

BOARD OF ENGINEERS
RECOMMENDED PRACTICE NO. 12

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TANK INSULATION

1. SCOPE AND SUMMARY

This Recommended Practice presents broad general principles for insulating new and existing tanks, and some details on determining justification. It also goes into preparation of specifications for bids or contracts on tank insulating work, and evaluation of materials and methods proposed by insulating contractors. It suggests design features desirable on new tanks if they are to be insulated; discusses preparations for existing tanks requiring insulation; mentions techniques on inspection and maintenance of existing tank insulations. Some background material is presented. The Recommended Practice includes types and brand names of several acceptable materials and others not recommended.

Insulation materials containing dry asbestos require special handling in construction and maintenance. The costs of such special handling, as influenced by present and anticipated future regulatory requirements, make the use of many of these materials uneconomic due to the hazards of inhaling asbestos fibers. Free crystalline silica is currently restricted by OSHA. Although fiberglass insulations contain silica-bearing material, in general, they do not contain free crystalline silica.

Summarizing, inert insulation materials such as mineral or glass fiber with resin binders and asbestos-free calcium silicate types are preferred as they are efficient, easy to handle, and resist mildew and water damage. Weather coats of corrugated aluminum sheet for vertical surfaces, and built-up asphalt and gravel for roofing, are most generally used. Laykold and chicken wire is good over dense insulation on roofs and around appurtenances. Proper flashing and joint sealing with provisions for expansion are important. Improved materials and methods are needed.

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3. INTRODUCTION

This Recommended Practice is based on the fact that tank insulation work is usually contracted. The insulating contractors normally propose the insulation details. The purchaser should specify essentials; therefore, the purchaser's specification need not be completely detailed.

Reference specifications and information useful for insulation work include:

Eng. Dept. Specification EG-1381, Thermal Insulation for Hot Lines and Vessels.

Eng. Dept. Specification EG-2634, Thermal Insulation for Cold Lines and Vessels.

Eng. Dept. Standard Drawing GB-N99995, Standard Insulation and Aluminum Weather-proofing Details for Hot Tanks.

Eng. Dept. Standard Drawing GA-N99786, Standard Insulation for Cold Vessels, Heat Exchangers and Cold Equipment.

Eng. Dept. Design Practice N-134-3, Polyurethane Insulation.

The essential preferences and exclusions discussed are intended for use in specifications. Other information is to help evaluate contractors' proposals on details that may or may not be covered by purchaser's specifications. Proposals which contractors may submit as alternatives should be studied to take advantage of all profitable ideas. Some Contractors have guaranteed the quality of their workmanship for 3 years.

4. REASONS FOR INSULATING TANKS

The reason for insulating any tank is a matter of economics, the objective being to minimize heat flow — either outward from hot or inward to cold contents. This may be desired for any one or a combination of several factors, the more common of which are:

- a. Reduction in size of — or elimination of — tank heaters, cooling coils, etc.
- b. Stabilization of operations, e.g., maintaining a more constant temperature in a fluid being fed to a process.
- c. Reduction of evaporation losses.
- d. Reduction of fire hazard where justified by minimizing heat absorption from possible adjoining fires.

5. EFFECTIVENESS OF INSULATION

A good-looking, mechanically-strong insulation job is not necessarily an effective job. If the insulation underneath a good-looking weather cover is not dry and properly distributed, it will not be as effective as planned. Effectiveness may be judged by exploring the exterior temperature. Any spot that feels noticeably warmer to the hand than the surrounding areas indicates

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poor insulation in that spot. Sun-heated surfaces may have to be inspected at night. If hand inspection reveals no abnormally warm spots, the insulation may be assumed generally satisfactory. Infrared thermography should be considered for a comprehensive inspection. Contact Engineering for more details.

Insulation need not be completely effective over its entire area to support its economic justification. Suppose 10 per cent of the total surface were insulated only half as effectively as planned; the 5 per cent reduction in heat savings would not have altered the decision to insulate. However, good workmanship, materials, and techniques would normally avoid such deficiencies at little or no added cost.

Low temperature applications cannot tolerate local deterioration of the vapor barrier because of condensation and corrosion problems at the steel surface.

6. TYPES OF INSULATION

There are many combinations of materials and construction from which to choose. Some are suitable under all normal operating conditions. Others are of limited utility and some that were used in the past are no longer recommended.

a. For Tanks in Hot Services

(1) Satisfactory Insulations

- (a) *Mineral and glass wool regular-fiber blankets with thermosetting binder.* The minimum density for shell insulation should be 3 lb per cu ft (except see "Fine Fiber" below). Roof insulation should be about 12 lb per cu ft density to prevent crushing under foot. The higher density material is more like a block than a blanket. The maximum service temperature is limited by the resin binder at about 350F.

Johns-Manville No. 412 Spintex (mineral) and Fiberglas PF613 (glass) are considered equal and are in common use. Typical pieces are 2 x 4 ft and 1, 1-1/2, 2, 3, and 4-in. thick. Two-inch has been most commonly used by the Company; however, other thicknesses may be economically justified depending on circumstances.

