PLAINTIFF'S EXHIBIT CHV-924

1. SCOPE AND SUMMARY

This Recommended Practice presents general principles for insulating new and existing tanks, plus some details to determine if insulation is justified. It also provides guidelines covering preparation of specifications for bids and contracts on tank insulation work and includes an evaluation of materials and methods of insulation that have been proposed by insulating contractors. It suggests design features desirable on new tanks if they are to be insulated; it discusses preparations for existing tanks requiring insulation; and mentions techniques on inspection and maintenance of existing tank insulations. Types of brand names of materials recommended are also included as well as some of those not acceptable.

Insulation materials containing asbestos fibers and free crystalline silica are no longer acceptable andhave been banned by OSHA. Fiberglass insulations contain silica-bearing material, in general, but they do not contain free crystalline silica. Many corporate insulation installations, however, have in place asbestos-containing insulation. Therefore, upon removal, regulations must be observed as outlined in the California OSHA Codes, Title 8, Section 8.

Conventional insulation materials such as mineral wool or fiberglass with resin binders and asbestos-free calcium silicate types are preferred for many applications because they are efficient, easy to handle, and resist mildew and water damage. Spray-applied, froth-or pour-type polyurethane foam also is used because of its initial lower cost and excellent K-factor, but each application must be fully evaluated with regard to combustibility and mechanical damage considerations. Weather coats of corrugated aluminum sheet for vertical surfaces, and built-up asphalt saturated felt and gravel for roofing are most generally used. Asphaltic, mastic or Laykold membranes reinforced with chicken wire are good over dense insulation and roofs and around appurtenances. Proper flashing and joint sealing with provisions for expansion are important. Polyurethane foam requires an elastomeric weathercoat system when used in an exterior environment to prevent vapor penetration and oxidation of the foam.

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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. Specification Eg-3354, Insulation of Heated Storage Tanks (Using Polyurethane Foam)

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

Eng. Dept. Design Practice D-131-4, Hot Oil Storage Tanks - Heat Loss, Heaters, Computer Program TANK**

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

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

Eng. Dept. Standard Drawing GB-N99993, Standard Insulation Item Numbers

Eng. Dept. Standard Drawing GA-N99784, Standard Insulation for Cold Lines

Eng. Dept. Standard Drawing GA-N99783, Standard Insulation for Hot Piping

Eng. Dept. Standard Drawing GA-N99785, Standard Insulation for Hot Vessels, Heat Exchangers and Hot Equipment

The essential preferences and exclusions discussed are intended for use in specifications. Proposals or practices submitted by contractors as alternatives to standard Company procedures should be studied to take full advantage of all profitable ideas. Workmanship and product guarantees should be obtained from the contractor. Some contractors have guaranteed the quality of their workmanship for three 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. Maintain crude oil or product in a viscous state above its pour point to maintain its flowability.

b. Reduction in size of-or elimination of-tank heaters, cooling coils, etc., contributing to reduced operating costs.

c. Stabilization of operations, e.g., maintaining a more constant temperature in a fluid being fed to a process.

d. Reduction of evaporation losses.

e. 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 reviewing the exterior temperature. Any spot that feels noticeably warmer to the hand than the surrounding areas indicates 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 or other heat measuring devices should be considered for a comprehensive inspection. Contact the Engineering Department for more details.

Insulation need not be completely effective over its entire area to support its economic justification. Suppose 10% of the total surface were insulated only half as effectively as planned; the 5% reduction in heat savings should not have altered the decision to insulate. However, good workmanship, materials, and techinques 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) Fiberglass semi-rigid board with thermosetting binder. This is the most widely used conventional insulation for tanks in the company. The minimum density for shell insulation should be 3 lb. per cu. ft. Roof insulation should be about 12 lb. per cu. ft. density to prevent crushing underfoot. The maximum service temperature is limited by the resin binder at 350° to 450°F. Most fiberglass products are rated at temperatures in excess of the binder burnout temperature-up to 850°F. Although the binder burnout temperature is in the same range, the use of fiberglass materials above 350°F should be reviewed with the Engineering Department before consideration.

John-Manville 1000 series Spin-glas, Owens-Corning IQ Board and Certainteed 850/fiberglass are considered equal and are in common use. Typical pieces are 2x4 ft. and 1, 1½, 2, 3, and 4 inch 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 the conductivity. The reverse is true for most materials, but in light fibrous insulation, air convection becomes appreciable. Low density boards contain more continuous air space, resulting in a lower resistance to air flow and greater contribution to convection heat transfer. Also due to convection effects, thermal resistance of this type of insulation (assuming constance fiber fineness) decreases with increasing temperature difference across the thickness.

