dry and coated in accordance with "COATING MANUAL".

APPLICATION: Installation details as specified in "THERMAL INSULATION
MANUAL - VOLUME 1", SPECIFICATION NO. 14-J

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather-Barrier</u>
Straight Pipe	Before pipe erection: Up to 5" NPS, slip cylindrical, unslit insulation on pipe, push insulation back 8" from ends of pipe as pipe is being fitted. After pipe erection: slip cylindrical insulation, install, brush contact adhesive on slit surfaces, press together	None Contact Adhesive	All piping: Concealed-none Indoors, exposed to water-vinyl finish Indoors-PVA finish Outdoors-Mastic



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(14-J, Contd) .

APPLICATION: Continued

Flanges and Valves	Preform covers of pipe cover- ing in accordance with UCC Fabrication Manual*	Contact Adhesive
Welded Ells	Sheets cut to dimensions on Figure 14-J-2	Contact Adhesive

*Or ASTM Recommended Practice C-450, latest revision.



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SPECIFICATION NO. 14-J, PREFORMED FLEXIBLE PLASTIC FOAM

(Moderate Temperature 33F to 180F)

EQUIPMENT INSULATION

	<u>VESSEL OR COLUMN</u>	<u>DUCT OR FLAT SURFACE</u>
PLANT _____	ITEM NO. _____ METAL _____	TOP AND BOTTOM: _____
UNIT _____	BODY: Dia. _____ LENGTH _____	WIDTH _____
WORK ORDER _____	HEADS _____ SHAPE _____	LENGTH _____
ACCOUNT NO. _____	SKIRT OR LEGS _____	SIDES: _____
DATE _____		WIDTH _____
		LENGTH _____
WEATHER BARRIER _____	INSULATION THICKNESS " _____	

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME I",
MATERIAL SPECIFICATIONS

Preformed Flexible Plastic	Spec. 14.	Flexible Sealer	VII. A. 68.
Foam Insulation	VII. A. 65.	PVA Finish Coating	
Contact Adhesive (Standard)	VII. A. 66.	(color as specified)	VII. A. 69.
Contact Adhesive (High Temp.)	VII. A. 67.	Weather Barrier Mastic,	
Vinyl Finish	VII. A. 89.	(color as specified)	
Strapping Tape	VII. A. 45.	Trowel Grade,	
Mastic (Caulking)		Designation WC	VII. B. 1. a.
		Spray Grade,	
		Designation WB	VII. B. 1. a.
		Reinforcing Cloth	VII. B. 1. b.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME I",
SPECIFICATION NO. 14-J

Surface:

Steel surfaces shall be sandblasted and coated with zinc silicate inorganic coating in accordance with "COATINGS MANUAL". Aluminum, copper or galvanized steel shall be clean and dry.

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APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION NO. 14-J

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather Barrier</u>
Vessel Body	Sheets cut slightly oversize - adhesive applied to surface and cut side of sheet, then applied from center of sheet outward. Edges bonded together with adhesive. Voids and termination sealed with flexible sealer.	Contact Adhesive	Vinyl finish-Indoors Mastic-Outdoors
Ducts	Same as for vessel body. Duct seam insulated as shown in Figure 14-J.1	Contact Adhesive	Vinyl finish-Indoors where exposed to water. PVA Finish-Indoors Mastic-Outdoors
Vessel Flanges	Not insulated unless otherwise specified		
Legs	Not insulated unless otherwise specified.		
Skirts & Cradles	Down a minimum 6" from vessel	Contact Adhesive	As used on vessel

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MAY, 1968SPECIFICATION NO. 15-H, HEAVY DENSITY FIBROUS GLASS(Moderate to High Temperature
70F to 750F)EQUIPMENT INSULATION

	<u>VESSEL OR COLUMN</u>	<u>DUCT OR FLAT SURFACES</u>
PLANT _____	ITEM NO. _____ METAL _____	TOP AND BOTTOM:
UNIT _____	BODY: Dia. _____ LENGTH _____	WIDTH _____
WORK ORDER _____	HEADS _____ SHAPE _____	LENGTH _____
ACCOUNT NO. _____	VESSEL FLANGES _____	SIDES:
DATE _____	MANHOLES _____	WIDTH _____
	NOZZLES _____	LENGTH _____
	SKIRT OR LEGS _____	

WEATHER BARRIER _____ INSULATION THICKNESS " _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIAL SPECIFICATIONS

Preformed Heavy Density Fibrous Glass Insulation	Spec. 15.	Bonding Adhesive	VII. A. 92.
Glass Wool Blanket	VII. A. 1.	Glass Wool Metal Mesh Blanket	VII. A. 93.
Expansion Sleeve	VII. A. 10.	PVA Finish Coating	
Equipment Insulation Strap	VII. A. 11.	(indoor finish)	VII. A. 95
Clips for Equipment Strap	VII. A. 12.	Glass Cloth Jacket	
Stainless Steel Wire	VII. A. 17.	(indoor finish cloth)	VII. A. 90.
Welding Pins	VII. A. 19.	Weather Barrier, as specified	
Stainless Steel Pins	VII. A. 20.	Mastic, color as specified	
Stainless Steel Skewers	VII. A. 21.	Designation WC	VII. B. 1. a.
Welding Pin Insulation Fasteners	VII. A. 22.	Reinforcing Cloth	VII. B. 1. b.
Pin Clips	VII. A. 23.	Stainless Steel Jacket	
Insulating Cement	VII. A. 6.	Designation M	VII. B. 2.
Heat Resistant Sealer	VII. A. 42.	Treated Steel Jacket	
Mastic (Caulking)	VII. A. 45.	Designation MT	VII. B. 3.
High Temp. Fabricating Cement	VII. A. 91.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
GENERAL SPECIFICATIONSSurface:

Steel shall be clean and dry, and when required shall be coated in accordance with "COATING MANUAL". Stainless steel shall be coated in accordance with "COATING MANUAL".

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(15-H, Equip, Contd)

Insulation Supports:

Welded (vendor applied where possible) as per Standard EQ-64. Bolted on as per Standards IS-31, 31A, 36, 42.

Tracing: (Where Required)

Heat Transfer Cement, Materials, MATERIAL SPECIFICATION VII. C. Application, GENERAL SPECIFICATION XIII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION NO. 15-H.

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather Barrier</u>
Curved Side Wall	Under 30" OD. Sectional pipe insulation, over 30" OD shop fabricated block	Strap	Indoor-PVA Finish Outdoors-Mastic or Steel Jacket
Heads	Preformed Block	Strap, Wire	All fittings and projections: Indoors-PVA Finish Outdoors-Mastic
Vessel Flanges	Preformed Covers as shown in Figure 15-H-8.	Strap, Skewers, Wire	
Nozzles	Preformed covers as shown in Figure 15-H-10	Strap, Wire	
Legs - Channel	Block down to fireproofing as shown in Figure 15-H-4	Strap, Wire	
Legs - Concrete Filled	Not insulated		
Skirts & Cradles	Not insulated		
Flat Surfaces	Block and insulating cement as shown in Figure 15-H-3	Pins and Pin Clips	

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MAY, 1968SPECIFICATION NO. 15-H, HEAVY DENSITY FIBROUS GLASS(Moderate to High Temperature
70F to 750F)PIPING INSULATIONPIPE

	<u>LINE NO.</u>	<u>SIZE</u>	<u>LOCATION</u>	<u>METAL</u>	<u>INSUL THICK"</u>
PLANT _____	_____	_____	_____	_____	_____
UNIT _____	_____	_____	_____	_____	_____
WORK ORDER _____	_____	_____	_____	_____	_____
ACCOUNT NO. _____	_____	_____	_____	_____	_____
DATE _____	_____	_____	_____	_____	_____

WEATHER BARRIER: _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"MATERIAL SPECIFICATION

Preformed Heavy Density Fibrous Glass Insulation	Spec. 15	Bonding Adhesive	VII. A. 92.
Glass Wool Blanket	VII. A. 1.	PVA Finish Coating (Indoor finish)	VII. A. 95.
Expansion Sleeve	VII. A. 10.	Glass Cloth Jacket	
Pipe Insulation Strap	VII. A. 13.	(Indoor finish cloth)	VII. A. 90
Clips for Pipe Strap	VII. A. 14.	Weather-Barrier - as specified	
Stainless Steel Wire	VII. A. 17.	Mastic-color as specified (Designation WC)	VII. B. 1. a.
Heat Resistant Sealer	VII. A. 42.	Reinforcing Cloth	VII. B. 1. b.
Mastic (Caulking)	VII. A. 45.	Stainless Steel Jacket (Designation M)	VII. B. 2.
High Temp. Fabricating Cement	VII. A. 91.	Treated Steel Jacket (Designation MT)	VII. B. 3.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"GENERAL SPECIFICATIONSSurface:

Steel and stainless steel shall be clean and dry and, when required, shall be coated in accordance with "COATINGS MANUAL".

Insulation Supports:

Vertical pipe, over 4" NPS. As shown in Figure 15-L-16.

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MAY, 1968**PREPARATION:** Continued

(15-H, Piping, Contd)

Tracing: Where required.

Steam, installed per Standards P-140, P-140A, Insulation Details. GENERAL SPECIFICATIONS VII. A. & B.

Electric, installed per Standard EL-43, Insulation Details. GENERAL SPECIFICATIONS XIII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1". SPECIFICATION NO. 15-H

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather-Barrier</u>
Straight Pipe	Sectional insulation, single layer up to 3" thk; double layer 3 1/2" thk and above as per GEN SPEC GA-1, GA-2	For all pipe & fitting wire up to 11" OD Strap above 11" OD	Indoors-PVA finish Outdoors-Mastic or steel jacket expansion sleeves
Insulation Expansion Joint	Horizontal, 1 every 21' straight pipe, Fig. 15-H-19; vertical 1 every 15' straight pipe, Fig. 15-H-13		
Gate and Globe Valves	Preformed covers as per UCC Fabrication Manual*, installed as per 15-H-18		All fittings: Indoors-PVA finish
Ball and Plug Valves	Field cut from sectional covering		Outdoors-Mastic
Flanged & Screwed Fittings Over 3" NPS	Preformed covers as per UCC Fabrication Manual, installed as per 15-H-14, 15, 16, 17		
Fittings Under 3" NPS	May be field fabricated		

* Or ASTM Recommended Practice C-450, latest revision.



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SPECIFICATION NO. 16-H, LOW DENSITY FIBROUS GLASS-

(Moderate Temperature
70F to 350F)

PIPING INSULATION

PIPE

	<u>LINE NO.</u>	<u>SIZE</u>	<u>LOCATION</u>	<u>METAL</u>	<u>INSUL THK "</u>
PLANT _____	_____	_____	_____	_____	_____
UNIT _____	_____	_____	_____	_____	_____
WORK ORDER _____	_____	_____	_____	_____	_____
ACCOUNT NO _____	_____	_____	_____	_____	_____
DATE _____	_____	_____	_____	_____	_____

WEATHER-BARRIER or INDOOR FINISH _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
MATERIALS SPECIFICATION

Preformed Low Density Fibrous		PVA Finish Coating & Lagging	
Glass Insulation	Spec. 16.	Adhesive	VII. A. 99.
Pipe Insulation Support	VII. A. 9.	Weather-Barrier Mastic	
Fabrication Cement	VII. A. 47.	(color as specified)	
Fire-Retardant Vapor-Barrier		Trowel Grade,	
Jacket & Butt Joint Strips	VII. A. 72.	Designation WC	VII. B. 1. a.
Strapping Tape	VII. A. 33.	Reinforcing Cloth	VII. B. 1. b.
Mastic (Caulking)	VII. A. 45.		
Vapor Seal Lap Cement	VII. A. 98.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
GENERAL SPECIFICATIONS

Surface:

Steel shall be clean and dry, and when required shall be coated in accordance with "COATINGS MANUAL". Stainless steel shall be coated in accordance with "COATINGS MANUAL".

Insulation Supports:

Vertical pipe, over 4" NPS shall be equipped with insulation supports directly above bottom fitting.

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(16-H, Piping, Cqntd)

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL
VOLUME 1". SPECIFICATION NO. 16-H

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather-Barrier or Indoor Finish</u>
Straight Pipe	Sectional insulation		
	Pipe insulation with factory attached jacket	Self-sealing lap	
	Pipe insulation without factory attached jacket	tape	
Gate and Glove Valves	Preformed as per UCC Fabrication Manual*, installed as shown in 16-H-2		
Flanged & Screwed Fittings over 3" NPS	Preformed as per UCC Fabrication Manual*, installed as shown in 16-H-1		
Ball and Plug Valves	Field cut from sectional covering	Strapping tape	
Fittings under 3" NPS	May be field fabricated		

*Or ASTM Recommended Practice C-450, latest revision

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SPECIFICATION NO. 17-RX, RIGID FIBROUS GLASS
HEATING, VENTILATION AND AIR CONDITIONING DUCT INSULATION
(On Interior of Duct)

DUCTS

	<u>DUCT</u> <u>NO.</u>	<u>WIDTH</u>	<u>HEIGHT</u>	<u>LENGTH</u>	<u>METAL</u>	<u>INSUL</u> <u>THICK "</u>
PLANT _____	_____	_____	_____	_____	_____	_____
BLDG. NO. _____	_____	_____	_____	_____	_____	_____
WORK ORDER _____	_____	_____	_____	_____	_____	_____
ACCOUNT NO. _____	_____	_____	_____	_____	_____	_____
DATE _____	_____	_____	_____	_____	_____	_____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME .",
MATERIAL SPECIFICATION.

Fibrous Glass Board with		Weather-Barrier Mastic	
Factory Vapor Barrier	Spec. 17-RX	(color as specified)	
Welding Pin Insulation Fasteners	VII. A. 22.	Trowel Grade,	
Pin Clips	VII. A. 23.	Designation WC	VII. B. 1. a.
Adhesive Type Pins	VII. A. 75.	Spray Grade,	
Fire Resistant Adhesive	VII. A. 100.	Designation WB	VII. B. 1. a.
Outer Covering (8 oz canvas)	VII. A. 102.	Reinforcing Cloth	VII. A. 1. b.
Joint Sealing Tape	VII. A. 103.		
PVA Finish Coating and			
Lagging Adhesive	VII. A. 99.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL, VOLUME 1",
SPECIFICATION NO. 17-RX.

Securement:

Where welding is permitted, use welding pins. Where welding is not permitted, use adhesive pins attached to duct with fire resistant adhesive. Spacing of pins shall be longitudinal 12" to 18". On surfaces less than 8" in width, one row down center. Above 8" one row each side. As shown in Figure 17-RX-1.



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APPLICATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
SPECIFICATION NO. 17-RX.

Insulation Application

Finish Coating or Weather-Barrier

Concealed

From

View

Indoors

Outdoors

Block impaled on pins, pins
pressed into surface 1/4"
pins clipped of 1/16" below
surface, pin holes sealed
with adhesive, cracks and
joints sealed with joint tape
embedded in adhesive

None

Canvas embedded
in PV finish, and
overcoated with
PVA finish

Mastic and
reinforcing
cloth as per
XIV. b.

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SPECIFICATION NO. 17-RY, RIGID FIBROUS GLASS
HEATING, VENTILATION AND AIR CONDITIONING DUCT INSULATION
(On Interior of Duct)

DUCTS

	<u>DUCT</u> <u>NO.</u>	<u>WIDTH</u>	<u>HEIGHT</u>	<u>LENGTH</u>	<u>METAL</u>	<u>INSUL</u> <u>THICK "</u>
PLANT _____	_____	_____	_____	_____	_____	_____
BLDG. NO. _____	_____	_____	_____	_____	_____	_____
WORK ORDER _____	_____	_____	_____	_____	_____	_____
ACCOUNT NO. _____	_____	_____	_____	_____	_____	_____
DATE _____	_____	_____	_____	_____	_____	_____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIALS SPECIFICATION

Fibrous Glass Board -	Spec.	PVA Finish Coating	VII. A. 99.
Neoprene Coated	No. 17-RY	Fire - Resistant Adhesive	VII. A. 100.
Welding Pin Insulation		Fire - Resistant Caulking	
Fasteners	VII. A. 22.	Mastic	VII. A. 101.
Pin Clips	VII. A. 23.		
Adhesive Type Pins	VII. A. 75.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
SPECIFICATION NO. 17-RY

Securement: Ducts up to 3000 FPM Air Velocity

Welding pins or adhesive pins shall be installed on interior top and side surfaces of the duct where the width of duct exceeds 12" and 24", respectively, on 16" maximum centers.

Ducts over 3000 FPM Air Velocity

Welding pins or adhesive pins shall be installed on interior top, side and bottom of duct on 16" maximum centers.

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(15-RY, Duct, Contd)

APPLICATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
SPECIFICATION NO. 17-RY

Ducts Up to 3000 FPM Air Velocity

Insulation with neoprene coating facing air flow shall be impaled on pins and adhered to the interior surfaces of the duct with fire resistant adhesive applied a minimum of 50% of the surface. Pinclips or speed washers shall be pushed on clips to secure insulation in place. Joints shall be tightly butted and caulked with fire resistant caulking mastic. As shown in Figure 17-RY-1.

Ducts Over 3000 FPM Air Velocity

All edges and ends of insulation shall be given heavy coat of fire resistant caulking mastic prior to application. Application shall be same as given above, with addition that a light brush coat (100 sq ft per gallon) of PVA finish coating and lagging adhesive shall be applied to all interior surfaces of the insulation.



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SPECIFICATION NO. 18-FX, FIBROUS GLASS BLANKET
HEATING, VENTILATION, AND AIR CONDITIONING DUCT INSULATION

(On Exterior of Duct)

DUCTS LOCATED IN CONCEALED INDOOR SPACE

DUCTS

	<u>DUCT</u> <u>NO.</u>	<u>WIDTH</u>	<u>HEIGHT</u>	<u>LENGTH</u>	<u>METAL</u>	<u>INSUL</u> <u>THICK "</u>
PLANT _____	_____	_____	_____	_____	_____	_____
BLDG. NO. _____	_____	_____	_____	_____	_____	_____
WORK ORDER _____	_____	_____	_____	_____	_____	_____
ACCOUNT NO. _____	_____	_____	_____	_____	_____	_____
DATE _____	_____	_____	_____	_____	_____	_____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIALS SPECIFICATION

Fibrous Glass Blanket With Fire-Retardant Vapor Barrier	Spec. 18-FX
Fire-Resistant Adhesive	VII. A. 100.
Joint Tape	VII. A. 104.

APPLICATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
SPECIFICATION NO. 18-FX

Insulation shall be adhered to ducts with fire-resistant adhesive. All joints shall be tightly butted and sealed with joint tape or with 2 inch wide flanges of factory applied vapor barrier facing, sealed with the fire-resistant adhesive. As shown in Figure 18-FX-1.



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SPECIFICATION NO. 18-FY, FIBROUS GLASS BLANKET
HEATING, VENTILATION AND AIR CONDITIONING DUCT INSULATION
(On Interior of Duct)

DUCTS

	<u>DUCT</u> <u>NO.</u>	<u>WIDTH</u>	<u>HEIGHT</u>	<u>LENGTH</u>	<u>METAL</u>	<u>INSUL</u> <u>THICK "</u>
PLANT _____	_____	_____	_____	_____	_____	_____
BLDG. NO. _____	_____	_____	_____	_____	_____	_____
WORK ORDER _____	_____	_____	_____	_____	_____	_____
ACCOUNT NO. _____	_____	_____	_____	_____	_____	_____
DATE _____	_____	_____	_____	_____	_____	_____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIALS SPECIFICATION

Fibrous Glass Blanket Coated One Side With Neoprene	Spec. 18-FY
Welding Pin Insulation Fasteners	VII. A. 22.
Pin Clips	VII. A. 23.
Grip Nails	VII. A. 73.
Fire Resistant Adhesive	VII. A. 100.

APPLICATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
SPECIFICATION NO. 18-FY.

Insulation installed to flat sheet metal before it is formed into ducts. The insulation liner and the metal shall be formed in the break as a unit. Application depends on duct air velocity.

Ducts With Air Flow Velocity Up To 1500 FPM

Edges of liner coated with adhesive. Liner attached to metal with grip nails, applied 3" from each corner and ends, spaced on 6" centers. Lines of grip nails shall be used to support liner between edges, one row for 10" span, two rows 10" to 22", three rows 22" to 36". Alternate Method: Adhere liner with adhesive, minimum adhered area not less than 50% with additional fastening of grip nails or welding pins and clips 3" from edges on 6" centers. Where width of duct exceeds 12", use one row down center, and where height exceeds 24", use one row down center.

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(18-FY, Duct, Contd)

Ducts With Air Flow Velocity 1500 to 4000 FPM

Metal 6" back from all edges, and edges shall be coated.

Ducts With Air Flow Velocity 4000 to 6000 FPM

Welding pins shall be placed 3" from all edges on 6" centers. Rows of pins between edges must be placed not over 12" apart. Liner shall be adhered to metal with adhesive at a minimum of 50% of areas. Liner 6" back from edges to be completely adhered with adhesive to duct. Edges of liner must be coated with adhesive. Typical installation shown in Figure 18-FY-1.

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SPECIFICATION NO. 19-J, FIBROUS GLASS with INTEGRAL FACING (On Side Wall),
FIBROUS GLASS (On Roof) (60F to 350F)

VESSEL INSULATIONVESSEL OR COLUMN

(Must be over 12' 0" in diameter)

PLANT _____ ITEM NO. _____ METAL _____
UNIT _____ BODY: Dia. _____ HEIGHT _____
WORK ORDER _____ HEADS _____ SHAPE _____
ACCOUNT NO. _____ VESSEL FLANGES _____
DATE _____ MANHOLES _____
NOZZLES _____

INSULATION THICKNESS": Side Walls _____ Heads _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIAL SPECIFICATIONS

Aluminum Faced Fibrous Glass	Spec. 19. J.	Battens	VII. A. 108.
Fibrous Glass Roof Insulation	Spec. 19. J.	Studs	VII. A. 109.
Equipment Insulation Strap	VII. A. 11.	Caps for Grooved Studs	VII. A. 110.
Clips for Equipment Strap	VII. A. 12.	Roof Tape	VII. A. 111
Expansion Springs or Bands	VII. A. 15.	Incombustible Adhesive	VII. A. 112.
Clips for Expansion Bands	VII. A. 16.	Flashing	VII. A. 31.
Stainless Steel Wire	VII. A. 17.	Weather Barrier Mastic	
Welding Pin Insulation Fasteners	VII. A. 22.	(color as specified)	
Pin Clips	VII. A. 23.	Trowel Grade,	
Sheet Metal Screws	VII. A. 32.	Designation WC	VII. B. 1. a.
Mastic	VII. A. 45.	Spray Grade,	
Lap Sealer	VII. A. 46.	Designation WB	VII. B. 1. a.
"S" Clips	VII. A. 107.	Reinforcing Cloth	VII. B. 1. b.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
GENERAL SPECIFICATIONS

Surface:

Steel shall be clean and dry and, when required, shall be coated in accordance with "COATING MANUAL". Stainless steel shall be coated in accordance with "COATING MANUAL".

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(19-J, Vessel, Contd)

Insulation Supports:

Welded (vendor applied where possible) as per Standard EQ-64. Bolted on as per Standards IS-31, 31A. Head securement - welding pins as per Figure 19. J. 1. Water shed, plate or angle, at top of cone head vessels as shown in Figure 19. J. 1.

Tracing: (Where Required)

Heat Transfer Cement Materials - MATERIAL SPECIFICATION VII. C., Application GENERAL SPECIFICATION XII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION No. 19. J.

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather Barrier</u>
Curved Side Wall	Fibrous glass panels as shown in Figures 19. J. 1, 2, 3	Strap or Studs	Factory attached Al
Head (cone shaped)	Fibrous glass roof insulation and 1/2" thick fibrous glass sheet insulation as shown in Figure 19. J. 1	Pins and Clips	Mastic
Nozzles	Preformed covers as shown in Figure 19. J. 4	Strap and Wire	Mastic

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SPECIFICATION NO. 19-H, MINERAL WOOL with INTEGRAL FACING (On Side Walls)
EXPANDED SILICA (On Roof) (60F to 450F)

VESSEL INSULATIONVESSEL OR COLUMN

(Must be over 12'0" in diameter)

PLANT _____ ITEM NO. _____ METAL _____
UNIT _____ BODY: Dia. _____ HEIGHT _____
WORK ORDER _____ HEADS _____ SHAPE _____
ACCOUNT NO. _____ VESSEL FLANGES _____
DATE _____ MANHOLES _____
NOZZLES _____
SKIRT OR LEGS _____

INSULATION THICKNESS": Side Walls _____ Heads _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME I",
MATERIAL SPECIFICATIONS

Mineral Wool with Integral		Sheet Metal Screws	VII. A. 32.
Aluminum Facing	Spec. 19-H	Aluminum Flashing	VII. A. 31.
Expanded Silica Insulation	Spec. 22.	High Temperature	
Cellular Glass Insulation	Spec. 10.	Fabrication Cement	VII. A. 34.
Equipment Insulation Strap	VII. A. 11.	Mastic	VII. A. 45.
Clips for Equipment Strap	VII. A. 12.	Lap Setting Sealer	VII. A. 46.
Expansion Springs or Bands	VII. A. 15.	"S" Clips	VII. A. 27.
Clips for Expansion Bands	VII. A. 16.	Weather Barrier Mastic	
Stainless Steel Wire	VII. A. 17.	(color as specified)	
Insulating Cement	VII. A. 7.	Trowel Grade,	
Welding Pins	VII. A. 19.	Designation WC	VII. B. 1. a.
Studs (supplied by mfg. for		Spray Grade,	
punched panels)	VII. A. 29.	Designation WB	VII. B. 1. a.
Stud Nuts (supplied by mfg.		Reinforcing Cloth	VII. B. 1. b.
for punched panels)	VII. A. 30.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME I",
GENERAL SPECIFICATIONS

Surface:

Steel shall be clean and dry, and when required shall be coated in accordance with
"COATING MANUAL". Stainless steel shall be coated in accordance with "COATING
MANUAL".

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(19-H, Vessel, Contd)

Insulation Supports:

Welded (vendor applied where possible) as per Standard EQ-64, bolted on as per Standards IS-31, 31A. Head securement pins as per Standard IS-40. Water shed plate or angle at top of cone head vessels as per Figure 19.H.1.

Tracing: (Where Required)

Heat Transfer Cement Materials - MATERIAL SPECIFICATION VII. C., Application - GENERAL SPECIFICATION XIII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL, VOLUME 1", SPECIFICATION NO. 19.H.

<u>Component</u>	<u>Type and Form Of Insulation</u>	<u>Securement</u>	<u>Weather Barrier</u>
Curved Side Wall	Mineral wool, aluminum faced panels as shown in Figure 19.H.1, 2, & 3	Studs or Strap	Factory Attached Aluminum
Heads	Preformed block as shown in Figure 19.H.1 & 5	Strap or Wire	Mastic
Nozzles	Preformed covers as shown in Figure 19.H.4	Strap and Wire	Mastic
Legs - Channel	Block	Strap and Wire	Mastic
Legs - Concrete Filled	Not Insulated		
Skirts - Outside	Mineral wool aluminum faced panel	Studs or Strap	Factory Attached Aluminum

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MAY, 1968SPECIFICATION NO. 21-H & HSS, ASBESTOS FIBER (High Temperature
Service - Max. 1000°F)PIPING INSULATION

	<u>LINE NO.</u>	<u>SIZE</u>	<u>LOCATION</u>	<u>METAL</u>	<u>INSUL THK "</u>
PLANT _____	_____	_____	_____	_____	_____
UNIT _____	_____	_____	_____	_____	_____
WORK ORDER _____	_____	_____	_____	_____	_____
ACCOUNT NO. _____	_____	_____	_____	_____	_____
DATE _____	_____	_____	_____	_____	_____

WEATHER BARRIER: Straight Pipe _____ Fittings: Mastic - Designation WCMATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIAL SPECIFICATIONS

Asbestos Fiber	Spec. 21.	Heat Resistant Sealer	VII. A. 42.
Cushioning Blanket	VII. A. 1.	Mastic (Caulking)	VII. A. 45
Insulating Cement	VII. A. 7.	Weather-Barrier: As Specified	
Pipe Insulation Support	VII. A. 9.	Mastic, color as specified,	
Pipe Insulation Strap	VII. A. 13.	Designation WC	VII. B. 1. a.
Clips for Pipe Strap	VII. A. 14.	Reinforcing Cloth	VII. B. 1. b.
Stainless Steel Wire	VII. A. 17.	Stainless Steel Jacket,	
Stainless Steel Pins	VII. A. 20.	Designation M	VII. B. 2.
High Temp. Fab. Cement	VII. A. 37.	Treated Steel Jacket,	
		Designation MT	VII. B. 3.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
GENERAL SPECIFICATIONS AND "ENGINEERING STANDARDS".Surface:

Surface shall be clean and dry. Steel and stainless steel, when required, shall be coated in accordance with "COATINGS MANUAL".

Insulation Supports:

Vertical pipes over 4" NPS as shown in Figure 21-H-1.

Tracing: (Where Required)

Steam, installed per Standards P-140, P-140; Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

Electric, installed per Standard EL-43; Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

Heat Transfer Cement, Materials, MATERIAL SPECIFICATIONS VII. C.
Application, GENERAL SPECIFICATIONS XIII. B.

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(21-H, 21-HSS, Piping, Contd)

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL VOLUME 1", SPECIFICATION NO. 21-H & HSS

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather-Barrier</u>
Straight Pipe	Sectional insulation (double layer 3 1/2" thick and over)	For all pipe and fittings: Wire up to 11" OD, Strap above 11" OD	Mastic or Steel Jacket
Insul. Expansion Joints	Install one every 21' of straight pipe, as shown in Figure 21-H-1. & 5.		Mastic
Gate and Globe Valves	Preformed as per "UCC Fab. Manual"*, as shown in Figure 21-H-4.		Mastic
Ball and Plug Valves	Field cut from sectional covering		Mastic
Flanged Fittings	Preformed as per "UCC Fab. Manual"*, as shown in Figure 21-H-3.		Mastic
Welded Ells	Preformed as per "UCC Fab. Manual"*, as shown in Figure 21-H-2.		Mastic
Screwed Fittings	Over 3" preformed. Under 3" may be field formed of pipe covering or insulating cement		Mastic

* Or ASTM Recommended Practice C-450, latest revision.

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MAY, 1968SPECIFICATION NO. 22-H, 22-HSS, EXPANDED SILICA(Moderate and High Temperature
Service, 70F to 1600F)EQUIPMENT INSULATION

	<u>VESSEL OR COLUMN</u>	<u>DUCT OR FLAT SURFACES</u>
PLANT _____	ITEM NO. _____ METAL _____	TOP AND BOTTOM:
UNIT _____	BODY: Dia. _____ LENGTH _____	WIDTH _____
WORK ORDERS _____	HEADS _____ SHAPE _____	LENGTH _____
ACCOUNT NO. _____	VESSEL FLANGES _____	SIDES:
DATE _____	MANHOLES _____	HEIGHT _____
	NOZZLES _____	LENGTH _____
	SKIRT OR LEGS _____	

WEATHER BARRIER _____ INSULATION THICKNESS " _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIALS SPECIFICATION

Expanded Silica Insulation	Spec. 22.	Fabrication Cement	VII. A. 38.
Cushioning Blanket	VII. A. 1.	Heat Resistant Sealer	VII. A. 42.
Mineral Wool Blanket		Mastic (Caulking)	VII. A. 45.
(netting - both sides)	VII. A. 5.	Weather Barrier - as specified	
Mineral Wool Blanket (one side		Mastic, color as specified,	
netting, other lath)	VII. A. 106.	Trowel Grade,	
Insulating Cement	VII. A. 7.	Designation WC	VII. B. 1. a.
Equipment Insulation Strap	VII. A. 11.	Mastic, color as specified,	
Clips for Equipment Strap	VII. A. 12.	Spray Grade,	
Stainless Steel Wire	VII. A. 17.	Designation WB	VII. B. 1. a.
Wire Netting	VII. A. 18.	Reinforcing Cloth	VII. B. 1. b.
Welding Pins	VII. A. 19.	Metal Jacket, stainless	
Stainless Steel Pins	VII. A. 20.	steel, Designation M	VII. B. 2.
Stainless Steel Skewers	VII. A. 21.	Treated steel,	
Welding Pin Insul Fasteners	VII. A. 22.	Designation MT	VII. B. 3.
Pin Clips	VII. A. 23.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
GENERAL SPECIFICATIONS and "ENGINEERING STANDARDS"Surface:Steel shall be clean and dry, and when required shall be coated in accordance with
"COATING MANUAL".

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Insulation Supports:

Welded (vendor applied where possible) as per Standard EQ-64. Bolted on as per Standards IS-31, 31-A, 36, 42.

Tracing: (Where Required)

Heat Transfer Cement, Materials - MATERIAL SPECIFICATION VII. C. Application, GENERAL SPECIFICATION XIII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION NO. 22-H, 22-HSS

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather Barrier</u>
Curved Side Walls			
Below 600F	Curved segments (double layer 3 1/2" thick and over)	Strap	Mastic or Steel
Above 600F and 12' OD	Glass blanket to 950F, mineral wool blanket over 950F. Inner layer under curved segments	Wire for Blanket Strap for Segments	Mastic or Steel
Heads	Same as for curved side wall	Strap & Wire	Mastic
Vessel Flanges	Preformed as shown in Figure 22-H-6	Strap & Wire	Mastic & stainless steel sleeves
Nozzles	Preformed as per "UCC Fab. Manual, as shown in Figure 22-H-10	Strap & Wire	Mastic
Irregular Surfaces	Block and insulating cement or insulating cement only	Strap & Wire	Mastic
Legs - Channel	Block down to fireproofing, as shown in Figure 22-H-11	Strap & Wire	Mastic
Legs - Concrete Filled	Not insulated		
Skirts & Cradles	Not insulated, unless required for protection		
Flat Surfaces	Flat block and insulating cement as shown in Figure 22-H-2	Pins, Clips, Wire, Netting	Mastic
Flat Surfaces Expansion Joint	Mineral wool blanket - lath one side, and insulating cement	Pins, Clips Wire	Mastic

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MAY, 1968SPECIFICATION NO 22-H & HSS, EXPANDED SILICA - (Moderate andPIPING INSULATIONHigh Temp. Service, 70F to
1600F)PIPE

	<u>LINE NO.</u>	<u>SIZE</u>	<u>LOCATION</u>	<u>METAL</u>	<u>INSUL THK "</u>
PLANT _____	_____	_____	_____	_____	_____
UNIT _____	_____	_____	_____	_____	_____
WORK ORDER _____	_____	_____	_____	_____	_____
ACCOUNT NO _____	_____	_____	_____	_____	_____
DATE _____	_____	_____	_____	_____	_____

WEATHER-BARRIER: Straight Pipe _____ Fittings: Mastic, Designation WCMATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
MATERIALS SPECIFICATION

Expanded Silica Insulation	Spec. 22.	Heat Resistant Sealer	VII. A. 42.
Cushioning Blanket	VII. A. 1.	Mastic (Caulking)	VII. A. 45.
Insulating Cement	VII. A. 7.	Weather-Barrier: As Specified	
Pipe Insulation Support	VII. A. 9.	Mastic, color as specified,	
Pipe Insulation Strap	VII. A. 13.	Designation WC	VII. B. 1. a.
Clips for Pipe Strap	VII. A. 14.	Reinforcing Cloth	VII. B. 1. b.
Stainless Steel Wire	VII. A. 17.	Stainless Steel Jacket,	
Stainless Steel Pins	VII. A. 20.	Designation M	VII. B. 2.
High Temperature Fabrication		Treated Steel Jacket,	
Cement	VII. A. 37.	Designation MT	VII. B. 3.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
GENERAL SPECIFICATIONS and "ENGINEERING STANDARDS"Surface:

Surface shall be clean and dry. Steel and stainless steel, when required, shall be coated in accordance with "COATING MANUAL".

