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In This Issue

Estimating Mineral Wool Insulation

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INSULATION ESTIMATING IS NOT WELL ADAPTED TO SHORT-CUT CALCULATIONS. THIS ARTICLE PERMITS MAKING DETAILED ESTIMATES

PROCESS EQUIPMENT COSTS

MINERAL WOOL insulating materials, for hot piping and other equipment, has a high rating from the standpoint of light weight and high thermal efficiency. One of the principal reasons why mineral wool insulations are not employed as much as magnesia and asbestos insulation is the fact that pipe coverers quite frequently complain of real or imagined silicosis and dermatitis. It cannot be denied that even when handling samples of mineral wool products tiny fibers quite often penetrate the skin of the hands of the person handling such samples. However, the use of a skin protecting antiseptic ointment over hands and arms, and other common safety measures, will enable a mechanic to install mineral wool pipe covering, blankets, blocks and cement just as quickly and efficiently as he would install other standardized insulation materials.

This is the second of a group of articles on the estimation of heat insulation costs, prepared by Mr. Otto. The first, dealing with cork insulation for cold lines and equipment, appeared in our May issue. Remaining articles, which will be concerned with other higher temperature insulations, will appear frequently, the next in an early issue.

Mineral Wool Blankets

Mineral wool blankets are used for flat or slightly curved surfaces of larger types of heated industrial equipment. The blankets consist of heat-resisting selected mineral wool, carefully felted and treated and secured between layers of metal fabrics of a large variety as listed in Table V. Blankets are widely used for heat exchangers, stills, tank cars, towers, boilers and breeches, kilns, ducts, tanks, vessels, ovens, washing machines, furnaces, vulcanizers and many other pieces of industrial equipment. Owing to its low thermal conductivity, blanket insulation is highly efficient; the efficiency can be increased by providing an air space within the insulation by using blankets with ribs turned out against the hot surface.

Estimators should be warned to investigate the type of blankets offered for specific insulation jobs. Not all mineral wool products possess the same chemical and physical characteristics. Mineral wool, also called slag wool, rock wool, etc., is made from a great variety of raw materials, among them lead slag, iron slag, limestone, basaltic lavas, copper slag and slags from other metal production. Lead slag wool usually receives preference because of certain valuable characteristics not found in other mineral wools. A lead slag containing 30 to 50 percent calcium oxide or combined calcium and magnesium oxide will yield a good mineral wool. Slags of other compositions need added ingredients for decreasing brittleness of the fiber and attaining springiness and chemical resistance. Where large quantities are involved the estimator should secure copies of the U. S. Government specifications for mineral wool blankets and should make certain that the offered mineral wool meets the tests for resistance to vibration, thickness of fibers, shot content, water repellency, and alkalinity.

Because mineral wool blankets are supplied in sizes of 2 x 4 ft. and 2 x 8 ft. the application can be done with less labor in shorter time than would be possible with most other insulation materials. The area which can be covered at one time is more than five times greater than standard sizes of other prefabricated branded insulations. The thicknesses for best results have been listed in Table III, from which the estimator will note that blankets are furnished in thicknesses up to 8 in. Many operators, however,

Table I—Thermal Conductivity of Mineral Wool Insulation

Mean Temperature, Deg. F.	*k* Factor, B.t.u./Hr., Sq. Ft., Deg. F. per In. — Density, Lb. per Cu. Ft.				
	6	8	10	12	Usual *
50	0.220	0.232	0.215	0.262	0.252
100	0.270	0.273	0.255	0.200	0.286
150	0.320	0.315	0.297	0.320	0.322
200	0.380	0.357	0.342	0.355	0.357
250	0.430	0.400	0.383	0.385	0.392
300	0.480	0.442	0.425	0.418	0.428
350	0.540	0.485	0.467	0.447	0.464
400	0.590	0.527	0.511	0.478	0.500
450	0.650	0.570	0.552	0.508	0.535
500	0.700	0.618	0.598	0.537	0.571
550	0.750	0.655	0.642	0.562	0.605
600	0.810	0.697	0.682	0.602	0.642
650	0.860	0.742	0.725	0.637	0.677
700	0.910	0.787	0.769	0.667	0.712
800	.....	.....	.....	.....	0.750
900	.....	.....	.....	.....	0.810
1,000	.....	.....	.....	.....	0.900
1,100	.....	.....	.....	.....	1.000
1,200	.....	.....	.....	.....	1.100

