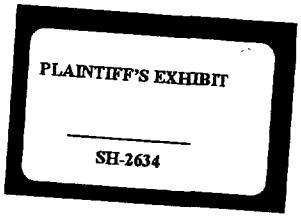

HOT SERVICE INSULATION

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HOT SERVICE INSULATION

1. SCOPE

1.1 This engineering standard covers the engineering design, selection of materials, and installation of materials for the insulation of piping, apparatus, and equipment operating in the temperature range from 150°F to 1200°F. This standard covers basic requirements for recurring insulation applications.

1.2 Reference to a particular material or equal shall serve only as a precise identification of the type and quality of the material required. Alternate materials will be considered. Sufficient engineering data for evaluation of alternate materials shall accompany proposals. Shell shall be the sole judge of the equality, design, workmanship, and suitability of materials offered on an alternate basis.

1.3 The Contractor shall furnish description of materials and sketches showing methods of installation, for applications proposed as alternates to those specified in this standard and for applications not covered by this standard.

2. REFERENCES

2.1 Engineering Standard 102, "Definitions and Requirements", shall be considered part of this standard.

3. JOB REQUIREMENTS

3.1 Contractor shall execute job in accord with the best practices for insulation work with a minimum of waste and debris and work shall present a neat and workmanlike appearance.

3.2 Contractor shall observe Shell safety regulations for personnel and equipment.

3.3 Contractor shall plan, schedule, and coordinate his work as required.

3.4 Contractor shall be responsible for the unloading, handling, protection and storage of materials, includin construction of required warehouses.

3.5 Contractor shall protect materials from damage and weather during all stages of handling and application until the final covering is applied.

3.6 Contractor shall provide, install and remove required scaffolding.

3.7 Contractor shall protect against and clean up splatter of insulating materials.

3.8 Contractor shall maintain a reasonably clean site; shall remove debris periodically; and upon completion of job shall remove materials, equipment, and debris to satisfaction of Shell.

3.9 If the plant is operating before the insulation work is complete, the Contractor shall secure all scaffolding and remove all unused material from the operating area at the end of each working day. The Contractor's activities during this period shall be such as to offer minimum practical interference with activities of operating personnel.

4. INSULATION MATERIALS

4.1 **Insulation:** Hydrous calcium silicate as manufactured by Johns-Manville (Thermobestos); Owens-Corning (Kaylo); Pabco (Cal Temp), or equal. Available forms are 36" long sectional pipe insulation, flat, scored, and beveled blocks.

4.2 **Insulating Cement:**

.1 A mineral wool insulating cement used as a filler between blocks, to fill cracks, voids, and joints. Eagle-Picher Super 66; Johns-Manville No. 450, or equal.

.2 A monolithic insulating cement hand finish for use on irregular surfaces such as pumps and turbines, Baldwin-Ehret-Hill BEH No. 1 Cement.

4.3 **Expansion Joint Filler:** An oil free spun mineral wool, half compressed, used to fill expansion joints in pipe and equipment insulation. Johns-Manville "Banroc".

4.4 **Glass Fabric:** Glass fabric for reinforcing the weatherproofing compounds shall have 20 threads per inch in both warp and fill, shall be resin sized, shall weigh about 1-1/2 oz. per sq. yd., and shall have a minimum strength of 60 pounds per inch of width. Benjamin Foster's Lag Fab, or equal.

4.5 **Wire Mesh:** Reinforcing wire mesh shall be 1" hex mesh x 0.032 (20 BWG) three twist Monel wire.

4.6 **Tie Wire:** Stainless steel type 304 soft annealed, 16 gage (.0625" dia.) to be used as tie wires, lacing wire and lacing hair pins.

4.7 **Stainless Steel Strapping:**

.1 ½" Band: Type 304 stainless steel, soft annealed temper, ½" wide x .020" thick with heavy duty stainless wing type seals.

.2 ¾" Band: Type 304 stainless steel, soft annealed temper, ¾" wide x .025" thick with heavy duty stainless wing type seals.

4.8 **Sheet Metal Screws:** #8 x ½" stainless steel self-tapping sheet metal screws, Pan Head "A" type slotted for screw driver installation.

4.9 **Breather Springs:** Techalloy Co. standard 4" and 2" springs to provide expansion for banding on equipment operating over 800°F.

4.10 **Weatherproofing Compound:** Final covering on insulation not covered by aluminum sheathing shall be an aluminum gray polyvinyl acetate emulsion. Vimasco Vinyl Mastic WC-1 or Benjamin Foster "Sealfas" Mastic No. 41-49. Surface temperature limits for the above are 200° F and 180°F respectively.

4.11 **High Temperature Flashing Compound:** Final covering on insulation where final coat bevels to bare pipe or bare equipment. For surface temperatures to 400°F: Eagle-Picher "Stalastic" standard grade. For surface temperatures to 700°F: Eagle-Picher "Stalastic" high temperature grade.

4.12 **Aluminum Jacketing:** .016" thick x 3/16" cross corrugated x 48" wide aluminum roll jacketing as manufactured by Childers Products Company. Jacketing to be fabricated from Type 5005-H14 aluminum alloy and shall have a factory applied "Polykraft" moisture barrier consisting of one layer of 50-lb. virgin Kraft paper coated on one side with a 1 mil polyethylene film.

4.13 **Aluminum Jacketing:** .024" thick x 3/16" cross corrugated x 48" wide aluminum roll jacketing as manufactured by Childers Products Company. Jacketing to be fabricated from Type 5005-H14 aluminum alloy and shall have a factory applied "Polykraft" moisture barrier consisting of one layer of 50-lb. virgin Kraft paper coated on one side with a 1 mil polyethylene film.

4.14 **Aluminum Sheeting:** .024" thick x 1¼" deep corrugated x 3/16" cross corrugated aliminum sheets as manufactured by Childers Products Company. Sheets are 33" wide and length shall be selected for convenient handling. Sheets shall be fabricated from Type 5005-H14 aluminum alloy and shall have a factory applied "Polykraft" moisture barrier consisting of one layer of 50-lb. virgin Kraft paper coated on one side with a 1 mil polyethylene film.

4.15 **Aluminum Jacketing:** .024" thick smooth aluminum sheets as manufactured by Childers Manufacturing Company. Sheets are to be of such size to be convenient in fabricating heads for equipment. Sheets are to be fabricated of Type 5005-H14 aluminum alloy and shall have a factory applied "Polykraft" moisture barrier consisting of one layer of 50-lb. virgin Kraft paper coated one side with a 1 mil polyethylene film.

4.16 **Aluminum Ell Jackets:** Insulated 45° and 90° long radius elbows shall be protected by two piece, deep drawn aluminum "Ell Jacs" as manufactured by Childers Products Company. "Ell Jacs" shall be fabricated from .024" thick Type 5005 aluminum alloy and have a factory applied colored epoxy moisture barrier inside and a clear epoxy coating on the outside.

5. GENERAL

5.1 Hot service piping and equipment shall be insulated to conserve energy, maintain process stability, protect personnel, or for a combination of these reasons. In general, hot service insulation shall be applied on piping operating above 150°F and on equipment operating above 170°F. In some cases, piping or equipment operating below the above temperatures will require insulation for process stability.

5.2 Internally insulated equipment and equipment where it is desirable to dissipate heat shall not be insulated. Guards for personnel protection may be required according to Section 6.