Insulation Supports:

Vertical pipe over 4" NPS as shown in Figure 22-H-13.

Tracing: (Where Required)

Steam, installed per Standards P-140, P-140A. Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

Electric, installed per Standard EL-43. Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

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(22-H, 22-HSS, Piping, Contd)

Tracing: (Continued)Heat Transfer Cement, Materials, MATERIAL SPECIFICATIONS VII. C.
Application, GENERAL SPECIFICATIONS XIII. B.APPLICATION: Installation details as specified in "THERMAL INSULATION
MANUAL - VOLUME 1", SPECIFICATION NO. 22-H & HSS

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather-Barrier</u>
Straight Pipe	Sectional insulation (double layer 3 1/2" thick and over)	For all pipe and fittings: Wire up to 11" OD, Strap over 11" OD	Mastic or Steel Jacket
Insulation Expansion Joints	Install one every 21' of straight pipe, as per Figure 22-H-13, 17.		Mastic and Stainless Steel Sleeves
Gate and Globe Valves	Preformed as per "UCC Fab. Manual"*, as shown in Figure 22-H-16.		Mastic
Ball and Plug Valves	Field cut from sectional covering		Mastic
Flanged Fittings	Preformed as per "UCC Fab. Manual"*, as shown in Figure 22-H-15.		Mastic
Welded Ells	Preformed as per "UCC Fab. Manual"*, as shown in Figure 22-H-14.		Mastic
Screwed Fittings	Over 3" preformed. Under 3" may be field formed of pipe covering or insulating cement		Mastic

* Or ASTM Recommended Practice C-450, latest revision.



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SPECIFICATION NO. 22-HSP, EXPANDED SILICA (Moderate to High

SPHERE INSULATION

Temperature
Service, 70F to
500F)

SPHERE

PLANT _____ ITEM NO. _____
UNIT _____ BODY: Dia. _____
WORK ORDER _____ MANHOLES _____
ACCOUNT NO. _____ NOZZLES _____
DATE _____ PROJECTIONS _____
LEGS _____
WEATHER BARRIER Mastic INSULATION THICKNESS" _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIALS SPECIFICATION

Expanded Silicate Insulation	Spec. 22.	Weather Barrier Mastic,	
Insulating Cement	VII. A. 7.	color as specified,	
Equipment Insulation Strap	VII. A. 11.	Trowel Grade,	
Clips for Equipment Strap	VII. A. 12.	Designation WC	VII. B. 1. a.
Wire Netting	VII. A. 18.	Mastic, color as specified	
Welding Pin Insulation Fasteners	VII. A. 22.	Spray Grade,	
Pin Clips	VII. A. 23.	Designation WB	VII. B. 1. b.
Stainless Steel Skewers	VII. A. 21.	Reinforcing Cloth	
Fabrication Cement	VII. A. 38.	Metal Jacket, Treated Steel,	
Heat Resistant Sealer	VII. A. 42.	Designation MT	VII. B. 3.
Mastic (Caulking)	VII. A. 45.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
and "ENGINEERING STANDARDS"

Surface:

Steel shall be clean and dry, and when required shall be coated in accordance with
"COATINGS MANUAL". Stainless steel shall be coated in accordance with
"COATINGS MANUAL".

Insulation Supports:

Shall be provided as shown on drawing. One to be located at equator, one to be
approximately 30° below and another to be approximately 30° above the equator.
These are primarily used as water stops. Welding pins space 4 to block,
supports the insulation to the sphere body.

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(22-HSP, Sphere, Contd)

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL, VOLUME 1", SPECIFICATION NO. 22-HSP

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather Barrier</u>
Body	Insulation shall be shop fabricated, geodesically shaped to fit sphere body. Impaled on pins, then secured by clips pressed into surface. Depression filled flush with caulking mastic as shown in Figure 22-H-SP-1	Pins, Clips	Mastic
Insulation Support	As shown in Figure 22-HSP-2		Mastic
Nozzles and Manholes	Preformed covers, as shown in Figures 22-HSP-3, 4	Strap, Wire	Mastic
Legs-Concrete Filled	Not insulated		
Legs-Not Filled	Block or preformed insulation to fire protection	Strap, Wire	Mastic
Tie Rods	2" thick sec. insulation as per Spec. 22-H	Strap	Steel Jacket

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MAY, 1968SPECIFICATION NO. 23-H, 23-HSS, CALCIUM SILICATE(High Temperature Service
Max. 950F)EQUIPMENT INSULATION

	<u>VESSEL OR COLUMN</u>	<u>DUCT OR FLAT SURFACES</u>
PLANT _____	ITEM NO. _____ METAL _____	TOP AND BOTTOM: _____
UNIT _____	BODY: Dia. _____ LENGTH _____	WIDTH _____
WORK ORDER _____	HEADS _____ SHAPE _____	LENGTH _____
ACCOUNT NO. _____	VESSEL FLANGES _____	SIDES: _____
DATE _____	MANHOLES _____	WIDTH _____
	NOZZLES _____	LENGTH _____
	SKIRT OR LEGS _____	

WEATHER BARRIER _____ INSULATION THICKNESS " _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIALS SPECIFICATION

Calcium Silicate Insulation	Spec. 23.	Fabrication Cement	VII. A. 38.
Cushioning Blanket	VII. A. 1.	Heat Resistant Sealer	VII. A. 42.
Mineral Wool Blanket		Mastic (Caulking)	VII. A. 45.
(netting both sides)	VII. A. 5.	Weather Barrier - as specified	
Mineral Wool Blanket (one		Mastic, color as specified	
side netting - other lath)	VII. A. 106.	Trowel Grade -	
Insulating Cement	VII. A. 7.	Designation WC	VII. B. 1. a.
Equipment Insulation Strap	VII. A. 11.	Mastic, color as specified,	
Clips for Equipment Strap	VII. A. 12.	Spray Grade -	
Stainless Steel Wire	VII. A. 17.	Designation WB	VII. B. 1. a.
Wire Netting	VII. A. 18.	Reinforcing Cloth	VII. B. 1. b.
Welding Pins	VII. A. 19.	Metal Jacket, stainless steel	
Stainless Steel Pins	VII. A. 20.	Designation M	VII. B. 2.
Stainless Steel Skewers	VII. A. 21.	Treated Steel,	
Welding Pin Insul Fasteners	VII. A. 22.	Designation MT	VII. B. 3.
Pin Clips	VII. A. 23.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
and "ENGINEERING STANDARDS"Surface:Steel shall be clean and dry, and when required shall be coated in accordance with
"COATINGS MANUAL"

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(22-H, 22-HSS, Equip, Contd)

Insulation Supports:

Welded (vendor applied where possible) as per Standard EQ-64. Bolted on as per Standard IS-31, 31A, 36, 42

Tracing: (Where Required)

Heat Transfer Cement, Materials - MATERIAL SPECIFICATION VII. C. Application - GENERAL SPECIFICATION XIII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION NO. 23-H, 23-HSS

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather Barrier</u>
Curved Side Walls			
Below 600F	Curved segments (double layer 3 1/2" thick and above)	Strap	Mastic or Steel
Above 600F and 12' OD	Glass blanket inner layer under curved segment	Strap and Wire	Mastic or Steel
Heads	Same as for curved side wall	Strap & Wire	Mastic
Vessel Flanges	Preformed as shown in Figure 23-HSS-6	Strap and Wire	Mastic
Nozzles	Preformed as per "UCC Fab. Manual", as shown in Figure 23-HSS-9, 10	Strap and Wire	Mastic
Irregular Surfaces	Block and insul cement or insul cement only	Strap & Wire	Mastic
Legs - Channel	Block down to fireproofing, as shown in Figure 23-HSS-12	Strap & Wire	Mastic
Legs - Concrete Filled	Not insulated		
Skirts and Cradles	Not insulated, unless required for protection		
Flat Surfaces	Flat block and insul cement as shown in Figure 23-HSS-2	Pins, Clips, Wire, Netting	Mastic
Flat Surface Expansion Joint	Mineral wool blanket - lath one side and insul cement	Pins, Clips, Wire	Mastic

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MAY, 1968SPECIFICATION NO. 23-H & HSS, CALCIUM SILICATE (High Tempera
Service - Max. 950°)PIPING INSULATION

	<u>PIPE</u>				
	<u>LINE NO.</u>	<u>SIZE</u>	<u>LOCATION</u>	<u>METAL</u>	<u>INSUL THK "</u>
PLANT _____	_____	_____	_____	_____	_____
UNIT _____	_____	_____	_____	_____	_____
WORK ORDER _____	_____	_____	_____	_____	_____
ACCOUNT NO. _____	_____	_____	_____	_____	_____
DATE _____	_____	_____	_____	_____	_____

WEATHER BARRIER: Straight Pipe _____ Fittings: Mastic-Designation WCMATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIALS SPECIFICATION

Calcium Silicate Insulation	Spec. 23.	High Temp. Fab. Cement	VII. A. 37.
Cushioning Blanket	VII. A. 1.	Heat Resistant Sealer	VII. A. 42.
Insulating Cement	VII. A. 7.	Mastic (Caulking)	VII. A. 45.
Pipe Insulation Support	VII. A. 9.	Weather-Barrier: As Specified	
Pipe Insulation Strap	VII. A. 13.	Mastic, color as specified,	
Clips for Pipe Strap	VII. A. 14.	Designation WC	VII. B. 1. a.
Stainless Steel Wire	VII. A. 17.	Reinforcing Cloth	VII. B. 1. b.
Stainless Steel Pins	VII. A. 20.	Stainless Steel Jacket,	
		Designation M	VII. B. 2.
		Treated Steel Jacket,	
		Designation MT	VII. A. 3.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
"GENERAL SPECIFICATIONS" and "ENGINEERING STANDARDS"Surface:

Surface shall be clean and dry. Steel and stainless steel, when required, shall be coated in accordance with "COATING MANUAL".

Insulation Supports:

Vertical pipe over 4" NPS as shown in Figure 23-HSS-13.

Tracing: (Where Required)

Steam, installed per Standards P-140, P-140A. Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

Electric, installed per Standard EL-43. Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

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MAY, 1968PREPARATION: Continued

22-H, 22-HSS, Piping, Contd)

Tracing: ContinuedHeat transfer cement, Materials, MATERIALS SPECIFICATIONS VII. C.
Application, GENERAL SPECIFICATIONS XIII. B.APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL
VOLUME 1", SPECIFICATION NO. 23-H & HSS

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather-Barrier</u>
Straight Pipe	Sectional insulation (double layer 3 1/2" thick and over)	For all pipe and fittings: Wire up to 11" OD Strap over 11" OD	Mastic or Steel Jacket
Insul. Expansion Joints	Install one every 211 of straight pipe, as per Figure 23-HSS-13, 17		Mastic and Stainless Steel Sleeves
Gate and Globe Valves	Preformed as per "UCC Fab. Manual"*, as shown in Figure 23-HSS-		Mastic
Ball & Plug Valves	Field cut from sectional covering		Mastic
Flanged Fittings	Preformed as per "UCC Fab. Manual"*, as shown in Figure 23-HSS-15		Mastic
Welded Ells	Preformed as per "UCC Fab. Manual*", as shown in Figure 23-HSS-14		Mastic
Screwed Fittings	Over 3" preformed. Under 3" may be field formed		Mastic

* Or ASTM Recommended Practice C-450, latest revision.

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MAY, 1968SPECIFICATION NO. 25-H, "HIGH TEMPERATURE CALCIUM SILICATE(High Temperature Service
750F to 1600F)EQUIPMENT INSULATION

	<u>VESSEL OR COLUMN</u>	<u>DUCT OR FLAT SURFACE</u>
PLANT _____	ITEM NO. _____ METAL _____	TOP OR BOTTOM: _____
UNIT _____	BODY:DIA. _____ LENGTH _____	WIDTH _____
WORK ORDER _____	HEADS _____	LENGTH _____
ACCOUNT NO. _____	VESSEL FLANGES _____	SIDE: _____
DATE _____	NOZZLES _____	WIDTH _____
	SKIRT OR LEGS _____	LENGTH _____
WEATHER-BARRIER _____	INSULATION THICKNESS " _____	

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIALS SPECIFICATION

Calcium Silicate-"High Tem-		Pin Clips	VII. A. 23.
perature Insulation	Spec. 25.	Fabrication Cement	VII. A. 38.
Calcium Silicate Insulation	Spec. 23.	Heat Resistant Sealer	VII. A. 42.
Mineral Wool Blanket (Netting		Mastic (Caulking)	VII. A. 45.
both sides)	VII. A. 5.	Weather Barrier - as specified	
Mineral Wool Blanket (One		Mastic, color as specified,	
side netting - other lath)	VII. A. 106.	Trowel Grade -	
Insulating Cement	VII. A. 7.	Designation WC	VII. B. 1. a.
Equipment Insulation Strap	VII. A. 11.	Mastic, color as specified,	
Clips for Equipment Strap	VII. A. 12.	Spray Grade -	
Stainless Steel Wire	VII. A. 17.	Designation WB	VII. B. 1. a.
Wire Netting	VII. A. 18.	Reinforcing Cloth	VII. B. 1. b.
Welding Pins	VII. A. 19.	Metal Jacket	
Stainless Steel Pins	VII. A. 20.	Stainless Steel,	
Stainless Steel Skewers	VII. A. 21.	Designation M	VII. B. 2.
Welding Pin Insulation		Treated Steel,	
Fasteners	VII. A. 22.	Designation MT	VII. B. 3.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
and "ENGINEERING STANDARDS"Surface:Surface shall be clean and dry, and when required shall be coated in accordance
with "COATING MANUAL".

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PREPARATION: Continued

(25-H, Equip, Contd)

Insulation Supports:

Welded (vendor applied where possible) as per Standard EQ-64. Bolted on as per Standard IS-31, 31A, 36, 42.

Tracing: (Where Required)

Heat Transfer Cement, Materials - MATERIAL SPECIFICATION VII. C. Application - GENERAL SPECIFICATION XII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION 25-H

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather-Barrier</u>
Curved Side Walls	Double layer - inner layer, high temperature calcium silicate, outer "Standard" calcium silicate	Strap	Mastic or Steel
Larger than 6'0" OD	Mineral Wool Blanket (wire netting both sides) under cured segment	Strap and Wire	Mastic or Steel
Heads	Same as for curved side walls	Strap and Wire	Mastic
Vessel Flanges	Preformed as shown in Figure 25-H-6	Strap and Wire	Mastic
Nozzles	Preformed as per "UCC Fab. Manual", as shown in Figure 25-H-8, 9	Strap and Wire	Mastic
Irregular Surfaces	Block and Insulating Cement	Strap and Wire	Mastic
Legs - Channel	Block down to fire proofing as shown in Figure 25-H-10	Strap and Wire	Mastic
Legs - Concrete Filled	Not insulated		
Skirts & Cradles	Not insulated, unless required for fire protection		
Flat Surfaces	Flat block, inner layer, high temperature calcium silicate, outer "Standard" calcium silicate and insulating cement as shown in Figure 25-H-2	Pins, Clips, Wire, Netting	Mastic
Flat Surface Expansion Joint	Mineral wool blanket - lath one	Pins, Clips, Wire	Mastic

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MAY 1968SPECIFICATION NO. 25H, HIGH TEMPERATURE CALCIUM SILICATEPIPING INSULATION(High Temperature Service
750F to 1600F)

	<u>PIPE</u>				
	<u>LINE NO.</u>	<u>SIZE</u>	<u>LOCATION</u>	<u>METAL</u>	<u>INSUL THK "</u>
PLANT _____	_____	_____	_____	_____	_____
UNIT _____	_____	_____	_____	_____	_____
WORK ORDER _____	_____	_____	_____	_____	_____
ACCOUNT NO _____	_____	_____	_____	_____	_____
DATE _____	_____	_____	_____	_____	_____

WEATHER-BARRIER: Straight Pipe _____ Fittings: Mastic - Designation WCMATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
MATERIALS SPECIFICATION

Calcium Silicate - "High Temp." Spec. 25.	Heat Resistant Sealer	VII. A. 42.
Insulation	Mastic (Caulking)	VII. A. 45.
Calcium Silicate Insulation Spec. 23.	Weather-Barrier: As specified	
Mineral Wool Blanket VII. A. 5.	Mastic, color as specified,	
Insulating Cement VII. A. 7.	Designation WC	VII. B. 1. a.
Pipe Insulation Strap VII. A. 13.	Reinforcing Cloth	VII. B. 1. b.
Clips for Pipe Strap VII. A. 14	Stainless steel Jacket	
Stainless Steel Wire VII. A. 17.	Designation M	VII. B. 2.
Wire Netting VII. A. 18.	Treated Steel Jacket,	
Stainless Steel Skewers VII. A. 21.	Designation MT	VII. B. 3.
High Temp. Fabrication Cement VII. A. 37.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
"GENERAL SPECIFICATIONS" and "ENGINEERING STANDARDS"Surface:

Surface shall be clean and dry. Steel, where required, shall be coated in accordance with "COATING MANUAL".

Insulation Supports:

Vertical pipe over 4" NPS, as shown in Figure 25-H-12.

Tracing: (Where Required)Steam, installed per Standards P-140, P-140A. Insulation Details.
GENERAL SPECIFICATION VII. A. & B.

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MAY, 1968PREPARATION: Continued

(25-H, Piping, CoHtd)

Tracing: Continued

Electric, installed per Standard EL-43. Insulation Details, GENERAL SPECIFICATION VII. A. & B.

Heat Transfer Cement, Materials, MATERIALS SPECIFICATIONS VII. C.
Application, GENERAL SPECIFICATIONS XII. B.APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION NO. 25-H.

Straight Pipe	Sectional Insulation (double layer 3 1/2" thick and over) H. T. calcium silicate single and inner layers. Standard calcium silicate outer layer.	For all pipe and fittings: Wire up to 11" OD Strap over 11" OD	Mastic or Steel Jacket
Insul. Expansion Joints	Install one every 21' single layer. Every 15' on multiple layers as shown in Figure 25-H-12		Mastic and Stainless Steel Sleeves
Gate & Globe Valves	Preformed as per "UCC Fab. Manual"*, as shown in Figure 25-H-15		Mastic
Ball & Plug Valves	Field cut from sectional covering		Mastic
Flanged Fittings	Preformed as per "UCC Fab. Manual"*, as shown in Figure 25-H-14		Mastic
Welded Ells	Preformed as per "UCC Fab. Manual"*, as shown in Figure 25-H-13		Mastic
Screwed Fittings	Preformed as per "UCC Fab. Manual"*		Mastic

* Or ASTM Recommended Practice C-450, latest revision.



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SPECIFICATION NO. 31-H, 31-HSS, PREFABRICATED STAINLESS-CASED ALUMINUM

(High Temperature Service up
to 1000F)

	<u>EQUIPMENT</u>	<u>PIPING</u>
PLANT _____	ITEM NO. _____	Insulation custom made to fit pipe valves and fittings.
UNIT _____	Insulation custom made to fit item	Drawings to manufacture must also show supports and their details and all interferences.
WORK ORDER _____		
ACCOUNT NO. _____		
DATE _____		

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIALS SPECIFICATION

Prefabricated Stainless Cased Aluminum	Spec. 31.
Stainless Steel Insulation Strap	VII. A. 13.
Clips for Insulation Strap	VII. A. 14.
Stainless Steel Sheet Metal Screws	VII. A. 32.
Snap-Lock type Fasteners	Furnished by Mfg.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
GENERAL SPECIFICATIONS and "ENGINEER'S STANDARDS"

Surface:

Surface shall be clean and dry. Steel and stainless steel, where required, shall be coated in accordance with "COATING MANUAL".

Insulation Supports:

Equipment supports shall be as per GENERAL SPECIFICATIONS* ARTICLE II.

Tracing: (Where Required)

Steam, installed per Standards P-140, & -140. A. Insulation details - custom made insulation to fit. Electric, installed per Standard EL-43. Insulation details - custom made insulation to fit. Heat Transfer Cement, materials - MATERIALS SPECIFICATIONS VII. C. Application, GENERAL SPECIFICATIONS XII. B.

APPLICATION: Insulation details as specified in "THERMAL INSULATION MANUAL, VOLUME 1", SPECIFICATION NOS. 31-H, 31-HSS

Thickness: Unless otherwise specified, insulation will be applied in single layer.



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APPLICATION: Continued

(31-H, 31-HSS, Equip & Piping,
Contd)

Equipment: Panels installed to shed water, secured in position by metal screws, strap or latches.

Piping: Pipe covering and fitting covers installed to shed water. Secured in position with strap or latches.

Weather Barrier: Casing furnished on prefabricated units serves as weather barrier.

Note: Insulation must be installed in sequence as designated on manufacturer's drawings.

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MAY, 1968SPECIFICATION No. 32-HFP and 32-HFPSS, BONDED EXPANDED SILICA

	<u>EQUIPMENT INSULATION</u>	(Atmospheric to Max. 1200F)
	<u>VESSEL OR COLUMN</u>	<u>DUCT OR FLAT SURFACE</u>
PLANT _____	ITEM NO. _____ METAL _____	TOP AND BOTTOM: _____
UNIT _____	BODY: Dia. _____ LENGTH _____	WIDTH _____
WORK ORDER _____	HEADS _____	LENGTH _____
ACCOUNT NO. _____	VESSEL FLANGES _____	SIDES: _____
DATE _____	NOZZLES _____	WIDTH _____
	SKIRT OR LEGS _____	LENGTH _____
WEATHER BARRIER _____	INSULATED THICKNESS" _____	

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIALS SPECIFICATION

Expanded Silica Insulation	Spec. 22.	Heat Resistant Sealer	VII. A. 42.
Cushioning Blanket	VII. A. 1.	Mastic (Caulking)	VII. A. 45.
Mineral Wool Blanket (wire netting both sides)	VII. A. 5.	Adhesive Type Pins	VII. A. 75.
Insulating Cement	VII. A. 7.	Weather Barrier, as specified	
Equipment Insulation Strap	VII. A. 11.	Mastic, color as specified,	
Clips for Equipment Strap	VII. A. 12.	Trowel Grade	
Stainless Steel Wire	VII. A. 17.	Designation WC	VII. B. 1. a.
Wire Netting	VII. A. 18.	Mastic, color as specified,	
Welding Pins	VII. A. 19.	Spray Grade	
Stainless Steel Pins	VII. A. 20.	Designation WB	VII. B. 1. a.
Stainless Steel Skewers	VII. A. 21.	Reinforcing Cloth	VII. B. 1. b.
Welding Pin Insulation Fasteners	VII. A. 22.	Metal Jacket	
Pin Clips	VII. A. 23.	Stainless Steel,	
Mineral Wool Blanket (wire net- ting on one side, expanded		Designation M	VII. B. 2.
metal on the other)	VII. A. 106.	Treated Steel,	
Fabrication Cement	VII. A. 38.	Designation MT	VII. B. 2.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
and "ENGINEERING STANDARDS"

Surface:

Surface shall be clean and dry. Steel and stainless steel, where required, shall be coated in accordance with "COATINGS MANUAL".

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MAY, 1968PREPARATION: Continued(32-HFP, 32-HFPSS, Equip,
Contd)Insulation Supports:

Welded (vendor applied where possible) as per Standard EQ-64. Bolted as per IS-31, 31A, 36, 42.

Tracing: (Where Required)

Heat Transfer Cement, Materials - MATERIAL SPECIFICATION VII. C. Application - GENERAL SPECIFICATIONS

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATIONS 32-HP, 32-HPSS

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather Barrier</u>
Curved Side Walls	Single layer to 3" thick, double layer 3 1/2" thick and greater where required by size or temperature. Cushion blanket shall be under curved block	Strap Strap & Wire	Mastic or Steel
Heads	Same as for curved side walls	Strap & Wire	Mastic
Vessel Flanges	Preformed as shown in Figure 32-H-6.		
Nozzles	Preformed as per "UCC Fab. Manual as shown in Figure 32-H-9.	Strap & Wire	Mastic
Irregular Surfaces	Block and insulating cement	Strap, Wire, Netting	Mastic
Legs - Channel	Block down to fire proofing, as shown in Figure 32-H-10	Strap & Wire	Mastic
Legs - Concrete Filled	Not insulated.		
Skirts & Cradles	Curved block same as vessel	Strap & Wire	Mastic or Steel
Flat Surfaces	Flat block, double layer 3 1/2" and over and insulating cement as shown in Figure 32-H-2	Pins, Clips, Wire, Netting	Mastic
Flat Surface Expansion Joint	Mineral Wool Blanket - lath one side, and insul. cement	Pins, Clips Wire	Mastic



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SPECIFICATION NO. 32-HFP and 32 HFPSS, BONDED EXPANDED SILICA
PIPING INSULATION (Atmospheric to Max. 1200F)

PIPE

	<u>LINE NO.</u>	<u>SIZE</u>	<u>LOCATION</u>	<u>METAL</u>	<u>INSUL THK "</u>
PLANT _____	_____	_____	_____	_____	_____
UNIT _____	_____	_____	_____	_____	_____
WORK ORDER _____	_____	_____	_____	_____	_____
ACCOUNT NO. _____	_____	_____	_____	_____	_____
DATE _____	_____	_____	_____	_____	_____

WEATHER-BARRIER, STRAIGHT PIPE _____ FITTINGS _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
MATERIALS SPECIFICATION

Expanded Silica Insulation	Spec. 22.	Heat Resistant Sealer	VII. A. 42.
Cushioning Blanket	VII. A. 1.	Mastic (Caulking)	VII. A. 45.
Insulating Cement	VII. A. 7.	Weather-Barrier:	
Pipe Insulation Support	VII. A. 9.	As Specified	
Pipe Insulation Strap	VII. A. 13.	Mastic, color as	
Clips for Pipe Strap	VII. A. 14.	specified, Designation WC	VII. B. 1. a.
Stainless Steel Wire	VII. A. 17.	Reinforcing Cloth	VII. B. 1. b.
Stainless Steel Skewers	VII. A. 21.	Stainless Steel Jacket,	
Fabrication Cement	VII. A. 21.	Designation M	VII. B. 2.
		Treated Steel Jacket,	
		Designation MT	VII. B. 3.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
GENERAL SPECIFICATIONS and ENGINEERING STANDARDS

Surface:

Surface shall be clean and dry. Steel and stainless steel, where required, shall be coated in accordance with "COATING MANUAL".

Insulation Supports:

Vertical pipe over 4" NPS as shown in Figure 32-H-12.

Tracing: (Where Required)

Steam, installed per Standards P-140, P-140A. Insulation Details,
GENERAL SPECIFICATIONS VII. A. & B.

Electric, installed per Standard EL-43. Insulation Details, GENERAL
SPECIFICATIONS VII. A. & B.

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MAY, 1968PREPARATION: Continued

(32-HFP, HFPSS, Piping, Contd)

Tracing: ContinuedHeat Transfer Cement, Materials - MATERIAL SPECIFICATIONS VII. C.
Application GENERAL SPECIFICATIONS XII. B.APPLICATION: Installation details as specified in THERMAL INSULATION MANUAL
VOLUME 1. SPECIFICATIONS NO. 32-HFP & HFPSS

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather-Barrier</u>
Straight Pipe	Sectional insulation, thickness schedule as per Spec. No. 32-HFP and HFPSS B. 2. 0. (2).	For all pipe and fittings: Wire up to 11" OD Strap over 11 OD	Mastic or Steel
Insul. Expansion Joint	Install one every 21 as shown in 32-H-16		Mastic and Stainless Steel
Gate and Globe Valves	Preformed as per "UCC Fab. Manual"* as shown in Figure 32-H-15	Strap over 11" OD	Mastic
Ball & Plug Valves	Field cut from sectional covering		Mastic
Flanged Fittings	Preformed as per "UCC Fab. Manual"* as shown in Figure 32-H-14		Mastic
Welded Ells	Preformed as per "UCC Fab. Manual"* as shown in Figure 32-H-13		Mastic
Screwed Fittings	Preformed as per "UCC Fab. Manual"*		Mastic

* Or ASTM Recommended Practice C-450, latest revision.

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MAY, 1968SPECIFICATION NO. 32-LFP and 32-LFPSS, CELLULAR GLASSand BONDED EXPANDED SILICA (Ambient to Low Temp.)EQUIPMENT INSULATIONVESSEL OR COLUMN

PLANT _____ ITEM NO. _____ METAL _____
UNIT _____ BODY: Dia. _____ LENGTH _____
WORK ORDER _____ HEADS _____
ACCOUNT NO. _____ VESSEL FLANGES _____
DATE _____ NOZZLES _____
SKIRT OR LEGS _____

WEATHER BARRIER _____ INSULATION THICKNESS" _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIAL SPECIFICATIONS

Cellular Glass Insulation	Spec. 10.	Anti-Abrasive Coating	
Expanded Silica Insulation	Spec. 22.	(Stainless steel substrate)	VII. A. 40.
Cushioning Blanket	VII. A. 1.	Joint Sealer	VII. A. 43.
Insulating Cement	VII. A. 7.	Lap Sealer	VII. A. 46.
Equipment Insulation Strap	VII. A. 11.	Adhesive Cement	VII. A. 65.
Clips for Equipment Strap	VII. A. 12.	Mastic (Caulking)	VII. A. 45.
Stainless Steel Wire	VII. A. 17.	Weather Barrier, as specified	
Stainless Steel Skewers	VII. A. 21.	Mastic, color as specified,	
Fabrication Cement for Cellular Glass	VII. A. 36.	Designation WC	VII. B. 1. a.
Fabrication Cement for Expanded Silica	VII. A. 38.	Reinforcing Cloth	VII. B. 1. b.
Anti-Abrasive Coating (steel substrate)	VII. A. 39.	Stainless Steel Jacket, Designation M	VII. B. 2.
		Treated Steel Jacket, Designation MT	VII. B. 3.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
and "ENGINEERING STANDARDS"Surface:

Surface shall be clean and dry and, where required, shall be coated in accordance with "COATING MANUAL"

Insulation Supports:

Welded (vendor applied where possible) as per Standard EQ-64. Bolted on as per Standards IS. 31, 31.a, 36, 42.

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MAY, 1968PREPARATION: Continued

(32-LFP, LFPSS, Equip, Contd)

Tracing: (Where Required)

Heat Transfer Cement, Materials - MATERIALS SPECIFICATION VII. C.

Application - GENERAL SPECIFICATION XII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION
MANUAL - VOLUME 1", SPECIFICATIONS 32-LFP & LFPSS

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather Barrier</u>
Curved Side Walls	1/2" cushion blanket, curved cellular glass block, single or multiple layer - depending upon specified thickness, and outer layer of 1 1/2" thick expanded silica	Wire and Strap	Mastic or Steel
Heads	Same as for curved side walls	Wire and Strap	Mastic
Vessel Flanges & Nozzles	Preformed of specified thickness of cellular glass and expanded silica as shown in Figures 32-LFP. 3, 4. & 5.	Wire and Strap	Mastic
Legs, Skirts & Cradles	Same as for curved side walls, carried down to concrete fire proofing or base pad	Wire and Strap	Mastic

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MAY, 1968SPECIFICATION NO. 32-LFP and 32-LFPSS, CELLULAR GLASS and BONDED
EXPANDED SILICA (Ambient to Low Temperature)PIPING INSULATION

	<u>PIPE</u>				
	<u>LINE NO.</u>	<u>SIZE</u>	<u>LOCATION</u>	<u>METAL</u>	<u>INSUL. THK "</u>
PLANT _____	_____	_____	_____	_____	_____
UNIT _____	_____	_____	_____	_____	_____
WORK ORDER _____	_____	_____	_____	_____	_____
ACCOUNT NO. _____	_____	_____	_____	_____	_____
DATE _____	_____	_____	_____	_____	_____
WEATHER-BARRIER, STRAIGHT PIPE _____				FITTINGS _____	

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
MATERIALS SPECIFICATION

Cellular Glass Insulation	Spec. 10	Anti-Abrasive Coating	VII. A. 39.
Expanded Silica Insulation	Spec. 22.	Joint Sealer	VII. A. 43.
Cushioning Blanket	VII. A. 1.	Lap Sealer	VII. A. 46.
Cushioning Glass Fiber Molded		Adhesive Cement	VII. A. 65
Pipe Insulation	VII. A. 4.	Mastic (Caulking)	VII. A. 45
Pipe Insulation Strap	VII. A. 13.	Weather Barrier: As Specified	
Clips for Pipe Strap	VII. A. 14.	Mastic, Color as Specified,	
Stainless Steel Wire	VII. A. 17.	Designation WC	VII. B. 1. a.
Strapping Tape	VII. A. 33.	Reinforcing Cloth	VII. B. 1. b.
Stainless Steel Skewers	VII. A. 21.	Stainless Steel Jacket,	
Fabrication Cement for		Designation M	VII. B. 2.
Cellular Glass	VII. A. 36.	Treated Steel Jacket,	
Fabrication Cement for		Designation MT	VII. B. 3.
Expanded Silica	VII. A. 38.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
GENERAL SPECIFICATIONS and "ENGINEERING STANDARDS"Surface:

Surface shall be clean and dry. Steel and stainless steel, where required, shall be coated in accordance with "COATING MANUAL".

Insulation Supports:

Vertical Pipe over 4" NPS as shown in Figure 32-H-12.

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MAY, 1968**PREPARATION:** Continued

(32-LFP, LFPSS, Piping, Contd)

Tracing: (Where Required)

Steam, installed per Standards P-140, P-140A. Insulation details, GENERAL SPECIFICATIONS VII. A. & B.

Electric, installed per Standard EL-43. Insulation details, GENERAL SPECIFICATIONS VII. A. & B.

Heat transfer cement, materials - MATERIAL SPECIFICATIONS VII. C.
Application GENERAL SPECIFICATIONS XIII. B.

APPLICATION: Installation details as specified in 'THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION NO. 32-LFP & LFPSS

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather-Barrier</u>
Straight Pipe	Inner layer or layers - the required thickness of cellular glass. Outer layer 1 1/2" bonded expanded silica. Where internal thermal shock is expected, molded glass fiber applied under cellular glass.	Inner layer of cellular glass, strapping tape; strap for all other.	Mastic or Steel
Insulation Contraction Joints	Up to 2 1/2" thick insul - one for each 45', 3" to 5" thick--one for each 33', 5" to 7 1/2" thick--one each 21" of straight pipe.		Mastic and Stainless Steel Sleeves
Gate & Globe Values	Preformed - same layers as for straight pipe, as shown in Figure 32-LFP-16.		Mastic
Ball & Plug Valves	Field fabricated.		Mastic
Flanged Fittings	Preformed - same layers as for straight pipe, as shown in Figure 32-LFP-14.		Mastic
Welded Ells	Preformed - same layers as for straight pipe, as shown in Figure 32-LFP-12.		
Screwed Fittings	Preformed - same layers as for straight pipe		Mastic



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SPECIFICATION NO. 37-H, INSULATED METAL CONDUIT (Temp. up to 750F)
UNDERGROUND PIPE INSULATION

PIPING

PLANT _____
UNIT _____
WORK ORDER _____
ACCOUNT NO. _____
DATE _____

Sections of piping are insulated and encased in metal conduit by manufacturer in accordance with drawings for specific installation. Sections are placed in position in trench and pipe, insulation and conduit are field connected.