* *Note:* The *k* factors listed under "Usual" represent maximum figures quoted by manufacturers of mineral wool insulations for their respective products, i.e. blankets, pipe coverings and loose mineral wool.

prefer to build heavy insulations up to the required thicknesses by using high temperature cement as a base and blankets of 4-in. thickness to make up the total required thickness.

The list prices for blanket insulation have been given in Table VI and the discounts are listed in Table XI. If the estimator has to calculate the job by material and labor, he should take the net cost of the blankets plus freight and hauling, the cost of the high temperature cement for undercoat, if required, the cost of the cement finish coat, and finally the cost of the weatherproofing coat, if it is an outside job. In addition, he must estimate the cost of erection of the scaffolding, the tackwelding of angle iron and cold rolled steel rings for supports of the blankets, and the actual labor cost for applying the blankets as well as the coatings. However, all these costs for the complete application job have been estimated and are listed in Table XII. The estimator therefore need only add together the net price of the type of blanket chosen and the square-foot prices for application as listed in Table XII to arrive at the total cost of the installation.

Table II—Thermal Conductivity of High Temperature Mineral Wool Blocks

Mean Temperature, Deg. F.	Brand *A*	Brand *B*
200	0.36	0.41
400	0.41	0.45
600	0.48	0.60
800	0.56	0.75
1,000	0.64	0.90
1,200	0.73	1.10
1,400	0.81	1.20
1,600	0.91	1.50

Table III—Guide for Thickness* of Mineral Wool Blanket Insulation

Operating Temperature, Deg. F.	Thickness of Blanket, In.	Thickness † of Base Coat, In.
100 to 200	1	..
201 to 300	1½	..
301 to 500	2	..
501 to 700	2½	..
701 to 900	3	..
901 to 1,100	3½	..
1,101 to 1,200	4	..
1,201 to 1,400	4	1
1,401 to 1,600	4	2
1,601 to 1,800	4	3

* To the above thicknesses add a ½-in. coat of mineral wool cement and, for outside installations, an additional ¼-in. coat of weatherscaling compound on top of the cement finish.

† Consists of mineral wool nodules, asbestos fiber and colloidal clay.

Pipe Covering

Like the blanket type mineral wool insulation, mineral wool pipe covering is also made from high temperature-resisting and moisture-repellent, long-fiber, specially selected mineral wool and the general specifications applying to blankets readily apply to pipe covering, since both are made from the same raw materials. Pipe covering is shipped flat and is fitted around the pipe for easy application. Mineral wool pipe covering actually is a small blanket, armored on the inside and the outside with expanded metal. The covering is held on the pipe by lacing the edges of the metal fabric together by means of No. 18 B.w.g. copper wire. The outside armor is usually full-fashioned copper-bearing expanded metal, whereas on the inside, against the hot surface, strips of the same material are used. Mineral wool pipe covering is made in 2-ft. long sections; for small and medium diameter pipes one section goes around the pipe completely, whereas for large diameter pipes two or more segments may be required. These sections and segments are also available for circular equipment and pipes having diameters larger than 30 in. Upon request this blanket type pipe insulation may be furnished in rectangular sections of 12 or 24 in. width and 24 or 36 in. length, both sides reinforced with galvanized wire netting of a wire thickness of 0.035 in., and both layers of wire netting fastened to each other through the blanket itself by wire spaced not more than 8 in. centers.

