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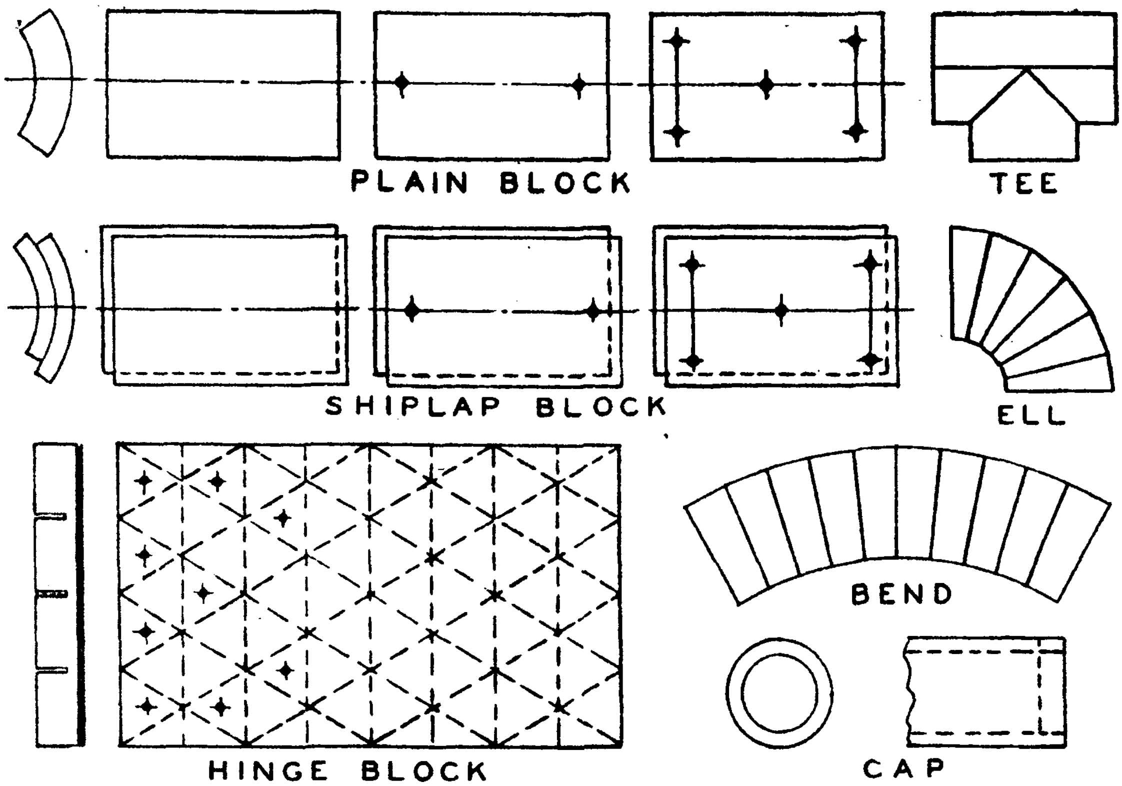

Fig. 1—Some of the shapes used in the new insulation method.

NEW PROCEDURES IN . . .

Industrial Thermal-Insulation Application

Thermal insulation is required in many refinery applications, where temperatures vary from the very low values used for refrigeration processes to the very high ones encountered in furnace operation.

These two articles, one on high-temperature insulation and the other on low-temperature insulation, bring together a number of pertinent facts on this important subject. New methods, materials, and concepts are highlighted.

by C. J. Kuhasz*
and E. C. Shuman†

METHODS have been developed which drastically reduce the installed cost of thermal insulation.

These include not only new application techniques, but also the development of prefabricated shapes which reduce cutting and forming in the field to a minimum. Advantages are (1) greater economy, (2) a saving in the amount of critical material required, (3) greater durability, and (4) elimination of the confusion resulting from the use of various grades and thicknesses of material.

These methods have been employed on three projects now in operation, with savings of $50,000 to $250,000, and on numerous others currently under construction. Savings run from 15 to 25 per cent of the cost based on previously used processes.

Reduction in number of insulating joints varies from 200 to 700 per cent, while reduction in the number of separate operations required for an installation runs from 30 to 60 per cent of those formerly required.

Former difficulties . . . Difficulties of older methods are concerned with the weathercoating, and are (a), failure of weathercoating at the joints between blocks under extreme elevated temperature service due to heat infiltration, (b), failure of bond between the insulation and weathercoating due in part to materials and in part to moisture saturation of the insulation by rain, and (c), failure of weathercoating due to insufficient weathering and heat resistance.

To avoid such difficulties and to make the method as nearly foolproof as possible the following steps were taken:

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(a) The design of joints for high temperature service was modified to insure that the weathercoating reinforcement would not be strained excessively as a result of expansion of the metal to which the insulation is applied. (b) The holes for the attachments were counter bored and packed to eliminate any possibility of over heating the coat by conduction through the pins. (c) All insulation was prime coated on the outside before installing against metal surfaces, in order to minimize water absorption from unexpected rains which may occur before the weathercoat is applied on the job.

General Description of Method . . .

Using this method of installing thermal insulation it is possible to apply insulation to the metal surfaces of vessels, equipment, piping, valves, fittings, bins, duct work, etc., at reduced installed costs that are well below those of other methods, even though initial material costs are slightly higher.

Insulating material . . . The method can be employed for all operating metal temperatures up to 1,200° F. while specifying one type of rigid insulation material known as hydrous calcium silicate in a single thickness. The density of this material is approximately 11 lb. per cubic foot and its average compressive strength about 150 lb. per square inch. The material is insoluble in water, has a high wet strength, is incombustible and its handleability is exceptionally good, resulting in a very small amount of waste. The material is supplied in 1 to 5-in. thickness in increments of ½ in., in the forms of flat and curved block and pipe insulation.