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIALS SPECIFICATION

Metal Conduit	Spec. 37.	Weather Barrier Mastic	VII. b. 1. a.
Insulation as Specified		Reinforcing Cloth	VII. b. 1. b.
Molded Glass Fiber Insulation	Spec. 15.	Pipe Insulation Strap	VII. A. 13.
Asbestos Fiber Insulation	Spec. 21.	Clips for Pipe Strap	VII. A. 14.
Expanded Silica Insulation	Spec. 22.		
Calcium Silicate Insulation	Spec. 23.		

TRENCH PREPARATION:

Bottom of trench shall be smooth, clean and dry.

PREPARATION:

Pipe shall be welded and tested before insulation over joints is installed.

FIELD CONNECTIONS: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPEC. No. 37-H

Field Welded Conduit Connections

Asbestos jacket shall be installed over insulation, conduit closure shall be installed over joint and seal welded. After testing with 15 psi air, welds shall be smoothed and entire connection wrapped with tape. Installation shown in Figure 37-H-1

Mechanical Conduit Connections

Exposed insulation shall be covered with mastic and reinforcing cloth. Metal jacket closure shall be installed over conduit with pour hole at top and secured with insulation strap. Space between insulation and metal jacket closure shall be filled with hot asphalt as shown in Figure 37-H-2.



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(37-H, Piping, Underground,
Contd)

CONDUIT TERMINALS:

Where the conduit terminates at a building, manhole, or pit, it shall extend through the concrete to the inner face. A water seal shall be applied between the conduit and the concrete. A water seal shall be applied to the conduit end.

BACKFILL:

Soil shall be carefully deposited in uniform layers not over 6" thick, carefully tamped, both sides being done simultaneously so as to not disturb the conduit. Boulders and concrete debris shall not be used as part of backfilling material.

CATHODIC PROTECTION:

Where required, cathodic protection shall be installed as specified by Electrical and Mechanical Groups in accordance with STANDARD SPECIFICATIONS B. 2. 60 and STANDARDS EL-75, 76 and 77. Details shall be coordinated so that purpose of each system is retained. Special attention is required at electrical isolating joints.



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SPECIFICATION NO. 38-H, URETHANE FOAM, (Atmospheric
PVC JACKETED PREINSULATED PIPE up to 250F)

PREINSULATED PIPE SYSTEM

PIPING

PLANT _____ Sections of insulated and encased PVC jacket by
UNIT _____ manufacturer. Pipe fittings are likewise so
WORK ORDER _____ produced. These pipe sections and fitting
ACCOUNT NO. _____ assemblies are field connected, junctions
DATE _____ insulated and jacket joined together with
manufactured compression couplings.

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIALS SPECIFICATION

Pipe or Tube Insulated With Urethane Foam	
Encased in PVC Conduit	Spec. 38.
Pipe or Tube Fittings Insulated With Urethane	
Foam Encased in PVC Conduit	Spec. 38.
Compression Coupling	Spec. 38.
Urethane Insulation for Coupling	Spec. 38.

TRENCH PREPARATION: Underground Installations.

Bottom of trench shall be smooth, clean and dry.

PREPARATION:

Compression coupling and its components must be placed on the conduit adjacent to points where sections of pipe, tube or fittings are to be joined prior to assembly. Pipe, tube and fittings are to be welded, or sweated, together at joints and tested.

FIELD CONNECTIONS: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPEC. NO. 38-H.

Urethane insulation shall be installed over uninsulated pipe at joints. The joining sleeves shall be slid in position over the insulated joints and the rubber gaskets compressed to seal around the conduit by tightening the clamp ring. As shown in Figure 38-H. 3.

PIPE ANCHOR, UNDERGROUND:

Underground pipe anchors are constructed as shown in Figure 38-H. 4.

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MAY, 1968CONDUIT TERMINALS:

(38-H Continued)

Where the conduit terminates at a building, manhole, or pit, it shall extend through the concrete to the inner face. A water stop sleeve shall be installed between the conduit and the concrete. A water seal shall be applied at end of the conduit. As shown in Figure 38-H. 5.

BACKFILL:

Soil shall be carefully deposited in uniform layers not over 6" thick, carefully tamped, both sides being done simultaneously so as to not disturb the conduit. Boulders and concrete debris shall not be used as part of backfill material.

CATHODIC PROTECTION

Where required, cathodic protection shall be installed as specified by Electrical and Mechanical Groups, and in accordance with STANDARD SPECIFICATIONS B. 2. 60, and STANDARDS EL-75, 76 and 77. Details shall be coordinated so that purpose of each system is retained. Special attention is required at electrical isolating joints.

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MAY, 1968SPECIFICATION NO. 39-H, UNDERGROUND BITUMINOUS FILL

(From 220F to 520F)

PIPING INSULATING

	<u>LINE NO.</u>	<u>SIZE</u>	<u>LOCATION</u>	<u>METAL</u>	<u>INSUL THICK "</u>
PLANT _____	_____	_____	_____	_____	_____
UNIT _____	_____	_____	_____	_____	_____
WORK ORDER _____	_____	_____	_____	_____	_____
ACCOUNT NO _____	_____	_____	_____	_____	_____
DATE _____	_____	_____	_____	_____	_____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
MATERIAL SPECIFICATIONS

Bituminous Fill Insulation		20-Gage Galvanized Steel	
Grade, depending on		Jacket	Spec. 39.
temperature	Spec. 39.	Weather-Barrier Mastic	VII. B.1. a
Corrosion-Resistant Coating			
40F to 120F	VII. A. 70.		

PREPARATION:

Bottom of trench shall be smooth, clean and dry. Piping shall be installed, supported and tested. Pipe surface shall be clean and dry and, where required, painted before installation of fill insulation.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL VOLUME 1", SPECIFICATION NO. 39.

Piping:

Thickness of insulation about pipe shall be as per Figure 39-H-1. If system passes under roads or other areas of heavy loads, thickness on top shall be increased 3". Fill insulation shall be tamped in position. Curing shall be at temperature and for period of time recommended by the manufacturer.

Expansion Loops:

Thickness of insulation shall be as per Figure 39-H-2. Installation shall be same as for pipe.

Transition and Termination:

Where the system emerges above surface, a sleeve of 20-gage galvanized steel shall extend from below grade to insulation used 12" above grade, as shown in Figure 39-H-3.

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MAY, 1968PREPARATION: Continued(39-H, Piping, Underground,
Contd)Transition and Termination: Continued

Where lines enter manhole or building wall, an asbestos rope or packing shall be applied between the pipe and the sleeves. Outer surface of galvanized steel jacket shall be coated with specified corrosion-resistant coating before it is installed.

BACKFILL:

Backfill shall not be installed before insulation is cured. Soil shall be carefully deposited in uniform layers of 6" thick and carefully tamped.

CATHODIC PROTECTION:

Where required, cathodic protection shall be installed as specified by Electrical and Mechanical Groups and in accordance with STANDARD SPECIFICATIONS B. 2. 60, and STANDARDS EL-75, 76 and 77. Details shall be coordinated so that purpose of each system is retained. Special attention is required at electrical isolating joints.



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SPECIFICATION NO. 40-J, CORK FILLED PVA MASTIC
EQUIPMENT OR PIPE INSULATION (34F to 180F)

EQUIPMENT

	<u>VESSEL OR COLUMN</u>	<u>DUCT OR FLAT SURFACE</u>
PLANT _____	ITEM NO. _____ METAL _____	TOP AND BOTTOM: _____
UNIT _____	BODY: Dia. _____ LENGTH _____	WIDTH _____
WORK ORDER _____	HEADS _____ SHAPE _____	LENGTH _____
ACCOUNT NO. _____	INSUL. THICK. _____	SIDES: _____
DATE _____		WIDTH _____
		LENGTH _____

<u>LINE NO.</u>	<u>SIZE</u>	<u>LOCATION</u>	<u>METAL</u>	<u>INSUL. THK"</u>
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIAL SPECIFICATIONS

Cork Filled PVA Mastic	Spec. 40.
Primer (In Application Section)	Spec. 40-J

PREPARATION:

Surface of equipment or pipe should be clean and dry then painted with primer.

APPLICATION:

Surface temperature must be above dew point of ambient air but not above 180F. Surface must be clean and dry. PVA mastic shall be applied in one coat by palm-
ing, troweling or spraying. Spraying not to be done on pipe less than 24".
Material shall be allowed to dry a minimum of 24 hours for each 1/8" of thick-
ness, plus an additional 24 hours if equipment or pipe is to be operated at a
temperature less than dew point of ambient air.



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THICKNESS AND COVERAGE

(40-J, Equip, Contd)

Thickness shall be as specified.

Coverage is as follows:	1/8" thickness	8 1/2 to 10 gallons per 100 sq ft
	1/4" thickness	17 to 20 gallons per 100 sq ft

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MAY, 1968SPECIFICATION NO. 41-H and 42-H, SPRAYABLE ASBESTOS FIBERS(41-H, Max. 700F,
42-H, Max. 1350F)EQUIPMENT INSULATION

	<u>VESSEL OR COLUMN</u>	<u>DUCT OR FLAT SURFACE</u>
PLANT _____	ITEM NO. _____ METAL _____	TOP AND BOTTOM:
UNIT _____	BODY: Dia. _____ LENGTH _____	WIDTH _____
WORK ORDER _____	HEADS _____	LENGTH _____
ACCOUNT NO. _____	VESSEL FLANGES _____	SIDES:
DATE _____	MANHOLES _____	WIDTH _____
	NOZZLES _____	LENGTH _____
	SKIRT OR LEGS _____	
WEATHER BARRIER _____	INSULATION THICKNESS " _____	

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIAL SPECIFICATIONS

Sprayable Amosite Asbestos Fiber Insulation	Spec. 41.	Cellular Glass Insulation	Spec. 10.
Sprayable Crocidolite Asbestos Fiber Insulation	Spec. 42.	Finishing Cement	VII. A. 78.
Equipment Insulation Strap	VII. A. 11.	Asbestos Paper	VII. A. 80.
Clips for Equipment Strap	VII. A. 12.	Asbestos Paper Adhesive	VII. A. 81.
Expansion Springs	VII. A. 15.	Lap Sealer	VII. A. 46.
Stainless Steel Wire	VII. A. 17.	"S" Clips	VII. A. 107.
Wire Netting	VII. A. 18.	Weather Barrier, as specified	
Welding Pin Insulation Fasteners	VII. A. 22.	Mastic, color as specified	
Pin Clips	VII. A. 23.	Designation WC	VII. B. 1. a.
Sheet Metal Screws	VII. A. 32.	Reinforcing Cloth	VII. B. 1. b.
Split Welding Pins	VII. A. 79.	Stainless Steel Jacket,	
		Designation M	VII. B. 2.
		Treated Steel Jacket,	
		Designation MT	VII. B. 3.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
GENERAL SPECIFICATIONSSurface:

Surface shall be clean and dry. Steel and stainless steel, where required, shall be coated in accordance with "COATING MANUAL".

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MAY 1968PREPARATION: Continued

(41-H, 42-H, Equip, Contd)

Insulation Supports:

Vessels and ducts over 24" shall be provided with pins as specified in Specification 41-H and 42-H to reinforce the insulation, as shown in Figures 41-H/42-H.1 and 41-H/42-H.2.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL, VOLUME 1", SPECIFICATION NO. 41-H, 42-H

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather Barrier</u>
Curved Side Walls	Spray and compacted asbestos fiber as shown in Figure 41-H/42-H.1	Pins, Clips, Wire and Netting	Steel or Mastic
Heads	Same as for curved side walls	"	Mastic
Vessel Flanges and Nozzles	Bolt head wrapped with asbestos paper prior to spraying of asbestos fiber	"	Mastic
Legs - Channel	Insulated down to concrete	"	Mastic
Flat Surface	Same as for curved side walls, with other surface of finishing cement reinforced with netting	"	Mastic



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SPECIFICATION NO. 43-H, 43-HSS, SPRAYED RIGID URETHANE FOAM
(50F to 250F)

EQUIPMENT INSULATION

	<u>VESSEL OR COLUMN</u>	<u>DUCT OR FLAT SURFACE</u>
PLANT _____	ITEM NO. _____ METAL _____	TOP AND BOTTOM
UNIT _____	BODY: Dia. _____ LENGTH _____	WIDTH _____
WORK ORDER _____	HEADS _____	LENGTH _____
ACCOUNT NO. _____	VESSEL FLANGES _____	SIDES:
DATE _____	MANHOLES _____	WIDTH _____
	SKIRTS OR LEGS _____	LENGTH _____

INSULATION THICKNESS " _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
MATERIAL SPECIFICATIONS

Urethane Foam System - Liquids		Weather-Barrier, as specified	
UCC NIAS Foam System		Mastic, color as specified	
T-352/T-624		Trowel Grade	
Urethane Rigid Foam Block	Spec. 12.	Designation WC	VII. b. 1. a.
Bonded Expanded Silica Block	Spec. 23.	Mastic, color as specified,	
Equipment Insulation Strap	VII. A. 11.	Spray Grade,	
Clips for Equipment Strap	VII. A. 12.	Designation WB	VII. b. 1. a.
Stainless Steel Wire	VII. A. 17.	Stainless Steel Jacket	VII. b. 2.
Asbestos Paper	VII. A. 80.	Treated Steel Jacket	VII. b. 3.
		Contact Adhesive	VII. A. 65
			or 66

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1",
SPECIFICATION NO. 43-H, 43-HSS

Surfaces to be Insulated

Carbon steel shall be cleaned of rust, mill scale, dirt or other contamination.
Painted steel shall be clean of dirt and paint and shall be fully dry.
Stainless steel shall be coated in accordance with Coating Manual prior to application of insulation.
Aluminum shall be cleaned of dirt or other contamination.

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PREPARATION: Continued

(43-H, HSS, Equip, Contd)

Prior to application, flanges, manholes and all other surfaces not to be insulated shall be wrapped with suitable covering. Instruments, equipment or piping within 25 feet shall be covered or screened for protection against overspray.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL, VOLUME 1", SPECIFICATION NOS. 43-H, 43-HS

<u>Component</u>	<u>Type and Form of Insulation</u>	<u>Securement</u>	<u>Weather Barrier</u>
Curved Side Walls	Sprayed urethane rigid foam	None	Steel or Mastic
Heads	Sprayed urethane rigid foam	None	Mastic
Vessel Flanges	None, unless specified. Pre-formed from rigid urethane block, where required. As shown in Figure 43-H-4		
Nozzles	Preformed from rigid urethane block. As shown in Figure 43-H-2	Contact Adhesive	Mastic
Legs - Channel	Expanded silica block to concrete	Wire	Mastic
Legs - Concrete Filled	None		Mastic
Flat Surfaces	Sprayed urethane rigid foam	None	Mastic

STANDARD SPECIFICATIONS



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PREFACE

INSULATION

1

JULY 1966

THERMAL INSULATION SPECIFICATIONS

INTRODUCTION

i. General

These Specifications describe the essential requirements for the purchase and application of thermal insulation materials.

They consist of General Specifications, Material Specifications, and Application Specifications. General Specifications are identified by the letters GS, Material Specifications by the letter M, and the Application Specifications by a two-digit number followed by one or more letters.

All materials required in the application of thermal insulation shall be as specified in Material Specifications - M.

The required Application Specification and the thickness of insulation to be used shall be indicated in an Insulation Design Schedule.

Letter Designations for Application Specifications

Letters following numbers in designations of Application Specifications (example: H or HSS in Specification No. 10-H, 10-HSS) indicate that the specified insulation is intended for a particular use, as follows:

B	Building construction
FP	Fire Protection
FX	Flexible insulation for exterior surface of ducts
FY	Flexible insulation for interior surface of ducts
H	Equipment and piping operating at high temperatures
J	Equipment and piping operating at moderate temperatures
OX	Equipment and piping in oxygen service
L	Equipment and piping operating at low temperatures
RX	Rigid insulation for exterior surface of ducts
RY	Rigid insulation for interior surface of ducts
SP	Spheres
SS	Insulation to be installed on stainless steel surfaces
U	Underground piping

iii. Presentation of Format

GS, M, 10-H, etc (SPECIFICATION IDENTIFICATION)

I., II., III., etc (ARTICLES)

A., B., C., etc (SECTIONS)

1., 2., 3., etc (Items)

a., b., c., etc (Subsections)

(1), (2), (3), etc (Paragraphs)

(a), (b), (c), etc (Units)

Reference to a particular Paragraph (4) of Specification GS shall be indicated thus: GS.XV.B.2.a.(4). Closely related references within a division may be identified thus: Article XIV.B of this specification, Item 2.a.(4) of this section, or Paragraph (3) above.



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THERMAL INSULATION SPECIFICATIONS

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SPECIFICATION - GS

General Specifications and Engineering Standards

ARTICLES:

- I. Condition of surfaces
- II. Insulation supports
- III. Securement
- IV. Nameplate clips
- V. Junction of thermal insulation with fire-resistant materials
- VI. Flashing
- VII. Sealing of hot projection
- VIII. Coating
- IX. Protection from abuse
- X. Protection cover
- XI. Appearance
- XII. Insulation for safety
- XIII. Steam or electric traced installations
- XIV. Weather-barrier mastic coating
- XV. Metal jackets - stainless steel or treated steel

STANDARDS: EL-43, IS-31, IS-31A, IS-36, IS-40, IS-42, P-82, P-140, and P-140A.

SPECIFICATION - M

Material Specifications for Thermal Insulation and Accessories

ARTICLES:

- I. Material - General
- II. Properties
- III. Dimensions of Curved Segments, Lagging, and Pipe Insulation
- IV. Condition of Material
- V. Preformed Valve, Fitting, and Flange Covers
- VI. Specifications for Individual Insulation Materials
- VII. Specifications for Individual Accessory Materials

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INSULATION

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CONTENTS - contd**APPLICATION SPECIFICATIONS - (as listed)**Individual Material Specifications and Accessories

Symbols: P & E = Piping and Equipment

SS = Stainless Steel

AD = Air Ducts

Specification Number and Designation	Description of Material	Operating Temperature Range, Degrees F	Miscellaneous Remarks: Location of Application - Type of Service, etc -
10-B	Cellular Glass	Atmospheric	Buildings
10-H & HSS	Cellular Glass	+ 70 to + 600	P & E, SS P & E
10-J & JSS	Cellular Glass	+ 50 to + 400	P & E, SS P & E
10-JU & JUSS	Cellular Glass	+ 50 to + 350	Underground Piping, SS Piping
10-L & LSS	Cellular Glass	- 200 to + 400	P & E, SS P & E Low Temperature Service
10-LSP	Cellular Glass	- 40 to + 150	Sphere
10-OX	Cellular Glass	- 200 to Atmos	P & E - Oxygen Service
11-			
12-H & HSS	Rigid Urethane Foam	+ 50 to + 250	AD, P & E and SS P & E
14-J	Flexible Plastic Foam	+ 32 to + 180	AD, P & E
15-H	Fibrous Glass, high density	+ 70 to + 750	P & E
15-L	Fibrous Glass, high density	- 20 to + 100	P & E
16-H	Fibrous Glass, low density	+ 70 to + 350	P & E
17-RX	Fibrous Glass, rigid	+ 60 to + 150	AD - Exposed - Exterior Surface
17-RY	Fibrous Glass, rigid	+ 60 to + 150	AD - Interior Surface
18-FX	Fibrous Glass, flexible	+ 60 to + 150	AD - Concealed - Exterior Surface
18-FY	Fibrous Glass, flexible	+ 60 to + 150	AD - Interior Surface
19-H	Mineral Wool, aluminum faced	+ 60 to + 450	Large diameter storage tanks
19-J	Fibrous Glass, aluminum faced	+ 60 to + 350	Large diameter storage tanks
21-H & HSS	Asbestos Fibers	+ 70 to + 1000	Piping, SS Piping
22-H & HSS	Bonded Expanded Silica	+ 40 to + 1600	P & E, SS P & E - High Temperature
22-HSP	Bonded Expanded Silica	+ 70 to + 500	Sphere
23-H & HSS	Inhibited Calcium Silicate	+ 70 to + 750	P & E, SS P & E
25-H	Hydrous Calcium Silicate	+ 750 to + 1600	P & E - High Temperature
31-H, HSS	Stainless Steel - Cased - Reflective	+ 33 to + 1000	P & E, SS P & E
32-HFP & HFPSS	Bonded Expanded Silica	+ 40 to + 1600	P & E - Fire Protection
32-LFP & LFPSS	Bonded Expanded Silica - Cellular Glass	- 200 to + 400	P & E, SS P & E - Fire Protection
37-H	Insulation as Specified	+ 40 to + 750	Underground Conduit
38-H	Urethane Foam - PVC Jacket	+ 50 to + 250	Underground Piping
39-H	Bituminous Fill	+ 220 to + 520	Underground Piping
40-J	Cork Filled PVA Mastic	+ 34 to + 180	P & E
41-H	Sprayed Asbestos - "Amosite"	+ 40 to + 700	Equipment, Ducts, Steel, etc
42-H	Sprayed Asbestos - "Crocidolite"	+ 40 to + 1350	Equipment, Ducts, Steel, etc
43-H & HSS	Sprayed Urethane Foam	+ 50 to + 250	Equipment, Storage Tanks



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— S. L. [unclear] —
— Force Comments —

GC
INSULATION

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THERMAL INSULATION GENERAL SPECIFICATIONS

SCOPE

These specifications describe the essential requirements for the application of thermal insulation materials. They also constitute an integral part of each individual specification.

I. CONDITION OF SURFACES

- A. Insulating materials shall be applied to clean, dry surfaces only.
- B. Where insulation is applied to carbon steel piping and equipment operating in the temperature range of 0 F to 150 F, the metal surfaces of said piping and equipment shall be coated by others, in accordance with Owner's Coating Specifications, prior to application of insulation.
- C. Where insulation is applied to stainless steel piping and equipment, the metal surfaces of such piping and equipment shall be coated by others, in accordance with Owner's Coating Specifications, prior to application of insulation.
- D. Where insulation is to be installed on equipment or piping flanges or flanged valves which are to be hot bolted, the insulation must not be installed until these are released by Owner's representative.

— Show hot bolting requirement on Insulation Schedule

II. INSULATION SUPPORTS

- A. Insulation on vertical equipment exceeding 3 ft 0 in. OD, where welding is permitted, shall be supported in accordance with Owner's Standard EQ-64. Where welding is not permitted, insulation shall be supported in accordance with Standard EQ-68.
- B. Insulation on horizontal equipment, 3 ft 0 in. diameter and larger, where welding is permitted, shall be supported in accordance with Owner's Standard EQ-65. Where welding is not permitted, insulation shall be supported in accordance with Owner's Standard EQ-69.
- C. Insulation applied to bottom head, inside of skirt, on skirt supported vessels, shall be supported in accordance with Owner's Standard EQ-64 or EQ-70, depending upon whether or not welding is permitted.
- D. Insulation on dished heads of vertical equipment shall be supported in accordance with Owner's Standard EQ-64, EQ-68 and EQ-67.
- E. Insulation on spherical vessels operating lower than 70 F shall be supported in accordance with Owner's Standard EQ-66.
- F. Where necessary to prevent entrance of moisture, uppermost support shall be replaced with a metal protective plate, as described in Article X of this specification, entitled "Protective Cover".
- G. Insulation on 3-inch NPS and larger vertical pipe and vertical vessels up to 1 ft 5 in. in diameter shall be supported by formed steel strapping (Spec VII.A.9) bolted around pipe near bottom of run. Additional supports shall be installed on pipe at intervals of 21 feet of vertical run.

— this size inconsistent with that stated in individual specs

III. SECUREMENT

- A. Tie-Wire Anchors. Angle clips, flat rectangular punched pins, and other approved attachments shall be used as insulation tie-wire anchors, where shape of vessel prevents normal methods of securement of preformed insulating materials. Blank nuts, where required, shall be attached, standing-edge to vessel surface, by light fillet welds. Angle clips shall be installed in accordance with Owner's Standard EQ-67. Pins shall be carbon steel or stainless steel to correspond with metal of the vessel.

B. Wire

1. Insulation shall be secured by wire applied at proper intervals by looping about the circumference, twisting ends tightly together to provide proper securement, and pressing wire ends into insulation to prevent projection. Wire shall be used for securement of all inner layers of pipe insulation, and outer layers up to and including 12-inch OD. Wire shall be used for securement of all outer layers of pipe insulation, and outer layers up to and including 12-inch OD. Wire shall be used for securement of all outer layers of pipe insulation, regardless of diameter, where weather-barrier is specified to be metal jacket.
2. Where shape of vessel prevents complete encirclement, securement shall be made to other tie-wires, wire cables, or anchors approved for this purpose.

C. Insulation Strap

1. All pipe insulation on traced line shall be secured as noted in the individual specification.
2. Outer layers of pipe insulation over 12-inch OD shall be secured with insulation strap except when metal jacket is used.
3. Strap shall be applied to cylindrical insulation at proper intervals by looping strap about the circumference, stretching to suitable tightness with an approved banding machine, and clamping in place at joint. Strap joint shall consist of one double-prong clip. Clips shall be located on the vertical side of pipe insulation.
4. Where shape of vessel prevents complete encirclement by strap, securement shall be made to tie-wires, wire cables, or other devices approved for this purpose.
5. Insulation strap shall be divided into lengths based on one strap joint for the first 15 feet of vessel circumference. These joints shall be spaced at equal distances around the vessel. Vessels over 15 feet in diameter (except where factory preformed panel insulation is specified) shall be equipped with vertical strap anchor angles spaced as shown on Owner's Standard EQ-64 or EQ-66.

C. Insulation Strap - Cont'd

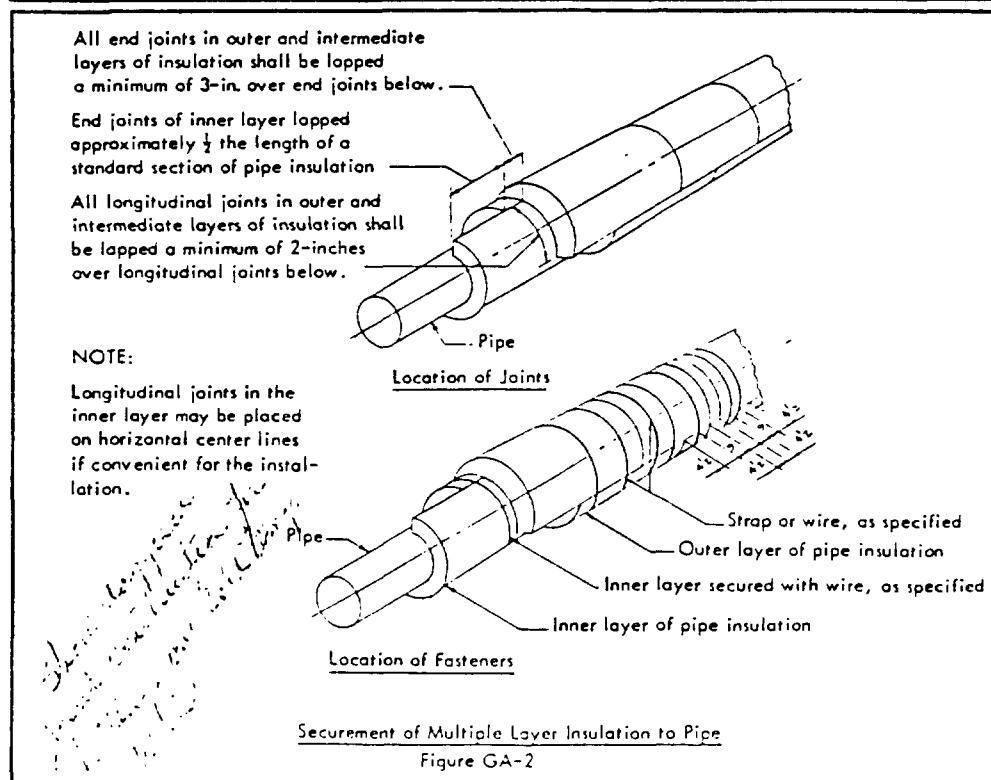
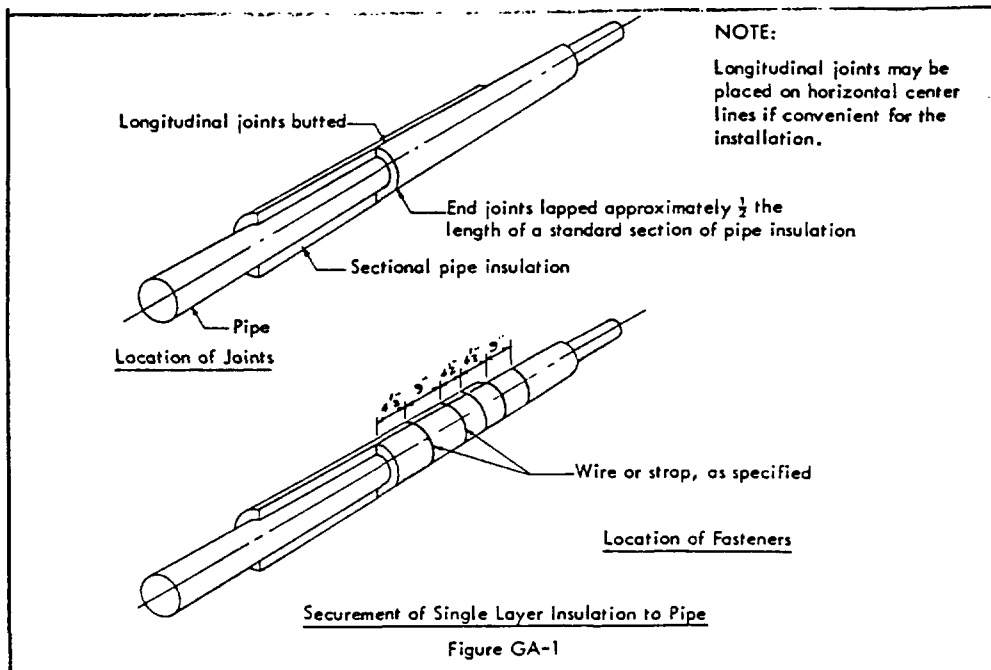
6. Insulation secured to interior or exterior of heating, ventilating, and air-conditioning ducts shall be as specified in individual specifications.

7. The inner layer and outer layer up to $4\frac{1}{2}$ inches in outside diameter of low temperature cellular glass insulation shall be secured with strapping tape.

D. Location of Insulation Joints and Spacing of Straps and Wire

1. Spacing of insulation strap and/or securing wire shall be based on length of insulation block or section for equipment and pipe. Where 36-inch lengths of insulation are applied in staggered arrangement, four loops will be required at approximately 9-inch intervals, so that no loop is located more than $4\frac{1}{2}$ inches from any end joint. Where 24-inch lengths are applied, in staggered arrangement, three loops per length will be required. Where 18-inch lengths are applied in staggered arrangement, two loops per length will be required.

2. Spacing of strap and wire on pipe insulation shall be as shown in Figures GA-1 and GA-2.



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IV. NAMEPLATE CLIPS

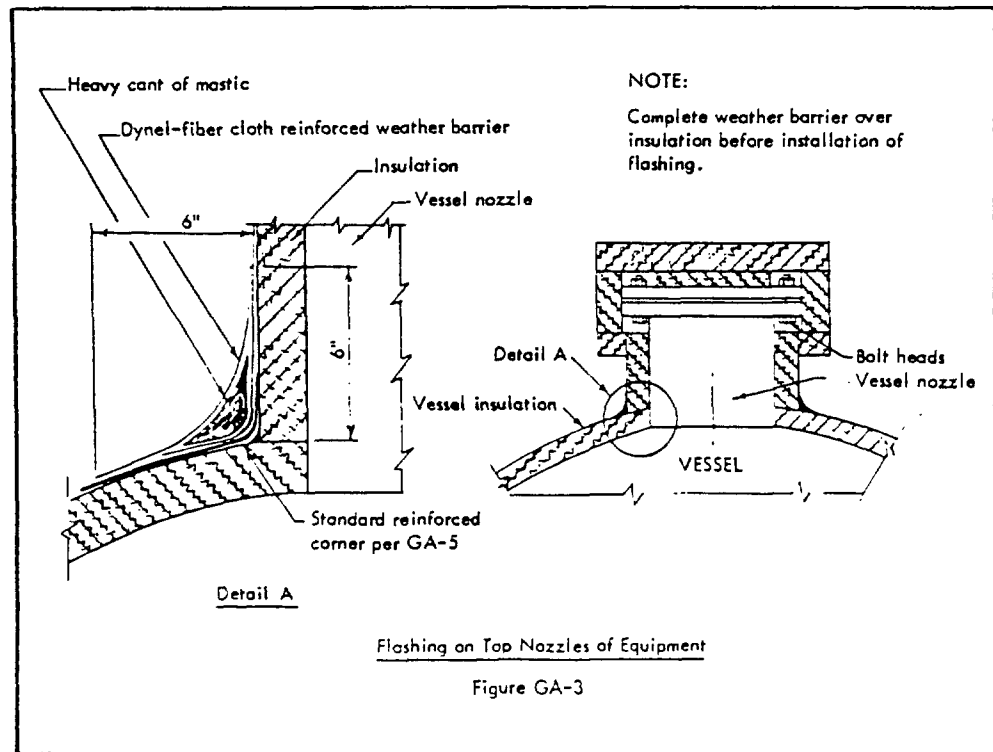
- A. Insulation mechanics shall cooperate with other crafts in the placement of nameplates and nameplate clips.
- B. On vessels insulated for service primarily above 32 F, nameplates shall not be covered by the insulation. The opening in the insulation shall be tapered to the nameplate perimeter.
- C. For vessels and equipment which operate at or below 32 F, the Field Inspector will provide a nameplate extension clip in accordance with Owner's Standard EQ-15. *Check EQ-15 on that nameplate is extending from the insulation plate is provided over.*

V. JUNCTION OF THERMAL INSULATION WITH FIRE-RESISTANT MATERIALS

- A. Insulation thickness on channel tank legs and similar equipment supports shall be not less than adjoining fire-resistant materials. Where thickness of thermal insulation exceeds that of fire-resistant materials, surface of insulation shall be neatly and uniformly finished with a wide bevel, and feathered to provide the appearance of a continuous surface.
- B. Junction of insulation with fire-resistant materials shall be sealed with weather-barrier coating.
- C. Concrete-filled structural tubing tank legs do not require external fireproofing. Vessel insulation shall butt against legs, and junction shall be sealed with weather-barrier coating. Covering for temperature control shall be the same as for channel legs, including weather barrier.

VI. FLASHING

- A. All nozzles on top of insulated equipment shall be provided with flashing as shown in Figure GA-3.



