sulation. The manufacturer's recommendations should be followed. Pipe insulation is usually fastened with staples across the joints between sections and with metal bands or wire rings to hold individual sections and keep all joints tight.

Surface finishes used over insulations depends upon the exposure, whether indoor or outdoor, the temperature of the insulated surface, and the appearance desired. The insulations over flat or large curved surfaces, operating at temperatures above the ambient, are usually coated with a finishing cement when exposed to indoor conditions and by a finishing cement plus a weatherproof finish when used outdoors. The insulation over pipes operating above ambient temperature is usually coated with a canvas cover for indoor exposure and an asphalt impregnated felt for outdoor exposure. Sectional pipe covering is available with a wide variety of surface finishes and jackets.

Insulation over surfaces operating at temperatures below the ambient must be protected from water vapor penetration, whether used indoors or outdoors.

The selection of an insulation for a particular service condition should be made with full consideration of a number of properties in addition to thermal conductivity. Factors which may, under certain circumstances, be of more importance than thermal conductivity are ease of application, fire resistance, heat stability, weathering stability, and resistance to damage by physical abuse. Other factors may apply to a particular installation. A complete evaluation of all insulations cannot be included here. Insulation manufacturers should be consulted with regard to the selection of insulation to meet specific requirements. In general, the use of skilled and experienced applicators will go a long way toward insuring a satisfactory installation.

Elbows and fittings should be covered with an insulation of equal thickness and material which is similar to the pipe covering. Pre-fabricated fittings are available for many types of insulation, such as cork and rock cork. Where asbestos cement or magnesia cement is used to build up the fittings, the material should be applied in layers not exceeding a thickness of $\frac{3}{8}$ in. The final coat should be mixed with 10 percent Portland cement and troweled smooth. After the final coat has thoroughly dried, it is recommended that canvas of the same weight as that used on the pipe covering be pasted over the surface. This procedure will prevent the built-up portions of the covering from falling off due to a slight bump or other minor damage.

On permanent installations of high quality, it is recommended that all coverings and fittings be further encased in 8-oz. canvas, drawn tight over rosin-sized paper and sewed in place, using not less than four stitches per inch.

All pipe covering which has a high differential temperature between the pipe surface and the ambient air should be provided with metal pipe sleeves around the covering to support the pipe by means of hangers on the outside of the covering, thus preventing the conduction of heat through the hangers.

HEAT LOSSES FROM INSULATED PIPES

Table 6 lists a number of typical thermal conductivities for various insulating materials. These conductivities have been selected as average design values for engineering calculations and must not be confused with

TABLE 6. THERMAL CONDUCTIVITY (k) OF INDUSTRIAL AND PIPE INSULATIONS
(*High & Medium Temperature*)
Expressed in Btu per (hour) (square foot) (Fahrenheit degree temperature difference per in.)