Table V—Type Numbers and Identification of Mineral Wool Blankets

Type No	Construction Details * One Side	Other Side
1	W. M.	W. M.
2	W. M.	S. L.
3	W. M.	E. M.
4	W. M.	⅛ in. R. L.
5	W. M.	⅛ in. R. L. (rib outside)
6	W. M.	¾ in. R. L.
7	W. M.	¼ in. R. L. (rib outside)
8	W. M.	M. L.
9	S. L.	S. L.
10	S. L.	E. M.
11	S. L.	⅛ in. R. L.
12	S. L.	⅛ in. R. L. (rib outside)
13	S. L.	¾ in. R. L.
14	S. L.	¾ in. R. L. (rib outside)
15	F. S.	F. S.
16	⅛ in. R. L.	⅛ in. R. L.
17	M. L.	M. L
18	M. L.	⅛ in. R. L.
19	M. L.	¾ in. R. L. (rib outside)
20	M. L.	¾ in. R. L.
21	M. L.	¾ in. R. L. (rib outside)
22	E. M.	E. M.
23	A. P.	A. P.

* *Key:* W. M., 1 in. galv. wire mesh; S. L., stucco lath; F. S., No. 12 mesh fly screen; R. L., rib lath; M. L., copper-bearing metal lath; E. M., expanded metal lath; A. P., asbestos paper.

It is a matter of personal preference whether a designer specifies mineral wool insulation or any of the other standard insulating materials for the average pipe covering job when no special difficulties are to be expected. However, for underground piping, for nested and bundled piping and certain other installations mineral wool pipe covering possesses definite advantages over other type of heat insulants.

In estimating pipe covering costs the engineer has to consider the cost of the material itself, the heat saving efficiency, the life of the insulation, and the cost of application. The heat saving efficiency is a result of the thermal coefficient, and in the case of mineral wool insulation the *k* factor is closely related to the density of the material. Table I lists the thermal coefficients of mineral wool products of various densities and gives also the average *k* factors of several standardized, branded mineral wool insulations. U. S. Government specifications call for a maximum density of 12 lb. per cu. ft., including the weight of armor in the case of blankets and pipe covering. As long as the estimator can get a guarantee of the density of the material to be offered he will be able, with the help of Table I, to determine the thermal conductivity and, therefore, the efficiency of the insulation he proposes to use for a certain job.

The list prices for mineral wool pipe covering are listed in Table VII and the discounts to the industrial buyer are given in Table XI. As in the case of mineral wool blankets the prices for mineral wool pipe covering are f.o.b. manufacturers' shipping points; the freight and hauling

Table IV—Guide for Thickness of Mineral Wool Pipe Covering*

Temperature, Deg. F.	Pipe Diameter, Inches: 2 to 3½ — Insulation Thickness,† Inches			4 to 4½ — Insulation Thickness,† Inches			5 and up — Insulation Thickness,† Inches		
	I	O	U	I	O	U	I	O	U
Below 212	1	1½	1	1	1½	1	1	1½	1
213 to 267	1	1½	1	1	1½	1	1	1½	1
268 to 338	1	1½	1	1	1½	1	1	1½	1
339 to 388	1	1½	1	1	1½	1	1½	2	1
389 to 500	1	1½	1	1½	2	1	1½	2	1
501 to 600	1½	2	1	1½	2	1	2	2½	1½
601 to 700	1½	2	1	2	2½	1½	2	2½	1½
701 to 800	2	2½	1½	2	2½	1½	2½	3	2
801 to 1,000	2	2½	1½	2½	3	2	3	3½	2½

* *Note:* Mineral wool pipe covering is not manufactured in thicknesses below 1 in. and not for pipes having a diameter of less than 2 in.

† *Key:* "I" stands for inside piping, "O" stands for outside piping, "U" stands for underground piping.

Table VI—List Prices for Mineral Wool Blanket Insulation

(Basis, dollars per square ft.)