Shop Fabricated Shapes

The bulk of the insulation material is shop fabricated in standard shapes and properly identified for field assembly. The size of each piece is predetermined for ease of manhandling and minimum damage during shipment and erection. In general, the length of each piece is 36 in. and the thickness is either cast or laminated up to 5 in.

For cylindrical surfaces of vessels, pipe, etc., the width of the curved blocks and the number of pieces around each circumference are determined by the diameter. In general, pipe insulation is supplied in two pieces for diameters from ¼ to 12 in., three pieces for 13 to 18 in., four to eight pieces for 19 to 40 in., and in nominally 18-in. wide pieces for diameters over 40 in. up to 60 ft.

For irregular curved surfaces, such as heads, cones, transitions, etc., blocks of two types are supplied: (a), 18 by 33-in. hinged blocks made by adhering woven glass fabric to individual small blocks of triangular shape (the glass fabric provides hinging action and there is little danger of the pieces breaking apart), (b), 9 by 18-in. curved blocks with the direction of curvature determined for best fit of surface covered. A change in radius is dictated when the space between the inside of the insulation and the metal surface exceeds ⅛ in. For flat surfaces such as bins, ducts, etc., flat blocks are supplied in widths up to 18 in.

For pipe fittings, valves, flanges, etc., of the butt weld type for diameters larger than 2½ in. and for flanged types larger than 1½ in., standard pipe insulation is cut, formed and securely held together with a water and heat resisting cement and is supplied preassembled weathercoated in two to four pieces. Pipe bends from 3 to 10 in. are also supplied from standard pipe insulation.

Insulation used on metal surfaces operating at temperatures below 700° F. have shapes provided with straight-edges cut normal to the outside surface of the piece. For metal surfaces above temperatures of 700° F. the shapes are provided with ½-in. shiplapped edges also cut normal to the outside surface. In addition all pieces for thicknesses of 2½ in. and over are provided with a 30° bevel cut about ⅜ in. deep along all the outside edges.

Insulation used on cylindrical, flat and irregular metal surfaces (except for cylindrical surfaces smaller than 24 in. in diameter operating below temperatures of 700° F.) the shapes are provided with two to five shoulder holes properly spaced, except for hinged block in which a multiplicity of holes are provided. For pieces 2 in. in thickness and below, the shoulder of the hole is 1 in. high and for 2½ in. and thicker is 1½ in. high. For cylindrical surfaces 24 in. and smaller operating at temperatures above 700° F. each shape is provided with two shoulder holes. As an alternate type, straight holes may be used for thicknesses of 2 in. and smaller. In all cases holes are drilled normal to the outside surface of the piece.

The small diameter of the shoulder hole is made large enough to admit a ceramic ferrule for a 3/16 or ¼-in. diameter welding stud, with sufficient clearance to allow proper venting of gases during welding and to prevent scraping the sides of the hole and picking up particles of insulation. The larger diameter is made large enough to admit a welding stud bending or speed clip fastening tool. When the alternate straight hole is used its diameter should be the same as the small diameter hole of the shoulder hole.

Regardless of operating temperatures and kind of metal surfaces insulated, the pieces are protected from moisture. This is done by either prime coating or weathercoating the outside surface of each piece prior to its erection. In general, insulation for cylindrical surfaces smaller than 24 in. in diameter and all pipe fittings, valves, flanges and pipe bends are furnished with a prime spray coat and a 1/16-in thick finished weathercoating applied before shipping. All other pieces are furnished with a film of spray coated water repellent primer applied to the outside surface and the ends, also prior to erection.

When the outside diameter of insulation is greater than 16 in. it is reinforced with a layer of glass fabric when used for pipe fittings, valves, flanges and specialties.

Some of the shapes used in the method described have been shown on Fig. 1.

Field fabricated shapes . . . For pipe fittings, etc., of the butt weld type under 3 in. in diameter, flanged type under 2 in. and for screwed type over 3½ in., standard pipe insulation is supplied for field fabrication.

In addition to the foregoing, on every installation certain items must be considered as specialties and do not fall into the present range of standard shapes. In such cases the economics of shop against field fabrication must be taken into account. A limitation against shop fabrication usually is due to damage of large assemblies in transit; in many cases, though, this can be overcome by increasing the number of pieces and shipping them disassembled. On the other hand, if field fabrication is decided upon it will be noted that most specialties can be made from standard pipe or flat insulation materials.

Mineral wool . . . Prefabricated mineral wool is available for pipe fittings, valves, etc., of the screwed type under 4 in. in diameter.

Felted mineral wool blanket in 1-in. thick layers are supplied for pipe bends under 3 in. in diameter, and for packing construction cracks and openings.

Reinforcement . . . Glass fabric is supplied for reinforcing and should be made in an evenly woven mesh, impregnated with a water resistant compound that is not soluble in the solvent in the weathercoating, in order to prevent possible damage to the glass fibres, which might occur if their coating is partially removed and friction between strands can be induced. The trend count should be no less than 20 per inch in both directions with a minimum strength of at least 60 lb. per inch of width and should weigh about 2½ oz. per square yard.

Fasteners . . . Welding studs are supplied in carbon or alloy steels in either the 3/16-in. diameter split pipe type or the ¼-in. diameter solid pin flux or slug loaded type with a 1-in. diameter metal speed clip, both types are furnished in lengths of 1½ and 2 in. with ceremic ferrules for good welding. Welding studs must be suitable for use with a welding gun of the timed volt-ampere type.

Weatherproofing . . . Prime coat materials which do not introduce water into the insulation and are suitable for spray application are used to prevent rain from being absorbed through the surface of the insulation. In order to obtain a good bond for the weathercoat, the primer should penetrate the surface of the block and not be soluble in the solvent of the weathercoat.

