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IN THE NEWS

General Interest:

Processing:

Production:

Exploration:

Pipelining:

$$= \frac{(2)(0.0065)(17)(5{,}280)(7.32)^2(51.4)}{(32.2)(0.673)}$$

$$= 148{,}300 \text{ lb./ft.}^2$$

$$\Delta X = (51.4)(300) = 15{,}400 \text{ lb./ft.}^2$$

Therefore:

$$[(14.7)(144)] - P_1 = -148{,}300 - 15{,}400;$$

$$\text{or } P_1 = 148.300 + 15{,}400 + 2{,}120$$

$$= 165{,}820 \text{ lb./sq. ft. abs.} = 1{,}151 \text{ psia.}$$

$$= \mathbf{1{,}136 \text{ psig.}}$$

A convenient equation may be developed for oil lines using Equation 3 above. If B = oil flow rate in bbl./day and d = internal pipe diameter expressed in inches:

$$v = 0.286 \text{ B}/d^2$$

$$f = \frac{0.04}{Re^{0.172}}$$

$$= \frac{0.04}{(d/12 \times \rho/\mu \times 0{,}286 \text{ B}/d^2)^{0.172}} \quad (4)$$

Then:

$$\Delta P_f = \frac{2fLv^2\rho}{gD}$$

$$= 1.470 \frac{LB^{1.828}\, \rho^{0.828}\, \mu^{0.172}}{d^{4.828}} \quad (5)$$

when the value of f from Equation 4 is substituted into the above equation and the result consolidated. The number of significant figures shown for the exponents result from the derivation and do not reflect the accuracy. For practical purposes these numbers may be rounded off to two significant figures.

Hazen-Williams Formula

The Hazen-Williams formula is an empirical equation that was originally developed for the flow of water. Like many such equations it contains an arbitrary constant for which a value is necessary. It has been used successfully for oil-line design where sufficient actual data were available to estimate a value of the constant C.

In common engineering terms this equation may be written as:

$$Q = 0.67\, CD^{2.63} (\Delta P/\rho L)^{0.54} \quad (17)$$

Where:

Q = flow rate, ft.^{3}/sec.
D = diameter, ft.
ΔP = pressure drop, lb./ft.^{2}
L = length, ft.
ρ = density, lb./ft.^{3}

The arbitrary constant C is primarily dependent on surface roughness but is also affected by pressure drop and diameter for the exponents used for these values usually differ slightly from the actual ones obtained.

Saph and Schoder Formula

This is another empirical equation that has sometimes been used to design water systems. It is usually written as:

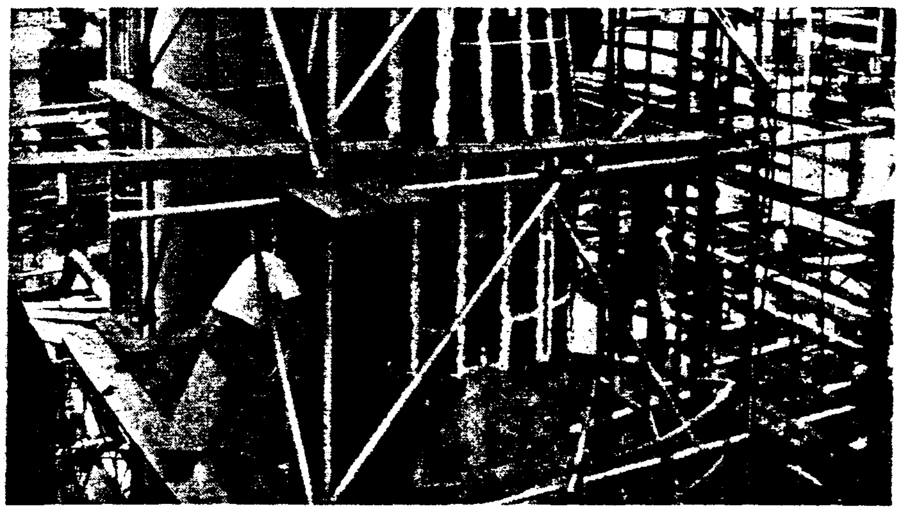
$$h = 0.38 \frac{v^{1.86}}{D^{1.25}} \quad (18)$$

Where:

h = friction loss, ft. water per 1,000 ft. pipe
v = velocity, ft./sec.
D = internal diameter, ft.