Conductivities of these materials depend on density. The lower the density, the higher is the conductivity. The reverse is true for most materials. But in light fibrous insulation air convection becomes appreciable. Blankets of 12 lb per cu ft density are 93 percent air by volume; 1 lb per cu ft blankets are 99-1/2 percent air. The air passages around the fibers are continuous. There is little resistance to the flow of air when the fibers are loosely packed. Thermal resistance of this type insulation (assuming constant glass fiber fineness) decreases with increasing temperature differential across the thickness because of convection.

Price increases with density and with increasing thermal resistance. Price and insulating value must be balanced to arrive at the proper density.

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- (b) *Light-weight "fine-fiber" blankets consisting of very fine glass fibers.* This material is bonded with thermosetting plastic resin to form blankets for easy handling and protection against damage by vibration. It is sold under such trade names as Gustin-Bacon Ultralite Blankets or Fiberglass Aerocor. While Company experience with this newer material has been limited, it has been used on tanks with good results. The densities are as low as 1/2 lb per cu ft but 3/4 lb per cu ft is the lightest recommended. Mechanical strength decreases with density.

The principal advantage is easy erection. Because of the fineness of the glass fiber, the material has better resistance to vibration and handling damage than conventional mineral or glass wool. It is shipped in large rolls which are laid up around the tank shell and held in place with a minimum of studs or wiring until the cover sheets are installed. Light-weight blankets are usually installed on the tank shell with a thickness greater than that actually required and are then compressed to a lesser thickness by the cover sheets placed over the insulation.

Thermal conductivity of this material is as low as that of conventional mineral wool blankets which are three times as dense. Apparently, the much finer fibers occurring in greater quantity in the same volume of insulation reduces internal convection. The price of the material and its insulating value must be considered in the economic justification. The price of the 3/4 lb per cu ft fine-fiber material is currently about the same as for the 3-1/4 lb per cu ft regular-fiber material. The thermal resistance of the latter is not over 2 to 5 percent greater.

- (c) *Conventional Block-Type Insulation* of hydrated calcium silicate. Typical brands are Kaylo, Thermobestos, and Caltemp. It is less susceptible to water damage and breakage than 85% magnesia without significant cost increase over the latter. The calcium silicate blocks are reinforced by asbestos or other mineral fibers. Block size is usually 6" x 36". Another type of block is primarily long fiber amosite asbestos with a temperature resistant siliceous binder. This is a strong, rigid, and water-resistant insulation of higher price, e.g., Unibestos and Caposite. Because of the higher material and greater handling costs, high-temperature block insulation has generally been restricted to services in excess of 450F. Thus it is used on pressure vessels, seldom on tanks. Installation of and maintenance work on insulation containing asbestos should comply with applicable Occupational Safety and Health Act requirements pertaining to asbestos fiber and silica dust. It appears that OSHA regulations will make calcium silicate and asbestos block insulation uneconomical for tanks.
- (d) *Foamglas.* This is generally used for cold insulation because of excessive cost. Foamglas can be used where no field welding is permitted. Although the blocks have good resistance to moisture penetration, moisture penetration at block edges and nozzles has been a serious problem. The problem has been generally the inability of vapor barrier systems to retain their resistance to water vapor permeation over the years and loss of seal at nozzles. Some tanks have experienced insulation failures after as little as a few years.

Another failure of a warm tank insulation system occurred when water leaked in and was vaporized at the surface of the tank, resulting in disintegration of the brittle Foamglas, destroying the insulation. Foamglas is limited to 300F maximum.

- (e) *Polyurethane*. Preformed block, sprayed, or poured-in-place (cast) polyurethane foam insulation may be used up to about 250–300F, depending on details of the installation and the polyurethane resin used. Advantages of polyurethane include ease of application (sprayed or poured-in-place), good resistance to most petroleum solvents, good insulation and mechanical strength, relatively low initial cost, and practically no maintenance cost if temperature limit is not exceeded. Note that the temperature restriction limits use on tanks subject to steam-out.

Polyurethane foams are organic and can burn. So-called "self-extinguishing" polyurethane foams meeting ASTM D-1692 are available but are not recommended for most new construction. Large scale tests have shown that some D-1692 foams will significantly feed a fire.

Fire retardant urethane foams which have a flame spread rating of 25 or less as tested in ASTM E84 are required on new construction to provide adequate fire resistance.

Weathercoats are required to protect the polyurethane from sunlight and to minimize ingress of water vapor. Sprayed-on flexible elastomeric weathercoats are commonly used. These weathercoats should also meet the flame spread rating of 25 or less, in accordance with ASTM E84. Metal weathercoats, intumescent paints and mastics, and cementitious coatings can also be used where improved fire resistance is required.

Commercial sandblast surface preparation and priming with an LZ1 primer compatible with the sprayed-on urethane is currently recommended. Some locations, mainly in dry climates, have had success with urethane foam where the steel was primed but not sandblasted. However, until long-term experience is developed on these applications, sandblasting and priming is recommended for all new construction.

Favorable atmospheric conditions for installing sprayed polyurethane foam insulation are warmth and low humidity. When installations must be made in cold weather conditions less than 50F, the tank should be heated with warm water or oil to provide adequate temperature for the curing of the urethane to take place. If heating the vessel is not feasible, alternate insulating materials may be necessary.

