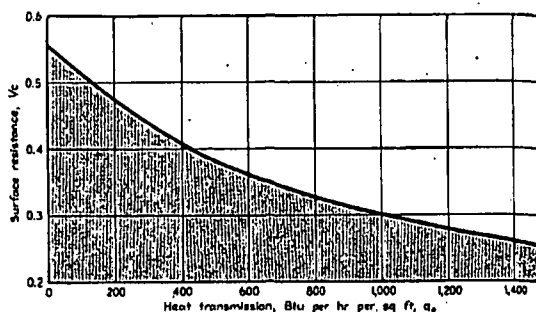


These three tables are based on thoroughly practical considerations of standard insulation thickness, heat loss, load factor, fixed charges, fuel cost, temperature conditions, operating hours and labor costs



INSULATION SURFACE RESISTANCE depends on the rate of unit heat flow; the resistance decreases with increasing heat transmission through insulation surface

Here Is a Quick Way to Find

III: Column Index for Table II on Economical Thickness of Insulation

Heat cost, \$ per 10 ⁶ Btu	20	25	30	35	40	45	50	55	60
Estimated operation, hr per yr									
Annual fixed charges, %									
	Column number								
8760	15	5	6	7	8	9	9	10	10
7200	15	5	6	6	7	8	8	9	10
6000	15	4	5	6	6	7	7	8	9
5000	15	3	4	5	5	6	7	7	8
8760	20	4	5	6	7	7	8	9	9
7200	20	3	4	5	6	6	7	7	8
6000	20	2	3	4	5	6	6	7	7
5000	20	2	3	3	4	5	5	6	6
8760	25	3	4	5	6	6	7	7	8
7200	25	2	3	4	5	5	6	6	7
6000	25	1	2	3	4	5	5	6	6
5000	25	1	2	2	3	4	4	5	5

► RECOMMENDATIONS by the industry for the economical thickness of 85% magnesia insulation have ordinarily been based on one factor, range of operating temperature; for pipe insulation, pipe sizes have also been considered. These recommendations have rarely taken account of other operating variables.

To assist in finding the most economical thickness of pipe insulation, a

study incorporating tables of economical thickness for varying hours of operation, cost of heat, amortization rate, temperature range and pipe size was prepared by the Magnesia Insulation Manufacturers Association and published by the American Society of Heating and Ventilating Engineers*.

A similar study of block insulation,

* ASHRAE Journal, Section of Heating, Cooling and Air Conditioning, October 1947.

prepared to aid in selecting the most economical thickness of single-layer 85% magnesia block insulation, is reported in the following discussion. As the majority of block insulations are finished with 1/2-in. asbestos cement, this factor has been taken into account in the calculations.

Heat-Loss Calculation. Table I was calculated with the following established equations for heat transmission

$$q = \frac{t_1 - t_2}{\frac{d_1}{k_1} + \frac{d_2}{k_2} + \frac{1}{U_1}}$$

where

- q = heat transmission, Btu per sq ft per hr
- t_1 = temperature of hot surface of insulation, F
- t_2 = temperature of air on cool side of insulation, F
- d_1 = thickness of first material (85% magnesia block), in.
- d_2 = thickness of second material (asbestos-cement finish), in.
- k_1 = conductivity of first material at mean temperature, Btu per hr per sq ft per in. per F
- k_2 = conductivity of second material at mean temperature, Btu per hr per sq ft per in. per F
- c = air-film conductivity, Btu per hr per sq ft per F
- U_1 = heat-transmission coefficient, Btu per hr per sq ft per F

The curve shows the relationship between the surface resistance (1/c) and total heat transmission. The resistance decreases as the heat transmission increases.

