

PLAINTIFF'S
EXHIBIT
MON-77

S.A.B.

INSULATION SPECS

002730

S. A. B.

INSULATION STANDARDS

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COATINGS AND INSULATION MANUAL

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STANDARDS

COATINGS AND INSULATION MANUAL
THERMAL INSULATION DESIGN

INTRODUCTION TO INSULATION STANDARDS

Information Standard

MAN. SECT. PART

K11.1 STD :

ISSUE A DATE 11/63

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"A" INDICATES APPROVAL OR ACCEPTANCE AT LOCATION. "B" AT "DIV" INDICATES DIVISION-AND APPROVAL OR ACCEPTANCE.

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1. SCOPE This Information Standard outlines the contents and use of Monsanto Standards for thermal insulation, and presents the criteria for design used in their preparation.

1.1 Objective The objective of thermal insulation Standards is to provide ready access to simple and reliable means for designing, selecting, and specifying systems of material to limit heat flow to or from process facilities. A good balance of cost, quality, and maintainability has been sought in preparation of the Standards.

2. CONTENTS OF STANDARDS Section 11 of the Table of Contents for the K Manual lists the thermal insulation Standards issued to date and approved for use in your Division. This paragraph is intended to explain what is found in each Standard or group of Standards.

Figure 1 (page 3 of this standard) is a logic-diagram "road map" that shows how the Standards may be used to meet a variety of process and mechanical design conditions.

2.1 Design Standards

2.1.1 K11.1 Std 2, *Identification and Schedule*, shows how to identify on drawings and in project schedules the type and thickness of insulation, and the type of weather covering to be applied to each piece of equipment or pipeline. Symbols and legend, examples of identification in use, and suggested forms for Thermal Insulation Schedule are included.

2.1.2 K11.1 Std 3, *Materials Selection Guide*, analyzes the considerations involved in selecting the proper type of thermal insulation for various application requirements, including temperature range, types of insulating materials, and service or exposure conditions. (It may later be necessary to add standards, beginning with K11.1 Std 12, to cover selection for plants or divisions which define their standard requirements in advance.)

2.1.3 K11.1 Std 4, *Heat Transfer Calculations*, contains equations, tables, and data useful in finding the required thickness of thermal insulation when alternate tabular values of thickness (see Par. 2.2 and Par. 3.3) are unsatisfactory. The tables of apparent, or effective, thickness of insulation over cylindrical surfaces are noteworthy. These were calculated with the aid of Monsanto's IBM 704 computer from the basic log mean ratios of diameters for each pipe size and insulation thickness.

2.1.4 K11.1 Std 7, *Mechanical Details*, will consider special design problems of insulation support, projections through insulation at low temperatures or very high temperatures (such as vessel supports, instrument leads, relief vents, etc), and other conditions which may require calculations for solving.

2.2 Insulants K11.2, *Insulant Material Specifications*, covers a group of standard procurement specifications. Preceding the materials specifications are product lists that identify the type and suppliers of materials needed for an insulation system. An "insulant system" comprises an insulating material (block, blanket, etc), strapping, clips, filler and patching materials, and other supplies needed for an insulating system excluding the weather covering.

2.3 Weather Barriers K11.3, *Weather Barrier Specifications*, covers a group of weather-barrier systems in the same way that Part 2 covers insulant systems.

2.4 Construction Specifications K11.4, *Construction Specifications*, provides instructions and graphic details on methods and workmanship for application of thermal insulation. K11.4 Std 1, *Introduction*, describes how to use contract documents, general insulation specifications, and other specifications, drawings, and schedules to set up complete thermal insulation project requirements. Use of the specifications in plant work also is discussed.

K11.4 Std 2, *General Insulation Specification*, covers requirements common to all kinds of thermal insulation application work. Subsequent Standards detail methods and workmanship for various kinds of insulants and services.

2.5 Economic Thickness K11.5 Std 2, *Economic Thickness Data*, contains a condensation of an extensive study by Union Carbide Chemicals Company and West Virginia University on the economic thickness of thermal insulation. The complete report is available from the National Insulation Manufacturers Association, but is much bulkier than the simplified format developed for this Standard. To apply the economic criterion to a specific plant it is necessary to determine or assume values for the unit cost of steam, the steam plant capital per unit of steam flow per hour, depreciation life of steam plant, unit cost of installed insulation, and depreciation life of insulation. All values for repairs, and for discounting the value of future

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REFERENCES

OTHER LOCATIONS OF DIVISIONS ARE SHOWN BY | OR OUTLINE. DELETIONS ARE SHOWN BY //



savings, are built into the equations. Future Monsanto study will be directed toward economic thickness analysis of low temperature insulation, which is not now covered.

3. DESIGN CRITERIA Research during development of the thermal insulation Standards included a study of design criteria for determination of insulation thickness. Three different sets of valid criteria have been found, each with a number of variations:

- (1) Process limitations imposing a maximum permissible rate of heat exchange with the surroundings.
- (2) An economic balance, such that the combined costs of insulation and heat loss are a minimum.
- (3) Limitations on the temperature of the external insulation surface.

Roughly speaking, all the criteria are equal in the sense that the insulation thickness used should be the thickest required by any of these conditions.

Variations in the above criteria are imposed by differences between elevated and low temperature requirements. Each of the considerations is further discussed in the following paragraphs.

3.1 Process Limitations A primary function of insulation is to keep the process hot enough or cold enough to meet operating requirements. This requirement takes precedence over all others when the following conditions are the controlling factors in insulation design:

- (1) For process temperatures above ambient (elevated temperatures):
 - (a) Excessive dephlegmation caused by unwanted condensation of volatile components in distillation equipment.
 - (b) Crystallization of solids from solutions or vapors.
 - (c) Undesirable viscosity changes in product near vessel or pipe walls.
 - (d) Yield loss or product deterioration from excessive heat input or pressure build-up to make up for insulation losses.
- (2) For process temperature below ambient (low temperature):
 - (a) Excessive boil-up of volatile components by unwanted heat influx in distillation equipment.
 - (b) Product loss from vaporization due to heat influx.
 - (c) Pressure build-up or product deterioration due to heat influx.

3.2 Economic Thickness The usual considerations in economic thickness determination are based on the premise that heat is supplied by a steam generation plant and distribution lines, and that heat loss essentially is directly from the steam. These assumptions are valid for steam mains and branches, and for steam-heated vessels and vaporizers. They probably are adequate for many other heated process services as well. For all such conditions, K11.5 Std 2, *Economic Thickness Data*, provides a complete economic analysis and insulation thickness table.

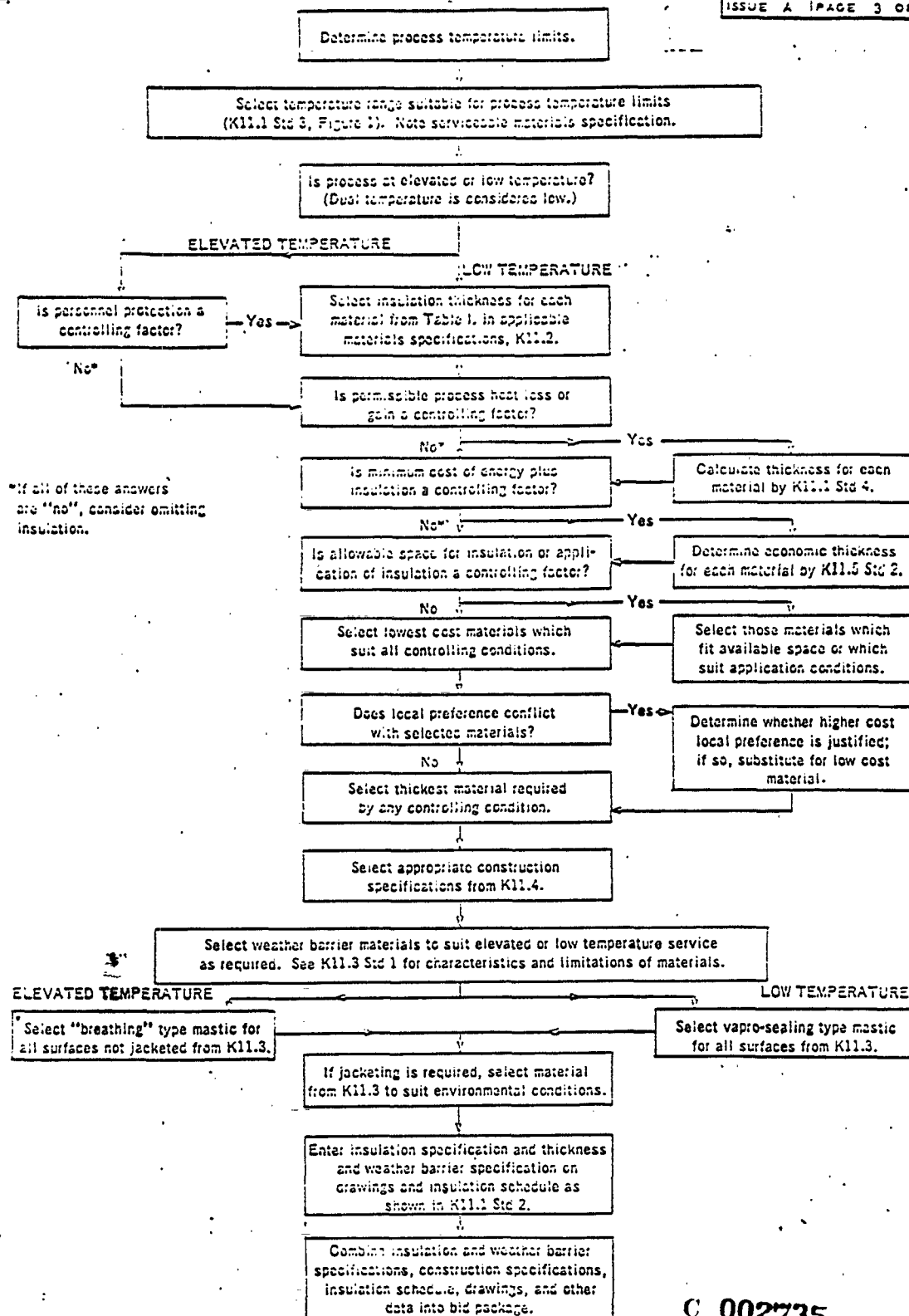
3.2.1 Unusual Conditions The standard economic thickness analysis breaks down, or at least requires extensive modification, when any of the following conditions prevail:

- (1) When process heat or energy is supplied from a source other than steam (as Dowtherm, Therminol, or electric power).
- (2) When expensive heat exchange equipment is used to transfer heat to the insulated process equipment.
- (3) When expensive mass transfer equipment (e.g., a vacuum distillation column) is involved in getting heat to the point where it will be lost through the insulation.

Any of the above factors may greatly increase the value of heat energy as compared with process steam; the optimum insulation thickness will be increased correspondingly. Theoretically, all of the factors mentioned above can be translated into equivalent steam costs and equivalent steam plant costs, and "plugged into" the charts in K11.5 Std 2 for use in the economic thickness tables. In practice, a direct economic analysis of the particular case under study may be preferable.

3.2.2 Refrigeration No economic thickness calculations have been worked out for low temperature services. One substantial variable not usually significant in elevated temperature services is the increasing direct and capital costs per Btu of refrigeration as process temperature is lowered. At present each case would have to be analyzed separately.

3.3 Surface Temperature Limits Recommended thickness tables published by thermal insulation manufacturers customarily are based either on a constant surface temperature or on a constant heat flux per unit of external surface. Unfortunately, the design premises often are unstated, and when stated are not comparable. Furthermore, there were apparent inconsistencies found within single sets of data.



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FIGURE 1. HOW TO USE THE THERMAL INSULATION STANDARDS



The entire approach to surface temperature design was re-examined in preparing Monsanto's Standards, and corrected thickness tables were prepared. These are included in the respective materials specifications as a convenience to users who may not have the back-up data or the opportunity to calculate the optimum process or economic thickness.

3.3.1 Elevated Temperatures The design temperature of the outer insulation surface is 120°F when in contact with 80°F still air. (Surface temperature of bright metal jacketing may be slightly higher because the radiant heat transfer coefficient is lower.) This design condition is equivalent to about 50 Btu/hr, sq ft of external insulation surface. Choice of a temperature below 130°F primarily is a safety consideration, though it also coincides with several manufacturer's practices. When a person inadvertently contacts a hot surface (as with the back of his arm or neck) the immediate hazard is not a burn, but an uncontrollable reflex jerk or jumping away; the design limits selected are unlikely to cause either a burn or indirectly cause other types of accident.

3.3.2 Low Temperature The basic design premise for surface temperatures below ambient is prevention of frost or condensation. There are two reasons for this limitation:

- (a) Water or ice on or under piping and equipment presents a slipping hazard and a housekeeping nuisance;
- (b) If moisture enters any surface imperfection it will ultimately cause extended failure of the insulation because of progressive saturation of the insulation and freezing.

Two different design conditions have been derived for limiting the surface temperature of "cold" insulation. The first one has been used by insulation manufacturers and is valid for temperatures down to -10°F. Below -10°F our work has shown that the second design condition is more critical.

- (1) For process temperature -10°F and higher: Ambient air conditions are 90°F, 80% relative humidity, still air. Insulation surface temperatures must be slightly above the 34.5°F wet bulb temperature at this condition. Maximum heat gain at the outer insulation surface is about 9 Btu/hr, sq ft.
- (2) For process temperature below -10°F: Ambient air conditions are 40°F, 80% relative humidity,

2 mph breeze. Insulation surface temperature must be slightly above the 37.5°F wet bulb temperature at this condition. Maximum heat flux based on outer insulation surface is about 4 Btu/hr, sq ft.

4. REFERENCES

4.1 Publications The following publications in addition to standard engineers' handbooks and suppliers' catalogs have been consulted in the preparation of the thermal insulation standards:

- (1) *Manual on Economic Thickness of Insulation*, Union Carbide Chemicals Company, 1960.
- (2) "How Much Insulation for Pipes and Flat Surfaces?", by C. S. Arents and H. M. Cather of West Virginia University, published in *Air Conditioning, Heating, and Ventilating* magazine, March through August issues, 1961.
- (3) "Characteristics of Thermal Insulation Materials", by W. C. Turner, Union Carbide Chemical Company, 1955.
- (4) "How to Compute Heat Losses Graphically", by Charles R. Kise, Baldwin-Ehrer-Hill, Inc., published in *Petroleum Refiner* magazine, 1959.

4.2 Other Standards and Specifications Standards and specifications published by others have been studied, and portions of them have been used as precedent for several recommended practices included in this work. The publications include:

- (1) Chocolate Bayou Plant thermal insulation specifications, prepared by the Bechtel Corporation, 1960.
- (2) Code of Practice No. 31C, Thermal Insulation, issued by MCL, Engineering Department, London, 1961.
- (3) Chemstrand Division Thermal Insulation Standards.
- (4) M. W. Kellogg Company Thermal Insulation Standards.
- (5) Catalytic Construction Company Thermal Insulation Standards.
- (6) Selected working practices used in thermal insulation project and maintenance work by the Nitro, Queeny, Krummrich, and Texas City plants, and by the Hydrocarbons, Inorganic, and Organic Division Engineering Departments.



STANDARDS

COATINGS AND INSULATION MANUAL
THERMAL INSULATION DESIGN

IDENTIFICATION, SYMBOLS, AND SCHEDULE

MAN. SECT. PART

K11.1 STD 2

ISSUE 1 DATE 12/61

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LOCATIONS

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"D" INDICATES APPROVAL OR ACCEPTANCE AT LOCATION. "M" AT "DIV" INDICATES DIVISION APPROVAL OR ACCEPTANCE.

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1. SCOPE This Design Standard covers the identification of thermal insulation systems on the Drawings and provides an Insulation Schedule that may be used to list insulation work for project purposes.

2. IDENTIFICATION OF THERMAL INSULATION SYSTEMS Thermal insulation systems are denoted on the Drawings by a numbered Identity and a symbol, as illustrated in Figure 1. They are denoted in the Insulation Schedule by a numbered identity.

2.1 Numbered Identity

2.1.1 First Part The first part of the numbered identity indicates the thickness of the insulation and the Insulation Materials Specification, e.g., $\frac{1}{2}$ " 100. The following rules apply to use of the first part of the numbered identity.

- (1) Decimal units shall not be used to indicate insulation thickness.
- (2) The insulation thickness indicated does not include the thickness of weather barrier materials.
- (3) Identification of insulation applied to piping or duct terminates at a numbered equipment item or where indicated by an insulation termination symbol as illustrated in Figure 1.
- (4) In-line components (line flanges, valves, flanged fittings, instrument components, or special fittings) shall be insulated only where directed by the appropriate construction specification, or where noted on the Drawings or in the Insulation Schedule. Type and thickness of insulation denoted by numbered identity for the line containing in-line components shall be used for the in-line components where so directed or noted.
- (5) The letter "D" following the insulation thickness designation (as 5" D 300, for example) denotes a double-layer of insulation

of similar type. (Specific arrangements for double-layer construction are given in each Materials Specification.)

- (6) Where required by design, two or more different types of insulation may be indicated. (Example, $\frac{1}{2}$ " 140, $\frac{1}{2}$ " 160 designates $\frac{1}{2}$ " thickness of fibrous glass blanket and $\frac{1}{2}$ " of cellular glass; application of the materials is in the order listed.)

2.1.2 Second Part The second part of the numbered identity indicates the weather barrier material to be applied over the insulation. The second part of the numbered identity is separated from the first part by a dash, e.g., $\frac{1}{2}$ " 100-15. ($\frac{1}{2}$ " of calcium silicate insulation covered with polyvinyl acetate weather barrier.) Two numbers are used where sheet jacketing materials are applied over mastic weather barrier materials, e.g., $\frac{1}{2}$ " 420-25, 65. ($\frac{1}{2}$ " of polyester polyurethane insulation covered with fire-retardant cutback asphalt weather barrier and protected by stainless steel jacketing; $\frac{1}{2}$ " 110-65, 10 indicated $\frac{1}{2}$ " of expanded silica insulation with stainless steel jacketing and fire-retardant "breathing" asphalt mastic for irregular surfaces and jacketing.)

2.2 Identification Symbols Symbols illustrated in Figure 1 are used to indicate thermal insulation on elevation flow sheets, piping and instrument diagrams, and piping drawings:

3. THERMAL INSULATION SCHEDULE The schedule as illustrated in Appendix A is used to tabulate equipment and lines to be insulated, and to identify the insulation system. For contract work, bare surface units and cost information are to be submitted by the bidder.

3.1 Availability of Forms This Form is available as Form No. ES 9 in pads of 50 on Vellum paper from the standards representative at your location.

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REFERENCES

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CATALYTIC CONSTRUCTION COMPANY
PHILADELPHIA 1, PA.

CC-557, Rev. 1, 5/57

PLANT: SAB Alkylation Facilities C.C.CO. CONTRACT NO 31,090
CLIENT: Monsanto Chemical Company SPECIFICATION NO. 31090-2200-00-4
LOCATION: Alvin, Texas

SPECIFICATION

for

THERMAL INSULATION OF EQUIPMENT AND PIPING

Approved _____ Date _____

Approved W.D. Krimm Date 3/20/64
CLIENT

Approved J.L. Green Date 5/11/64
C.C.CO.

Prepared by William T. Cornish Date Feb. 27, 1964
C.C.CO.

Rev. 1	W.D.K.	5/11/64			W.D.K.	5/11/64	002738		
AMENDMENT	Approved	Date	Approved	Date	Approved	Approved	Approved	Approved	Date
	CLIENT				CATALYTIC CONSTRUCTION CO.				

CATALYTIC CONSTRUCTION COMPANY

PHILADELPHIA 2, PA.

CO-512, 12/55

UNIT	TEMP. °C	TEMP. °C	TEMP. °C	TEMP. °C	DATE	INSULATION SPECIFICATION No. SP-31090-2200-00-4
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Rev.						LISTING OF SPECIFICATIONS AND THICKNESSES FOR CALCIUM SILICATE INSULATION WITH ALUMINUM JACKETING
Rev.						

SPECIFICATION	MONSANTO MAN. SECT. PART	SEE NOTE
Insulation Materials: Introduction Product List Calcium Silicate Mineral Wool	K11-2 STD 1 K11-2 STD 2 K11-2 STD 100 Page 1 K11-2 STD 130 Page 1	7
Weather Barrier Materials: Introduction Product List Asphalt Aluminum Stainless Steel	K11-3 STD 1 K11-3 STD 2 K11-3 STD 10 K11-3 STD 60 K11-3 STD 65	6 7
Construction: General Insulation Rigid Insulation System	K11-4 STD 2 K11-4 STD 10X	

NOTES:

- Unless otherwise specified, all equipment and piping shall be insulated with calcium silicate insulation and weatherproofed with aluminum jacketing in accordance with the following specifications:

Insulation Materials	K11-2 Std. 100
Weather Barrier Materials	K11-3 Std. 60
Construction	K11-4 Std. 2
Construction	K11-4 Std. 10X
- On surfaces not covered by jacketing, insulation shall be weatherproofed with asphalt mastic. Mastic shall conform to Specifications K11-3 Std. 1 and K11-3 Std. 10. Application shall be in accordance with Specification K11-4 Std. 10X.
- Acceptable insulation materials shall be in accordance with Specifications K11-2 Std. 1 and K11-2 Std. 2.
- Acceptable weather barrier materials shall be in accordance with Specifications K11-3 Std. 1 and K11-3 Std. 2.
- Stainless steel jacketing shall be applied in the same manner as aluminum jacketing. Materials shall conform to Specification K11.3 Std. 65. Thickness of jacketing shall be 0.010".
- Use flat aluminum on heads of vessels and towers.
- This material shall be used on specially designated equipment and piping only.

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CATALYTIC CONSTRUCTION COMPANY
PHILADELPHIA 2, PA.

INSULATION SPECIFICATION NO. SP-31090-2200-00-4

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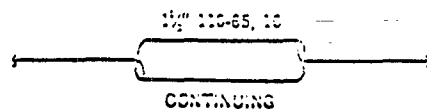
THICKNESS TABLE FOR FIBERGLASS SILICATE INSULATIONSYNTHETIC DIATOMITE - DEG. F

<u>PIPE SIZE (INCHES)</u>	<u>UP TO 200</u>	<u>201 TO 300</u>	<u>301 TO 400</u>	<u>401 TO 500</u>	<u>501 TO 550</u>	<u>551 TO 600</u>
UP TO 1	1	1	1½	2	2	2½
1½ TO 2	1	1	1½	2	2½	2½
3 TO 4	1	1½	2	2½	2½	3
6	1	1½	2	2½	3	3
8 TO 36	1½	1½	2	2½	3	3½
FLAT	1½	1½	2	2½	3	3½

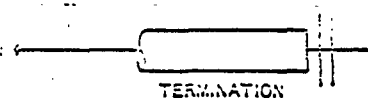
NOTES

1. All thicknesses of insulation are nominal and in inches.
2. For personnel protection use thickness listed above minus ½", except minimum thickness for pipe size 8 to 36" shall be 1½".
3. Insulation 3½" thick shall be applied in double layers with 1½" inner layer and 2" outer layer.

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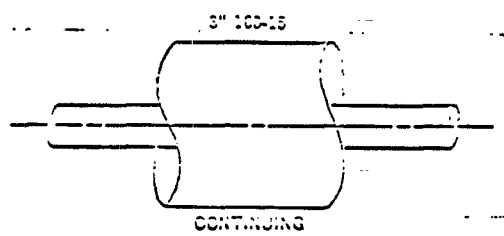


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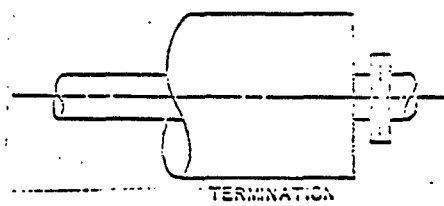


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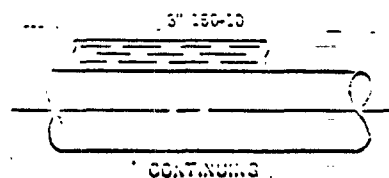
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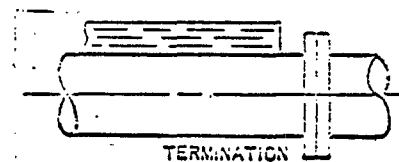
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TERMINATION



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TERMINATION

PIPING OVER 4" IPS

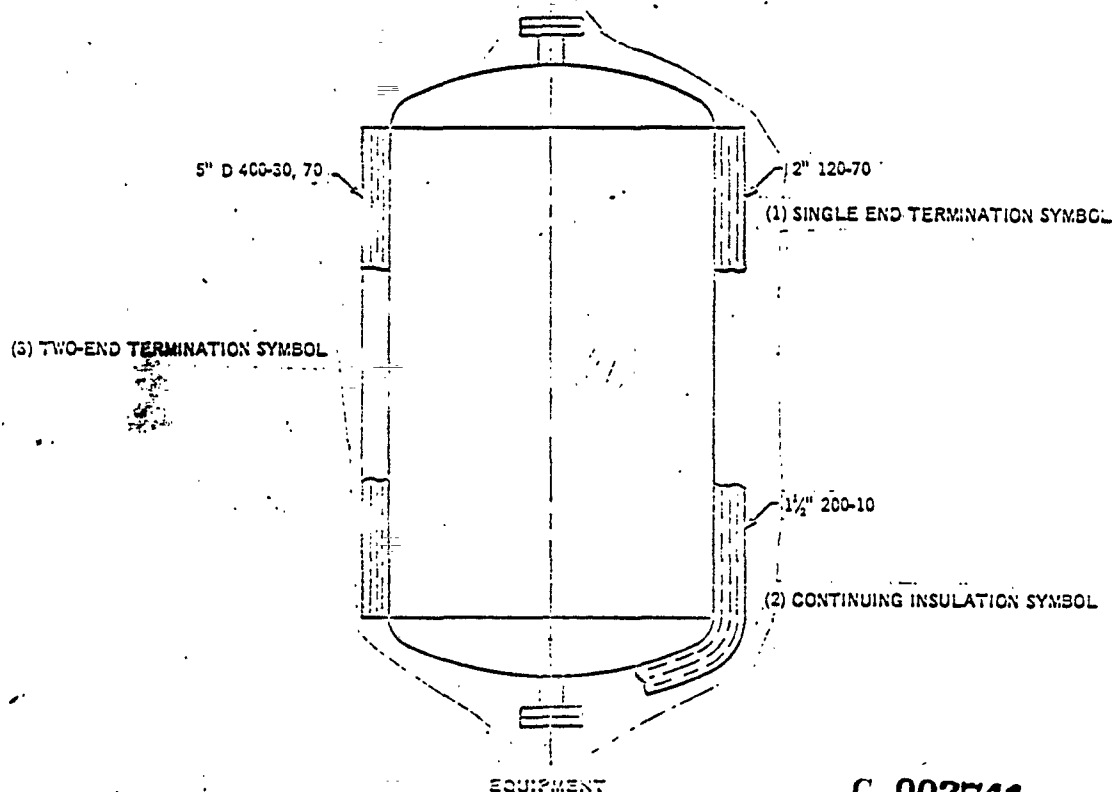


FIGURE 1. TYPICAL IDENTIFICATION SYMBOLS

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MONSANTO CHEMICAL COMPANY
THERMAL INSULATION SCHEDULE FOR EQUIPMENT AND PIPING

SECTION NO. _____ AREA _____
ESTIMATE NO. _____ C.A. NO. _____
PREPARED BY _____ DATE _____
SHEET _____ OF _____

[illegible]

NOTE:
1. For piping, linear feet; for equipment, square feet.

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Checked						
Approved						

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TABLE OF CONTENTS FOR PLACEMENT

"X" INDICATES APPROVAL OR ACCEPTANCE AT LOCATION. "A" AS "X" INDICATES APPROVAL OR ACCEPTANCE AT LOCATION.

1. SCOPE This Design Standard lists considerations for selecting thermal insulation materials to suit the requirements of elevated and low temperature services, and guides the selection of insulation systems for each of several temperature ranges within these major temperature divisions. It provides graphical thickness comparisons for each insulant that may be used in each temperature range. Finally, it lists comparative properties of insulants, cements, and environmental barrier materials found in the Materials Specifications.

2. CONSIDERATIONS FOR MATERIALS SELECTION Three major considerations influence selection of thermal insulation materials:

2.1 Reduction of Heat Flow The primary consideration is that the insulant must adequately retard heat transfer out of or into material within the insulated space.

2.2 Control of Moisture The second consideration is that the insulation system must prevent penetration of liquid water and adequately control the passage of moisture vapor. This consideration differs in the selection of materials and design of systems for elevated and low temperature services:

- (1) Systems for elevated temperature service must prevent the entry of liquid water, but must "breathe" so that moisture vapor trapped in the insulant may be driven to the atmosphere when the insulated surface is heated.
- (2) Systems for low temperature service must be constructed of insulants that are resistant to moisture vapor transmission, and must be sealed to prevent the passage of moisture in either liquid or vapor form into the system.

2.3 Mechanical and Physical Properties The third consideration is that the insulation materials conform to several basic mechanical and physical criteria. Among these are:

- (1) Adequate insulating value without excessive insulation thickness.
- (2) Freedom from tendency to cause or foster corrosion of steel or alloy surfaces.
- (3) Resistance to deterioration from moisture, weather, or exposure to chemical environments.
- (4) Workability and ease of application.

- (5) Availability in the necessary variety of sizes and shapes without undue delay in delivery.
- (6) Conformity to recognized dimensional standards.

3. OTHER CONSIDERATIONS

3.1 Insulation Materials for Elevated Temperature Service Insulants for elevated temperature service may be rigid (block) type, batt or blanket type, or sprayed type. Rigid and blanket types may be secured in place with studs, clips, or finger straps welded or cemented to the equipment or piping surface, by wires or machine-stretched bands, or by a combination of these methods.

Environmental barrier materials for elevated temperature service may be "breathing" type mastics, or sheet materials in the form of jacketing. These materials are not considered an integral part of the insulation Materials Specification, and have their own Materials Specifications numbers so that choice of material may be designated on the Drawings.

3.2 Insulation Materials for Low Temperature Service Insulants for low temperature service usually are rigid blocks and segments, and are secured in place with wire or machine-stretched bands. Studs, pins, clips, or other similar devices that provide a "cold finger" when the insulant is impaled over them are not recommended as securing devices. Foamed in place and blanket materials may be used in the less rigorous ranges of low temperature.

Environmental barrier materials for reduced temperature service must be sealing type mastics. These materials must be applied with care in a manner that will encapsulate the insulation, and must be maintained so that their moisture-resisting qualities are not impaired. These materials are not considered an integral part of the insulation Materials Specification, and have their own Materials Specifications numbers so that choice of material may be designated on the drawings.

Jacketing may be applied over the insulation system, after the environmental barrier mastic is applied, when additional mechanical protection is required. Jacketing must be wired or banded in place: screws or rivets that will pierce the environmental barrier seal may not be used.

C 002743

REFERENCES

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4. TEMPERATURE RANGES Chemical plant operating temperatures may range from below -425 to above 2000°F, and there is no known insulating material that can provide adequate service across this entire temperature range. Figure 1 shows eight

temperature ranges which correspond fairly well with both process requirements and with limitations of available insulants; it lists the Materials Specifications that may be used economically and safely within each range limit.