Design considerations for polyurethane insulation are more fully discussed in Board of Engineers E&M Bulletin No. 57A and Engineering Department Design Practice N-134-3, Polyurethane Foam.

Sprayed-on urethane has a slightly rough surface and will not achieve a smooth "signboard" quality with even the most skilled applicators.

(2) Insulations Not Recommended

- (a) *Loose Bulk Material* – A number of tanks were insulated by dumping loose mineral wool or other bulk material between the tank shell and the asbestos-cement or metal sheets which were secured to the tank leaving suitable clearance for the insulation. The loose mineral wool was tamped into the space for more firmness. It was found the insulation progressively settled in spite of the tamping. There is no cost advantage.
- (b) *"Plastic" Insulation* – This does not refer to modern plastics but is the name applied by the trade to pulped asbestos or mineral fiber in insulating concrete. It is troweled in place over reinforcing mesh. The result is a relatively solid mass with poor insulating value. Results vary with the manner of application. It was widely used some years ago. Drawbacks are that it cracks easily, wets easily, dries slowly, and costs more than some other types. OSHA requirements for working with asbestos must be considered in the use of this material.
- (c) *Sprayed Mastic Types* – These are usually more costly than other types considering the insulating value received. Insul-Mastic is an example. It is made of Gilsonite and pulverized cork. It is usable up to thicknesses of 1/4 to 3/8-in. and temperatures up to 180F. Mastics generally have a very short service life. They may be suitable for some few services but are not generally recommended. Painting over mastics has not been satisfactory. *Use of mastic may also be limited because of fire resistance considerations.*
- (d) *85% Magnesia* – This is more susceptible to breakage and water damage than competing block insulations without having significant cost advantage. It contains some asbestos and OSHA requirements for working with asbestos must be considered in the use of this material.

b. For Atmospheric Tanks Storing LP-Gas
And Other Similar Low Temperature Liquids
(Temperature ranging down to approximately -60F)

The following materials may be considered for such service, although the company experience has not been extensive.

- (1) Sprayed polyurethane foam.
- (2) Foamed-in-place polyurethane.
- (3) Rigid foam blocks (polyurethane, Styrofoam, Foamglas, etc.).
- (4) Balsa (for special applications).

Resistance to elevated temperatures is limited except in the case of Foamglas. See 6a(1)(e) for polyurethane temperature considerations. Of the above materials, only Foamglas will not support combustion.

Cold insulation must be vapor resistant. If water vapor diffuses through the insulation toward the cold surface, it condenses within the pores and destroys the insulating value and may corrode the tank shell. The structure of these materials is largely composed of closed cells which provide a vapor barrier. However, a vaportight weathercoat is also required over cracks in the insulation, over gaps between insulating blocks, and over areas where cell structure may be partially fractured. (Painting of tank steel is required. Refer to Section 13 following for coverage of this subject.)

7. WEATHERPROOFING

Materials for satisfactorily weatherproofing insulation of the wool type must be firm, while the softer weatherproofing materials may be used on rigid block insulation.

a. Satisfactory Weatherproofing

- (1) *Aluminum Sheets* — These are commonly used over glass fiber and mineral fiber blanket on many Company tanks. Preferred installation technique is external stainless steel banding. Studs or insulation support bars and metal screws are also commonly used to give the weatherjacket added resistance to wind damage.

Both flat and corrugated sheets are in use, although corrugated is more common. Cross-crimped sheets are available and provide additional protection from wind damage. Corrugated sheets are available in 1-1/4" and 2-1/2" deep corrugations, with the 1-1/4" corrugations more commonly used.

The spacing of the bands may have to be reduced with the more flexible aluminum sheets. Corrugated sheets are more rigid than flat sheets of the same thickness and require fewer bands. If flat sheets are wanted, they can be thicker to compensate for the lack of corrugations if found economical. Corrugated sheets joined with screws and having corrugations running horizontally have been used successfully without external banding, although, in general, application of aluminum weatherjacket without stainless banding is not recommended. Aluminum sheet without banding performed successfully for 12 years on 36-ft-diameter tanks in services up to 350F. But on a 60-ft-diameter tank, aluminum installed in this manner failed, to a degree, by tearing at the screws. This means that if corrugations are horizontal expansion joints of some kind should be provided, or corrugations should be vertical on large tanks.

Aluminum has good atmospheric corrosion resistance and can be used in almost all locations, except coastal applications where subject to salt spray or in certain chemical plant environments, where painting may be required. However, material studies appear to indicate that aluminum alloy applications may be satisfactory for coastal areas if the outside surfaces are properly prepared, primed and painted. Only the alloys best for atmospheric corrosion resistance are recommended. Alloys 3003 or 5052 have good atmospheric corrosion resistance and have been used with good success. Copper bearing alloys such as 2024 should not be used. Aluminum sheets should not be installed directly over calcium silicate or magnesia blocks (because of alkaline reaction) unless sheets are backed with an asphalt or polyethylene moisture barrier. Such sheets are commercially available. Suitable aluminum sheet is generally less expensive than asbestos-cement sheets.