5.3 Recommended insulation thickness for the combination of personnel protection and minimum process stability are shown on Chart No. 1. This thickness is considered the minimum for any hot surface insulation.

5.4 Recommended insulation thicknesses, where energy conservation and high process stability are the controlling insulation criteria, are shown on Chart No. 2. Tabulated thicknesses are based on still air, 80°F ambient temperature and insulating materials having approximate thermal conductivity values of .37 at 200°F and .55 at 600°F. Under these conditions, the tabulated thicknesses are optimum thicknesses for heat conservation under average operating conditions and assure adequate temperature control. Where wide variances from the above conditions exist, such as areas with high wind velocities or where the process dictates more extreme requirements, the insulation thicknesses should be re-evaluated.

5.5 Where materials are mentioned in procedures, refer to Section 4 for material specifications, e.g. "insulation" means hydrous calcium silicate, "insulating cement" means Eagle-Picher Super 66, etc.

5.6 Surfaces to be insulated shall be clean of oil, grease, loose scale, dirt, insulation debris, etc.

5.7 Insulated steel surfaces which operate below 250°F (except stainless steel) or which will not be in continuous operation, shall be cleaned and prime coated before application of insulation in accord with Engineering Standard 1901, Paints and Paint Application.

5.8 Stainless steel piping and equipment surfaces under insulation and operating from 120°F to 400°F shall have one (1) coat of Dampney "Thur-Ma-Lox" No. 70 silicone coating. Surface Preparation: Descale, remove all moisture, oil and grease.

5.9 Insulation supports, anchor nuts, etc., shall be welded to equipment and piping by the fabricators prior to any required stress relieving operation.

5.10 Insulation work shall not be started prior to hydrostatic or pneumatic tests. Should it be necessary to start insulation work prior to such tests, written approval shall be obtained from Shell; however, welds, threads, union fittings, and flanged joints must be left uninsulated until tests are completed.

5.11 All flanged valves, buttweld valves, flanges, and flanged fittings shall be insulated in the following lines:

.1 Steam traced or electric traced lines.

.2 Steam lines to drivers and process equipment.

.3 Superheated steam lines when the steam temperature is less than 100°F above the saturated steam temperature.

5.12 Valves, flanges, or flanged fittings shall not be insulated in the following lines, unless otherwise specified:

.1 All process lines.

.2 Low pressure steam lines (under 75 psig) leading to heat transfer equipment, unit heaters, traps, or points where steam is disposed as waste.

.3 Superheated steam lines where the steam temperature is 100°F or more above the saturated steam temperature.

.4 The flange and cover on manways on hot equipment.

5.13 Steam traps and their outlet piping shall not be insulated except for personnel protection or where the outlet piping is arranged so that a liquid head of condensate can collect. Inlet piping to traps shall be insulated.

5.14 Manufacturers' equipment and code name plates shall be left exposed. Insulation shall be cut on 45° angle from the nameplate edges and sealed off with weather proofing compounds according to paragraphs 5.24 and 5.25.

5.15 All materials shall be applied in a manner to reduce shrinkage to a minimum. Excessive cracks that develop in any materials shall be repaired with a like material.

5.16 Insulation shall be applied with staggered circumferential joints and all joints tightly butted. Ragged and open joints shall be neatly filled with insulating cement.

5.17 For surfaces over 600°F and 2" IPS and larger, insulation shall be double layer construction, staggering all joints on second layer with respect to first layer.

5.18 Insulation supports on vertical vessels, exchangers and piping shall be located at the bottom of the insulated area and on 12'-1" centers thereafter on exchangers and vessels. Supports shall be 1/4" thick and 1/2" less than the insulation thickness in width, minimum width shall be 1/2". Insulation supports on piping and exchangers shall be located a sufficient distance from the flanges to permit removing bolts without interference or damaging the insulation. The 1" voids between the top of supported insulation and the succeeding supports shall be filled with half compressed mineral wool insulation (4.3) to provide filled expansion joints. Final covering shall overlap the expansion joint and allow proper slippage for expansion.

5.19 Insulation and final coverings around structural support attachments on vessels, exchangers and piping in hot service shall be closely fitted around such projections. Insulation voids in these areas shall be filled with insulating cement. The openings in the final coverings shall be sealed off against the structural steel and back 2" under adjacent covering with high temperature flashing compound (4.11) and applied according to paragraph 5.25.

5.20 Insulation shall be stopped short on uninsulated and insulated flanges and unions a sufficient distance to permit removing the bolts or breaking the union without damaging the insulation. The insulation shall be finished off at these points on a 45° bevel and sealed off with flashing compound according to paragraphs 5.24 and 5.25.

5.21 Where wires are used for insulation ties or lacing, they shall be drawn taut to imbed them flush with the face of the insulation, firmly twisted, and the excess ends cut off and the twisted ends bent over and imbedded in the insulation.

5.22 Where bands are used for insulation ties and final covering, they shall be machine stretched and scaled to remove slack only.

5.23 If picks or other sharp objects are used for making screw holes in the aluminum, they must have a permanently attached depth stop located 1/2" from point of pick.

5.24 Where insulation is beveled 45° from hot piping or equipment, the weatherproof flashing covering shall start at the hot surface and extend 2" under the adjacent covering. Flashing compound (4.11) shall be applied according to paragraph 5.25.

5.25 Insulated fittings and surfaces not covered with metal sheathing shall be given a coating of weatherproofing compound (4.10). The weatherproofing mastic (4.10) shall be applied over the surface of the insulation and securing bands to a wet thickness of approximately 1/32". While the mastic is still wet, glass fabric shall be pressed into it and smoothed; care being exercised to prevent rupturing the fabric. All edges thall be overlapped at least 3". The second coat of mastic, approximately 3/32" wet, shall be applied at once over the glass cloth reinforced mastic. The coating shrinks to about half its wet thickness and therefore the wet thicknesses noted should be generous enough to provide a final reinforced dry thickness of 1/16" minimum.

6. PERSONNEL PROTECTION

6.1 Insulation for personnel protection shall generally be applied to hot surfaces which can be inadvertently contacted by personnel in normal performance of their duties. Such hot surfaces shall be insulated to a height 7'-0" above normal walking or standing surfaces and horizontally 1'-6" from the edge of platforms, walkways and ladders.

6.2 Insulation thicknesses for personnel protection shall be such that the external surface temperature of the insulation shall be a maximum of 150°F for piping and 170°F for other equipment. Chart No. 1 specifies minimum insulation thickness for personnel protection.

6.3 Personnel protection on equipment such as vertical vessels, coolers and condensers may require partial insulation if temperatures during normal operation and confined access cause them to be an unusually severe hazard.

6.4 Internally insulated equipment and equipment where it is desirable to dissipate heat shall not be insulated for personnel protection even though temperatures exceed 170°F. Personnel protection for these hot surfaces shall be by the installation of expanded metal guards around the equipment or as otherwise specified by Shell.

7. TRACED PIPING AND EQUIPMENT

7.1 Steam and electric traced lines shall be insulated with either extended leg or oversize insulation. After the tracers have been secured snugly against lines with bands or wire, the two half sections of pipe insulation shall be wired in place. All joints and voids in the insulation shall then be filled with insulating cement.