STANDARD SPECIFICATIONS

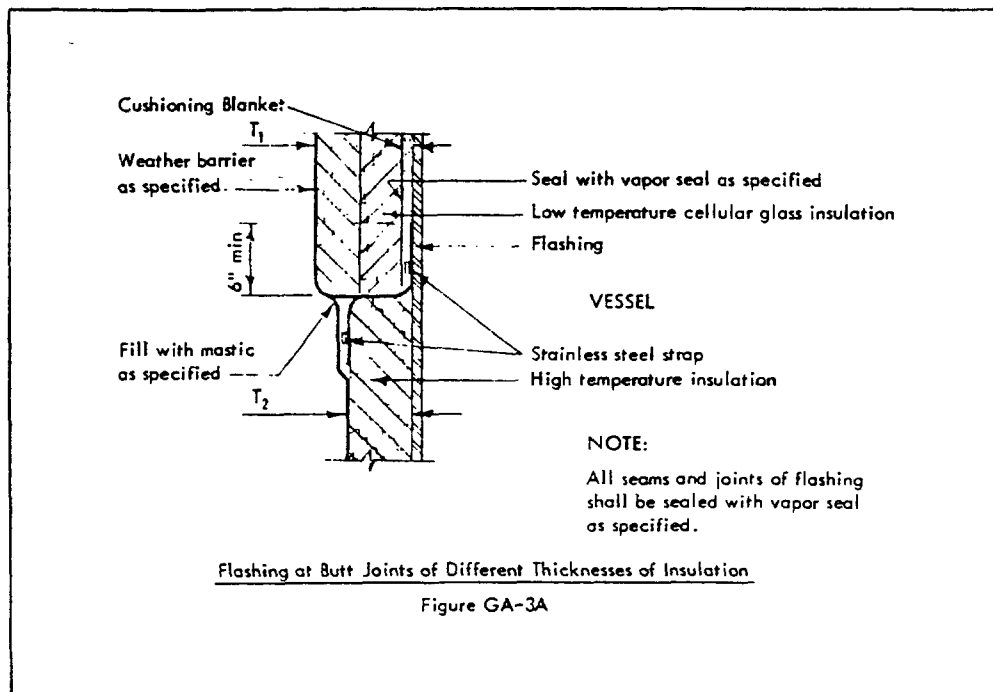


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VI. FLASHING - contd

B. Where a vertical vessel such as a column is insulated for gradient temperatures, with the low temperature above, flashing shall be installed between different thicknesses of insulation where noted in schedule to prevent condensate from entering the high temperature insulation on the lower side of the joint. Flashing material shall be as specified in the MATERIAL SPECIFICATIONS, Article VII, A. 83. It shall be secured to the vessel and the outside of the insulation with the equipment insulation straps specified in the MATERIAL SPECIFICATIONS, Article VII, A. 11. All seams and joints of flashing shall be sealed with vapor seal as specified in the individual specifications. Typical installation is shown in Figure GA-3A.



VII. SEALING OF HOT PROJECTION

Where hot brackets, hangers, or supports project through the insulation and weather-barrier mastic or metal jackets, the junction shall be sealed with heat-resistant sealer as specified in Article XIV. B.6 of this specification.

VIII. COATING

Coating of bare and insulated surfaces, where required, shall be done by others in accordance with Owner's Coating Specification. Insulation shall not be applied on painted surfaces until such surfaces are completely finished and dry in accordance with coating specification.

IX. PROTECTION FROM ABUSE

A. Insulation subject to mechanical abuse, such as abrasion or brushing, or where otherwise required, as designated by the Owner, shall be protected with a covering jacket of not thinner than 18 gage (minimum) galvanized sheet metal. Jacket shall be secured firmly in place with insulation strap, spaced 10 inches (maximum) on centers, or sheet metal screws where use of strap is impracticable. Sheet metal screws shall not be used on jackets on low temperature insulation where possibility exists of piercing weather-vapor barrier membrane.

B. Corners of insulated ducts, breechings, and other flat-surfaced equipment shall be reinforced by installation of expanded metal lath corner bead. Bead shall be provided by the Insulation Contractor and installed by insulation mechanics, following application of insulation block, securing it firmly to block tie wires. Cement shall be forced through lath flange to provide proper key.

X. PROTECTIVE COVER

Insulation terminating at an intermediate point in the height of a vessel shall be protected from physical abuse and moisture penetration by installation of a continuous metal plate attached to vessel by means of a continuous weld immediately above insulation. This protection shall be provided by others in accordance with Owner's specification. Insulation may be bevelled and mastic sealed to shell if desirable and operating temperature is below 250 F.

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XI. APPEARANCE

Lapped joints, selvage ends, and other irregularities of surfacing materials shall be concealed from general view wherever possible.

XII. INSULATION FOR SAFETY

A. Where it is required to insulate piping or equipment for safety, only that portion shall be insulated which is located 6 ft 0 in. or less above a floor or operating level if the axis of the pipe or equipment is vertical, and, for horizontal axes, at all elevations 7 ft 0 in. or less above any floor or operating level. Piping in trenches, unless otherwise specified, shall not be insulated for safety below grating level. Exposed ends of insulating shall be beveled to provide proper seal and drainage.

B. Where specified, thermal insulation shall be omitted and protection provided by erection of a suitable safety guard. This guard will be provided by the Owner.

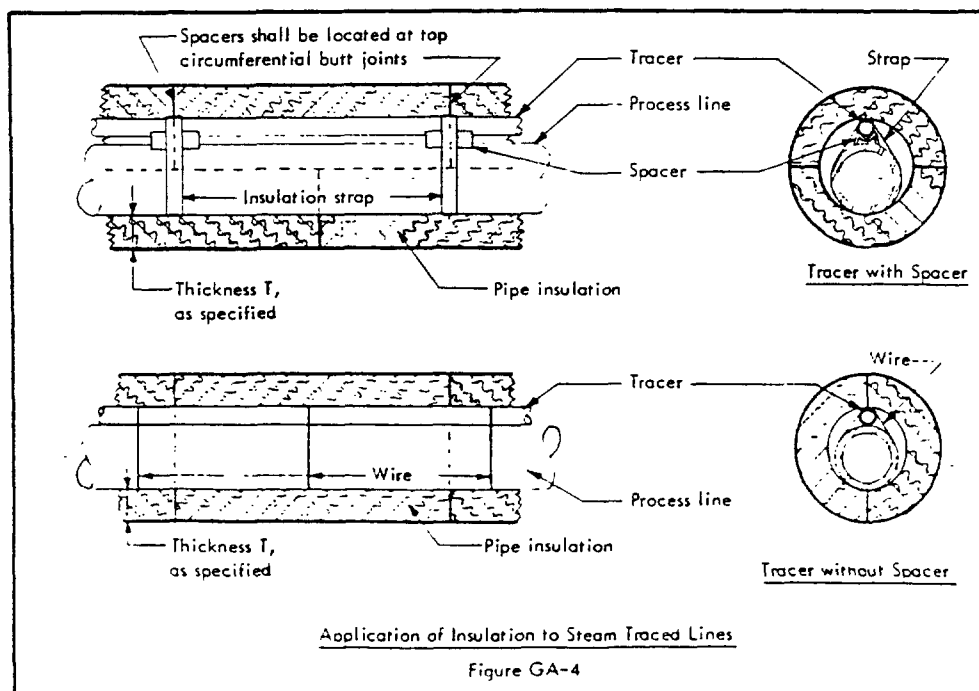
XIII. STEAM OR ELECTRIC TRACED INSTALLATIONS (as specified)

A. Air Convection Tracing System

1. Insulation Schedules and/or tracing drawings shall designate traced lines with the symbol ST (steam traced without spacers), or STW (steam traced with spacers).

2. Accessories. Pressed steel spacers shall be used only when specifically required for separation between the tracer and pipe. These spacers shall be furnished by the Insulation Contractor and as specified in the MATERIAL SPECIFICATIONS, Article VII.C.1.a.

3. Assembly. Type and size of tracer lines, methods of clamping, hanging and supporting them, and size of pipe insulation to be applied shall be in accordance with Owner's Standards P-140 and P-140A, and Figure GA-4 supplemented by Insulation Design Schedules and steam or electric tracing drawings, where required. In addition to assembly directions contained in Standards EL-43, P-140 and P-140A, pressed steel spacers (and pressed steel clamps, where installed) shall be spaced on 18-inch centers for copper tracer lines. Temporary installation of assembly will be done by the Owner.



4. Pipe insulation shall be applied in required sizes and carefully fitted to heated companion lines in the manner prescribed in these specifications and in the individual specifications. Tracer assembly shall be firmly and permanently secured in place before application of insulation. Where spacers are specified, they shall be added or relocated where required to ensure firmness and separation of tracer from pipe.

5. Protective Wrapping. When aluminum piping is to be traced, or when otherwise required, aluminum piping shall be separated from tracer assembly by not less than two wrappings of glass cloth tape applied to the line. Care shall be taken that tracer line does not contact aluminum line at any point. Where tracer may touch the aluminum between supports, the line shall be wrapped with glass cloth tape to prevent contact. Glass cloth tape shall be as specified in MATERIAL SPECIFICATIONS, Article VII.C.2.b.(6).

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XIII. STEAM OR ELECTRIC TRACED INSTALLATIONS - contd

B. Heat Transfer Cement Tracing System

1. The heat transfer cement used shall be suitable for the temperature and installation requirements. It shall be as called for on Insulation Design Schedule, Insulation Equipment and/or Line List, or as otherwise prescribed by the designer of the tracing system.

2. Materials

a. Heat Transfer Cement (See MATERIALS SPECIFICATIONS, Article Numbers as Noted)

(1) Standard Grade - VII. C. 2. a. (1).

(2) T-3 Grade - VII. C. 2. a. (2).

(3) T-63 Grade - VII. C. 2. a. (3).

(4) T-85 Grade - VII. C. 2. a. (4).

(5) T-80 Grade - VII. C. 2. a. (5).

(6) T-5 Grade - VII. C. 2. a. (6).

b. ^{(1) E-1} Accessories (See MATERIALS SPECIFICATIONS, Article Numbers as Noted)

(1) Primer for coating of aluminum surfaces prior to application of Standard Grade, T-3 Grade, and T-63 Grade heat transfer cements - VII. C. 2. b. (1).

(2) Mill Varnish Stripper - VII. C. 2. b. (2).

(3) Metal Retainer for Cement - VII. C. 2. b. (3).

(4) Pipe Insulation Strap - VII. A. 13.

(5) Clips for Pipe Strap - VII. A. 14.

3. Surface Preparation

a. Surface of pipe, or equipment to which heat transfer cement is to be applied shall be cleaned of dirt, rust, scale, paint, and varnish. Paint or varnish shall be removed with mill varnish stripper, in accordance with manufacturer's directions, on areas to which tracers and heat transfer cement are to be applied. Badly scaled or rusted steel shall be cleaned by sandblasting before application of tracer or heat transfer cement.

b. Galvanized or aluminum surfaces shall be primed with ALP Primer after cleaning, before application of Standard Grade, T-3 Grade, or T-63 Grade of heat transfer cement.

4. Application of Tracers - Type and size of tracers shall be as scheduled. Steam and liquid tracers shall be secured to pipe by strap or wire in accordance with Owner's Standard P-140. Electric tracers shall be installed in accordance with Owner's Standards EL-41 through EL-47. Tracers or plate coils shall be installed on equipment as scheduled, or shown on drawings. Care shall be taken if coils or tracers are installed on aluminum equipment or piping that the two metals do not come into contact. See Section A.5 of this Article.

5. Application of Heat Transfer Cements - After installation of tracers, except plate coils, on pipe and equipment, the specified grade of heat transfer cement shall be applied in accordance with one of the following procedures, as required:

a. Standard Grade and T-63 Grade cements shall be applied with hand tools, or with manual or power caulking guns having special nozzles. The cement shall be applied over the tracer in a layer approximately 1/4-inch thick, and forced into the spaces adjacent to the line of contact between the tracer and the traced pipe or equipment. Special care shall be exercised to fill these spaces completely, to ensure maximum surface contact. The width of the peripheral contact of cement and pipe, pipe fittings, or equipment shall be a minimum of three times the diameter of the tracer. Over irregular surfaces such as pumps and valves, and where tracers are closely spaced, cement may be troweled over tracers in a solid layer 1/4-inch thick. If thickness in excess of 3/4 inch is required, cement shall be installed in two layers, with air drying of at least 24 hours between applications. Application details are shown in Figure GA-4A.

b. Where it is impossible or impracticable to clean pipe surfaces, or where vibration is excessive, e.g. pipe connected to reciprocating machinery, or where curing may be delayed, the Standard Grade and T-63 Grade cements shall be applied to straight pipe by means of metal retainers. The retainer shall be filled with sufficient cement to fill all voids between it, the pipe, and the tracer. The filled retainer shall be placed over the tracer and pulled tight with strap. Straps shall be placed on 24-inch centers with a common band at overlap of adjoining retainers. Application details are shown in Figure GA-4A. The retainers are shown in Figure GA-4B.

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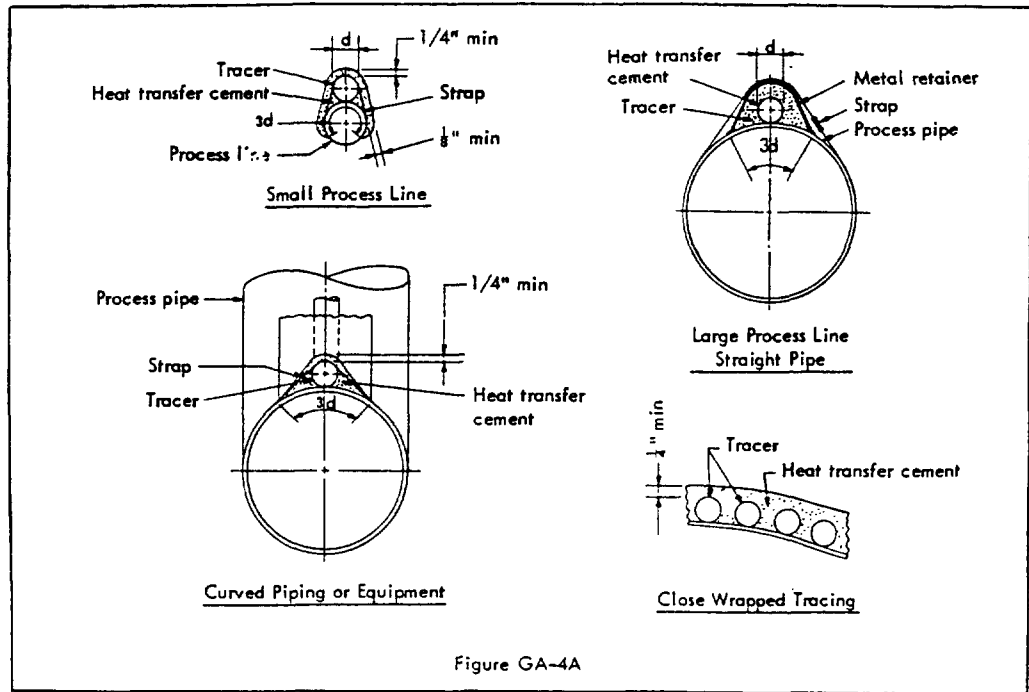
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XIII. STEAM OR ELECTRIC TRACED SYSTEMS - contd

B. Heat Transfer Cement Tracing System - contd

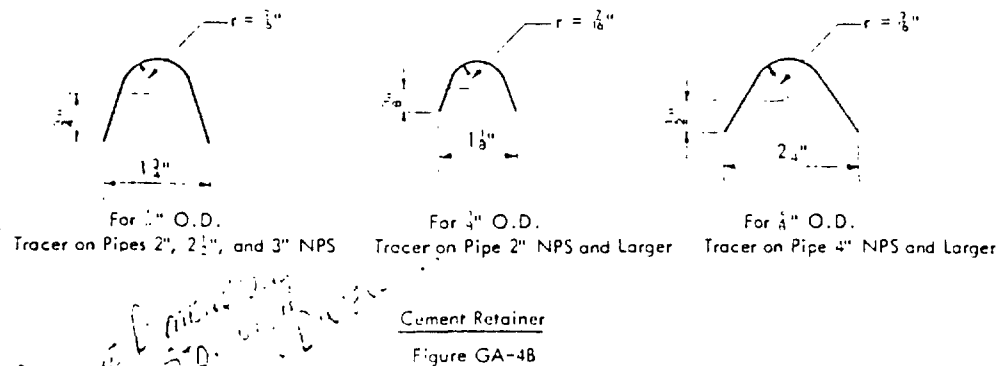
5. Application of Heat Transfer Cements - contd



NOTE: Use No. 22 gage galvanized sheet steel on carbon steel pipes.

No. 26 gage stainless steel on stainless steel pipes.

No. 18 gage Series 3000 or 5000 aluminum alloy on aluminum pipes.





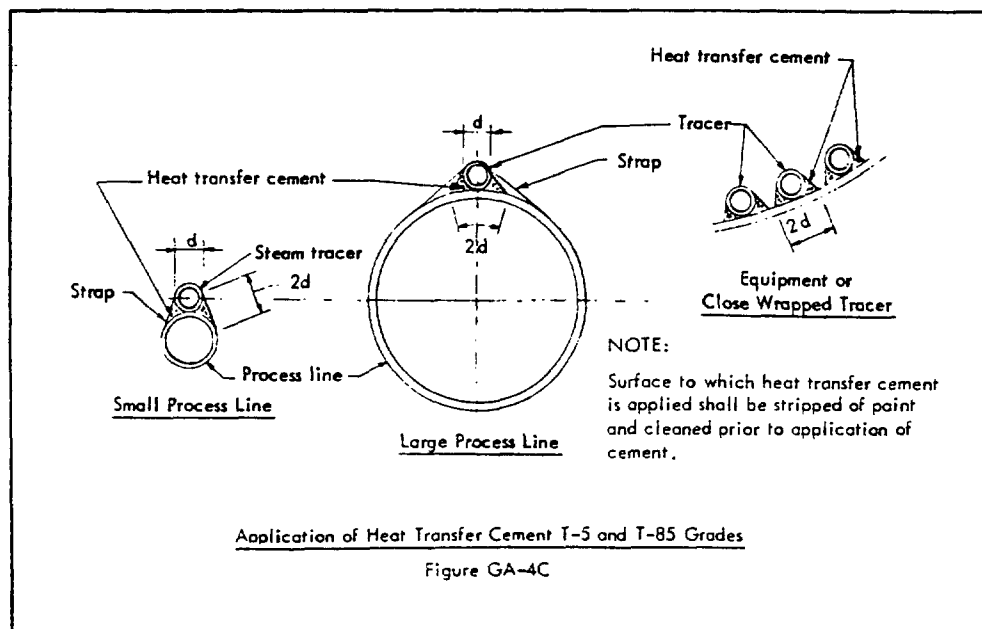
XIII. STEAM OR ELECTRIC TRACED SYSTEMS - contd

B. Heat Transfer Cement Tracing System - contd

5. Application of Heat Transfer Cement - contd

c. T-3 Grade cement, for plate coils, shall be applied to surfaces prepared in accordance with Articles XIII. B. 3. a. and b. Thickness of the cement shall be not less than 1/16 inch nor more than 1/8 inch. The plate coil, with the cement on the surface toward the vessel to which the coil is to be attached, shall be firmly and carefully pressed to the surface of the vessel to obtain a tight cemented bond. Securement of the plate to the vessel shall be as shown or called for on the drawings.

d. T-5 Grade, T-85 Grade, and T-80 Grade cements, which are supplied in cartridges, shall be applied with manual or power caulking guns. The cement shall be forced into the spaces adjacent to the line of contact between the tracer and the traced pipe or equipment. Special care shall be exercised to fill these spaces completely, to ensure maximum surface contact. The width of the peripheral contact of cement and pipe, pipe fittings, or equipment shall be a minimum of twice the diameter of the tracer. Application details are shown in Figure GA-4C.



6. Weather and Temperature Restrictions

a. Standard Grade, T-3 Grade, and T-63 Grade heat transfer cements contain water and are water soluble. If these cements are applied without the use of metal retainers, a period of eight hours shall elapse before application of insulation and weather barrier. During this period and until insulation and weather barrier are installed, these cements shall be protected from rain, sleet, and snow with temporary waterproofing.

b. The minimum application temperature for T-5 Grade and T-85 Grade heat transfer cement is 70 F. If the ambient temperature or the temperature of the cartridges of cement is below 70 F, the cartridges shall be heated above 70 F before application. T-85 Grade and T-80 Grade cements should be stored under refrigeration, but shall be heated above 70 F before use. If they have been stored at room temperature longer than 90 days, they shall be heated above 120 F before use, then shall be used within 24 hours.

7. Curing

a. Standard Grade, T-3 Grade, and T-63 Grade heat transfer cements shall be allowed to air set for a minimum of four hours prior to startup of tracer for heat curing. Heat curing shall be done by gradually raising the temperature of the tracer to not less than 160 F nor more than 212 F. The cement shall be cured for four to six hours, except that large masses of cement, such as those on valves, and on close wrapped tracers for equipment such as pumps and vessels, shall be cured for 24 hours. T-63 Grade cement, because of its slower setting time, shall be given a minimum of four hours of additional curing at 250 F.

b. Curing procedures are as follows:

Steam tracing systems:	Open trap end of tracer to atmosphere, then open valve at header just sufficiently to bleed steam and condensate through the tracer. Maintain steam on the tracer for the period of time specified above.
Electric tracing systems:	Set thermostat at 200 F, or, if this is impossible, reduce voltage so that temperature of the tracer cannot exceed 212 F for the period of time specified above.



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XIII. STEAM OR ELECTRIC TRACED SYSTEMS - contd

B. Heat Transfer Cement Tracing System - contd

7. Curing - contd

c. T-85 Grade cement requires no special curing technique. The setting or hardening time is proportional to the operating temperature. If installation operates at fairly low temperature (100 F to 150 F), this cement will remain soft and tacky for several months. If operating temperature is above 250 F, it will set hard in a few hours. T-85 Grade cement may be subjected to temperatures up to 375 F immediately after application.

d. T-80 Grade cement, for use at temperatures from below freezing to 300 F, requires no special curing. Its properties are similar to those of T-85 Grade cement.

e. T-5 Grade cement requires no curing, as it does not harden or set.

8. Application of Insulation

a. Insulation shall be as scheduled and shall be applied in accordance with the individual specifications.

b. Inside diameter of insulation to fit over traced piping shall be as called for in Owner's Standard P-140A.

XIV. WEATHER-BARRIER MASTIC COATING

Insulation shall be protected with a weather-barrier mastic coating unless otherwise specified.

A. Materials (See MATERIAL SPECIFICATIONS, Article Numbers as Noted)

1. Weather-Barrier Mastic - Trowel Grade - VII.B.1.a.

2. Weather-Barrier Mastic - Spray Grade - VII.B.1.a.

3. Reinforcing Cloth - VII.B.1.b.

4. Mastic (Caulking) - VII.A.45.

5. Heat-Resistant Sealer - VII.A.42.

6. Expansion Strip - VII.A.10.

7. Lap Sealer - VII.A.46.

B. Application

1. Insulation shall be installed before application of weather barrier.

2. Surface of insulation shall be smooth, even and free of voids, and in relatively dry state.

3. On outside installations, insulation shall be sloped for water drainage.

4. Sharp outside corners of insulation shall be rounded off as shown in Figure GA-5.

5. A heavy fillet of mastic shall be applied to all inside corners of insulation, and to inside corners of metal projections of moderate and low temperatures, prior to application of weather-barrier mastic.

6. A heavy fillet of heat-resistant sealer shall be applied around all metal projections which will be above 180 F in service. The sealer shall be applied outward from the junction of the projection for a distance six inches on the metal and six inches over the surface of the insulation.

7. Insulation shall be protected from weather as soon after installation as possible. However, standard mastic shall not be applied when atmospheric temperature is below 32 F or when temperature is expected to be as low as 25 F within the next 24 hours. Low temperature mastic shall be used when atmospheric temperature is less than 32 F but above 20 F.

8. Where mastic is to be spray applied, adjacent areas not to be coated, such as valve stems, handles, gauge glasses, instruments, equipment, structural steel, floors or walls, shall be masked or otherwise protected.

9. Spray application shall consist first of a spray tack coat of spray grade weather-barrier mastic into which the reinforcing cloth is thoroughly embedded. Joints of reinforcing shall be uniform and not less than two inches in width, and shall have a smooth unbroken surface. All inside and outside corners shall be rounded and the weather-barrier coating provided with an overlapped layer of reinforcing cloth as shown in Figure GA-5. After the first coat has taken its set, a second coat shall be spray applied which completely covers and fills all voids in the cloth. The combined thickness of the weather-barrier coating and reinforcing cloth shall not be less than 55 mils when dry, or approximately 3/32 to 4/32-in. total wet film.

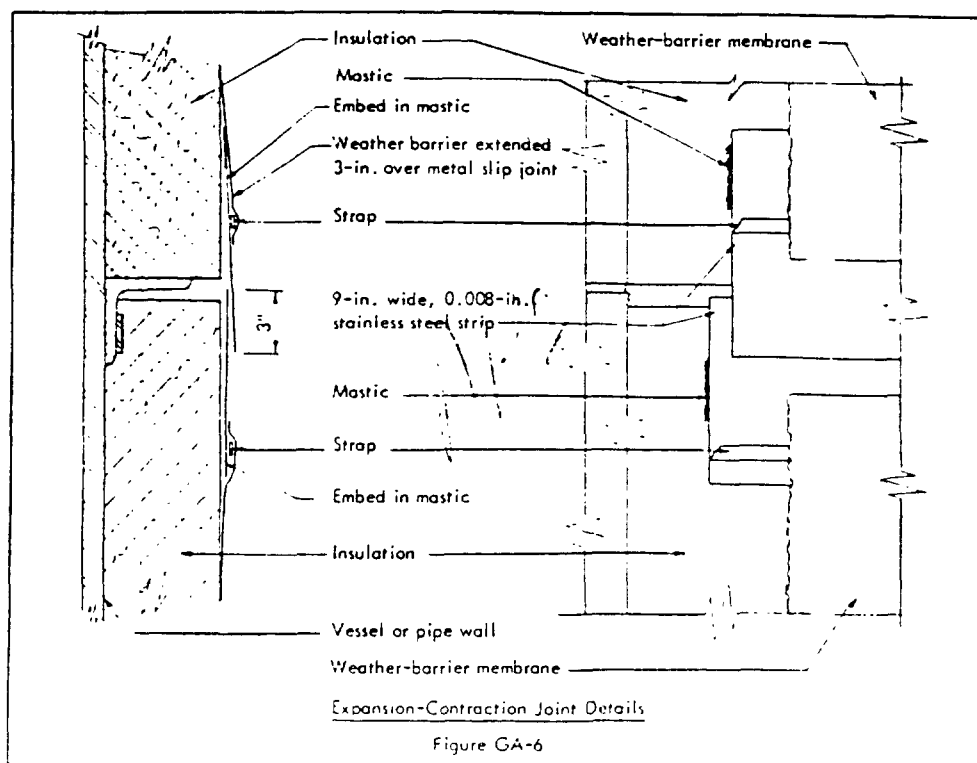
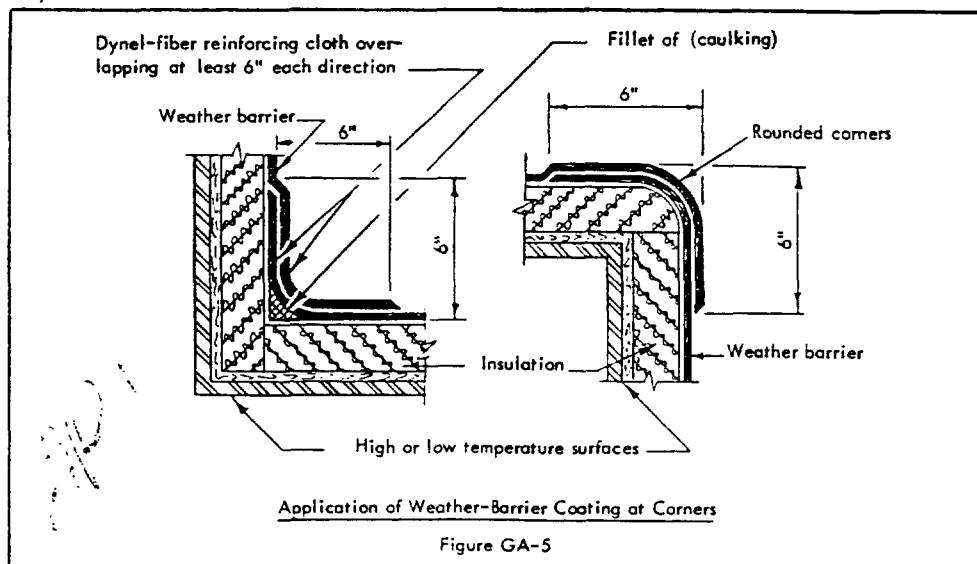
XIV. WEATHER-BARRIER MASTIC COATING - contd

8. Application - contd

10. Palmed or troweled application shall consist of first bonding the reinforcing cloth to the surface with small amounts of weather-barrier mastic. Cloth shall be pulled taut with joints overlapped uniformly two inches. All inside and outside corners shall be rounded and the weather-barrier coating provided with an overlapped layer of reinforcing cloth as shown in Figure GA-5. Trowel grade weather-barrier mastic shall then be troweled or palmed over cloth, pressing it through the mesh to obtain bond with insulation surface. Care shall be taken that openings in weave of cloth are completely sealed. After weather barrier has partly set, it shall be water brushed to a smooth, even surface. The combined thickness of the weather-barrier coating and reinforcing cloth shall not be less than 1/16 inch when dry, or approximately 3/32 to 4/32-in. total wet film.

11. Weather-barrier membrane shall be carried out six inches onto metal, beyond termination of insulation and supports, skirts, or other projections, and shall be sealed to the metal.

12. Expansion joints in weather barrier over expansion openings in high temperature insulation shall be constructed with expansion strip, as shown in Figure GA-6. Joints installed in vertical position shall be arranged to shed water. Joints installed in horizontal position shall be constructed in similar manner except that a bead of lap sealer shall be placed between the two layers of expansion strip so as to prevent entry of water, but not to restrict movement between sheets.



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XIV. WEATHER-BARRIER MASTIC COATING - contd

B. Application - contd

13. Contraction joints in low-temperature insulation shall be as called for in individual specifications.

14. Unless otherwise specified, outer finish of indoor insulation shall be same as called for in these weather-barrier specifications.

XV. METAL JACKETS - STAINLESS STEEL OR TREATED STEEL

The letter M added to the regular designation of any application specification (examples: 10-HM, 10-JM, etc) indicates that the weather barrier shall consist of a jacket of Type 430, or any austenitic type, stainless steel. The letters MT added to the regular designation indicate that the weather barrier shall consist of vinyl-coated galvanized steel. Split systems of weather barrier shall be specifically designated (example: 23-H on fittings and 23-HM for straight pipe).

A. Materials

1. Weather-Barrier Stainless Steel and Carbon Steel Jackets (See MATERIAL SPECIFICATIONS, Article Numbers as Noted)

- a. Equipment over 24 inches OD - VII. B. 2. a. and VII.B.3.a.
- b. Equipment 24 inches OD and under - VII. B. 2. b. and VII.B.3.b.
- c. Pipe Preformed Jacket - VII. B. 2. c.
- d. Smooth jacket for pipe - VII. B. 2. d.
- e. Closure band for both ends of pipe jackets - VII. B. 2. e. and VII.B.3.c.
- f. Preformed jackets for fitting covers - VII. B. 2. f.

2. Accessories (See MATERIAL SPECIFICATIONS, Article Numbers as Noted)

- a. Sheet Metal Screws - VII. A. 32.
- b. Equipment Insulation Strap - VII. A. 11.
- c. Pipe Insulation Strap - VII. A. 13.
- d. Clips for Equipment Strap - VII. A. 12.
- e. Clips for Pipe Strap - VII. A. 14.
- f. "S" Clips - VII. A. 27.
- g. Jacket Support Clips - VII. A. 28.
- h. Stainless Steel Wire - VII. A. 17.
- i. Expansion Strip - VII. A. 10.
- j. Lap Sealer - VII. A. 46.
- k. Heat-Resistant Sealer - VII. A. 42.

B. Application

1. Equipment

- a. Equipment insulation secured with bands shall be recessed under band clips. Clips shall be embedded flush with insulation to provide a smooth, even surface for application of jacket.
- b. Jacket shall be installed from bottom up. The first course shall be supported by jacket support clips attached to insulation support. Vertical joints shall be lapped to a minimum of three inches. A bead of lap sealer shall be placed between the layers of metal on all vertical joints before joint is fastened together with screws on six-inch centers. Care shall be taken that screws do not bind circumferential joint preventing relative motion between two courses of jacket. Subsequent courses of jacket shall be supported by "S" clips, overlapped three inches to shed water. At top of vessel a six-inch wide stainless steel flashing strip shall be embedded in weather-barrier mastic and banded in place. It shall lap top course of jacketing three inches, but shall not be attached to the jacket. Additional weather barrier, used over vessel head, shall be applied down over flashing to provide water shed. Details are shown in Figure GA-7 for corrugated metal jacket.