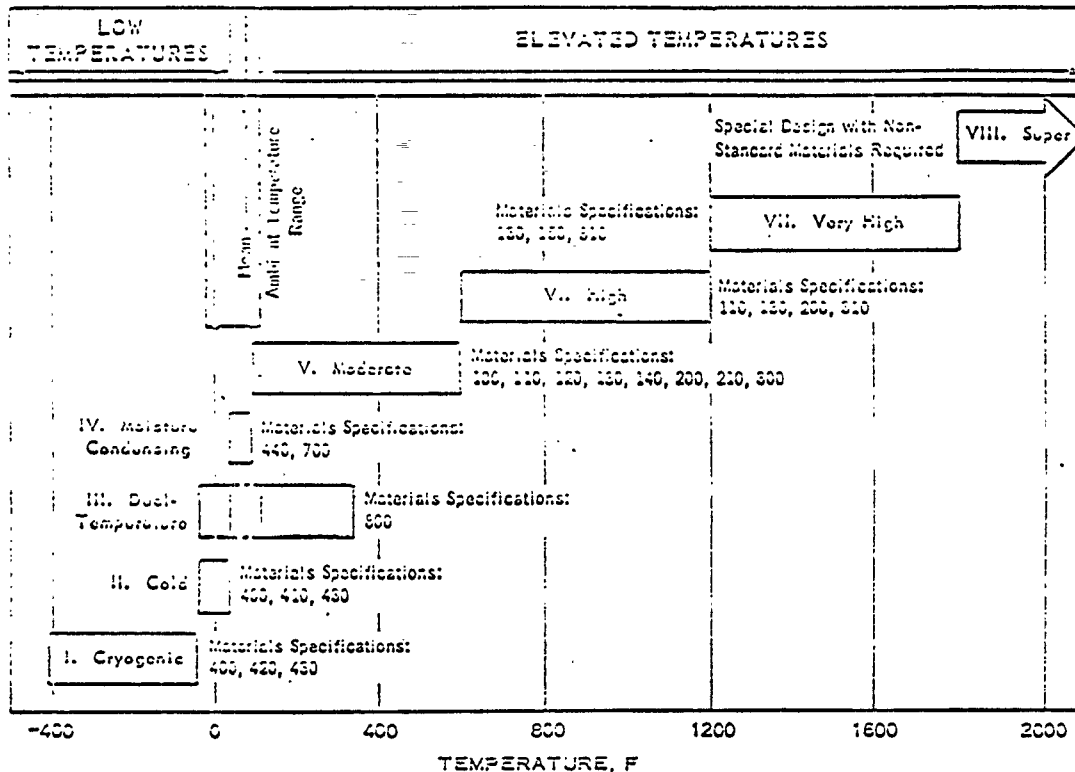


FIGURE 1

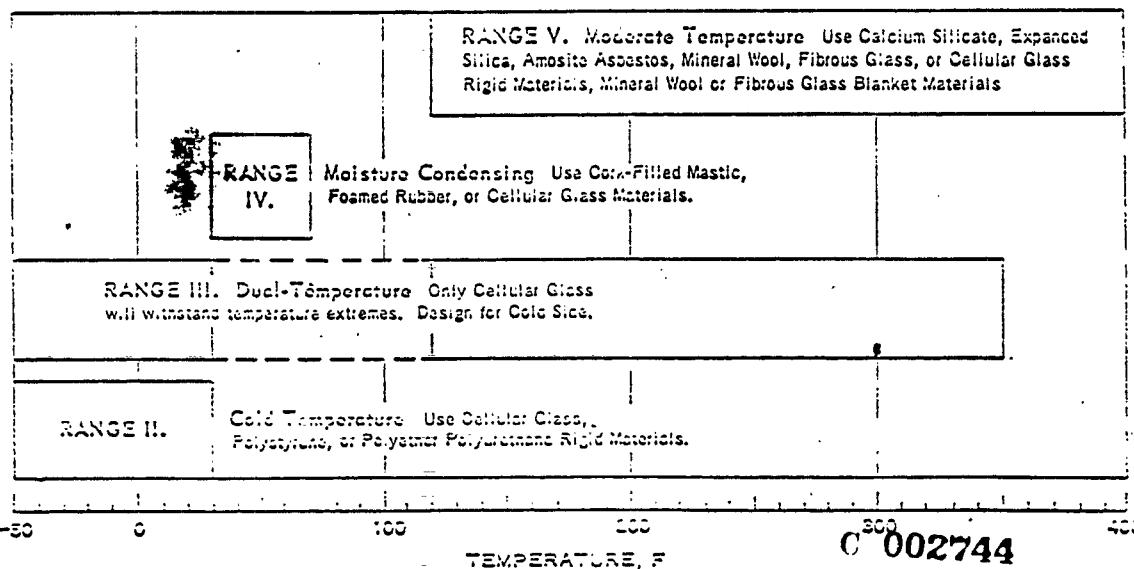


FIGURE 1-A. 80% OF INSULATION DESIGN WILL BE FOR SERVICES WITHIN FOUR TEMPERATURE RANGES

C 002744



5. INSULATION THICKNESS COMPARISON The following figures show the relative thickness of insulation materials required to provide comparable insulating value in each of the temperature ranges.

5.1 Insulators for Low Temperature Service

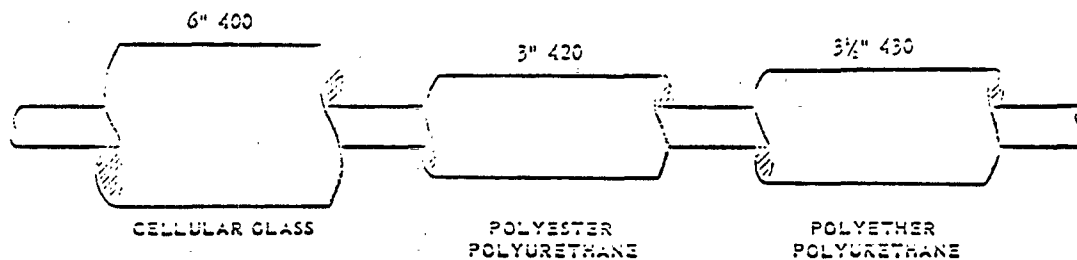


FIGURE 2

Materials Recommended for Range I; Relative Thickness Required to Provide Comparable Insulating Value Over 4\" IPS Pipe at -100°F.

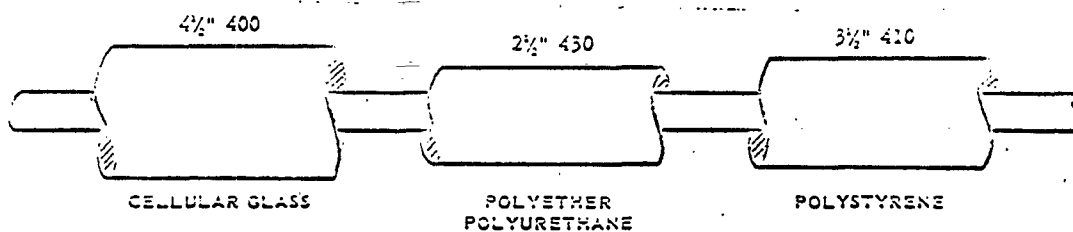


FIGURE 3

Materials Recommended for Range II; Relative Thicknesses required to Provide Comparable Insulating Value Over 4\" IPS Pipe at -50°F.

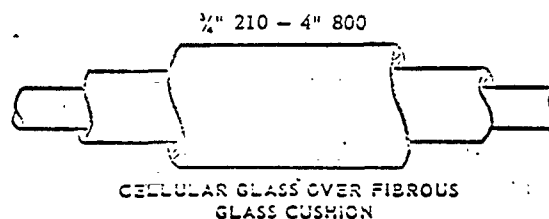


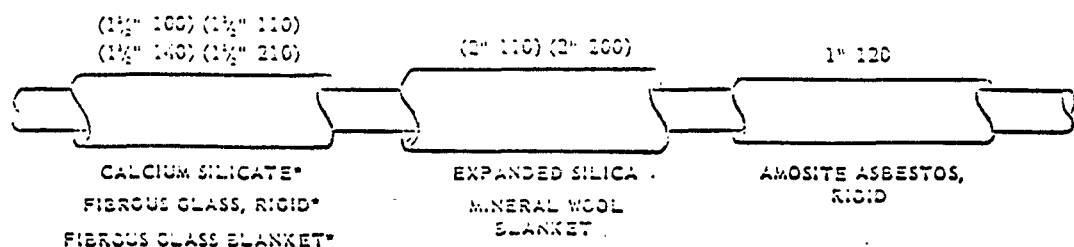
FIGURE 4

Materials Recommended for Range III; Thickness Required to Provide Adequate Insulating Value Over 4\" IPS Pipe at -50°F.

C 002745



5.2 Insulents for Elevated Temperature Service



*Do not apply these materials over Stainless Steel surfaces.

FIGURE 5

Materials Recommended for Range V; Relative Thicknesses Required to Provide Comparable Insulating Value over 4" IPS Pipe at 450 F.

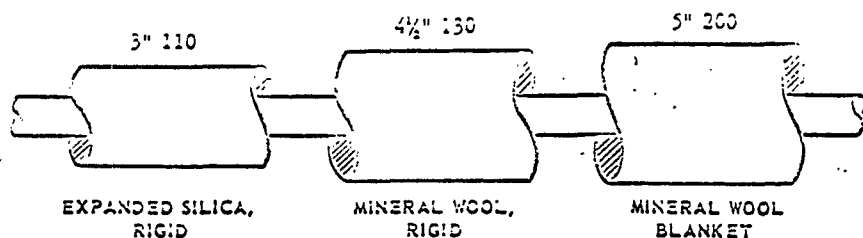


FIGURE 6

Materials Recommended for Range VI; Relative Thicknesses Required to Provide Comparable Insulating Value over 4" IPS Pipe at 1000 F.

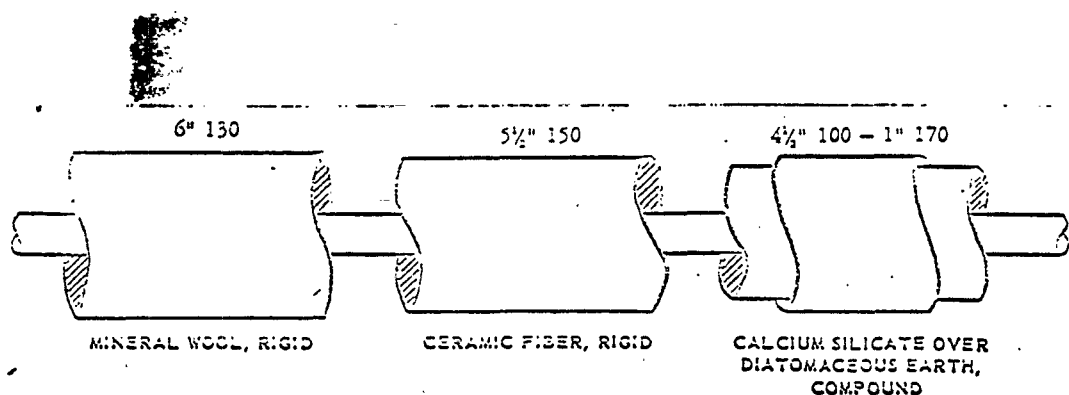


FIGURE 7

Materials Recommended for Range VII; Relative Thicknesses Required to Provide Comparable Insulating Value over 4" IPS Pipe at 1600 F.



6. MATERIALS PROPERTIES The following tables provide physical and mechanical properties of all available insulants, cements, and environmental barrier mastics. Materials are included (for comparison purposes) that do not appear in the Materials Specifications.

6.1 Rigid Insulation Materials

Insulation Characteristics	Type of Insulation		
	Amosite Asbestos	Calcium Silicate	Cellular Glass
Composition	Amosite Asbestos Fibers with Diatomaceous Silicate Binder	Reacted Hydrous Calcium Silicate and Asbestos Fiber	Hermetically-Sealed Cells of Formed Glass
General Form	Block and Pipe Insulation	Block and Pipe Insulation	Block and Pipe Insulation
ASTM Specification	C391-59T	C345-60T	C343-56
Thermal Conductivity (at Mean Temperatures)	0.33 at 100 F 0.42 at 300 F 0.55 at 600 F	0.35 at 100 F 0.43 at 300 F 0.56 at 600 F	0.36 at 0 F 0.42 at 100 F 0.55 at 300 F
Temperature Limits	1200 F Max, 120 F Min	1200 F Max, 120 F Min	800 F Max, -400 F Min
Thermal Shock Resistance	Good within its Temperature Limits	Good within its Temperature Limits	Will Spall and Crack when Subjected to Rapid Changes in Temperature
Fire Exposure	Incombustible	Incombustible	Incombustible
Specific Heat, Btu/lb/°F	.22 to .30	.22 to .30	.20
Density, lbs/cu ft	18	10 to 18	9 to 10
Compressive Strength, PSI	33 to 110 at 5% Deformation	66 to 104 at 5% Deformation	100
Tensile Strength, PSI	10 to 40	7.16 to 37	84
Flexural Strength, PSI			100
Modulus of Elasticity, PSI			200,000
Absorptivity (of Moisture by Volume)	1% to 6%	80% to 85%	0.2% (on surface only)
Resistance to Acids	Good	Little to Fair	Good, Except HF and H ₃ PO ₄
Resistance to Caustics	Good	Somewhat Good	Good
Remarks		Subject to Shrinkage after Wetting. Do not Apply over Stainless Steel.	Requires Bore Coating

C 002747



Insulation Characteristics	Type of Insulation			
	Diatomaceous Earth	Expanded Silica	Fibrous Glass (Low Density)	Fibrous Glass (High Density)
Composition	Diatomaceous Earth with Inorganic Binders	Inorganic Vitrified Air Cells with Inorganic Fibers and Binders	Fibrous Glass with Phenol-Formaldehyde Binders	Fibrous Glass with High-Temperature Inorganic Binders
General Form	Block and Pipe Insulation	Block and Pipe Insulation	Block and Pipe Insulation	Block and Pipe Insulation
ASTM Specification	C334-59T			
Thermal Conductivity (at Mean Temperatures)	0.63 at 200 F 0.69 at 500 F 0.78 at 800 F 0.84 at 1000 F	0.34 at 100 F 0.42 at 300 F 0.50 at 600 F 0.78 at 1000 F	0.26 at 75 F 0.55 at 250 F	0.31 at 100 F 0.47 at 500 F
Temperature Limits	1900 F Max, 120 F Min	1600 F Max, 120 F Min	450 F Max, 0 F Min	1000 F Max, 0 F Min
Thermal Shock Resistance	Good within its Temperature Limits	Good within its Temperature Limits	Good within its Temperature Limits	Good within its Temperature Limits
Fire Exposure	Incombustible	Incombustible	Fails at 450 F	Fails at 1100 F
Specific Heat, Btu/lb/°F	.22 to .23	.22 to .30	.20	.20
Density, lbs/cu ft	22 to 26		1 to 6	8 to 12
Compressive Strength, PSI	86 to 118 at 5% Deformation	65 at 1% Deformation	4.1 at 10% Deformation	
Tensile Strength, PSI	18 to 20	70		
Flexural Strength, PSI			33 to 50	
Modulus of Elasticity, PSI				
Absorptivity (of Moisture by Volume)	75% to 86%	.2%	7% to 8%	7% to 8%
Resistance to Acids	Good	Good	Good, Except HF and H ₃ PO ₄	Good, Except HF and H ₃ PO ₄
Resistance to Caustics	Good	Good	Good	Good
Remarks	Use Only as Inner Layer in High-Temperature Service		Do not Apply Over Stainless Steel	Do not Apply Over Stainless Steel



6. MATERIALS PROPERTIES The following tables provide physical and mechanical properties of all available insulants, cements, and environmental barrier mastics. Materials are included (for comparison purposes) that do not appear in the Materials Specifications.

6.1 Rigid Insulation Materials

Insulation Characteristics	Type of Insulation		
	Amosite Asbestos	Calcium Silicate	Cellular Glass
Composition	Amosite Asbestos Fibers with Diatomaceous Silicate Binder	Reacted Hydrous Calcium Silicate and Asbestos Fiber	Hermetically-Sealed Cells of Foamed Glass
General Form	Block and Pipe Insulation	Block and Pipe Insulation	Block and Pipe Insulation
ASTM Specification	C391-59T	C345-60T	C345-56
Thermal Conductivity (at Mean Temperatures)	0.33 at 100 F 0.42 at 300 F 0.55 at 600 F	0.35 at 100 F 0.43 at 300 F 0.56 at 600 F	0.56 at 0 F 0.41 at 100 F 0.55 at 300 F
Temperature Limits	1200 F Max, 120 F Min	1200 F Max, 120 F Min	300 F Max, -400 F Min
Thermal Shock Resistance	Good within its Temperature Limits	Good within its Temperature Limits	Will Spall and Crack when Subjected to Rapid Changes in Temperature
Fire Exposure	Incombustible	Incombustible	Incombustible
Specific Heat, Btu/lb/°F	.22 to .30	.22 to .30	.20
Density, lbs/cu ft	18	10 to 18	9 to 10
Compressive Strength, PSI	35 to 110 at 5% Deformation	66 to 104 at 5% Deformation	100
Tensile Strength, PSI	10 to 40	7.16 to 37	84
Flexural Strength, PSI			100
Modulus of Elasticity, PSI			200,000
Absorptivity (of Moisture by Volume)	1% to 6%	80% to 85%	0.2% (on surface only)
Resistance to Acids	Good	Little to Fair	Good, Except HF and H ₃ PO ₄
Resistance to Caustics	Good	Some to Good	Good
Remarks		Subject to Shrinkage after Wetting. Do not Apply over Stainless Steel.	Requires Bore Coating

C 002749



Insulation Characteristics	Type of Insulation		
	Polyurethane		Vegetable Cork
	Polyester Type	Polyether Type	
Composition	Expanded Polyurethane	Expanded Polyurethane	Cork Granules and Natural Resin Binders
General Form	Block and Pipe Insulation	Block and Pipe Insulation	Block and Pipe Insulation
ASTM Specification			C352-56
Thermal Conductivity (at Mean Temperatures)	0.11 at 0 F 0.14 at 150 F	0.19 at 0 F 0.23 at 150 F	0.24 at 0 F 0.27 at 100 F
Temperature Limits	225 F Max, -425 Min	225 F Max, -300 F Min	200 F Max, -300 F Min
Thermal Shock Resistance	Good within its Temperature Limits	Good within its Temperature Limits	Good within its Temperature Limits
Fire Exposure	Decomposition Begins at 250 F; Fire-Retardant	Decomposition Begins at 250 F; Will Burn	Softens at 200 F; Will Burn
Specific Heat, Btu/lb/°F	.27	.27	.43
Density, lbs/cu ft	2 to 8	2 to 8	6 to 10
Compressive Strength, PSI	25 at 10% Deformation	10 to 18 at 10% Deformation	25 at 25% Deformation
Tensile Strength, PSI	50	50	
Flexural Strength, PSI	50	50	15
Modulus of Elasticity, PSI	1400	1400	
Absorptivity (of Moisture by Volume)	1%	1%	4% to 8%
Resistance to Acids	Good	Good	Not Resistant
Resistance to Caustics	Good	Good	Not Resistant
Remarks			Not Included in Monsanto Standards



6.1 Rigid Insulation Materials (Continued)

Insulation Characteristics	Type of Insulation	
	Foamed Rubber	Ceramic Fiber
Composition	Closed Cell Foamed Plastic	Al_2O_3 and SiO_2 with Asbestos Fiber
General Form	Flexible Tubular Pipe Covering; Sheets for Flat Surfaces	Blocks, Flat Sheets, Pipe Covering, Fitting Covers
ASTM Specification		
Thermal Conductivity, (at Mean Temperatures)	0.25 at 80 F 0.29 at 120 F	0.50 at 600 F 2.26 at 2000 F
Temperature Limits	230 F Max, 32 F Min	2300 F Max, 32 F Min
Thermal Shock Resistance	Good within its Temperature Limits	Excellent
Fire Exposure	Falls at 220 F; Will Burn	Incombustible
Specific Heat, Btu/lb/°F	0.195	
Density, lbs/cu ft	7	25
Compressive Strength, PSI	40 at 10% Deformation	
Tensile Strength, PSI	81	
Flexural Strength, PSI		
Modulus of Elasticity, PSI		
Absorptivity (of Moisture by Volume)	3.9%	100% by Weight
Resistance to Acids	Resistant to Most Common Acids	Good
Resistance to Caustics	Resistant to Most Common Caustics	Poor
Remarks		Expensive. For Extremely High-Temperature Service Only.

C 002751

6.2 Blanket Insulation Materials

Insulation Characteristics	Type of Insulation		
	Fibrous Glass (Low Density)	Mineral Wool (Low Density)	Polyurethane
Composition	Fibrous Glass with Phenolformaldehyde Binder	Mineral Wool with Binders	Expanded Polyurethane
General Form	Various Thicknesses and Density Felts	Blanket, with or without Metal Mesh	Pre-foamed Blanket
Thermal Conductivity (at Mean Temperatures)	0.27 at 40 F 0.29 at 70 F 0.32 at 100 F	0.36 at 200 F 0.57 at 600 F	0.10 at 0 F 0.13 at 200 F
Temperature Limits	350 F Max, 50 F Min	1800 F Max, 120 F Min	225 F Max, -150 F Min
Thermal Shock Resistance	Good within its Temperature Limits	Good within its Temperature Limits	Good within its Temperature Limits
Fire Exposure	Flash Point of Resin is 700 F	Incombustible	Decomposition Begins at 250 F; Will Burn
Density, lbs/cu ft	1/2 to 3	3 to 8	1 to 3
Absorptivity (of Moisture by Volume)	93%	85%	3% to 5%
Resistance to Acids	Good Except HF and H_3PO_4	Requires Protection from All Liquids	Good
Resistance to Caustics	Good	Requires Protection from All Liquids	Good
Remarks	Do not Apply to Stainless Steel		

6.3 Sprayed and Foamed-in-Place Insulation Materials

Insulation Characteristics	Type of Insulation		
	Asbestos		Polystyrene
	Amosite Type	Crocidolite Type	
Composition	100% White Long Asbestos Fiber and Dry Inorganic Binder; Must be Mixed with Water	100% Blue Long Asbestos Fiber and Dry Inorganic Binder; Must be Mixed with Water	Resins and Catalyst, for Foaming-in-Place with Spray Equipment
Thermal Conductivity	0.33 at 100 F 0.46 at 400 F	0.36 at 200 F 0.59 at 700 F	0.25 at 40 F
Temperature Limits	700 F Max, 120 F Min	1300 F Max, 120 F Min	225 F Max, -150 F Min
Thermal Shock Resistance	Good within its Temperature Limits	Good within its Temperature Limits	Good within its Temperature Limits
Fire Exposure	Incombustible	Incombustible	Decomposition Begins at 250 F; Will Burn
Density, lbs/cu ft	12	14	3 to 4
Absorptivity (of Moisture by Volume)	75%	75%	3% to 5%
Resistance to Acids	Good	Good	Good
Resistance to Caustics	Good	Good	Good
Remarks	Do not use as Pipe Covering		

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6.3 Sprayed and Foamed-in-Place Insulation Materials (Continued)

Insulation Characteristics	Type of Insulation		
	Polyurethane	Cork-Filled Asphalt Mastic	Cork-Filled Polyvinyl Acetate
Composition	Resins and Catalyst, for Foaming-in-Place with Spray Equipment	Trowell and Spray Grades of Asphalt Emulsion Filled with Cork Granules; in 5-Gallon Pails or 55-Gallon Drums, Ready-Mixed	Trowell and Spray Grades of PVA Filled with Cork Granules; in 5-Gallon Pails or 55-Gallon Drums, Ready-Mixed
Thermal Conductivity (at Mean Temperatures)	0.19 at 0 F	0.50 at 70 F	0.50 at 70 F
Temperature Limits	225 F Max, -150 F Min	275 F Max, -50 F Min	300 F Max, 40 F Min
Thermal Shock Resistance	Good within its Temperature Limits	Good within its Temperature Limits	Good within its Temperature Limits
Fire Exposure	Decomposition Begins at 250 F; Will Burn	Fire-Retardant when Cured; Flash Point of Asphalt Binder 275 F	Fire-Retardant; Self-Extinguishing within one Minute after Flame is Removed
Density, lbs/cu ft	3 to 4	50	50
Absorptivity	3% to 5%	Impermeable	Impermeable
Resistance to Acids	Good	Not Resistant to Nitric Solutions or Strong Acetic Solutions	Good
Resistance to Caustics	Good	Not Recommended in Strong Alkaline Solutions	Good
Remarks	Use with Caution and then Only with Qualified Applicators	Will Burn Until Cured. Take Necessary Precautions During Application	White Color - Use when Dark Colors are Objectionable

C 002753

6.4 Insulation Cements

Insulation Characteristics	Type of Insulation		
	Asbestos	Vermiculite	Mineral Wool
Composition	Asbestos Fibers and Binders	Expanded Vermiculite and Binders	Mineral Wool and Binders
General Form	Cement to be Mixed with Water	Cement to be Mixed with Water	Cement to be Mixed with Water
Thermal Conductivity (at Mean Temperatures)	1.10 at 200 F 1.40 at 500 F	0.70 at 200 F 0.80 at 500 F	0.47 at 100 F 0.60 at 300 F
Temperature Limits	1000 F Max, 120 F Min	1900 F Max, 120 F Min	1600 F Max, 120 F Min
Thermal Shock Resistance	Good within its Temperature Limits	Good within its Temperature Limits	Good within its Temperature Limits
Fire Exposure	Incombustible	Incombustible	Incombustible
Density, lbs/cu ft	35 to 60	27	34 to 55
Absorptivity	High	High	Porosity 78%
Resistance to Acids	Good	Good	Not Resistant
Resistance to Caustics	Good	Good	Not Resistant

NOTE

1. It is not recommended that thermal insulation cements be employed as a complete system. Cements generally are used as an auxiliary material with either rigid or blanket materials, for covering valves, elbows, special fittings, and irregular shapes; and for pointing-up crevices, cracks, and surface damage. Cements may be used under special design conditions as a cover coat over the insulation materials, and under weather coat or vapor seal.

6.5 Environmental Barrier Mastics

6.5.1 Materials for Cryogenic, Cold, and Dual-Temperatures Services

Material Characteristics	Type of Mastic		
	Cut-Back Asphalt	Co-Polymer Vinyl	Polyester
Composition	Solvent Cut-Back of Asphalt Base with Mineral Fillers	Co-Polymer Vinyl with Mineral Fillers	Chlorosulfonated Polyethylene
General Form	Ready-to-Apply Mastic in Spray and Trowel Grades	Ready-to-Apply Mastic in Spray Grade	Ready-to-Apply Mastic in Spray Grade
Temperature	200 F Max, -40 F Min	160 F Max, 40 F Min	200 F Max, 40 F Min
Fire Exposure	Fire-Retardant; Self-Extinguishing within One Minute after Direct Flame is Removed	Will Burn	Will Burn
Film Build	1/4" Wet in One Coat	11 Mills in Three Coats	7 Mills in Three Coats
Perm-Inch Rating	0.0016 to 0.0028	0.005	0.001
Resistance to Acids	Good	Good	Good
Resistance to Caustics	Good	Good	Good
Resistance to Grease, Oil, or Solvents	Poor	Good	Good
Abrasion Resistance	Good	Poor	Poor
Remarks		Expensive	Expensive

6.3.1 Materials for Elevated Temperatures

Material Characteristics	Type of Mastic	
	Asphalt Emulsion	Polyvinyl Acetate
Composition	"Breathing" Type Asphalt Emulsified with Bentonite Clay	"Breathing" Type Polyvinyl Acetate
General Form	Ready-to-Apply Mastic in Spray and Trowel Grades	Ready-to-Apply Mastic in Spray and Trowel Grades
Temperature Limits	200 F Max, 40 F Min	200 F Max, 40 F Min
Fire Exposure	Fire-Retardant; Self-Extinguishing within One Minute after Direct Flame is Removed	Fire-Retardant; Self-Extinguishing within One Minute after Direct Flame is Removed
Film Build	1/2" Wet in One Coat	1/2" Wet in One Coat
Permeance Rating	0.010 to 0.020	0.010 to 0.020
Resistance to Acids	Good	Good
Resistance to Alkalis	Good	Good
Resistance to Grease, Oil, or Solvents	Poor	Good
Abrasion Resistance	Good	Good

HEAT TRANSFER CALCULATIONS

1. **SCOPE** This Design Standard provides equations and Tables for calculating heat loss and heat gain through thermal insulation on both flat and cylindrical surfaces. Definitions of terms used in the equations and Tables, and convection coefficients for flat and cylindrical surfaces in elevated and low temperature services also are given.

2. USE OF THIS STANDARD Figure 1 is a Flow Chart that shows how the equations and Tables in this Design Standard are used in solving thermal insulation problems.

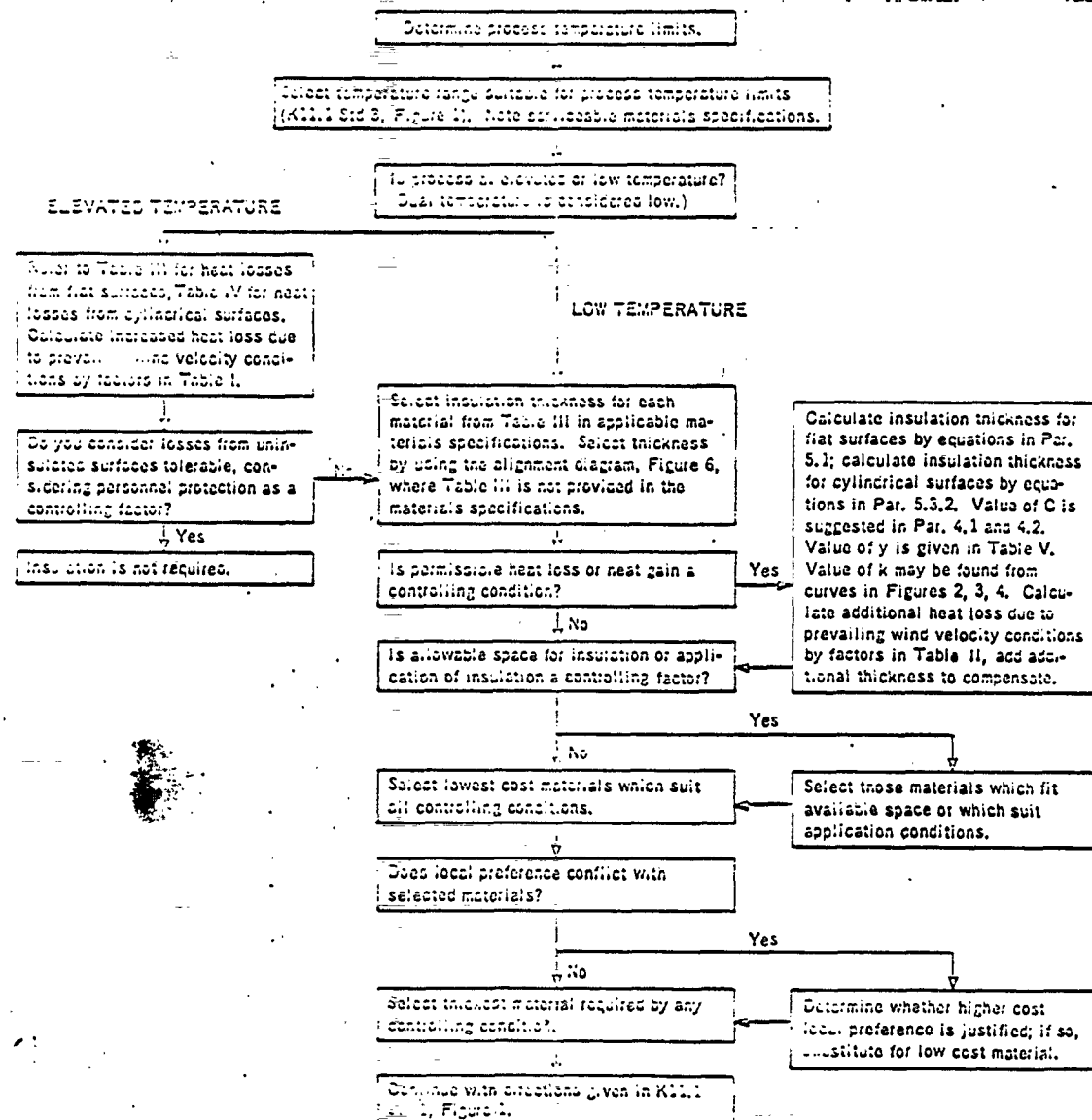


FIGURE 1. HOW TO USE THE EQUATIONS, TABLES, AND FIGURES

REFERENCES

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3. DEFINITIONS OF TERMS Terms used in this standard have the following definitions:

- Q = Heat flux, Btu/hr, sq ft, from bare steel surfaces.
 - q = Heat flux, Btu/hr, sq ft, at equipment or pipe surface beneath the insulation.
 - q = Heat flux, Btu/hr, sq ft, at outer surface of insulation.
 - t_1 = Temperature, F , of the hot or cold surface to be insulated.
 - t_a = Temperature, F , of air surrounding the insulation (ambient).
 - t_s = Temperature, F , of the outer surface of insulation.
 - $\Delta t_1 = t_1 - t_a$ for elevated temperature service,
 $= t_a - t_1$ for low temperature service.
 - $\Delta t_2 = t_s - t_a$ for elevated temperature service,
 $= t_a - t_s$ for low temperature service.
 - RH = Relative humidity of ambient air.
 - R = The sum of resistances, hr, sq ft, $^{\circ}F$ /Btu, through the insulation and the air film surrounding the insulation, e.g., $\frac{x}{k} + \frac{1}{C}$ for flat surfaces.
 - C = Convection coefficient, Btu/hr, sq ft, $^{\circ}F$, used to estimate resistance through the air film surrounding the insulation.
 - $\frac{x}{k}$ = Internal resistance of a single thickness of insulation over a flat surface; x = thickness of insulation, in inches; k = conductivity of the insulation, Btu/hr, sq ft, in., at the mean temperature $\frac{t_1 + t_2}{2}$.
 - $\frac{y}{k}$ = Internal resistance of a single thickness of insulation over a cylindrical surface; y = equivalent thickness of insulation; k is defined above.
- NOTE:** Where the sum of internal resistances of insulation in double layer or composite systems is expressed as $\frac{x_1}{k_1} + \frac{x_2}{k_2}$ for flat surfaces, and $\frac{y_1}{k_1} + \frac{y_2}{k_2}$ for cylindrical surfaces, x_1 and y_1 always represent the inner layer of insulation, x_2 and y_2 always represent the outer layer; k_1 and k_2 are selected to suit the materials and mean temperatures indicated by x_1 , y_1 , x_2 and y_2 .
- D_o = Outside diameter of the outer layer of insulation, inches.
 - D = Outside diameter of the inner layer of insulation, inches.
 - D_p = Outside diameter of pipe or equipment, inches.

d = Inside diameter of either the inner layer or outer layer of insulation, inches.