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

(b) Mineral wool semi-rigid board with thermosetting binders. This type of insulation is usually formulated from iron slag using an organic/inorganic binder. The in-service temperature limitation is about 1200°F although the binder burnout temperature is about 400°F. The binder is non-punking and the company has successfully used this insulation material to 1100°F. Typical densitites are between 10 and 11 lbs. per cu. ft.

Eagle Picher Epitherm 1200 and 40/8 Insulation N-1200 mineral wool products are in common use. The material has a K-factor of 0.26 Btu-in/hr-F-ft^2 at 75°F. It is not recommended for areas where foot travel may occur unless special precautions are taken to prevent crushing-such as using a heavier jacket material.

(c) Hydrated calcium silicate block-type insulation. Typical brands are PABCO Super Caltemp and Johns-Manville Thermo 12. It is less susceptible to water damage and breaking than 85% magnesia which is no longer being manufactured. Calcium silicate insulation materials contain no asbestos fibers in compliance with applicable OSHA requirements pertaining to asbestos fiber and silica dust. Block size is usually 6" x 36". Its temperature limitation is about 1200°F, but because of its high installed cost it has generally been restricted to services in excess of 450°F. Typical densitites are about 13 lbs. per cu. ft. The material has a K-factor of 0.40 Btu-in/Ft^2 Hr°F at 100° mean temperature, but at temperatures above 550°F the K-factor will be somewhat less than that of mineral wools.

(d) Foamglas. Foamglas is a silica-based, closed-cell foam manufactured by Pittsburgh-Corning. It is generally used only for cold insulation because of high cost and can be used where field welding would not normally be permitted because of its superior fire resistance.

Although the blocks have good resistance to moisture penetration, moisture penetration at block edges and nozzels 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 300°F maximum.

(e) Polyurethane. Preformed block, sprayed, or poured-in-place (cast) polyurethane foam insulation may be used up to about 200-300°F, 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 are subject to steam-out. It has a low K-factor (approx. 0.16 Btu-in/F-ft^2-hr at 75°F-aged). Core densitites of 2 to 2.5 lbs. per cu. ft. on the shell and 3.0 to 3.5 lbs. per cu. ft. for the roof are normally specified.

Fire-retardent urethane foams which have a flame spread rating of 25 or less as tested per ASTM E-84 are required on new construction to provide adequate fire resistance. Polyurethane foams are organic and can burn. So-called "self-extinguishing" polyurethane foams meeting ASTM D-1692 are available but are not recommended for new construction. Large scale tests have shown that some D-1692 foams will significantly feed a fire, hence the E-84 test criteria are recommended instead.

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 E-84. Metal weathercoats, intumescent paints ands mastics, and cementitious coatings can also be used where improved fire resistnace is required.

Commercial sandblast surface preparation (SSPC-6) and priming with an amine adduct-cured epoxy compatible with the sprayed-on urethane are required on all tank insulation applications. Fire retardents can form acidic water which are rapidly corrode uncoated steel.

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

Design considerations and fire safety instructions for polyurethane insulation are more fully discussed in the

Engineering Department, Design Practice N-134-3, and Specification EG-3354.

Sprayed-on urethane has a slightly rough surface and will not achieve a smooth "signboard" quality with even the most skilled applicators. Care must be taken to plan jobs during seasons when it is not windy or raining as this will prevent a high-quality application.

(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.

Loose fiberglass insulation has been used successfully in pontoons on floating roofs. The insulation is blown in the pontoon through the compartment manways.

(b) "Plastic" Insulation - This does not refer to modern plastics but is the name applied by the trade to mineral fiber in insulating concrete. It is troweled in place ower reinforcing mesh. The result is a relatively solid mass with poor insulating value. Results vary with the matter 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.

(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 180°F. 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) 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, Fiberglass Aerocor and Johns-Manville Microlite. This type of insulation is designed for residential use and should not be considred for tank insulation.

b. For Atmospheric Tanks Storing LPG 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 (example: CBI to Temp "CW" system).

(3) Rigid foam blocks (polyurethane, Styrofoam, Foamglas, etc.).

(4) Balsa (for special applications).

In additional, two other systems involving different materials are used for insulating liquid ammonia tanks (temp. -29F). One system, called the "Double Wall System," uses loose Pearlite as the insulation media between the tank shell and outer wall. The second system, called "Alumiseal," utilizes multiple sheets of aluminum with an air space between shell and individual rows (one or more) of aluminum sheets.