7.2 When a heat transfer cement such as "Thermon", "Zeston", or equal is specified, the cement shall completely cover the tracer and shall be applied with a trowel or caulking gun in a "V" shape with a minimum thickness at the center of the tracer of 1/4". Width of cement at top of "V" will vary with size of tracer. Refer to manufacturer's recommendations.

7.3 Steam and electrically traced systems shall be completely insulated including equipment, valves, flanged fittings, and tracer line loops.

7.4 Tracer line loops brought outisde the insulation for external connectors shall be insulated with flexible woven asbestos tape.

8. INSTRUMENTS

8.1 Insulate level instruments where required with the method for insulating irregular surfaces. Use pipe covering wherever possible.

8.2 Insulate gage column piping but not gage glasses.

8.3 Insulate instrument leads up to the instrument connection whenever the main process line is insulated except (1) when instrument leads are purged and (2) when seal pots are installed, the seal pots are to be insulated.

9. PIPING INSULATION

9.1 Insulation Application

.1 All straight sections of piping thru 24" O.D. shall be insulated with sectional pipe insulation (4.1).

.2 All straight sections over 24" O.D. shall be insulated with block insulation. The blocks shall be either curved or flat blocks cut into beveled lags to fit the contour of the piping.

.3 Insulation 16" O.D. and under shall be secured with wire (4.6) spaced a maximum of 9" on centers.

.4 Insulation 18" and over shall be secured with 1/2" bands (4.7) spaced a maximum of 12" on centers.

.5 All cracks, voids and joints, in the insulation surface shall be filled with insulating cement (4.2.1), either trowelled or palmed on after wires or bands are installed to produce an even surface and assure required thickness.

.6 Pipe bends and ells shall be insulated with mitred segments of pipe insulation. Individual mitred segments shall be prefabricated into ell covers by cementing together to form two half covers. An insulating cement finish should be applied over insulation on bends and ells after it has been securely wired on to give a smooth, even surface.

.7 Welded and screwed fittings and valves (if requiring insulation) under 1-1/2" IPS shall be insulated with insulating cement (4.2.1) applied in approximately 1/2" thick layers to a thickness equal to that of adjacent insulation and trowelled or hand palmed smooth.

.8 When permanent type insulation covers are required for flanged fittings and valves, either sectional pipe insulation of proper size to fit the outside diameter of the flange or block insulation lags shall be used. The flange or valve insulation should extend approximately 2" over the ends of the pipe insulation. Annular spaces between flanges and pipe insulation shall be filled with rings or collars or blocks and/or insulating cement. The insulation shall be securely wired or banded and finished with insulating cement to a smooth, even surface.

.9 When removable type flange covers are required for flanges fittings and valves, a frame made in two half sections of Monel wire mesh (4.5) shall be provided to which the blocks or sectional insulation may be attached. The flange cover shall extend 2" over the ends of the adjacent pipe insulation and the ends of the pipe insulation terminated and bevelled (to allow for removal of stud bolts) as previously described. After the frame is insulated, the inside and outside surfaces of the insulation shall be finished with insulating cement. The two half sections of removable flange covers shall be held in place with bands after the desired finish has been applied to the insulation.

9.2 Weatherproofing Covering

.1 Weatherproof covering on straight insulated pipe shall be .016" thick x 3/16" corrugated aluminum jacketing (4.12) and shall be machine rolled to the O.D. of the insulation, fitted snugly over insulation, joints lapped a minimum of 2 inches (circumferentially and longitudinally), arranged to shed water and secured with bands.

.2 Bands 1/2" wide (4.7) shall be placed on each circumferential lap with intermediate bands on maximum 12" centers.

.3 Each section of final covering on vertical piping larger than 10" shall be supported from the next lower section with two "S" clips made from the banding material. The bottom section of the final covering shall be supported by extended insulation support clips. Longitudinal joints on vertical pipe covering shall be staggered.

.4 Final weatherproof covering on insulated ells, 1/2" thru 24" IPS, shall be prefabricated aluminum ell covers (4.16). Covers shall lap 2" under the aluminum final covering on the adjacent straight pipe and be secured with 1/2" bands.

.5 Weatherproof covering for insulated flanges and flanged valves shall be fabricated from .024" thick smooth aluminum (4.15). The aluminum jackets shall be fabricated to provide maximum weather protection and secured with bands and metal screws as required for adequate securement. Jackets shall lap 2" under the aluminum final covering on the adjacent piping.

.6 Insulated fittings not covered by metal sheathing and areas where such covering is not practical or economical shall be given a final weatherproof covering according to paragraph 5.25.

10. VESSEL AND EXCHANGER INSULATION

10.1 Insulation Application

.1 Vessel shells, exchanger shells, and channels 24" O D. and smaller shall be insulated with sectional pipe insulation (4.1). Equipment larger than 24" O.D. shall be insulated with block insulation (4.1). The blocks shall be either curved or flat blocks cut into beveled lags to fit the contours. The insulation shall be secured with 3/4" bands on a maximum of 18" centers. On vessels over 30" O.D. operating at temperatures of 800°F and higher, breather springs (4.9) shall be used with all securement bands.

.2 The heads of vessels and exchangers shall be insulated with block insulation. The blocks shall be either curved or flat blocks cut into segmental beveled lags to fit the head contours. The insulation and that on vessel transition sections shall be secured with 3/4" bands anchored with lacing wire hair pins to 1/2" nut blanks welded to the vessel. Anchors on top heads shall be as required for good securement. Anchors on bottom heads, transition sections of vertical vessels, and heads of horizontal vessels shall be on 12" centers both ways.

.3 As an alternate to the above, the heads of vessels and exchangers 3' O.D. and under may be insulated with broken block insulation imbedded in a coat of insulating cement. The voids between the broken blocks shall be filled level with insulating cement troweled or hand palmed to a smooth surface.

.4 Flanges, manways and nozzles shall not be insulated unless specified by Shell. When insulation is required, the insulation shall be that specified for shells and shall be contained in a two-piece prefabricated removable housing. The design of the housing shall be submitted to Shell for approval.

.5 Insulation shall be stopped short of uninsulated flanges a sufficient distance to permit removing the bolts without damaging the insulation. Insulation shall be stopped short of uninsulated nozzles and manways a sufficient distance to expose the nozzle to shell welds for inspection. Insulation shall be finished off at these points on a 45° bevel and sealed off with weatherproofing compound according to paragraphs 5.24 and 5.25.

.6 Insulation supports and expansion joints shall be provided on all vertical vessels and towers according to paragraph 5.18.

.7 Exchanger channel insulations shall be made in removable sections; the design of the housing shall be submitted to Shell for approval.

10.2 Weatherproofing of Vessels and Exchangers

.1 Insulation on vertical and horizontal vessels and exchanger shells 30" diameter or smaller shall be covered with .016" thick x 3/16" cross corrugated aluminum jacketing (4.12) and applied in the same manner as for pipe covering as described in paragraph 9.2.

.2 Insulation on horizontal vessels and exchanger shells larger than 30" diameter shall be covered with .024" thick x 3/16" cross corrugated aluminum jacketing (4.13). The jacketing shall be fitted snugly to the insulation and both longitudinal and circumferential joints shall be lapped a minimum of 3" and arranged to shed water. 3/4" bands (4.7) shall be placed on each circumferential joint with intermediate bands on not more than 24" centers. Self-tapping metal screws (4.8) shall be installed on 6" centers in all longitudinal joints.