STANDARD SPECIFICATIONS

UNION
CARBIDE

CHEMICALS, OLEFINS, PLASTICS,
SILICONES DIVISIONS AND
UNION CARBIDE CANADA

GS
INSULATION
12
SEPTEMBER 1969

XV. METAL JACKETS - STAINLESS STEEL OR TREATED STEEL - contd

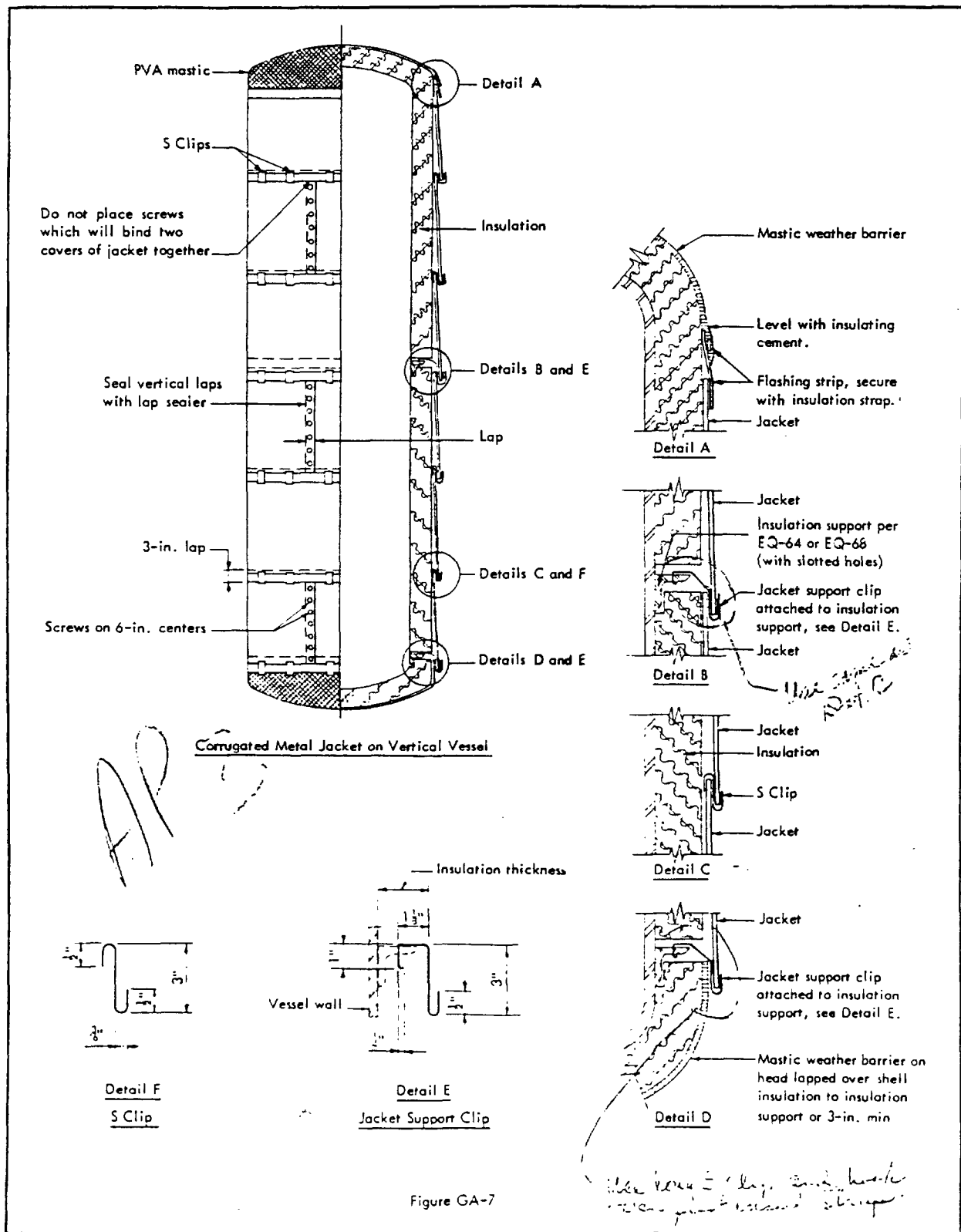


Figure GA-7



STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

GS
INSULATION
13
SEPT 1970

XV. METAL JACKETS - STAINLESS STEEL OR TREATED STEEL - contd

B. Application - contd

1. Equipment - contd

c. When smooth stainless steel jacket is used, a bead of lap sealer shall be placed between the layers on each vertical joint before joint is fastened together with screws on six-inch centers. Vertical and circumferential joints shall be lapped a minimum of three inches. The first course of jacket shall be supported by jacket support clips attached to the vessel insulation support. Subsequent courses of jacket shall be supported by "S" clips, overlapped three inches to shed water. Jacket shall be secured circumferentially with 1/2-inch stainless steel bands, above circumferential joint, and on 18-inch centers. Sheet metal screws shall be installed in jacket to aid in spacing and to prevent slipping of bands. Care shall be taken that neither the screws nor the bands bind the circumferential joint preventing relative motion between two courses of jacket. Top flashing shall be as specified for vertical vessels over 2 ft 0 in. in diameter. Details are shown in Figure GA-8 and GA-7. Expansion strap shall be used to secure metal jackets on vessels over 15' 0" in diameter.

When preformed stainless steel jacket with "Z" joint is used to cover small vessels, vertical or horizontal, it shall be installed in the manner specified for application of preformed pipe jacket in Item 2.a of this section. Details are shown in Figure GA-9.

d. Horizontal vessels jacketed with smooth stainless steel shall be insulated in same manner as vertical vessels except that all circumferential joints shall be sealed with a bead of lap sealer placed between the layers of metal before securing the jacket in place with strap. Strap shall be placed directly over the joint. The longitudinal laps shall be installed on sides to shed water, and shall be secured on six-inch centers with screws. Details are shown in Figure GA-10.

e. Heads of vessels shall be jacketed with preformed or field formed smooth surface stainless steel jacket. All joints of preformed head jackets shall be fastened together to form a watertight assembly. Field formed jacket joints, or joints where preformed jackets fit together, shall have laps sealed with joint sealer. Jacketing shall be secured in place by straps, screws, or other approved fasteners.

f. Insulation on irregular surfaces and vessel trim, where use of metal jacket is impracticable, shall be protected with mastic weather-barrier coating as called for in Article XIV.B. of this specification.

2. Piping

a. Preformed and preapplied stainless, or treated, steel jackets with preformed longitudinal "Z" joint shall be applied as follows:

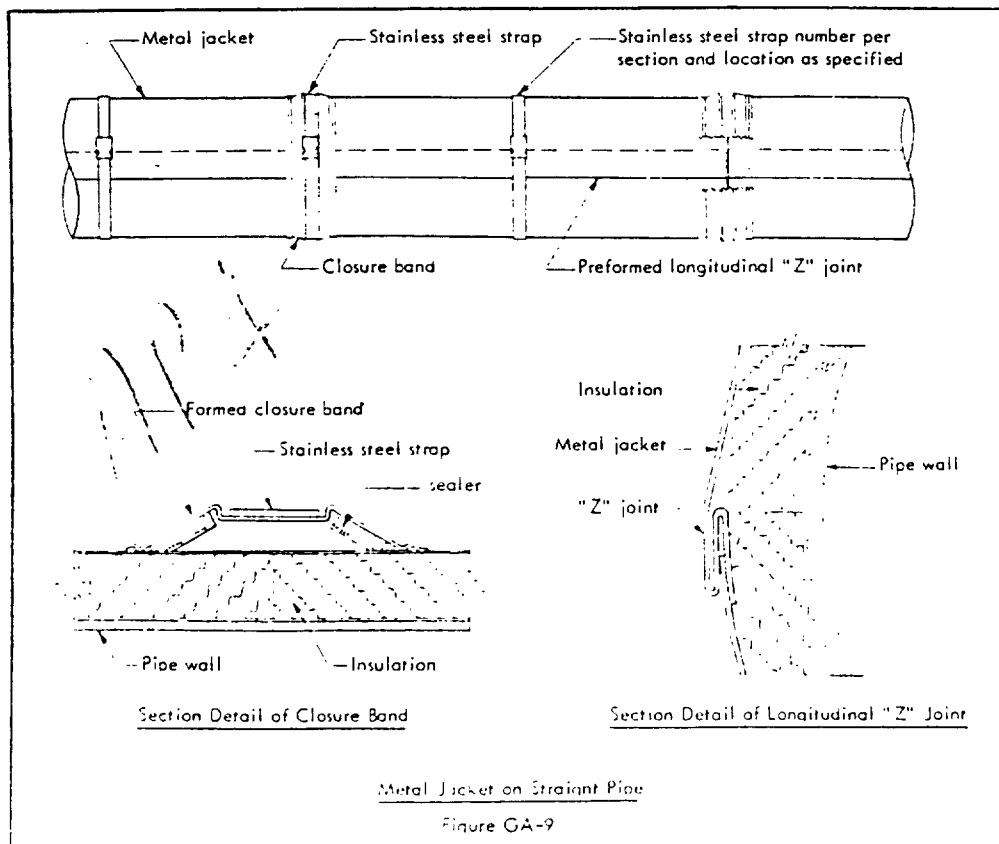
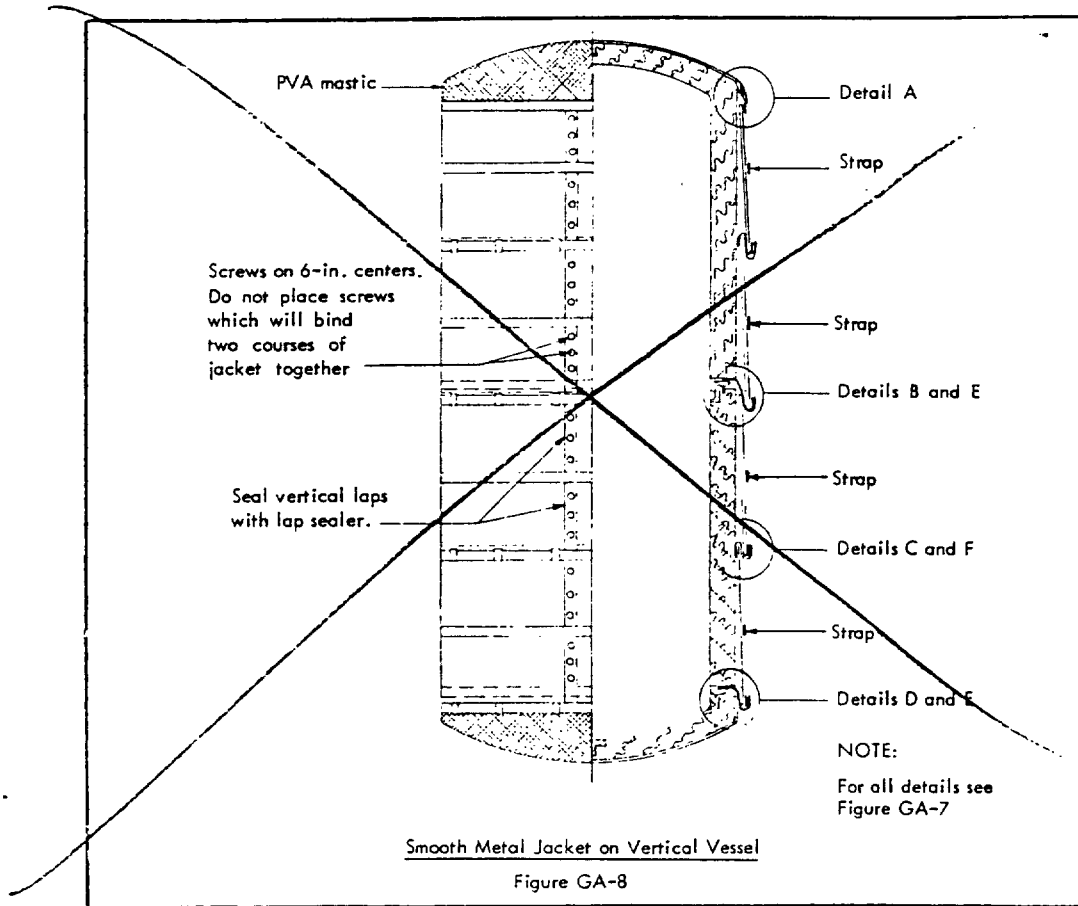
(1) Inner layer of insulation, if any, shall be secured with stainless steel wire if high temperature, or with glass filament tape if low temperature.

(2) Factory attached jacket to a single or outer layer insulation shall be installed with the insulation. Insulation and jacket shall be installed by placing the insulation around the pipe, or inner layer, and engaging the "Z" joint. Longitudinal joint on horizontal pipe shall be located on horizontal centerline of pipe with open end down to ensure runoff of water. Jacketing 6-5/8 inches and smaller shall be secured with one strap at center of the assembly. Larger diameter insulation and jacketing shall be secured with two straps, each approximately 12 inches from end of assembly. Details are shown in Figure GA-9.

(3) Where necessary (such as where insulation must be cut to fit around obstructions) to install the single or outer layer of insulation prior to the installation of jacket, the insulation shall be secured with wire. Ends of wire shall be twisted and embedded in surface of insulation so as to provide a smooth even surface for application of the jacket. Jacket shall then be installed as specified above.

(4) The butt joint between adjacent assemblies shall be sealed with a closure band. If non-setting sealer of closure band is protected with paper, the paper shall be removed before installation. Closure bands shall be secured with stainless steel strap.

XV. METAL JACKETS - STAINLESS STEEL OR TREATED STEEL - contd



STANDARD SPECIFICATIONS



CHEMICALS, OLEFINS, PLASTICS,
SILICONES DIVISIONS AND
UNION CARBIDE CANADA

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JULY 1

XV. METAL JACKETS - STAINLESS STEEL OR TREATED STEEL - contd

B. Application - contd

2. Piping - contd

c. Stainless steel jackets for insulation valve covers and insulation fitting covers shall, where possible, be factory or shop preformed to fit the covers in accordance with ASTM Recommended Practice C 450, latest revision. Jackets shall be secured to covers by screw strap, or fasteners furnished by the manufacturer, depending upon their design. All laps shall be installed to shed water or shall be sealed with lap sealer.

d. Field cut and formed jackets for closely connected and special fittings shall be fabricated and formed of soft annealed stainless steel strip. All joints shall be lapped a minimum of two inches and shall be sealed with lap sealer. Formed pieces shall be secured with stainless steel strap or screws.

e. Hot metal projections through the insulation and weather-barrier jackets shall be seal caulked with heat-resistant sealer.

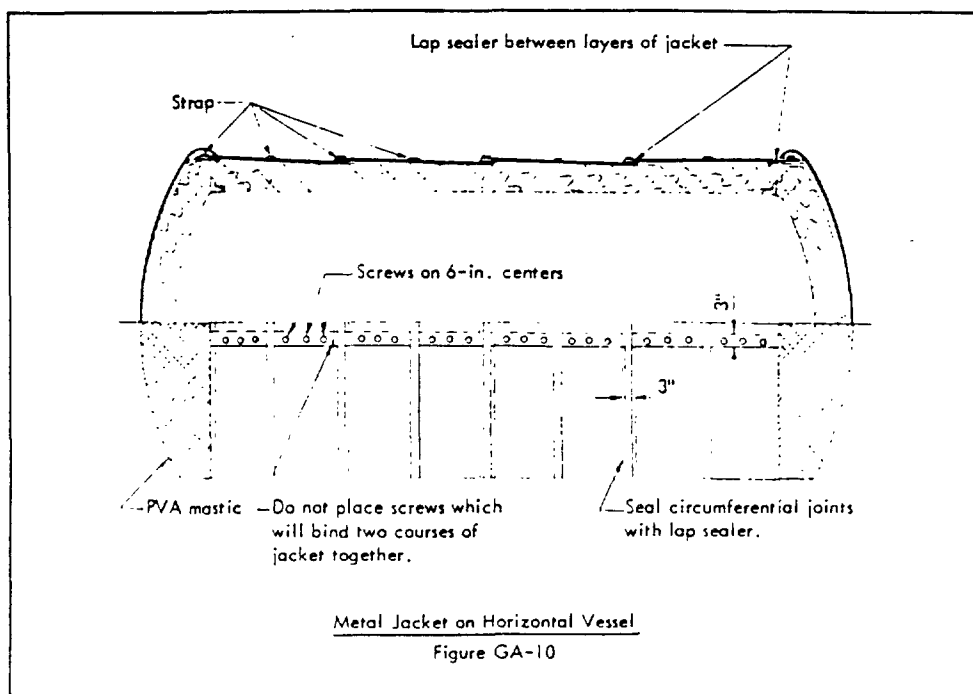
3. Metal Jackets in Combination with Weather-Barrier Mastics - Where especially specified, the stainless steel jacketing may be used in combination with weather-barrier mastics.

a. Equipment

(1) Where vessel heads are specified to be weather protected with mastic and the cylindrical section to be protected with metal jacketing, the mastic shall be installed in accordance with Article XIV.B. of this specification. Metal of cylindrical section of vertical vessel shall be lapped over bottom head mastic at least three inches. At top of vessel a six-inch wide stainless steel flashing strip shall be embedded into weather-barrier mastic and banded into place. It shall lap top course of jacketing three inches, but it shall not be attached to the jacket. Additional weather-barrier mastic used over head insulation shall be carried down over the flashing to provide water shed. Details are shown in Figure GA-7.

(2) At junction of weather-barrier mastic and jacket of horizontal vessel the mastic shall be lapped over the metal jacket for a minimum of three inches.

b. Piping - Where straight pipe is metal jacketed and fittings weather protected with mastic, the mastic weather barrier shall be installed in accordance with Article XIV.B. of this specification. The mastic weather barrier on fittings shall be lapped over the metal jacketing one inch. Where possible, over this butt joint between the mastic weather barrier on fittings and the metal pipe jacket, a closure band shall be installed as specified in Article XV. B. 2. a. (4) of this specification.

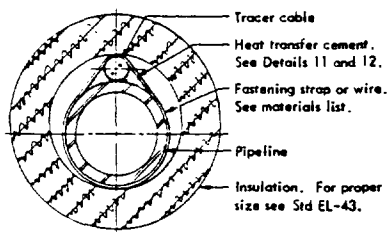


STANDARD

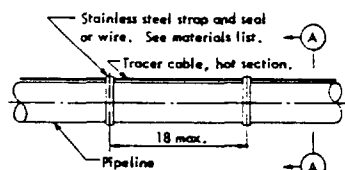
UNION CARBIDE
CHEMICALS, OLEFINS, PLASTICS,
SILICONES DIVISIONS AND
UNION CARBIDE CANADA

EL-4
ELECTRICAL-DETAILS
6-1-

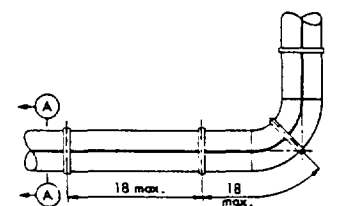
ELECTRIC TRACING SYSTEM DETAILS AND MATERIALS



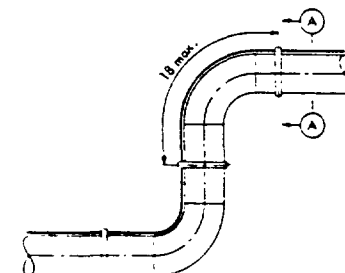
Section A-A
Typical cross section of completely installed tracer cable



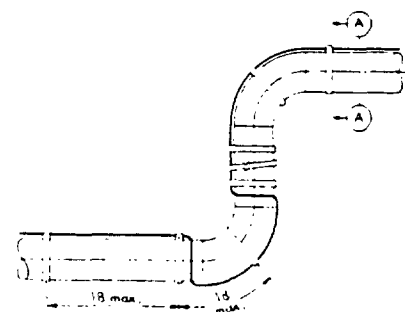
DETAIL 1
Elevation - Tracer cable on straight pipe run



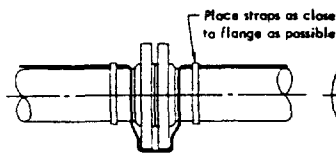
DETAIL 2
Plan - Tracer cable on pipe run with 90° elbow



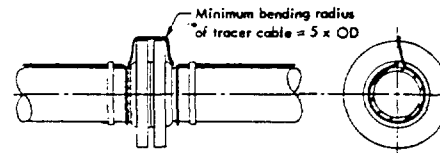
DETAIL 3
Elevation - Tracer cable on vertical pipe run of less than 3-inches nominal size



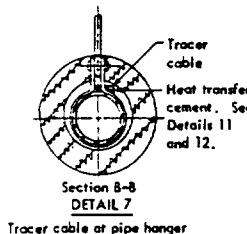
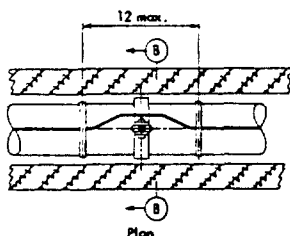
DETAIL 4
Elevation - Tracer cable on vertical pipe run of 3-inches nominal size and larger



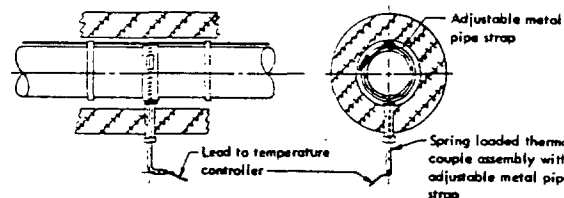
DETAIL 5
Elevation - Tracer cable on pipe flange 2-inches nominal size and smaller



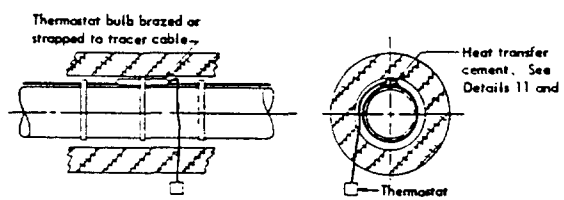
DETAIL 6
Elevation - Tracer cable on pipe flange larger than 2-inches nominal size



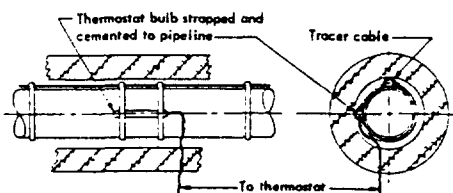
DETAIL 7
Tracer cable at pipe hanger



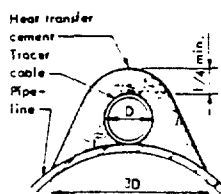
DETAIL 8
Elevation - Thermocouple installation for pipeline temperature control



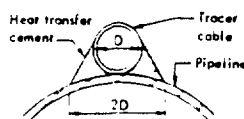
DETAIL 9
Elevation - Thermostat bulb installation for tracer cable sheath temperature control



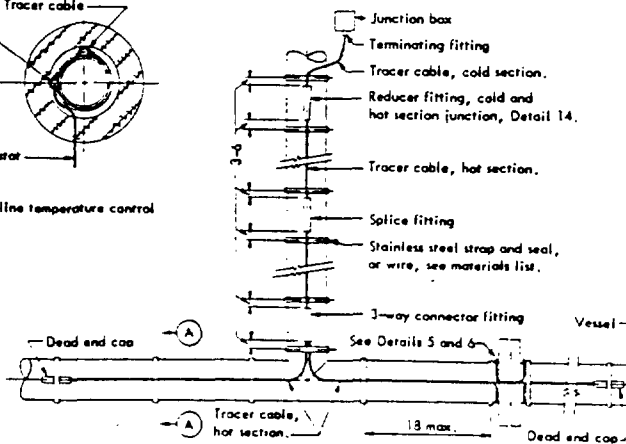
DETAIL 10
Elevation - Thermostat bulb installation for pipeline temperature control



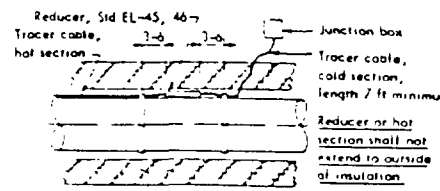
DETAIL 11
Installation of tracer cable with heat transfer cement type T-63 or Std



DETAIL 12
Installation of tracer cable with heat transfer cement type T-65



DETAIL 13
Plan - Typical installation of tracer cable fittings (See Stds EL-41, 42, 43 and 46).



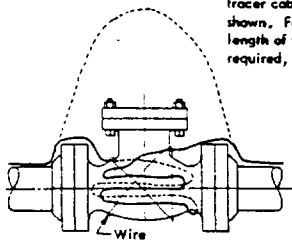
DETAIL 14
Elevation - Tracer cable, cold and hot section junction.

NOTE: Notes and dimensions not given for various details are the same as for details 1 and 2.

(OVER)

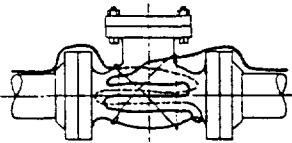
All dimensions given in inches

Form a loop and wrap tracer cable around as shown. For approximate length of tracer cable required, see table No. 2.



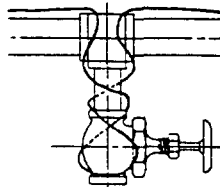
DETAIL 15

Tracer cable applied to check valve



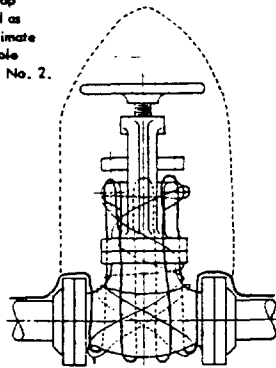
DETAIL 17

Valve electrically traced and heat transfer cement applied



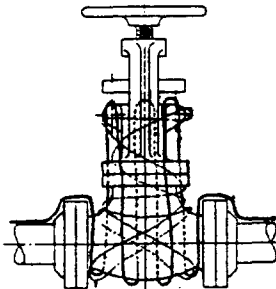
DETAIL 19

Elevation - Tracer cable run on blow-off valve



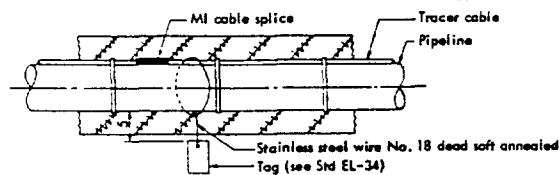
DETAIL 16

Tracer cable applied to globe or gate valve



DETAIL 18

Valve electrically traced and heat transfer cement applied



Detail 20

Installation Detail of Identification Tag for the Location of Tracer Cable Hot Splices on Long Tracer Systems

STAINLESS STEEL BANDING DATA									
Pipe Size, In.	1/2	3/4	1	1 1/4	2	3	4	6	8
Feet per Band	.46	.52	.59	.746	.870	1.16	1.42	1.98	2.50
Pipe Size, In.	10	12	14	16	18	20	24	30	36
Feet per Band	3.06	3.60	3.91	4.43	4.96	5.48	6.53	8.10	9.66

TABLE 3 - HEAT TRANSFER CEMENT REQUIREMENTS			
MI Cable Size In.	Process Line Size In.	Ft of Tracing per Gal. Std or T-63, Hand Trowel Appl.	Ft of Tracing per 1/6 Gal. Cartridge T-85
.246	All	50	40
.340	All	49	30
.543	1/2 - 1 1/2	30	16
.543	All other	33	16

It is suggested to add 10% to amounts given for estimating and waste.

TABLE 2 - ELECTRICALLY TRACED VALVES
Tracer Cable and Heat Transfer Cement Data

Valve Size In.	Feet of Tracer Cable Required	Gallon per Valve (Std & T-63) ¹	Cartridge per Valve (T-85) ²
1/2	1 - 2	0.14	.03 - .07
3/4	1 - 3	0.21	.03 - .1
1	2 - 3	0.29	.07 - .1
1 1/2	2 1/2 - 4	0.36	.08 - .13
2	3 - 5	0.43	.10 - .13
2 1/2	4 - 7	0.71	.27 - .47
4	6 - 10	1.00	.40 - .67
6	9 - 15	1.43	.60 - 1.00
8	12 - 20	2.00	.80 - 1.34
10	15 - 25	2.50	1.00 - 1.67
12	18 - 30	3.00	1.20 - 2.00
14	21 - 35	3.50	1.75 - 2.82
16	24 - 40	4.00	2.00 - 3.33
18	27 - 45	4.50	2.25 - 3.75
20	30 - 50	5.00	2.50 - 4.16
24	36 - 60	6.00	3.00 - 5.00
30	45 - 75	7.50	3.75 - 6.25
36	54 - 90	9.00	4.50 - 7.50

¹ Hand trowel application completely covering valve surface is recommended.

² Hand gun application as listed on each side of tracing is recommended.

MINERAL INSULATED CABLE INSTALLATION DETAILS

In order to provide an efficient and dependable electric tracing system, it is mandatory that the installation instructions be followed carefully and that good workmanship be applied.

Tracer Cable Installation:

The size of the tracer cable (No. and size of conductors) shall be as specified on the electrical tracer system design drawing.

The tracer cable shall be installed on top of, parallel to, and as much as possible in direct contact with the pipeline; and shall be fastened with stainless steel wire (up to 2-inch diameter lines), or stainless steel straps (over 2-inch diameter lines), at a spacing not to exceed 18-inches. At tracer fittings the fastening wire or strap shall be installed within 3 to 6 inches from the fitting. At pipe flanges or valves, the fasteners shall be as close to these items as possible and in no case shall this distance be more than 3-inches.

The configuration of the tracer cable shall follow the design drawing when special layouts are given for vessels or other equipment.

No allowance for expansion shall be made by forming loops in the tracer cable hot section. A normal installation contains sufficient irregularities to allow for expansion between fastening wires or straps.

The entire hot section of the tracer cable shall be contained under the pipeline insulation; the connecting cold section shall be fastened under the insulation in accordance with Detail 14, and then be continued to the outside of the insulation.

All tracer cable fittings shall be cemented to the pipeline in a manner similar to Details 11 and 12, as shown for tracer cables.

Proper insulation sizes for electrically traced pipelines may be selected from Standard EL-140A.

Heat Transfer Cement Installation:

Heat transfer cement shall be applied to pipeline surfaces that should be essentially free of loose paint, mill scale, rust or dirt, and of grease, oil or mill varnish. Wire brushing, sandblasting and solvent cleaners for the removing of oil and grease, shall be used to clean pipeline surfaces in order that heat transfer cements may be applied properly.

If heat transfer cement is to be applied to aluminum or galvanized surfaces, Therman¹ ALP primer should be used. The to be primed surface shall be wiped free of loose scale, dirt or oil. The primer shall be applied with a stiff brush, and then be allowed to set for 24 hours before the heat transfer cement is applied. Only the surface to be covered by cement needs to be primed.

Heat transfer cements types T-63 or Standard by Therman¹ shall be applied by a hand trowel, a caulking gun or pumping equipment using a special nozzle (see Detail 11). Therman type T-85 cement shall be applied by a caulking gun covering the tracer and pipeline as shown in Detail 12. For best results, care should be taken to force heat transfer cement thoroughly around and under the tracer cable.

The same general technique as explained above in applying heat transfer cement is applicable to vessels, valves, flanges and other equipment where tracer cable is used.

The curing of heat transfer cement shall be in strict accordance with manufacturers recommendations (see table 1).

¹As manufactured by Therman Manufacturing Company, Houston, Texas, or approved equal.

REFERENCES:

List of all Standards on MI Cable and Electric Tracing Data STD EL-40

MATERIALS FOR ELECTRIC TRACING SYSTEMS

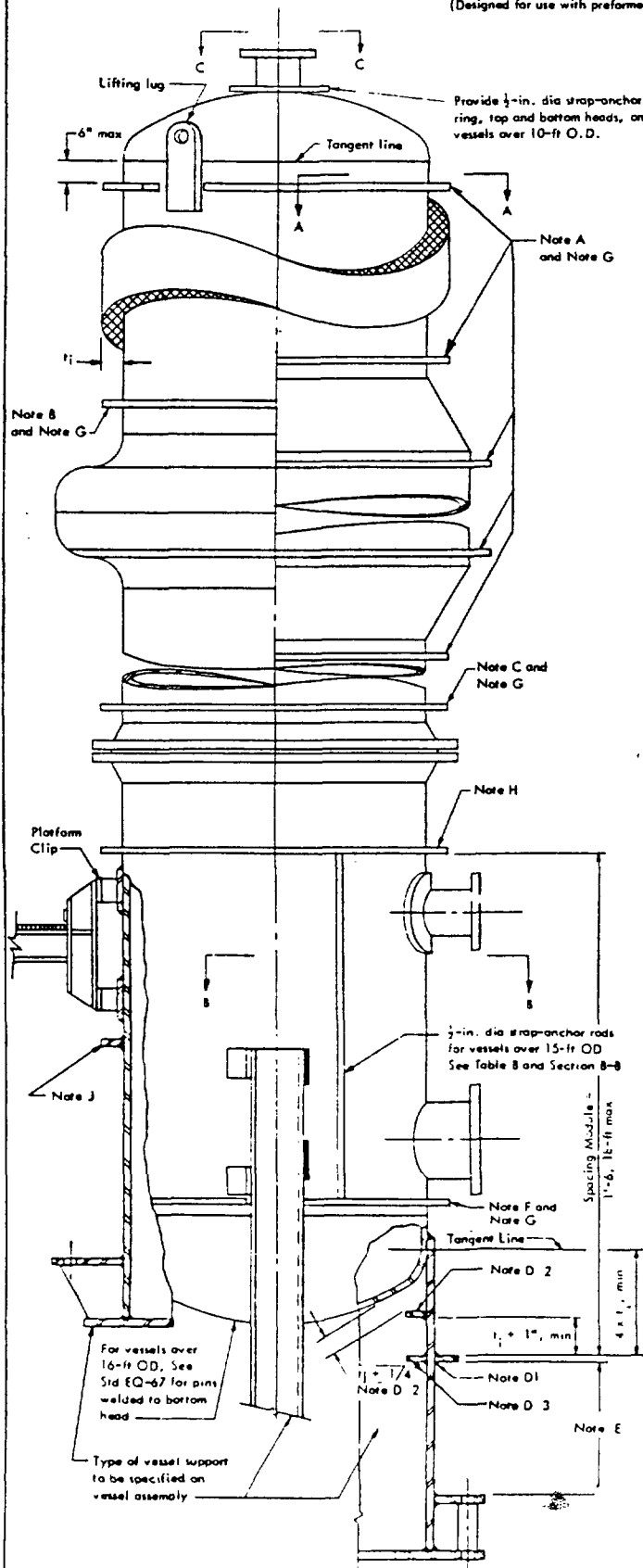
Item	Description
Tracer Cable	Mineral insulated cable by General Cable Corp., 1, 2, or 3 copper or alloy conductors, bare copper sheath, for use up to 250 C temperatures. For temperatures over 250 C the cable sheath shall consist of stainless steel or other suitable metal.
Fittings	Terminations and seals for cold sections by General Cable Corporation. Splices, reducer, 3-way connectors and dead-end caps for hot sections by Bundy Corporation.
Straps and Clips	For pipeline tracers: 3/8-in. x 0.015-in. thick dead soft annealed stainless steel straps, with double pronged 3/8-in. x 1/2-in. Econ-O-Clips, by Techalloy Company, Rahns, Pennsylvania, or approved equal. For vessels and equipment tracers: Same as above except 1/2-in. x 0.020-in. straps and 1/2-in. x 1/2-in. Econ-O-Clips.
Strapping Tool	No. 111 steelbinder with stainless steel nose, by A. J. Gerrard & Company, Des Plaines, Illinois, or approved equal.
Wire	18 gage (0.047-in. Dia.) dead soft annealed stainless steel wire.
Heat Transfer Cement	Therman, types T-63, T-80, T-85, or Std., as manufactured by Therman Manufacturing Company, Houston, Texas, or approved equal.

TABLE 1 - PROPERTIES OF THERMON HEAT TRANSFER CEMENTS

DATA		STANDARD	T-63	T-80 ¹	T-85
Maximum Temp	F	500 Cont.	750 Int.	1250	325
Minimum Temp	F		-320	-100	-220
Shear Band lb/sq. in.			150		1000 - 1800
Start-up Curing		4 Hrs-Air Dry 4-24 Hrs-180-212 F	4 Hrs-Air Dry 4 Hrs-180-212 F 4 Hrs-250 F		
Each curing time and temperature indicated must be executed in sequence.					
Installation					
Shelf Life			One Year +		50-90 Days
Water Soluble			Yes		No
Volume Resistivity			0.267 OHM IN.	3.3 OHM IN.	146 OHM IN.
Ambient Temperature for Application is +10 F or above.					

**WELDED-ON INSULATION SUPPORTS FOR VERTICAL VESSELS,
 INCLUDING TANKS, OVER 3-FT O.D.**

(Designed for use with preformed shapes, panel, and block form insulation)


TABLE A

Insulation Thickness, t_i (in.)	Bar Size		Weld Size, t_w (in. $\times 45^\circ$)
	Thickness, t_r (in.)	Width, w_r (in.)	
$1 < t_i \leq 1\frac{1}{2}$	3/16	1	3/16
$1\frac{1}{2} < t_i \leq 3\frac{1}{2}$	3/16	1-1/2	3/16
$3\frac{1}{2} < t_i \leq 9$	1/4	3	1/4

GENERAL NOTES

All support rings shall be slotted except where noted otherwise. Provide insulation support rings at maximum spacing of 18-in. Shorter spaces shall be a multiple of 1-ft 6-in. Select support ring size from Table A.