Weathercoat materials suitable for indoor or outdoor spray application are used, such as asphaltic, bituminous and rubber based. The type selected should be based upon the temperature conditions to which the weathercoating will be subjected to, such as heat transfer, magnitude of joint movement and number of times the joint opens and closes in a given period. They should be moderately fast drying, flexible and resilient over a wide range of temperatures with a working temperature of at least 300° F., have good adhesion and good weathering properties and long life.

Coatings should not support combustion to an extent that they will spread fires that reach them. It must be recognized that many solvents are flammable, so that care is essential during application and for a short time thereafter. No serious problem has arisen from this condition in the field.

Cement . . . High temperature plastic cement materials suitable for temperatures up to at least 1,200° F. are used to prevent rain from being absorbed by the insulation in places where the use of weathercoat is prohibited because of excessive metal temperatures. This high temperature cement should be fast setting, have good weathering properties, low water absorption, good adhesion to insulation and metal, high coefficient of expansion to minimize checking and cracking, and when applied should be of troweling consistency.

Other commonly used materials such as metal wire, bands, cables, wire mesh, lacing wire, nails, sheet metal, plastic cements, etc., will not be described herein.

Installing Insulation

To obtain the best results during the service life of the insulation it is very important to adhere to the procedure described for applying the materials to cylindrical, flat and irregular curved metal surfaces.

In order to avoid entrance of water into the insulation, whenever practical, erection of the insulation should be started at the top most part of the metal surface. Around all irregularities projecting from the metal surfaces, pieces of insulation should be cut to fit neatly.

All pieces are installed in such a manner that the flow of heat by convection is minimized along the joints between adjacent blocks. For vessels, equipment, etc., set in a vertical position the longitudinal joints should be staggered and the circumferential or transverse joints should be continuous. In the horizontal position the longitudinal joints should be continuous and the circumferential or transverse joints should be staggered. In all cases the joints between adjacent blocks are butted together tightly.

Cutting reduced . . . To reduce unnecessary cutting and the number of joints, a survey should be made of the metal surface to be insulated, and the first row of pieces to be installed should be started with a longitudinal joint in line with the greatest number of projections which are on more or less a common centerline.

Where shiplapped pieces are used for irregular curved surfaces, it will be found that some of the shop fabricated material will not always fit the curvature and it is necessary to do some lapping in the field. In such cases a mechanically operated tool has been used to cut the lap.

Where hinged blocks are used, they should be cut and fit to conform as nearly as possible to the contour of the metal surface, and protruding edges should be pounded with a wooden mallet to form a reasonably smooth surface.

Insulation should extend beyond the straight portion of cylindrical metal surface a sufficient amount to allow good trimming to conform to the insulation of heads, cones, transitions, etc. The void occurring at the junction of the shell and head insulation should be filled with waste block whenever additional stiffness is required.

The object of individually supporting each piece of insulation is to control and localize to small increments the movement caused by expanding hot metal surfaces. The effect is to distribute the total metal expansion to a great number of positive joints between adjacent blocks. For example, a hot metal surface with a circumference of 95 ft. 0 in., expands 4 in. to 95 ft. 4 in.; using 18-in. wide blocks, the joint between adjacent blocks opens up to 1/16 in. due to the expanding metal surface. Without individual support, it is conceivable for the insulation at some place to open as much as 4 in.

Fastening insulation . . . In general, all pieces of insulation are firmly secured to the metal surfaces with carbon or alloy steel welding studs, either of the split pin type embedded into the insulation, where the metal surface is comparatively clean, or the solid pin flux loaded type with a speed clip, where the metal surface is heavily mill scaled, rusted or painted. When the metal thickness is within the sheet metal range the use of welding studs may be prohibited, in order not to burn through the metal.

In most cases, each piece of insulation is manually held in place while at least two welding studs are fastened to the metal surface. This procedure may be continued for a number of

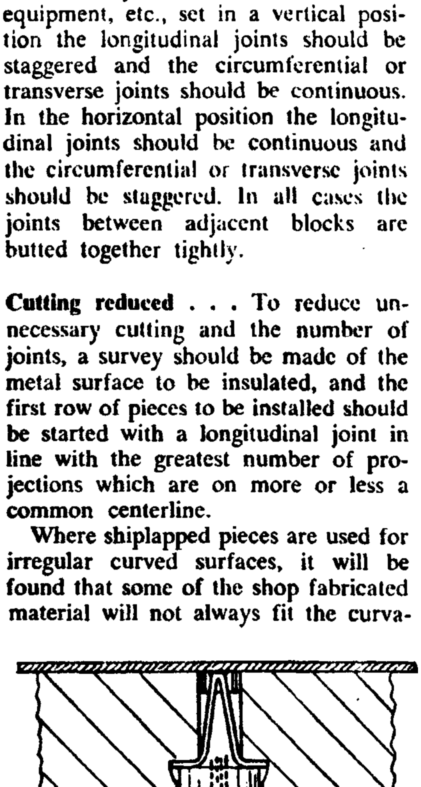


Fig. 2—Installation of split-pin type of welding stud.

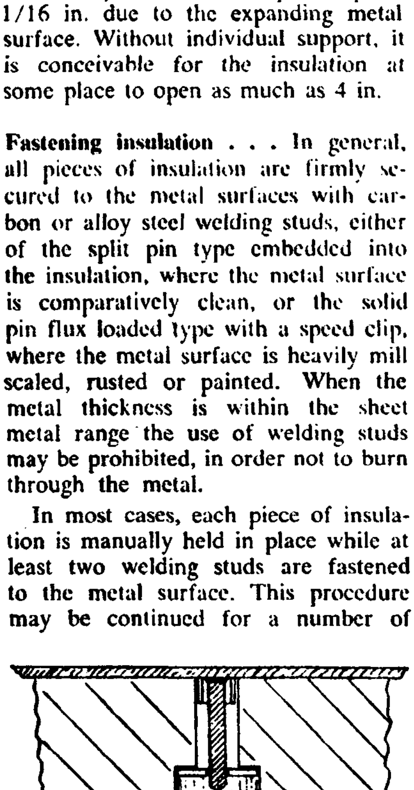


Fig. 3—Installation of solid-pin flux type of welding stud.

blocks or all welding studs can be fastened in each block before proceeding to the next block. The proper number of welding studs used to secure each block will depend on the position of the piece, such as overhead, vertical, etc.