4. CONVECTION COEFFICIENTS An adequate treatment of convection coefficients is not within the scope of this standard. The following coefficients (expressed as C and defined above), are suggested for use in heat transfer equations:

4.1 Flat Surfaces The value of C for flat surfaces in still air at elevated temperatures may be considered 1.59 for vertical plates, 1.79 for horizontal plates facing upward, and 0.89 for horizontal plates facing downward.

The value of C for flat surfaces in still air at low temperatures may be considered 1.59 for vertical plates, 0.89 for horizontal plates facing upward, and 1.79 for horizontal plates facing downward.

4.2 Cylindrical Surfaces The value of C for cylindrical surfaces in still air, at both elevated and low temperatures, may be considered 1.6.

The value of C for cylindrical surfaces in air moving at 2 miles per hour nominal velocity, at both elevated and low temperatures, may be considered 1.77. The effect of air moving at higher velocities is indicated in Table II, but exact coefficients are not given.

5. HEAT TRANSFER CALCULATIONS Heat transfer calculations when personnel protection at elevated temperatures and prevention of moisture condensation on the insulation surface at low temperatures are the governing design factors are not covered in this standard. Thickness of insulation adequate to meet these design conditions have been calculated from equations based on the insulation surface, and are presented in tabular form in each of the Materials Specifications for insulation. There is no point in repeating these equations here.

Equations in this standard are based on the hot or cold equipment surface beneath the insulation, and are provided for use when control of process temperature and heat flow is the governing design factor.

5.1 Flat Surfaces The equation for calculating heat flow through a single layer of insulation over a flat surface is:

$$q = \frac{\Delta t_1}{\frac{x}{k} + \frac{1}{C}}; q = Q \quad (1)$$

The value of k is determined from Figures 2, 3, and 4; the value of C is suggested in Par. 4.1. For increased heat loss due to wind velocity conditions, multiply 9 by conversion factors in Table II.

Where more than one layer of insulation is applied over a flat surface, the equation becomes:

$$q = \frac{\Delta t_1}{\frac{x_1}{k_1} + \frac{x_2}{k_2} + \frac{1}{C}}; q = Q \quad (2)$$

5.2 Cylindrical Surfaces Cylindrical insulation or pipe covering offers a path of varying area for the flow of heat, and equations are more complicated than for flat surfaces. The classical mathematical treatment utilizes a log mean area for the transfer of heat.

By suitable rearrangement of terms, it is possible to calculate heat flux both on the basis of the external surface of the insulation, and on the basis of the pipe or equipment surface diameter. In practice, there are uses for both methods of calculation; however, only the pipe or equipment surface basis is covered in this standard.

Note that while heat fluxes q and Q are equal for flat surfaces, this is never true for cylindrical surfaces.

5.3 Calculations for Cylindrical Surfaces Equations are based on the pipe or equipment diameter which does not vary with insulation thickness. Calculations are intended to provide the rate of heat loss or gain from or into the process fluid at the pipe or equipment wall.

Equations (1) and (2) still are applicable as long as the heat flow area or the effective thickness of insulation are adjusted to suit a cylindrical object. The common method used for this adjustment is the calculation of an *effective insulation thickness*, y , which takes into account the variable area in the heat flux path.

5.3.1 Calculation of y The following equation defines y :

$$y = 2.513 D_p \log \left(\frac{D}{d} \right) \quad (3)$$

Values of y for single layer insulation in thicknesses 1", 1½", 2", 2½", and 3" over piping ½" through 40" pipe size; and values of y for each layer of double insulation in thicknesses 1", 1½", 2", 2½", and 3" over thicknesses 1", 1½", 2", 2½", and 3" over piping 3" through 40" have been calculated by Equation (3) and are given in Table V.

5.3.2 Heat Flow Equations The equation for calculating heat flux from the surface of a cylindrical object through a single layer of insulation is:

$$q = \frac{\Delta t_1}{\frac{y}{k} + \frac{1}{C} \left(\frac{D_p}{D_o} \right)} \quad (4)$$

The value of y is given in Table V. The value of k is determined from Figures 2, 3, and 4. The value of C is suggested in Par. 4.2. For increased heat loss due to wind velocity conditions, multiply Q by conversion factors in Table II.

Where more than one layer of insulation is required, or the variation of k with temperature is large and it is desirable to treat the insulation as consisting of layers of varying heat resistance, the equation becomes:

$$Q = \frac{\Delta t_1}{\frac{y_1}{k_1} + \frac{y_2}{k_2} + \frac{1}{C} \left(\frac{D_p}{D_o} \right)} \quad (5)$$

5.4 Temperature of the Insulation Surface Temperature of the insulation surface, t_s , may be found by dividing the heat flux for the external surface of the pipe, or equipment by C to obtain the temperature difference:

$$Q \left(\frac{D_p}{D_o} \right) = q = \frac{\Delta t_2}{\frac{1}{C}}; \Delta t_2 = \frac{q}{C} = \frac{Q}{C} \left(\frac{D_p}{D_o} \right) \quad (6)$$

From Paragraph 3, "Definitions":

$$\begin{aligned} \Delta t_2 &= t_s - t_a \text{ for elevated temperature service;} \\ &= t_a - t_s \text{ for low temperature service.} \end{aligned}$$

Substituting in Equation (6):

$$\begin{aligned} t_s &= t_a + \frac{q}{C} \text{ for elevated temperature service;} \\ t_s &= t_a - \frac{q}{C} \text{ for low temperature service.} \end{aligned}$$

5.5 Square Feet to Linear Feet Where it is necessary to determine the rate of heat transfer per linear foot of pipe or cylindrical surface, multiply Q in Equation (4) and (5) by the appropriate conversion factors in Table V.

6. HEAT LOSSES FROM BARE SURFACES Many insulation manufacturers rate their product in terms of efficiency percentage according to results of the following equation:

$$\text{Efficiency} = \left(\frac{V - q}{V} \right) 100 \quad (7)$$

Efficiency ratings so derived can be misleading because of other variables that are not considered. The concept of insulation "efficiency" is not recommended.

Tables III and IV show heat losses from uninsulated flat and cylindrical surfaces at various temperature gradients. To determine the effect of wind velocity on heat loss from bare surfaces, multiply the factors



In Tables III and IV by the conversion factors in Table I. Do not use the conversion factors in Table IV to determine increase in heat loss from insulated surfaces, however.

7. INSULATION THICKNESS TO PREVENT MOISTURE CONDENSATION AT MODERATE TEMPERATURES The alignment diagram, Figure 3, provides a rapid means for calculating adequate thickness of insulation to prevent moisture condensation on surfaces cooler than the ambient temperature, and under a variety of relative humidity conditions. Solve problems as indicated by the dotted line on the diagram, entering the chart at the lower left

scale. This chart provides adequate thickness under still air conditions at moderate temperatures; since still air conditions are the most serious condition in moisture-condensation problems at these temperatures, no conversion factors for wind velocity conditions is required.

This alignment diagram has been reprinted directly from the current edition of the *ASHRAE GUIDE*, and we have no record of results from actual field use. However, recommended thicknesses are within the range of those actually calculated and appearing in the Materials Specifications, and the approach seems adequate for the practical solution of problems.

TABLE I
Increased Heat Loss due to Wind Velocity Conditions, Bare Surfaces.*

Temp., F. of Uninsulated Hot Surface	Wind Velocity, Miles Per Hour				
	2½	5	7½	10	15
200	1.43	1.72	1.92	2.10	2.42
300	1.40	1.66	1.86	2.03	2.33
400	1.36	1.60	1.77	1.93	2.21
500	1.32	1.54	1.70	1.85	2.10
600	1.30	1.48	1.63	1.75	1.97
700	1.26	1.43	1.56	1.66	1.85
800	1.23	1.37	1.49	1.59	1.77
900	1.19	1.33	1.44	1.53	1.67
1000	1.17	1.25	1.36	1.40	1.52
1100	1.15	1.26	1.33	1.40	1.52
1200	1.13	1.23	1.29	1.33	1.44

*Factors shown in this Table are averaged for flat surfaces and for various pipe sizes, and are recommended as close enough for practical use.

TABLE II
Increased Heat Loss due to Wind Velocity Conditions, Insulated Surfaces.*

Insulation Thickness (Inches)	Wind Velocity, Miles Per Hour					
	5	10	15	20	25	30
7	1.07	1.09	1.11	1.12	1.13	1.14
1½	1.05	1.07	1.08	1.09	1.10	1.11
2	1.04	1.06	1.07	1.075	1.08	1.085
2½	1.03	1.04	1.05	1.055	1.06	1.07
3	1.025	1.035	1.04	1.045	1.05	1.06
3½	1.02	1.03	1.035	1.04	1.045	1.05
4	1.015	1.025	1.03	1.035	1.04	1.045
4½	1.013	1.023	1.026	1.033	1.038	1.043
5	1.011	1.021	1.025	1.031	1.036	1.041
5½	1.009	1.019	1.024	1.029	1.034	1.039
6	1.007	1.017	1.022	1.027	1.032	1.037

*Factors shown in this Table are averaged for flat surfaces and for various pipe sizes, and are recommended as close enough for practical use.

TABLE III

Heat Loss from Bare Flat Surfaces under Still Air Conditions at 70°F Ambient Temperature.

Temperature of Uninsulated Hot Surface, F	Btu/Square Feet, Hour		
	Vertical Surface C = 1.394	Horizontal Surface	
		Facing Upward C = 1.79	Facing Downward C = 0.89
100	50	67	42
200	300	355	252
300	650	860	600
400	1150	1550	965
500	1800	2420	1510
600	2650	3570	2125
700	3750	5070	3150
800	5100	6850	4260
900	6800	8200	5700
1000	8900	12100	7500
1100	11400	15400	9600
1200	14400	19400	12100
1300	17900	24100	15000
1400	21750	29350	18250
1500	26000	35000	21800
1600	30500	41200	25600
1700	35500	48000	29600
1800	40800	55000	34300
1900	46500	62800	39000

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TABLE IV

Heat Loss from Bare Cylindrical Surfaces under Still Air Conditions at 70° Ambient Temperature. $C = 1.6$ for all Cylindrical Surfaces.

Temp F of Hot Surface	Pipe Size (IPS or Nominal), Inches								
	1/2	3/4	1	1 1/2	2	3	4	6	8
100	13	16	20	27	34	48	61	67	112
200	76	93	114	130	156	260	354	503	644
300	163	205	250	326	432	620	764	1122	1436
400	267	353	434	613	753	1083	1370	1976	2530
500	445	547	674	955	1176	1695	2149	3105	3988
600	649	801	969	1403	1732	2505	3179	4604	5927
700	901	1113	1379	1960	2423	3511	4467	6479	8356
800	1218	1506	1855	2661	3295	4784	6094	8656	11433
900	1602	1964	2462	3514	4355	6357	8079	11769	15211
1000	2075	2576	3194	4566	5665	8259	10545	15366	19695
1100	2644	3232	4060	5841	7251	10582	13513	19740	25566
1200	3317	4122	5123	7345	9133	13344	17049	24909	32293

Temp F of Hot Surface	Pipe Size (IPS or Nominal), Inches							
	10	12	14	16	18	20	24	30
100	136	159	174	197	221	244	289	351
200	791	930	1009	1142	1282	1416	1683	2042
300	1769	2076	2258	2560	2875	3168	3772	4642
400	3114	3664	3985	4529	5074	5618	6679	8242
500	4918	5809	6316	7160	8032	8897	10595	13103
600	7312	8627	9404	10697	12010	13270	15825	19606
700	10325	12194	13301	15124	16992	18777	22375	27756
800	14147	16721	18236	20769	23346	25810	30836	38299
900	18812	22248	24279	27663	31109	34432	41112	51107
1000	24621	29133	31644	36257	40768	45157	53958	67126
1100	31679	37501	40965	46689	52539	58159	69536	86586
1200	40051	47429	51856	59089	66456	73691	88221	109672

NOTE: Heat loss is given in Btu's per Linear Foot of cylindrical surface per hour; to convert to square feet, use the appropriate factor in Table VI.

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TABLE V. VALUES OF y FOR SINGLE-LAYER AND DOUBLE-LAYER INSULATION¹

Pipe Size (inches)		Factors (Note 1)	Single Layer or Inner Layer Insulation		Outer Layer over Single Layer Insulation Thickness, inches				
Nominal	OD (D_p)		Thk		1	1½	2	2½	3
½	0.84	D	1	2.88					
		y							
		D	1½	4.00					
		y		0.68					
		D	2	5.00					
		y		0.75					
¾	1.05	D	2½	6.63					
		y							
		D	3	7.63					
		y							
		D	1	3.50					
		y		0.63					
1	1.32	D	1½	4.50					
		y		0.76					
		D	2	5.56					
		y		0.88					
		D	2½	6.63					
		y		0.97					
1½	1.65	D	3	7.63					
		y		1.04					
		D	1	3.50					
		y		0.64					
		D	1½	4.50					
		y		0.81					
2	2.00	D	2	5.56					
		y		0.95					
		D	2½	6.63					
		y		1.07					
		D	3	7.63					
		y		1.16					

¹D = D_i , $y = y_i$ for single or inner layer; D = D_o , $y = y_o$ for outer layer.

TABLE V. VALUES OF y FOR SINGLE-LAYER AND DOUBLE-LAYER INSULATION¹
(Continued)

Pipe Size (Inches)		Factors (Note 1)	Single Layer or Inner Layer Insulation		Outer Layer over Single Layer Insulation Thickness, inches				
Nominal	OD (D_p)		Thk		1	1½	2	2½	3
1½	1.90	D	1	4.00					
		y		0.71					
		D	1½	5.00					
		y		0.92					
		D	2	6.63					
		y							
		D	2½	7.63					
		y							
		D	3	8.63					
		y							
		D							
		y							
2	2.38	D	1	4.50					
		y		0.76					
		D	1½	5.56					
		y		1.01					
		D	2	6.63					
		y		1.22					
		D	2½	7.63					
		y		1.39					
		D	3	8.63					
		y		1.53					
		D							
		y							
3	3.50	D	1	5.56	7.63	8.63			
		y		0.81	0.55	0.77			
		D	1½	6.63		9.63	10.75		
		y		1.12		0.65	0.85		
		D	2	7.63			11.75	12.75	14.00
		y		1.36			0.76	0.90	1.06
		D	2½	8.63				14.00	15.00
		y		1.56				0.85	0.97
		D	3	9.63					16.00
		y		1.77					0.89
		D							
		y							

¹ $D = D_i$, $y = y_i$ for single or inner layer; $D = D_o$, $y = y_o$ for outer layer.

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TABLE V. VALUES OF y FOR SINGLE-LAYER AND DOUBLE-LAYER INSULATION¹
(Continued)

Pipe Size (inches)		Factors (Note 1)	Single Layer or inner Layer Insulation		Outer Layer over Single Layer Insulation Thickness, Inches						
Nominal OD (D_p)			Thk		1	1½	2	2½	3		
4	4.50	D	1	6.63	6.63	9.63					
		y		0.87	0.59	0.64					
		D	1½	7.63		10.75	11.75				
		y		1.19		0.77	0.97				
		D	2	8.63			12.75	14.00	15.00		
		y		1.47			0.88	1.09	1.24		
		D	2½	9.63				15.00	16.00		
		y		1.71				1.00	1.14		
		D	3	10.75					17.00		
		y		1.95					1.03		
		6	6.63	D	1	8.63	10.75	11.75			
				y		0.87	0.73	1.02			
D	1½			9.63		12.75	14.00				
y				1.24		0.93	1.24				
D	2			10.75			15.00	16.00	17.00		
y				1.60			1.10	1.32	1.52		
		D	2½	11.75				17.00	18.00		
		y		1.90				1.22	1.41		
		D	3	12.75					19.00		
		y		2.17					1.32		
		8	8.63	D	1	10.75	12.75	14.00			
				y		0.95	0.74	1.14			
D	1½			11.75		15.00	16.00				
y				1.33		1.05	1.33				
D	2			12.75			17.00	18.00	19.00		
y				1.68			1.24	1.49	1.72		
		D	2½	14.00				19.00	20.00		
		y		2.09				1.32	1.54		
		D	3	15.00					21.00		
		y		2.39					1.45		

¹ $D = D_1$, $y = y_1$ for single or inner layer; $D = D_2$, $y = y_2$ for outer layer.

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TABLE V. VALUES OF y FOR SINGLE-LAYER AND DOUBLE-LAYER INSULATION¹
(Continued)

Pipe Size (Inches)		Factors (Note 1)	Single Layer or Inner Layer Insulation		Outer Layer over Single Layer Insulation Thickness, Inches				
Nominal OD (D_p)			Thk		1	1½	2	2½	3
10	10.75	D	1	12.75	15.00	16.00			
		y		0.92	0.87	1.22			
		D	1½	14.00		17.00	18.00		
		y		1.42		1.04	1.35		
		D	2	15.00			19.00	20.00	21.00
		y		1.79			1.27	1.55	1.81
		D	2½	16.00				21.00	22.00
		y		2.14				1.46	1.71
		D	3	17.00					23.00
		y		2.45					1.62
12	12.75	D	1	15.00	17.00	18.00			
		y		1.04	0.80	1.16			
		D	1½	16.00		19.00	20.00		
		y		1.45		1.10	1.42		
		D	2	17.00			21.00	22.00	23.00
		y		1.63			1.35	1.64	1.93
		D	2½	18.00				23.00	24.00
		y		2.20				1.56	1.83
		D	3	19.00					25.00
		y		2.54					1.75
14	14.00	D	1	16.00	18.00	19.00			
		y		0.93	0.82	1.20			
		D	1½	17.00		20.00	21.00		
		y		1.36		1.14	1.48		
		D	2	18.00			22.00	23.00	24.00
		y		1.76			1.40	1.72	2.01
		D	2½	19.00				24.00	25.00
		y		2.14				1.64	1.92
		D	3	20.00					26.00
		y		2.50					1.84

¹ $D = D_i$, $y = y_i$ for single or inner layer; $D = D_o$, $y = y_o$ for outer layer.

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TABLE V. VALUES OF y FOR SINGLE-LAYER AND DOUBLE-LAYER INSULATION¹
(Continued)

Pipe Size (inches)		Factors (Note 1)	Single Layer or Inner Layer Insulation		Outer Layer over Single Layer Insulation Thickness, inches						
Nominal	OD (D_p)		Thk		1	1½	2	2½	3		
16	16.00	D	1	18.00	20.00	21.00					
		y		0.84	0.84	1.23					
		D	1½	19.00		22.00	23.00				
		y		1.37		1.17	1.53				
		D	2	20.00			24.00	25.00	26.00		
		y		1.75			1.46	1.79	2.10		
16	16.00	D	2½	21.00				26.00	27.00		
		y		2.18				1.71	2.01		
		D	3	22.00					28.00		
		y		2.55					1.93		
		18	18.00	D	1	20.00	22.00	23.00			
				y		0.85	0.85	1.26			
D	1½			21.00		24.00	25.00				
y				1.39		1.20	1.57				
D	2			22.00			26.00	27.00	28.00		
y				1.81			1.50	1.84	2.17		
18	18.00	D	2½	23.00				28.00	29.00		
		y		2.21				1.77	2.09		
		D	3	24.00					30.00		
		y		2.55					2.01		
		20	20.00	D	1	22.00	24.00	25.00			
				y		0.95	0.87	1.28			
D	1½			23.00		26.00	27.00				
y				1.40		1.23	1.60				
D	2			24.00			28.00	29.00	30.00		
y				1.82			1.54	1.89	2.23		
20	20.00	D	2½	25.00				30.00	31.00		
		y		2.23				1.82	2.15		
		D	3	26.00					32.00		
		y		2.62					2.08		

¹ $D = D_1$, $y = y_1$ for single or inner layer; $D = D_2$, $y = y_2$ for outer layer.

TABLE V. VALUES OF y FOR SINGLE-LAYER AND DOUBLE-LAYER INSULATION¹
(Continued)

Pipe Size (inches)		Factors (Note 1)	Single Layer or Inner Layer Insulation		Outer Layer over Single Layer Insulation Thickness, Inches				
Nominal	OD (D_o)		Thk		1	1½	2	2½	3
24	24.00	D	1	26.00	26.00	29.00			
		y		0.96	0.89	1.31			
		D	1½	27.00		30.00	31.00		
		y		1.41		1.26	1.65		
		D	2	28.00			32.00	33.00	34.00
		y		1.85			1.50	1.97	2.33
		D	2½	29.00				34.00	35.00
		y		2.27				1.91	2.26
		D	3	30.00					36.00
		y		2.68					2.19
30	30.00	D	1	32.00	34.00	35.00			
		y		0.97	0.91	1.34			
		D	1½	33.00		36.00	37.00		
		y		1.43		1.31	1.72		
		D	2	34.00			37.00	38.00	40.00
		y		1.87			1.67	2.05	2.44
		D	2½	35.00				40.00	41.00
		y		2.31				2.00	2.37
		D	3	36.00					42.00
		y		2.73					2.31
36	36.00	D	1	38.00	40.00	41.00			
		y		0.97	0.92	1.37			
		D	1½	39.00		42.00	43.00		
		y		1.44		1.33	1.76		
		D	2	40.00			44.00	45.00	46.00
		y		1.90			1.72	2.12	2.52
		D	2½	41.00				46.00	47.00
		y		2.34				2.07	2.46
		D	3	42.00					48.00
		y		2.77					2.40

¹ $D = D_o$, $y = y_1$ for single or inner layer; $D = D_o$, $y = y_2$ for outer layer.

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TABLE V. VALUES OF y FOR SINGLE-LAYER AND DOUBLE-LAYER INSULATION¹
(Continued)

Pipe Size (Inches)		Factors (Note 1)	Single Layer or Inner Layer Insulation		Outer Layer over Single Layer Insulation Thickness, Inches				
Nominal	OD (D_p)		Thk		1	1½	2	2½	3
40	40.00	D	1	42.00	44.00	45.00			
		y		0.95	0.93	1.35			
		D	1½	43.00		46.00	47.00		
		y		1.45		1.25	1.75		
		D	2	44.00			48.00	49.00	50.00
		y		1.91			1.74	2.16	2.60
		D	2½	45.00				50.00	51.00
		y		2.36				2.12	2.52
		D	3	45.00					52.00
		y		2.80					2.46

¹ $D = D_i$, $y = y_i$ for single or inner layer; $D = D_o$, $y = y_o$ for outer layer.

TABLE VI. SQUARE FEET PER LINEAR
FOOT OF PIPE, BARE

Pipe Size, IPS or Nominal (Inches)	Bare	Pipe Size, IPS or Nominal (Inches)	Bare
½	.220	10	2.82
¾	.272	12	3.37
1	.346	14	3.66
1½	.500	16	4.18
2	.625	18	4.71
3	.917	20	5.25
4	1.18	24	6.30
6	1.74	30	7.85
8	2.26	36	9.44

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STANDARDS

 t_F = Mean Temperature, $\frac{(t_1 + t_2)}{2}$, $t_F = 60^\circ\text{F}$.

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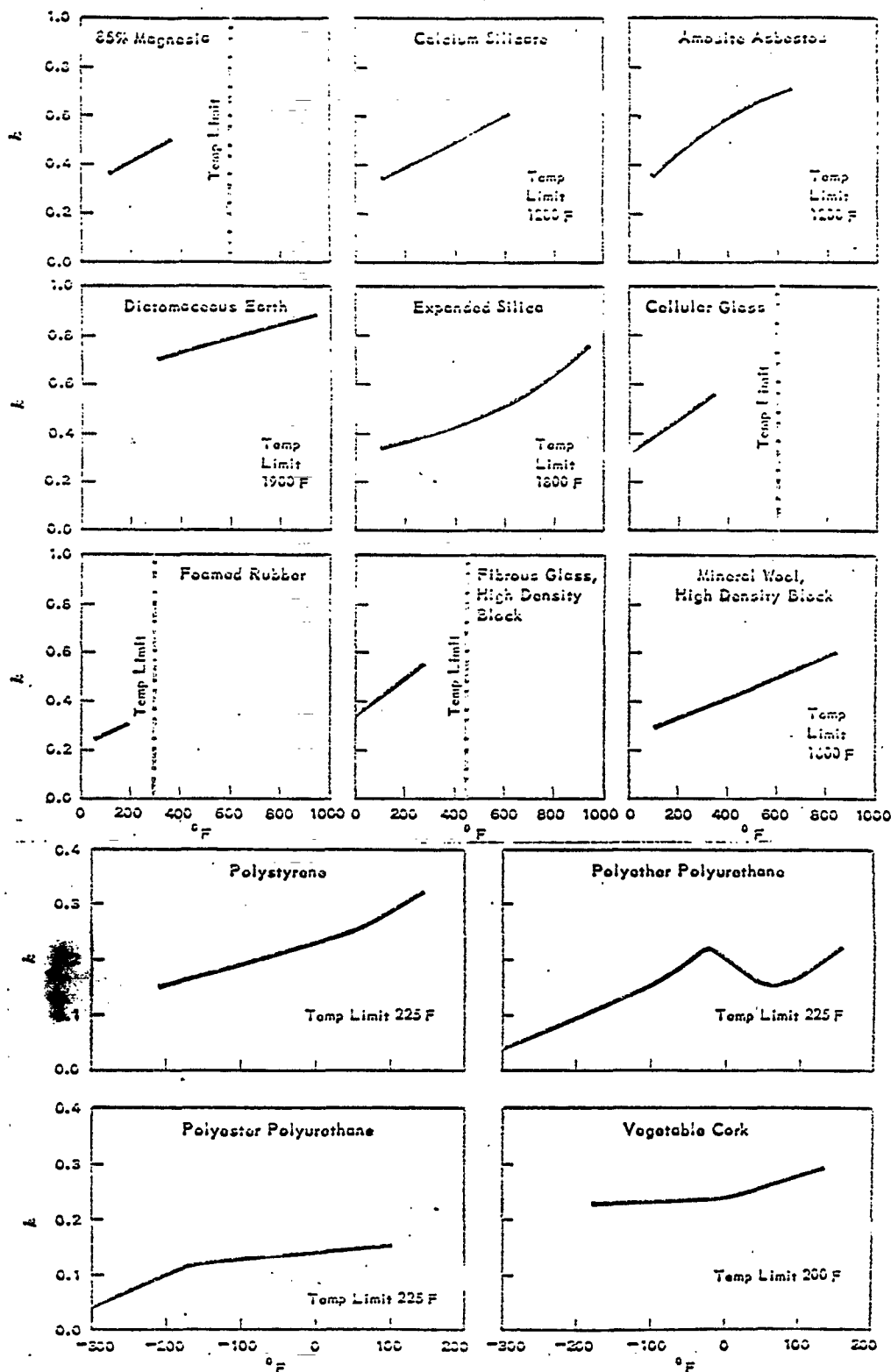
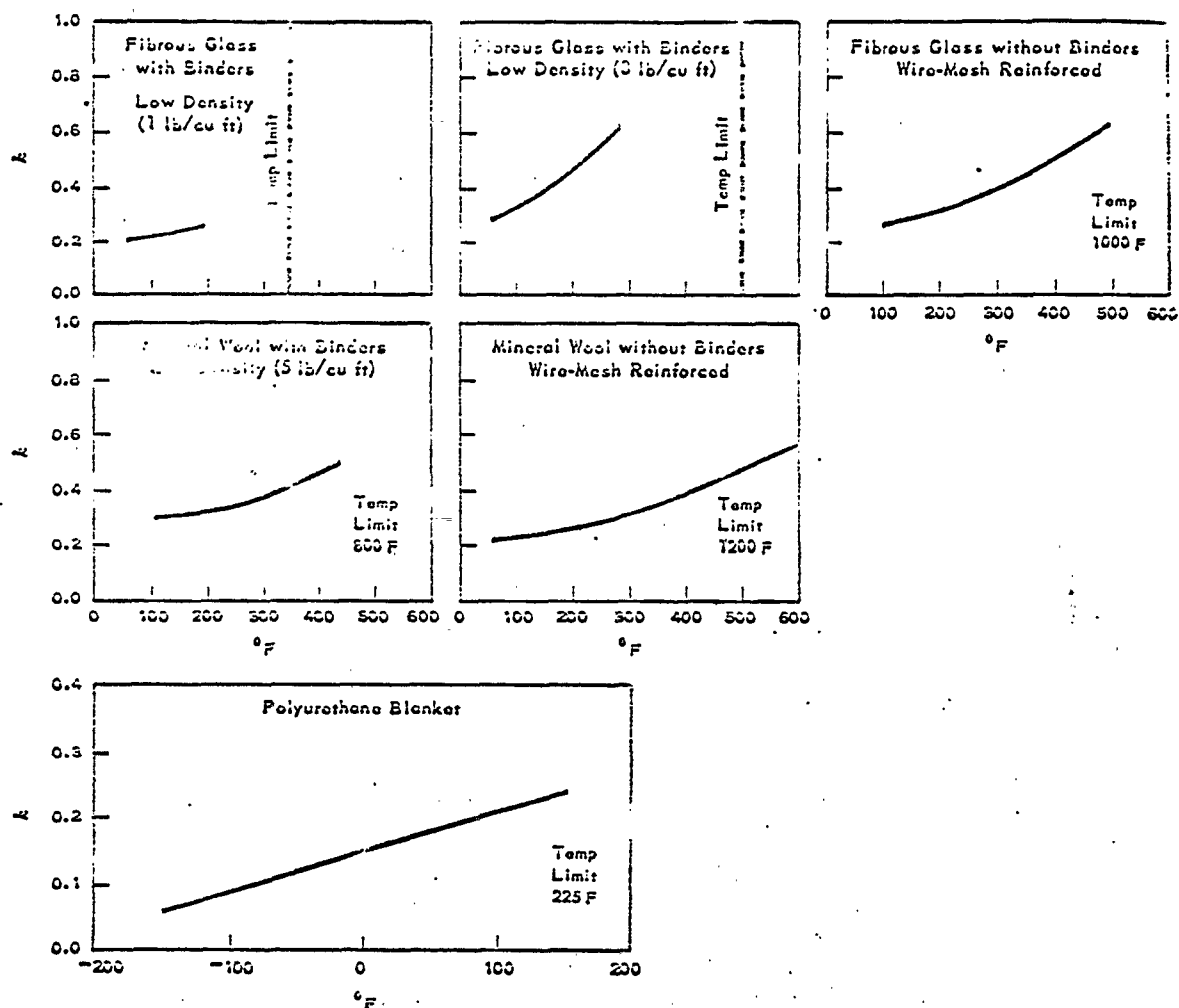
 k = Btu/inch thickness/hr sq ft/°F.