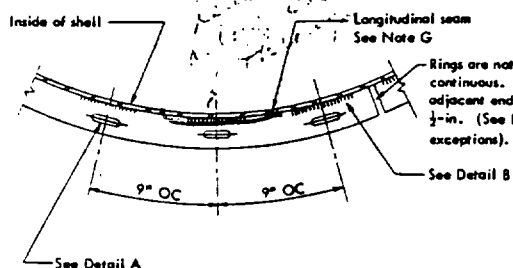
Material for supports shall be as noted on vessel assembly drawing or in the vessel specifications. Welding procedure for attaching supports to a new vessel shall be equal to that for the pressure-containing enclosure. Attachment of supports to an existing (used) ASME Code Vessel shall be in conformance with the applicable Code requirements including post-weld heat treatment when required. Stiffening rings should be spaced at insulating support ring modules, if practicable, and may be used in lieu of standard insulating support rings on vessels subject to external pressure. Do not slot stiffening rings.

SPECIFIC NOTES

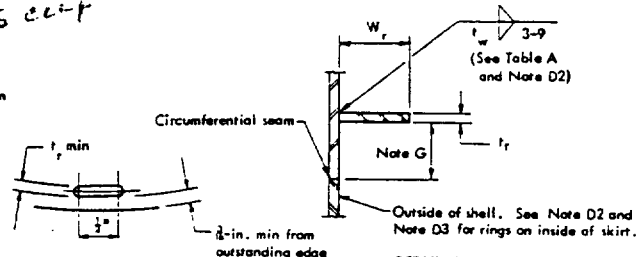
- Provide insulation support rings at the top and bottom of each shell transition section. For dished top heads, provide ring on the straight flange of the head or on the shell adjacent to the head.
- Provide support ring above shell expansion joint.
- Provide an insulation support ring above each flanged shell joint. Clearance between the top (back) of the flange and the top of the ring shall be sufficient to provide access for tightening flange bolts but not less than 9-inches.
- Provide the following insulation support rings on vessel skirts:
 - One ring on the outside of the skirt at $4 \times t_i$ inches minimum, below the head tangent line.
 - One $2\frac{1}{2}$ -in. $\times$ 1-in. slotted ring inside skirt. Locate this ring to provide $t_i + \frac{1}{2}$ -in. clearance between the bottom head and the inner edge of the ring. Weld on low side only.
 - On vessels designed for service below 0°C (32°F), provide a second (lower) ring inside the skirt opposite the ring of D.1. above. The lower inside ring shall be of the same thickness and width as the outside (opposite) ring. Slots are not required in the inside, lower ring.
- Welded-on insulation support ring on the outside of skirt with doubler-ring type base for use with prestressed anchor bolts must be spaced at least 3-ft 2-in. above the top base ring. Install bolted-on insulation support ring per Sid EQ-6d where this clearance cannot be obtained.
- For leg or lug-supported vessels with dished bottom heads, provide an insulation support ring on the straight flange of the bottom head or on the shell adjacent to the bottom head.
- Locate rings and rods to provide minimum clearance of 1-inch between the ring or rod attachment weld and the vessel circumferential or longitudinal seam edges. Ring or rod attachment welds shall not cross seams in the vessel.
- Locate rings and rods to clear shell connections, reinforcement rods, lifting lugs, etc., where possible. Ring locations above nozzles are preferred to those below nozzles.
- Where impossible to avoid interference between shell openings or attachments and rings, an opening of minimum practicable length shall be left in the ring. Provide 1-inch, minimum, clearance between ring or rod attachment welds and attachment weld of the interfering item.
- Provide support ring below Platform Clip Attachment. Locate at nearest multiple of 9-inches above next lower ring.

(SEE OVER FOR TYPICAL DETAILS)

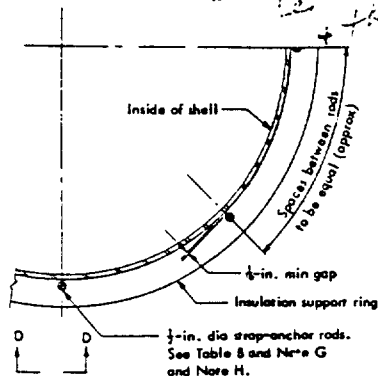
**WELDED-ON INSULATION SUPPORTS FOR VERTICAL VESSELS,
INCLUDING TANKS, OVER 3-FT O.D.**



SECTION A-A
Typical



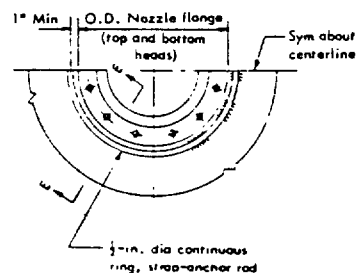
DETAIL B
Typical



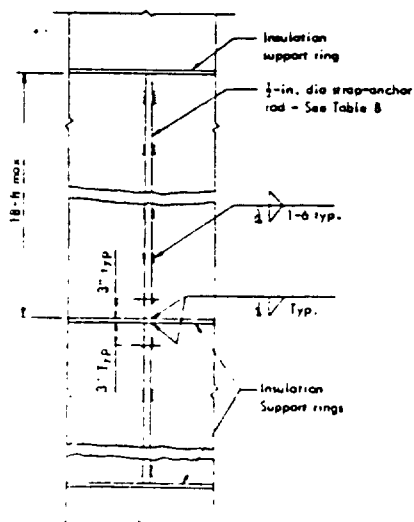
SECTION B-B
Typical

TABLE B

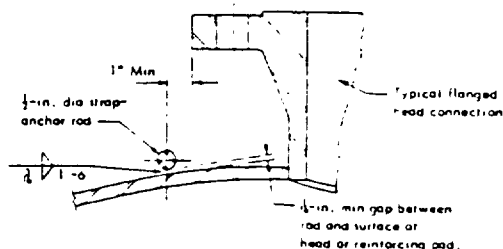
O.D. of Vessel	No. of Strap-Anchor Rods Required
15'-0 to 27'-0	4
27'-1 to 36'-0	8
36'-1 to 50'-0	16
Over 50'-0	One rod for each 9-ft of circumference or fraction thereof



VIEW C-C
Typical



ELEVATION D-D
Typical



SECTION E-E
Typical

**WELDED-ON INSULATION SUPPORTS FOR
HORIZONTAL VESSELS OVER 3-FT O.D.**

(Designed for use with preformed shapes, panel, and block form insulation)

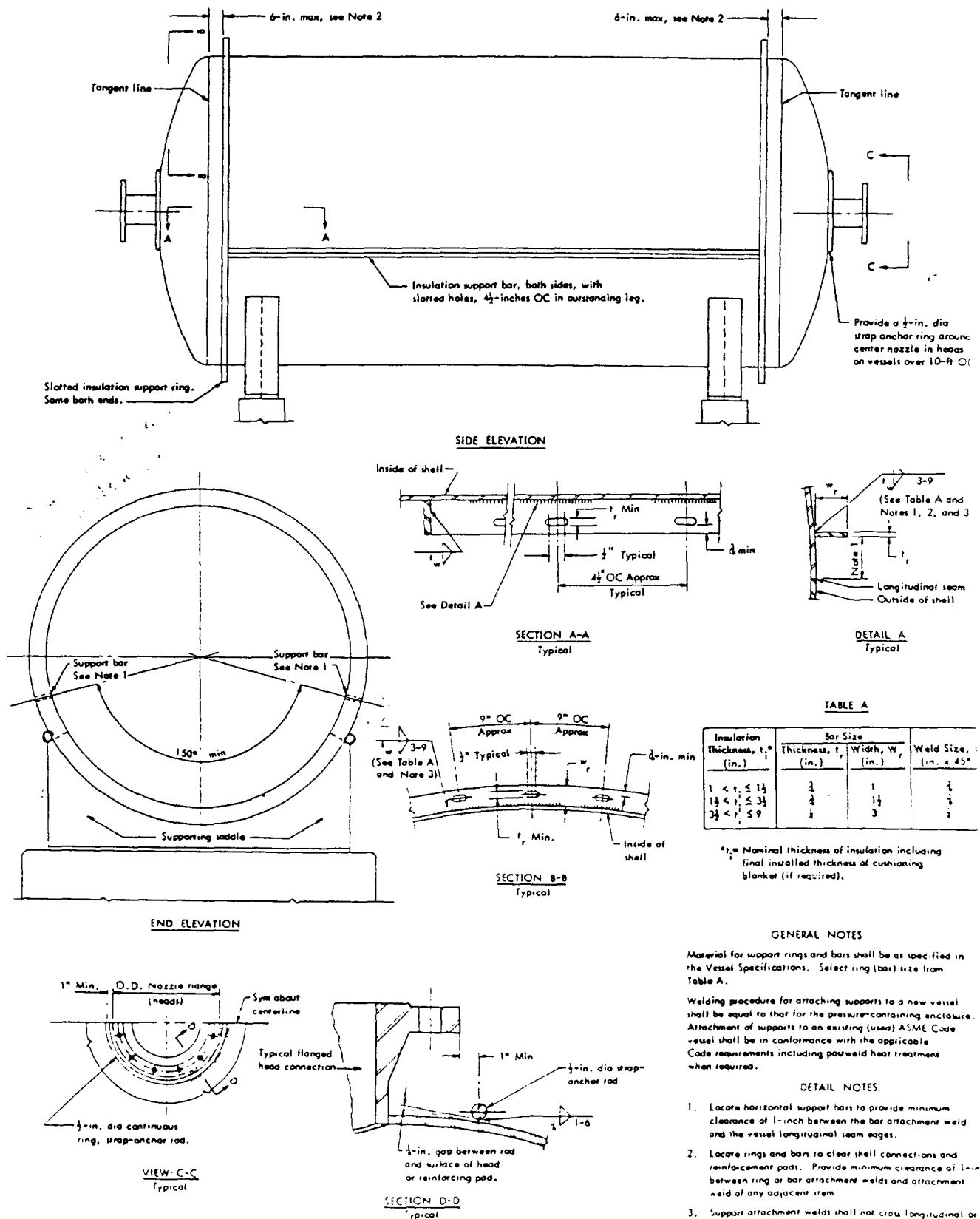


TABLE A

Insulation Thickness, t_i (in.)	Bar Size (in.)	Width, W_r (in.)	Weld Size, t_w (in. $\times$ 45°)
$1 < t_i \leq 1 1/2$	3	1	1/2
$1 1/2 < t_i \leq 3/4$	3	1 1/2	1/2
$3/4 < t_i \leq 9$	3	3	1

t_i = Nominal thickness of insulation including final installed thickness of cushioning blanket (if required).

GENERAL NOTES

Material for support rings and bars shall be as specified in the Vessel Specifications. Select ring (bar) size from Table A.

Welding procedure for attaching supports to a new vessel shall be equal to that for the pressure-containing enclosure. Attachment of supports to an existing (used) ASME Code vessel shall be in conformance with the applicable Code requirements including postweld heat treatment when required.

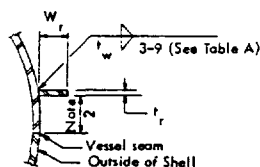
DETAIL NOTES

1. Locate horizontal support bars to provide minimum clearance of 1-inch between the bar attachment weld and the vessel longitudinal seam edges.
2. Locate rings and bars to clear shell connections and reinforcement pads. Provide minimum clearance of 1-inch between ring or bar attachment welds and attachment weld of any adjacent item.
3. Support attachment welds shall not cross longitudinal or circumferential welds in the vessel.

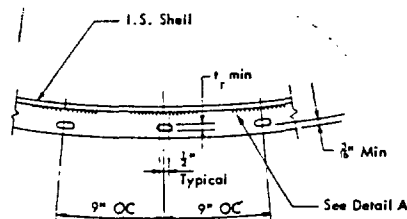
WELDED-ON INSULATION SUPPORTS FOR SPHERICAL VESSELS FOR OPERATING TEMPERATURES LOWER THAN 70F (21C)

(Designed for use with preformed shapes, panel, and block form insulation)

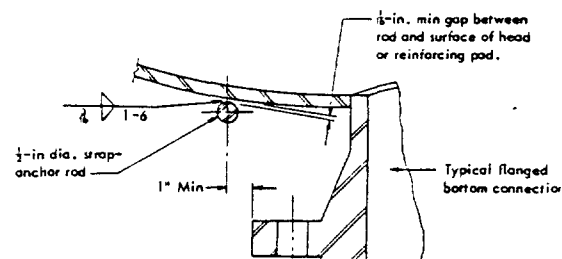
*Question the Force
Suggestion*



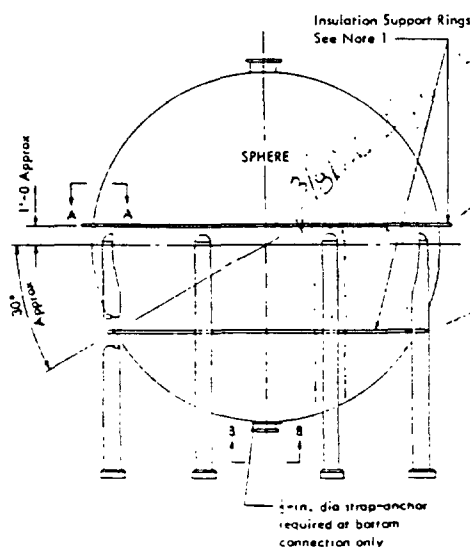
DETAIL A
See Notes 2 & 3



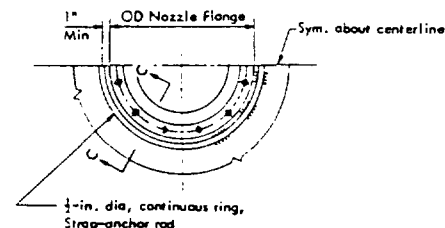
SECTION A-A
Typical



SECTION C-C



ELEVATION



VIEW B-B

Insulation Thickness, t_i (in.)	Bar Size		Weld Size, r (in. x 45°)
	Thickness, t_i (in.)	Width, W (in.)	
$1 < t_i \leq 1-1/2$	$1/2$	1	$1/4$
$1-1/2 < t_i \leq 2-1/2$	$3/4$	$1 1/2$	$3/8$
$2-1/2 < t_i \leq 9$	1	2	$1/2$

GENERAL NOTES

Provide each sphere with two slotted insulation support rings as shown on this Standard. Other insulation supports, where required, shall be as specified in the Vessel Specifications. Select support size from TABLE A.

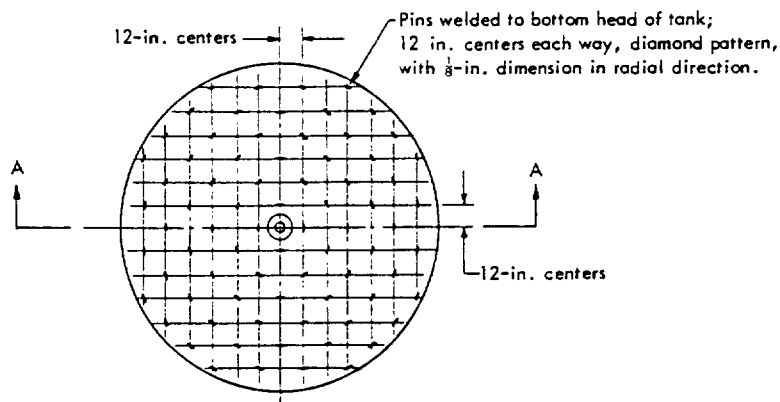
Material for supports shall be as noted in the Vessel Specifications. Welding procedure for attaching supports to sphere shall be equal to that for the pressure containing enclosure.

DETAIL NOTES

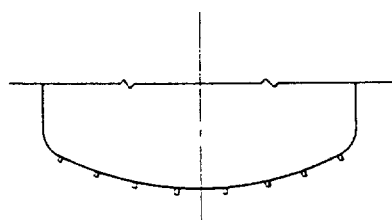
- Support rings shall be provided for all spheres to be insulated for operating temperatures lower than 70F (21C). Rings are not to be continuous. Openings between adjacent ends shall not exceed 1/2-inch.
- Adjust ring location, if necessary, to provide minimum clearance of 1-inch between the ring attachment weld and sphere girth weld edges. Locate rings to clear shell connections and reinforcement pads. Provide minimum clearance of 1-inch between ring attachment welds and attachment weld of any adjacent item.
- Support attachment welds shall not cross meridional welds.

INSULATION SUPPORT PINS FOR WELDING TO CARBON STEEL BOTTOM HEADS OR TO FLAT SURFACES

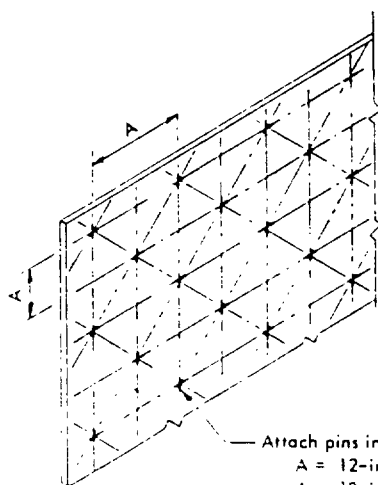
(Designed for use with preformed shapes, panel, and block form insulation)



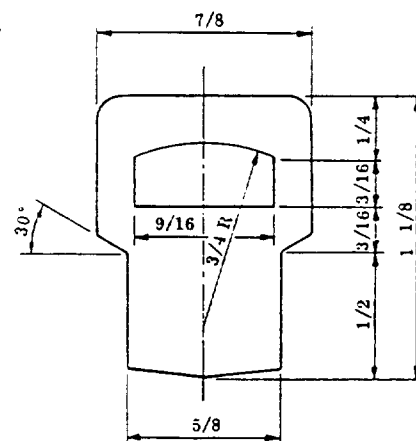
VIEW OF BOTTOM HEAD



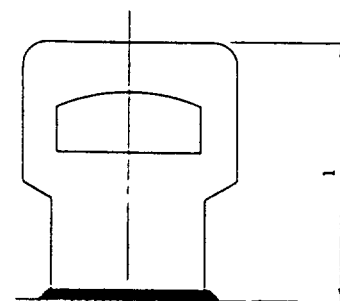
ELEVATION A-A



TYPICAL FLAT SURFACES



Before Welding



After Welding
Front Elevations of Pin

NOTE:

This standard applies to flat surfaces and to bottom heads of carbon steel vessels over 16-ft OD for operating temperatures above 70F.

Pins shall be as manufactured by KSM Products, Inc., Moorestown, New Jersey, or other approved securement.

Pins shall be welded to vessel with a KSM-CD-60 Capacitor Discharge Stud Welding Unit (or approved equal) with accessory chuck to suit pins.

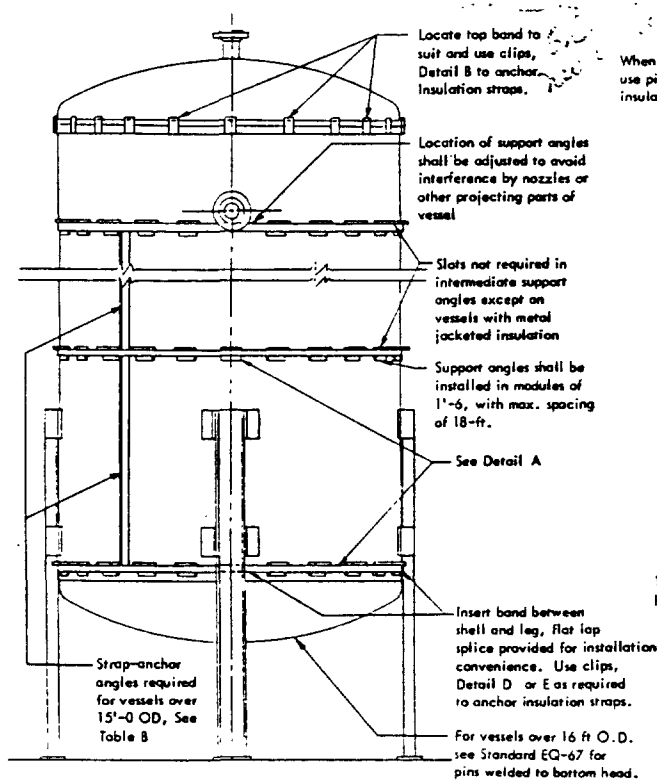
Pins shown are 8-in. thick.

Pins shall be welded to vessels subject to postweld heat treatment before the final heat treatment.

Pins may be welded in the field to vessels and other equipment not subject to postweld heat treatment.

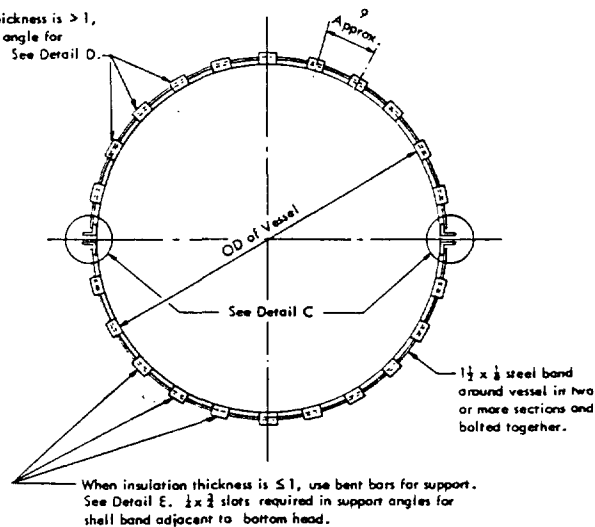
BOLTED-ON¹ INSULATION SUPPORTS FOR VERTICAL VESSELS OVER 3-FT O.D.

(Designed for use with preformed shapes, panel, and block form insulation)



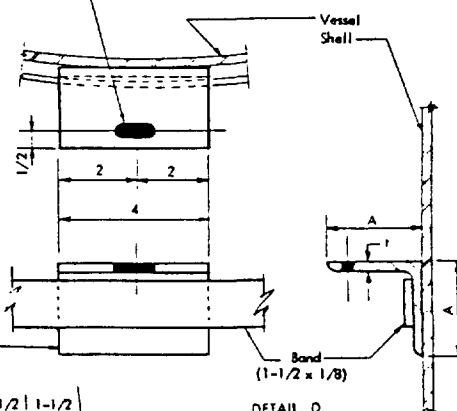
ELEVATION

When insulation thickness is > 1 , use pieces of steel angle for insulation support. See Detail D.

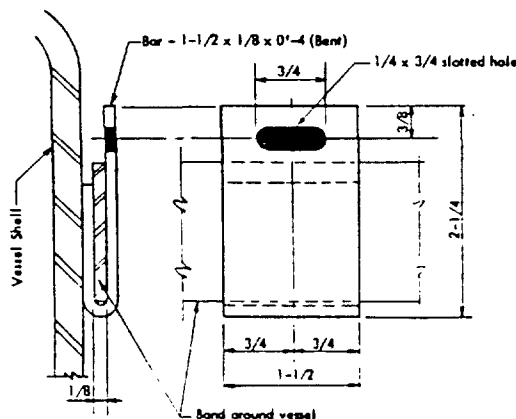


DETAIL A

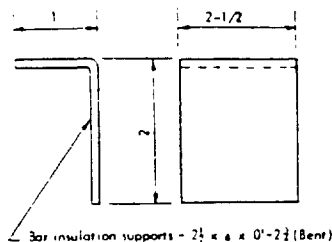
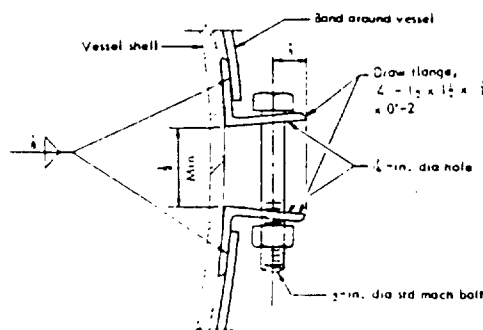
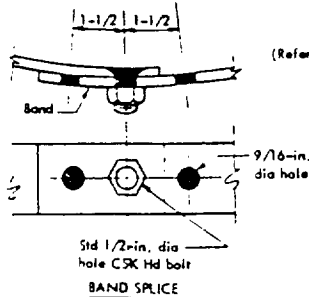
1/4 x 3/4 slotted hole where required



(Refer to Table A for dim A and I)



DETAIL B



¹ Bolted-on insulation supports are to be used only for FIELD INSTALLATIONS on vessels on which welding is either not permissible without postweld heat treatment or because of area constraints, or when welded-on insulation supports are not otherwise practicable

TABLE A		
Insulation Thickness, t_1 (in.)	Angle Thickness, t (in.)	Angle Leg A (in.)
$1 < t_1 \leq 3 1/2$	5	1 1/2
$3 1/2 < t_1 \leq 9$	4	3

NOTE:

Bolts shall be 1/2-in. dia standard machine bolts with square heads and hex nuts, unless otherwise indicated.

All steel parts shall be coated, or otherwise protected the same as the vessel to which they are attached, prior to the attachment.

Use stainless steel bands and aluminum clips on aluminum vessels

REFERENCES

Bolted on Insulation Support Angle for Inside of Skirt for Vertical Vessels

Std EQ-70

Strap-Anchor Angles for Vessels Over 15 ft O.D.

See Over

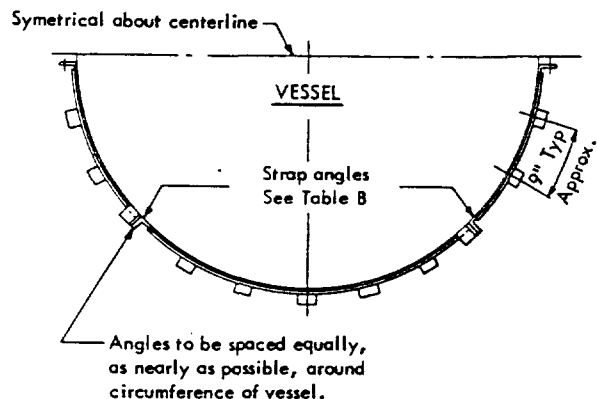
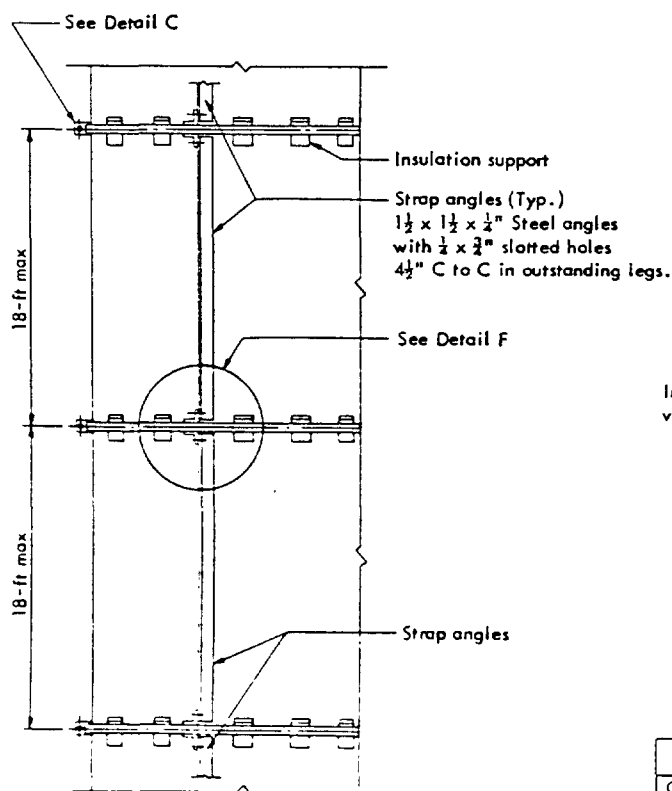
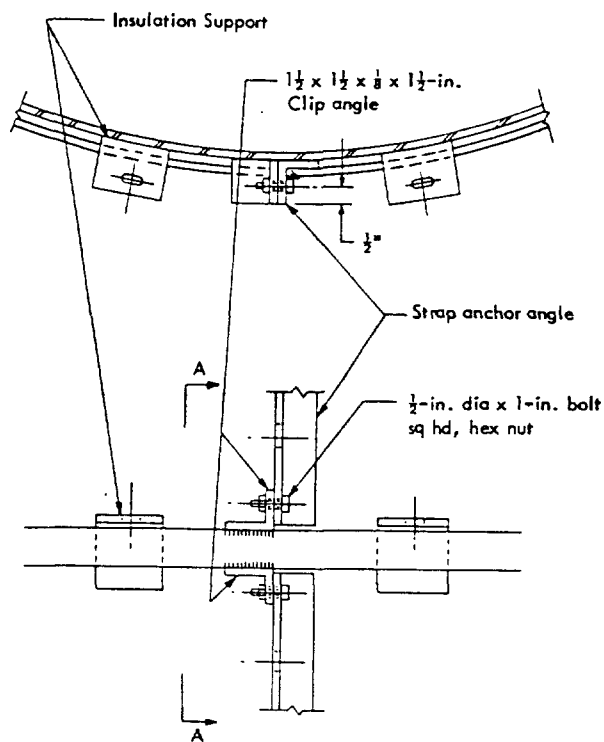
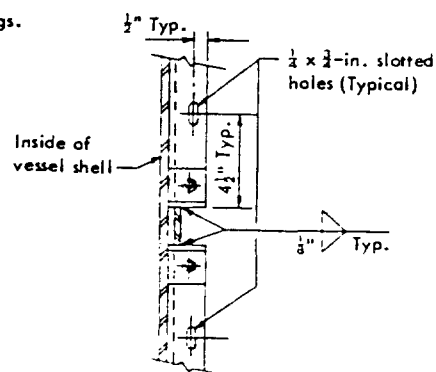
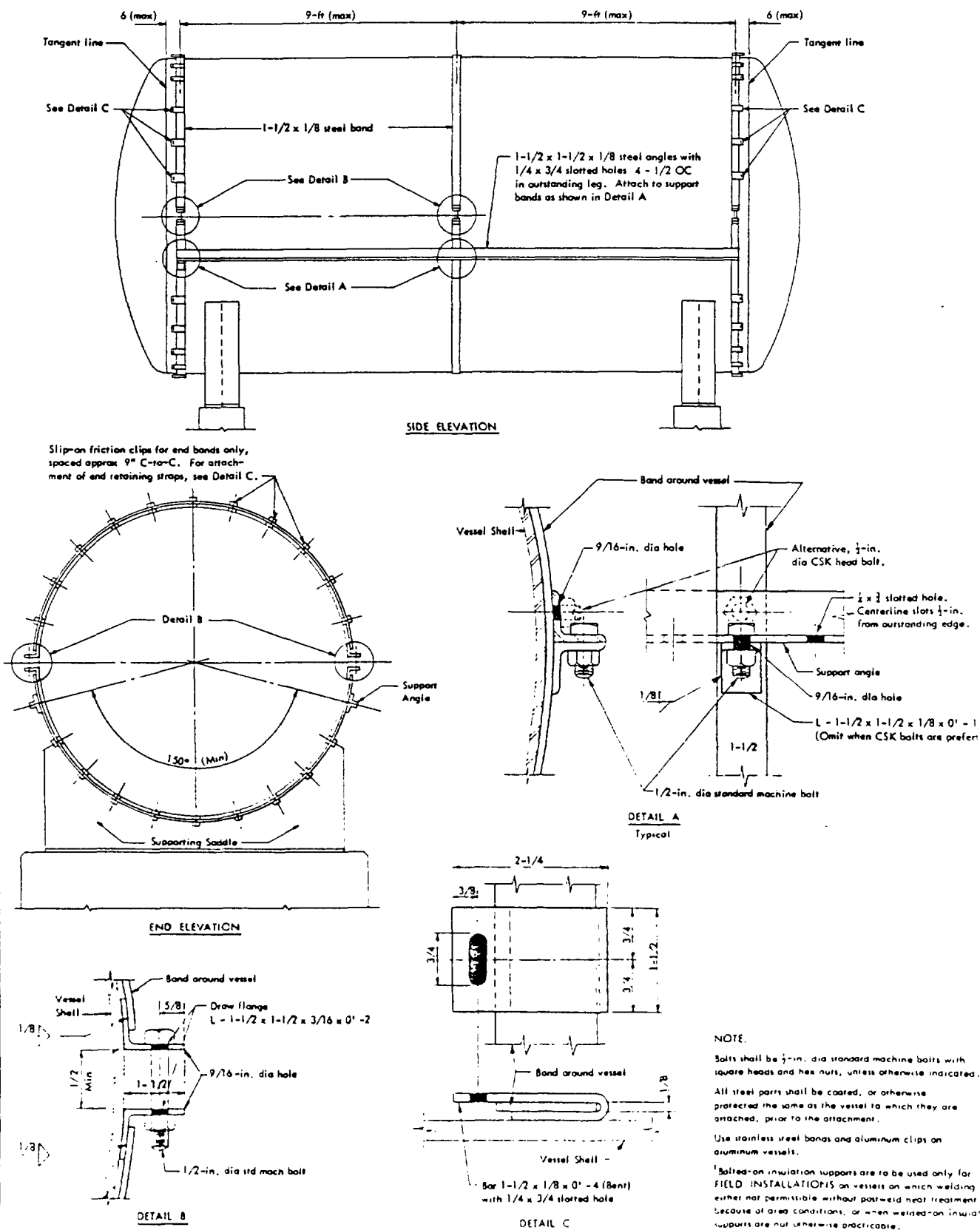
BOLTED-ON INSULATION SUPPORTS FOR VERTICAL VESSELS OVER 3-FT O.D.
STRAP-ANCHOR ANGLES FOR VESSELS OVER 15-FT O.D.