Resistance to elevated temperatures is limited; see 6a(1)(e) for polyurethane temperature considerations. Of the above materials, Foamglas, Alumiseal and Pearlite 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 vapor-tight weather-coat 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. **WEATHERPROFFING**

a. Satisfactory Weatherproofing

(1) Aluminum Sheets - There are commonly used over fiberglas and mineral wool insulation on most company tanks. Preferred in-

stallation technique is external stainless banding. Studs or insulation support bars and metal screws or T-rivets are also commonly used to give the weatherjacket added resistance to wind damage.

All aluminum jacketing should be backed with a bonded moisture barrier, generally with a highly impermeable sheet (polythylene with Kraft paper), to prevent corrosion of the aluminum sheet.

Both flat and corrugated sheets are in use, although corrugated is more common. Cross-crimped sheets are avilable 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 more flexiable 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 sheets without banding performed successfully for 12 years on 36-ft diameter tanks in services up to 350°F. But on a 60-ft-diameter tank, aluminum stalled 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. Steel weatherjacketing (.010 inches thick) coated with a baked vinyl organsol is also available. This product (one tradename "Steel Jack") costs about 40% more than aluminum weatherjacketing. Only the alloys best for atmospheric corrosion resistance are recommended. Alloy 3003 or 5052 has good atmospheric corrosion resistance and has been used with good success. Copper-bearing alloys such as 20243 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. Suitable aluminum sheets are generally less expensive than asbestos-cement sheets. Type 304 stainless steel is used for weatherjacketing in corrosive environments too severe for bare aluminum or coated steel.

Company practice has generally been to use corrugated 0.016-inch aluminum with stainless steel bands on 2-foot centers on the West Coast and other moderate wind areas. More frequent band spacing and rivet spacing may be recommended as minimum precaution in high 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 determinded before increasing thickness as the increase in thickness weatherjacket costs as much as 50%. Aluminum bands do not have sufficient long-term strenght and are not acceptable. Band tensioning devices should be a spring type. Corrugated bands relax and do not maintain sufficient tension.

(2) Built-Up Roofing - Two systems are in common use for tanks. Preferred system is to apply two layers of 45-lb. roof felt over 2" or more roof deck insulation block such as Owens-Corning "Roof Deck" insulation board alternating with hot roofing asphalt. The "Roof Deck" insulation board is impaled onto pins spot-welded to the roof plates. Individual sheets of the 45-lb. roof felt in each ply are overlapped at least one foot. Joints in the second ply can either be staggered from the joints in the first ply or run 90° to the first ply. The second system may consist of four layers of 15-lb. asbestos roofing felt alternating with hot roofing asphalt, all applied over block insulation dipped in asphalt to adhere to the roof plate or over plain building board of pressed wood fibers. A "pea gravel" topping applied at 4-lbs. per sq. ft. is applied over both roofing systems to resist high winds. Chevron Alkuminum Asbestos Coating may also be used as the final coating to provide a reflective, longer lasting finish.

(3) Asphalt or Mastic and Chicken Wire - For large vessels, company experience indicates that asphaltic (Laykold) or mastic supported with chicken wire or fiberglass cloth is suitable over rigid insulation, such as Foamglas, or calcium silicate blocks, provided care is taken to maintain a bond with the insulation as necessary. Over softer materials, such as fiberglass and mineral wool blankets, asphalt and mastic weathercoating have been disappointing as expansion tends to shrink and crack, both when exposed to elevated temperatures.

When there are many connections, as for a process column or vessel, the adaptability of asphalt or mastic and chicken wire or fiberglass cloth weathercoating to irregular shapes results in a lower installed cost than for more rigid materials. The insulation is usually covered first with a low shrinkage insulating cement in these applications.

b. Weathercoating Types No Longer Recommended

(1) Abestos-Cement Sheet - Asbestos-cement sheets (ASTM C220-55 Type F - Flexible) have been used in the past with some degree of success. However, because it is more expensive than aluminum, has a tendency to crack in service and contains asbestos, it is no longer in general use. The major concern with asbestos-cement sheet is during repair or removal. Like-asbestos containing insulation, asbestos-cement sheets must also be handled in accordance with OSHA Title 8, Section 5208 regulations.

(2) Masonite Boards - Hard boards of pressed wood fibers and resin binders, typified by Masonite, have been specified by some operators for weathercoating in the past, but also are no longer in general use. This material also has a tendency to crack in service and is not water resistance. To be water resistant, it should be painted before erection. Maintenance of exterior paint would then have to be included in the cost study.

(3) 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 should accomplish two things:

a. Prevent leakage at the edges of weatherjacketing.

b. Channel water away so that it will not form puddles.