To install the split pin type welding stud, the pin with a ceramic ferrule is inserted into the shoulder hole and welded to the metal surface, after which the ends of the pin are bent over and embedded into the insulation by using a special tool designed for this purpose. Refer to Fig. 2.

To install the solid pin flux or slug loaded type welding stud, the pin with a ceramic ferrule is inserted into the shoulder hole and welded to the metal surface, after which the speed clip is placed on a magnetized tool inserted in the hole and pressed over the pin until it bears firmly against the shoulder. Refer to Fig. 3.

Packing holes . . . In general, after blocks are securely held against the metal surface, either a calcium silicate dowel or mineral wool is inserted into the hole. Where thickness of insulation is under 2½ in., packing may be omitted without any detrimental effects. It is to be noted that only two lengths of welding studs are required regardless of the insulation thickness, one length for 2 in. and less, and one length for 2½ in. or over.

The object of using the packed shoulder hole is to prevent the transfer of heat from the hot metal surface through the welding stud to the weathercoating, thereby maintaining approximately the same temperature at the stud location as is over the entire area of the blocks.

Applying Reinforced Weatherproofing

Insulation and spray applied weathercoating reinforced with glass fabric is comparatively simple to install when compared with conventional methods of using metal wire mesh and multilayer troweled on water bearing plastic cement and weathercoat, or sheet metal covering. It is to be pointed out that one of the most troublesome features and costly items of the conventional methods was the great amount of water bearing plastic cements, which the method described has eliminated.

In general, after blocks have been secured to the metal surface and all cracks and openings larger than ⅛ in. in width have been packed with mineral wool (normal joints between adjacent pieces of insulation will be sufficiently tight to require no packing), the reinforcing and weathercoating

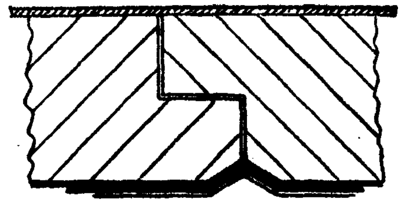


Fig. 4—Reinforcing weathercoating at insulation joints for thick insulation.

proceeds as soon as practical without interfering with mechanics.

It should be noted that when at any time the insulation cannot be completely covered with glass fabric, due to conditions in the field, the tack spray coat must be continued until it covers all the exposed surfaces of the insulation before leaving that area of work. The finish weathercoating should be sprayed over the glass fabric to a thickness which will dry to approximately 1/16 in.

Where metal temperatures are above 300° F. the weathercoating should not come in contact with the metal surfaces, at such places a high temperature cement should be used. Preferably the finish coat should be applied as soon as practical, so that scaffolding can be removed and waste cleaned up as the work progresses. With respect to patent scaffolding it can be reused more often than heretofore and a smaller initial amount is required when compared with installing insulation by conventional methods.

Glass fabric reinforcing should be cut into strips about 7 ft. long, and when installing, it should be lapped along all edges at least 3 in. Prior to installing glass fabric it is important to see that the tack spray coat is wet, because if it is not there will be no adhesion between the block and the glass fabric. When embedded into the tack coat the glass fabric should not be pulled tight or stretched, rather, it should be layed on the tack coat and pressed into it just free of wrinkles. In fact, some small wrinkling will be helpful as it will show some slippage of the individual glass fibers within the weathercoating.

The finish weathercoating must be uniformly sprayed to a thickness of 1/16 in. over the entire area of the glass fabric in order to protect the fabric against deterioration.

Sealing Joints Between Blocks

Reinforcing weathercoating for insulation 2½ in. in thickness and over should be applied to the joints between adjacent blocks, in the same way and, at the same time as the block surfaces. The glass fabric should be pressed into

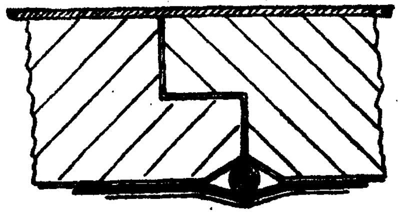


Fig. 5—Installation of insulation on high-temperature metallic surfaces.

the tack coat and formed to the contour of the notch and covered with weathercoating. Refer to Fig. 4.

This type of joint allows the hot metal surface to which the blocks are rigidly fastened to move without putting tension on the weathercoating, thereby keeping it free from cracks. The joint functions as follows: during the first heat up of the metal surface and as the metal expands the reinforced weathercoating starts to peel back from the apex of the notch, the peeling action continues until the maximum expansion of the metal surface is reached.

Upon cooling of the metal surface the weathercoating recedes into the notch. The only stress to which the weathercoat is subjected to is flexing action caused by subsequent cycles of heating and cooling.

For extremely high temperature metallic surfaces a joint similar to the preceding one is used, except a heat retardant seal of soft asbestos rope or its equal is inserted in the notch over the joint between the blocks prior to installing reinforced weathercoating. Refer to Fig. 5.

This type of joint is similar to that described above, except a heat retardant seal is furnished to reduce the transfer of heat by convection from the metal surface to the weathercoating, thereby keeping it free from cracks and embrittlement; furthermore, the seal will prevent charring of the weathercoating.

Miscellaneous applications . . . Although the greater part of every project requiring insulation consists of covering plain metal surfaces, there are many places on vessels, equipment, etc., where special considerations must be employed to provide a satisfactory installation. Several of the most important are described herewith.