.3 Insulation on vertical vessels and towers larger than 30" diameter shall be covered with .024" thick aluminum sheets with 1-1/4" deep x 3/16" cross corrugations (4.14). Deep corrugations shall run vertical and longitudinal joint shall lap 2 corrugations; the circumferential joints shall be lapped a minimum of 3" and arranged to shed water. The sheets shall be banded with 3/4" bands (4.7) on not more than 24" centers with a band over each circumferential joint. Band support loops shall be provided for all banding. Metal screws (4.8) shall be installed on 6" centers in all longitudinal joints. Each section of metal sheeting on vertical equipment shall be supported from the next lower section with "S" clips made from 3/4" banding material (4.7) and spaced on 2'-0" centers. The bottom section of final covering shall be supported by clips attached to the insulation support.

.4 Insulated heads on horizontal vessels 30" diameter or smaller and the bottom heads of vertical vessels within skirts shall be covered with weatherproof compound according to paragraph 5.25.

.5 Insulated heads of horizontal vessels larger than 30" diameter and the top heads of all vertical vessels shall have covers fabricated from .024" thick smooth aluminum (4.15) Gored head sections shall be overlapped a minimum of 2" and fastened with sheet metal screws on 6" centers. All seams shall be lapped to provide maximum weather protection. Where metal covering is not applicable, the alternate weather covering shall be weatherproofing compound according to paragraph 5.25 upon approval from Shell.

.6 Where operating temperatures exceed 800°F, breather springs shall be used on bands securing the metal sheathing. For vessels and equipment from 4' diameter to 10' diameter, support bands shall be provided with 2" breather springs; over 10' diameter, breather springs shall be 4" (4 9).

11. MECHANICAL EQUIPMENT INSULATION

11.1 Insulation Application

.1 Pumps, turbines and other irregular shaped equipment shall be insulated with insulating cement (4.2.2) built up in layers of 3/4" to 1" thick to the required thickness. The insulation shall be reenforced at approximately the midpoint of insulation thickness with hex mesh (4.5).

.2 Flanges, bearing housings, threaded connections and supports shall not be insulated unless specified by Shell.

.3 The insulation shall stop short of uninsulated flanges a sufficient distance to permit removal of bolts without damaging the insulation.

11.2 Weatherproofing of Equipment

.1 Equipment insulation shall be sealed with a weatherproofing compound according to paragraphs 5.24 and 5.25.

12. TANK INSULATION

12.1 Insulation Application

.1 Tanks 12' O.D. and less shall be insulated with block insulation in accord with 10.1 for vessels. Insulation thickness shall be in accord with Chart 2 or as specified by Shell.

.2 Shells of tanks larger than 12' O.D. and below 450°F shall be insulated with fibrous glass, rigid board insulation, Johns-Manville "Spintex" No. 414 FSK, or equal. Insulation thickness shall be in accord with paragraph 5.4 or as specified by Shell.

.3 The fibrous glass boards shall be butted snugly and banded with 3/4" bands on 18" centers.

.4 Nozzles, manways, and roofs shall not be insulated unless specified by Shell.

12.2 Weatherproofing of Tanks

.1 Insulation on tanks shall be covered with .024" thick, 1-1/4" deep x 3/16" cross corrugated aluminum sheets (4.14) and applied and banded according to paragraph 10.2.3.

.2 A top insulation flashing angle shall be provided.

.3 Proper and complete flashing is required for all metal to insulation joints according to paragraph 5.24.

CHART NO. 1
RECOMMENDED INSULATION THICKNESSES
FOR PERSONNEL PROTECTION AND AVERAGE PROCESS STABILITY

PIPING
FOR INSULATION SURFACE TEMPERATURES OF 150°F.

PIPE SIZE INCHES	INSULATION THICKNESS, INCHES							
	1	1½	2	2½	3	3½	4	4½
	MAXIMUM TEMPERATURE, °F.							
1 Down	650	850	1100	1200				
1½	550	750	900	1200	1200			
2	550	750	900	1150	1200			
3	500	700	850	1150	1200	1200		
4	500	650	800	1000	1150	1200		
6	430	600	800	900	1050	1200		
8		600	750	900	1050	1200	1200	
10		600	750	900	1000	1150	1200	
12		600	750	850	1000	1100	1200	
14 & Up		550	700	800	950	1050	1150	1200

VESSELS, EXCHANGERS, PUMPS, COMPRESSORS, AND TURBINES
FOR INSULATION SURFACE TEMPERATURES OF 170°F.

INSULATION THICKNESS, INCHES	1	1½	2	2½	3
MAXIMUM TEMPERATURE, °F	600	800	950	1100	1200

LAM 002260

CHART NO. 2
RECOMMENDED INSULATION THICKNESSES
FOR ENERGY CONSERVATION, HIGH PROCESS STABILITY AND STEAM SYSTEMS

PIPING

PIPE SIZE INCHES	INSULATION THICKNESS, INCHES							
	1	1½	2	2½	3	3½	4	4½
	MAXIMUM TEMPERATURE, °F							
1 Down	400	700	800	1100	1200			
1½	400	700	800	1100	1200			
2	400	700	800	1100	1200			
3	300	500	700	900	1100	1200		
4	200	400	600	700	900	1100	1200	
6	200	300	500	700	800	1100	1200	
8		300	500	700	800	900	1100	1200
10		300	400	500	700	800	1100	1200
12		300	400	500	700	800	1000	1100
14 & Up		300	400	500	700	800	900	1100

VESSELS, EXCHANGERS, PUMPS, COMPRESSORS, AND TURBINES

FLAT		300	400	500	700	800	900	1100

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COLD SERVICE INSULATION

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7. VESSEL AND EXCHANGER INSULATION

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8. SPHERE INSULATION

COLD SERVICE INSULATION

1. SCOPE

1.1 This engineering standard covers the engineering design, selection of materials, and installation of materials for the insulation of piping, apparatus and equipment operating in the temperature range from 50°F to -450°F. This standard covers basic requirements for recurring insulation applications.

1.2 Reference to a particular material shall serve only as a precise identification of the type and quality of the material required. Alternate materials will be considered. Sufficient engineering data for evaluation of alternate materials shall accompany proposals. Shell shall be the sole judge of the equality, design, workmanship, and suitability of materials offered on an alternate basis.

1.3 The Contractor shall furnish description of materials and sketches showing methods of installation for applications proposed as alternates to those specified in this standard and for applications not covered by this standard.

2. REFERENCES

2.1 Engineering Standard 102, "Definitions and Requirements", shall be considered part of this standard.

3. JOB REQUIREMENTS

3.1 Contractor shall execute job in accord with the best practices for insulation work with a minimum of waste and debris and work shall present a neat and workmanlike appearance.

3.2 Contractor shall observe Shell safety regulations for personnel and equipment.

3.3 Contractor shall plan, schedule, and coordinate his work as required.

3.4 Contractor shall be responsible for the unloading, handling, protection and storage of materials, including construction of required warehouses.

3.5 All insulation shall be stored in a dry place and shall be protected from contact with water from the time it is received until it is vapor-sealed. These precautions apply to all types of insulation, including cellular glass.

3.6 Contractor shall provide, install and remove required scaffolding.

3.7 Contractor shall protect against and clean up splatter of insulating materials.

3.8 Contractor shall maintain a reasonably clean site; shall remove debris periodically; and upon completion of job shall remove materials, equipment, and debris to satisfaction of Shell.