Thickness, Inches	Type Numbers: 1	2, 3, 8	9, 17, 10, 22	11, 5, 12, 18, 4, 19	13, 7, 14, 6	16, 20, 21	15	23
1	0.40	0.45	0.55	0.60	0.70	0.75	0.60	0.65
1¼	0.45	0.53	0.60	0.65	0.75	0.83	0.65	0.70
1½	0.50	0.60	0.65	0.70	0.80	0.90	0.70	0.75
1¾	0.55	0.65	0.70	0.75	0.85	0.95	0.75	0.80
2	0.60	0.70	0.75	0.80	0.90	1.00	0.80	0.85
2½	0.70	0.80	0.85	0.90	1.00	1.10	....	....
3	0.80	0.90	0.95	1.00	1.10	1.20	....	....
3½	0.88	0.98	1.03	1.08	1.18	1.28	....	....
4	0.95	1.05	1.10	1.15	1.25	1.35	....	....
4½	1.03	1.13	1.18	1.23	1.35	1.45	....	....
5	1.10	1.20	1.25	1.30	1.45	1.55	....	....
5½	1.18	1.28	1.33	1.38	1.55	1.65	....	....
6	1.25	1.35	1.40	1.45	1.65	1.75	....	....
6½	1.35	1.43	1.48	1.53	1.75	1.85	....	....
7	1.40	1.50	1.55	1.60	1.85	1.95	....	....
7½	1.48	1.58	1.63	1.68	1.95	2.05	....	....
8	1.55	1.65	1.65	1.75	2.05	2.15	....	....

Table VII—List Prices for Mineral Wool Pipe Covering

(Basis, dollars per lineal foot)

Pipe Sizes,* Inches	Wall Thickness of Covering, Inches: 1	1½	2	2½	3	4
2	0.70	0.90	1.30	1.65	2.20	3.10
2½	0.75	1.00	1.40	1.75	2.30	3.25
3	0.85	1.10	1.50	1.85	2.45	3.40
3½	0.95	1.20	1.60	1.95	2.60	3.55
4	1.05	1.30	1.70	2.05	2.75	3.70
4½	1.15	1.40	1.85	2.20	2.90	3.85
5	1.25	1.50	2.00	2.35	3.05	4.00
6	1.35	1.65	2.15	2.50	3.30	4.20
7	1.50	1.80	2.30	2.70	3.55	4.50
8	1.65	1.95	2.50	2.95	3.80	4.80
9	1.80	2.15	2.75	3.20	4.10	5.10
10	2.00	2.35	3.00	3.50	4.40	5.50
12	2.20	2.70	3.30	3.80	4.80	6.00
14	2.50	3.00	3.60	4.20	5.30	6.50
16	2.80	3.30	4.00	4.60	5.80	7.10
18	3.10	3.60	4.40	5.00	6.30	7.60
20	3.40	3.90	4.80	5.50	6.90	8.20
24	4.00	4.60	5.60	6.40	7.90	9.50
30	5.00	5.60	6.80	7.80	9.40	11.20

* Sizes 2 to 12 in. are nominal; 14 in. and larger are O. D.

Table VIII—List Prices for Mineral Wool High Temperature Blocks

(Basis, dollars per sq. ft., f.o.b. shipping point)

Thickness, Inches	List Price	Thickness, Inches	List Price
½	$0.27	2¼	$0.68
¾	0.27	2½	0.75
1	0.30	2¾	0.83
1¼	0.38	3	0.90
1½	0.45	3¼	0.98
1¾	0.53	3½	1.05
2	0.60	4	1.20

Table IX—List Prices * for Mineral Wool Insulating Cement

(Basis, dollars per 50-lb. bag)

Quantity	National Buyer	Average Buyer
C. L. lots	$3.00	$3.15
40 Bags and over, but less than C. L. L.	3.30	3.50
39 Bags and less	3.55	3.75

* *Note:* Full freight allowance to buyer's destination for C. L. L. For less than car load lots full freight allowance up to $1.25 per 100 lb. freight rate.