FIGURE 2. MEAN CONDUCTIVITY FACTORS

RIGID INSULATION MATERIALS

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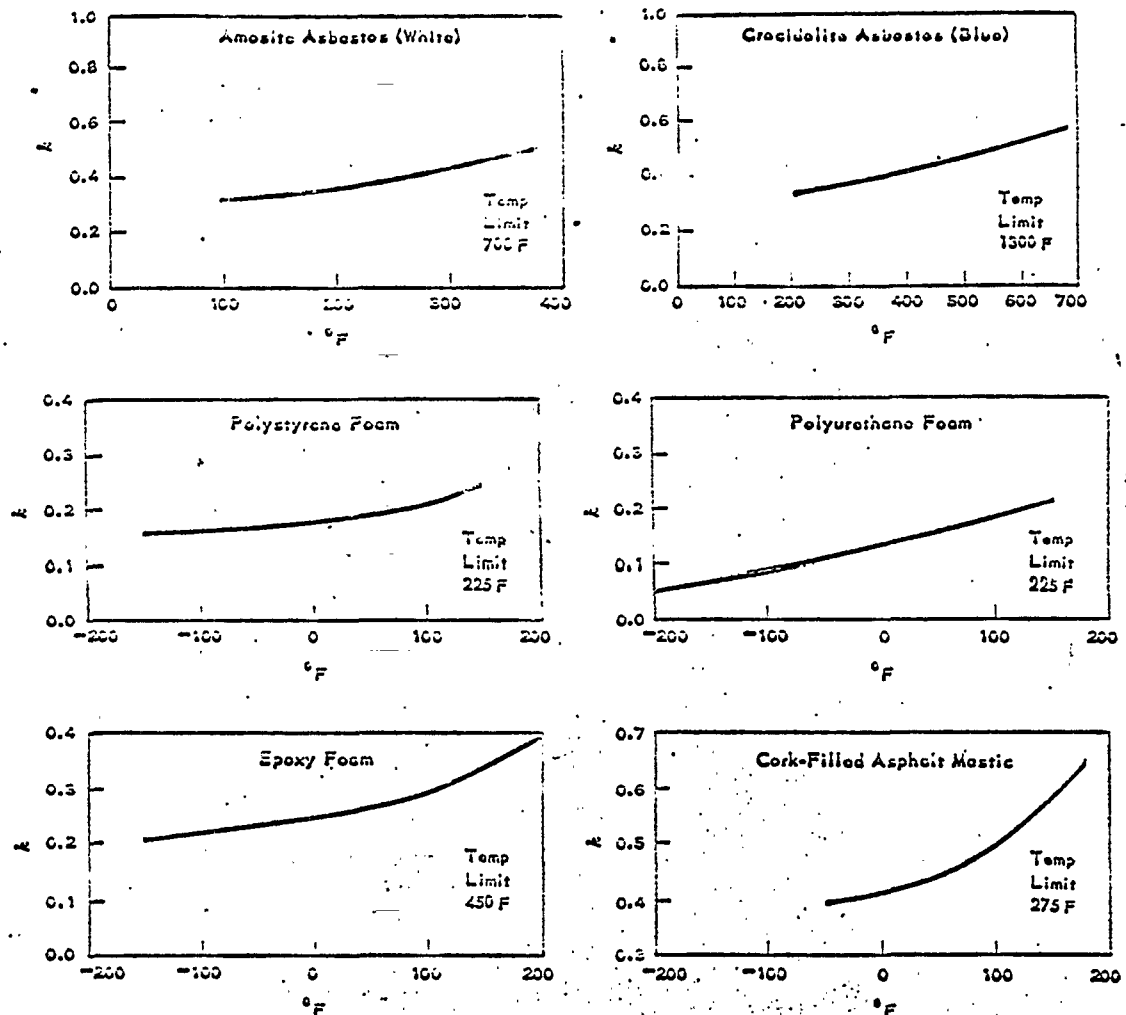


$^{\circ}\text{F}$ = Mean Temperature, $\frac{(t_1 + t_2)}{2}$, $t_a = 80^{\circ}\text{F}$.

k = Btu/inch thickness/hr/sq ft/ $^{\circ}\text{F}$.

FIGURE 3. MEAN CONDUCTIVITY FACTORS FOR BLANKET OR BATT INSULATION MATERIALS

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$^{\circ}\text{F}$ = Mean Temperature, $\frac{(t_1 + t_2)}{2}$, $t_2 = 80^{\circ}\text{F}$.

k = Br/Inch thickness/hr/sq ft/ $^{\circ}\text{F}$.

FIGURE 4. MEAN CONDUCTIVITY FACTORS FOR FOAMED AND SPRAYED INSULATION MATERIALS

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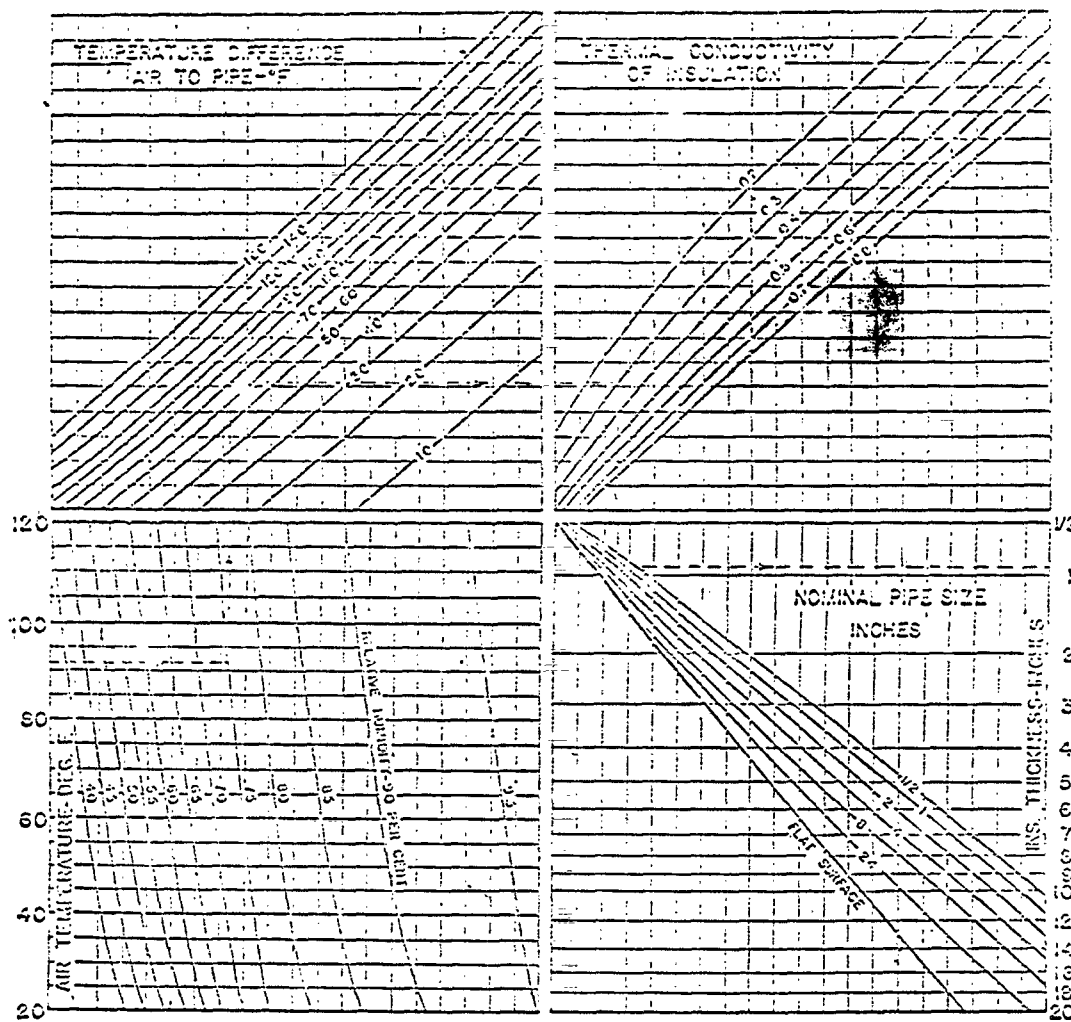


FIGURE 5. THICKNESS OF PIPE INSULATION TO PREVENT
 CONDENSATION ON OUTER SURFACE

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INTRODUCTION

1. SCOPE This Information Standard describes the format and content of the Insulation Materials Specification and gives the premises for thickness and temperature limitations that are shown.

2. FORMAT AND CONTENT

2.1 Product Lists Product lists are provided for materials used in insulation systems for elevated and low temperature services. Materials listed are of comparable quality within their generic classification. Trade names and suppliers listed are those compiled from the literature; omission of any trade name or supplier is inadvertent.

The product lists describe in tabular form available items within each generic classification of insulation and auxiliary materials, trade names, name and address of suppliers, and delivery information. These lists are intended for Monsanto internal use only.

2.1.1 Nomenclature Terms used to describe shapes and sizes of insulation materials are those used widely in the industry. It is recommended that the terms given be used in purchasing insulation components: there are instances where additional cost was incurred because items were not described precisely.

2.2 Materials Specifications Each Materials Specification covers a particular generic type and composition of insulation material, and the auxiliary materials required to make up an adequate system. These Specifications are intended for both Monsanto internal use and use by contractors, and may be attached to and become part of Contract Documents.

Composition of the insulation material is described first. Shown next, in tabular form, are the shapes and sizes normally used in Monsanto practice, and the items to which they are applied. ASTM Specification, if available, appears in this table.

A second table describes auxiliary materials by commonly-used terms, gives the generic type, and shows where each material is used in the insulation system.

2.2.1 Thickness and Temperature Limitations Materials handling and storeroom considerations indicate that it is desirable to limit the number of available thicknesses of insulation materials. For this reason, the Materials Specifications show 2" as the minimum thickness used. Insulation in thicknesses 1" through 3" are applied in single layers; thicknesses 3½" through 6" are applied in double layers, with the layer of greater thickness applied last for greater mechanical protection.

Maximum hot-surface temperatures, in degrees F, are given for each single and double thickness of insulation over flat and cylindrical surfaces in elevated temperature service. Design conditions for these temperatures are 120F at the insulation surface in 80F still air. Heat loss averages 38-40 Btu/hr, sq ft, based on exterior.

Minimum cold-surface temperatures, in degrees F, are given for each single and double thickness of insulation over flat and cylindrical surfaces in low temperature service. The temperature-thickness combinations shown are those that will prevent condensation of moisture on the insulation surface.

Design conditions to the left of and below the heavy black line on the tables in these specifications are 90F still air at 80% relative humidity; heat gains average 7-9 Btu/hr, sq ft, based on exterior. Design conditions to the right of and above the heavy black line in the tables are 40F air at 80% relative humidity and moving at 2 miles per hour velocity; heat gains average 2-4 Btu/hr, sq ft, based on exterior.

Thicknesses in these tables may be used when process control or economic thickness requirements do not govern insulation design. For a more comprehensive discussion of design criteria see K11.2 Std 1.

C 002772

STANDARDS

COATINGS AND INSULATION MANUAL
THERMAL INSULATION MATERIALS SPECIFICATIONS

PRODUCT LIST

Insulation Systems for Elevated Temperature Service

PRODUCT PART

K11.2 STD 2

ISSUE 1 DATE 1964

PAGE 1 OF 2

1. SCOPE This Product List covers trade names and suppliers of materials described in the Thermal Insulation Materials Specifications for temperatures ranging from 200 to 2300 F. Materials listed are of comparable quality within their generic classification. Insulating materials are listed first; listing of auxiliary materials follows.

2. INSULATING MATERIALS

ITEM: Generic Classification and Availability	TRADE NAME	SUPPLIER	NOTES
CALCIUM SILICATE:			
Flat blocks with and without bevel; curved and bevelled sidewall segments; head segments to suit flat and standard dished heads; sections and segments for straight pipe.	CALSILITE	The Ruberoid Co., New York, N.Y.	Curved sidewall segments and head segments are special order items. Allow 2-4 weeks for delivery. All other items are carried in stock.
	CALTEMP	Fiberboard Paper Products Co., San F., Cal.	
	RYLO	The Eagle-Picher Co., Cincinnati, Ohio	
	KAYLO	Owens-Corning Fiberglas Co., Toledo, Ohio	
	KAYTHERM (block)	Keasbey & Mattison Co., Ambler, Pa.	
	K & M ZEBRA (pipe)		
	THERMASIL	Bolwin-Ehret-Hill, Inc., Trenton, N.J.	
THERMOBESTOS	Johns-Manville Corp., New York, N.Y.		
Shaped head segments to suit 2-1 elliptical heads and standard radius flanged heads; preformed covers for pipe fittings, line flanges, and screwed or butt-welding valves to 12" IPS.	TRI-CALITE	Muncet Cork Corp., North Bergen, N.J.	Head segments are special order items; allow 5 weeks for delivery. Fitting covers available in 2-4 weeks after order.
	ALL TRADE NAMES LISTED ABOVE	B & B Engineering Co., Houston, Texas	
		Preformed Metal Products Co., Snyveport, La.	Special Order items; 2-4 weeks delivery.
Sections and segments to suit pipe bends conforming to standard radius.		B & B Engineering Co., Houston, Texas	

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REFERENCES

LATEST ADDITIONS OR REVISIONS ARE SHOWN BY



2. INSULATING MATERIALS (Continued)

ITEM: Generic Classification and Availability	TRADE NAME	SUPPLIER	NOTES
EXPANDED SILICA:			
Flat blocks with and without bevel; curved and bevelled sidewall segments; head segments to suit flat and standard dish heads; sections and segments for straight pipe.	CAREYTEMP	The Philip Carey Co., Cincinnati, Ohio	Curved side-wall segments are special order items. Allow 2-4 weeks for delivery.
Premolded covers for pipe fittings, line flanges, and screwed or butt-welding flanges to 12" IPS; preformed sections and segments to suit pipe bends conforming to standard radius; snap-on head segments to suit 2-1 elliptical and standard radius flanged heads.		B & B Engineering Co., Houston, Texas.	Fitting covers are stock items. All others are special order items; allow 2-4 weeks for delivery.
RIGID AMOSITE ASBESTOS:			
Flat blocks with and without bevel; head segments to suit flat and standard dish heads; sections for straight pipe.	ABOSITE	Aber Co., Inc., Houston, Texas	Stock Items.
	UNIBESTOS	Pittsburgh Corning Co., Pittsburgh, Pa.	
Curved and bevelled sidewall segments; preformed covers for pipe fittings, line flanges, and screwed and butt-welding flanges to 12" IPS; shaped head segments to suit 2-1 elliptical and standard radius flanged heads; sections and segments to suit pipe bends conforming to standard radius.	ABOSITE	Aber Co., Inc., Houston, Texas	2-4 weeks delivery
	UNIBESTOS	B & B Engineering Co., Houston, Texas	
		Preformed Metal Products Co., Shreveport, La.	
RIGID MINERAL WOOL:			
Flat blocks without bevel.	MONO-BLOCK	Baldwin-Ehret-Hill, Inc., Trenton, N.J.	Stock Items
	CAREY MINERAL WOOL BLOCK	The Philip Carey Co., Cincinnati, Ohio	
	J-M SPINTEX	Johns-Manville Corp., New York, N.Y.	
	PV SUPERTEMP	The Eagle-Picher Co., Cincinnati, Ohio	
	WEBER'S H-T BLOCK	48 Insulations, Inc., Aurora, Ill.	
MINERAL WOOL BATT AND BLANKET:			
Reinforced with expanded metal mesh.	B-E-H No. 100	Baldwin-Ehret-Hill, Inc., Trenton, N.J.	Stock Items
	MINERAL WOOL BLANKET	The Philip Carey Co., Cincinnati, Ohio	
	J-M BANROC BLANKET	Johns-Manville Corp., New York, N.Y.	
	COPRIERE	48 Insulations, Inc., Aurora, Ill.	

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2. INSULATING MATERIALS (Continued)

ITEM: Generic Classification and Availability	TRADE NAME	SUPPLIER	NOTES
Non-reinforced.	J-M SPARTEX	Johns-Manville Corp., New York, N.Y.	Stock Items
RIGID FIBROUS GLASS:			
Flat sheets and blocks without bevel.	G-B FIBER GLASS INSUL- ATION BOARD	Gustin-Bacon Mfg. Co., Kansas City, Mo.	Stock Items
	FIBERGLAS PF	Owens-Corning Fiberglass Co., Toledo, Ohio	
Sections for straight pipe.	G-B SNAP ON	Gustin-Bacon Mfg. Co., Kansas City, Mo.	
	FIBERGLAS PIPE INSUL- ATION	Owens-Corning Fiberglass Co., Toledo, Ohio	
	SUPERGLAS	The Eagle-Picher Co., Cincinnati, Ohio	
	PPG FIBER GLASS	Pittsburgh Plate Glass Co., Pittsburgh, Pa.	
	THERMOGLAS PIPE COVERING	The Philip Carey Co., Cincinnati, Ohio	
	J-M MICRO-LOK	Johns-Manville Corp., New York, N.Y.	
Premolded covers for pipe fittings, line flanges, and screwed or butt-welding valves.	G-B SNAP ON	Gustin-Bacon Mfg. Co., Toledo, Ohio	
	FIBERGLAS PIPE INSUL- ATION	Owens-Corning Fiberglass Co., Toledo, Ohio	
	SUPERGLAS	Insulocoustic Corp., New York, N.Y.	
	PPG FIBER GLASS		
	THERMOGLAS PIPE COVERING		
	J-M MICRO-LOK		
RIGID FIBROUS GLASS, HIGH DENSITY:			
Flat sheets and blocks without bevel.	GPL-400	Owens-Corning Fiberglass Co., Toledo, Ohio	Stock Items
Sections for straight pipe.			
Premolded covers for pipe fittings, line flanges, and screwed or butt-welding valves.			

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2. INSULATING MATERIALS (Continued)

ITEM: Generic Classification and Availability	TRADE NAME	SUPPLIER	NOTES
FIBROUS GLASS BLANKET:			
Resin-bonded, non-reinforced	J-M MICROLITE	Johns-Manville Corp., New York, N.Y.	Stock Material
	FIBERGLAS AEROWRAP	Owens-Corning Fiberglas Co., Toledo, Ohio	
	PPG SUPERFINE	Pittsburgh Plate Glass Co., Pittsburgh, Pa.	
	G-B BLANKET	Gustin-Bacon Mfg. Co., Kansas City, Mo.	
Without binder, non-reinforced	FIBERGLAS TW-F INSUL- ATING WOOL	Owens-Corning Fiberglas Co., Toledo, Ohio	
Resin-bonded, wire mesh reinforced	FIBERGLAS METAL MESH BLANKET	Owens-Corning Fiberglas Co., Toledo, Ohio	
Without binder, wire mesh reinforced	FIBERGLAS BLANKET TYPE PIPE INSULATION	Owens-Corning Fiberglas Co., Toledo, Ohio	
CERAMIC FIBER:			
Flat blocks with and without bevel; sections and segments for straight pipe.	FIBERFRAX	Carborundum Corp., Niagara Falls, N.Y.	Stock Items
	J-M CERTAFELT	Johns-Manville Corp., New York, N.Y.	
Covers for pipe fittings, line flanges, and screwed or butt-welding valves to 12" IPS.	FIBERFRAX	B & B Engineering Co., Houston, Texas	2-4 weeks delivery.
	J-M CERTAFELT		
DIATOMACEOUS EARTH:			
Flat blocks with and without bevel; sections and segments for straight pipe.	HI-TEMP No. 19	The Philip Carey Co., Cincinnati, Ohio	Stock Items
	HY-TEMP	Keasbey & Mattison Co., Ambler, Pa.	
	J-M SUPEREX	Johns-Manville Corp., New York, N.Y.	
	PRASCO 15-C	Fiberboard Paper Products Co., San Francisco, Cal.	
Covers for pipe fittings, line flanges, and screwed or butt-welding valves to 12" IPS; AVAILABLE ONLY IN LAMINATE WITH OUTSIDE COVER SPECIFIED.	ALL TRADE NAMES LISTED ABOVE	B & B Engineering Co., Houston, Texas	Special order items; 2-4 weeks delivery.
		Preformed Metal Products Co., Shreveport, La.	

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2. INSULATING MATERIALS (Continued)

ITEM: Generic Classification and Availability	TRADE NAME	SUPPLIER	NOTES
CELLULAR GLASS:			
Flat blocks with and without bevel; curved and beveled sidewall segments; nose segments to suit flat and standard dished heads; sections and segments for straight pipe.	FOAMGLAS	Pittsburgh Corning Co., Pittsburgh, Pa.	Stock Items
Preformed covers for pipe fittings, line flanges, and screwed or butt-welding valves to 12" IPS.		B & B Engineering Co., Houston, Texas	2-4 weeks delivery.
		Preformed Metal Products Co., Shreveport, La.	
		Armstrong Contracting & Supply Co., St. Louis, Mo.	
Sections and segments to suit pipe bends conforming to standard radius; shaped head segments to suit 2-1 elliptical and standard radius flanged heads.		B & B Engineering Co., Houston, Texas	Special Order Items.
SPRAYED ASBESTOS:			
Amosite (White)	LIMPET	Keesbey & Mattison Co., Ambler, Pa.	Stock Material
Oreocel/lite (Blue)			

3. ANTI-SWEAT MASTIC COATINGS

ITEM: Generic Classification and Availability	TRADE NAME	SUPPLIER	NOTES
CORK-FILLED ASPHALT:			
Fire-retardant cork-filled "breathing" type asphalt mastic, in 5-gallon pails and 55-gallon drums, ready mixed.	K-KOTE	Monsanto Chemical Co., Hydrocarbons Division, El Dorado, Ark.	Stock Material
	60-24 CORK-FILLED MASTIC	Benjamin Foster Co., Philadelphia, Pa.	
CORK-FILLED POLYVINYL ACETATE:			
Fire-retardant cork-filled PVA mastic, in 5-gallon pails and 55-gallon drums, ready mixed.	LION CORK-FILLED PVA	Monsanto Chemical Co., Hydrocarbons Division, El Dorado, Ark.	Stock Material
	CORK-FILLED PVA	Vimasco Corp., S. Charleston, W. Va.	

C 002777



4. AUXILIARY MATERIALS

ITEM	TRADE NAME	SUPPLIER	NOTES
HIGH TEMPERATURE CEMENT. Expanded vermiculite cement with heat resistant binder. Available dry in 50-pound bags.	"33" INSULATING CEMENT	The Eagle-Picher Co., Cincinnati, Ohio	Stock Materials
	SUPEREX CEMENT	Johns-Manville Corp., New York, N.Y.	
	"11" INSULATING CEMENT	M. H. Detrick Co., Chicago, Ill.	
CAULKING AND FINISHING CEMENT. Nodular mineral fibers combined with bonding materials. Available in 50-pound bags.	MW-50 CEMENT	The Philip Carey Co., Cincinnati, Ohio	Stock Materials
	CAREYTEMP CEMENT		
	302 CEMENT	Johns-Manville Corp., New York, N.Y.	
FILLER MATERIAL. Calcined diatomaceous earth and long asbestos fiber, without binder. Available in 50-pound bags.	CELATON	The Eagle-Picher Co., Cincinnati, Ohio	Stock Materials
	SIL-G-CEL	Johns-Manville Corp., New York, N.Y.	
FINGER STRAPS. Order to suit insulation thickness.	CARBON STEEL, MONEL, STAINLESS STEEL	A. J. Gerrard Co., Des Plaines, Ill.	Stock Items
STUDS AND CAPS. Order size and length to suit insulation thickness.	NELSON STUDS	Gregory Industries, Lorain, Ohio	
FLASHING STRIPS. Available in rolls 4" to 12" wide x 50-yards long.	SARALLOY PLASTIC SHEET	The Dow Chemical Co., Midland, Mich.	Stock Material
BANDS AND SEALS. $\frac{3}{4}$ " x .015 Monel bands available in 1000-foot coils; seals available in lots of 1000.	HY-COR-X MONELSTRAPPING; NO. 204 M SEALS	A. J. Gerrard Co., Des Plaines, Ill.	Stock Items
	MONEL BANDS AND SEALS	Insulcoastic Corp., New York, N.Y.	
		Preformed Metal Products Co., Shreveport, La.	
BANDS AND SEALS. $\frac{1}{2}$ " x .020 316 Stainless Steel bands, seal no. 42; $\frac{3}{4}$ " x .015 302 Stainless Steel bands, seal no. 42	STAINLESS STEEL BANDS AND SEALS	Signode Steel Strapping Co., Chicago, Ill.	Stock Items
		Acme Steel Products Co., Chicago, Ill.	
TIE WIRE. 16 gauge Type 302 or 304 cold-drawn, bright annealed Stainless Steel wire. Available in 50-pound rolls.		A. J. Gerrard Co., Des Plaines, Ill.	002778
		Insulcoastic Corp., New York, N.Y.	
		Signode Steel Strapping Co., Chicago, Ill.	
		Preformed Metal Products Co., Shreveport, La.	

CALCIUM SILICATE SYSTEM

Elevated Temperature

K11.2 STD 100

ISSUE 1 DATE 7/22

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1. INSULATING MATERIAL

1.1 Description Insulating material is premolded reacted hydrous calcium silicate and asbestos fiber. The following shapes and sizes normally are used in Monsanto practice:

ITEM	APPLICATION	SIZE	SPEC.
Flat blocks without bevel.	All flat surfaces; Vessels over 24"Ø in diameter.	24" wide x 36" long, 1" to 3" thick.	ASTM C-344
Flat blocks bevelled to suit specified diameter.	Vessels 6"Ø in diameter to 24"Ø in diameter.	12" wide x 36" long, 1" to 3" thick.	
Sidewall segments curved and bevelled to suit specified diameter.	Vessels 3'Ø in diameter to 6'Ø in diameter.	12" wide x 48" long, 1" to 3" thick.	
Head segments shaped to suit type and specified diameter.	Vessel heads.	1" to 3" thick.	
Sectional covers.	Copper tubing 3/8" to 3" diameter.	ID to suit specified diameter. 1" to 3" thick.	
Sectional cover 24" diameter, segmental cover 12" and 36" diameter.	Pipe and vessels to 36" diameter.	ID to suit specified diameter. 1" to 3" thick.	
Premolded sectional covers to 6" IPS, preformed sectional covers 8" to 36" nominal pipe size.	Copper tubing and pipe fittings, valves, and flanges.	ID to suit specified diameter. 1" to 3" thick.	

1.2 Thickness Thickness stated on Drawings or in the Thermal Insulation Schedule shall be used. Thicknesses given in Table I shall be used only when directed by the Engineer and when operating temperatures are given.

2. AUXILIARY MATERIALS

2.1 Description The following materials are used with the insulating material to form a complete system. Apply them as directed in the Construction Specifications.

ITEM	GENERIC TYPE	APPLICATION
WELDING STUDS	Carbon steel studs and clips.	Used to secure insulation to vessel and piping surfaces.
HIGH TEMPERATURE CEMENT	Expanded vermiculite cement with heat resistant binder. ASTM C-196 Spec.	Used to point up broken or rounded corners and irregular surfaces; fill voids and slots; build-up insulation on small pipe fittings.
FILLER MATERIAL	Calcined diatomaceous earth and long asbestos fiber, without binder.	Used to pack expansion spaces and to build-up insulation where preformed fitting covers are not available.
CHUCKING AND FINISHING CEMENT	Nodular mineral fibers combined with bonding material.	Used to smooth depressions and to fill minor voids and irregularities in the finished insulation surface.
CLANDS AND SEALS	0.015" flat Stainless Steel bands and sealing devices.	Used to secure insulation to vessels and piping.
TIE WIRE	16 gauge cold-drawn, bright-annealed Stainless Steel wire.	Used to secure insulation to vessels and piping.

C 002779



TABLE 1. MAXIMUM HOT-SURFACE TEMPERATURES (DEGREE F)

IPS and Nominal Pipe Size	NOMINAL INSULATION THICKNESS ^a									
	Single Layer					Double Layer ^b				
	1"	1½"	2"	2½"	3"	3½"	4"	4½"	5"	6"
½"	500	900	1200							
¾"	500	900	1200							
1"	500	900	1200							
1½"	500	900	1100	1200						
2"	500	900	1100	1200						
3"	400	600	900	1100	1200					
4"	500	600	900	1100	1200					
6"	200	500	600	900	1100	1200				
8"		400	600	900	1100	1200				
10"		300	500	600	900	1000	1200			
12"		300	500	600	900	1000	1200			
14"		200	400	500	600	900	1100	1200		
16"		200	300	500	600	900	1000	1200		
18"		200	300	500	600	900	1000	1100	1200	
20"			250	400	500	600	900	1100	1200	
24"			250	350	450	550	800	950	1050	1200
30"			250	350	450	550	700	950	1050	1200
36"			250	350	450	550	650	950	1000	1200
Flt			200	300	400	500	600	900	1000	1200

^aTable 1 is based on design conditions to hold the temperature of the insulation surface to 120 F in 60 F still air. When hot-surface temperature falls between two thickness columns, use the greater thickness.

^bInsulation in thicknesses 3½" through 6" shall be applied in double layers according to the following schedule:

- 3½" : 1½" inner layer, 2" outer layer.
- 4" : 2" inner layer, 2" outer layer.
- 4½" : 2" inner layer, 2½" outer layer.
- 5" : 2½" inner layer, 2½" outer layer.
- 5½" : 2½" inner layer, 3" outer layer.
- 6" : 3" inner layer, 3" outer layer.