Weld seam lanes . . . When weld seams in metal surfaces require periodic inspection, the seams are covered with 6-in. wide single or 9-in. wide shiplapped curved or flat blocks. In general, the metal surfaces to within 3 in. of either side of the weld seam are insulated and weathercoated first, form-

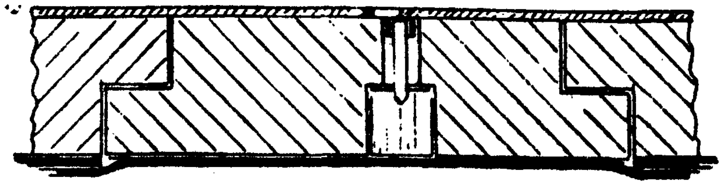


Fig. 6—Installation of insulation for weld seams.

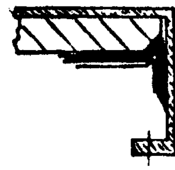


Fig. 7—Insulation of projections, which are cold metal surfaces.

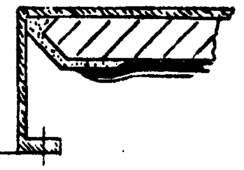


Fig. 8—Insulation of projections which are hot metal surfaces.

ing a lane, after which the lane blocks are placed in the lane and secured with welding studs. Reinforced weathercoating is then installed and lapped at least 3 in. over the permanent insulation. When it is necessary to remove lane blocks, the weathercoating is cut along the edges of the lane, welding studs opened, and lane blocks lifted from place. To replace, the same procedure for installing is used. Refer to Fig. 6.

Projections Through Insulation

Where metal surfaces project through the insulation, such as nozzles, etc., which are below 300° F. The edges of the block adjacent to the projection should be beveled at an angle of 45° 1 in. deep on the inside. The blocks should be installed by extending them to within ¼ in. of the projection and firmly secured, after which the bevel and adjacent block, and 4 in. of the projections surface should be sealed with two layers of reinforced weathercoating. When glass fabric is installed it should be pressed into the contour of the bevel and overlap the glass fabric on the block by at least 2 in. Refer to Fig. 7.

Where hot metal surfaces project through the insulation, which are above 300° F., The edges of the block adjacent to the projection should be beveled at an angle of 45° 1 in. deep on the inside and 45° on the outside. The blocks should be installed by extending them to within 1 in. of the projection and firmly secured, after which the space between the projection and the block should be sealed by troweling it full of high temperature cement, which should be extended along the surface of the block for at least 4 in.

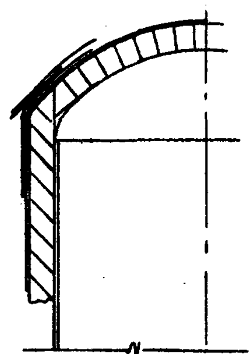
Water should be kept off the cement for several hours to allow setting. After the cement has dried a 4 in. wide strip of reinforced weathercoating should be placed over the joint between the block weathercoating and the cement. Refer to Fig. 8.

These seals are to prevent water from getting into the insulation and behind the weathercoating and, to decrease the transfer of excessive heat to the weathercoating, thereby, overcoming cracking, peeling, embrittling, loss of resiliency and general deterioration of the weathercoating.

Insulation flashing . . . The top head of vertical vessels should be provided with a rain drip properly flashed to the insulation. Refer to Fig. 9. The seal should be made by installing two layers of glass fabric on the vertical blocks and then extending it over the knuckle curvature by at least 12 in. A rain drip made of galvanized sheet metal at least 6 in. wide should then be installed around the curvature by nailing it into the insulation. The edge of the drip should extend about ¾ in. beyond the vertical blocks. The drip should be covered with a layer of weathercoating, extending over the head insulation.

The heads of horizontal vessels should be finished as described above, except the rain drip is omitted.

Where insulation terminates on the metal surface for temperatures above 300° F. the ends of the blocks are flashed against the metal surface. Refer to Fig. 10. The seal is made by beveling the ends of the block at 45° in direction of drainage, after which a piece of galvanized sheet metal flashing is extended along the metal surface about 4 in. and along the surface of the block for 4 in. The flashing should be fastened to the metal surface with a continuous metallic bead. Before flashing is installed the blocks should be weathercoated to within 2 in. of the bevel so that flashing can be extended over it.



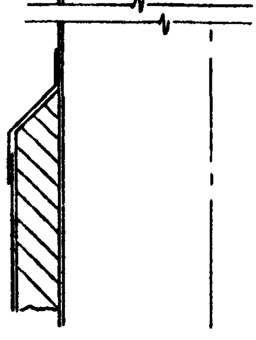


Fig. 9—(Top) Rain drip should be provided for top head of vertical vessels.

Fig. 10—(Bottom) Termination of insulation on metal surfaces above 300° F.

Where insulation terminates on metal surfaces for temperature below 300° F., the ends of the blocks are flashed against the metal surface as described above, except reinforced weathercoating is substituted for the sheet metal.

These seals are to prevent water from entering joints between insulating blocks or between blocks and metal surfaces, thereby keeping insulation dry, which in turn reduces corrosion effects on the metal surfaces covered.

Straight and Bent Pipe Application

In general, shop weathercoated insulation should be installed on straight pipe of 22 in. in diameter and smaller and on pipe bends from 3 to 10 in. in diameter. Depending upon metal surface temperatures, either weathercoated hinge block or 9 in. wide shiplapped curved pieces should be installed on pipe bends larger than 10 in. and on irregular metal surfaces. For pipe bends under 3 in. in diameter, felted mineral wool blanket in 1-in. thick layers should be installed. It should be noted that shop weathercoated pieces are optional for indoor application.