PLAN

ELEVATION

DETAIL F

SECTION A-A

TABLE 8	
Outside Diameter of Vessel	Number of Vertical Angles Required
15'-0 to 27'-0	4
27'-1 to 36'-0	8
36'-1 to 50'-0	16
Over 50'-0	One angle for each 9-ft of circumference, or fraction thereof

BOLTED-ON¹ INSULATION SUPPORTS FOR HORIZONTAL VESSELS OVER 3-FT OD

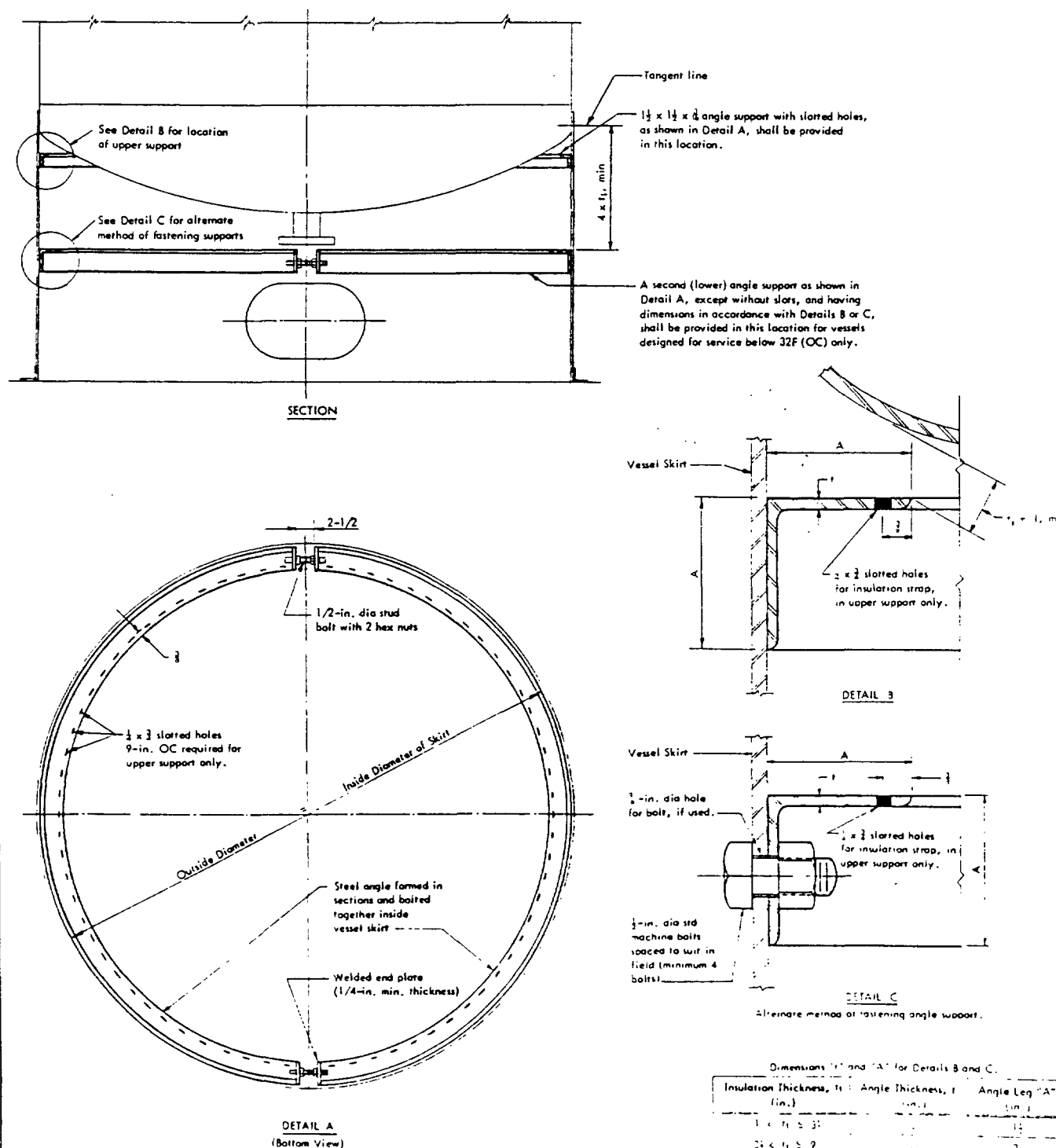
(Designed for use with preformed shapes, panel, and block form insulation)



UNLESS OTHERWISE INDICATED, ALL DIMENSIONS GIVEN IN INCHES

BOLTED-ON¹ INSULATION SUPPORT ANGLE FOR INSIDE OF SKIRT FOR VERTICAL VESSELS

(Designed for use with Preformed Shapes, Panel, and Block Form Insulation)



¹Bolted-on insulation supports are to be used only for FIELD INSTALLATIONS on vessels on which welding is either not permissible without postweld heat treatment or because of area conditions, or when welded-on insulation supports are otherwise not practicable.

NOTE:

All steel parts shall be coated, or otherwise protected the same as the vessel to which they are attached, prior to the attachment.

For aluminum angles on aluminum vessels.

REFERENCES

Specification for Insulation Supports for Vertical Vessels Over 3-in. OD

and EQ-6d

UNLESS OTHERWISE INDICATED, ALL DIMENSIONS GIVEN IN INCHES.

UNION CARBIDE CORPORATION



CHEMICALS, OLEFINS, PLASTICS
AND SILICONES DIVISIONS

CRADLE SUPPORTS FOR INSULATED PIPES

ENGINEERING
STANDARD NO.
P-82

CLASSIFICATION:
DATA

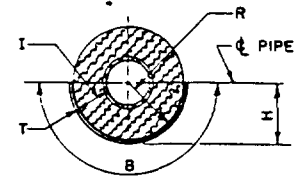
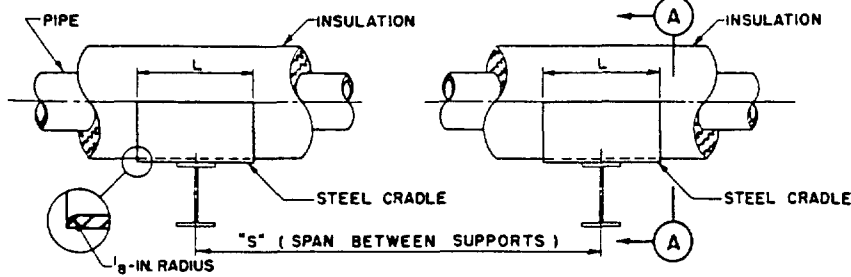
SPONSOR:
DEPT 936

REVIEWED BY
S.H. Smith, Jr.

APPROVED BY
K.S. Nelson

ISSUED (AS IS-19)
5-25-51

REVISED:
9-1-65



SECTION A-A

LEGEND:

H = DIMENSION FROM ϕ OF PIPE TO BOTTOM OF CRADLE
T = CRADLE THICKNESS
L = CRADLE LENGTH

B = PLATE WIDTH BEFORE FORMING
R = BENDING RADIUS FOR PLATE ("H" MINUS "T")
S = SPAN, IN FEET, BETWEEN SUPPORTS.

NOM PIPE SIZE	DIMEN- SIONS	"I" INSULATION THICKNESSES (NOMINAL)																		"L" CRADLE LENGTH						N P S
																				"S" SPAN						
		1	1½	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	10	10-FT	12-FT	15-FT	18-FT	20-FT	25-FT	
1½	H	1½	2	2½	3½	4	4½	5	5½	6	6½	7¼	7¾	8¼	—	—	—	—	—	10	—	—	—	—	—	
	T	14 GA ————— 8 ————— 3½6 ————— 4 —————																		10	—	—	—	—	—	
3	H	1½	2	2½	3½	4	4½	5	5½	6	6½	7¼	7¾	8¼	—	—	—	—	—	10	—	—	—	—	—	
	T	14 GA ————— 8 ————— 3½6 ————— 4 —————																		10	—	—	—	—	—	
1	H	4½	6¼	7¾	10¾	12	13½	15	17	18½	20	22	23½	25	—	—	—	—	—	10	—	—	—	—	—	
	T	14 GA ————— 8 ————— 3½6 ————— 4 —————																		10	10	—	—	—	—	
1½	H	1¾	2¼	2¾	3½	4	4½	5	5½	6	6½	7¼	7¾	8¼	—	—	—	—	—	10	10	—	—	—	—	
	T	14 GA ————— 8 ————— 3½6 ————— 4 —————																		10	10	—	—	—	—	
2	H	2¼	2¾	3½	4	4½	5	5½	6	6½	7¼	7¾	8¼	8¾	9¼	9¾	10¼	10¾	11¾	10	10	10	—	—	—	
	T	14 GA ————— 8 ————— 3½6 ————— 4 ————— 5½6 —————																		10	10	10	—	—	—	
3	H	7	8¾	10¾	12	13½	15	17	18½	20	22	23½	25	26½	28	30	31½	33	36	10	10	10	—	—	—	
	T	14 GA ————— 8 ————— 3½6 ————— 4 ————— 5½6 —————																		10	10	10	—	—	—	
4	H	3½	4	4½	5	5½	6	6½	7¼	7¾	8¼	8¾	9¼	9¾	10¼	10¾	11¼	11¾	12¾	10	10	10	12	—	—	
	T	14 GA ————— 8 ————— 3½6 ————— 4 ————— 5½6 —————																		10	10	10	12	—	—	
6	H	4½	5	5½	6	6½	7¼	7¾	8¼	8¾	9¼	9¾	10¼	10¾	11¼	11¾	12¼	12¾	13¾	10	10	12	16	16	—	
	T	14 GA ————— 8 ————— 3½6 ————— 4 ————— 5½6 ————— 3½8 —————																		10	10	12	16	16	—	
8	H	—	6	6½	7¼	7¾	8¼	8¾	9¼	9¾	10¼	10¾	11¼	11¾	12¼	12¾	13¾	13¾	14¾	10	12	16	16	20	—	
	T	————— 3½6 ————— 4 ————— 5½6 ————— 3½8 —————																		10	12	16	16	20	—	
10	H	—	7¼	7¾	8¼	8¾	9¼	9¾	10¼	10¾	11¼	11¾	12¼	12¾	13¾	13¾	14¾	14¾	15¾	12	16	20	20	24	—	
	T	————— 3½6 ————— 4 ————— 5½6 ————— 3½8 ————— 7½6 —————																		12	16	20	20	24	—	
12	H	—	8¼	8¾	9¼	9¾	10¼	10¾	11¼	11¾	12¼	12¾	13¾	13¾	14¾	14¾	15¾	15¾	16¾	12	16	20	24	24	—	
	T	————— 14 ————— 5½6 ————— 3½8 ————— 7½6 —————																		12	16	20	24	24	—	
14	H	—	8¾	9¼	9¾	10¼	10¾	11¼	11¾	12¼	12¾	13¾	13¾	14¾	14¾	15¾	15¾	16¾	17¾	16	20	24	24	30	36	
	T	————— 14 ————— 5½6 ————— 3½8 ————— 7½6 —————																		16	20	24	24	30	36	
16	H	—	9¾	10¼	10¾	11¼	11¾	12¼	12¾	13¾	13¾	14¾	14¾	15¾	15¾	16¾	16¾	17¾	18¾	16	20	24	30	36	42	
	T	————— 14 ————— 5½6 ————— 3½8 ————— 7½6 ————— 12 —————																		16	20	24	30	36	42	
18	H	—	10¾	11¼	11¾	12¼	12¾	13¾	13¾	14¾	14¾	15¾	15¾	16¾	16¾	17¾	17¾	18¾	19¾	20	24	30	36	36	42	
	T	————— 14 ————— 5½6 ————— 3½8 ————— 7½6 ————— 12 —————																		20	24	30	36	36	42	
20	H	—	11¾	12¼	12¾	13¾	13¾	14¾	14¾	15¾	15¾	16¾	16¾	17¾	17¾	18¾	18¾	19¾	20¾	24	24	30	36	42	48	
	T	————— 14 ————— 5½6 ————— 3½8 ————— 7½6 ————— 12 —————																		24	24	30	36	42	48	
24	H	—	13¾	14¼	14¾	15¾	15¾	16¾	16¾	17¾	17¾	18¾	18¾	19¾	19¾	20¾	20¾	21¾	22¾	30	30	36	42	48	54	
	T	————— 14 ————— 3½8 ————— 7½6 ————— 12 —————																		30	30	36	42	48	54	

ALL DIMENSIONS GIVEN IN INCHES

OVER

ENGINEERING STANDARD NO. P-82

NOTE:

Dimensional insulation data is taken from standard insulation tables. It should be noted that the insulation OD and ID are standardized to match the OD of standard nominal pipe sizes, and for thicknesses over 2 1/2-in., multilayer construction is used.

Cradle design is based on a maximum bearing value of 20 lb per sq in. for cellular glass, with one percent allowable deformation without damage to the insulation. Other types of insulation will tolerate greater pressures and higher percentages of deformation without loss of insulation values.

The bottom 120° arc has been established as the effective cross-sectional bearing area for insulation and supporting cradles, with the first inch of insulation next to the pipe absorbing the greatest proportion of the load pressure. Cradle material beyond the 120° arc is useful for installation and retention only.

The following equations are the results of complex formulae reduced to simplified ratios for ease of application.

$$T = .0125 D_2 \quad L = .0125 \frac{12wS}{D_2} \quad \text{or} \quad .15 \frac{wS}{D_2}$$

Where:

T = thickness of cradle in inches	w = unit wt per foot of pipe, water, and insulation, plus 10% safety factor.
L = length of cradle in inches	f = (20 lb/sq in.) bearing value for insulation
D ₁ = OD of bare pipe in inches	c = (1.5) coefficient of friction for longitudinal movement.
D ₂ = OD of insulation in inches	
S = span between supports in feet	

"T" and "L" have been adjusted to increments most suitable for practical application. "L" has been further controlled by the greater of three minimum values as follows:

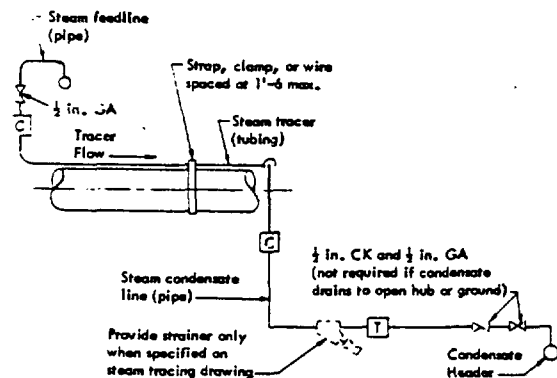
(1) ten inches (2) one pipe diameter (3) $\frac{wS}{D_1 f}$

Cradles are intended for use in straight run horizontal piping with flanges and fittings, short vertical runs less than S/2, and installations not subject to vibration.

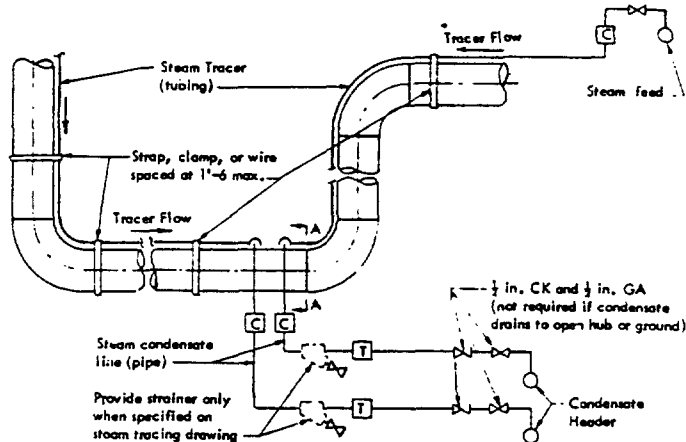
Runs including valves or long vertical portions shall be treated with special consideration.

Where severe vibration is anticipated, such as in compressor lines, the insulation between the cradle and the pipe shall be resistant to vibration.

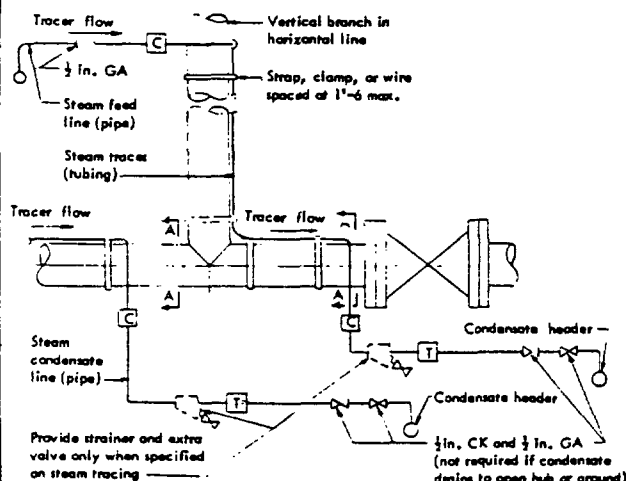
STEAM TRACING SYSTEM DETAILS AND MATERIALS



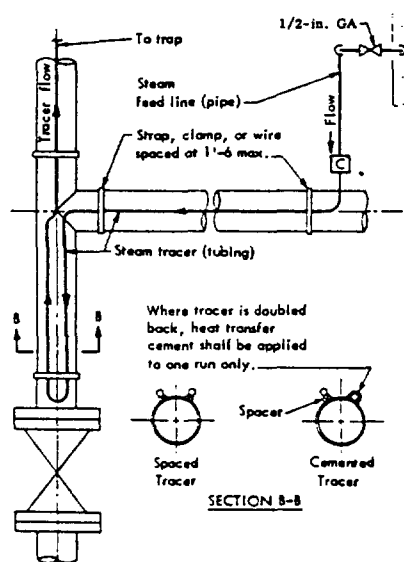
ELEVATION OF TYPICAL STRAIGHT RUN



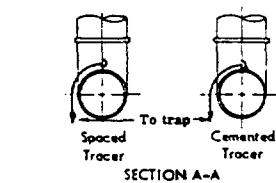
ELEVATION OF POCKET IN VERTICAL RUN



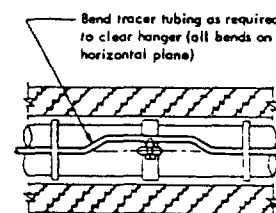
ELEVATION OF VERTICAL BRANCH IN HORIZONTAL LINE



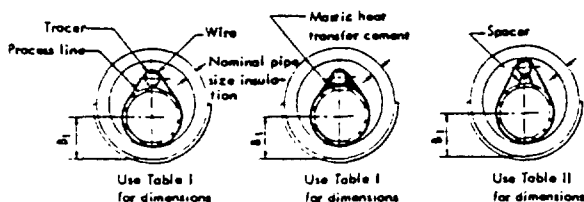
PLAN OF HORIZONTAL BRANCH IN HORIZONTAL RUN



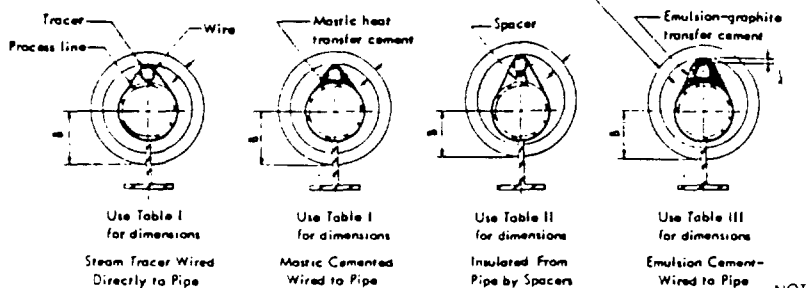
SECTION A-A



PLAN

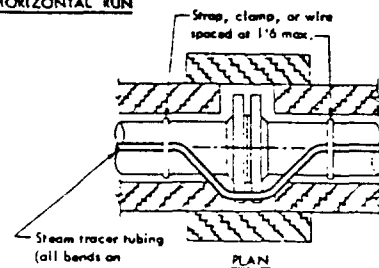


SUPPORTED ON INSULATION



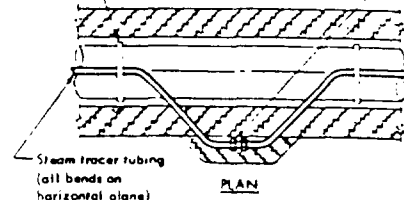
SUPPORTS ATTACHED TO PROCESS PIPE

DETAILS OF STEAM TRACER ATTACHMENT



PLAN

All fittings (unions, tees, etc) in tracers shall be brought outside of regular insulation and insulated as shown (except when reflective insulation is used).



PLAN

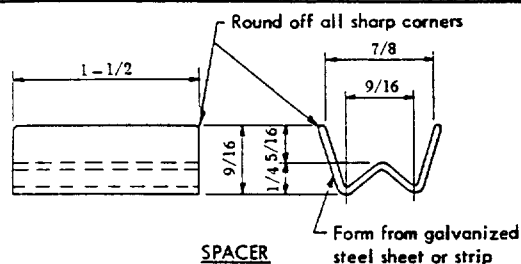
NOTE:

Refer to Std P-140A
Tables I, II and III.

NOTE:

Units containing lines with high freezing points shall be termed Special Requirement. These lines should be given special instruction by the Process engineer for Control. Details for this Control should be shown on the steam tracer design drawings.

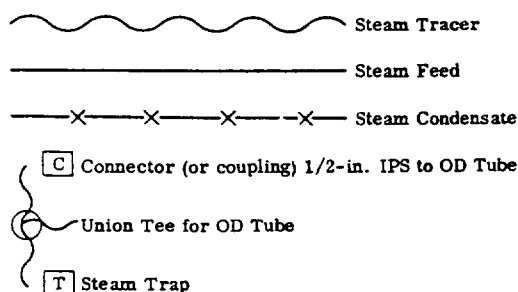
Unless otherwise indicated, all dimensions given in inches.



NOTE:

Size of tracer (3/8-in. OD or 5/8-in. OD), material of tracer (copper, stainless steel, or aluminum), and type of tracing system (spaced or cemented) shall be as specified on the steam tracing drawings. Nominal size, thickness, and specification of insulation for traced line shall be as specified in the insulation schedule. Insulation for steam supply and condensate lines that do not have line numbers shall be as specified on the steam tracing drawings.

All steam tracing is shown diagrammatically on steam tracing drawings with symbols having the following meanings:



All aluminum tubing tracers shall be insulated from system components of other materials by inserting a stainless steel connector at all points where the aluminum tubing connects to components of other materials.

Shop-fabricated piping that is to be steam traced shall be supported as shown or specified on the piping drawings. Field-fabricated piping that is to be steam traced, and for which supports are not detailed on the piping drawings, shall be supported in accordance with Standards P-77 or P-81, or as otherwise necessitated by job conditions. Lines less than 3/4-in. OD may be supported by cradles as shown on Standard P-82. Except for lines less than 3/4-in. OD, methods of support that would impose a load on the insulation or tracer shall not be used.

Steam tracer tubing shall extend beyond pipe insulation only far enough to make feed and condensate line connections. Fittings shall be used only at beginning and end of tracer, at branches, and at ends of standard lengths of tubing. Changes in direction shall be made by bending the tubing. Tracer tubing shall be installed parallel to, and along the top of the line being traced.

REFERENCES:

Steam Tracing System —	
Insulation Sizes and Assembly	
Dimensions	Std P-140A
Spaced Tracer Data	Std P-141
Cemented Tracer Data	Std P-142

*Do not use aluminum tubing at direction changes of 90 degrees or more. Where such changes occur at intervals of 20 feet or less, use stainless steel throughout. For intervals greater than 20 feet, make the direction change with stainless steel tubing, and use a stainless steel tubing union with an aluminum sleeve at each joint, installed so that aluminum connects to aluminum.

MATERIALS FOR STEAM TRACING SYSTEMS

ITEM	COPPER	STAINLESS STEEL	ALUMINUM*
Tracer Tubing	ASTM B88 Type L annealed copper tube in 60-ft coils (3/8-in. OD x .030-in. thk, or 5/8-in. OD x .040-in. thk)	ASTM A269 TP304 Stainless Steel tube for use in steam service. Flaring Test (Section 8) is required and good bending properties are necessary. (3/8-in. or 5/8-in. OD x .035-in. thk)	5050-0 Aluminum Alloy, Alcoa "Utili-tube", or approved equal. (3/8-in. OD x .035-in. thk or 5/8-in. OD x .049-in. thk)
Fittings for Tracer (Connectors, Unions, Tees, etc)	Brass, Ferrule-type with cutting edge. (Imperial "Hi-Seal", Crawford "Swagelok", or approved equal.)	AISI Type 316 Stainless Steel, Ferrule-type with cutting edge. (Imperial "Hi-Seal", Crawford "Swagelok", Parker "Ferrulok", or approved equal)	Ferrule-type with cutting edge (Imperial "Hi-Seal", Crawford "Swagelok", Parker "Ferrulok", or approved equal). Connectors (IPS to OD) shall be AISI Type 316 stainless steel, all other fittings shall be aluminum alloy.
Spacers	Per this Standard	Per this Standard	Per this Standard
Straps	1/2-in. wide x .020-in. thk soft annealed stainless steel (any 18-8 type) straps with double pronged clips.		1/2-in. wide x .034-in. thk aluminum alloy straps with double pronged clips.
Wire	18 gage (.047-in. dia) annealed temper (bright annealed, or annealed and pickled) stainless steel (any 18-8 type) wire.		16 gage (.0508-in. dia) aluminum alloy wire.
Steam Traps	Size, manufacturer and model number as specified on steam tracing drawings.		
Steam Supply Header and Feed Lines, and Steam Condensate Lines	Valve and Piping Specification as called for on steam tracing drawings.		
Heat Transfer Cement	Standard Thermon, manufactured by Thermon Manufacturing Company, Houston, Texas, or approved equal.		

STANDARD

UNION CARBIDE CHEMICALS, OLEFINS, PLASTICS,
SILICONES DIVISIONS AND
UNION CARBIDE CANADA

P-14C
PIPING - DA
6-1-

INSULATION SIZES FOR HEAT TRACED SYSTEMS

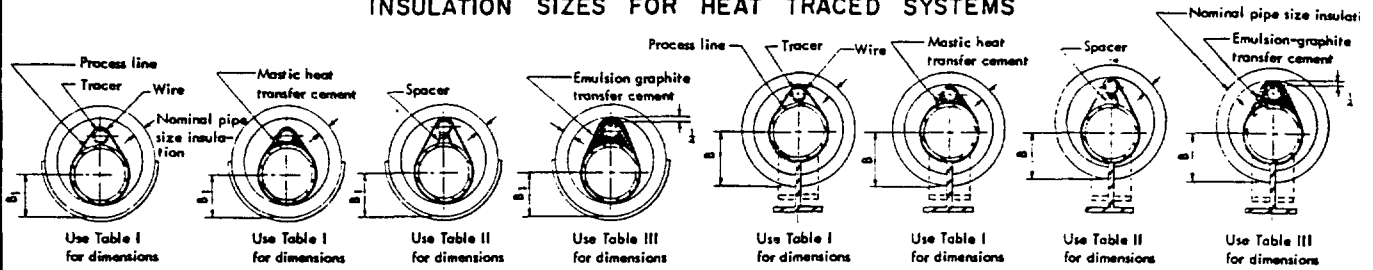


TABLE I — WITHOUT SPACERS

Supported on Insulation

PROCESS LINE SIZE	TRACER SIZE OD	NOMINAL PIPE SIZE INSULATION	DIMENSION B ₁ FOR NOMINAL INSULATION THICKNESS				
			1	1 1/2	2	2 1/2	3
1/2	1/2	1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
1/2 OD	1/2	1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
1	1	1	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
1 OD	1	1	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2

TABLE II — WITH SPACERS

Supported on Insulation

PROCESS LINE SIZE	TRACER SIZE OD	NOMINAL PIPE SIZE INSULATION	DIMENSION B ₁ FOR NOMINAL INSULATION THICKNESS				
			1	1 1/2	2	2 1/2	3
1/2	1/2	1	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
1/2 OD	1/2	1	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
1	1	1 1/2	2 1/2	2 1/2	3 1/2	4 1/2	4 1/2
1 OD	1	1 1/2	2 1/2	2 1/2	3 1/2	4 1/2	4 1/2

TABLE III — WITHOUT SPACERS
EMULSION-GRAPHITE HEAT TRANSFER CEMENT
Supported on Insulation

PROCESS LINE SIZE	TRACER SIZE OD	NOMINAL PIPE SIZE INSULATION	DIMENSION B ₁ FOR NOMINAL INSULATION THICKNESS				
			1	1 1/2	2	2 1/2	3
1/2	1/2	1	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
1/2 OD	1/2	1	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
1	1	1 1/2	2 1/2	2 1/2	3 1/2	4 1/2	4 1/2
1 OD	1	1 1/2	2 1/2	2 1/2	3 1/2	4 1/2	4 1/2

Supports Attached to Process Pipe

PROCESS LINE SIZE	TRACER SIZE OD	NOMINAL PIPE SIZE INSULA- TION	DIMENSION B FOR NOMINAL INSULATION THICKNESS				
			1	1 1/2	2	2 1/2	3
1/2	1/2	1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
1/2 OD	1/2	1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
1	1	1	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
1 OD	1	1	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
1 1/2 OD	1 1/2	1 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
2	2	2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
2 OD	2	2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
2 1/2	2 1/2	2 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
2 1/2 OD	2 1/2	2 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
3	3	3	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
3 OD	3	3	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
3 1/2	3 1/2	3 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
3 1/2 OD	3 1/2	3 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
4	4	4	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
4 OD	4	4	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
4 1/2	4 1/2	4 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
4 1/2 OD	4 1/2	4 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
5	5	5	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
5 OD	5	5	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
5 1/2	5 1/2	5 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
5 1/2 OD	5 1/2	5 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
6	6	6	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
6 OD	6	6	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
6 1/2	6 1/2	6 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
6 1/2 OD	6 1/2	6 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
7	7	7	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
7 OD	7	7	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
7 1/2	7 1/2	7 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
7 1/2 OD	7 1/2	7 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
8	8	8	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
8 OD	8	8	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
8 1/2	8 1/2	8 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
8 1/2 OD	8 1/2	8 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
9	9	9	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
9 OD	9	9	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
9 1/2	9 1/2	9 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
9 1/2 OD	9 1/2	9 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
10	10	10	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
10 OD	10	10	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
10 1/2	10 1/2	10 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
10 1/2 OD	10 1/2	10 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
11	11	11	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
11 OD	11	11	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
11 1/2	11 1/2	11 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
11 1/2 OD	11 1/2	11 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
12	12	12	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
12 OD	12	12	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
12 1/2	12 1/2	12 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
12 1/2 OD	12 1/2	12 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
13	13	13	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
13 OD	13	13	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
13 1/2	13 1/2	13 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
13 1/2 OD	13 1/2	13 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
14	14	14	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
14 OD	14	14	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
14 1/2	14 1/2	14 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
14 1/2 OD	14 1/2	14 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
15	15	15	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
15 OD	15	15	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
15 1/2	15 1/2	15 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
15 1/2 OD	15 1/2	15 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
16	16	16	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
16 OD	16	16	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
16 1/2	16 1/2	16 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
16 1/2 OD	16 1/2	16 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
17	17	17	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
17 OD	17	17	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
17 1/2	17 1/2	17 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
17 1/2 OD	17 1/2	17 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
18	18	18	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
18 OD	18	18	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
18 1/2	18 1/2	18 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
18 1/2 OD	18 1/2	18 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
19	19	19	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
19 OD	19	19	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
19 1/2	19 1/2	19 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
19 1/2 OD	19 1/2	19 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
20	20	20	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
20 OD	20	20	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
20 1/2	20 1/2	20 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
20 1/2 OD	20 1/2	20 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
21	21	21	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
21 OD	21	21	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
21 1/2	21 1/2	21 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
21 1/2 OD	21 1/2	21 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
22	22	22	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
22 OD	22	22	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
22 1/2	22 1/2	22 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
22 1/2 OD	22 1/2	22 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
23	23	23	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
23 OD	23	23	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
23 1/2	23 1/2	23 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
23 1/2 OD	23 1/2	23 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
24	24	24	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
24 OD	24	24	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
24 1/2	24 1/2	24 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
24 1/2 OD	24 1/2	24 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
25	25	25	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
25 OD	25	25	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
25 1/2	25 1/2	25 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
25 1/2 OD	25 1/2	25 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
26	26	26	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
26 OD	26	26	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
26 1/2	26 1/2	26 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
26 1/2 OD	26 1/2	26 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
27	27	27	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
27 OD	27	27	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
27 1/2	27 1/2	27 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
27 1/2 OD	27 1/2	27 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
28	28	28	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
28 OD	28	28	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
28 1/2	28 1/2	28 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
28 1/2 OD	28 1/2	28 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
29	29	29	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
29 OD	29	29	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
29 1/2	29 1/2	29 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
29 1/2 OD	29 1/2	29 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
30	30	30	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
30 OD	30	30	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
30 1/2	30 1/2	30 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
30 1/2 OD	30 1/2	30 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
31	31	31	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
31 OD	31	31	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
31 1/2	31 1/2	31 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
31 1/2 OD	31 1/2	31 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
32	32	32	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
32 OD	32	32	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
32 1/2	32 1/2	32 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
32 1/2 OD	32 1/2	32 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
33	33	33	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
33 OD	33	33	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
33 1/2	33 1/2	33 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
33 1/2 OD	33 1/2	33 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
34	34	34	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
34 OD	34	34	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
34 1/2	34 1/2	34 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
34 1/2 OD	34 1/2	34 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
35	35	35	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
35 OD	35	35	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
35 1/2	35 1/2	35 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
35 1/2 OD	35 1/2	35 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
36	36	36	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
36 OD	36	36	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
36 1/2	36 1/2	36 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
36 1/2 OD	36 1/2	36 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
37	37	37	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
37 OD	37	37	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
37 1/2	37 1/2	37 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
37 1/2 OD	37 1/2	37 1/2	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
38	38	38	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2
38 OD	38	38	1 1/2	1 1/2	2 1/2	3 1/2	3 1/2

TABLE III - WITHOUT SPACERS
EMULSION-GRAPHITE HEAT TRANSFER CEMENT - contd

PROCESS LINE SIZE	TRACER SIZE OD	NOMINAL PIPE SIZE INSULA- TION	DIMENSION B FOR NOMINAL INSULATION THICKNESS				
			1	1	2	2	3
4	$\frac{1}{2}$ $\frac{1}{2}$	5 5	$3\frac{1}{2}$ $4\frac{1}{2}$	$4\frac{1}{2}$ $4\frac{1}{2}$	$4\frac{1}{2}$ $4\frac{1}{2}$	$5\frac{1}{2}$ 5	$5\frac{1}{2}$ $5\frac{1}{2}$
5 OD	$\frac{1}{2}$ $\frac{1}{2}$	6 6	$4\frac{1}{2}$ $4\frac{1}{2}$	$4\frac{1}{2}$ $4\frac{1}{2}$	$5\frac{1}{2}$ $5\frac{1}{2}$	6 $5\frac{1}{2}$	$6\frac{1}{2}$ $6\frac{1}{2}$
6 OD	$\frac{1}{2}$ $\frac{1}{2}$	7 7		$5\frac{1}{2}$ $5\frac{1}{2}$	$5\frac{1}{2}$ $5\frac{1}{2}$	$6\frac{1}{2}$ $6\frac{1}{2}$	7 $6\frac{1}{2}$
6	$\frac{1}{2}$ $\frac{1}{2}$	7 7		$5\frac{1}{2}$ 5	$5\frac{1}{2}$ $5\frac{1}{2}$	$6\frac{1}{2}$ 6	$6\frac{1}{2}$ $6\frac{1}{2}$
8 OD	$\frac{1}{2}$ $\frac{1}{2}$	9 9		$6\frac{1}{2}$ $6\frac{1}{2}$	7 $6\frac{1}{2}$	$7\frac{1}{2}$ $7\frac{1}{2}$	$8\frac{1}{2}$ $7\frac{1}{2}$
8	$\frac{1}{2}$ $\frac{1}{2}$	9 9		$6\frac{1}{2}$ 6	$6\frac{1}{2}$ $6\frac{1}{2}$	$7\frac{1}{2}$ $7\frac{1}{2}$	$7\frac{1}{2}$ $7\frac{1}{2}$
10 OD	$\frac{1}{2}$ $\frac{1}{2}$	11 11		$7\frac{1}{2}$ $7\frac{1}{2}$	$8\frac{1}{2}$ 8	$8\frac{1}{2}$ $8\frac{1}{2}$	$9\frac{1}{2}$ 9
10	$\frac{1}{2}$ $\frac{1}{2}$	11 11		$7\frac{1}{2}$ $7\frac{1}{2}$	$7\frac{1}{2}$ $7\frac{1}{2}$	$8\frac{1}{2}$ $8\frac{1}{2}$	$8\frac{1}{2}$ $8\frac{1}{2}$
12 OD	$\frac{1}{2}$ $\frac{1}{2}$	14 14		$8\frac{1}{2}$ $8\frac{1}{2}$	$9\frac{1}{2}$ $9\frac{1}{2}$	$9\frac{1}{2}$ $9\frac{1}{2}$	$10\frac{1}{2}$ $10\frac{1}{2}$
12	$\frac{1}{2}$ $\frac{1}{2}$	14 14		$8\frac{1}{2}$ $8\frac{1}{2}$	9 $8\frac{1}{2}$	$9\frac{1}{2}$ $9\frac{1}{2}$	10 $9\frac{1}{2}$
14	$\frac{1}{2}$ $\frac{1}{2}$	15 15		$8\frac{1}{2}$ $8\frac{1}{2}$	$9\frac{1}{2}$ $9\frac{1}{2}$	$9\frac{1}{2}$ $9\frac{1}{2}$	$10\frac{1}{2}$ $10\frac{1}{2}$
16	$\frac{1}{2}$ $\frac{1}{2}$	17 17		$9\frac{1}{2}$ $9\frac{1}{2}$	$10\frac{1}{2}$ $10\frac{1}{2}$	$10\frac{1}{2}$ $10\frac{1}{2}$	$11\frac{1}{2}$ $11\frac{1}{2}$
18	$\frac{1}{2}$ $\frac{1}{2}$	19 19		$10\frac{1}{2}$ $10\frac{1}{2}$	$11\frac{1}{2}$ $11\frac{1}{2}$	$11\frac{1}{2}$ $11\frac{1}{2}$	$12\frac{1}{2}$ $12\frac{1}{2}$
20	$\frac{1}{2}$ $\frac{1}{2}$	21 21		$11\frac{1}{2}$ $11\frac{1}{2}$	$12\frac{1}{2}$ $12\frac{1}{2}$	$12\frac{1}{2}$ $12\frac{1}{2}$	$13\frac{1}{2}$ $13\frac{1}{2}$
24	$\frac{1}{2}$ $\frac{1}{2}$	25 25		$13\frac{1}{2}$ $13\frac{1}{2}$	$14\frac{1}{2}$ $14\frac{1}{2}$	$14\frac{1}{2}$ $14\frac{1}{2}$	$15\frac{1}{2}$ $15\frac{1}{2}$

¹Use Type 1 mortar Cement by Thermon Mfg. Co., Houston 19, Texas, or approved equal.