C 002780

COATINGS AND INSULATION MANUAL
THERMAL INSULATION MATERIALS SPECIFICATIONS

EXPANDED SILICA SYSTEM

Elevated Temperature

MAN. SECT. PART

K 11.2 STD 110

ISSUE 1 DATE 1/64

PAGE 1 OF 2

1. INSULATING MATERIAL

1.1 Description Insulation material is premolded expanded silica with binders, reinforced with inorganic fibers. The following shapes and sizes normally are used in Monsanto practice:

ITEM	APPLICATION	SIZE
Flat blocks without bevel.	All flat surfaces; Vessels over 24"Ø in diameter.	24" wide x 36" long, 1" to 3" thick.
Flat blocks bevelled to suit specified diameter.	Vessels 6"Ø in diameter to 24"Ø in diameter.	12" wide x 36" long, 1" to 3" thick.
Sidewall segments curved and bevelled to suit specified diameter.	Vessels 3"Ø in diameter to 6"Ø in diameter.	12" wide x 18" long, 1" to 3" thick.
Head segments shaped to suit type and specified diameter.	Vessel heads.	1" to 3" thick.
Sectional covers.	Copper tubing 5/8" to 3" diameter.	ID to suit specified diameter. 1" to 3" thick.
Sectional covers to 24" diameter, segmental covers 30" and 36" diameter.	Pipe and vessels to 36" diameter.	ID to suit specified diameter. 1" to 3" thick.
Premolded sectional covers to 6" IPS, preformed sectional covers 8" to 36" nominal pipe size.	Copper tubing and pipe fittings, valves, and flanges.	ID to suit specified diameter. 1" to 3" thick.

1.2 Thickness Thickness stated on Drawings or in the Thermal Insulation Schedule shall be used. Thicknesses given in Table I shall be used only when directed by the Engineer and when operating temperatures are given.

2. AUXILIARY MATERIALS

2.1 Description The following materials are used with the insulating material to form a complete system. Apply them as directed in the Construction Specifications.

ITEM	GENERIC TYPE	APPLICATION
WELDING STUDS	Carbon steel studs and clips.	Used to secure insulation to vessel and piping surfaces.
HIGH TEMPERATURE CEMENT	Expanded vermiculite cement with heat resistant binder. ASTM C-196 Spec.	Used to point up broken or rounded corners and irregular surfaces; fill voids and slots; build-up insulation on small pipe fittings.
FILLER MATERIAL	Calcined diatomaceous earth and long asbestos fiber, without binder.	Used to pack expansion spaces and to build-up insulation where preformed fitting covers are not available.
CAULKING AND FINISHING CEMENT	Nodular mineral fibers combined with bonding materials.	Used to smooth depressions and to fill minor voids and irregularities in the finished insulation surface.
BANDS AND SEALS	1/4" x 0.015" flat stainless steel bands and sealing devices.	Used to secure insulation to vessels and piping.
TIE WIRE	16 gauge cold-drawn, bright-annealed Stainless Steel wire.	Used to secure insulation to vessels and piping.

C 002781

TABLE 1. APPROXIMATE AIR-TEMPERATURES (DEGREES F)

IPS and Nominal Pipe Size	Nominal Insulation Thickness ¹										
	Single Layer					Double Layer ²					
	1"	1½"	2"	2½"	3"	3½"	4"	4½"	5"	5½"	6"
1"	400	500	600	1200	1000						
1½"	400	500	600	1200	1000						
2"	400	500	600	1200	1000						
2½"	300	500	700	1100	1000	1800					
3"	300	500	700	1100	1000	1800	1800				
3½"	200	400	700	800	1200	1800	1800				
4"		300	600	800	1100	1400	1800				
5"		300	600	700	800	1000	1400	1800			
6"		200	400	600	800	1000	1200	1400	1800		
8"			400	600	700	800	1000	1200	1400	1800	
10"			300	500	700	800	1000	1200	1400	1800	
12"			300	500	600	800	1000	1200	1400	1800	
14"			300	500	700	800	1000	1200	1400	1800	
16"			300	500	700	800	1000	1200	1400	1800	
18"			300	500	600	800	1000	1200	1400	1800	
20"			300	500	600	800	1000	1200	1400	1800	
24"			300	450	600	800	1000	1200	1400	1800	1800
30"			200	450	600	800	1000	1200	1400	1800	1800
36"				300	500	800	1000	1200	1400	1500	1800
Flt.				200	400	700	1000	1200	1400	1500	1800

*Table 1 is based on design conditions to hold the temperature of the insulation surface to 120°F in 80°F still air. When hot-surface temperature falls between two thickness columns, use the greater thickness.

Insulation in thicknesses 3½" through 6" shall be applied in double layers according to the following schedule: —

- 3½" = 1½" inner layer, 2" outer layer.
4" = 2" inner layer, 2" outer layer.
4½" = 2" inner layer, 2½" outer layer.
5" = 2½" inner layer, 2½" outer layer.
5½" = 2½" inner layer, 3" outer layer.
6" = 3" inner layer, 3" outer layer.

**COATINGS AND INSULATION MANUAL
THERMAL INSULATION MATERIALS SPECIFICATIONS**

RIGID AMOSITE ASBESTOS SYSTEM

Elevated Temperature

MAN. SECT. PART

K11.2 STD 120

ISSUE 1 DATE 1/60

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1. INSULATING MATERIAL

1.1 Description Insulating material is premolded long fiber Amosite asbestos combined with an inert silicate binder and diatomaceous earth. The following shapes and sizes normally are used in Monsanto practice:

ITEM	APPLICATION	SIZE
Flat blocks without bevel.	All flat surfaces; vessels over 24"0" in diameter.	18" wide x 36" long, 1" to 3" thick.
Flat blocks bevelled to suit specified diameter.	Vessels 12"0" in diameter to 24"0" in diameter.	12" wide x 36" long, 1" to 3" thick.
	Vessels 4"0" in diameter to 12"0" in diameter.	6" wide x 36" long, 1" to 3" thick.
Sectional covers.	Vessels 3'0" in diameter to 4'0" in diameter.	ID to suit specified diameter. 1" to 3" thick.
Head segments shaped to suit type and specified diameter.	Vessel heads.	1" to 3" thick.
Sectional covers.	Copper tubing, 3/8" through 3-1/8" in diameter.	ID to suit specified diameter. 1" to 3" thick.
Sectional covers.	Pipe and vessels to 36" diameter.	ID to suit specified diameter. 1" to 3" thick.
Preformed sectional covers.	Pipe fittings, valves, and flanges.	ID to suit specified diameter. 1" to 3" thick.

1.2 Thickness Thickness stated on Drawings or in the Thermal Insulation Schedule shall be used. Thicknesses given in Table I shall be used only when directed by the Engineer and when operating temperatures are given.

2. AUXILIARY MATERIALS

2.1 Description The following materials are used with the insulating material to form a complete system. Apply them as directed in the Construction Specifications.

ITEM	GENERIC TYPE	APPLICATION
WELDING STUDS	Carbon steel studs and clips.	Used to secure insulation to vessel and piping surfaces where additional support is required.
HIGH TEMPERATURE CEMENT	Expanded vermiculite cement with heat resistant binder. ASTM C-190 Spec.	Used to point up broken or rounded corners and irregular surfaces; fill voids and slots; build-up insulation on small pipe fittings and tubing fittings.
FILLER MATERIAL	Calcined diatomaceous earth and long asbestos fiber, with-out binder.	Used to pack expansion spaces and to build-up insulation where preformed pipe coverings are not available.
CAULKING AND FINISHING CEMENT	Needle mineral fibers combined with bonding materials.	Used to smooth depressions and to fill minor voids and irregularities in the finished insulation surface.
BANDS AND SEALS	1/2" x 0.015" flat Monel bands and sealing devices.	Used to secure insulation to vessels and piping.
WIRE	16 gauge cold-drawn, bright-annealed Stainless Steel wire.	Used to secure insulation to vessels and piping.

C 002783

TABLE 1. MAXIMUM HOT-SURFACE TEMPERATURES (DEGREE F)

IPS and Nominal Pipe Size	INSULATION THICKNESS ^a									
	Single Layer				Double Layer ^b					
	1"	1½"	2"	2½"	3"	3½"	4"	4½"	5"	6"
½"	600	700	800	1000						
¾"	600	700	800	1000						
1"	600	700	800	1000						
1½"	400	500	600	1000	1100					
2"	400	500	600	1000	1100					
3"	300	500	600	1000	1100	1200				
4"	300	500	600	1000	1100	1200				
5"	300	500	700	800	1100	1200				
6"		400	600	800	1000	1100	1200			
8"		400	600	800	1000	1100	1200			
10"		400	600	800	1000	1100	1200			
12"		400	600	800	1000	1100	1200			
14"		400	600	800	900	1000	1100	1200		
16"		400	600	800	900	1000	1100	1200		
18"		300	500	700	800	900	1000	1100	1200	
20"		300	500	700	800	900	1000	1100	1200	
24"		300	500	700	800	900	1000	1100	1200	
30"		300	500	700	800	900	1000	1100	1200	
36"		200	300	600	700	800	900	1000	1100	1200
Flt			200	300	600	700	800	900	1000	1200

^aTable 1 is based on design conditions to hold the temperature of the insulation surface to 120 F in 80 F still air. When hot-surface temperature falls between two thickness columns, use the greater thickness.

^bInsulation in thicknesses 3½" through 6" shall be applied in double layers according to the following schedule:

- 3½" : 1½" inner layer, 2" outer layer.
- 4" : 2" inner layer, 2" outer layer.
- 4½" : 2" inner layer, 2½" outer layer.
- 5" : 2½" inner layer, 2½" outer layer.
- 5½" : 2½" inner layer, 3" outer layer.
- 6" : 3" inner layer, 3" outer layer.

COATINGS AND INSULATION MANUAL
THERMAL INSULATION MATERIALS SPECIFICATIONS
RIGID MINERAL WOOL SYSTEM
Elevated Temperature

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1. INSULATING MATERIAL

1.1 Description Insulating material is preformed spun mineral fibers and inorganic binders. The material is flexible enough to fit cylindrical contours. The following shapes and sizes normally are used in Monsanto practice. Pipe covering is not available.

ITEM	APPLICATION	SIZE
Flat blocks.	All flat surfaces; vessels over 24"Ø in diameter.	24" wide x 36" long, 1" to 3" thick.
	Vessels 3"Ø in diameter to 24"Ø in diameter.	12" wide x 36" long, 1" to 3" thick.

1.2 Thickness Thickness stated on Drawings or in the Thermal Insulation Schedule shall be used. Thickness given in Table I shall be used only when directed by the Engineer and when operating temperatures are given.

2. AUXILIARY MATERIALS

2.1 Description The following materials are used with the insulating material to form a complete system. Apply them as directed in the Construction Specifications.

ITEM	GENERIC TYPE	APPLICATION
WELDING STUDS	Carbon steel studs and clips.	Used to secure insulation to vessel and piping surfaces where additional support is required.
HIGH TEMPERATURE CEMENT	Expanded vermiculite cement with heat resistant binders ASTM D-188 Spec.	Used to point up broken or rounded corners and irregular surfaces; fill voids and slots.
FILLER MATERIAL	Calcined diatomaceous earth and long asbestos fiber, with cut binder.	Used to pack expansion spaces.
CAULKING AND FINISHING CEMENT	Needle mineral fibers combined with bonding materials.	Used to smooth depressions and to fill minor voids and irregularities in the finished insulation surface.
BANDS AND SEALS	1/2" x 0.015" flat Monel bands and sealing devices.	Used to secure insulation to vessels and piping.
TIE WIRE	16 gauge cold-drawn, bright annealed Stainless Steel wire.	Used to secure insulation to vessels and piping.

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TABLE 1. MAXIMUM HOT-SURFACE TEMPERATURES (DEGREE F)

FEET BLOCK	NOMINAL INSULATION THICKNESS ¹									
	Single Layer					Double Layer ²				
	1"	1½"	2"	2½"	3"	3½"	4"	4½"	5"	6"
TEMPERATURE			200	400	700	1000	1200	1400	1500	1600

¹Table is based on design conditions to hold the temperature of the insulation surface to 120 F in 50 F still air. When hot-surface temperature falls between two thickness columns, use the greater thickness.

²Insulation in thicknesses 3½" through 6" shall be applied in double layers according to the following schedule:

- 3½" : 1½" inner layer, 2" outer layer.
- 4" : 2" inner layer, 2" outer layer.
- 4½" : 2" inner layer, 2½" outer layer.
- 5" : 2½" inner layer, 2½" outer layer.
- 5½" : 2½" inner layer, 3" outer layer.
- 6" : 3" inner layer, 3" outer layer.

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CONTINUOUS INSULATING SYSTEM
THERMAL INSULATION MATERIALS, PART 1, PART 2
INSULATING GLASS SYSTEM
Elevated Temperature

REVISIONS

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REVISIONS

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1. INSULATING MATERIAL

1.1 Description Insulating material is premanufactured glass wool, resin bonded. Sheet materials are flexible enough to fit cylindrical contours without folds. The following shapes and sizes normally are used in Monsanto practice.

ITEM	APPLICATION	SIZE
Flat sheets.	All flat surfaces; vessels over 3'0" in diameter.	24" wide x 40" long, 1" and 2" thick.
Sections, covers.	Copper tubing 1/2" to 3" diameter.	ID to suit specified diameter, 1" to 3" thick.
Sections, covers to 12" diameter; segmental covers to 36" diameter.	Pipe and vessels to 30" diameter.	ID to suit specified diameter, 1" to 3" thick.
Preformed covers to 3" copper tubing and 4" IPS; preformed covers 3" IPS to 30" nominal pipe size.	Copper tubing and pipe fittings, valves, and flanges.	ID to suit specified diameter, 1" to 3" thick.

1.2 Thickness Thickness stated on Drawings or in the Thermal Insulation Schedule shall be used. Thicknesses given in Table 1 shall be used only when directed by the Engineer and when operating temperatures are given.

2. AUXILIARY MATERIALS

2.1 Description The following materials are used with the insulating material to form a complete system. Apply them as directed in the Construction Specifications.

ITEM	GENERIC TYPE	APPLICATION
WELDING STUDS	Carbon steel studs and clips.	Used to secure insulation to vessels and piping surfaces where additional support is required.
HIGH TEMPERATURE CEMENT	Expanded vermiculite cement with most resistant binder. ASTM C-158 Spec.	Used to point up broken or rounded corners and irregular surfaces; fill voids and slots; build-up insulation on small pipe fittings and tubing fittings.
FILLER MATERIAL	Loose glass fiber without binder.	Used to pack expansion spaces and to build-up insulation where preformed fitting covers are not available.
CAULKING AND FINISHING CEMENT	Nonshrink mineral fibers cement with bonding materials.	Used to smooth depressions and to fill minor voids and irregularities in the finished insulation surface.
BANDS AND SEALS	1/2" x 0.015" Non Metal Bonds and sealing devices.	Used to secure insulation to vessels and piping.
TIE WIRE	16 gauge cold-drawn, bright, annealed Stainless Steel wire.	Used to secure insulation to vessels and piping.

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REFERENCES

PART 111.2 FOR REVISIONS ARE SHOWN BY

111.2 OUTLINE

DELETIONS ARE SHOWN BY


 TABLE 1. MAXIMUM HOT-SURFACE
 TEMPERATURES (DEGREE F)

IPS and Nominal Pipe Size	NOMINAL INSULATION THICKNESS*				
	1"	1½"	2"	2½"	3"
½"	400	450			
¾"	400	450			
1"	400	450			
1½"	400	450			
2"	400	450			
3"	400	450			
4"	400	450			
6"	400	450			
8"	400	450			
10"	400	450			
12"	300	400	450		
14"	300	400	450		
16"	300	400	450		
18"	300	400	450		
20"	300	400	450		
24"	200	300	400	450	
30"		300	400	450	
36"		300	400	450	
Flat		200	300	400	450

*Table 1 is based on design conditions to hold the temperature of the insulation surface to 120 F in 50 F still air. When hot-surface temperature falls between two thickness columns, use the greater thickness.

COATINGS AND INSULATION MANUAL
THERMAL INSULATION MATERIALS SPECIFICATIONS
SPRAYED AMOSITE ASBESTOS SYSTEM
 Elevated Temperature

MANUFACTURER

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1. INSULATING MATERIAL

1.1 Description Insulating material is long fiber amosite asbestos with inorganic binder. Material is mixed with water in and sprayed from proprietary equipment by licensed applicators to specified thicknesses on all flat and cylindrical surfaces.

1.2 Thickness Thicknesses stated on Drawings or in the Insulation Schedule shall be used. Thicknesses given in Table I shall be used only when directed by the Engineer and when operating temperatures are given.

2. AUXILIARY MATERIALS

2.1 Description Auxiliary materials consist of Wire Cloth Reinforcement secured over insulating material in thicknesses 2" and greater.

TABLE I. MAXIMUM HOT-SURFACE TEMPERATURES (DEGREE F)

	Nominal Insulation Thickness				
	1"	1½"	2"	2½"	3"
Flat surfaces; tanks, vessels, equipment, and pipe over 24" in diameter. Not recommended for smaller piping.	200	300	500	600	700

Table I is based on design conditions to provide 120 F hot-surface temperature falls between two thickness columns, use the greater thickness.

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**COATINGS AND INSULATION MANUAL
THERMAL INSULATION MATERIALS SPECIFICATIONS
SPRAYED CROCIDOLITE ASBESTOS SYSTEM
Elevated Temperature**

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1. INSULATING MATERIAL

1.1 Description Insulating material is long fiber crocidolite asbestos with inorganic binder. Material is mixed with water in and sprayed from proprietary equipment by licensed applicators to specified thicknesses on all flat and cylindrical surfaces.

1.2 Thickness Thicknesses stated on Drawings or in the Insulation Schedule shall be used. Thicknesses given in Table I shall be used only when directed by the Engineer and when operating temperatures are given.

2. AUXILIARY MATERIALS

2.1 Description Auxiliary materials consist of Wire Cloth Reinforcement secured over insulating material in thicknesses 2" and greater.

TABLE I. MAXIMUM HOT-SURFACE TEMPERATURES (DEGREE F)

Flat surfaces; tanks, vessels, equipment, and pipe over 24" in diameter. Not recommended for smaller piping.	Nominal Insulation Thickness				
	1"	1½"	2"	2½"	3"
	400	600	800	1000	1200

Table I is based on design conditions to provide 120 F. hot-surface temperature falls between two thickness columns, use the greater thickness.

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COATINGS AND INSULATION MANUAL
THERMAL INSULATION MATERIALS SPECIFICATIONS
CORK-FILLED ASPHALT MASTIC SYSTEM
Moisture-Condensing Temperature

MANUFACTURE

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1. INSULATING MATERIAL Insulating material is Vapor Sealing Asphalt Mastic with Ground Cork Filler.

1.1 Description and Application Characteristics

Material Description	Film Thickness One Coat		Coverage* Sq. Ft./Gal.	Limitations
	Wet	Dry		
Medium Grade for spray application	1/4"	1/8"	13	Materials not recommended for areas where solvent or alkali splash and spillage are prevalent.
Heavy Grade for trowel or palm application.	1/4"	1/8"	6	

*Coverage values are 75% of theoretical; for estimating purposes only.

2. MIXING INSTRUCTIONS Agitate with mechanical agitator.

3. THINNING INSTRUCTIONS No thinning required.

3.1 Clean-Up Thinner Mineral spirits.

4. APPLICATION INSTRUCTIONS Spray medium grade material to specified thickness using Graco Mobile 9-1 Ratio Mastic Pump and DeVilbiss PMBC gun with 1/4" nozzle. Use 1" material hose. Trowel or palm heavy grade material to specified thickness; keep trowel wet with mineral spirits.

4.1 Pot Life Indefinite.

4.2 Recoat Time Let each coat cure 36 hours before adding additional coats.

5. THICKNESS Apply in thicknesses shown on the Drawings or specified in the Thermal Insulation Schedule.

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INTRODUCTION

1. SCOPE This Information Standard covers the content and use of Weather Barrier Materials Specifications for insulation systems in elevated and low temperature service. It provides as well the characteristics and limitations for each material that might influence selection and use.

2. CONTENT Each Specification for Weather Barrier Materials describes in generic terms the primary and auxiliary materials necessary to form a complete protective system. Wet and dry film thickness for each coat of the material specified, and theoretical coverage per gallon are given. Pertinent safety precautions are flagged, and limitations of interest to the applicator are provided.

3. USE Weather Barrier Materials Specifications are numbered individually so that the materials selected for use with an insulation system can be called out on the Drawings and in the Thermal Insulation Schedule. See K11.1 Std 2.

4. MATERIALS CHARACTERISTICS AND LIMITATIONS

4.1 Weather Barrier Mastics for Elevated Temperature Service Weather Barrier Mastics for elevated temperature service are fire-retardant grades of "breathing" type asphalt emulsions and polyvinyl acetate.

4.1.1 Asphalt Emulsions Asphalt emulsions usually are applied by trowel or with special spray apparatus in two coats, each $\frac{1}{8}$ " thick when wet. Each coat will shrink to approximately $\frac{1}{16}$ " thickness when dry. Coverage for each coat is approximately 12 square feet per gallon.

Color of the cured film is black, and color coating with other materials usually is not effective. The cured materials may remain soft for 90 days or more, depending on climatic conditions.

Asphalt emulsions are not recommended for areas subject to solvent or alkali splash and spillage.

4.1.2 Polyvinyl Acetate Polyvinyl acetate usually is applied by conventional spray apparatus in two coats, each $\frac{1}{8}$ " thick when wet. Each coat will shrink to approximately $\frac{1}{16}$ " thickness when dry. Coverage for each coat is approximately 15 square feet per gallon.

Color of the cured film is light gray. The cured materials have been successfully color coated with latex paints.

4.2 Weather Barrier Mastics for Low Temperature Service Weather Barrier Mastics for low temperature service are fire-retardant grades of vapor-sealing cut back asphalt, epoxy, vinyl, and polyester resins.

4.2.1 Cut Back Asphalt Cut Back Asphalt vapor sealing materials are applied by brush or with conventional spray apparatus in two coats, each $\frac{1}{8}$ " thick when wet. Each coat will shrink to approximately $\frac{1}{16}$ " thickness when dry. Coverage for each coat is approximately 12 square feet per gallon.

Color of the cured film is black, and color coating with other materials usually is not effective. The cured materials may remain soft for 90 days or more, depending on climatic conditions.

Cut back asphalt materials are not recommended for areas subject to solvent or alkali splash and spillage.

4.2.2 Epoxy Epoxy Weather Barrier Mastics are high-build catalyzed materials with a special Silica filler. They are applied by trowel in two coats, each coat $\frac{1}{8}$ " thick when wet. The cured material has no appreciable shrinkage. Coverage for each coat is approximately 20 square feet per gallon.

SENSITIVE PERSONS SHOULD WEAR GLOVES AND PROTECTIVE CREAMS WHEN HANDLING OR APPLYING THESE MATERIALS. IF MATERIAL IS SPILLED ON THE SKIN, FLUSH AT ONCE WITH SOAP AND WATER.

Color of the cured film is chrome-oxide green. The cured film may be color coated with epoxy, vinyl, or urethane protective coatings if desired.

Material is expensive at approximately 75¢ per square foot per coat.

4.2.3 Vinyl Vinyl Weather Barrier Mastics are high-build materials that are applied in two coats with airless spray apparatus. Each coat is approximately 20 mils thick when wet, and there is no appreciable shrinkage when cured. Coverage for each coat is approximately 16 square feet per gallon.

These materials come in a variety of colors, and color coating is unnecessary.

4.2.4 Polyester Polyester Weather Barrier Mastics are high-build catalyzed styrene materials with flaked glass filler. They are applied with special spray apparatus in two coats; each coat is approximately 40 mils thick when wet, and there is no appreciable shrinkage when cured. Coverage is approximately 10 square feet per gallon.

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color of the cured film is silver-gray. The cured film may be color coated with vinyl protective coatings if desired.

Material is expensive at approximately 55¢ per square foot per coat.

4.3 Sheet Weather Barrier Materials Sheet Weather Barrier Materials are metal, asphalt felt, and asbestos cloth impregnated with a special cement.

4.3.1 Metal Sheet Materials Metal Sheet Weather Barrier Materials are Stainless Steel and Aluminum in specified gage and temper. They may be either factory-applied over piping, or may be field-applied

with sheet metal screws, pop rivets, or machine-stretched bands. Sheet metal screws and pop rivets may not be used to secure metal sheet materials to insulation in low temperature service.

4.3.2 Asphalt Felt Materials Asphalt Felt Weather Barrier Materials are asphalt-impregnated asbestos roofing felts. They are usually field applied, and are secured with twisted wire or machine-stretched bands.

4.3.3 Asbestos Cloth Asbestos Cloth Weather Barrier Material is a heavy-weave cloth made of asbestos rope without binders. It is impregnated with a hard-curing cement when applied, and cures so that it will bear foot traffic.

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COATINGS AND INSULATION MANUAL
INSULATION WEATHER BARRIER MATERIALS SPECIFICATIONS

PRODUCT LIST
 Elevated Temperature

MINI-SPEC PART

K11.3 STD 2

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1. SCOPE This Procurement Specification lists trade names and suppliers of materials described generically in the Weather Barrier Materials Specifications. Materials listed herein are considered to be of comparable quality within their classification, and are equally acceptable for use in Monsanto projects. Mastie materials are listed first; listing of jacketing materials and auxiliary materials follow.

2. WEATHER BARRIER MATERIALS

ITEM	TRADE NAME	SUPPLIER	NOTES
"BREATHING" TYPE ASPHALT EMULSION. Available in 5-gallon containers and in 55-gallon drums.	LION NOKORODE FIRE-RETARDANT, SEAL PERM. NO-FLASH	Monsanto Chemical Co., Hydrocarbons Division, El Dorado, Ark.	Stock Material
	30-50 SAFETEE MASTIC	Benjamin Foster Co., Philadelphia, Pa.	
POLYVINYL ACETATE. Available in 5-gallon containers and in 55-gallon drums.	LION POLY-VINYL ACETATE	Monsanto Chemical Co., Hydrocarbons Division, El Dorado, Ark.	Stock Material
	VIMASCO WGI	Vimasco Coatings Corp., Charleston, W. Va.	
	IC 551	Insulcooustic Corp., New York, N. Y.	
	PITTKOTE 400	Pittsburgh Corning Co., Pittsburgh, Pa.	
	PVA COATING	Benjamin Foster Co., Philadelphia, Pa.	

3. JACKETING MATERIALS

3.1 Aluminum

ITEM	TRADE NAME	SUPPLIER	NOTES
ALUMINUM SHEETS, .016" thick with $\frac{1}{16}$ " corrugation, complete with moisture barrier. Available in rolls 36" wide at 300 sq. ft. per roll, 48" wide at 400 sq. ft. per roll.	CHILDERS	Childers Mfg. Co., Houston 8, Texas	Stock Material
	LOC-JAC Z-CRIMP JACKETING	Preformed Metal Products Co., Shreveport, La.	
	AL-COR-JAC	Insulcooustic Corp., New York, N.Y.	
ALUMINUM FITTING COVERS to suit tees and 45 degree and 90 degree short and long radius elbows in standard pipe sizes 2" thru 36"; complete with moisture barrier.	ELL-JACS and TEE-JACS	Childers Mfg. Co., Houston 8, Texas	Stock Items
	ALU. ELBOS and ALUMITEES	Preformed Metal Products Co., Shreveport, La.	
	PUMPED ELBOWS	General Aluminum Supply Co., Kansas City, Mo.	

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ITEM	1
TRADE NAME	1
SUPPLIER	1
NOTES	1

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3.1 Aluminum (Continued)

ITEM	TRADE NAME	SUPPLIER	NOTES
ALUMINUM VALVE COVERS to suit ASA 150 and 300 lb. flanged valves in sizes 1" thru 12".	ALUMI-FLANGES	Preformed Metal Products Co., Shreveport, La.	Stock Items
	REMOVABLE FLANGE COVERS	St. Louis Blow Pipe Co., St. Louis, Mo.	
ALUMINUM CORE TYPE JACKETING for 1 to 1 elliptical heads, 1' 0" in diameter thru 15' 0" in diameter. (Heads larger than 42" diameter are shipped in individual segments for field assembly.)	ALUMINUM CORE TYPE HEADS	Preformed Metal Products Co., Shreveport, La.	Stock Items

3.2 Stainless Steel

ITEM	TRADE NAME	SUPPLIER	NOTES
STAINLESS STEEL JACKETING .010" thick, with $\frac{1}{8}$ " corrugation, No. LB Finish, Standard annealed, soft temper; complete with moisture barrier. Available in rolls 30" wide x 50' 0" long.	STAINLESS STEEL JACKETING	U.S. Steel Supply Co., 311 S. Sara Street, St. Louis, Mo.	Stock Material
		Preformed Metal Products Co., Shreveport, La.	
	STAINLESS STEEL JACKETING	Johns-Manville Corp., New York, N.Y.	
STAINLESS STEEL VALVE COVERS to suit ASA 150 and 300 lb. flanged valves in sizes 1" thru 12".	STAINLESS STEEL REMOVABLE VALVE COVERS	St. Louis Blow Pipe Co., St. Louis, Mo.	Stock Items

3.3 Asbestos Felt

ITEM	TRADE NAME	SUPPLIER	NOTES
50-LB. ASBESTOS FELT IMPREGNATED WITH FIRE-RETARDANT ASPHALT. Available in rolls 32" wide, each roll contains one square.	ASBESTOS FIRE-RETARDANT JACKETING	Johns-Manville Corp., New York, N.Y.	Stock Material
		Philip Carey Co., Cincinnati, Ohio	

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4. AUXILIARY MATERIALS

ITEM	TRADE NAME	SUPPLIER	NOTES
REINFORCING MEMBRANE, asphalt impregnated or starch sized. Available in 10 × 10, or 10 × 20 mesh, in rolls 100' 0" long and from 4" to 36" wide.	FIBERGLAS PERMAPLY	Owens-Corning Fiberglas Corp., Toledo, Ohio	Stock Material
	STANDARD GLASS MESH	Labco Corp., Cleveland, Ohio	
	FIBER GLASS	Pittsburgh Plate Glass Co., Pittsburgh, Pa.	
	PERMA GLAS-MESH	Perma Glas-Mesh Corp., Dover, Ohio	
WIRE CLOTH REINFORCEMENT, 1" hexagonal mesh. Available in rolls 50-yards long × 36" wide.	Type 316 STAINLESS STEEL POULTRY MESH	U.S. Steel Supply Co., 311 S. Sara Street, St. Louis, Mo.	Stock Material
	RIGIMESH	Micrometallic Co., Glen Cove, N.Y.	
STRAPS AND SEALS, aluminum or Stainless Steel; ½" and ¾" × .015" thick. Strapping available in coils approximately 850 ft. long; seals available in packages of 1000.	No. 204 GB	A. J. Gerrard Co., Melrose Park, Ill.	Stock Items
		Insulcoustic Corp., New York, N.Y.	
		Signode Steel Strapping Co., Chicago, Ill.	
		Acme Steel Co., Chicago, Ill.	
		Preformed Metal Products Co., Shreveport, La.	
SHEET METAL SCREWS, Stainless Steel and Aluminum. Pan head, No. 7 × ½".		A.J. Gerrard Co., Melrose Park, Ill.	Stock Items
		Preformed Metal Products Co., Shreveport, La.	
		Insulcoustic Corp., New York, N.Y.	
POP RIVETS, aluminum. Rivetting gun also available.		Insulcoustic Corp., New York, N.Y.	Stock Items
STAINLESS STEEL WIRE. .0475" diameter (18 gauge), Type 304 Stainless Steel, cold-drawn, bright-annealed. Available in 1000-ft. coils.		U.S. Steel Supply Co., 311 S. Sara Street, St. Louis, Mo.	Stock Material

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COATINGS AND INSULATION MANUAL
INSULATION WEATHER BARRIER MATERIALS SPECIFICATIONS

MAN. SECT. PART

K 11.3 STD 10

"BREATHING" TYPE ASPHALT

Elevated Temperature

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1. WEATHER BARRIER MATERIALS Weather barrier materials are "breathing" type asphalt mastic, fire-retardant spray grade for general weather barrier application, trowel grade for providing heavy fillets at inside corners in the insulation construction. Color of the cured film is black.