Whenever practicable, insulation for butt weld fittings, valves and pipe bends should be installed prior to the pipe insulation. Where flanged type fittings and valves are to be insulated, the pipe insulation should be insulated first in order to allow fitting and valve insulation to extend over the pipe insulation. .

Installed loose . . . Insulation should be installed with recognition of the desirability of a specified degree of fit, and adjusted to be moderately loose for the temperatures expected. When installing the pieces, full circumferential joints are used between adjacent pieces of shop weathercoated insulation, and where practicable all longitudinal joints should be placed on, or as near as possible to the horizontal center line of the pipe. Where prime coated pieces of insulation are installed the vertical joints should be staggered and horizontal joints made continuous. In all cases joints between adjacent pieces of insulation must be tightly butted together.

Wherever shop weathercoated insulation is used, the pieces should be secured to the metal pipe surfaces with wire loops that have the ends twisted and embedded in the insulation, or steel bands. The type of securement and the number used for each 36-in.-long piece will depend on the diameter of the pipe.

Packed openings . . . Openings larger than 1/8 in. in all insulation should be packed with mineral wool. Normal joints between adjacent pieces of insulation will be sufficiently tight to require no packing.

After shop weathercoated insulation has progressed along the pipe sufficiently not to interfere with mechanics installing it, the longitudinal and circumferential joints between adjacent pieces of insulation should be weathercoated, so that no moisture can enter the insulation. Weathercoating is either applied by brushing, troweling or smearing on with a glove to a smooth finish.

All exposed surfaces such as ends and edges should also be weathercoated. Prior to sealing circumferential joints they should be reinforced with a band of glass fabric at least 3 in. wide embedded in the weathercoating. Where beveled edge is used the glass fabric should be pressed into the joint; where straight edge is used the fabric should be relatively loose to permit some movement when the pipe expands.

Where projections extend through the insulation, the joint should be sealed in the same manner as described for vessels, etc.

Where prime coated insulation is installed, the application procedure should be the same as described for vessels, etc.

Pipe Fittings, Valves Flanges

In general, shop fabricated weathercoated insulation covers should be installed on pipe fittings, valves, flanges, etc., from 3 to 24 in. in diameter. For diameters under 3 in. either standard pipe insulation or mineral wool as described herein should be installed. It should be noted that when the diameter of the insulation used is greater than 16 in. the fittings, etc., are reinforced with glass fabric. Shop weathercoated pieces are optional for indoor application.

Whenever practicable, insulation for buttweld type elbows, tees, valves, etc., should be installed prior to the pipe insulation; butt weld caps and reducers are considered part of the pipe insulation. Where flanged or screwed type fittings and valves are to be insulated such as flanged joints, elbows, tees, valves, couplings, etc., the pipe insulation is installed first.

When butt weld fitting insulation cannot be installed as mentioned, the location of the extremities of the fitting should be marked on the metal surface of the pipe, so that when fitting insulation is installed it can be butted tightly against the pipe insulation without cutting it.

Parallel to pipe . . . All fitting insulation should be installed with the center lines parallel and normal to the pipe insulation of which they are a part. All joints in the fitting insulation, and where it comes in contact with pipe insulation should be butted tightly together.

Where fitting insulation overlaps pipe insulation, such as in the case of flanged type, the space between the outside of the pipe insulation and the inside of the fitting insulation should be packed with scrap insulation or mineral wool. In many cases, because of the nesting arrangement of the insulation sizes, the need for packing is eliminated.

In places where it is possible to damage fitting insulation after it has been installed or where additional rigidity is required because of external weights resting on the fitting, such as flange type, the void between the metal pipe fitting and the inside of the insulation should be reinforced with filler pieces made from scrap insulation. Places like these are the only ones where this should be done; all other voids are to remain unfilled.

Openings larger than 1/8 in. in all insulation should be packed with mineral wool. A typical case is the space left after cutting valve insulation for bonnet flanges of a globe valve.

Shop weathercoated fitting insulation should be secured to the metal pipe fitting with wire loops that have the ends twisted and embedded in the insulation, or with steel bands. The type of securements and the number used will depend on the size and the number of pieces installed. Flanged fitting insulation should be secured where it overlaps the pipe insulation.

Joints in fitting insulation should be weathercoated, reinforced and sealed as the work progresses against moisture as described for shop weathercoated pipe insulation. In addition all exposed ends, edges, etc., should be completely sealed with weathercoating. Furthermore, all joints between fitting insulation and pipe insulation should be reinforced with glass fabric.

When fitting insulation is made in the field, either of shop weathercoated insulation or mineral wool the individual pieces of insulation should be secured with wire loops, reinforced with a layer of glass fabric and finally given a finish coat of weatherproofing.

Where it is necessary to insulate fittings larger than 24 in. in diameter, prime coated curved pieces are used. The individual pieces should be either secured with wire loops or steel cables after which the insulation should be given a first spray coat of weatherproofing into which is embedded a layer of glass fabric properly lapped and finally a finish spray coat of weatherproofing.

Insulation for steam tracing . . . In some cases, the outside metal surfaces of equipment, pipe and fittings are provided with tubing, through which steam flows for the purpose of furnishing additional heat, or for stabilizing the chemical process, usually referred to as steam tracing.

In such cases, the insulation size used on equipment and piping, includes the steam tracer tube, so that when the insulation is installed it is placed against the tubing. When fittings are steam traced the size of the insulation is not increased to include the tubing, instead, at points of interference the insulation is gouged out to accommodate the steam tracer tube. In order to reduce the amount of gouging the tubing should be located on the metal surface where the joint in fitting insulation will occur. The insulation procedure for installing, packing, securing, reinforcing, and weathercoating is the same as described herein. Where welding studs are used to secure insulation, care must be taken to avoid welding to the steam tracer tubing.

Insulation for Turbines, Pumps

Where hinged block can be used conveniently against irregular metal surfaces, they are installed, packed, secured, reinforced and weatherproofed as described herein.