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Company practice has generally been to use corrugated 0.016-inch aluminum with stainless steel bands on 4-foot centers on the West Coast and other moderate wind areas. More frequent band spacing and screw spacing are recommended as a minimum precaution in higher wind areas. (Refer to RP-11 for wind maps if local data not available.) Thicker aluminum (0.020–0.024-inch) may be justified in severe wind areas. Local experience should be determined before increasing thickness as the increase in thickness increases weatherjacket costs as much as 50%. Aluminum bands do not have sufficient long term strength and are not acceptable. Band tensioning devices should be a spring-type or a stainless steel coiled wire. Corrugated bands relax and do not maintain sufficient tension.

- (2) *Asbestos-Cement Sheet* – ASTM C220-55 Type F (Flexible) is a very satisfactory material that is both hard and rather flexible. It is not the least expensive type of weatherproofing, but its good performance justifies the cost in some cases. A number of manufacturers make corrugated sheets (for buildings) but not many produce the flat sheets. Sheets are commonly available in thicknesses of (inches) – 1/8, 3/16, 1/4, 3/8, 1/2, and lengths (feet) – 4, 8, 10, 12, and widths of 4 ft. The 3/16-in. thickness is most commonly used.

Philip Carey Manufacturing Company makes a general utility type called Industrial A–C Board. This was used in Chevron Asphalt's Cincinnati Refinery and is performing satisfactorily.

GAF's 3/16" Panelstone "U" sheet (formerly Ruberoid Stonewall), which was used at Chevron Asphalt's Mobile facility, embrittled. While flexibility is not as important for large tanks, Type F (as distinguished from Type U, utility) is most often used. Chevron Asphalt has replaced much of the asbestos-cement in service with aluminum.

Precurved sheets are available for small diameter tanks. The precurved material is generally recommended for tanks under 10 ft. in diameter. As applied most frequently by the Company, it has numerous lapped and battened joints which permit the tank to expand without opening spaces to the weather. It has good structural strength and excellent resistance to normal industrial environments encountered in Company operations.

Ordinarily it is unnecessary to paint asbestos-cement sheets for protection. However, most black-oil tanks ultimately have oil stains on the exterior resulting from improper tank vents, spills, or other mishaps. These stains cannot be eradicated practically. Therefore, painting would be required to preserve an unstained appearance. Some feel painting is required for protection in extremely corrosive atmospheres. Any installation of asbestos-cement board which might for any reason require painting sometime during its life should be primed on the reverse side and edges before erection. If this is not done and the front side of the sheets are painted, blistering and peeling can sometimes occur because of moisture diffusion through the sheet from the insulation side. Sheets to be painted upon erection should preferably be completely coated over both sides and all edges with a vinyl sealer before erection. However, careful selection of "breathing-type" paints have proved successful when painting unsealed asbestos-cement sheets.

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OSHA regulations should again be kept in mind when considering asbestos-cement sheets.

- (3) *Masonite Boards* — Hard boards of pressed wood fibers and resin binders, typified by Masonite, are being specified by some operators for weathercoating. This material is not very water resistant, but may be satisfactory if completely painted before erection. Maintenance of exterior paint would then have to be included in the cost study.
- (4) *Built-Up Roofing* — This may consist of four layers of 15-lb asbestos roofing felt alternating with hot roofing asphalt, all applied over block insulation or plain building board of pressed wood fibers. An asphalt and gravel surface may finish the top satisfactorily for foot traffic. Chevron Aluminum Asbestos Coating may be used to provide a reflective, longer-lasting finish. The built-up roof may be particularly advantageous to resist wind-driven rain and in snow country where water might seep through the lapped joints of sheet roofing.

Asbestos-cement and aluminum sheets have frequently been used for weatherproofing the roof insulation. These materials must be applied over a fairly rigid insulation, otherwise foot traffic will cause the lap joints to separate as only one sheet at a time is depressed under foot.

- (5) *Laykold and Chicken Wire* — For large tanks, Company experience indicates that Laykold and chicken wire is suitable over rigid insulation, such as foam glass, or calcium silicate blocks, provided care is taken to maintain a bond with the insulation as necessary. Over softer materials, such as Fiberglas and mineral wool blankets, Laykold weathercoating has been disappointing as expansion tends to shrink and crack Laykold when exposed to elevated temperature.

Where there are many connections as for a process column or vessel, the adaptability of the Laykold and chicken wire to irregular shapes results in a lower installed cost than for more rigid materials.

b. Weathercoating Types No Longer Recommended

- (1) *Canvas Coverings Using Adhesives* (such as Arabol) are not satisfactory. They are not resistant to impact and tearing. It is difficult to properly shrink them in place, which is necessary to avoid a wrinkled, unsightly surface. Fungicides are usually necessary to prevent the growth of molds if the weatherproofing is moist for long periods of time.

8. FLASHING AND SEALING

Flashing and sealing against water leakage at the edges of weathercover sheets is a problem that has never been completely solved. Considering the large investment required for tank insulation, any reasonable expenditure that will improve the effectiveness of flashed or sealed joints would seem warranted.