Table X—List Prices * of Loose and Granulated Mineral Wool

(Basis, dollars per ton)

	C. L. L.	L. C. L.
Loose mineral wool	$52.00	$58.00
Granulated mineral wool	71.00	76.50

* *Note:* Full freight allowance up to $0.80 per 100 lb. on C. L. L. and up to $1.25 per 100 lb. on L. C. L. The minimum car load quantity is 24,000 lb.

charges, therefore, must be added. The estimator will find that the list prices and discounts quoted by a number of manufacturers are identical. He, therefore, must make his choice on the differences in chemical and physical properties. Besides other requirements mentioned before (see Blankets) the material to be selected by the estimator shall have not more than 20 percent by weight of shot, which are small glassy pellets and beads without recognizable insulating properties; the sulphur content must be below 0.5 percent; the sodium oxide content must be below 0.25 percent, and in the heat test the material must be subjected for 6 hr. to 1,000 deg. F. without showing signs of fusion, shrinkage or detrimental changes.

Mineral wool pipe covering is suitable for all heated pipes up to 1,000 deg. F. and is especially well adapted for buried pipes, for piping in trenches, channels, tunnels, and wherever pipes are so close to the ground, wall or ceiling (or to neighboring pipes) that the installation of premolded sectional pipe covering, made from other standardized insulating materials, presents difficulties. The small rectangular mineral wool sections can easily be slipped around a pipe and the two ends are clamped together on the accessible side by means of hog rings or laced together with flexible wire. It is only necessary to have enough clearance for the thickness of the blanket pipe covering itself. The thicknesses recommended for efficient heat saving under various conditions have been listed in Table IV. If the installation can be kept dry it is not necessary to cover the mineral wool, except when a neat appearance is required, in which case a coat of ½-in. mineral wool cement or asbestos cement may be applied. Or, instead of the cement finish, a layer of 45- or 65-lb. roofing felt may be installed. For greater heat savings economy, either a cement coating or roofing felt may be laid over the pipe covering. For outdoor jobs it is recommended to cover the insulation with roofing felt or galvanized sheet metal.

The cost of applied mineral wool pipe covering is the aggregate of the pipe covering itself, freight, hauling, lacing wire, cement coat, roofing paper, scaffolding, and labor. In order to arrive at the total cost of mineral wool pipe covering the estimator should determine the net delivered cost of the pipe covering itself and should add the cost of installation as listed in Table XIII. It will be noted that only three thicknesses have been listed; application costs for other thicknesses should be approximated. The cost for application is based on $2 per hour for labor and cost prices for cement, canvas and roofing felt, wire, twine, etc., are those prevailing in June 1947.

Blocks and Boards

Wherever flat surfaces of heated equipment have to be insulated against heat losses, the designing engineer will find that certain mineral wool insulating blocks possess characteristics which make the use of mineral wool desirable. These blocks are effective over the entire temperature range up to 1,600 deg. F., and in the case of products of a few manufacturers, up to 1,700 deg. F., in contrast with most other standardized insulating blocks which are made for either high or normal temperatures, not both. The k factors for these blocks

are lower than those listed in Table I, as may be seen by comparing the figures in this table with those in Table II. The density of these blocks is usually 18 lb. per cu. ft., which is light in weight for high temperature insulating material.

As a rule these blocks are widely used for breechings, behind furnace refractories, for lehrs, ovens, boiler walls, annealing pits, hot air ducts, heat treating furnaces, kilns in glass and ceramic industries, chilling pits, pit covers, turbines, and tanks and towers in refineries. The thicknesses to be applied correspond with those given in Table III but no undercoat is required for higher temperatures. The maximum thickness of these blocks is 4 in.; a 6-in. thick insulation, therefore, consists either of two layers of 3 in. each, or one layer of 4 in. and a second layer of 2-in. thickness. For sizes and thicknesses of high temperature mineral wool insulation blocks see Table XIV.