3.9 If the plant is operating before the insulation is complete, the contractor shall secure all scaffolding and remove all unused material from the operating area at the end of each working day. The Contractor's activities during this period shall be such as to offer minimum practical interference with activities of operating personnel.

4. INSULATION MATERIALS

4.1 Insulation: Foamglas, a cellular glass insulation as manufactured by Pittsburg Corning Corporation. Available forms are flat block, sectional pipe insulation, curved segments, bevelled lags, head segments, and factory fabricated valve and fitting covers.

4.2 Cushioning Material: Fibrous glass in flexible blanket form. To be used to fill contraction joints. Johns-Manville Spintex No. 411 or Pittsburg Corning Temp-mat.

4.3 Joint Sealer: A vapor sealing mastic to be used as a joint sealer with cellular glass insulation. Pittsburg Corning Pittseal 111 or Benjamin Foster Foamseal No. 30-45. (Service limitations: -100°F to 300°F)

4.4 Bore Coating: A vinyl base material for coating inner surfaces of insulation to prevent abrasion due to vibration or other causes. Pittsburg Corning Anti-Abrasive Compound 1A. (May be used to -327°F)

4.5 Glass Fabric: Glass fabric for reinforcing the weatherproofing compound shall have 20 threads per inch in both warp and fill, shall be resin sized, shall weigh about 1½ oz. per square yard, and shall have a minimum strength of 60 pounds per inch of width. Benjamin Foster's Lag Fab, or equal.

4.6 Wire Mesh: Reinforcing wire mesh shall be 1" hex mesh x 0.032" (20 BWG) three twist Monel wire.

4.7 Tie Wire: Stainless steel type 304 soft annealed, 16 gage (.0625" dia.) to be used as tie wires, lacing wire and lacing hair pins.

4.8 Stainless Steel Strapping:

.1 ½" Band: Type 304 stainless steel, soft annealed temper, ½" wide x .020" thick with heavy duty stainless wing type seals.

.2 ¾" Band: Type 304 stainless steel, soft annealed temper, ¾" wide x .025" thick with heavy duty stainless wing type seals.

4.9 Sheet Metal Screws: #8 x ½" stainless steel self-tapping sheet metal screws, Pan Head "A" type slotted for screw driver installation.

4.10 Breather Springs: Techalloy Co. Standard 4" and 2" springs.

4.11 Weatherproofing Compound: Final covering on insulation not covered by aluminum sheathing shall be an aluminum gray polyvinyl acetate emulsion. Vimasco Vinyl Mastic WC-1, Benjamin Foster "Sealfas" Mastic No. 41-49, or Pittcote 400.

4.12 Aluminum Jacketing: .016" thick x 3/16" cross corrugated x 48" wide aluminum roll jacketing as manufactured by Childers Products Company. Jacketing to be fabricated from Type 5005-H14 aluminum alloy and shall have a factory applied "Polykraft" moisture barrier consisting of one layer of 50-lb. virgin Kraft paper coated on one side with a 1 mil polyethylene film.

4.13 Aluminum Jacketing: .024" thick x 3/16" cross corrugated x 48" wide aluminum roll jacketing as manufactured by Childers Products Company. Jacketing to be fabricated from Type 5005-H14 aluminum alloy and shall have a factory applied "Polykraft" moisture barrier consisting of one layer of 50-lb. virgin Kraft paper coated on one side with a 1 mil polyethylene film.

4.14 **Aluminum Sheeting:** .024" thick x 1¼" deep corrugated x 3/16" cross corrugated aluminum sheets as manufactured by Childers Products Company. Sheets are 33" wide and length shall be selected for convenient handling. Sheets shall be fabricated from Type 5005-H14 aluminum alloy and shall have a factory applied "Polykraft" moisture barrier consisting of one layer of 50-lb. virgin Kraft paper coated on one side with a 1 mil polyethylene film.

4.15 **Aluminum Sheeting:** .024" thick smooth aluminum sheets as manufactured by Childers Products Company. Sheets are to be of such size to be convenient in fabricating heads for equipment. Sheets are to be fabricated of Type 5005-H14 aluminum alloy and shall have a factory applied "Polykraft" moisture barrier consisting of one layer of 50-lb. virgin Kraft paper coated on one side with a 1 mil polyethylene film.

4.16 **Aluminum Ell Jackets:** Insulated 45° and 90° long radius elbows shall be protected by two piece, deep drawn aluminum "Ell Jacs" as manufactured by Childers Products Company. "Ell Jacs" shall be fabricated from .024" thick Type 5005 aluminum alloy and have a factory applied colored epoxy moisture barrier inside and a clear epoxy coating on the outside.

5. GENERAL

5.1 Cold service equipment and piping shall be completely insulated to conserve energy, maintain process stability, protect personnel, prevent moisture condensation, or for a combination of these reasons. In general, cold service insulation shall be for the reduction of heat gain and applied on equipment and piping operating at 50°F or less which are part of a refrigeration system or contain fluids which are cooled by a refrigeration system.

5.2 Piping and equipment which is not part of a refrigerated system but which operates at temperatures below ambient shall be insulated to prevent surface condensation on the piping or equipment, in such locations where the dripping of condensate may cause electrical hazards, damage to equipment, or discomfort to personnel.

5.3 The insulation shall be cellular glass, of either single or multiple layer construction, and shall be properly vapor sealed and flashed to provide one homogeneous mass of insulation through which water vapor cannot penetrate.

5.4 The recommended thicknesses for cellular glass insulation are shown on Table 1. Figures in table are degrees Fahrenheit and are minimum for use with thickness and design conditions stated. When design temperature falls between two thickness columns, use the greater thickness. Table is based on thickness required to prevent condensation on surfaces with .9 emissivity, 90°F still air at 80° relative humidity and the cellular glass insulation having approximate thermal conductivity values of .35 at 0°F and .29 at -100°F. Heat gains average 8-9 Btu/Hr./S.F. insulation surface. Where other design conditions are used, thicknesses should be adapted to meet job requirements. Technical data is available from Pittsburgh Corning Corporation for calculating insulation thicknesses for design conditions other than specified above.

5.5 Where materials are mentioned in procedures, refer to Section 4 for material specifications, e.g. "insulation" means cellular glass; "wire mesh" means 1" hex mesh x .032" diameter three twist Monel wire, etc.

5.6 Surfaces to be insulated shall be clean of oil, grease, loose scale, dirt, insulating debris, etc., and shall be dry.

5.7 Surface preparation of piping and equipment shall be in accordance with Engineering Standard 1901, Paints and Paint Application.

5.8 Insulation supports, anchor nuts, etc., shall be welded to equipment and piping by the equipment fabricators prior to any required stress relieving operation.

5.9 Insulation work shall not be started prior to hydrostatic or pneumatic tests. Should it be necessary to start insulation work prior to such tests, written approval shall be obtained from Shell; however, welds, threads, union fittings, and flanged joints must be left uninsulated until tests are completed.

5.10 When butted joints do not fit closely, the voids shall not be filled with joint sealer which has no value as insulation. Voids are to be eliminated by refitting or replacing the insulation. Any damaged corners shall be trued before application.

5.11 The blocks of insulation in any layer shall fit snugly over the surface beneath them and the surface of the outer layer shall present a smooth contour. The use of curved segments meets these requirements best but flat block on the larger diameter vessels will usually be satisfactory.