When hinged block cannot be used conveniently, plastic cements are applied to the irregular metal surfaces in 1½-in. thick layers, with each layer reinforced with 1-in. hexagonal galvanized poultry mesh, as used conventionally. However, after the hard coat of plastic cement has been applied and completely dry, the entire surface of the insulation is given a first spray coat of weathercoating, into which is embedded a layer of glass fabric properly lapped, and finished with a 1/16-in. thickness of weathercoating.

Weathercoating should not be applied by the spray method where overspray will require too much cleaning up; in such cases it should be applied by either brushing, troweling or smearing on with a glove, to a smooth finished surface.

It should also be recognized that by using the methods described herein more engineering of insulation is required than heretofore. However, this added cost is more than offset by the fact that all parts of the installation are not only properly insulated with the correct material, but when the work is finished there will be no disagreements as to the amounts of insulation used for equipment, piping, fitting, etc., between purchase and applicators. On many installations in the past this was not so and necessitated the employment of measuring teams. It is to be noted that when the methods described are specified the applicator can quote on the insulation work, without any doubt as to the correctness of the amount of material and the labor involved; on the other hand, the purchaser knows what he is getting when the work is completed.

Advantages of Method . . .

A. Cost Benefits

The writers have found the following major cost factors to be noteworthy. It is recognized that all factors are not of the same importance on all installations and therefore no importance is attached to the order in this list.

Much less basic material need be requisitioned. Instead of about 10 per cent excess for contingencies, only 1½ to 3 per cent need be requisitioned, depending on quantities and types of materials involved.

Auxiliary materials, such as structural steel shelf angles, channels, plates, etc., welded to hot metal surfaces solely for supporting and attaching of insulation are entirely eliminated when split pin or solid type welding studs are utilized. Small pieces of steel attached at specified locations on equipment, etc., are costly and at present critical.

In general costly materials needed to protect insulation against weather during erection are practically eliminated, and only comfort of workers need be considered. It is to be noted that with the methods described, insulation can be applied in subzero climates with little danger of freezing; in the past this was a very costly item to control.

Rain resisting . . . The material, hydrous calcium silicate, resists rain. If applied insulation becomes saturated before weathercoating, or before application, it is not damaged except by freezing; drying before coating is all that is required, but this is essential to prevent trapping moisture in the insulation. It is to minimize the danger of this occurring that the insulation is prime coated in the shop. Insulation saturated after application does not fall off.

In general, no heat need be provided to dry out wet insulation. The elimination of water-mixed plastic cements makes it no longer necessary to employ costly heating equipment and waiting time, previously required to dry or thaw out insulation. The only time such equipment is needed is when the weatherproofing is not applied as outlined herein or when plastic cement is used for irregular surfaces.

Corrosion minimized . . . Because these methods produce weather protected insulation of a high degree of moisture resistance, and because practically no water-mixed materials are used, corrosion will be minimized on all metal surfaces covered. Furthermore, hydrous calcium silicate is alkaline and therefore rust inhibitive.

Insulation work may be started wherever convenient; however, it is best and more economical to start installing insulation at the topmost surface and progressively weatherproof downward so that rain, even though unexpected, will not wet the insulation and run behind it, and further accelerate corrosion of the metal surfaces. It should be noted that wetting the insulation is also of concern to the extent that moisture must be removed before the insulation is completely weatherproofed, to avoid building up vapor pressure and decreasing thermal efficiency of the insulation until it becomes dry.

Errors reduced . . . Because only one kind of basic insulation material of a single thickness is used for the full range of temperatures up to 1,200° F., it will be found that errors in applying the improper insulation is greatly reduced, compared with projects of which several materials are specified. The amount of handling of individual pieces and the accompanying breakage also are decreased. Furthermore, handleability of hydrous calcium silicate, particularly where small cutouts are needed, simplifies application.

An appreciably smaller number of field operations are required; in most cases about half as many when other methods of application are considered.

The larger pieces of insulation now made available through this procedure, nominally 18 by 36 in., reduces the number of joints to seal, pieces to handle and the amount of breakage.

Simplified operation . . . Either single or shiplapped pieces are installed and secured to the metal surfaces by the same procedure; this greatly reduces and simplifies the number of field operations when multiple layer insulation is applied. Furthermore, the use of shiplapped pieces has eliminated continuous full depth joints between the outside of the insulation and the metal surface to the vanishing point. It is significant to note that continuous full depth joints have been observed, even in some cases where multiple layers of 4 or 6-in. wide pieces of insulation have been used.

Individual mounting of the pieces makes it comparatively easy to support the insulation at places where large openings occur in the metal surfaces and where small and large pieces of equipment are fastened to the metal surfaces such as metal reinforcing pads, manholes, nozzles, etc. Furthermore, all metal rings used for fastening insulation cables and bands at these points have been eliminated.

The use of hinged block which are normally 4.5 sq. ft., simplified installing the insulation on double curved metal surfaces by eliminating the usual 4 or 6-in. wide field scored blocks equivalent to 1.0 or 1.5 sq. ft. respectively, and through the elimination of successively applied water bearing plastic cements.

Waste reduced . . . Running the cylindrical, longitudinal or vertical insulation beyond the junction of double curved surfaces, firmly supports the insulation on the double curve and simplifies installing it whenever short radii occur. The use of filler blocks made from scrap insulation, which is always available, not only provides the necessary support where needed but helps to dispose of waste insulation material and reduce the amount of cleaning up when the work is completed.

Reinforcing the outside surface of the insulation with glass fabric simplifies the application while at the same time providing an inert material not subjected to deterioration from corrosion or other deleterious effects. It is essential that material conforming to the specifications set forth herein be employed, since the use of inferior material will not produce a satisfactory job.