For high temperature operations thermal expansion and contraction factors are of prime importance. These blocks, when subjected to a temperature of 1,200 deg. F. in a muffle furnace, showed only 0.03 percent shrinkage and at 1,740 deg. F. the shrinkage was only 0.84 percent. After being immersed in water for 72 hours the weight of sample pieces increased only 22 percent. When manufactured by reputable companies, such blocks are inert and chemically neutral, the pH value usually lying between 6.8 and 7.2. Their application is commonly done in the same manner as with magnesia blocks, asbestos blocks and other standardized insulating materials for the same purpose. However, high temperature mineral wool blocks may also be applied by means of hot asphalt; the blocks will not be affected when dipped in hot asphalt of 450 deg. F., picking up approximately 0.18 lb. asphalt per square foot of surface.

List prices are quoted in Table VIII and the respective discounts from the list prices are scheduled in Table XI. When estimating the cost of application the engineer has to consider the cost of the block itself plus freight and hauling charges in addition to the cost of the sundries used in the installation work and the labor cost. The sundries vary with the type of finish desired. For inside installation a ½-in. coat of insulating cement, and a good paint coat, is usually sufficient. Where damage to the insulation by labor, dripping water, or steam can be expected, 8-oz. canvas should be applied over the cement coat. For outside installations a layer of 65-lb. roofing felt or galvanized sheet metal should be applied. In all cases the cost of wire, bands, supports, twine, canvas, roofing felt, etc., has to be included in the calculation. The cost of labor depends on many factors, for instance the height of the equipment, the cost of erecting scaffolding, whether vertical or horizontal equipment has to be covered and, finally, what type of men will be on the job. For estimating purpose it will be close enough if the cost figures given in Table XII (applying to mineral wool blankets) are used for high temperature mineral wool insulation blocks and boards.

Table XI—Discounts From List Prices for Mineral Wool Insulations

Product	Discount, Percent—C. L. Lots	L.C.L. Lots
Mineral wool blankets	65	63
Mineral wool pipe covering	65	63
High temperature blocks		
(a) National buyers *		
Zone 1	45	43
Zone 2	42	32
Zone 3	43	33
(b) Average buyer *		
Zone 1	41	37
Zone 2	35	24
Zone 3	36	25
Mineral wool insulating cement	0	0
Loose mineral wool	0	0
Granulated mineral wool	0	0

* *Note:* Zone 3 comprises certain counties in Colorado, Texas, California, Nevada, Oregon, Washington, Wyoming; Zone 2 comprises most of the rest of the counties in Colorado, Nevada, Oregon, Texas, Washington; Zone 1 comprises practically all the rest of the United States.

Table XII—Cost of Installing Mineral Wool Blankets *

Thickness, Inches	(Basis, dollars per sq. ft.) Installation Height—Below 15 ft.	15 to 25 ft.	Above 25 ft.
1	$0.75	$0.85	$0.92
1¼	0.80	0.90	0.98
1½	0.85	1.00	1.09
1¾	0.90	1.06	1.14
2	0.95	1.12	1.19
2½	1.00	1.18	1.26
3	1.05	1.25	1.35
3½	1.10	1.30	1.40
4	1.15	1.35	1.46
4½	1.25	1.45	1.59
5	1.30	1.60	1.70
5½	1.35	1.65	1.78
6	1.40	1.70	1.84
6½	1.45	1.75	1.89
7	1.50	1.80	1.95
7½	1.55	1.85	2.05
8	1.60	1.95	2.15

* Based on $2 per hour labor cost. Deduct 10 percent for inside jobs without weatherproofing.