5.12 When important nameplates or code stampings are covered with insulation, duplicated plates shall be provided and attached to the equipment on the outer face of an inserted wooden block of the same thickness as the insulation. All surfaces of the wood shall be well sealed, including all of the face to which the plate is attached.

5.13 On irregular surfaces where wires are used for insulation ties or lacing, they shall be drawn taut to imbed them flush with the face of the insulation, firmly twisted, the excess ends cut off and the twisted ends bent over and imbedded in the insulation.

5.14 Where bands are used for insulation ties and final covering, they shall be machine stretched and sealed to remove slack only.

5.15 If picks or other sharp objects are used for making screw holes in the aluminum, they must have a permanently attached depth stop located 1/2" from point of pick.

5.16 When aluminum jacketing is to be applied over the cellular glass insulation, finishing or vapor sealing mastic is not required except as specified to seal the butt joints perpendicular to the insulation surface.

5.17 Insulated fittings and surfaces not covered with metal sheathing shall be given a coating of polyvinyl acetate weatherproofing mastic (4.11). The weatherproofing mastic shall be applied over the surface of the insulation and securing bands to a wet thickness of approximately 1/32". While the mastic is still wet, glass fabric (4.5) shall be pressed into it and smoothed; care being exercised to prevent rupturing the fabric. All edges shall be overlapped at least 3". The second coat of mastic, approximately 3/32" wet, shall be applied at once over the glass cloth reinforced mastic. The coating shrinks to about half its wet thickness and therefore the wet thicknesses noted shall be generous enough to provide a final reinforced dry thickness of 1/16" minimum. The mastic and glass fabric shall extend a minimum of 2" under adjacent aluminum jacketing.

6. PIPING INSULATION

6.1 Insulation Application

.1 All cold piping shall be insulated with cellular glass insulation (4.1) to the thicknesses specified in Table 1.

.2 Where single layer insulation is used, the cellular glass insulation shall be applied to piping with butt joints staggered and all joints tightly butted and buttered with joint sealer (4.3). Any excess sealer shall be removed from the surface.

.3 On multiple-layer insulation, the additional layer or layers shall be applied with side and end joints staggered over joints of the preceding layer.

.4 Only outer layer joints of multiple layer applications shall be buttered with joint sealer (4.3) before installation. The joints shall be drawn together when insulation is applied so that only a very thin vapor seal separates the sections of insulation. No bead of sealer shall remain at the joint.

.5 Insulation on straight sections with an O.D. of 12" or less shall be secured with ½" stainless steel bands (4.8.1) and for larger diameters the bands shall be ¾" (4.8.2). Band spacing shall be on 9" centers for 18" lengths of insulation and on 12" centers for 24" lengths.

.6 Insulation for pipe bends shall be mitered from pipe covering to make two-piece covers. The pieces comprising one half a cover shall be cemented together to form a unit.

.7 Fittings and flanges in insulated lines shall be completely insulated. Valves shall be insulated to the bottom of the packing box. If extended valve bonnets are used, insulate to the mid-point of the extension. Two piece fabricated covers shall be used for valves and fittings. Insulation on valves, flanges, and fittings shall be secured with bands or wire as required for adequate securement.

.8 Where piping is subject to excessive vibration, the bore of the inner layer shall be coated with a thin application of bore coating (4.4) to fill surface cells only and allowed to dry before application of insulation to piping.

.9 Longitudinal contraction joints shall be provided when the combination of straight run piping length and operating temperature require them to prevent damage to the insulation. Differential contraction between Foamglas and various metals is available from Pittsburg Corning Corporation. Contraction joints shall consist of 1 inch space between adjacent lengths of insulation packed with cushioning blanket (4.2) and covered with an 18 inch long section of oversize insulation. The oversize insulation section shall be cemented to the regular size insulation with joint sealer on one end and a slip joint on the other end to allow for contraction. Contraction joints, when required, shall be at flanges wherever possible.

.10 Hangers shall be on the outside of the insulation and shall not be in contact with the pipe. Curved metal shields shall be used between the hangers and the bottom of the insulation; bearing stress shall be less than 33 psi. The metal shield shall be heavily galvanized where it contacts aluminum sheathing.

.11 Where insulated pipe rests on pipe supports, the insulation may be locally replaced with dry oak wood or other suitable material having high compressive strength and low thermal conductivity which will serve as a combination insulation and support. The wooden insert shall be properly sealed at all junctures with the cellular glass. Steel bearing plates shall be provided and proper provision for expansion and contraction shall be made.

6.2 Weatherproofing Covering

.1 Weatherproof covering on straight insulated pipe shall be .016" thick x 3/16" corrugated aluminum jacketing (4.12) and shall be machine rolled to the O.D. of the insulation, fitted snugly over insulation, joints lapped a minimum of 2 inches (circumferentially and longitudinally), arranged to shed water and secured with bands.

.2 Bands ½" wide (4.8.1) shall be placed on each circumferential lap with intermediate bands on maximum 12" centers.

.3 Each section of final covering on vertical piping larger than 10" shall be supported from the next lower section with two "S" slips made from the banding material. Longitudinal joints on vertical pipe covering shall be staggered.

.4 Final weatherproof covering on insulated ells, ½" thru 24" IPS, shall be prefabricated aluminum ell jackets (4.16). Covers shall lap 2" under the aluminum final covering on the adjacent straight pipe and be secured with ½" bands.

.5 Weatherproof covering for insulated flanges and flanged valves shall be fabricated from .024" thick smooth aluminum (4.15). The aluminum jackets shall be fabricated to provide maximum weather protection and secured with bands and metal screws as required for adequate securement. Jackets shall lap 2" under the aluminum final covering on the adjacent piping.

.6 Insulated fittings not covered by metal sheathing and areas where aluminum covering is not economical shall be given a final weatherproofing covering according to paragraph 5.17.

7. VESSEL AND EXCHANGER INSULATION

7.1 Insulation Application

.1 Vessel shells, exchanger shells, and channels 24" O.D. and smaller shall be insulated with cellular glass sectional pipe insulation (4.1). Equipment larger than 24" O.D. shall be insulated with curved sidewall segments or beveled lags fabricated to fit the diameter of the equipment to which it is applied Insulation shall be applied with joints staggered, all joints tightly butted, and thickness as specified in Table 1.

.2 Additional layers of cellular glass insulation shall be applied in the same manner as the first layer with side and end joints staggered over joints of preceding layer, so that no two joints coincide. An additional layer of cellular glass insulation shall be applied over the outside layer where insulation supports are located.

.3 When blocks are being fitted, the edges of the blocks shall be cut and rubbed to provide a tight and square butt joint.

.4 All butt edges and ends of outermost layer (or single layer) shall be sealed with a buttered coat of joint sealer (4.3). The joints shall be drawn together so that a very thin seal joint is accomplished. No bead of sealer is to remain at the joint.

.5 Each layer of cellular glass insulation shall be secured in place with ¾" stainless bands (4.8.2) where contour of equipment permits firm and effective attachment. Strapping shall be spaced on 9" centers where 18" lengths of insulation are used and on 12" centers for 24" lengths. On irregular surfaces where use of banding is impractical, the insulation shall be properly secured with stainless wire (4.7).