STANDARD SPECIFICATIONS



CHEMICALS, OLEFINS, PLASTICS,
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THERMAL INSULATION MATERIAL SPECIFICATIONS

SCOPE

These specifications describe the essential requirements for the purchase of thermal insulation, including block, pipe covering, preformed shapes, and accessory materials.

Materials and accessories as listed in individual specifications shall be of quality, type, or identification as called for in these Material Specification

I. MATERIAL - GENERAL

A. Types and Dimensions

1. Material furnished under these specifications shall be of type and thickness listed on Insulation Design Schedules, Insulation Equipm and/or Line Lists, or as otherwise prescribed by the Purchaser.

2. Pipe insulation shall be furnished in conventional lengths, plus or minus not more than 3/32 inch, with ends cut square. Inside diam shall fit firmly on specified pipe size and outside diameter shall correspond to a Nominal Pipe Size, with the exception of Specification No. 14, Preformed Flexible Plastic Foam.

B. Sampling for Testing. Where vendor is unable to provide acceptable test or performance data, to meet the requirements of these specifications, representative samples of insulating and accessory materials shall be submitted to the Purchaser in sizes and amounts required for testing. In all instances these samples, which shall be supplied without cost to Purchaser, shall be shipped by Vendor within seven days following receipt of written request.

C. Packaging. Unless otherwise agreed, material shall be packed in substantial containers, so constructed as to ensure safe delivery of material by common and other approved carrier in a condition satisfactory to the Purchaser.

D. Marking and Identification. Unless otherwise specified, shipping containers shall be legibly marked with name of material, size, type, quantity contained therein; name of Insulation Contractor, if any, and purchase order number under which shipment is made. In addition, where required, container shall bear the work order number, the Item or Line Number for which material is intended, and its relative position and section of application.

E. Attachments

1. Standard lacquered or brass bands, customarily furnished by the manufacturer of pipe insulation, will not be required.

2. Canvas or other factory-applied surfacing, where required with insulating material, shall be as called for on bills of material or purchase requisitions.

F. Approved Equals. Other insulating and/or accessory materials may be approved by the Purchaser, but only where clearly shown that properties involved conform to these specifications.

II. PROPERTIES

A. Properties of insulation shall be in accordance with the applicable standard ASTM Test Methods, latest revision.

B. Test values for a given insulating material shall be in accordance with limits called for in properties listed for that material within these specifications.

C. ASTM Test Methods for the following properties are:

Breaking Load - Calculated Flexural Strength - Block Insulation	C 203
Breaking Load - Calculated Flexural Strength - Pipe Insulation	C 446
Compressive Strength	C 165
Deflection Strength	C 209 - 14 through 16
Density - Block Insulation	C 303
Density - Pipe Insulation	C 302
Density - Blanket Insulation	C 167
Fire Resistance - Combustibility	E 136
Fire Resistance - Flammability of Plastic Foams and Sheeting	D 1692
Fire Resistance - Flame Spread	C 209 - Part 32
Hardness	C 569
Hot Surface Performance	C 411
Maximum Use Temperature	C 447
Resistance to Abrasion	C 421
Resistance to Dropping	C 487
Shrinkage after Heat Soaking	C 356
Specific Heat	C 351
Tensile Strength	C 209 - 18 through 24; C 446
Thermal Conductivity (Depending on Material and Temperature)	C 177, C 335, C 420, or C 518
Water Absorption	C 209 - 25 through 28
Water Vapor Transmission	C 355



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CHEMICALS AND PLASTICS OPERATIONS DIVISION
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III. DIMENSIONS OF CURVED SEGMENTS, LAGGING, AND PIPE INSULATION

A. Dimensions of NPS pipe insulation shall be in accordance with ASTM C 312 and C 521, latest revisions.

B. Unless otherwise specified, curved side wall segments of insulation for hot equipment, and pipe insulation, with the exception of cellular glass, shall be installed in single layer up to and including 3-inch thickness. Thickness $3\frac{1}{2}$ -inch and greater shall be in layers as shown below.

Total Scheduled Nominal Thickness, Inches	Inner Layer Nominal Thickness, Inches	Middle Layer Nominal Thickness, Inches	Outer Layer Nominal Thickness, Inches
3-1/2	1-1/2	None	2
4	2	None	2
4-1/2	2	None	2-1/2
5	2-1/2	None	2-1/2
5-1/2	2-1/2	None	3
6	3	None	3
6-1/2	2	2	2-1/2
7	2	2-1/2	2-1/2
7-1/2	2-1/2	2-1/2	2-1/2
8	2-1/2	2-1/2	3
8-1/2	2-1/2	3	3
9	3	3	3

C. On cylindrical side walls of hot vessels up to 12 ft 0 in. OD, and for all multiple layer applications, insulation shall be molded or pre-formed curved side wall segments in accordance with ASTM Recommended Practice C 450, latest revision.

D. On cylindrical side walls of block insulated hot vessels over 12 ft 0 in. OD single layer insulation up to 3-inch thickness shall be mitered lagging in accordance with ASTM Recommended Practice C 450, latest revision.

E. Unless otherwise specified, cellular glass insulation on low temperature equipment and piping and all other applications shall be installed in single layer up to and including 2-1/2-inch thickness. Insulation in excess of 2-1/2 inches total thickness shall be applied in multi-layer construction in accordance with the following table.

Total Scheduled Thickness, Inches	Inner Layer Thickness, Inches	Outer Layer Thickness, Inches
3	1-1/2	1-1/2
3-1/2	1-1/2	2
4	2	2
4-1/2	2	2-1/2
5	2-1/2	2-1/2
5-1/2	2-1/2	3
6	3	3
6-1/2	3	3-1/2
7	3-1/2	3-1/2
7-1/2	3-1/2	4
8	4	4
8-1/2	4	4-1/2
9	4-1/2	4-1/2

IV. CONDITION OF MATERIAL

Insulating materials, other than cements and mastics, shall be dry when applied.

V. PREFORMED VALVE, FITTING, AND FLANGE COVERS

A. All fittings, such as valve, flange, ell and tee covers, and shapes such as curved segments and head covers specified to be molded, shaped, or fabricated shall have dimensions in accordance with ASTM Recommended Practice C 450, latest revision.

B. Parts of such fittings shall fit tightly together and shall be cemented together with fabrication cement as called for in individual specifications and as designated in these specifications.

VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS

Individual insulation materials, as identified by Specification Numbers, shall be of composition and shall have properties as listed.

STANDARD SPECIFICATIONS



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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS - contd.

SPECIFICATION NO. 10: CELLULAR GLASS INSULATION

Composition

Material shall be composed of glass, completely inorganic, processed and cellulated at temperatures sufficient to produce a rigid, cellular thermal insulation.

Properties

Alkalinity

pH shall be between 6.9 and 7.5.

Capillarity

After 7 days on wet surface, gain in weight shall be 0%.

Coefficient of Expansion

Shall average 4.6×10^{-6} per degree F.

Combustibility

Shall be incombustible.

Compressive Strength

Shall be not less than 100 psi.

Density

Shall be not less than 8 lb per cu ft, nor more than 11 lb per cu ft.

Flexural Strength

Shall be not less than 75 psi.

Hygroscopicity

Two-inch cubes dried at 220 F to constant weight, then exposed to air at 70 F and 90% relative humidity for 14 days, shall not gain any weight.

Maximum Use Temperature

Maximum temperature without mechanical, thermal, or chemical failure shall be not less than 800 F.

Resistance to Acids

Shall be impervious to common acids and fumes except hydrofluoric and hot phosphoric.

Shear Strength

Shall be not less than 40 psi.

Specific Heat

Shall average 0.20 Btu per lb per degree F.

Tensile Strength

Shall be not less than 40 psi.

Thermal Conductivity

The thermal conductivity at the given mean temperatures shall not exceed the following values:

Mean Temp, °F	Btu/inch, hr, sq ft, °F
0	0.36
100	0.42
200	0.48
300	0.56
400	0.63
600	0.74

Thermal Diffusivity at 75 F

Shall average 0.42 sq ft per day.

Water Absorption

After 24-hour submersion, shall not exceed 0.2% by volume (surface only).

Water Vapor Transmission

Shall have a WVT of zero grains per sq ft per hour.

Do not feel that this is necessary

STANDARD SPECIFICATIONS



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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS - contd

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS - contd

SPECIFICATION NO. 12: RIGID URETHANE FOAM

Composition

Material shall be composed of polyurethane foamed into a closed cell rigid thermal insulation.

Properties

Closed Cell Content Shall be not less than 90%, as determined on sample 2" x 2" x 2" in accordance with ASTM D 1940.

Coefficient of Expansion Shall not exceed the following:

Temperature Range, ° F	Coefficient of Expansion, per ° F
75 to 200	8.0×10^{-5}
When tested in accordance with ASTM D 696.	

Combustibility Shall not have burning extent over 2 inches when tested in accordance with ASTM D 1692.

Compressive Strength Shall be not less than 15 psi at yield point in any direction when tested in accordance with ASTM D 1621.

Density Shall be not less than 2.1 lb per cu ft, nor more than 4.5 lb per cu ft when tested in accordance with ASTM D 1622.

Flexural Strength Shall be not less than 20 psi in any direction in accordance with ASTM D 790.

Maximum Use Temperature Maximum temperature without mechanical, thermal, or chemical failure shall be not less than 200 F.

Resistance to Acids, Caustics and Solvents Shall be resistant to common hydrocarbon solvents, mild acids and caustics provided that they do not exceed 10% concentrations. (Not resistant to ketones)

Shear Strength Shall be not less than 20 psi in any direction when tested in accordance with ASTM C 273.

Specific Heat Shall average 0.25 Btu per lb per degree F.

Thermal Conductivity The thermal conductivity at the given mean temperatures shall not exceed the following values: (Sample to be aged at 70 F for 30 days before test)

Mean Temp, ° F	Btu/inch, hr, sq ft, ° F
0	0.16
100	0.17

Thermal Shock Resistance Shall not spall, chip, crack, or otherwise fail when heated to 200 F and then quenched with water.

Water Absorption After 24-hour submersion, increase in weight shall not exceed 0.15 lb per sq ft of exposed surface.

Water Vapor Transmission Shall have water vapor transmission of less than 3.5 perm inches when tested by wet cup method (ASTM C 355).

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS - contd

SPECIFICATION NO. 14: PREFORMED FLEXIBLE PLASTIC FOAM

Composition

Material shall be preformed flexible foamed plastic, having a closed cell structure.

Properties

Alkalinity pH shall be 5 to 9.

Combustibility. Shall be self-extinguishing.

Density Shall be not less than 5 nor more than 8 lb per cu ft.

Maximum Use Temperature Shall not fail mechanically, thermally or chemically when subjected to continuous temperature of 180 F (sheet insulation) or 200 F (pipe insulation).

Resistance to Acids Shall have good resistance to most common acids.

Resistance to Caustics Shall have good resistance to most common caustics.

Specific Heat Shall average 0.42 Btu per lb per degree F.

Thermal Conductivity The thermal conductivity at the given mean temperatures shall not exceed the following values:

Mean Temp, °F	Btu/inch, hr, sq ft, °F
75	0.26
120	0.27

Water Absorption (by immersion) Shall not exceed 2.5% gain, by volume.

Water Vapor Transmission. Shall not exceed 0.15 perm, inch, by wet cup test.

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS - contd

SPECIFICATION NO. 15: PREFORMED FIBROUS GLASS - HIGH DENSITY (Over 10 lb per cu ft)

Composition

Material shall be composed of fibrous glass molded into pipe and block insulation with an inorganic non-punking binder. Insulation for low temperature service up to and including 1-1/2-inch thickness for 6-inch NPS and smaller pipe, and 2-inch thickness for 4-inch NPS and smaller pipe, shall have factory applied fire-retardant vapor-barrier jackets consisting of aluminum foil laminated with a special embossed white kraft paper reinforced with glass fiber yarn for puncture resistance, and having self-sealing longitudinal lap joints with a self-extinguishing pressure-sensitive adhesive protected by release paper.

Properties

Alkalinity pH shall be 8.

Capillarity After 7 days on wet surface, gain in weight shall be 0%.

Compressive Strength 7.38 psi at 10% deformation.

Density:

Pipe Shall be not less than 10 nor more than 13 lb per cu ft.

Block Shall be not less than 10 nor more than 11 lb per cu ft.

Dimensional Stability Linear shrinkage after heating for 24 hours at 1,000 F: 1.67%.

Hygroscopicity When exposed to air at 120 F and 95% relative humidity for 96 hours, shall be less than 0.2% by volume.

Maximum Use Temperature Shall be suitable for use from minus 120 F to plus 1,000 F without mechanical, thermal, or chemical failure.

Resistance to Acids Good, except to hydrofluoric and phosphoric.

Resistance to Alkalies Poor.

Specific Gravity Shall average 2.6 true, 0.17 apparent.

Specific Heat Shall average 0.20 Btu per lb per degree F.

Thermal Conductivity The thermal conductivity at the given mean temperatures shall not exceed the following values:

Mean Temp, °F	Btu/inch, hr sq ft, °F
0	0.28
70	0.29
100	0.31
200	0.35
300	0.39
400	0.44
500	0.47

Thermal Diffusivity at 75 F 0.4 sq ft per day.

Water Absorption (by immersion) 2.22%.

Sizes Available:

Pipe Dimensional standard sizes, 1-inch, 1-1/2-inch, and 2-inch thick up to 12-inch NPS in sectional form and 33-inch NPS in segmental form.

Block 1-inch, 1-1/2-inch, and 2-inch thick by 24 inches by 48 inches.

Water Vapor Transmission (through jacket) Shall not exceed 0.01 perm.

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS - contd

SPECIFICATION NO. 16: PREFORMED FIBROUS GLASS - LOW DENSITY (3 to 5 lb per cu ft)

Composition

Material shall be composed of fibrous glass molded into pipe insulation with a modified phenolic type binder. Insulation up to and including 1-1/2-inch thickness for 14-inch OD and smaller pipe, and 2-inch thickness for insulation sizes up to but not including 11-inch NPS, shall have factory-applied, fire-retardant vapor-barrier jackets consisting of aluminum foil laminated with a special embossed white kraft paper reinforced with glass fiber yarn for puncture resistance, and having self-sealing longitudinal lap joints with a self-extinguishing pressure-sensitive adhesive protected by release paper.

Properties

Alkalinity	pH shall be between 7 and 10.												
Capillarity	After 7 days on wet surface, gain in weight shall be 0%.												
Density	Shall be greater than 3 and less than 5 lb per cu ft.												
Hygroscopicity	When exposed to air at 120 F and 95% relative humidity for 96 hours, shall be less than 0.2% by volume.												
Loss on Ignition	Shall be between 8 and 19% by weight.												
Maximum Use Temperature	Shall be suitable for use from minus 120 F to plus 375 F without mechanical, thermal, or chemical failure.												
Thermal Conductivity	The thermal conductivity at the given mean temperatures shall not exceed the following values:												
	<table> <tr> <th>Mean Temp, °F</th><th>Btu/inch, hr, sq ft, °F</th></tr> <tr> <td>0</td><td>0.20</td></tr> <tr> <td>50</td><td>0.22</td></tr> <tr> <td>75</td><td>0.23</td></tr> <tr> <td>100</td><td>0.24</td></tr> <tr> <td>200</td><td>0.31</td></tr> </table>	Mean Temp, °F	Btu/inch, hr, sq ft, °F	0	0.20	50	0.22	75	0.23	100	0.24	200	0.31
Mean Temp, °F	Btu/inch, hr, sq ft, °F												
0	0.20												
50	0.22												
75	0.23												
100	0.24												
200	0.31												
Thermal Diffusivity at 75 F	0.46 sq ft per day (5 lb) 0.77 sq ft per day (3 lb)												
Water Absorption (by immersion)	Percentage of volume is very high, due to open fibrous structure, but does not retain if water can run out.												

STANDARD SPECIFICATIONS



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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS - contd

SPECIFICATION NO. 17-RX: PREFORMED FIBROUS GLASS VAPOR SEAL RIGID-FACED INSULATION - for use on the exterior surfaces of heating, ventilating, and air conditioning ducts.

Composition

Material shall be composed of fibrous glass with a modified phenolic resin binder, formed into a rigid board and faced with a factory-applied vapor barrier of 0.0025-inch aluminum foil, having and Underwriters' Laboratory label with Flame Spread 15 to 20, Smoke Developed 0 to 10.

Properties

Alkalinity pH shall be between 7 and 10.

Capillarity After 7 days on wet surface, gain in weight shall be 0%.

Density (average of 10 samples) Shall be not less than 5.0 nor more than 9.0 lb per cu ft.

Hygroscopicity When oven-dried to constant weight, then exposed to air at 70 F and 90% relative humidity for 14 days, gain in weight shall be less than 2%.

Resistance to Abrasion Weight loss shall be less than the following:
After first 10-minute run: 35%
After second 10-minute run: 55%

Thermal Diffusivity at 75 F Shall average not more than 0.77 sq ft per day.

Water Absorption (by immersion) Percentage of volume is very high due to open fibrous structure, but does not retain if water can run out.

SPECIFICATION NO. 17-RY: PREFORMED FIBROUS GLASS COATED RIGID INSULATION - for use on the interior surfaces of heating, ventilating, and air conditioning ducts.

Composition

Material shall be composed of fibrous glass with a modified phenolic resin binder, formed into a rigid board, and coated on one side with neoprene compound.

Properties

Alkalinity pH shall be between 7 and 10.

Capillarity After 7 days on wet surface, gain in weight shall be 0%.

Density (average of 10 samples) Shall be not less than 6.0 nor more than 6.5 lb per cu ft.

Maximum Use Temperature Shall be suitable for use from minus 120 F to plus 250 F without mechanical, thermal, or chemical failure.

Resistance to Acids Fairly good, except to hydrofluoric.

Resistance to Alkalies Poor.

Specific Heat Shall average 0.20 Btu per lb per cu ft.

Tensile Strength (Parting Strength, Average) Shall be greater than 1.2 lb per gram of weight.

Thermal Conductivity The thermal conductivity at the given mean temperatures shall not exceed the following values:

Mean Temp, °F	Btu/inch, hr, sq ft, °F
75	0.26
100	0.27

Thermal Diffusivity at 75 F 0.8 sq ft per day.

Water Absorption (by immersion) Percentage of volume is very high, due to open fibrous structure, but does not retain if water can run out.

STANDARD SPECIFICATIONS



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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS - contd

SPECIFICATION NO. 18-FX: FIBROUS GLASS FLEXIBLE DUCT INSULATION - for use on the exterior surfaces of heating, ventilating, and air conditioning ducts that are in concealed spaces.

Composition

Material shall be composed of fibrous glass with a modified phenolic resin binder, formed into a flexible blanket and faced with a factory-applied fire-retardant vapor barrier of foil-reinforced kraft paper having a perm rating of not more than 0.05. Non-permanent fire-retardant treatments such as salts will not be allowed.

Properties

Alkalinity	pH shall be between 7 and 10.						
Capillarity	After 7 days on wet surface, gain in weight shall be 0%.						
Density (average of 10 samples)	Shall be not less than 0.9 lb per cu ft.						
Hygroscopicity	When oven-dried to constant weight, then exposed to air at 70 F and 90% relative humidity for 14 days, gain in-weight shall be not more than 2%.						
Maximum Use Temperature (glass core)	Shall be suitable for use from minus 120 F to plus 375 F without mechanical, thermal, or chemical failure.						
Resistance to Acids	Fairly good, except to hydrofluoric.						
Resistance to Alkalies	Poor.						
Specific Heat	Shall average 0.20 Btu per lb per degree F.						
Tensile Strength (average parting strength)	Shall be more than 1.2 lb per gram of weight.						
Thermal Conductivity	The thermal conductivity at the given mean temperatures shall not exceed the following values:						
	<table> <tr> <th>Mean Temp, °F</th><th>Btu/inch, hr, sq ft, °F</th></tr> <tr> <td>75</td><td>0.26</td></tr> <tr> <td>100</td><td>0.27</td></tr> </table>	Mean Temp, °F	Btu/inch, hr, sq ft, °F	75	0.26	100	0.27
Mean Temp, °F	Btu/inch, hr, sq ft, °F						
75	0.26						
100	0.27						
Thermal Diffusivity	2.5 sq ft per day.						
Water Absorption (by immersion)	Percentage of volume is very high, due to open fibrous structure, but does not retain if water can run out.						

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS - contd

SPECIFICATION NO. 18-FY: FIBROUS GLASS FLEXIBLE DUCT INSULATION - acoustical and thermal insulation for use on the interior surface of supply and return air ducts carrying conditioned and warm air respectively.

Composition

Material shall be composed of fibrous glass with a modified phenolic resin binder, formed into a flexible blanket, and coated on one side with neoprene compound.

Properties

Alkalinity	pH shall be between 7 and 10.								
Capillarity	After 7 days on wet surface, gain in weight shall be 0%.								
Density (average of 10 samples)	Shall be not less than 2 lb per cu ft.								
Erosion Resistance	Shall withstand air velocities up to and including 7,500 feet per minute with no erosion.								
Flame Spread	Shall be less than 25.								
Friction Coefficient.	Shall not exceed 0.020.								
Loss on Ignition	Shall be not less than 12 nor more than 20% by weight.								
Maximum Use Temperature	Shall be suitable for use from minus 120 F to plus 250 F without mechanical, thermal, or chemical failure.								
Noise Reduction Coefficient	Shall be 0.75 or above - No. 6 mounting.								
Odor	Shall be essentially odorless.								
Resistance to Acids	Fairly good, except to hydrofluoric.								
Resistance to Alkalies	Poor.								
Smoke Developed	Shall be less than 50.								
Specific Gravity	Shall average 2.5 true, 0.030 apparent.								
Specific Heat	Shall average 0.20 Btu per lb per degree F.								
Thermal Conductivity	The thermal conductivity at the given mean temperatures shall not exceed the following values:								
	<table> <tr> <th>Mean Temp, °F</th><th>Btu/inch, hr, sq ft, °F</th></tr> <tr> <td>50</td><td>0.22</td></tr> <tr> <td>75</td><td>0.23</td></tr> <tr> <td>100</td><td>0.25</td></tr> </table>	Mean Temp, °F	Btu/inch, hr, sq ft, °F	50	0.22	75	0.23	100	0.25
Mean Temp, °F	Btu/inch, hr, sq ft, °F								
50	0.22								
75	0.23								
100	0.25								
Thermal Diffusivity at 75 F	1.2 sq ft per day.								
Water Absorption.	Percentage of volume is very high, due to open fibrous structure, but does not retain if water can run out.								

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS - contd

SPECIFICATION NO. 19-H: MINERAL WOOL WITH INTEGRAL ALUMINUM FACING FOR VESSEL SIDE WALLS AND EXPANDED SILICA FOR VESSEL ROOFS OR HEADS

Composition

Material shall be composed of curly mineral wool preformed and bonded to 3/4 hard, 0.016-inch thick, ribbed 3003 alloy aluminum to form panels 50.3-inches wide by 100-inches long. Panels shall be factory drilled for studs when they are to be secured to vessel by stud welding. Panels shall not be drilled when they are to be secured to vessel by strapping.

Properties - Mineral Wool (Attached to Aluminum Facing)

Alkalinity	pH shall be not less than 6.0 nor more than 8.6.
Combustibility	Shall be incombustible.
Compressive Strength	Shall be not less than 0.28 psi at 10% deformation.
Density	Shall be not less than 4 nor more than 4.5 lb per cu ft.
Hygroscopicity	Shall be not more than 17% by weight.
Maximum Use Temperature	Shall not fail mechanically, thermally, or chemically when subjected to surface or soaking temperature of 450 F.
Thermal Conductivity	The thermal conductivity at the given mean temperatures shall not exceed the following values:

Mean Temp, °F	Btu/inch, hr, sq ft, °F
50	0.24
100	0.26
200	0.33
300	0.43

Thermal Diffusivity at 75 F Shall average 0.02 sq ft per hr.

EXPANDED SILICA As specified in SPECIFICATION NO. 22.

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS - contd

SPECIFICATION NO. 19-J: ALUMINUM-FACED FIBROUS GLASS PANELS AND FIBROUS GLASS ROOF INSULATION

Composition

For Side Walls. Material shall be composed of fibrous glass with a modified phenolic binder, with an integral 0.016-inch-thick embossed aluminum facing on one side, formed into panels 48 inches wide by 96 inches long.

For Roof or Heads. Material shall be composed of fibrous glass with resin binder, formed into a semi-rigid board and faced with factory-applied glass reinforced asphalt with a kraft finish.

Properties

		Aluminum Faced Fibrous Glass		Fibrous Glass Roof Insulation	
Alkalinity	pH shall be	8.0 (min.), 10.0 (max.)		8.0 (min.), 10.0 (max.)	
Capillarity	After 7 days on wet surface, gain in weight shall be	0		0	
Coefficient of Expansion	Shall be	0		8.0×10^{-5} (Ave.)	
Combustibility.	Flash Point	700 F (Resin)		425 F (Asphalt)	
	Melting Point	1,200 F (Glass)		150 F (Asphalt)	
	" "			1,200 F (Glass)	
Compressive Strength		0.7 psi at 10% deformation		10 psi at 10% deformation	
Density		$3.25 \pm 10\%$		11 (min.), 18 (max.)	
Hygroscopicity	Two-inch cubes dried at 220 F to constant weight, then exposed to air at 70 F, 90% R.H. for 14 days shall gain not more than	1% by weight		1% by weight	
Maximum Use Temperature	Shall not fail mechanically, thermally, or chemically within temperature limits of	60 to 450 F		Atmospheric to 350 F	
Resistance to Acids	Impervious to common acids and acid fumes except hydrofluoric and hot phosphoric	Yes		Yes	
Resistance to Alkalies		Poor		Poor	
Specific Heat	Shall average	0.2 Btu/lb		0.2 Btu/lb	
Thermal Conductivity	When tested in accordance with ASTM C 177, latest revision, the thermal conductivity shall not exceed the following values at the given mean temperatures	Mean Temp, °F	Conductivity Btu/inch, hr, sq ft, °F	Mean Temp, °F	Conductivity Btu/inch, hr, sq ft, °F
		0	0.20	0	0.24
		100	0.24	100	0.28
		200	0.29	200	0.34
		300	0.35		
Thermal Diffusivity	Shall average, sq ft/hr	0.033		0.004 at 70 F (12 lb density)	
Water Absorption	After 24-hour submersion weight gain shall not exceed	400%		400%	

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS - contd

SPECIFICATION NO. 21: ASBESTOS FIBER

Composition

Material shall be composed of asbestos fibers blended with suitable inorganic binder, processed and molded at sufficient temperatures to produce a rigid, homogeneous thermal insulation.

Properties

Absorptivity Not over 85% of volume after 24 hours submersion.

Alkalinity pH shall be 10.5.

Coefficient of Expansion Shrinkage shall be less than 0.7% when heated to 750 F.
(or Volume and Linear Shrinkage)

Combustibility. Shall be incombustible.

Compressive Strength When tested in accordance with ASTM C 165, latest revision, the percentage of deformation produced by loading shall not exceed the following:

Deformation, %	Load, psi
2	5.5
5	11.0
10	17.0

Corrosiveness to Stainless Steel Shall not contribute to stress corrosion of austenitic stainless steel.

Density Shall be not less than 14 nor more than 18 lb per cu ft.

Flexural Strength. Shall be not less than 100 psi when tested in accordance with ASTM C 203, latest revision.

Hardness. A 1/8-inch ball point under a 1-kg load shall produce a maximum penetration of 0.40 mm.

Hygroscopicity Two-inch cubes oven-dried to constant weight, then exposed to air at 70 F, and 90% relative humidity for 14 days, shall gain a maximum of 12.1% of the original weight.

Maximum Use Temperature Maximum temperature without mechanical, thermal, or chemical failure shall be not less than 1,200 F.

Resistance to Acids and Caustics Solutions or vapors of those commonly used in industry have negligible effect on physical characteristics.

Shrinkage Shall be not more than 0.25% when tested at 1,200 F.

Specific Heat Shall be not less than 0.22, nor more than 0.24, Btu per lb per degree F.

Thermal Conductivity The thermal conductivity at the given mean temperatures shall not exceed the following values:

Mean Temp, °F	Btu/inch, hr, sq ft, °F
100	0.32
200	0.37
300	0.42
400	0.47
600	0.57

Thermal Diffusivity Shall be approximately 0.197 sq ft per day.

Thermal Shock Resistance Material shall not spall, chip, crack, or otherwise fail when heated to 750 F and then quenched with water.

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS - contd

SPECIFICATION NO. 22: BONDED EXPANDED SILICA

Composition

Material shall be composed of expanded silica (perlite), reinforced with asbestos and glass fibers in suitable proportion, and with other binding fillers added to provide proper structural strength.

Properties

Alkalinity pH shall be not below 8.0 and not above 9.8.

Capillarity After 7 days on wet surface, gain in weight shall be less than 1%.

Combustibility Shall be incombustible.

Compressive Strength Strength at 5% deformation shall be not less than 80 psi.

Corrosiveness to Stainless Steel Shall not contribute to stress corrosion of austenitic stainless steel.

Density Shall be not less than 9.5 lb per cu ft, nor more than 11.5 lb per cu ft.

Dusting Fabrication and erection dusting shall be within the allowable criteria established by the Plant Medical Department.

Flexural Strength Shall be not less than 80 psi.

Hygroscopicity Two-inch cubes, oven-dried to constant weight, then exposed to air at 70 F and 90% relative humidity for 30 days shall gain less than 1% of the original weight.

Resistance to Abrasion Sample shall lose not more than 40% of original weight after first 10-minute run, and not more than 70% after second 10-minute run.

Maximum Use Temperature Material shall be suitable for temperatures up to 1,600 F.

Resistance to Acids Excellent; when immersed in 25% concentration of sulfuric acid, hydrochloric acid, or aqua regia, shall show no damage in 100 hours.

Resistance to Caustics Good for most common caustics.

Shrinkage 0.47% at 1,000 F and 1.25% at 1,500 F soaking heat.

Specific Heat Will be furnished later.

Thermal Conductivity Shall not exceed the following values at the given mean temperatures:

Mean Temp, ° F	Btu/inch, hr, sq ft, °F
100	0.34
200	0.40
300	0.45
400	0.50
600	0.58
1,000	0.78

Tensile Strength 25 psi.

Thermal Diffusivity Shall not exceed 0.33 sq ft per day at 100 F mean temperature.

Thermal Shock Resistance Shall not be damaged by rapid change in temperature.

Water Absorption After 24-hour submersion, gain shall not exceed 4% by volume of water.

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS - contd

SPECIFICATION NO. 23: INHIBITED CALCIUM SILICATE

Composition

Material shall be composed of hydrous calcium silicate blended with asbestos fibers in suitable proportion, with or without inorganic filler, and with an inhibitor added to prevent stress corrosion of stainless steel.

Properties

Alkalinity pH shall be not below 8 nor above 10.

Breaking Load Not less than 20 lbs when testing a specimen 6 inches wide by 1 inch thick over a 10-inch span.

Coefficient of Expansion Not less than 1.9×10^{-6} average on reheat to 1,200 F.

Combustibility. Shall be incombustible.

Compressive Strength The percentage of deformation produced by loading shall not exceed the following:

Load, Psi	Deformation, %
70	2
150	5
200	10

Corrosiveness to Stainless Steel Shall not cause stress corrosion cracking of stainless steel after six months when tested by A. W. Dana method reported in October 1957 issue of ASTM Bulletin.

Density Shall be not less than 10 lbs per cu ft, or more than 13 lbs per cu ft.

Dusting Fabrication and erection dusting shall be within the allowable criteria established by the Plant Medical Department.

Flexural Strength Shall be not less than 50 psi.

Hardness A 1/8-inch ball point under a 1-kg load shall produce a maximum penetration of 0.50 mm.

Hygroscopicity. When oven-dried to constant weight, then exposed to air at 70 F and 90% relative humidity for 14 days, shall gain a maximum of 26% of the original weight.

Maximum Use Temperature Maximum temperature without mechanical, thermal, or chemical failure shall be not less than 1,200 F.

Resistance to Acids and Caustics Shall be resistant to most common caustics (not considered an acid-resisting material).

Shrinkage Shall be not more than 1.6% at 1,200 F.

Specific Heat 0.21 to .28 Btu per lb per degree F at 400 F.

Tensile Strength Shall be not less than 20 psi.

Thermal Conductivity The thermal conductivity at the given mean temperatures shall not exceed the following values:

Mean Temp, °F	Btu/inch, hr, sq ft, °F
100	.33
200	.37
300	.41
400	.46
600	.57

Thermal Diffusivity Shall average 0.013 to 0.016 sq ft per hour.

Thermal Shock Resistance. Shall not spall, chip, crack, or otherwise fail when heated to 1,200 F and then quenched with water.

Water Absorption. After 24-hour submersion, shall gain not more than 480% of the original weight.