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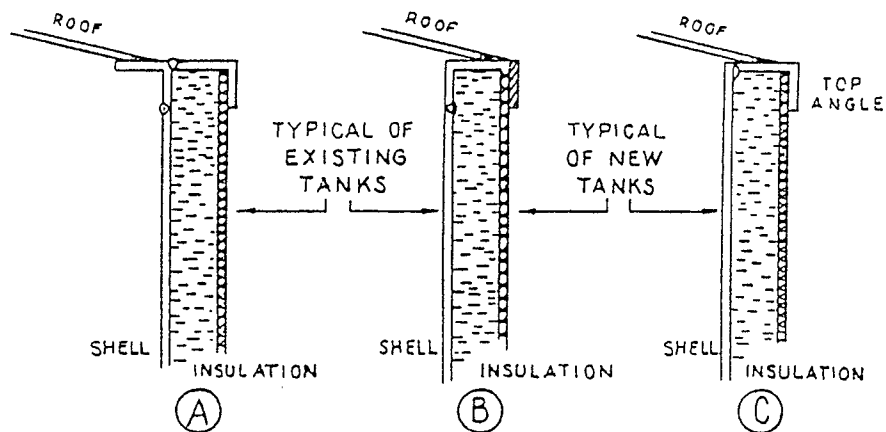
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Lead flashing creeps and leaves openings unless it is held tightly against a surface with continuous bands or bars. Aluminum or other sheet metal flashing does not readily conform to irregular surfaces even under pressure.

Soft compounds of asphalt, adhesives, or plastics (e.g., Albaseal) have been used to seal gaps directly or to seal underneath the flashing. However, these generally harden, and crack with long exposure to air and sun; "Thiokol Caulking Compound" or "Coast Pro-Seal Caulking Compound" are highly adhesive and may remain elastic and shrink-resistant for longer periods of time. "Stalastic" is reputed to stay soft at temperatures up to 400F. A material is needed which will last ten years or longer without change. Presently, two years is all that can be confidently expected.

Areas around tank appurtenances and attachments are most in need of better sealing materials and methods.

One of the most important zones for sealing is fortunately the easiest of accomplishment. This is at the top of the shell insulation. If the horizontal leg of the top angle of the tank is turned outward (see Figure B), the insulation and weathercover can be fitted tightly beneath this angle and a supplementary flashing of light steel can be continuously welded to the angle lapping over the vertical weathercoat. Otherwise, the horizontal leg of an angle may be continuously welded to the tank, and the vertical leg (see Figure A) turned down to cover the top two or three inches of insulation. Figure C shows similar construction on a new tank.



Flashing between roof attachments and aluminum or asbestos-cement sheets has been disappointing. Built-up roofing of asbestos felt and asphalt finished with Chevron Aluminum Asbestos Coating may be used to flash around the appurtenances. Built-up roofing eventually shrinks and cracks after long exposure to air and sun but may give good service for many years. One layer of glass fiber mat may extend the life of the material when used as flashing, and may help resist cracking in the transition zones. The fabric flashing at manhole and nozzle necks should be banded with glass fabric tape before the final asphalt application so shrinkage will not draw the material away from the neck. Steel banding cuts the flashing material.

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To seal the edge of the roof insulation and the top of the shell insulation under the same cover is poor practice. It causes roofing leaks to let water reach the shell insulation beneath the flashing. Shell insulation should be flashed separately from the roof.

Expansion allowance should be provided in any connections between roof weathercoat and shell weathercoat, e.g., straps, secondary flashing, etc.

9. APPLICATION

Insulation application techniques are first to hold the insulation in place, and second to weatherproof it effectively with provision for expansion.

a. The insulation may be held in place by one or a combination of the following methods:

- (1) Impaling it on numerous studs welded to the tank shell or roof.
- (2) Pressing it firmly against the tank shell with several circumferential bands equipped with expansion devices to maintain tension at all times. The bands may be inside the weatherproofing, outside, or both.
- (3) Supporting it with a framing of channels and angles attached to the shell.
- (4) Paste to the shell with asphalt or other adhesive. This is for cold insulation; it is not suitable for hot insulation.

b. The following remarks will deal with accessory materials and certain devices which may be encountered in various combinations.

- (1) *Studs* are usually welded to the tank shell — and often to the roof — for anchoring the insulation and cover sheets to the tank steel. (*WARNING* — Stud welding on thin plate less than 3/16" thickness may burn holes in the plate. Inspect the operation closely especially if the studs are put through insulation that is already in place.) Studs should be hit with a hammer as they are installed to test the weld. Backup washers behind the weatherjacket permit nuts to be tightened against the outside of the sheets while maintaining the insulation space. One stud only through the middle of each sheet minimizes the number of perforations and leaves the remainder of the sheet free to slip as the tank expands. Studs are also used in the gap between vertical edges of the sheets. These hold the batten which covers the gap. The gaps allow for expansion and the battens hold the edges of the sheets tight against the insulation. Studs should be of stainless steel at the outside end to prevent rust from staining the exterior as well as to preserve the studs. A duplex stud has been in common use. It consists of a carbon steel shank (welded to the shell of the tank) and a stainless steel end factory-assembled to the shank. The stainless steel is the only exposed part. Advantages are lower first cost and a better quality weld between the stud and the tank.