1.1 Description and Application Characteristics

Material Description	Film Thickness		Coverage ¹ Sq Ft/Gal	Limitations
	Wet	Dry		
Fire-retardant "breathing" type asphalt mastic, spray grade.	1/4"	3/32"	13	Material may remain soft for 30 days or more, depending on climatic conditions. Materials are not recommended for areas subject to solvent or alkali splash and spillage.
Fire-retardant "breathing" type asphalt mastic, trowel grade.	Determined by requirements of construction.			Trowel must be kept wet with mineral spirits.

¹Coverage values are 75% of theoretical; for estimating purposes only.

2. Mix Mix spray grade materials thoroughly with mechanical agitation.

3. THINNING No thinning required.

3.1 Clean-Up Thinner Mineral spirits.

4. APPLICATION Apply spray grade materials by brushing or with spray equipment described in Paragraph 4.1. Apply trowel grade materials with steel trowel.

4.1 Spray Equipment Use DeVilbiss P-MBC gun with MB-4339-1/2" nozzle combination. Use 1/2" material hose.

4.2 Pot Life of Materials Indefinite.

4.3 Recoat Time Two hours at 75 F.

5. AUXILIARY MATERIALS Auxiliary materials are glass fiber mesh, 10 x 10 mesh, asphalt impregnated, in sheets for vessels and equipment, in rolls for piping.

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REFERENCES

LATEST ADDITIONS OR REVISIONS ARE SHOWN BY | OR OUTLINING. DELETIONS ARE SHOWN BY ~~~~~~~~~

COATINGS AND INSULATION MANUAL
INSULATION WEATHER BARRIER MATERIALS SPECIFICATIONS

POLYVINYL ACETATE

Elevated Temperature

MANUAL PART

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1. WEATHER BARRIER MATERIALS Weather barrier materials are polyvinyl acetate (PVA) mastic, fire-retardant spray grade for general weather barrier application, trowel grade for providing heavy fillets at inside corners in the insulation construction. Color of the cured film is light gray to white.

1.1 Description and Application Characteristics

Material Description	Film Thickness		Coverage ¹ Sq. Ft./Gal	Limitations
	Wet	Dry		
Fire-retardant polyvinyl acetate mastic, spray grade.	1/4"	1/2"	15	Not resistant to aromatic or chlorinated hydrocarbons, esters, or ethers.
Fire-retardant polyvinyl acetate mastic, trowel grade.	Determined by requirements of construction.			

¹Coverage values are 75% of theoretical; for estimating purposes only.

2. MIXING Mix spray grade materials thoroughly with mechanical agitation.

3. THINNING Thin as required for spraying with Methyl Ethyl Ketone (MEK) or Methyl Isobutyl Ketone (MIBK).

3.1 Clean-Up Thinner Methyl Ethyl Ketone.

4. APPLICATION Apply spray grade materials by brushing or with spray equipment described in Paragraph 4.1. Apply trowel grade materials with steel trowel.

4.1 Spray Equipment Use DeVilbiss P-MBC gun with MB-4339-1/4" nozzle combination. Use 1/2" material hose.

4.2 Pot Life of Materials Indefinite.

4.3 Recoat Time Six hours at 75 F.

5. AUXILIARY MATERIALS Auxiliary materials are glass fiber mesh, 10 x 10 mesh, non-impregnated, in sheets for vessels and equipment, in rolls for piping.

C 002798

ASBESTOS FELT JACKETING

Elevated Temperature

1. WEATHER BARRIER MATERIALS Jacketing materials are 50 lb asphalt-impregnated asbestos roofing felt, in rolls 36" and 48" long.

1.1 Material Requirements and Coverage See Tables I and II.

2. AUXILIARY MATERIALS

2.1 Straps and Seals Straps and seals used to secure asbestos felt in place shall be $\frac{1}{2}$ " $\times$.015" thick aluminum or stainless steel.

2.2 Tie-Wire Tie wire used to secure asbestos felt in place shall be .0475" diameter (18 gauge) Type 304 stainless steel, cold-drawn and bright annealed.

2.3 Fitting Covers Use weather barrier mastic to cover insulated pipe fittings, flanges, and valves.

TABLE I. ASBESTOS FELT WITH 2" LAP

Quantities (Square Feet) Required for 100 Linear Feet of Pipe Covering ^a											
Pipe Size (in.)	Nominal Insulation Thickness (Inches)										
	1	1½	2	2½	3	3½	4	4½	5	5½	6
¾	99		156		202	225	256	284	315		
1	96	130	155	200	226	255	283	312	340		
1½	97	128	156	201	226	255	283	313	340		
2	114	142	172	201	229	256	284	313	341		
2½	114	155	171	200	228	255	284	312	340		
3	127	155	183	227	255	283	312	340	367		
4	142	171	201	229	256	284	313	341	369		
6	171	201	229	256	284	313	341	369	405	416	450
8	201	229	256	284	313	341	369	403	430	457	480
10	256	284	313	341	369	403	430	457	486	506	533
12		341	369	405	429	457	486	515	543	562	590
14		403	431	458	486	514	541	569	597	603	642
16		458	486	516	541	569	598	626	654	675	682
18		486	516	543	571	598	626	654	681	707	727
20		543	571	599	626	654	681	709	737	754	781
24		598	629	654	682	709	737	764	792	808	834
28		654	682	709	737	764	792	820	847	875	880
30		764	729	820	847	875	903	930	958	972	1135
36		930	958	986	1013	1041	1069	1096	1124	1156	1180

^aQuantities, in square feet, are those required to cover 100 linear feet of insulated straight piping. Longitudinal 2" laps are included; 2" butt laps, based on 48" long rolls of felt, also are included.

C 002799

TABLE II. LENGTH OF CUT OR "STRETCH OUT" FOR
ASBESTOS FELT OVER PIPE COVERING

Pipe Size (in.)	Nominal Thickness of Pipe Covering										
	Length of Cut for Asbestos Felt, in Inches (Calculated to nearest 1/2)										
	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6
1	11 1/2		17 1/2		23	25	29 1/2	32 1/2	35 1/2		
1 1/2	11	11	17 1/2	20 1/2	23 1/2	25	32	35 1/2	38 1/2		
2	11	14 1/2	17 1/2	21 1/2	25	28	31 1/2	35 1/2	38		
3	13	16	19 1/2	22 1/2	26	29	32 1/2	35 1/2	39		
3 1/2	13	17 1/2	19 1/2	25 1/2	28	31	32 1/2	35 1/2	39		
4	14 1/2	17 1/2	22 1/2	26	29	32 1/2	35 1/2	38 1/2	41 1/2		
5	16	19 1/2	22 1/2	28	30	31 1/2	35 1/2	38 1/2	42		
6	18 1/2	22 1/2	26	30	32 1/2	35 1/2	38 1/2	42	45	48 1/2	52
8	21 1/2	26	29	32 1/2	35 1/2	38 1/2	42	45	48 1/2	52	55 1/2
10	25	32 1/2	35 1/2	38 1/2	42	45	48 1/2	52	55 1/2	58 1/2	61 1/2
12		28	42	45	48 1/2	52	55 1/2	58 1/2	61 1/2	65	68
14		48	48 1/2	52	55 1/2	58 1/2	61 1/2	65	68	71	74
16		52	55 1/2	58 1/2	61 1/2	65	68	71	74	77 1/2	80 1/2
18		55 1/2	58 1/2	61 1/2	65	68	71	74	77 1/2	80 1/2	83 1/2
20		61 1/2	65	68	71	74	77 1/2	80 1/2	83 1/2	86 1/2	90
24		68	71	74 1/2	77 1/2	80 1/2	83 1/2	86 1/2	90	93	96 1/2
30		74 1/2	77 1/2	80 1/2	83 1/2	86 1/2	90	93	96 1/2	99 1/2	102 1/2
36		85 1/2	90	93	96 1/2	99 1/2	102 1/2	105 1/2	108 1/2	112	115
42		105 1/2	108 1/2	112	115	118 1/2	121 1/2	124 1/2	127 1/2	130 1/2	134

ALUMINUM JACKETING

Elevated and Low Temperatures

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1. WEATHER BARRIER MATERIALS

1.1 Description Aluminum jacketing is commercially available in standard forms of 36" x 96" sheets; rolls 36" wide at 300 square feet per roll; and rolls 48" wide at 400 square feet per roll. Material in both sheets and rolls is .016" thick, with $\frac{3}{16}$ " corrugation. A factory-attached moisture barrier covers the inner surface.

1.2 Fitting Covers Pre-fabricated sectional covers for insulated short and long-radius elbows, tees, line flanges, and screwed and butt-welded ASA 150 lb and 300 lb valves shall be used when readily available.

1.3 Head Covers Pre-fabricated gore-type covers for insulated 2 to 1 elliptical heads shall be used through 13'-0" diameter when readily available.

1.4 Material Requirements and Coverage (for insulated piping)

TABLE 1. ALUMINUM WITH 2" LAP

Quantities (Square Feet) Required for 100 Linear Feet of Pipe Covering ¹											
Pipe Size (in.)	Nominal Insulation Thickness (Inches)										
	1	1½	2	2½	3	3½	4	4½	5	5½	6
¾	99		156		202	228	258	284	315		
1	96	130	155	200	226	255	283	312	340		
1½	97	128	156	201	226	256	283	313	340		
2	114	142	172	201	229	256	284	313	341		
3	114	155	171	200	228	255	284	312	340		
4	127	155	198	227	255	283	312	340	367		
6	142	171	201	229	256	284	313	341	369		
8	171	201	229	256	284	313	341	369	405	416	450
10	201	229	256	284	313	341	369	423	429	450	480
12	256	284	313	341	369	403	430	457	486	506	533
14		341	369	405	429	457	488	515	543	562	590
16		403	431	458	486	514	541	569	597	603	642
18		458	486	516	541	569	598	626	654	675	692
20		486	516	543	571	598	626	654	681	707	727
24		543	571	599	626	654	681	709	737	754	781
30		598	629	654	682	709	737	764	792	800	834
36		654	682	709	737	764	792	820	847	875	889
42		764	729	820	847	875	903	930	958	972	1135
48		930	958	966	1013	1041	1069	1095	1124	1136	1163

¹Quantities, in square feet, are those required to cover 100 linear feet of insulated straight piping. Longitudinal 2" laps are included; 2" butt laps, based on 48" long rolls of felt, also are included.

C 002801



TABLE II. LENGTH OF CUT OR "STRETCH OUT" FOR
ALUMINUM JACKETING OVER PIPE COVERING

Pipe Size (In.)	Nominal Thickness of Pipe Covering										
	Length of Cut for Aluminum, in Inches (Calculated to Nearest 1/4")										
	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6
1/2	11 1/4		17 1/4		25		29 1/4		35 3/4		
3/4	11	11	17 1/4	22 3/4	25 3/4	29	32	35 1/2	39 1/4		
1	11	14 1/4	17 1/4	22 3/4	26	29	32 1/2	35 1/2	39		
1 1/4	13	16	19 1/4	22 3/4	26	29	32 1/2	35 1/2	39		
1 1/2	13	17 1/4	19 1/4	22 3/4	26	29	32 1/2	35 1/2	39		
1 3/4	14 1/4	17 1/4	22 3/4	26	29	32 1/2	35 1/2	38 3/4	41 3/4		
2	16	19 1/4	22 3/4	26	29	32 1/2	35 1/2	38 3/4	42		
3	18 1/2	22 3/4	26	29	32 1/2	35 1/2	38 3/4	42	46	48 3/4	52
4	22 3/4	26	29	32 1/2	35 1/2	38 3/4	42	46	48 3/4	52	55 1/2
6	29	32 1/2	35 1/2	38 3/4	42	46	48 3/4	52	55 1/2	58 1/2	61 1/2
8		29	42	46	48 3/4	52	55 1/2	58 1/2	61 1/2	65	68
10		46	48 3/4	52	55 1/2	58 1/2	61 1/2	65	68	71	74
12		52	55 1/2	58 1/2	61 1/2	65	68	71	74	77 1/2	80 1/2
14		55 1/2	58 1/2	61 1/2	65	68	71	74	77 1/2	80 1/2	83 1/2
16		61 1/2	65	68	71	74	77 1/2	80 1/2	83 1/2	86 1/2	90
18		68	71	74 1/2	77 1/2	80 1/2	83 1/2	86 1/2	90	93	96 1/2
20		74 1/2	77 1/2	80 1/2	83 1/2	86 1/2	90	93	96 1/2	99 1/2	102 1/2
24		86 3/4	90	93	96 1/2	99 1/2	102 1/2	105 1/2	108 3/4	112	115
30		105 3/4	108 3/4	112	115	118 1/2	121 1/2	124 1/2	127 3/4	130 3/4	134

2. AUXILIARY MATERIALS

2.1 Straps and Seals Straps and seals used to secure Aluminum Jacketing in place shall be 3/4" x .016" aluminum for vessel and equipment jacketing, 1/2" x .016" aluminum for piping jacketing.

2.2 Screws and Rivets Sheet metal screws used to secure Aluminum Jacketing in place (over insulation in elevated temperature service only) shall be Pan Head No. 7 x 1/2", aluminum. Pop rivets used in similar service shall be aluminum.

STAINLESS STEEL JACKETING

Elevated and Low Temperatures

K11.3 STD 55

ISSUE A DATE 1/64

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1. WEATHER BARRIER MATERIALS

1.1 Description Stainless Steel Jacketing is commercially available in forms of 36" x 96" sheets; rolls 36" wide at 300 sq ft per roll; and rolls 48" wide at 400 sq ft per roll. Material in both sheets and rolls in .016" thick, with $\frac{1}{16}$ " corrugation. Moisture barrier backing on the inner surface is not required.

1.2 Fitting Covers Prefabricated sectional covers for insulated short and long radius elbows, tees, line flanges, and screwed and butt-welded ASA 150 lb and 300 lb valves shall be used when readily available.

1.3 Head Covers Prefabricated gore-type covers for insulated 2 to 1 elliptical heads shall be used through 15'-0" diameter when readily available.

1.4 Material Requirements and Coverage (for Insulation Piping) See Tables I and II.

2. AUXILIARY MATERIALS

2.1 Straps and Seals Straps and seals used to secure Stainless Steel jacketing in place shall be $\frac{1}{4}$ " x .016" stainless steel or monel for vessel and equipment jacketing, $\frac{1}{4}$ " x .016" stainless steel or monel for pipe jacketing.

2.2 Screws and Rivets Sheet metal screws used to secure Stainless Steel Jacketing in place (over insulation in elevated temperature service only) shall be Pan Head No. 7 x $\frac{1}{4}$ " stainless steel. Pop rivets used in similar service shall be stainless steel.

TABLE I. STAINLESS STEEL WITH 2" LAP

Quantities (Square Feet) Required for 100 Linear Feet of Pipe Covering ^a											
Pipe Size (in.)	Nominal Insulation Thickness (Inches)										
	1	1½	2	2½	3	3½	4	4½	5	5½	6
¾	99		156		202	228	258	284	315		
½	96	130	155	200	226	255	283	312	340		
¼	97	128	156	201	226	256	283	313	340		
1	114	142	172	201	229	256	284	313	341		
1½	114	155	171	200	228	255	284	312	340		
2	127	155	198	227	255	283	312	340	367		
	142	171	201	229	256	284	313	341	369		
3	171	201	229	256	284	313	341	369	405	416	450
4	201	229	256	284	313	341	369	423	429	450	460
6	256	284	313	341	369	403	430	457	486	506	533
8		341	369	405	429	457	488	515	543	562	590
10		403	431	458	486	514	541	569	597	603	642
12		458	486	516	541	569	598	626	654	675	692
14		488	516	543	571	598	626	654	681	707	727
16		543	571	599	626	654	681	709	737	754	781
18		598	629	654	682	709	737	764	792	808	834
20		654	682	709	737	764	792	820	847	875	889
24		764	729	820	847	875	903	930	958	972	1135
30		930	958	986	1013	1041	1069	1096	1124	1156	1163

^aQuantities, in square feet, are those required to cover 100 linear feet of insulated straight piping. Longitudinal 2" laps are included; 2" butt laps, based on 48" long rolls of felt, also are included.

C 002803



TABLE II. LENGTH OF CUT OR "STRETCH OUT" FOR STAINLESS STEEL
JACKETING OVER PIPE COVERING

Pipe Size (in.)	Nominal Thickness of Pipe Covering										
	Length of Cut for Stainless Steel, in Inches (Calculated to Nearest 1/4")										
	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6
3/8	11 1/4		17 1/4		23	25	29 1/4	32 1/2	35 1/4		
1/2	11	11	17 1/4	22 1/4	25 1/4	29	32	35 1/2	38 1/2		
3/4	11	14 1/2	17 1/4	22 1/4	26	29	32 1/2	35 1/2	39		
1	13	16	19 1/2	22 1/4	26	29	32 1/2	35 1/2	39		
1 1/4	13	17 1/2	19 1/2	22 1/4	26	29	32 1/2	35 1/2	39		
1 1/2	14 1/2	17 1/2	22 1/2	26	29	32 1/2	35 1/2	38 1/2	41 1/2		
2	16	19 1/2	22 1/2	26	29	32 1/2	35 1/2	38 1/2	42		
3	19 1/2	22 1/4	26	29	32 1/2	35 1/2	38 1/4	42	46	48 3/4	52
4	22 1/4	26	29	32 1/2	35 1/2	38 1/4	42	46	48 3/4	52	55 1/4
6	29	32 1/2	35 1/2	38 3/4	42	46	48 1/4	52	55 1/2	58 1/2	61 1/2
8		29	42	46	48 1/4	52	55 1/4	58 1/4	61 1/2	65	68
10		46	48 3/4	52	55 1/4	58 1/4	61 1/2	65	68	71	74
12		52	55 1/4	58 1/2	61 1/2	65	68	71	74	77 1/4	80 1/2
14		55 1/4	58 1/2	61 1/2	65	68	71	74	77 1/4	80 1/2	83 1/4
16		61 1/2	65	68	71	74	77 1/4	80 1/2	83 1/4	86 1/4	90
18		68	71	74 1/4	77 1/4	80 1/2	83 1/4	86 1/4	90	93	96 1/4
20		74 1/4	77 1/4	80 1/2	83 1/4	86 1/4	90	93	96 1/4	99 1/2	102 1/2
24		86 1/4	90	93	96 1/4	99 1/2	102 1/4	105 1/4	108 1/4	112	115
30		105 1/4	108 1/4	112	115	118 1/4	121 1/4	124 1/4	127 1/4	130 1/4	134

INTRODUCTION

1. SCOPE This Information Standard describes the content and use of the Thermal Insulation Construction Specifications.

2. CONTENT AND USE

2.1 General Insulation Specification A General Insulation Specification is provided, covering instructions common to all types of materials applications; it is provided to spare repetition of those instructions in the System Construction Specifications. The General Insulation Specification is referred to in the System Construction Specifications and may, with the System Construction Specifications applicable to the work at hand, become part of the Contract Documents.

2.2 System Construction Specifications Construction Specifications are provided for each of the various types of insulation systems, e.g., rigid, batt and blanket, and sprayed or foamed; separate System Construction Specifications are provided for elevated and low temperature applications within these categories.

Procedures outlined in the System Construction Specifications are those considered adequate by reputable contractors, with modifications to suit field tested and accepted Monsanto practices.

The System Construction Specifications contain Typical Drawings of application details. These drawings supplement and illustrate instructions contained in the text.

2.3 Limitations Details of application for thermal insulation systems in Temperature Ranges IV, V, and VI are adequately covered in the System Construction Specifications. Every detail of application for systems in Temperature Ranges I, II, III, IV, and VIII is not fully covered at this time. (For scope and discussion of Temperature Ranges see K11.1 Std 3.)

Data for many items in tank, pressure vessel, and piping design for low temperature service and extremely-high temperature service are still evolving, and insulation details for these items therefore are not provided. When these data are available for use, the System Construction Specifications will be revised to suit. Construction details not covered in these Specifications will have to be worked out as special design problems.

3. OTHER CONTRACT DOCUMENTS The General Insulation Specification and the System Construction Specifications have been prepared so that there will be no conflict between them and the following Monsanto Contract Forms:

- (1) G428, Rev 3/62, "Lump-Sum Agreement".
- (2) G430, Rev 3/62, "Cost-Plus Agreement".
- (3) G440, Rev 3/62, "General Conditions".
- (4) G441, Rev 3/62, "Certificate of Insurance".

Supplementary General Conditions to suit requirements of an individual project; the Thermal Insulation Schedule (see K11.1 Std 2); the Project Drawings; and Monsanto's Purchase Order are other Contract Documents that may be required.

GENERAL INSULATION SPECIFICATION

1. GENERAL

1.1 Scope This Construction Specification covers the handling, application, and inspection requirements common to all types of thermal insulation systems for all temperature ranges. It shall be used in conjunction with the System Construction Specifications and the Materials Specifications applicable to the work at hand.

1.2 Definitions

1.2.1 Application Application comprises all work required to install the insulating materials, auxiliary materials, and weather barrier materials (including jacketing, where required), necessary to form a complete thermal insulation system that will pass a final inspection and be accepted by the Engineer.

2. MATERIALS HANDLING

2.1 Packaging Materials shall be packed in substantial containers so constructed as to insure safe delivery to the job site in a condition satisfactory to the Engineer.

2.2 Marking and Identification Shipping containers shall be legibly marked with name of material, size, type, and quantity contained therein; name of the contractor; and purchase order number under which shipment is made. In addition, where required, containers shall bear the project or work order number.

2.3 Storage at Job Site Materials shall be retained in their original containers until ready for application. Containers shall be stored at the job site in a building or shelter which will completely protect them from the weather. Containers shall be stored on wood decks or pallets within the shelter, and shall not come in contact with the ground during storage. Storage shall be arranged so that materials already stored will be used before newly-delivered materials.

2.4 Condition of Materials Insulation materials, other than sprayed, foamed-in-place, cement, and mastic types, shall be applied only when dry.

If, in the opinion of the Engineer, moisture content of insulation materials is excessive because of exposure to rain or high humidity, the materials shall be heated sufficiently to drive out trapped

moisture prior to application. If warpage or other deterioration has occurred because of wetting and drying, the material shall not be incorporated in the work.

3. CONDITION OF SURFACES Surfaces to be insulated shall be clean and dry. The insulation contractor shall be responsible only for the removal of oil, grease, dust, and similar accumulations of surface dirt; he will not be held responsible for the removal of mill scale, rust scale or deposits, old paint, or similar firmly adhering accumulations.

Crevices in the construction (such as those caused by the installation of back-to-back angles), and pockets or voids (such as those occasionally found at the juncture with the vessel of legs, brackets, ladder and platform supports, etc), shall be treated prior to the application of insulation. They shall be filled by the insulation contractor with cement compatible with design temperature conditions.

Name plates, support rings and angles, finger straps, clips, studs, and rods for fastening bands and wires shall be welded to the surface of the equipment or piping by others.

Many of the vessels and items of equipment to be insulated are fabricated of special alloys; many are stress-relieved or otherwise heat-treated. No welding shall be done for attachment of additional supports, clips, studs, etc, unless specifically approved by the Engineer. However, the insulation contractor may, where approved by the Engineer, apply additional straps, clips, etc, with adhesive cement compatible with design temperature conditions.

4. APPLICATION Insulation materials shall not be applied when the relative humidity is greater than 90%, or when rain or snow is falling. Work may be stopped because of excessively high or low ambient temperature or because of high wind velocity conditions at the discretion of the Engineer.

At the close of work each day, insulating materials that have been applied during the day shall be protected from the weather by coverings or methods that are suitable to the Engineer. However, insulating materials covered by weather barrier mastics or jacketing during the day need not be so protected.

C 002806

REFERENCES

ADDITIONS OR REVISIONS ARE SHOWN BY | OR OUT-LINING. DELETIONS ARE SHOWN BY ~~_____~~.



STANDARDS

COATINGS AND INSULATION MANUAL
THERMAL INSULATION CONSTRUCTION SPECIFICATIONS
RIGID INSULATION SYSTEMS
Elevated Temperature

MAN. SECT PART

K11.4 STD 10X

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1. GENERAL

1.1 Scope This Construction Specification covers application of rigid thermal insulation systems to vessels, equipment, and piping operating within process temperature limits 130 to 2000 °F. It shall be used in conjunction with the General Insulation Construction Specification and with the Insulation Materials Specifications that describe in detail the materials selected for the Work.

1.2 Definitions

1.2.1 Rigid Insulation for Vessels and Equipment Rigid insulation materials for vessels and equipment are preformed boards, flat blocks, bevelled lags, curved sidewall segments, and shaped head segments of relatively high density and comprehensive strength, in specified sizes and thicknesses, shown in Typical Drawings contained herein. (Batt and blanket insulation materials, sprayed-in-place insulation materials, and molding -type cement insulations are not covered in this Specification.)

1.2.2 Rigid Pipe Covering Rigid pipe coverings are sections or segments pre-molded in specified thickness to suit standard pipe and insulation dimensions; and preformed or premolded sections in specified thickness to suit dimensions of standard threaded or butt-welding short and long radius elbows, tees, reducing fittings, line flanges, and valves. Covers for flanged fittings and valves, special fittings, and pipe bends are formed in the field from pipe covering.

2. APPLICATION, VESSELS AND EQUIPMENT Insulation materials shall be applied in single or double layers of the thickness shown in the Drawings and the Thermal Insulation Schedule. Insulation materials, auxiliary materials, and weather barrier materials shall be those shown in the Materials Specifications.

2.1 Supports and Fastening Devices The Contractor shall inspect the items to be insulated to see that support and fastening devices are installed in conformity with typical drawings contained herein. When additional support and fastening devices are required, the Engineer shall direct and approve their installation. In no case shall the Contractor proceed with the attachment of these items, without permission and approval from the Engineer.

2.2 General Apply insulation directly against vessel or equipment surface. Blocks shall be laid with edges tightly butted, with the end joints of each layer as well as all joints between multiple layers (where required) staggered. All layers of insulation shall be secured with insulation straps on 12" centers. Insulation applied to irregular surfaces where straps cannot be used, shall be secured with wire, drawn taut, twisted and the ends embedded into the insulation. Individual pieces of insulation having any voids, broken corners or irregular surfaces shall be pointed up with high temperature cement when being laid up.

C 002807

REFERENCES C.W.S., W.G.C. & C.M.O.

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For surfaces with diameters less than 24", use pipe insulation. All irregular openings shall be filled with insulating cement.

2.3 Head Blocks Blocks shall be cut to suit and, where required, temporarily held in place with fibrous adhesive or with a spring loaded line until machine-stretched bands are applied.

All layers of insulation on top heads of vertical equipment and heads of horizontal equipment shall be secured in place with straps spaced 12" around circumference. Straps shall be fastened between insulation supports or circumferential straps and a floating ring (made of 1/4" dia. rod) placed in the center of the head. Diameter of ring shall be held to a minimum. Straps must be spaced so that all blocks are securely fastened to head.

2.4 Nozzles and Manholes Insulation for nozzle necks shall be included with vessel. Flanges shall not be insulated when service temperature is less than 300 F unless required for personnel protection or process. Insulation shall be sealed at nozzles and manholes with weatherproofing mastic or flashing.

Where nozzles interfere with strapping, a ring of 1/4" dia. rod (furnished by insulation contractor) shall be placed around the nozzle and straps fastened to this with two seals per strap. Insulation for manholes, handholes and access flanges and covers shall be of the removeable type to permit re-use of the insulation.

2.5 Heat Exchangers Flanges on heat exchangers shall not be insulated. Insulation shall be stopped at flanges to permit removal of bolts. Channels and shells shall be insulated as specified in the Insulation Schedule. The area inside of bolts on cover plates shall be insulated.

2.6 Vessel Legs Vessel legs shall be insulated as part of the vessel. Vessel insulation shall be brought up to and butted against the tank leg. Insulation shall extend around legs and down legs a distance of 12" below the lower tangent line. Thickness of insulation around leg shall be a minimum of one-half of the shell insulation thickness.

2.7 Expansion Joints Insulation expansion joints shall be provided at each insulation support. The 1-1/2" space between the support and the insulation shall be packed with loose mineral wool. The mineral wool shall be retained with an 8" wide band of asbestos-felt strapped to insulation support-- See Detailed Drawings contained herein.

3.0 APPLICATION - PIPING

3.1 General All installation procedures, unless otherwise noted herein, shall be in strict accordance with the manufacturer's recommendations. Omission of details from these specifications shall not relieve the vendor from his obligation of supplying a properly designed installation.

All necessary hydrostatic and pressure tests shall be complete prior to application of insulation.

3.1.2 Unless otherwise specified flanges and valves in process lines will not be insulated unless the temp. exceeds 500 F.

3.1.3 All flanges & valves in steam lines shall be insulated.

3.2 Pipe

3.2.1 Insulation for service at 600°F and less shall be applied in a single layer with the longitudinal joints staggered. The sections shall be tightly butted and fastened with wire loops or straps on 9" centers.

3.2.2 Insulation for service at 601°F and over shall be applied in two or more layers. Circumferential and longitudinal joints shall be staggered and each layer shall be fastened with wire loops or straps on 9" centers.

3.2.3 The ends of wire loops shall be tightly twisted and depressed against the insulation.

3.2.4 Traced lines - Contractor shall use oversize pipe insulation or oval sections to cover traced pipe. Materials and installation shall be the same as specified for untraced pipe. The full extent of tracers, including take-offs, jumpers, expansion loops, etc., shall be insulated. Valves and flanges in traced lines shall be insulated.

3.2.5 All insulation shall be beveled at flanges to permit removal of bolts without damaging insulation.

3.3 Fittings

3.2.1 Cover fittings, line flanges, and valves with premolded or preformed covers wherever possible. When premolded or preformed fitting covers are not available, or when flanged fittings and valves are to be covered, carefully cut, miter, and fit pipe covering material to suit the requirement. Carefully fill all cuts, voids, and crevices with high temperature cement.

4.0 FINISH APPLICATION VESSELS & EQUIPMENT

4.1 Weather Barrier Apply weather barrier mastic only to those surfaces that are not to be covered by metal, felt, or asbestos jacketing.

Apply to the outer surface of the installed installation, as directed in the Materials Specification, Sect. K11.3, sufficient environmental barrier mastic to form a coat of specified thickness. Use a depth gage to measure wet and dry film thickness. Be certain that the material is applied evenly to the surface, without skips, holidays, sags, or runs. Apply heavy fillets of trowel grade mastic to all inside corners. While this coat and the fillets are still wet, embed into it sheets of reinforcing membrane or wire cloth, as specified, overlapping all edges three inches. See that the reinforcing membrane is smooth, without blisters or projecting wrinkles, or that wire cloth follows the insulation contours smoothly. Reinforce the weather barrier at corners and terminate the weather barrier at uninsulated surfaces as shown in typical drawings contained herein.

Follow this application with a second coat of weather barrier mastic of specified thickness. Be certain that the material is applied evenly to the surface without skips, holidays, sags, or runs. Check the dry film thickness on both coats with a depth gage to see that the specified thickness has been attained.

4.2 General Jacketing of Vessels and Equipment Vessels and equipment shall be fully or partially jacketed, as specified. Jacketing may be metal, felt, or asbestos cloth, as specified in the appropriate Materials Specification.

All laps shall be arranged so as to shed water. Suitable flashing shall be provided at all nozzles, manholes and other projections to prevent the entrance of water.

4.2.1 Vertical Shells Metal Jacketing shall be applied directly to the insulating block surface and neatly fitted in place. Expansion joints for jacketing shall be provided by cutting a row of circumferential screws at each insulation support. The jacket shall be strapped at the insulation support. For details see typical drawings contained herein.

4.2.2 Horizontal Shells In general, the construction will be similar to that for a vertical shell. An expansion joint shall be provided by cutting one row of circumferential screws and strapping the jacket at this joint. Circumferential joints shall be weatherproofed with a 1/8" bead of plastic sealer. For details see typical drawings contained herein.