The limitations of the above two empirical equations are obvious and their use cannot be generally recommended. However, where sufficient data and know-how are available they can give satisfactory results.

ON THE JOB . . . . . . IN THE PLANTS



SHEET-METAL JACKET being applied over pointed blocks on a column in the atmospheric group at Tidewater's Delaware refinery.

Mineral wool used as . . .

Tidewater Insulates Refinery

by E. L. Waller* and H. L. Humes†

THE trend of petroleum-processing units towards higher and higher operating temperatures increases the importance of thermal insulation. Because of the vital role which insulation on equipment and piping plays in the prevention of costly heat loss and the maintenance of correct process temperatures, its selection and design merit careful consideration.

At the largest single refinery construction project ever undertaken, Tidewater Oil Co.'s new Delaware Flying A refinery near Delaware City, Del., over 750,000 board feet of mineral-wool block insulation are used. The basis for determining the insulation requirements is the normal operating temperature. At the new Delaware Flying A refinery all surfaces above 150° F. are insulated for heat conservation, for personnel protection and for temperature control.

Surfaces with operating temperatures from 75° to 150° F. are insulated only where unusually close operational temperature control is necessary. Below 75° F. surfaces are insulated only where required for temperature and condensation control.

Piping and equipment (with only six exceptions) normally operating above 150° F. is insulated for personnel protection to a height of 7 ft. above the operating level. The exceptions are hot pump cases, coolers, turbines, con-

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densers, heat-exchanger flanges, piping-valves, and flanges.

Material Selection

Low conductivity over a wide range of surface temperatures is considered especially desirable. The ability of one basic insulating material to cover surfaces operating at many different temperatures simplifies purchasing and warehousing, and, usually precludes the necessity for stocking special high-temperature insulations.

A relatively high degree of structural strength also is important. For this reason rigid block type of insulation, rather than the more flexible types, is considered superior, because today the added labor cost of adequately supporting flexible type of insulations more than offsets any saving in material cost. The insulation should be resilient in order to fit snugly the surface to which it is applied, and to adjust itself to a limited amount of thermal expansion. Resistance to abrasion also is desirable so that the material may be salvaged if removed for maintenance of the vessel.

A final, but by no means less-important criterion, is ease of both handling and application, since erection costs exceed material costs by approximately 50 per cent.

A felted block type of insulation manufactured from spun mineral fibers was selected to insulate all surfaces operating at temperatures above 600° F. In addition, it was applied on all insulated flat surfaces and all cylindrical surfaces greater than 24 in. in diameter in the temperature range 150° to 1,700° F.

Combining low thermal conductivity (for instance, .51 B.t.u., in./hr., sq. ft., °Fahrenheit at 600° F.) and a wide temperature range (to 1,700° F.) with excellent structural strength, resilience, abrasion resistance, comparatively low moisture absorption and low alkalinity this material meets the desired criteria. Lightweight and easily cut with a knife or saw, it is simple to handle and apply. It conforms readily to irregular and curved surfaces.

In addition it is available in thicknesses from 1 to 6 in. and in a wide range of standard sizes up to 24 by 36 in. Thus, because it is easily shaped, only the larger sizes need be stocked. Smaller sizes can be cut from large blocks in the field as required.

Thickness . . . Insulation, except that applied merely for personnel protection, should pay for itself, either in B.t.u.'s saved or in maintaining temperature control during extreme weather conditions. At the Tidewater project, calculation of insulation thicknesses was based on normal-operating surface temperatures and a 4-year payoff life.

