

data on commonly used forms of tunnels and conduit systems, have been published by the *National District Heating Association*.³

Another form of underground insulation consists of the direct burial of the pipe in a trench with a complete covering of about 4 in. of a granular bitumen which, upon heating, forms a semiplastic, waterproof covering having a very good insulating value. The pipe must be supported on a solid insulating substance such as insulating blocks or asbestos cement pipe sections filled with an insulating cement. The expansion of steam and hot water pipes, using loop expansion joints, offers no difficulty as the plastic nature of the warm material allows free movement of the pipes. Care must be exercised in installing this material in accordance with the manufacturer's recommendations.

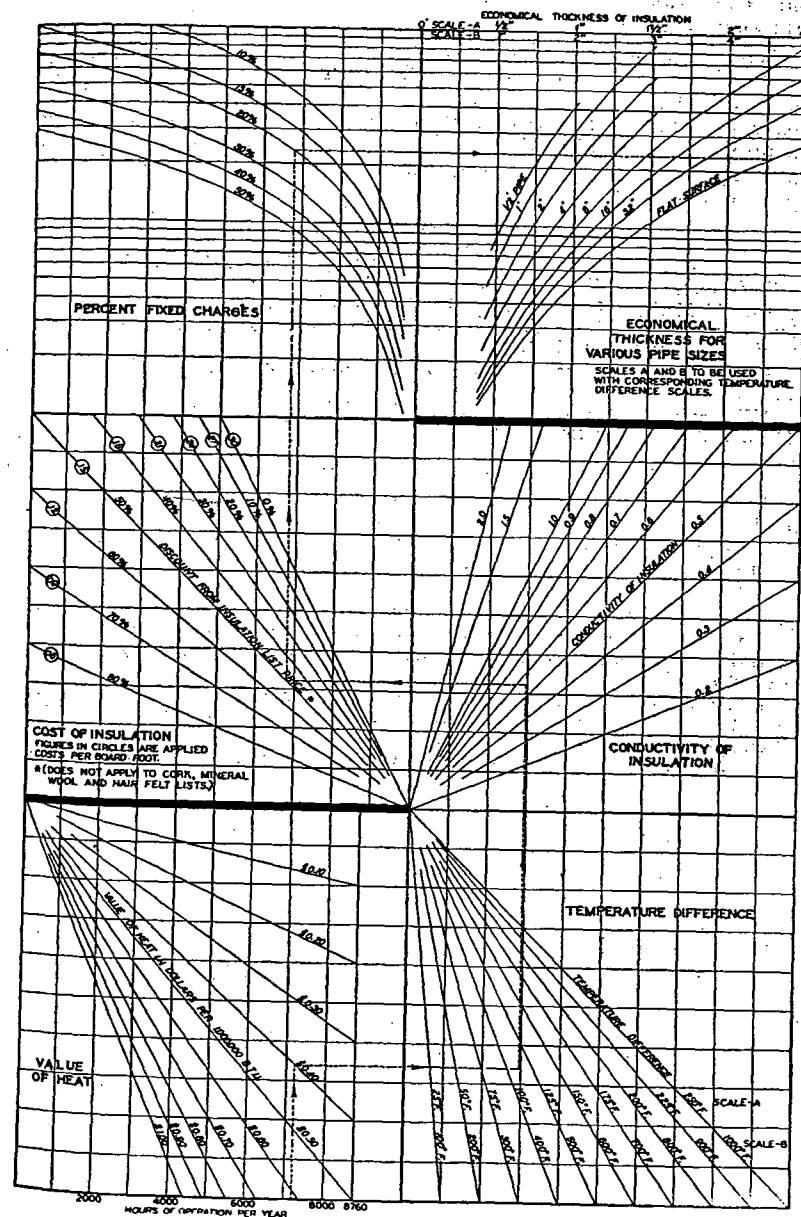
Pipes in tunnels are covered with sectional insulation to provide maximum thermal efficiency, and are also finished with good mechanical protection in the form of metal or waterproofing membrane outer jackets.

TABLE 11. THICKNESS OF LOOSE INSULATION FOR USE AS FILL IN UNDERGROUND CONDUIT SYSTEMS

STEAM PRESSURE PSI OR CONDITION	STEAM TEMPERATURE FAHRENHEIT DEGREES	MINIMUM THICKNESS OF INSULATION IN INCHES					MINIMUM DISTANCE BETWEEN STEAM AND RETURN
		STEAM LINES			RETURN LINES		
		Pipes Less than 4 In.	Pipes 4 In. to 10 In.	Pipes Larger than 12 In.	Pipes Less than 4 In.	Pipes 4 In. and Larger	
Hot Water, or 0 to 25	212 to 267	1½	2	2½	1¼	1½	1
25 to 125	267 to 352	2	2½	3	1¼	1½	1¼
Above 125, or superheat	352 to 500	2½	3	3½	1¼	1½	1½

In some instances, where actual submersion of hot lines may occur, it has been found good practice to fasten the covering securely with corrosion resistant wire, and then sew on a wire-inserted asbestos fabric jacket with wire. This jacket is porous. The principle of withstanding submersion is that water may enter as water, then actually boil at the pipe surfaces and escape as steam without rupturing the insulation or jacket. Conduit systems are in more general use than tunnels. Pipes carried in conduits may be insulated with sectional insulation; however, the more usual practice is to fill the entire section of the conduit around the pipes with high quality, loose insulating material. The insulation must be kept dry at all times, and for this purpose effective waterproofing membranes enclose the insulation. A drainage system is also provided to divert water which may tend to enter the conduit.

The economical thickness of insulation for underground work is difficult to determine accurately due to the many variables which have to be considered. As a result of theories⁴ previously developed, together with other experimental data which have been presented, the usual endeavor is to secure not less than 90 percent efficiency for underground piping. Table 11 can be used as a guide in arriving at the minimum thickness of loose insulation fills to use for laying out conduit systems. Other factors such as the number of pipes and their combination of sizes, as well as the



(L. B. McMillan, Proc. National District Heating Association, Vol. 18, p. 138).

FIG. 6. CHART FOR DETERMINING ECONOMICAL THICKNESS OF PIPE INSULATION