4.2.3 Heads End heads of horizontal vessels, top heads of vertical vessels and bottom heads of vertical vessels that are not enclosed within a skirt shall be finished with metal jacketing made up of wedge shaped sections. Where the diameter of the head is too small for such fabrication, flat construction will be permitted. Lap joints shall be used on bottom heads of vertical vessels only. Laps shall be 2" and shall be weatherproofed with a 1/8" bead of plastic sealer.

4.2.4 Bottom Heads Inside Skirt When the bottom head is within a skirt, one coat of finishing cement (5/8" wet thickness) shall be applied over the insulation. Sufficient material shall be applied to level off any surface depressions. After the cement is dry, wire mesh shall be tightly stretched over the cement and securely tied. One coat of weatherproofing (1/4" wet thickness) shall be applied over the mesh and trowelled smooth.

4.2.5 Heat Exchangers In general, the construction will be similar to that for a horizontal shell. Where the insulation is cut back at flanges, the jacketing shall end flush with the block. Finish to 45 with insulating cement and weatherproofing.

5.0 FINISH APPLICATION TO PIPING

5.1 Weather Barrier Follow procedure outlined in 4.1.

5.2 Jacketing of Piping Piping shall be fully or partially jacketed, as specified. Jacketing may be factory applied or field applied. Field applied jacketing may be metal, felt, or asbestos cloth, as specified.

Jacketing shall be neatly and firmly fitted to the surface of the insulation. Lap joints shall be located on the lower one-half of horizontal runs with the exposed edge facing downward. Adjacent sections shall be lapped two inches. Metal jacketing shall be secured with machine-stretched bands, or with sheet metal screws or pop rivets, as specified. Felt jacketing shall be secured with machine-stretched bands or with tightly-twisted wire, as specified. Asbestos cloth jacketing usually is secured with cement. Long radius and short radius 45 degree and 90 degree elbows shall be covered with commercially available fitting covers. Other fittings and valves adjacent to jacketed piping shall be coated with weather barrier mastic, as outlined in Paragraph 4.1. The mastic shall extend over the adjoining edge of the jacketing two inches.



6.0 INSULATION SUPPORTS AND EXPANSION JOINTS

6.1 Insulation supports, as detailed herein shall be supplied and installed on vertical lines by piping contractor. Supports shall be located three inches above welded or screwed joints of elbows or tees where vertical lines originate. Supports shall also be located three inches above all flanged joints in vertical lines. Supports are not required on vertical rises less than 10'-0" except above flanged joints. Items with projecting surfaces, such as tees, may be used as insulation supports.

6.2 On vertical pipe lines insulated by single layer construction, insulation expansion joints shall be located at each insulation support. On horizontal pipelines insulated by single layer construction, insulation expansion joints shall be located in accordance with Section 6.5.

6.3 On horizontal or vertical pipe lines insulated by multi-layer construction, insulation expansion joints shall be provided only at locations such as elbows, tees, insulation supports, etc., where a line of cleavage will occur as a result of expansion. One (1) joint shall be required for each run of uninterrupted straight pipe except on runs less than specified in (Section 6.5) for particular temperature range involved in which case the expansion joint may be omitted.

6.4 All insulation expansion joints shall be provided by Insulation Contractor.

6.5 Support and Expansion Joint Location

Pipe Line Temperature	Location of Insulation Supports and/or Expansion Joints
Ambient to 500 F.	One every 30 ft. of straight pipe
501 to 800 F.	One every 20 ft. of straight pipe
801 to 1000 F.	One every 15 ft. of straight pipe
1001 to 1200 F.	One every 10 ft. of straight pipe

Expansion joints: A 1-1/2" space shall be provided at designated locations. Space shall be packed with mineral wool, which shall be retained by the jacketing. See detail contained herein.

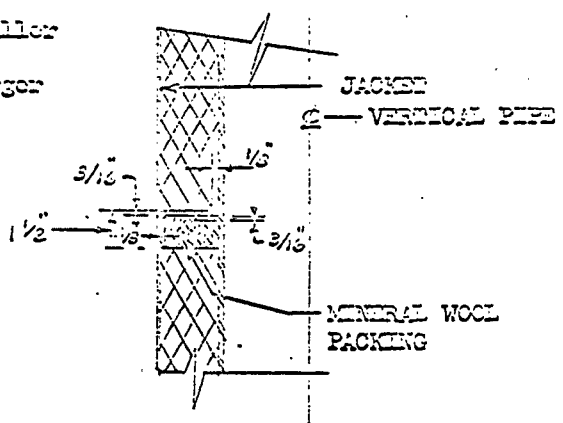
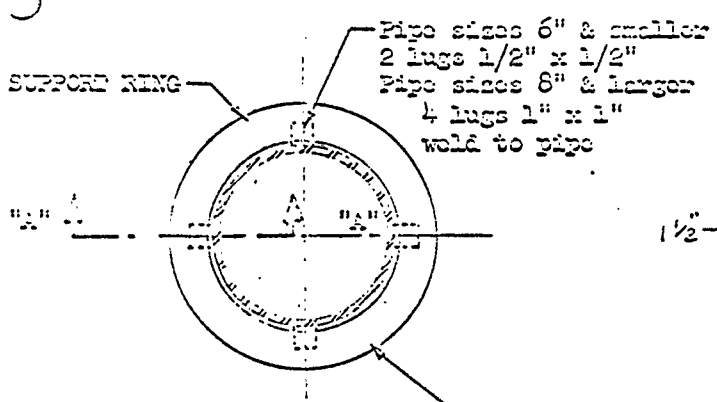
7.0 PERSONNEL PROTECTION

7.1 In general, only lines operating at temperatures exceeding 160 F. with which personnel may easily come into contact shall be insulated for personnel protection to a height of 7 feet above and 3 feet away from operating floors or platforms.

C 002811



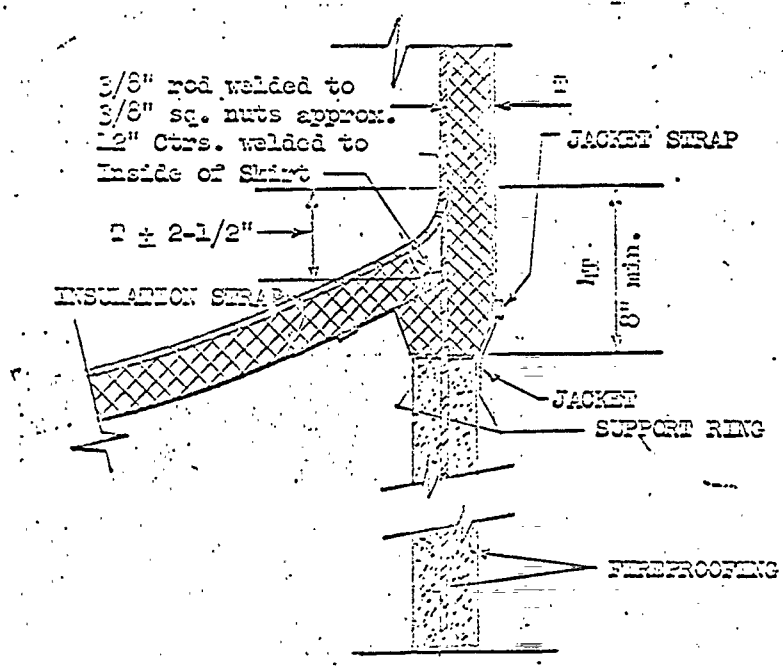
INSULATION SUPPORTS AND EXPANSION JOINTS



On traced lines support ring shall be approximately same O.D. and I. D. as pipe covering to be used. Extend lugs as required.

SECTION 'A-A'

PIPE MATERIAL	LUG MATERIAL	SUPPORT MATERIAL
Carbon Steel	Carbon Steel	Carbon Steel
Stainless "	Carbon Steel	Carbon Steel
Aluminum	Aluminum	Aluminum
Copper	Copper	Carbon Steel
Monel	Carbon Steel	Carbon Steel



DETAILS INSULATION, SUPPORTS & JACKING
FOR VESSELS ON LONG SKIDS

BLOCK INSULATION SUPPORTS VERTICAL VESSELS

1 1/2" LONG SLOTTED HOLE IN ANGLE AT END CLIPS ONLY

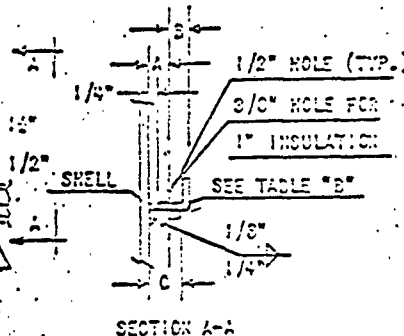
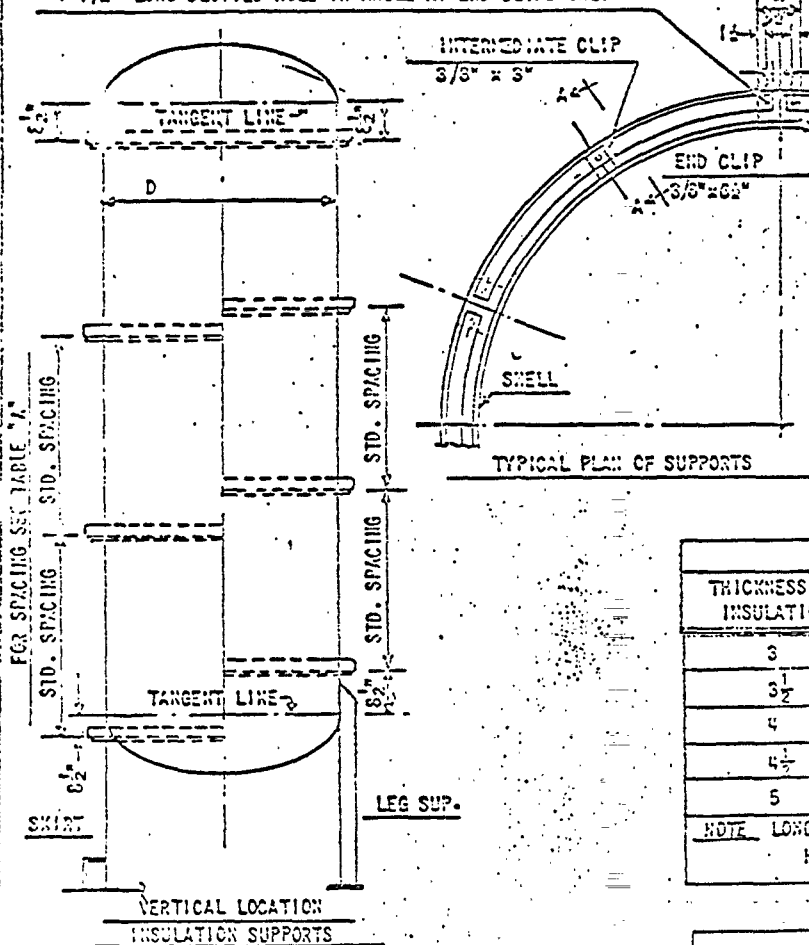


TABLE "A"	
OPERATING TEMPERATURE	SUPPORT SPACING
300 TO 600° F	9'-12"
700 TO 900° F	7'-7 1/2"
1000 TO 1200° F	6'-10"

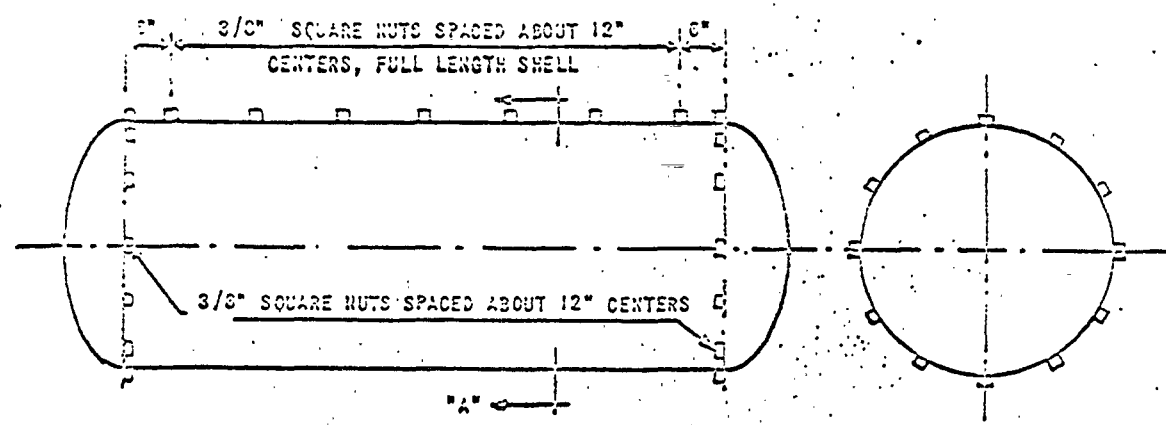
THICKNESS OF INSULATION	SIZE OF ANGLE	A	B	C
3	2½ X 2½	1½	1½	2½
3½	3 X 2½ X ½	1½	1¾	3
4	3½ X 3 X ½	2	2	3½
4½	3½ X 3 X ¾	2½	2	4
5	4 X 3 X ¾	2½	2½	4

NOTE LONGER LEG OF ANGLE TO BE IN HORIZONTAL

DIA. OF VESSEL	NUMBER OF CLIPS	
	END	INTERMEDIATE
UP TO 4'-0"	2	2
4'-1" TO 6'-0"	3	3
6'-1" TO 8'-0"	4	4
8'-1" TO 10'-0"	5	5
10'-1" TO 12'-0"	6	6
12'-1" TO 14'-0"	7	7
14'-1" TO 16'-0"	8	8

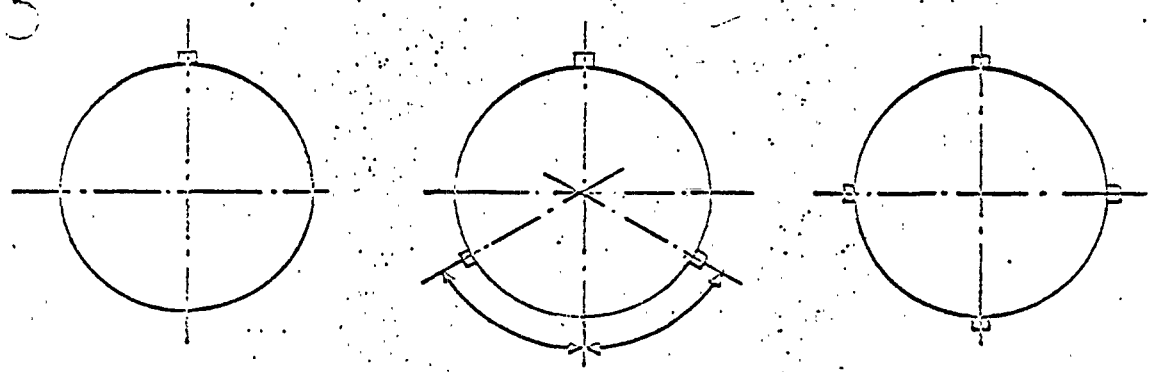
C 002813

INSULATION SUPPORTS - HORIZONTAL VESSELS



ELEVATION

END VIEW



VESSELS TO 4'-0" DIA.
 1-LONGITUDINAL ROW OF NUTS

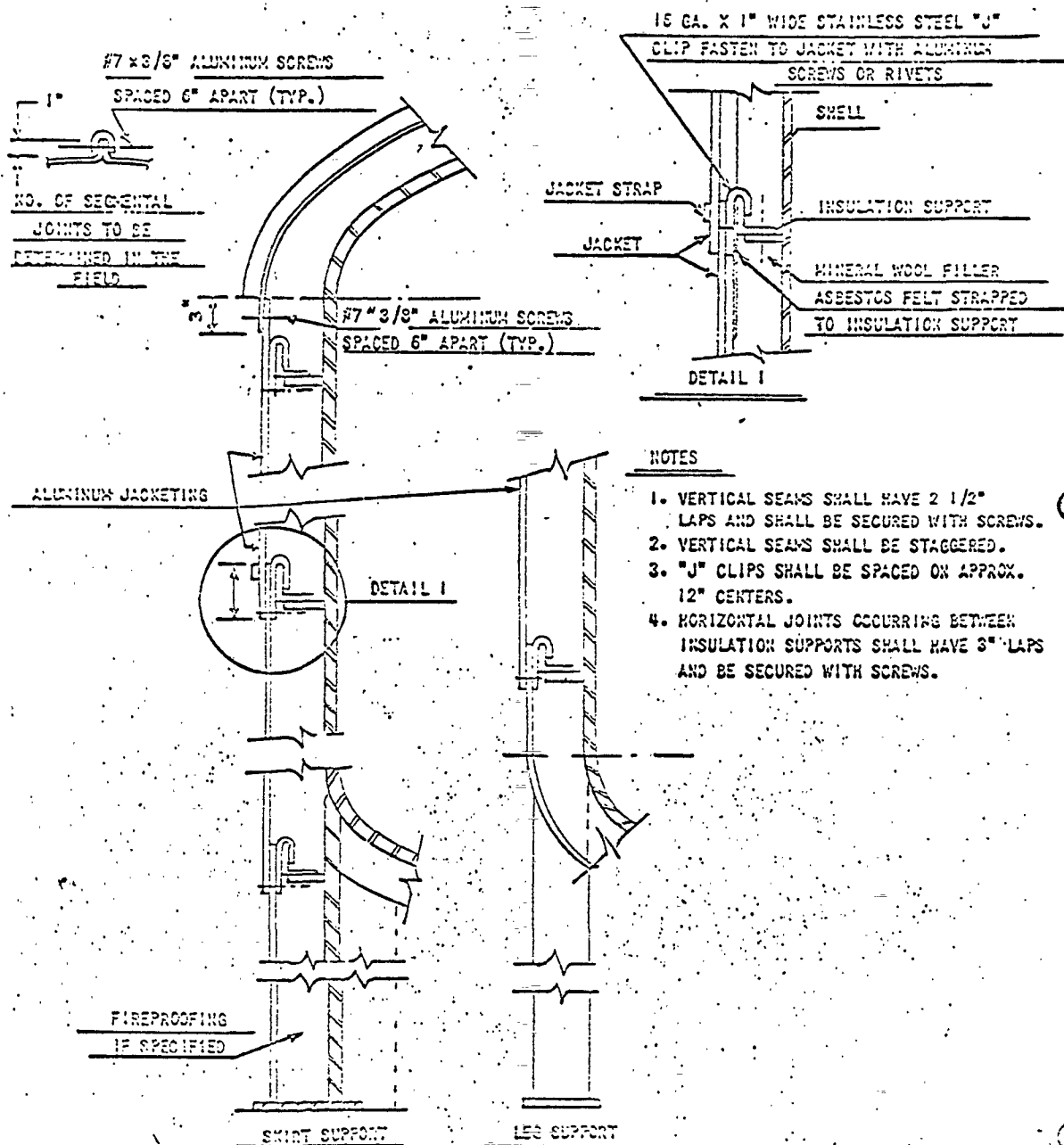
VESSELS OVER 4'-0" TO 8'-0" DIA.
 3 - LONGITUDINAL ROWS OF NUTS

VESSELS OVER 8'-0" DIA.
 4-LONGITUDINAL ROWS OF NUTS

SECTION "A A"



STANDARDS

K11.4 STD 30X
ISSUE A PAGE 9 OF 13METAL JACKET DETAILS
VERTICAL VESSELS WITH BLOCK INSULATION

FOR SHORT SKIRTS

C 002815

METAL JACKET DETAILS - HORIZONTAL VESSELS

#7 x 3/8" ALUMINUM SCREWS
SPACED 6" APART

#7 x 3/8" ALUMINUM SCREWS
SPACED 6" APART

ALUMINUM JACKETING

1/2"

NO. OF
SCREWS
DETERMINED BY
FIELD

VESSELS OVER 2'-6" DIA.

ALUMINUM JACKETING

#7 x 3/8" ALUMINUM
SCREWS SPACED 6" APART

ALUMINUM
END PL

VESSELS 2'-6" DIA. AND UNDER

NOTES:

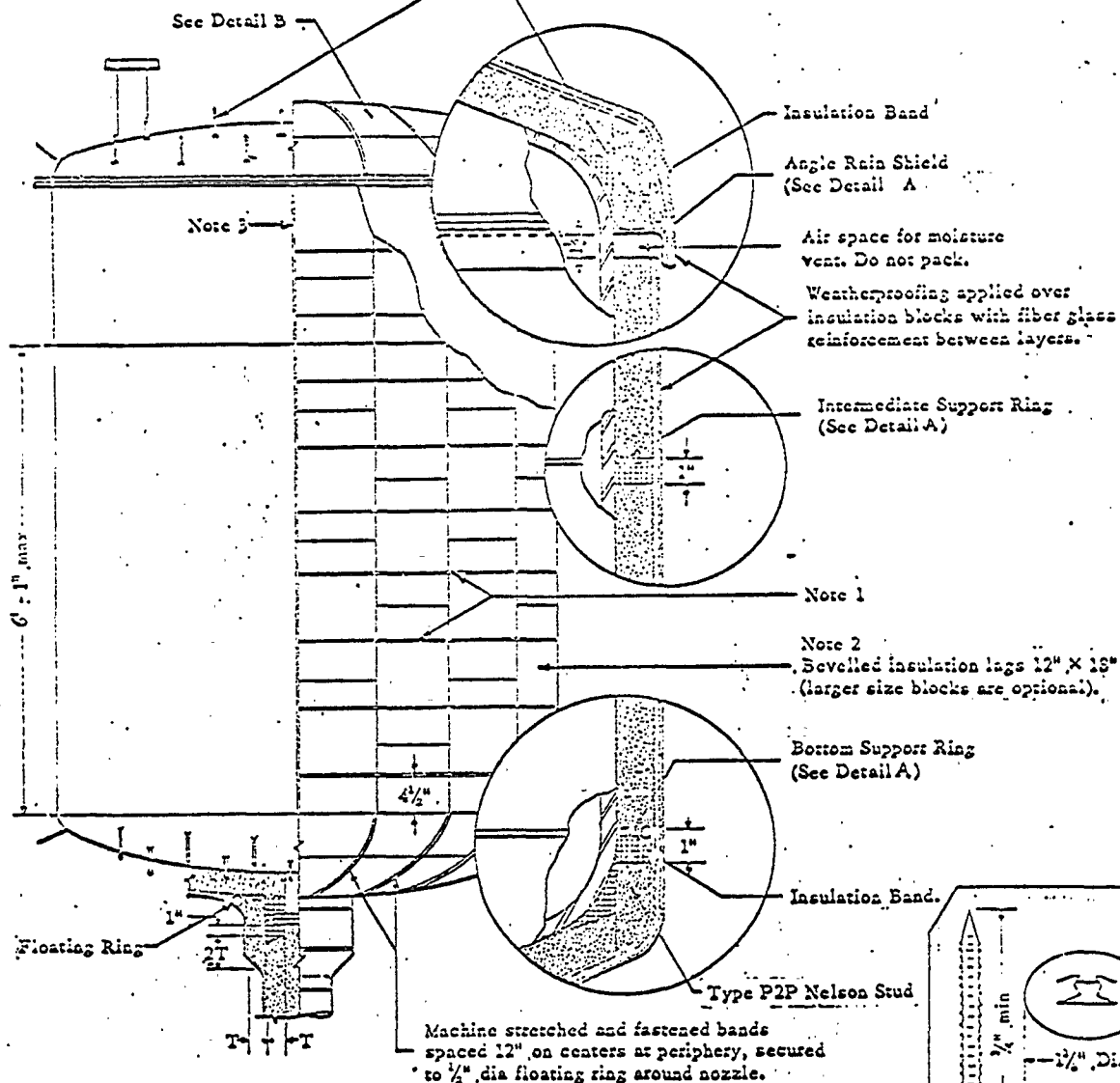
1. HORIZONTAL JOINTS SHALL BE STAGGERED.
2. SEAMS SHALL HAVE APPROXIMATELY 3" LAPS AND BE SECURED WITH ALUMINUM SCREWS.

C 002816



STANDARDS

Type P2P Nelson Studs With Speed Clips (see detail below). Optional Securement Device

K 11.4 STD 10X
ISSUE A PAGE 11 OF 13

Notes

Pack these areas tightly with filler material.

1. Machine stretched and fastened bands. Apply first band $4\frac{1}{2}$ " above bottom support ring, space on 9" centers thereafter.
2. Start courses of insulation lags at support rings after heads are covered. Stagger joints (use full block then half-block on first course, full blocks thereafter).
3. $\frac{1}{2}$ " dia rod tackwelded to $\frac{1}{4}$ " nuts or $\frac{1}{8}$ " rod spacers 16" on centers. Space rods around vessel circumference as follows:

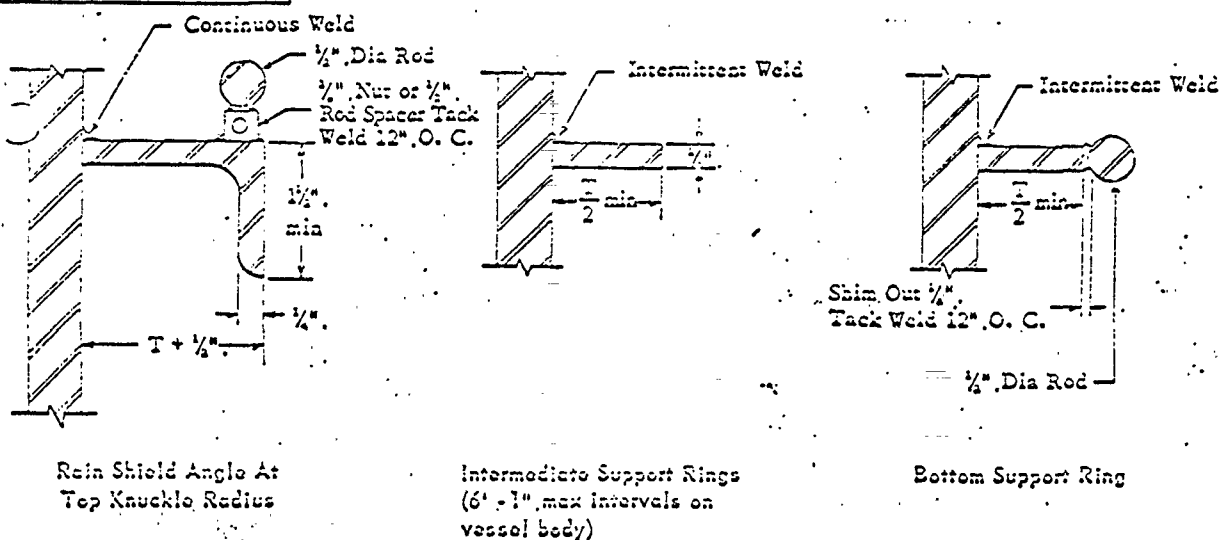
Vessel Dia	No. of Tie Rods
up to 4' - 0"	none
4' - 1", to 9' - 0"	2
9' - 1", to 14' - 0"	3
Over 14' - 0" dia	space rods so that insulation bands will not exceed 15' - 0" length.

1. Weld stud to surface free of dirt or mill scale on 12" centers around periphery, on 9" centers vertically.
2. Impale insulation over stud and force down clip on protruding end of stud.
3. Press clip against insulation and snap off excess stud.

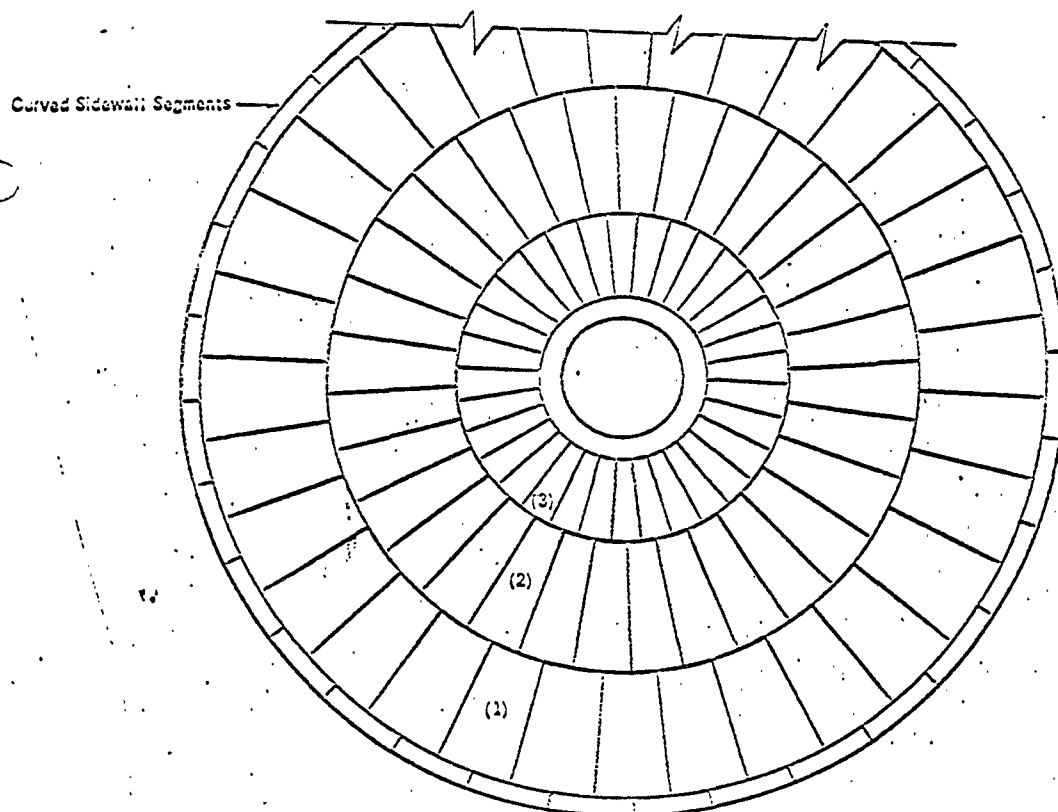
P2P Nelson Stud

APPLICATION OF RIGID INSULATION TO VESSELS
WEEKLY TEMP. = 400 F

C 002817

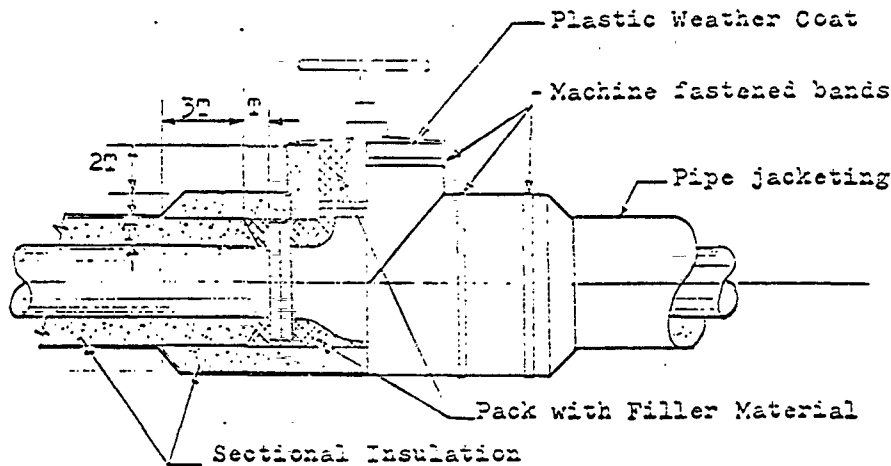


DETAIL A. DETAILS OF RAIN SHIELD ANGLE AND SUPPORT RINGS MAX TEMP 400 F.