Cost of heat was estimated at 25 cents per million B.t.u.; cost of applied insulation at 26 cents per board foot. Mean ambient temperature was assumed to be 50° F., and average wind velocity as 15 m.p.h. Block thicknesses determined in this manner are shown in Table 1.

Weatherproofing . . . Basically, two methods were employed to weatherproof tank and vessel insulation. Plastic weatherproofing was used on small apparatus and exchangers and on the bottom heads of large vertical cylinders and columns. With minor exceptions, sheet-metal jackets protect insulation on the tops and sides of large horizontal and vertical vessels and tanks.

Either roofing paper or sheet metal covers most pipes and lines, while roofing felts weatherproof the tops of the A.P.I. storage tanks.

Small Equipment

Appropriate thicknesses (see Table 1) of 6 by 36-in. mineral-wool block insulate all apparatus and exchangers having radii of from 13 to 30 in. For equipment with radii greater than 30 in., 12 by 36-in. blocks were used.

Adjacent blocks were applied with staggered joints, butted tightly together. To fit the smaller diameter, units blocks were field cut and scored on inner surfaces. Elastic bands composed of ropes and springs or of rubber strips tied together, held the blocks initially until utility wire was wrapped around the vessel to secure them temporarily. Finally the block was permanently secured by ¾ by .022-in. stainless-steel expander strap, 5-ft. corrugated and 5-ft. plain, sealed with closed type of seals and the utility wire was removed.

At manholes, large nozzles, support brackets, and on vessel heads, securement with expander strap is impractical. Here studs were welded to the vessel surface. A web of 14-gage tie wire, fastened to the studs, secures the block. Interrupted expander straps also are anchored to the tie wires.

After the block was secured, all joints, cracks, and bruises were pointed with a white mineral-wool insulating-finishing cement. Then the cement was applied over the entire surface in a single ½-in. layer and finished with a slightly rough outer face.

Reinforcement of the subsequent layer of plastic weatherproofing was accomplished by laying wire mesh over the cement coat. The mesh was attached with ⅜ by 2-in. galvanized iron staples driven through the cement into the mineral-wool block. Sides and ends of adjacent mesh sections were interwoven.

First step in weatherproofing apparatus and exchangers was the application of a filler coat of plastic weatherproofing compound over the cement and mesh. The filler coat consisted of two parts No. 20 dry, washed sand and four parts by weight of asphaltic mastic weatherproofing. Then a finish coat of mastic alone was applied.

Application of multilayer block insulation on small apparatus and exchangers was very similar to that of the single layer just described. However, the inner layer of block was secured with 14-gage galvanized iron wire on 8-in. centers instead of expander strap, and only bruises—not joints—in the inner layer of block were pointed with mineral-wool cement.

The outer layer, its joints staggered with respect to those of the inner layer, was then applied and secured with expander strap.

Large units . . . The larger vessels, tanks and columns at the Delaware refinery are insulated with spun mineral-wool blocks in the same way as the smaller equipment, with the addition of expansion joints. Columns wth radii from 13 to 60 in. were insulated with 6 by 36-in. blocks. Those greater than 60 in. in radius were covered with 12 by 36-in. blocks.

Longitudinal spacing of these units of insulation is accomplished by welding a continuous ring of steel angles around the vessel shell at intervals along the vessel length. Minimum ring spacing is 9 ft. Maximum angle-support spacing is 15 ft. except on A.P.I. storage tanks.

Insulation on the heads of vessels is secured with a combination of welding studs, tie wires and circumferential expander strap. Blocks were field cut to conform to the shape of the surface and pointed.

TABLE 1—INSULATION THICKNESS SCHEDULE, MINERAL-WOOL BLOCK ON APPARATUS AND TANKS

Temperature range degrees F.	Thickness, (in.) Temperature control, heat conservation	Personnel protection only
150-299	1½	1
300-399	1½	1½
400-499	2	1½
500-599	2	1½
600-699	2½	1½
700-799	2½	2
800-900	*3	2
900-1,000	*3	2½
1,000-1,100	*3½	2½

*Double-layer insulation, first layer, 1½ in. thick.