Values of k_1 for 85% magnesia were

I: Unit Heat Loss for 85% Magnesia Block Insulation, 1/2-in. Asbestos Cement Finish

Block thickness, in.	Vertical Position				
	Difference, F*	100	200	300	400
1		0.297	0.308	0.320	0.332
1 1/2		0.216	0.224	0.233	0.242
2		0.170	0.176	0.183	0.190
2 1/2		0.140	0.145	0.150	0.156
3		0.119	0.1235	0.128	0.1325

* Hot surface to air

II: Thickness of Insulation Recommended as Economical

Column number	1	2	3	4	5	6	7	8	9	10
Hot surface temperature, F	Insulation thickness, in.									
180	1	1	1	1	1	1 1/2	1 1/2	2	2	2
212 to 266	1	1	1	1	1 1/2	1 1/2	2	2	2 1/2	2 1/2
267 to 337	1	1	1 1/2	1 1/2	1 1/2	2	2	2 1/2	3	3
338 to 387	1	1 1/2	1 1/2	2	2	2 1/2	2 1/2	3	3	3
388 to 499	1 1/2	1 1/2	2	2	2 1/2	2 1/2	3	3	3	3
500 to 600	1 1/2	2	2	2 1/2	2 1/2	3	3	3	3	3

Economical Insulation Thickness

obtained from conductivity tests made by the insulation manufacturers:

Conductivity Tests	
Mean temperature, F	k
100	0.39
300	0.45
500	0.51

The conductivity, k , for asbestos cement was assumed to be 1.50 for all mean-temperature values.

Insulation Thickness. Cost of applying insulation blocks is made up of the following items: (1) 85% magnesia block insulation (2) hexagonal wire mesh (3) asbestos cement finish (4) labor. Cost of wire mesh and asbestos-cement finish is independent of block-insulation thickness, so total cost should vary only with labor and block thickness.

Consensus of the insulation contracting industry states that theoretically there should be a slight increase in cost of application per sq ft of block with increasing thickness, but the difference is so slight that using a variable labor figure is not justifiable. Therefore, it is assumed that an insulation mechanic would apply about the same square footage per day of any single layer thickness of block from 1 to 3 in. thick. Hence, the only cost variable for the finished installation has been the cost of this block insulation, taken as 22¢ per board foot. This figure is based on a 1947 survey among

insulation contractors in various sections of the country. All other costs are fixed and need not be considered to establish economical thickness provided the surface is to be insulated at all.

The economical thickness results in the smallest sum per year of cost of insulation and cost of heat lost through the insulation.

Example:
Cost of heat, \$ per 10⁶ Btu 80
Annual hr of operation 7200
Fixed charge rate, % 20
Boiler steam pressure, psig 100
Steam temperature, F 338
Air temperature, F 75
Annual cost of insulation, \$
= 0.22 × fixed charge rate × thickness
= 0.22 × 0.20 × 1 = \$0.044 per year
Cost of heat lost annually
= hr operation × heat cost × U_1 × ($t_1 - t_2$)
= 7200 × 0.50 × 0.315 × (338-75)
= \$0.298 per year

Similar calculations for other thicknesses result in the following annual costs:

Insulation thickness, in.	Annual cost, \$
1	0.044
1 1/2	0.068
2	0.088
2 1/2	0.110
3	0.132

The above table shows minimum cost occurs with the 2 1/2-in. thickness, which is then the economical choice.

Table II was calculated on the above basis for conditions varying over the following ranges:

Heat cost, \$ per 10⁶ Btu 20 to 60

Operation, hr per yr 5000 to 8760
Fixed charges, % 10 to 25
To use Table II, first refer to Table III to find the column number corresponding to the desired hours of operation, fixed charge rate and heat cost. With the column number and initial steam temperature find the economical thickness in Table II. For the example worked out above, Table III shows that column No. 7 applies. Then in Table II, under column 7 opposite 338 F find the economic thickness of 2 1/2 in.

STEEL MILL POWER

When steel-mill engineers talk power, it's with a capital "P". Jones & Laughlin's new 5-stand tandem mill at the Aliquippa Works, which has rolled strip at 6250 fpm (over 71 miles per hr), takes the output of two huge mg sets rated at 14,200 kw. Designed and built by Mesta Machine Co., the mill has six CE motors with a combined capacity of 16,850 hp, which because of special insulation can carry 20,100 hp continuously without overheating. Each of the twin stands has a separate generator to supply dc to its stand and reel motors; with amplydne control this arrangement makes for ease of operation and fullest possible adjustment of stand speed.