Table XIII—Cost of Installing Mineral Wool Pipe Covering *

Pipe Size, Inches	(Basis, dollars per lin. ft.) Thickness of Pipe Covering, 1 In.—No Finish	Roofing Felt Finish	Sewed Canvas Finish	½-In. Cement Finish and Roofing Felt
2	$0.25	$0.45	$0.75	$0.65
2½	0.30	0.50	0.80	0.70
3	0.35	0.55	0.87	0.75
3½	0.40	0.60	0.93	0.80
4	0.50	0.70	1.04	0.90
5	0.60	0.80	1.16	1.05
6	0.75	0.95	1.32	1.22

* Add 10 cents per lin. ft. for 1½-in. thickness and 15 cents per lin. ft. for 2-in. thickness.

Insulating Cement

Mineral wool in the form of plastic cement is used as a base beneath other insulating materials, as a finish coat on top of other insulation, and for the covering of valves and fittings. It may also be used for the full covering of smaller pieces of equipment, especially when the surfaces are quite irregular. However, when larger pieces are to be insulated it is usually more econom-

Table XIV—Forms, Dimensions, Packaging and References of Mineral Wool Insulations

Blankets

23 types, as listed in Table V.
Thicknesses from 1 to 8 in.
Sizes 2 x 4 or 2 x 8 ft. Special sizes upon request.
Packed in 200-lb. test cartons or crates.
Guide for selection of thicknesses, see Table III.
List prices, see Table VI.
Discounts from list prices, see Table XI.
Cost of installation, see Table XII.
Thermal conductivity, see Table I.

Pipe Covering

Thicknesses from 1 to 4 in.
Length of sections, 2 ft.
Width of sections: to cover circumference of pipes 2 to 30 in.
Packed in cartons or crates.
Guide for selection of thicknesses, see Table IV.
List prices, see Table VII.
Discounts, see Table XI.
Cost of installation, see Table XIII.
Thermal conductivity, see Table I.

High Temperature Blocks

Thicknesses from 1 to 4 in.
Sizes 6x18 in., 6 x 36 in., 12 x 18 in., 12 x 36 in.
Shipped in cartons of approx. 40 lb. as follows:
2½-in. thick blocks, 45 boardfeet per carton.
3½-in. thick blocks, 42 boardfeet per carton.
All other thicknesses, 36 boardfeet per carton.
Guide for selection of thicknesses, see Table III.
List prices, see Table VIII.
Discounts, see Table XI.
Cost of installation, see Table XII.
Thermal conductivity, see Table II.

Plastic Cement

Packed in bags of 50, 40, 35 lb. (multiwall paper bags).
Thickness of Insulation: ½ in. thicker than pipe covering.
List prices, see Table IX.
Discounts: none.

Loose and Granulated Fibers

Packed in multiwall paper bags of 35 and 40 lb.
List prices, see Table X.
Discounts: none.

ical to employ blankets, boards or blocks. The reason is the slowness in applying one layer after another of wet cement, the need of steam to dry out the layers, and the waiting period between the drying of each layer. This cement consists of mineral wool fiber, asbestos fiber and adhesive binders, thoroughly mixed, and is easily appliable with a trowel. Sodium chloride must be absent, sulphur content must be below 0.5 percent, shot content must be below 10 percent and the cement must not support corrosion. The thermal conductivity should be about 0.9 at a mean temperature of 200 deg. F. and 1.10 at a mean temperature of 700 deg. F. For estimating purposes the engineer can take 50 sq. ft. of 1-in. thickness for 100 lb. of cement as a safe figure. Some brands of mineral wool cement exceed this coverage minimum; if the coverage is appreciably below 50 sq. ft. then the material does not possess the same insulating value and must therefore be lower in price. The adhesive property of mineral wool cement should be not less than 3 lb. per sq. inch. A shrinkage of 20 percent is permissible, and the dried insulating cement should not weigh more than 30 lb. per cu. ft.

The list prices for this cement have been given in Table IX and as shown by Table XI there is no discount available, but freight allowance will be granted by the manufacturers.