- (2) *S Clips* or *Z Clips* are hooked over the top edge of each aluminum and asbestos-cement sheet so that the hanging hook will receive and support the bottom edge of the sheet

above. The sheets are thereby laid up in shingle fashion with the upper overlapping the lower about 3 inches. These clips should be austenitic stainless steel (item of minor expense).

- (3) *Battens* are strips about 4 inches wide which cover the vertical gaps between the asbestos-cement sheets. The battens are drawn against the sheets by taking up on stud nuts which are spaced at about 2-ft intervals down the center of the battens. Like the weathercover sheets, the battens are installed shingle fashion with the lower end of each overlapping the one below.

Originally battens were cut from asbestos-cement board but the material was too brittle for this purpose. Galvanized iron was also used but the galvanizing did not remain completely intact. Light gage (20 to 24) material such as austenitic stainless steel may be used for battens if embossed or otherwise formed for greater stiffness. Aluminum has also been offered for battens but its resistance to coastal atmospheres is questionable as already described.

Battens may be eliminated by lapping the corrugations of aluminum weathercoating.

- (4) *Bands* of austenitic stainless steel are usually used on the outside of the weathercover to hold the insulation firmly against the tank shell. As discussed earlier, aluminum bands are not recommended. They are usually 3/4-in. wide by 0.020-in. thick and are generally located over the lapped horizontal joints and at intermediate points of each course of sheets — spacing therefore being about 4 ft. maximum. Tension is maintained in the bands by some kind of expanding device. Special consideration, such as additional expansion springs, are needed for cold climates to accommodate the larger total shrinkage and growth of stainless steel bands. Heavy steel springs (galvanized or stainless steel) are popular. Heavy coiled stainless wire is sometimes used in place of springs — these should also be stainless steel. Bands that are corrugated to introduce spring tension are not satisfactory because the corrugations in the bands tend to relax.
- (5) A *bottom angle* of light structural steel welded to the tank shell, or of galvanized sheet metal resting on studs, may be used to support the bottom course of insulation a few inches above the bottom of the tank. This is required because most insulation that touches the ground will soak up water. This preserves the insulation from exposure to ground water and enables visual inspection of the shell-to-bottom joint. Another method is to leave the bottom shell exposed as above without any added support for the insulation, relying on the normal studs and the restraint of the banded weathercoat to keep the insulation from sagging.
- (6) Where *framing* instead of bands is used to hold insulation in place, the weathercover sheets (usually corrugated aluminum for this technique) would be fastened to the framing and to each other at the lapped joints. No battens are required. There is reason to believe this method does not hold the insulation against the tank shell as firmly as do the bands. Therefore, stainless steel bands are preferred in place of framing.
- (7) *Screws* are used, to some degree, in nearly all tank insulating jobs but especially to join the aluminum weathercover sheets over roof insulation. They are gasketed, self-tapping, aluminum or stainless steel sheet metal screws; this applies to either shell or roof

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insulation. Sheet metal screws are also used for asbestos-cement roof sheets but they must be harder and more alkaline resistant than aluminum. Stainless steel is the preferred material for all screws. Screwed roof joints should be sealed with a soft mastic or adhesive before driving the screws.

- (8) *Bonded Insulation*, where no banding is required, has been used on some Company tanks. The Mobile Refinery of Chevron Asphalt Company has some examples. The insulation is cemented to the asbestos-cement sheets in the shop leaving a 3-in. margin at the bottom and are drilled on 1-ft centers triangularly spaced. They are pinned to the tank with flat head pins inserted through the holes and stud welded to the tank shell. This results in about 32 insulation pins being welded on for each sheet, and even though some of the welds may be of poor quality, a sufficient number are sound and result in a suitable insulation job. Application begins at the bottom of the tank and the next panel of material has a 3-in. overlap over the first, etc., to the top of the tank.

Chevron Asphalt – Mobile had installed this type of insulation. The GAF Panelstone sheets embrittled and were blown off the tank. Chevron Asphalt now uses aluminum weatherjacketing with stainless bands.

- (9) *Roof insulation* may be attached by:

- (a) Impaling it on short studs or prongs that will protrude and puncture the weathercoat even under foot traffic.
- (b) Impaling it on longer studs that also hold the weathercover sheets.
- (c) Sticking the insulation to the tank roof plates with a suitable adhesive which will not evaporate and condense in the insulation at roof temperatures. Chevron Asphalt has used this method on heated tanks with Petrolastic 215 as the adhesive. However, this method is best on cold rather than hot tanks.

- (10) Incorporate improved application methods; keep updating techniques.

- (11) Existing tanks should be thoroughly inspected for leaks and be repaired before insulating. Shell thickness should be gaged and new plates installed wherever necessary to provide corrosion allowance beyond the expected life of the insulation.

10. TANK DESIGN FOR INSULATION

In designing a new tank that may ultimately be insulated, attention should be given to the following factors: (Refer to Board of Engineers Tank Data Book and Corporation Engineering Department's Design Practices for basic design criteria.)