Considering the large investment required for tank insulation, any reasonable expenditure that will improve the effectiveness of flashed or sealed joints would seem warranted.

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 pressures.

Various caulking compounds have been used to seal gaps directly or to seal underneath flashing. A silicone caulking compound such as Dow-Cornings' 732 and a butyl rubber caulking compound such as Foster's 95-94 has been used successfully on outside surfaces of tank insulation using aluminum sheeting. On hot surfaces between 180°F and 400°F, a high solids asphaltic cutback such as H.T. Stalastic has been used. Care must be taken when selecting a suitable caulking compound since cracking or shrinking after a short period could result in water pentetration.

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 to accomplish. 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 and sealing details between roof and sheet insulation should follow design practices detailed in Drawing GB-N99995 details G and H in Specification EG-1381. Details of flashing around manways and nozzels are also covered in details A and D-D. These details should be followed closely since ineffective flashing could result in premature failures.

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 if 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. This technique (called the Impalement Method) is covered in Specification EG-1381 and is suitable for fiberglass and mineral wool block insulation.

(2) Pressing it firmly against the tank shell with several circumferential bands equipped with expansion devices to maintain tension at all times. Both interior (over the insulation) and exterior bands (over the weathercoat) are provided and are attached to vertical steel strips (Laybar Method) bolted on studs welded to the tank. Only the exterior bands are provided with the expansion devices. This technique is also covered in Specification EG-1381.

(3) Supporting it with a framing of channels and angles to the shell. Typically, framing is not done over the entire tank but restricted to areas around stairs and nozzles.

(4) Paste to the shell with asphalt or other adhesive. This is for cold insulation; it is not suitable for hot insulation.

(5) Fitting together insulation panels which have polyurethane foam attached to the underside. Owens-Corning offers insulating panels for tanks operting at temeratures below 250°F. This system called "Zip-Rib" has not been used to date by the company because of its high cost.

(6) Always support the insulation 6 inchs off the ground. Wicking from ground moisture can cause serious shell corrosion problems.

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 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 performations 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 stainless steel on the outside end to prevent rust from staining the weatherjacket and 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 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. J-clips are pop riveted to the aluminum weatherjacket to hold up the stainless steel bands around the tank circumference. The clips should be austenitic stainless steel (item of minor expense).

(3) Bands of austenitic stainless steel are usually used on the outside of the weathercover to hold the insulation firmly against the tank sheet. 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 considerations, 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.

(4) 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 at least 6 inches above the bottom of the tank. This is required because most insulation that touches the ground will soak up water. This preserve the insulation from exposure to ground water and enables visual inspection of the shell-to-bottom joint.

(5) Where framing instead of bands is used to hold insulation in place, the weathercover sheets (usually corrugated aluminum for this technique) can be fastened to the framing and to each other at lapped joints. 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.

(6) 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 insulation. 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.

(7) 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 insulatin 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.

(8) Roof insulation may be attached by:

(a) Impaling it on 10-gage steel studs welded to the roof. The studs are bent over washers to secure the insulation so the studs will not puncture the weathercoat under foot traffic. (See Drawing GB-N99995 - Detail G Specification EG-1381.

(b) Sticking the insulation to the tank roof plates with a suitable adhesive which will not evaporate and condense the insulation at roof temperature. 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.

(9) Incorporate improved application methods; keep updating techniques.

(10) 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 Engineering Advisory Committee's Tank Data Book and Corporation Engineering Department 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:

(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 shell.s

(3) Provide at least 4-in. clearance from bank shell to any parts of wing-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**

The economic considerations of tank insulation are reviewed in Design Practice D-131-4, Hot Oil Storage Tanks: Heat Loss, Heaters, Computer Program TANK**, which determines the economic insulation thickness based on the factors discussed following.

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 the 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 thickness 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, the 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).

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 that can lead to premature failures. The most common problems include.

a. Nearly horizontal surfaces and depressions cause poor drainage. Therefore, the weathercoat must exclude water from any direction-shingle construction alone is not adequate.

b. Roof insulation must support foot traffic without undue deflection perforation or impaling studs puncturing the weathercoat.

c. Height of roof appurtenances must permit flashing over the insulation and allow room for removing flange bolts. New tanks to be insulated including 4 to 6 in. clearance wherever insulation may be applied.

The best of roof insulation is a compromise of many factors. Specifying a firm (12 lb. per cu. ft.) insulation and durable weathercoat can minimize many problems. With tanks operating above 200-250°F, minor leakage may be driven out of the insulation by evaporation near the point of entry before if 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 wool or fiberglass 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 insulation properites and ease of application. Fire-retardant urethanes meeting the flame spread rating of 25 per ASTM E-84 are required for new construction to provide adequate fire resistance. A skilled and knowledgeable application is required and poor result in disbonding have been experienced where the foam was applied to damp surfaces.