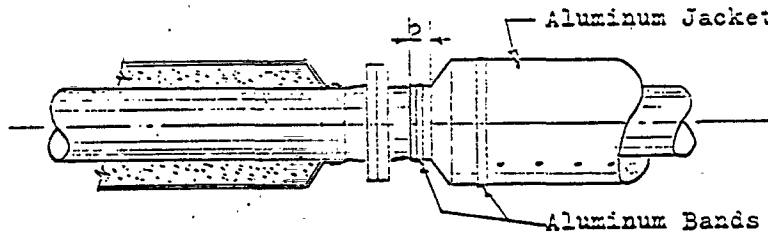


Begin Application of Shaped Head Segments at Vessel Perimeter (1) Lay in Rings (2) and (3) of Successively Smaller Segments Until Center is Reached, Carefully Staggering All Joints.
Secure with Bands Spaced 12" OC Around Vessel Perimeter and Fastened to Upper Support Ring on Sidewall;
Secure to Floating Ring at Nozzle or Manhole; Cross Head and Secure to Support Ring Otherwise.

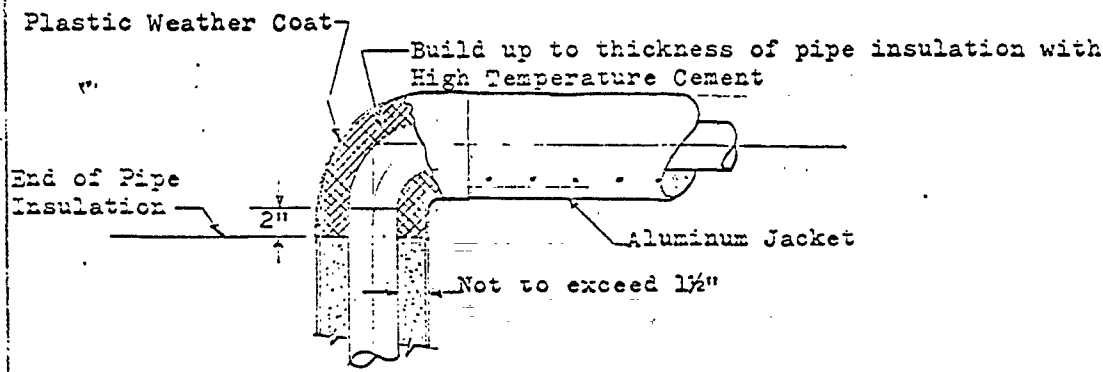
DETAIL B. PLACEMENT OF SHAPED SEGMENTS ON VESSEL DISH HEADS.



INSULATION DETAILS FOR FLANGED VALVES (For Steam & Process).
WHERE REQUIRED AND TEMPERATURE ABOVE 350 F.



TERMINATION OF INSULATION AT UNINSULATED FLANGES AND VALVES



INSULATION FOR 4" IPS AND SMALLER FITTINGS AND VALVES
WHEN PREMOULDED COVERS ARE NOT USED

C 002819



STANDARDS

COATINGS AND INSULATION MANUAL
THERMAL INSULATION CONSTRUCTION SPECIFICATIONS
SPRAYED INSULATION SYSTEMS
Elevated Temperature

MAN. SECT PART

K11.4 STD 50

ISSUE 1 DATE 1/64

PAGE 1 OF 1

1. GENERAL

1.1 Scope This Construction Specification covers application of sprayed thermal insulation systems to vessels, spheres, and equipment, and to piping 24" pipe size and larger, that operate within temperature limits 120 F to 700 F. It shall be used in conjunction with the General Insulation Specification and with the appropriate Materials Specifications.

1.2 Definitions Sprayed insulation materials usually are a combination of long-fibered asbestos with an inorganic binder. The materials are moistened with water in a specially-designed proprietary mixing device and are applied with proprietary pneumatic spray equipment.

2. APPLICATION

2.1 Temperature Limits Materials are moist when applied, so application should not be made at ambient temperature lower than 32 F unless the surface to be insulated is suitably pre-heated; or if there is possibility of freezing ambient temperature during the drying period following application.

2.2 Insulation Supports Insulation supports, supplied by others, usually consist of welded studs spaced on 12" staggered centers; stud length usually is equal to one-half of the insulation thickness.

2.3 Spraying Procedures Insulation can be applied only with proprietary equipment. It is sprayed in moist state, and requires pressing and smoothing operations at intervals during the operation to provide a homogeneous, firmly-adhering layer without joints, fissures, or irregularities in thickness. Application must be made by workmen skilled in operation of the application equipment. Allow the insulation to dry.

3. WEATHER BARRIER When the insulation has dried to the extent that surface moisture no longer is evident, apply by conventional spray apparatus a coating of "breathing" type mastic $\frac{1}{4}$ " thick when wet. While this coat is still tacky, imbed into it glass fiber reinforcing membrane, overlapping all edges 2". Apply by conventional spray apparatus a final coating of "breathing" type mastic $\frac{1}{4}$ " thick when wet, and allow to dry.

002820

REFERENCES

REVISIONS OR DELETIONS ARE SHOWN BY 1 FOR OUTLINING. DELETIONS ARE SHOWN BY

CATALYTIC CONSTRUCTION COMPANY
PHILADELPHIA 2, PA.

THERMAL INSULATION SCHEDULE

Appendix "A" to SP-31090-2200-00-4

Page 1 of 9

GENERAL

1. Insulation materials and application shall be in accordance with Catalytic Specification No. 31090-2200-00-4.
2. Where discrepancies exist between this schedule and drawings or specifications, this schedule shall govern.
3. The following legend is used herein:
HC: Heat Conservation
PP: Personnel Protection
S: Shell Side of Exchanger
T: Tube Side of Exchanger

EQUIPMENT

1. Insulation thickness and specification to be used shall be as listed herein.
2. Vents and drains from insulated equipment shall be insulated with the equipment up to the first block valve. Thickness of this insulation shall be 1/2" less than on adjacent surfaces except the minimum thickness shall be 1".
3. The sizes of equipment listed herein are for reference only. Actual sizes are given on the reference drawings.
4. Equipment requiring insulation for heat conservation shall be insulated completely. All equipment shall be insulated for this purpose unless otherwise noted.
5. Equipment requiring insulation for personnel protection shall be insulated all over except as noted herein or on the drawing.

PIPING

1. Pipe lines to be insulated are listed in Piping Summary Tables F-301 and F-302. The thickness of insulation and specification to be used are listed therein.
2. The full extent of lines requiring insulation for heat conservation shall be insulated except as specified in Monsanto Specification K11-4 STD 10X, Section 3.1.2.
3. Piping requiring insulation for personnel protection shall be insulated only to the extent specified by Monsanto Specification K11.4 STD 10X, Section 7.1 and as shown on the piping drawings. Valves & flanges in portions of lines insulated for personnel protection shall be insulated.

C 002821

THERMAL INSULATION SCHEDULE

Page 2 of 9

INSTRUMENTS

1. In addition to the instruments listed herein to be insulated, the following instruments shall be insulated as part of the piping.
 - a. All control valves and orifice flanges located in steam lines.
 - b. All steam traced control valves and orifice flanges.
 - c. All control valves and orifice flanges with operating temperatures over 500°F.
 - d. All instruments located in sections of pipe lines or on equipment insulated for personnel protection.
2. Control valves are designated as FCV, LCV, PCV and TCV.
3. Instrument lines from flow meter orifices to transmitters shall be insulated.
4. Care shall be taken that the insulation does not interfere with the operation or visibility of instruments such as level and pressure gauges.

C 002822

8-22

MONSANTO COMPANY

THERMAL INSULATION SCHEDULE FOR EQUIPMENT AND PIPING

DIVISION _____

LOCATION _____

PROJECT _____

SECTION NO. _____

AREA _____

ESTIMATE NO. _____

S.A. NO. _____

PREPARED BY _____

DATE _____

SHEET 3 OF 9

Line or Equip.	Reference Drawing Number	Size of Pipe or Equipment	Design Temp, F	Thickness and Specification Number K11-2	Bidder to Submit			Remarks	
					Bare Surface to Cover		Unit Cost \$		Total Cost \$
					Quantity	Units ¹			
51D1	51D1	4'-0 I.D. & 18" O.D.	208	1½ STD 100					
51D2	51D2 SH.1	20" I.D. & 5'6 O.D.	Varies	2½ STD 100					
51D3	51D3 SH.1	9'0" I.D. & 5'-6 I.D.	Varies	1½, 2 & 3 STD 100					
51D4	51D4 SH.1	10'-6 x 145'-6	Varies	2½ & 3 STD 100					
51D5	51D5 SH.1	5'-6 x 123'-0	Varies	2½ & 3 STD 100					
51E1	VP-46-88-9-5	3½"x21'-0 U-Tube	S-455 T-195	S-2½, T-1 STD 100					
51E2	VP-46-88-11-5	10-3/4"x 16'-0	S-194 T-107	S-1 STD 100				Insulate Shell Side Only, PP	
51E3	VP-46-88-10-4	8-5/8" x 8'-0	S-455 T-208	S-2½, T-1½ STD 100				Insulate Exp. Joint with 2" Thick Insu	
51E6	VP-46-88-10-5	18" x 16'-5	S-455 T-250	S-2½, T-1½ STD 100					
51E7	VP-46-88-10-6	12-3/4"x 16'-4	S-455 T-425	S-2½, T-2½ STD 130				Weather Barrier Spec K1103 STD 65	
51E8	VP-46-88-10-7	35½" x 17'-0	S-250 T-105	S-1 STD 100				Insulate Shell Side Only. PP	
51E9	VP-46-88-24-1	1.9" O.D. Tube *	S-107 T-455	T-1½ STD 100				Insulate Tube Side Only. PP	
51E10	VP-46-88-11-1	54" x 16'-0	S-354 T-320	S-2, T-2 STD 100					
51E12	VP-46-88-10-8	35½" x 17'-0	S-233 T-107	S-1 STD 100				Insulate Shell Side Only. PP	
51E13	VP-46-88-11-2	40" x 16'-0	S-331 T-107	S-1½ STD 100				Insulate Shell Side Only. PP	
51E14	VP-46-88-10-3	14" x 4'6	S-280 T-88	S-1 STD 100				Insulate Shell Side Only. PP	
51E15	VP-46-88-11-6	26" x 18'-0	S-280 T-107	S-1 STD 100				Insulate Shell Side Only. PP	

NOTE:

1. For piping, linear feet; for equipment, square feet.

	Orig	Date	Rev 1	Date	Rev 2	Date
By						
Checked						
Approved						

C 002823

ANSANTO COMPANY

THERMAL INSULATION SCHEDULE FOR EQUIPMENT AND PIPING

DIVISION _____ LOCATION _____
PROJECT _____SECTION NO. _____ AREA _____
ESTIMATE NO. _____ E.A. NO. _____
PREPARED BY _____ DATE _____
SHEET 4 OF 9

Line or Equip.	Reference Drawing Number	Size of Pipe or Equipment	Design Temp, F	Thickness and Specification Number K11-2	Bidder to Submit				Remarks
					Bare Surface to Cover		Unit Cost \$	Total Cost \$	
					Quantity	Units ¹			
51E16	VP-46-88-11-3	24" x 8'-0	S-406 T-107	S-2 Std 100					Insulate shell side only. PP
51E17	VP-46-88-11-4	14" x 8'-0	S-380 T-89	S-1½ Std 100					Insulate shell side only. PP
51E18	VP-46-88-9-1	3½x21'-0 U-Tube*	S-107 T-380	T-1½ Std 100					Insulate Tube side only. PP
51E20	VP-46-88-11-7	18" x 17'-0	S-525 T-107	S-2½ Std 100					Insulate shell side only. PP
	*Exchanger has two sections								
51H1	VP-46-88-6-1	4" Pipe	572	3 Std 100					Insulate external process piping only.
51H2	VP-46-88-6-2	4" Pipe	572	3 Std 100					Insulate external process piping only.
51H3	VP-46-88-6-3	4" Pipe	572	3 Std 100					Insulate external process piping only.
51J1	VP-46-88-5-1	See Dwg.	366	1½ Std 100					Insulate steam line, separator & chest only.
51J2									

NOTE:

1. For piping, linear feet; for equipment, square feet.

	Orig	Date	Rev 1	Date	Rev 2	Date
By						
Checked						
Approved						

C 002824

MONSANTO COMPANY

THERMAL INSULATION SCHEDULE FOR EQUIPMENT AND PIPING

DIVISION _____ LOCATION _____
PROJECT _____SECTION NO. _____ AREA _____
ESTIMATE NO. _____ E.A. NO. _____
PREPARED BY _____ DATE _____
SHEET 5 OF 9

Line or Equip.	Reference Drawing Number	Size of Pipe or Equipment	Design Temp, F	Thickness and Specification Number K11-2	Bidder to Submit			Remarks	
					Bare Surface to Cover		Unit Cost \$		Total Cost \$
					Quantity	Units ¹			
51P1-162	-	3 x 1½ x 8½	100	1½ Std 100				Steam Traced	
51P3	-	3 x 1½ x 8½	110	1½ Std 100				Steam Traced	
51P4-162	-	3 x 1½ x 8½	208	1½ Std 100				Steam Traced	
51P7-162	-	3 x 2 x 8½	114	1½ Std 100				Steam Traced	
51P9-162	VP-46-88-14-1	10 x 21	515	3 Std 100					
51P12-162	-	6 x 4 x 10½	280	1 Std 100				PP	
51P13-162	-	10 x 8 x 20	538	3 Std 100					
51P15-162	-	3 x 1½ x 10½	380	1½ Std 100				PP	
51P16-162	-	6 x 4 x 10½	525	3 Std 100					
51P19-162	-	4 x 3 x 13	180	1½ Std 100				Steam Traced	
51P27-162	-	3 x 1½ x 8½	415	2½ Std 100				Steam Traced	
51R3-162	51R3	7'-0 x 23'-6	515	3 Std 130				Weather Barrier Spec K11-3 Std 65	
51S3	VP-46-88-18-1		125	1½ Std 100				Steam Traced. Cover to be Removable	

NOTE:

1. For piping, linear feet; for equipment, square feet.

LEGEND: PUMP SIZES

3 x 1½ x 8½
 ↑ ↑ ↑
 Suction Discharge Casing
 Dia. Dia. Dia.

	Orig	Date	Rev 1	Date	Rev 2	Date
By						
Checked						
Approved						

C 002825

THERMAL INSULATION SCHEDULE FOR EQUIPMENT AND PIPING

SECTION NO. _____ AREA _____
ESTIMATE NO. _____ E.A. NO. _____
PREPARED BY _____ DATE _____
SHEET 6 OF 9

8-26

1. For piping, linear feet; for equipment, square feet.

	Orig	Date	Rev 1	Date	Rev 2	Date
By						
Checked						
Approved						

C 002826

CATALYTIC CONSTRUCTION COMPANY
PHILADELPHIA 2, PA.

INSULATION SCHEDULE

Page 7 of 9

INSTRUMENTS

INST. NO.	INST. NAME	OPER. TEMP. OF	STREAM TRACED	LOCATION				INSUL. THK. STD.	INSUL. SPEC. K11-2	REMARKS
				STAND- TYPE	EQUIP. ITHK. NO.	PIPELINE NO.	AREA			
LT-7	Level Transmitter	208	Yes	-	51D1			1 1/2	100	
LT-9	"	110	Yes	-	51T2			1 1/2	100	
LT-14	"	122	Yes	-	51T14			1 1/2	100	
LT-22	"	115	Yes	-	51T3			1 1/2	100	
LT-23	"	115	Yes	-	51T3			1 1/2	100	
LT-24	"	514	No	-	51D3			3	100	
LT-30	"	538	No	-	51D4			3	100	
LT-34	"	525	No	-	51D5			3	100	
LT-35	"	380	No	-	51T5			2	100	
LG-3	Level Gauge	208	Yes	2"	51D1			1 1/2	100	
LG-4	"	110	Yes	2"	51T2			1 1/2	100	
LG-5	"	110	Yes	2"	51T2			1 1/2	100	
LG-16	"	110	Yes	2"	51T3			1 1/2	100	
LG-17	"	110	Yes	2"	51T3			1 1/2	100	
LG-18	"	514	No	2"	51D3			2 1/2	100	
LG-21	"	280	No	2"	51T4			1	100	
LG-22	"	538	No	2"	51D4			2 1/2	100	
LG-25	"	525	No	2"	51D5			2 1/2	100	
LG-26	"	380	No	2"	51T5			1 1/2	100	
LG-28	"	175	Yes	2"	51T9			1	100	
LG-32	"	212	No	2"	51T16			1 1/2	100	
FT-1	Flow Transmitter	150	Yes	-	320P659.1			1 1/2	100	
FT-5	"	100	Yes	-	51R1-1.1			1 1/2	100	
FT-6	"	100	Yes	-	51P1-1.1			1 1/2	100	
FT-8	"	500	No	-	S51.53			2 1/2	100	
FT-9	"	210	Yes	-	51P4-1.2			1 1/2	100	
FT-24	"	210	Yes	-	51P4-1.1			1 1/2	100	
FT-30	"	114	Yes	-	51P7-1.1			1 1/2	100	
FT-31	"	114	Yes	-	51P7-1.2			1 1/2	100	
FT-38	"	320	No	-	51E10.1			1 1/2	100	
FT-43	"	538	No	-	51R3-1.2			2 1/2	100	
FT-57	"	538	No	-	51P13-1.2			2 1/2	100	

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INSULATION SCHEDULE

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INSTRUMENTS

INST. NO.	INST. NAME	OPER. TEMP. OF TRACED	LOCATION				INSUL. SPEC. K11-2, Std	REMARKS
			STAND-PIPE	EQUIP. ITEM NO.	PIPELINE NO.	AREA		
IA-46	Level Alarm	212	-	51T6			1	
PT-23	Press. Transmitter	320	-	51D3			1 1/2	
PG-1	Pressure Gauge	100	-	51P1-1			1 1/2	
PG-7	"	208	-	51P4-1			1 1/2	
PG-8	"	110	-	51P3			1 1/2	
PG-14	"	122	-	51T14			1 1/2	
PG-17	"	140	-	51T8			1 1/2	
PG-21	"	415	-	51P27-1			2 1/2	
PG-23	"	230	-	51D3			1 1/2	
PG-26	"	115	-	51T3			1	
PG-30	"	114	-	51P7-1			1 1/2	
PG-31	"	514	-	51P9-1			3	
PG-32	"	514	-	51D3			3	
PG-37	"	425	-		S51.4		2	Insulate Back of Case
PG-55	"	425	-		S51.3		2	Insulate Back of Case
PG-66	"	Amb.	-		51P19-1.2		1	
PG-67	"	Amb.	-		51P19-1.3		1	
PG-68	"	Amb.	-		51P19-1.4		1	
PG-72	"	Amb.	-		51P19-1.7		1	
PG-78	"	298	-		S51.20		1 1/2	Insulate Back of Case
PG-79	"	353	-		S51.15		2	Insulate Back of Case
PG-80	"	212	-	51T16			1	Insulate Back of Case
PSV-1	Safety Valve	120	-	51T1			1 1/2	
PSV-3	"	120	-		320PE59		1 1/2	
PSV-4	"	100	-	51P1-1			1 1/2	
PSV-5	"	100	-	51P1-2			1 1/2	
PSV-10	"	100	-		51T1.1		1 1/2	
PSV-11	"	100	-		51PG-1.4		1 1/2	
PSV-13	"	208	-	51P4-1			1 1/2	
PSV-14	"	208	-	51P4-2			1 1/2	
PSV-16	"	110	-	51P3			1 1/2	
PSV-25	"	120	-	51T14			1 1/2	
PSV-28	"	Amb.	-		G51.22		1 1/2	
PSV-30	"	140	-	51T8			1 1/2	
PSV-31	"	Amb.	-		G51.10		1 1/2	

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INSULATION SCHEDULE

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INSTRUMENTS

INST. NO.	INST. NAME	OPER. TEMP. OF	STEAM TRACED	LOCATION			INSUL. THICK.	INSUL. SPEC. KII-2 Std	REMARKS
				STAND-PIPE	EQUIP. NO.	PIPELINE NO.			
PSV-36	Safety Valve	425	No		51E7	51P4-1.1	2	100	
PSV-39	"	208	Yes			51T3.6	1 1/2	100	
PSV-44	"	115	Yes			51D3.1	1 1/2	100	
PSV-45	"	233	No				1 1/2	100	
PSV-73	"	366	No		51T16	51P1-1.1	2	100	
PSV-76	"	100	Yes			51P4-1.1	1 1/2	100	
PSV-79	"	208	Yes			51T2.1	1 1/2	100	
PSV-81	"	100	Yes			51P4-1.2	1 1/2	100	
PSV-82	"	208	Yes			51P4-1.2	1 1/2	100	
PSV-83	"	208	Yes			51P4-1.4	1 1/2	100	
PSV-84	"	208	Yes			S51.20	1 1/2	100	
PSV-89	"	298	No				1 1/2	100	

C 002829

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SECTION .95

INSULATION SPECS

UTILITIES

ENVIRONMENTAL CONTROL

DISTRIBUTION

C 002830

X.95 Insulation

Insulation is provided on vessels, equipment, and piping for heat conservation, process stability, prevention of condensation, and personnel protection. Preformed polyurethane is used to reduce heat leak in cold service; calcium silicate is used in high temperature service. In temperature ranges from +25F to 150F mineral wool, foam glass, and "K-Kote" Mastic are used. Mineral wool is also used as fire protection over polyurethane on vessels and equipment.

Design K values for these materials are shown in Figure 1.

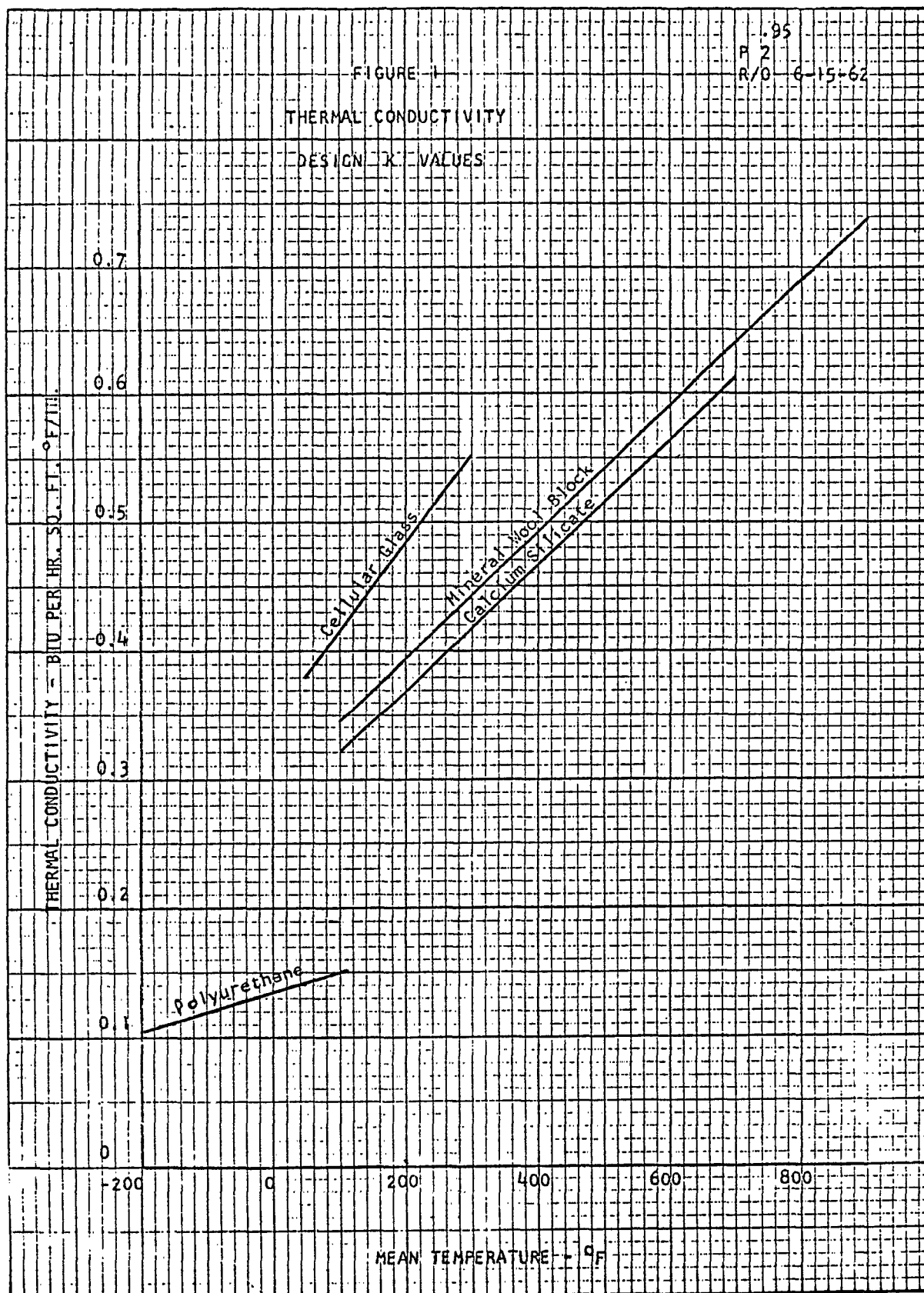
High temperature insulation to 1200F is preformed Kaylo, a calcium silicate material by Owens-Corning Fiberglass Corporation. For temperatures above 1200F, Kaylo 20 High Temperature Insulation is used. Insulation thicknesses for equipment and piping appear in Figures 2 and 3, respectively. Multiple layers are provided for the higher temperature ranges. The insulation system is completed by accessories including insulation filler, caulking mastic, reinforcing membrane of glass fiber, and Lion Oil Seal Perm weather coating. In battery limits, aluminum sheet is used for protective jacketing on piping while asbestos roofing felt is used off battery limits. Expansion joint spacing is approximately 18 ft on piping.

Low temperature insulation is Type U-200 preformed, fire retardant, rigid polyester polyurethane, foamed with Freon 11, by Union Asbestos & Rubber Company. On vessels and equipment, polyurethane insulation is fireproofed with two inches of mineral wool block. Figures 4 and 5 show polyurethane thicknesses for equipment and piping. Piping expansion joint spacing is shown in Figure 6. Accessory materials to form a complete insulation system include lagging adhesive, joint sealer, caulking mastic, glass fiber reinforcing membrane, interior and exterior vapor barriers, and aluminum protective jacketing.

Insulating materials and thicknesses used for temperatures between +25F and 150F appear in Figure 7. Moisture seals have been provided for temperatures below 80F. Mineral wool block is "PV Supertemp" by Eagle-Picher Company; foam glass block is preformed cellular glass block, 9 to 11 pound density, by Pittsburgh-Corning Corporation; and insulating mastic is "K-Kote", a cork filled asphaltic mastic by Lion Oil Company.

Measures have been taken to avoid frost on appurtenances attached to cold equipment. Wood blocks are used to isolate foundations, ladders, platforms, and similar items from low temperature services. Tapered insulation is employed where required on instrument runs, safety valve inlets, and similar connections.

Insulation summaries are included in this section showing size, configuration, and insulation codes for major items of equipment.



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FIGURE 2

HOT VESSEL & EQUIPMENT INSULATION

Code Number	101	151	201	251	301	302	352	402	452	Special
Temperature Range	200 & below	201 300	301 400	401 500	501 600	601 900	901 1000	1001 1100	1101 1200	Over 1200
Thickness Single Layer	1"	1½"	2"	2½"	3"					Required insulation to be specified for individual equipment.
Thickness Double Layer						3"	3½"	4"	4½"	

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FIGURE 3

HOT PIPING INSULATION

THICKNESS IN INCHES

Code	R	S	T	U	V	W	X
Temperature Range °F	151 to 450	451 to 600	601 to 750	751 to 900	901 to 1050	1051 to 1200	1201 to 1800
1" & Under	1"	1"	1½"	2"	2"	2½"	FOR INSULATION OF PIPING, VESSELS AND EQUIPMENT WITHIN THE RANGE OF +1201 THRU +1800F, SEE INSTRUCTIONS FOR SPECIFIC ITEMS
1½"	1"	1½"	1½"	2"	2"	2½"	
2"	1"	1½"	1½"	2"	2½"	2½"	
3"	1"	1½"	1½"	2"	2½"	3"	
4"	1½"	1½"	2"	2"	2½"	3"	
6"	1½"	2"	2"	2½"	3"	3"	
8"	1½"	2"	2"	2½"	3"	3½"	
10"	1½"	2"	2½"	2½"	3"	3½"	
12"	1½"	2"	2½"	2½"	3"	3½"	
14"	1½"	2"	2½"	2½"	3"	3½"	
16"	1½"	2"	2½"	3"	3"	3½"	
18"	1½"	2"	2½"	3"	3"	3½"	
20"	1½"	2"	2½"	3"	3"	3½"	
24"	1½"	2"	2½"	3"	3"	4"	

Over 24" as specified on the drawings

SINGLE LAYER

DOUBLE LAYER

NOTE: Double layer insulation required for 3" IPS and less,
above 750F and for piping 4" IPS and larger, above
600F.

FIGURE 4

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LOW TEMPERATURE INSULATION FOR VESSELS AND EQUIPMENT

THICKNESS IN INCHES

Insulation Code No.	30	35	40	45	50	55	60
Temperature Range							
from	+25	-45	-85	-125	-165	-210	-255
to	-44	-84	-124	-164	-209	-254	-300
External Layer (Mineral Wood)	2"	2"	2"	2"	2"	2"	2"
Polyurethane	1"	1½"	2"	2½"	3"	3½"	4"
Approx. Total Thickness	3"	3½"	4"	4½"	5"	5½"	6"

Single Layer of Polyurethane

Two Layers of Poly-
urethane

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FIGURE 5

LOW TEMPERATURE INSULATION FOR PIPING
(POLYURETHANE PREFORMED PIPE INSULATION)

Insulation Code	A	B	C	D	E	F	G	H
Temp. Range °F	+70 +26	+25 -10	-11 -50	-51 -100	-101 -150	-151 -200	-201 -250	-251 -300

Pipe Size	(Thickness in Inches)							
1" & Smaller	3/4"	1"	1 1/2"	1 1/2"	2"	2"	2 1/2"	2 1/2"
1 1/2"	3/4"	1"	1 1/2"	1 1/2"	2"	2"	2 1/2"	2 1/2"
2"	3/4"	1"	1 1/2"	2"	2"	2 1/2"	2 1/2"	3"
3"	3/4"	1 1/2"	1 1/2"	2"	2 1/2"	2 1/2"	3"	3"
4"	3/4"	1 1/2"	1 1/2"	2"	2 1/2"	3"	3"	3 1/2"
6"	3/4"	1 1/2"	2"	2 1/2"	2 1/2"	3"	3 1/2"	3 1/2"
8"	1"	1 1/2"	2"	2 1/2"	2 1/2"	3"	3 1/2"	4"
10"	1"	1 1/2"	2"	2 1/2"	3"	3 1/2"	3 1/2"	4"
12"	1"	1 1/2"	2"	2 1/2"	3"	3 1/2"	3 1/2"	4"
14" & Over	1 1/2"	1 1/2"	2"	2 1/2"	3"	3 1/2"	4"	4 1/2"

Use two layers for
insulation over 3"

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FIGURE 6

SPACING BETWEEN 1" EXPANSION JOINTS FOR COLD PIPING INSULATION

<u>Operating Temperature °F</u>	<u>Maximum Spacing</u>
-50 and above	35.0 ft
-100	25.0 ft
-150	20.0 ft
-200	16.0 ft
-250	14.0 ft
-300	12.5 ft

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FIGURE 7

THICKNESS OF INSULATION

Temperature Range	+26 to +40	+41 to +55	+56 to +80	+80 to +150
Thickness, inches	2	1½	1	½
Code - Min Wool Block	20	15	10	*
Code - Foam Glass	20f	15f	10f	*
Code - K-Kote	-	-	-	5

* NOTE: One-inch blocks, Codes 10 or 10f may be used in this range if circumstances make it desirable. Mastic, (Code 5) shall not be used on large vessels or columns.

PLAINTIFF'S
EXHIBIT
MON-77

S.A.B.

INSULATION SPECS

6 002730