.6 Head insulation, as well as insulation around manholes and other connections, may be fastened in place using a floating ring of steel rod or standard cable. One end of the band is fastened to the floating ring and the other is anchored to an extra band or bands placed around the sidewall insulation. Bands shall be spaced on 12" centers around the perimeter of the extra band or bands.

.7 Insulation supports on vertical vessels, exchangers and piping shall be located at the bottom of the insulated area and on 12'-1" centers thereafter on exchangers and vessels. Supports shall be ¼" thick and ½" less than the insulation thickness in width; minimum width shall be ½". On equipment requiring multiple-layer shall be of such length as to support 1/2 of the thickness of the outer layer of insulation. A one inch contraction joint shall be provided below each intermediate insulation support. Cushioning blanket material (4.2) shall be packed in the contraction joint. An additional layer of insulation equal in thickness to the outer layer shall be applied over the outside layer where the contraction joint is located and be completely sealed with joint sealer.

.8 One inch of cushioning blanket material (4.2) shall be packed around nozzles, vessel flanges and other projections where they extend through the insulation in order to allow for contraction or expansion of insulation. Such areas shall be flashed and sealed.

.9 Where equipment is supported on metal saddles, insulation shall be carried down over the saddles to the concrete piers. The top of the concrete shall be coated with joint sealer before application of insulation.

.10 Structural supports and legs of equipment shall be insulated with cellular glass insulation as part of equipment area. Insulation shall extend over structural members or legs and down legs a distance of four times insulation thickness, but not less than 12". Thickness shall be as specified for body of equipment. Spaces between flanges and webs of structural members shall be filled with cellular glass blocks cemented in place.

.11 Skirts supporting vertical equipment shall be insulated inside and outside as part of equipment area, cellular glass insulation to extend downward from junction of inside of skirt with insulated bottom head a distance of not less than four times the thickness of insulation, but in no case less than one foot. Thickness shall be as specified for body of equipment. Insulation shall be secured to inside of skirt with an approved adhesive. Insulation inside skirt shall be supported on angle or plate support. Blank nuts on 12 inch centers shall be provided on inside of skirt for securement of bottom head insulation. Where welding is prohibited, a punched, expanding split ring type angle shall be used.

.12 Constant radius heads may be insulated with special factory-shaped head segments. On ellipsoidal heads, and as an alternate for all other heads, the sidewall insulation may be extended to a point in line with the crown of the head so that a flat circular disk made of standard flat blocks may be installed. When this type of construction is used on large vessels, the extended materials shall be properly supported. Fill the void between head and insulation with cushioning material (4.2).

.13 Flat heads shall be insulated with standard flat blocks trimmed to fit inside the extended sidewall insulation.

.14 Heads and manholes that must be removed occasionally shall be insulated so that insulation can be removed without damage. Covers are assembled and installed as a complete unit, or in sections. On larger vessels, additional external support should be provided for the removable heads. These covers shall be protected with sheet metal or fabric membranes and sealed so as to be vapor tight.

7.2 Weatherproofing Covering

.1 Insulation on vertical and horizontal vessels and exchanger shells 30" diameter or smaller shall be covered with .016" thick x 3/16" cross corrugated aluminum jacketing (4.12) and applied in the same manner as for pipe covering as described in paragraph 6.2.

.2 Insulation on horizontal vessels and exchanger shells larger than 30" diameter shall be covered with .024" thick x 3/16" cross corrugated aluminum jacketing (4.13). The jacketing shall be fitted snugly to the insulation and both longitudinal and circumferential joints shall be lapped a minimum of 3" and arranged to shed water. ¾" bands (4.5.2) shall be placed on each circumferential joint with intermediate bands on not more than 24" centers. Self-tapping metal screws (4.9) shall be installed on 6" centers in all longitudinal joints.

.3 Insulation on vertical vessels and towers larger than 30" diameter shall be covered with .024" thick aluminum sheets with 1¼" deep x 3/16" cross corrugations (4.14). Deep corrugations shall run vertical and longitudinal joint shall lap 2 corrugations; the circumferential joints shall be lapped a minimum of 3" and arranged to shed water. The sheets shall be banded with ¾" bands (4.8.2) on not more than 24" centers with a band over each circumferential joint. Band support loops shall be provided for all banding. Metal screws (4.9) shall be installed on 6" centers in all longitudinal joints. Each section of metal sheeting on vertical equipment shall be supported from the next lower section with "S" clips made from ¾" banding material (4.8.1) and spaced on 2'-0" centers. The bottom section of final covering shall be supported by clips attached to the insulation support.

.4 Insulated heads on horizontal vessels 30" diameter or smaller and the bottom heads of vertical vessels within skirts shall be covered with weatherproof compound according to paragraph 5.17.

.5 Insulated heads of horizontal vessels larger than 30" diameter and the top heads of all vertical vessels shall have covers fabricated from .024" thick smooth aluminum (4.15). Gored head sections shall be overlapped a minimum of 2" and fastened with sheet metal screws on 6" centers. All seams shall be lapped to provide maximum weather protection. Where metal covering is not applicable, the alternate weather covering shall be weatherproofing compound according to paragraph 5.17 upon approval from Shell.

8. SPHERE INSULATION

8.1 Spheres shall be insulated with cellular glass insulation to the thickness specified in Table 1.

8.2 All spheres having a diameter of 20 feet or more shall have an insulation support welded around the shell at the equator. This support shall be an angle with the horizontal leg of such length to support one-half of the thickness of the outermost (or single) layer of insulation.

8.3 Cellular glass insulation shall be flat block which shall be abraded against the curved surface to which it is to be applied prior to application. The block shall be abraded sufficiently to eliminate any "wobble" of the block on the curved surface. Flat block size shall be selected to require the least amount of abrasion.

8.4 Butting edges shall be abraded to each other to provide a uniformly square butt joint. All blocks shall be "dusted" prior to application.

8.5 The shaped block shall be dipped in hot erection asphalt to provide complete coverage on the contact face as well as one long and one short edge. The block shall be applied to the surface immediately while the asphalt is still molten.

8.6 Blocks shall be applied so that all joints are tightly butted and vertical butt joints staggered from those of the preceding course. It is extremely important that all butt joints are completely sealed with asphalt. Any excess asphalt at the joint surface shall be removed.

8.7 Additional layer or layers of insulation, where specified, shall be applied in the same manner as the first layer, with side and end joints staggered over joints of the preceding layer so that no two joints coincide.

8.8 Insulation of sphere support legs shall extend over and down legs a distance of not less than 36 inches from the lowest juncture of the leg with the sphere. Thickness shall be as specified for body of the sphere. The insulation shall be supported by an angle or plate welded around the support leg. All joints in the insulation shall be sealed with hot asphalt at time of application.

8.9 Banding of insulation shall be accomplished after the final layer is applied as follows:

.1 On spheres less than 40 feet in diameter, the installation shall be secured in place with 3/4" stainless steel strapping (4.8.2), on a maximum of 2' - 0" centers at the equator, and fastened to a floating ring at the top and a floating ring at the bottom of the sphere. The floating ring shall be made from 1/2" stainless steel rod shaped into a ring 6 feet in diameter.

.2 On spheres over 40 feet in diameter, only the bottom half of the insulation is to be banded. The installation below the equator support shall be secured in place with 3/4" stainless steel strapping fastened to the equator support on a maximum of 2' - 0" centers, and to a floating ring on the bottom of the sphere.