Fiber and Granules

Mineral wool in loose and granulated form has only restricted use in the chemical industry. The insulating qualities of these two types are the same; they differ only in their physical shape. The loose wool is in long fiber form as it comes from the cupola and in this form it is well suited for filling large areas such as on ovens or furnaces. The granulated form is the loose wool reduced to nodules varying in sizes from ¼ in. to ⅜ in.; this is used for filling more confined spaces where it is not easy to pack the bulk loose wool. In the industry we find both types principally used for furnace and boiler walls, hot water tanks, expansion joints, incinerator walls, glass annealing equipment, oven walls and, in addition, as fill material around pipes in trenches and boxes.

A good mineral wool in loose and granulated form will stand 1,350 deg. F. temperature without fusion; on the other hand it must not absorb moisture, and must retain its resilience. A mineral wool which settles is of no value whatsoever. Mineral wool furnished for fill purposes usually weighs 8 lb. per cu. ft. and has a thermal conductivity of 0.26 at 70 deg. F. mean temperature difference. The k factors listed in Table I under 8 lb. density apply to the better grades of mineral wool. A material of this density will cover approximately 17 to 18 sq. ft. 3 in. thick per bag of 35 lb.

List prices for both types of mineral wool fill material have been given in Table X and from Table XI it will be seen that no discount is applicable. However, the manufacturers will allow certain freight rebates.

Cost of application cannot be given because the entire cost is the wages for labor and since filling of open spaces with mineral wool can hardly be called insulation work it is possible to employ common labor.

Estimating Installations of Chemical Equipment

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PROCESS EQUIPMENT COSTS

THIS ARTICLE is intended as a brief discussion of a few practical methods of cost estimating, including the necessary philosophy pertinent to good estimating. In large chemical plants, the production and maintenance engineers have the advantage of a special engineering division, where facilities are available, which usually includes mechanical and chemical engineers, estimators, project engineers, structural and design engineers, draftsmen, etc. Their files are generally very complete and contain manufacturers' catalogs, cost standards, design standards, and so on. This paper is not intended to interest such estimators.

The discussion, then, is directed toward the production chemist or plant engineer in a small or medium sized plant, who is called upon infrequently by management to prepare an estimate. Such a man has good cause to consider himself "on the spot." Few men in this category have files of manufacturer's catalogs and other information needed for proper selection of standard type equipment, and lack any facilities for estimating the cost of equipment requiring special design. If the estimator were given adequate time to consult with outside manufacturers, fabricators and engineers, he would be perfectly capable of arriving at a close and reasonable cost. However, this time is seldom to be had since management requires many weeks and sometimes months to formulate its future plans to the point of asking for an estimate. Yet, after the request for an estimate, time becomes of extreme importance. Although management has many problems to settle before it is in a position to require an estimate, it is generally agreed that estimators are not given the time required to turn out a clear and concise estimate.

There are many methods used in estimating—the most amusing one is the well known "Guesstimate" or "Quickie." It is usually accomplished by a telephone or verbal conversation in which a person requires a quick, rough cost. This method is very vulnerable, as it results in snap judgment on the part of the estimator without any thought given to the many details which may demand additional time and money at a later date. There is justification for this type of estimate if it is used to give management an indication of the financial scope of the project. However, a formal estimate should be required for appropriation purposes.

An estimate that is based on a similar previous installation can be produced satisfactorily with a minimum of thought and time, provided the estimator has a clear and concise picture of what is required and has available actual costs of previous installations.

Estimates that cover unfamiliar equipment, however, require the utmost in thought, vision, available specifications and a working knowledge of design. It is true that by contacts with manufacturers, discussion might bring forth many practical ideas which could be included in the design and perhaps a verbal estimate could be obtained. However, this procedure requires considerable time and if the design is complicated, might still require an outside consultant. Data on hook-up items which are normally included in an estimate and include pipe, fittings, valves and specialties in all materials of construction are