A flexible elastomeric coating is commonly used to provide the necessary weatherjacket. Like the foam, this coating must also meet a flame spread of 25 or less per ASTM E-84. 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 period of time, but has been observed on tanks operating below the flast point of water at atmospheric pressure-i.e., up to about 200°F. Such corrosion has been reported on tanks insulated with mineral wool, fiberglass, polyurethane foam, Foamglas and 85% magnesia blocks; however, no correlation seems to exist between incidence of corrosion and type of insulation material.

Significant shell corrosion has recently been experienced on two LPG sheres where failure of the vapor barrier allowed moisure pentration. These spheres operate in the 30-40°F range. Based on similar occurences of shell corrosion at other locations, priming of tank shell plate is required where the operating temperature will be less than 150°F. In such cases the usual procedure is to abrasive blast or remove mill scale (commerical finish-NACWE No. 3) and prime the clean steel with a relatively heavy coat of inhivitive primer, generally an amine adduct epoxy type. This primer mut be selected for suitability over the entire temperature range to which the steel may be subjected in service. In installations where Foamglas or polyurethane foam blocks are used, the coating procedures described earlier where the blocks are covered with mastic should be followed.

In those areas where it is necessary, the cost of abrasive blasting 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 either before or after rolling the plate, thereby reducing the amount of field blasting. If priming of the steel is required, consideration should be given to using this coating system as an alternate to field blasting and priming. After shop priming and field delivery, approximately 30% of the tank surface (weld areas and surfaces contaminated during shipment) may require a topcoat before insulation is installed.

14. INSPECTION

Tank inspection 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 prompty 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

b. 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, altrasonic 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. Weathercoats should also be inspected to look for breaks and tears, which may cause future problems.

GLOSSARY OF COMMON TRADE NAMES

TRADE NAME	MANUFACTURER	DESCRIPTION
Aerocor	Owens-Corning Fiberglas Corp	Fine-fiberglass insulation, PF-330 series.
Albaseal	Johns-Manville	Soft (permanently plastic) wealer with synthetic resin base.
Arabol	The Arabol Manufacturing Co.	Adhesives made to specification (reference was to a vinyl plastic).
**Asbestocite	Johns-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	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.
Intermediate Service Boards (ISB)	Owens-Corning Fiberglas Corp.	Fiber glass insulation 3 lbs per cu. ft. density-850°F
Fiberglas PT-613	Owens-Corning Fiberglas Corp.	Fiberglass insulation 3-1/4 lb. per cu. ft. density.

**No longer available
+Contains dry asbestos fiber.

Fiberglas 703 & 705	Owens-Corning Fiberglas Corp.	Fiberglass insulation 3 lb. & 6 lb. per cu. ft. density -60 to 450°F
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, asbetos, and clay.
**+Kaylo	Kaylo Division Owens-Illinois Glass co.	Calcium silicate insulation (discontinued).
Laykold	Chevron Asphalt Co.	Emulsified asphalt surfacing products.
Loose Insulating Wool	40/8 Insulation	Mineral fibers 6-20# density-1400°F (Rockwool type).
Masonite	Masonite Corp.	Pressed, bonded wood fibers. Various products (reference was to a hard board).
Panelstone	G.A.F	Asbestos-cement sheet, Type F (flexible).
Petrolastic 215	Chevron Asphalt Co.	Asphaltic cement.
Spintex No. 412	Johns-Mansville	Mineral fiber insulation 3-1/2 lb. per cu. ft. density.
Spin-Glas	Johns-Manville	Fiberglas, 3 lb density - 850°F
Stalastic	Eagle-Picher Co.	Soft sealing compound.
+ Stonewall	G.A.F.	Asbestos-cement board, now called Panelstone "U".
Styrofoam	Dow Chemical Co.	Expanded Cellular polystyrene.

**No longer available
+Contains dry asbestos fiber.

+ Thermobestos	Johns-Manville	Hydrous calcium silicate rigid insulation.
Thermafiber	U.S. Gypsukm	Mineral fibers 2-3# density-1000°F (Rockwool type).
Thikol 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.
Industrial Board	Certainteed Co.	Fiberglass insulation, 3 lb. density, 20 to 450°F.
850/Fiber Glass	Certainteed Co.	Fiberglass insulation, 3 lb. density, 550 to 850°F.

**No longer available
+Contains dry asbestos fiber.