8.10 A one inch expansion - contraction joint shall be provided below the equator insulation support. Cushioning blanket material (4.2) shall be packed in the joint. An additional layer of insulation equal in thickness to the outer layer shall be applied over the expansion - contraction joint and sealed in place with joint sealer (4.3). A vapor barrier sheet shall be applied over this additional layer of insulation and extend a minimum of 6 inches above and below the completed joint.

8.11 One inch of cushioning blanket material (4.2) shall be packed around nozzles, sphere flanges and other projections where they extend through the insulation in order to allow for contraction or expansion of the sphere. Special care should be taken to seal and flash these areas against the entrance of moisture.

8.12 After the specified thickness of insulation has been applied and banded, the sphere shall be given a coating of weatherproofing mastic (4.11). The weatherproofing mastic shall be applied over the surface of the insulation and securing bands to a wet thickness of approximately 1/32". While the mastic is still wet, glass fabric (4.5) shall be pressed into it and smoothed; care being exercised to prevent rupturing the fabric. All edges shall be overlapped at least 3". The second coat of mastic, approximately 3/32" wet, shall be applied at once over the glass cloth reinforced mastic. The coating shrinks to about half its wet thickness and therefore the wet thicknesses noted shall be generous enough to provide a final reinforced dry thickness of 1/16" minimum.

TABLE NO. 1

RECOMMENDED MINIMUM THICKNESSES FOR SPECIFIED TEMPERATURES

PIPE SIZE	NOMINAL FOAMGLAS THICKNESS																					
	1"	1½"	2"	2½"	3"	3½"	4"	4½"	5"	5½"	6"	6½"	7"	7½"	8"	8½"	9"	9½"	10"	10½"	11"	11½"	12"
½"	45	10	-25	-45	-95	-140	-275	-300	-335	-390	-450												
¾"	50	25	-10	-25	-70	-135	-225	-255	-300	-340	-415	-450											
1"	50	25	-10	-25	-70	-130	-180	-255	-300	-340	-415	-450											
1¼"	50	30	5	-25	-60	-105	-145	-200	-265	-315	-375	-425	-450										
1½"	50	30	15	-15	-45	-100	-120	-185	-230	-290	-345	-390	-440	-450									
2"	50	30	15	-15	-45	-90	-120	-175	-225	-290	-340	-385	-430	-450									
2½"	50	30	15	-10	-35	-60	-105	-130	-175	-235	-290	-330	-375	-415	-450								
3"	50	30	15	-10	-35	-60	-105	-135	-175	-235	-290	-330	-375	-415	-450								
3½"	50	30	15	-10	-35	-60	-105	-135	-175	-235	-290	-330	-355	-415	-450								
4"	50	30	20	0	-30	-55	-85	-135	-160	-205	-255	-300	-340	-375	-420	-450							
4½"	50	30	20	0	-30	-55	-85	-135	-160	-205	-255	-300	-340	-380	-420	-450							
5"	50	45	25	0	-25	-45	-80	-110	-140	-175	-220	-220	-305	-345	-380	-415	-450						
6"	50	45	25	0	-25	-45	-70	-105	-125	-160	-195	-240	-290	-325	-360	-395	-430	-450					
7"		45	25	0	-25	-40	-65	-95	-120	-150	-185	-220	-275	-305	-340	-375	-410	-450					
8"		45	25	0	-15	-35	-60	-85	-115	-145	-175	-215	-255	-295	-325	-360	-395	-425	-450				
9"		45	25	5	-10	-35	-55	-80	-105	-135	-170	-200	-240	-265	-315	-345	-380	-415	-445	-450			
10"		45	30	10	-10	-25	-50	-70	-105	-125	-150	-185	-225	-265	-300	-330	-360	-410	-420	-440	-450		
11"		45	30	10	-5	-25	-45	-70	-105	-120	-145	-175	-210	-255	-290	-320	-350	-380	-410	-435	-450		
12"		45	30	15	-5	-25	-45	-65	-95	-115	-140	-170	-205	-245	-285	-325	-340	-370	-400	-425	-450		
14"		45	30	15	0	-25	-40	-55	-80	-105	-130	-160	-190	-225	-265	-295	-325	-355	-380	-410	-430	-450	
16"		45	30	20	0	-25	-35	-55	-75	-105	-125	-150	-180	-210	-250	-285	-310	-340	-365	-395	-425	-450	
18"		45	30	20	0	-25	-35	-50	-70	-105	-115	-145	-175	-200	-235	-275	-295	-325	-355	-380	-410	-435	-450
20"		50	30	20	0	-25	-35	-45	-65	-95	-110	-135	-165	-190	-225	-260	-290	-315	-345	-370	-395	-425	-450
24"		50	30	20	0	-25	-35	-45	-65	-85	-105	-130	-155	-180	-205	-240	-270	-300	-330	-355	-380	-405	-430
28"		50	30	20	5	-10	-25	-45	-60	-80	-105	-125	-145	-170	-200	-235	-260	-295	-315	-340	-365	-390	-415
32"		50	30	20	5	-10	-25	-40	-60	-75	-105	-120	-140	-170	-190	-225	-250	-285	-305	-330	-350	-375	-400
36"		50	30	20	10	-5	-25	-40	-55	-75	-105	-115	-135	-160	-185	-215	-240	-280	-300	-320	-345	-365	-390
VESSEL O.D.	← SINGLE LAYER →							← TWO LAYERS →								← THREE LAYERS →							
42"		50	30	25	10	-5	-20	-35	-55	-70	-95	-110	-130	-155	-175	-195	-230	-260	-290	-310	-330	-355	-375
48"		50	30	25	10	-5	-20	-35	-50	-70	-90	-105	-125	-145	-170	-190	-225	-245	-280	-305	-325	-345	-365
54"		50	35	25	10	-5	-20	-35	-50	-65	-85	-105	-125	-145	-165	-190	-215	-240	-270	-295	-315	-340	-360
60"		50	40	25	10	-5	-20	-30	-50	-65	-85	-105	-125	-140	-165	-185	-210	-230	-260	-290	-310	-330	-350
66"		50	40	25	10	-5	-15	-30	-50	-65	-80	-105	-120	-140	-160	-180	-205	-230	-260	-285	-305	-325	-345
72"		50	40	25	10	0	-15	-30	-50	-65	-80	-105	-115	-135	-155	-180	-200	-230	-255	-285	-305	-320	-340
78"		50	40	25	10	0	-15	-30	-45	-65	-80	-105	-115	-135	-155	-175	-200	-225	-250	-280	-300	-315	-340
96"		50	40	25	10	0	-15	-30	-45	-65	-80	-105	-115	-170	-150	-170	-190	-220	-240	-270	-290	-310	-330
108"		50	40	25	10	0	-15	-30	-45	-60	-75	-105	-110	-130	-150	-170	-190	-215	-240	-265	-290	-305	-325
120"		50	40	25	10	0	-15	-30	-45	-60	-75	-105	-110	-130	-145	-170	-190	-210	-230	-260	-290	-305	-320
144"		50	40	25	10	0	-15	-30	-45	-60	-75	-95	-110	-125	-145	-165	-185	-205	-230	-255	-280	-300	-305
Over 144" to Flat		50	40	25	15	0	-10	-25	-40	-55	-65	-80	-105	-115	-130	-145	-165	-180	-200	-220	-240	-265	-290