- a. Minimize the number of attachments to reduce opportunities for leaks through the weathercoat.
- b. Provide clearance of 4-in. to 6-in. for insulation and flashing:

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- (1) Nozzle and manhole necks should be at least 4 to 6 in. long to facilitate flashing and bolt removal.
- (2) Double stringer stairs should be mounted at least 4 in. away from tank shells.
- (3) Provide at least 4 in. clearance from tank shell to any parts of swing-pipe counterweight tracks, gage boards, etc., especially for counterweights, pointers, winches, and other moving parts.
- c. Top angle of tank should be large enough to act as flashing over the top of the shell insulation and weathercoat.
- d. Include support angle for insulation if desired.

11. ECONOMIC CONSIDERATIONS

- a. Desired liquid temperature.
- b. Climatic conditions (sustained minimum and/or maximum average temperatures, winds, precipitation, etc.).
- c. Rate of heat input or heat loss from bare tank including the effects of transfer of stock in and out of tank.
- d. Selection of proper materials for service, temperature, and weather conditions; and recognizing the influence of regulatory limitations on maintenance of asbestos-containing materials.
- e. How often and for what duration the liquid temperature must be maintained.
- f. Thermal conductivities of various insulating materials (the lower, the more effective).
- g. Size and cost of required tank heating equipment or cooling coils and accessories, without insulation and with insulation of various thicknesses.
- h. Quantities and costs of heating or cooling mediums under same conditions.
- i. Evaporation rates for various insulation possibilities and value of the stock.
- j. Costs of a minimum practical thickness of insulation and incremental cost of additional thicknesses of insulation. These costs must be developed for each different kind of insulation.
- k. Possibility of fire exposure, some measure of the frequency and the risk of damage if uninsulated, and the amount of protection afforded by insulation.
- l. Cost of sandblasting and priming tank steel to control corrosion under insulation under certain circumstances (see Section 13).

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- m. Wind velocities and whether more frequent band and screw spacing or thicker aluminum is required.

12. ROOF INSULATION

Roofs associated with insulated tank shells are not necessarily insulated, but depend on economics. However, when used roof insulation presents some special problems:

- a. Nearly horizontal surfaces and depressions cause poor drainage. Therefore, the weathercoat must exclude water from any direction – shingled construction alone is not adequate.
- b. Roof weatherproofing must support foot traffic without undue deflection or perforation.
- c. Height of roof appurtenances must permit flashing over the insulation and allow room for removing flange bolts. New tanks to be insulated should be designed specifically for insulation including 4 to 6 in. clearance wherever insulation may be applied.

The best of roof insulation installations is a compromise with circumstances. However, troubles can be minimized by specifying a firm (12 lb per cu ft) insulation and durable weathercoat. By using roof insulation on tanks operating above 200 to 250F, minor leakage may be driven out of the insulation by evaporation near the point of entry before it penetrates deeply. At lower temperatures, if water can enter at some point, it will migrate beneath the insulation to areas that are effectively weatherproofed where the escape of water vapor may be largely prevented. Then condensation in the cooler areas of the insulation will reduce insulation efficiency, and the water and residual salts will cause corrosion of the tank steel.

Although mineral fiber or glass fiber block has been used extensively in the past for roof insulation, use of polyurethane foam for roof insulation has been increasing. The primary advantages of polyurethane are its low cost, outstanding insulating properties and ease of application. Fire-retardant urethanes meeting the flame spread rating of ASTM E-84 are required for new construction to provide adequate fire resistance. A skilled and knowledgeable applicator is required and poor results and disbonding have been experienced where the foam was applied to damp surfaces.

A flexible elastomeric coating is commonly used to provide the necessary weatherjacket. This coating must also meet the E-84 flame spread requirements. See Design Practice N-134-3 for a comprehensive discussion of polyurethane insulation.

13. PAINTING TANK STEEL

Corrosion of tank shell or roof plates under insulation is sometimes rapid enough to reduce tank life sharply. This occurs when moisture condenses against the surface of the tank, particularly in areas where the atmosphere is especially corrosive because of marine or industrial contaminants. It is more common on insulated tank plates which are at or near ambient temperature for long periods of time, but has been observed on tanks operating below the flash point of water at atmospheric pressure – i.e., up to about 200F. Such corrosion has been reported on tanks insulated with granular mineral wool, fiber glass blankets, polyurethane foam Foamglas and 85% magnesia blocks; no correlation seems to exist between incidence of corrosion and type of insulating material.

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Significant shell corrosion has recently been experienced on two LPG spheres where failure of the vapor barrier allowed moisture penetration. These spheres operate in the 30-40F range. Based on similar occurrences of shell corrosion at other locations, priming of tank shell plate is required where the operating temperature will be less than about the mean dew point plus 20F (generally less than 70F). In such cases the usual procedure is to sandblast, to remove mill scale and rust from the new steel plates, and prime the clean steel with a relatively heavy coat of inhibitive primer. This primer must, of course, be selected for suitability over the entire temperature range to which the steel may be subjected in service. In those areas where it is necessary, the cost of such sandblasting and priming of tank steel must be taken into account in connection with the overall economic justification of the insulation.