FORM	MATERIAL (COMPOSITION)	ACCEPTED MAX. TEMP. FOR USE[a] F	DENSITY Lb/Cu Ft	TYPICAL CONDUCTIVITY k AT MEAN TEMP. FAHR.							
				40	70	100	200	300	500	700	900
BLANKETS	MINERAL WOOL (*Rock, Slag, or Glass*)										
	Metal Reinforced	1200	6–15			0.29	0.35	0.42	0.56		
	Felt-Flexible Type	450	0.5–3	0.23	0.25	0.26	0.34	0.45			
	Felt-Semi-Rigid Type	450	2–8	0.24	0.25	0.27	0.35	0.44			
	VEGETABLE & ANIMAL FIBER										
	Hair Felt or Hair Felt plus Jute	180	10	0.27	0.28	0.30					
BLOCKS AND BOARDS	ASBESTOS										
	Molded Amosite & Binder	1200	18			0.37	0.40	0.47	0.56	0.66	0.76
	Laminated Asbestos Paper	700	30			0.40	0.45	0.50	0.60		
	Corrugated & Laminated Asbestos Paper										
	4 ply	300	11–13		0.54	0.57	0.68	0.80			
	6 ply	300	15–17		0.49	0.51	0.59	0.69			
	8 ply	300	18–20		0.47	0.49	0.57	0.65			
	CALCIUM SILICATE	1200	11			0.33	0.38	0.43	0.53	0.64	0.75
	CELLULAR GLASS	800	9	0.37	0.39	0.41	0.48	0.55			
	CORKBOARD (*Without Added Binder*)	200	6.5–8	0.26	0.27	0.28					
	DIATOMACEOUS SILICA	1500	22						0.60	0.64	0.68
		1900	25						0.70	0.75	0.80
	85% MAGNESIA										
	Mag. Carb. & Asbestos	600	11–14			0.39	0.42	0.45	0.51		
	MINERAL WOOL (*Rock, Slag or Glass*)										
	Low Temp. (Asphalt or Resin Bonded)	200	6–18	0.28	0.29	0.31					
	High Temp. (Resin Bonded)	600	6–10			0.28	0.35	0.43			
	(With Inorganic Binder)	1600	16–24			0.34	0.39	0.44	0.54	0.64	
	PLASTICS (Foamed)	175	1.6	0.26	0.28	0.31					
	RUBBER (Foamed)	150	5	0.23	0.24	0.25					
PIPE INSULATION	ASBESTOS										
	Molded Amosite & Binder	1200	16			0.33	0.38	0.43	0.53		
	Laminated Asbestos Paper	700	30			0.40	0.45	0.50	0.60		
	Corrugated & Laminated Asbestos Paper										
	4 Ply per in.	300	11–13		0.54	0.57	0.62	0.80			
	6 Ply per in.	300	15–17		0.49	0.51	0.59	0.69			
	8 Ply per in.	300	18–20		0.47	0.49	0.57	0.65			
	CALCIUM SILICATE										
	Calc. Sil. & Asbestos	1200	11			0.36	0.40	0.44	0.55		
	CELLULAR GLASS	800	9	0.37	0.39	0.41	0.48	0.55			
	CORK (*Without Added Binder*)	200	7–10	0.27	0.28	0.29	0.30				
	DIATOMACEOUS SILICA	1500	22						0.60	0.64	0.68
		1900	25						0.70	0.75	0.80
	85% MAGNESIA										
	Mag. Carb. & Asbestos	600	11–14			0.39	0.42	0.45	0.51		
	MINERAL WOOL (*Rock, Slag or Glass*)										
	Low Temp. (Asphalt or Resin Bonded)	200	15	0.28	0.30	0.33	0.39				
	Low Temp. (Fine Fiber Resin Bonded)	450	3	0.22	0.23	0.24	0.27	0.31			
	High Temp. Blanket-Type (Metal Reinforced)	1200	6–15			0.29	0.36	0.42	0.56		
	PLASTICS (Foamed)	175	1.6	0.26	0.28	0.31					
	RUBBER (Foamed)	150	5	0.23	0.24	0.25					
	VEGETABLE & ANIMAL FIBER										
	Wool Felt	180	20	0.29	0.31	0.33					
	Hair Felt or Hair Felt plus Jute	180	10	0.27	0.28	0.30					
INSULATING CEMENT	85% MAGNESIA	600	18			0.46	0.52	0.58			
	Mag. Carb. & Asbestos										
	MINERAL WOOL (*Rock, Slag or Glass*)	1800	24–30			0.49	0.61	0.73	0.85		
	With Colloidal Clay Binder										

[a] These temperatures are generally accepted as maximum. When operating temperature approaches these limits the Manufacturer's recommendations should be followed.

actual test data. The conductivity of any particular insulation or pipe covering can only be obtained from unbiased tests, or from data guaranteed by the manufacturer.

The terms *standard* and *double standard* thickness of magnesia and diatomaceous silica pipe covering have been declared obsolete by the