Facilities and procedures have been developed in the past several years whereby tank plate can be shop-coated with an inorganic zinc primer, thereby reducing the amount of field sandblasting. If priming of the steel is required, consideration should be given to using this coating system as an alternate to field sandblasting and priming.

14. INSPECTION

Tank inspections should regularly include an inspection of the weather coat, especially at areas where weather coat tends to come loose, to verify the effectiveness of the weather coat system. Insulation in high wind areas should also be inspected promptly after major storms. Particular attention should be given to:

- a. entire roof-to-shell seal,
- b. appurtenance openings in the roof and shell,
- c. any oil-soaked areas around breather valves or vents, and
- d. bottom-to-shell joint area to determine if bottom insulation has been soaked by rainwater or oil.

Where the weather seals are broken and moisture and water can accumulate behind the insulation, corrosion of steel must be considered. To minimize repair work for inspection under insulation, ultrasonic testing "speed check" plugs can be used. These removable insulation plugs permit the inspector to gauge the tank shell without damage and subsequent repair to the insulation or flashing.

When corrosion occurs under insulation, it is most frequently seen at areas where water can be trapped, such as at horizontal clips, the bottom of the tank, or where a bonded insulation is locally disbonded from the steel. Corrosion under insulation can be a serious problem when broken seals permit moisture to get behind the insulation. High humidity climates intensify the potential corrosion problems. Tankage operating at subambient temperatures, such as LPG or ammonia tankage, have experienced severe corrosion under insulation when vapor barriers have deteriorated and permitted entry of water rundown and water vapor diffusion through the insulation.

Tank inspections should also look for broken, slipped, or loose bands. Weather coats should also be inspected to look for breaks and tears, which may cause future problems.

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GLOSSARY OF TRADE NAMES USED IN TEXT

Trade Name	Manufacturer	Description
Aerocor	Owens-Corning Fiberglas Corp.	Fine-fiber Fiberglas insulation, PF-330 series.
Albaseal	Johns-Manville	Soft (permanently plastic) sealer with synthetic resin base.
Arabol	The Arabol Manufacturing Co.	Adhesives made to specification. (Reference was to a vinyl plastic.)
** Asbestocite	John-Manville	Asbestos-cement sheet (discontinued).
† Caltemp	Pabco Industrial Insulations Division of Fiberboard Paper Products Corp.	Hydrous calcium silicate rigid insulation.
Super Caltemp, Type NA	Pabco Industrial Insulators Division of Fiberboard Paper Products Corp.	Hydrous calcium silicate rigid insulation, free of asbestos (New 1971).
† Caposite	Cape Asbestos Co.	Long-fiber amosite asbestos with siliceous binder. Hard rigid insulation.
Chevron Aluminum Asbestos Coating	Standard Oil Co. of Calif.	Asphalt with asbestos fibers for reinforcing and aluminum pigment for heat reflection.
† Flexboard	Johns-Manville	Like Asbestocite. Marketed for buildings.
Fiberglas PF-613	Owens-Corning Fiberglas Corp.	Fiber glass insulation 3-1/4 lb per cu ft density.
Foamglas	Pittsburgh Corning Corp.	Foamed glass with closed-cell structure.
† Industrial A-C Board	The Philip Carey Mfg. Co.	Asbestos-cement board, Type U (Utility grade).
Insul-Mastic 553	Insul-Mastic Corp. of America	Gilsonite base sprayable mastic with granulated cork and fillers of mica, asbestos, and clay.
** † Kaylo	Kaylo Division Owens-Illinois Glass Co.	Calcium silicate insulation (discontinued).
Laykold	Chevron Asphalt Co.	Emulsified asphalt surfacing products.
Masonite	Masonite Corp.	Pressed, bonded wood fibers. Various products. (Reference was to a hard board.)
Nicholson & Galloway	Nicholson & Galloway	Specialists in sheet metal and insulation work.
† Panelstone	G.A.F.	Asbestos-cement sheet, Type F (Flexible).
Petrolastic 215	Chevron Asphalt Co.	Asphaltic cement.
Spintex No. 412	Johns-Manville	Mineral fiber insulation 3-1/2 lb per cu ft density.
Stalastic	Eagle-Picher Co.	Soft sealing compound intended for the exterior of boiler refractory, etc.
† Stonewall	G.A.F.	Asbestos-cement board, now called Panelstone "U."
Styrofoam	Dow Chemical Co.	Expanded cellular polystyrene.
† Thermobestos	Johns-Manville	Hydrous calcium silicate rigid insulation.
Thiokol Caulking Compound	Thiokol Chemical Corp., or Coast Pro-Seal & Mfg. Co.	Thiokol liquid polymer rubber caulking compound.
Ultralite	Gustin-Bacon Mfg. Co.	Fine glass fiber insulation.
† Unibestos	Union Asbestos & Rubber Co.	Long-fiber amosite asbestos with siliceous binder. Hard rigid insulation.

** No longer available.

† Contains dry asbestos fiber.

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