Installing an extra layer of glass fabric and a metal rain drip at and along the juncture of head and cylindrical insulation on vertical vessels will prevent potential cracking of the weatherproofing at this point, and make it possible to stop water from getting behind the insulation. Furthermore, rain water as it runs down the head is diverted from against the sides of the insulation by the rain drip.

Better fit . . . Furnishing curved segments of insulation of different radii for double curved surfaces will allow the insulation to fit better against these surfaces and appreciably decrease the amount of cutting and cracking of the insulation during application.

On metal surfaces, such as are found in rectangular and square bin and duct construction it will be seen that the use of welding studs greatly simplifies securing the insulation at corners, stiffeners, etc.

With individual mounting, any part or piece of insulation can be removed without disturbing the remaining insulation or have it fall off, when it is necessary to make changes to the metal surfaces insulated or to repair the insulation. Removed material when handled with moderate care can be reused.

Each piece of insulation is individually mounted and the relative change in dimensions due to longitudinal and radial thermal expansion of the metal surface and the shrinkage of the insulation need be compensated for at the joints only of the small units, usually 4½ sq. ft.

Operations reduced . . . The strength of the insulation material and the independent support method described for installing, and removing insulation at weld lanes has simplified the application at these places by reducing the number of field operations, and has eliminated the double continuous steel plate border strips, previously tack welded along both sides of the seam. These plates were used to fasten the cables or bands of the permanent insulation and provide a lane for removable insulation over the weld seam.

The use of welding studs for securing insulation to metal surfaces has eliminated all sagging, when insulation is installed in overhead positions or any other position where the dead weight of the insulation rests on the attachment, such as cables, bands, etc.

The subsequent attachment of cables, bands, etc., for securing insulation is eliminated in the case of vessels, equipment, etc., except when alternate method of application is used.

Little job cleaning . . . The strength of the material is such that workmen can walk on it without damaging any materials. While not recommended in general, in cases where necessary, scaffold planks can be placed on the finished insulation without damage. Furthermore, few repairs are needed at the end of the job because both the insulation and the coating resist moderate abuse.

Little expense in job cleanup is involved. A job involving about $100,000 worth of insulation has only enough waste material accumulated to be carried away in a pickup truck.

After completion of the job, since practically all items are listed on a materials order, measuring teams are not needed for quantity surveys, with subsequent negotiations because of disagreements.

In case of fire the mounting of individual pieces prevents the falling off of the insulation as occurs when cables or bands are used.

B. Personnel Considerations

From the standpoint of the workmen, the following factors should be considered.

1. It is felt that as the installed cost of thermal insulation decreases, the amount of insulation to be applied will be increased.

2. Hydrous calcium silicate is pleasant to handle, and permits a better appearing job for the conscientious craftsman.

3. There is inherently less dust than with other softer materials and the basic material is not a hazard.

4. Since the amount of gymnastic work around fittings to be applied from high scaffolds is reduced, so is the accident hazard reduced.

5. Due to hydrous calcium silicate being insoluble in water, it does not produce a slimy surface on planking after rain when partially redried, and thereby reduces the accident hazard.

C. Maintenance

A major problem in thermal insulation in the past has been maintenance which is always necessary because of job accidents which result in damage to either the weathercoating or the insulation or both. It seems obvious that repairs to the coating or the insulation have been simplified with procedures described.

When damage occurs to the weathercoating, it is repaired by brushing on weathercoating or brushing on weathercoating reinforced with glass fabric depending upon the extent of damage.

When damage occurs to the insulation, it is removed and new insulation installed. It should be noted that where the welding stud method of attachment is used, only those pieces damaged need be removed and replaced without disturbing remaining material. If already weathercoated, the coating is cut along joints, and the replacement made and recoating applied, using glass fabric reinforcing where desirable. This partial removal also applies to parts of fittings which are damaged.

In service, it is anticipated that for high temperatures there may be some distress in joints, even though reinforced, after some time of service. If so, maintenance crews can recoat the checked areas easily by brushing on additional coating and reinforcing. It is felt that recurrence after such treatment will occur rarely especially where the bevel type joint is used.

Here is an item on which improvement can be expected when more elastic and durable coatings become available. It is to be noted that conventional coatings used in the past always were a source of a great amount of maintenance due to checking and cracking.

In service, it is also to be noted that due to the toughness of the weathercoating and strength of the insulation material, equipment and piping covered with insulation can readily be used to support scaffold planks with moderate dead loads, without damage.

Specifications, Equipment, and Storage . . .

No equipment is required for this method that is not already on the market. The following equipment is used in addition to the usual tools of the trade of insulation applicators:

1. Welding generators, 400 amp., for every two weld guns.

2. Weld gun of the timed-volt-ampere type, equipped with proper chuck and ferrule holder.

3. Spray equipment with necessary compressed air and accessories.

4. Hand electric drill for extra holes for weld-pins. Canvas or rubber gloves for wiping on coating.

As mentioned, code requirements or

considerations sometimes prohibit field welding of even light metal such as welding studs on equipment. In these cases, the present conventional methods of supporting insulation with steel clips, etc., must be provided, and the insulation secured with cables, bands, or wire. Also, provision must be made for expansion joints. However, from this point on, packing, reinforcing and weatherproofing procedures described can be followed. The galvanized sheet metal strip at expansion joints can be installed as noted below.

When the use of welding studs is not prohibited, and it is desired to use cables or bands, the steel supports can still be eliminated by using welding studs on only the bottom row of insulating blocks, where the insulation starts, and immediately above the planned expansion joint. Since this row of blocks is fixed, and the material has sufficient strength to carry the insulation above it to the next expansion joint, shelf angles are not required. The intervening insulation can then be attached by cables or bands.

Again, a sufficiently strong material permits the construction of a simple expansion joint by nailing a 6 to 8-in. wide strip of galvanized sheet metal to the insulation immediately above and over the joint. The glass fabric for the section above the joint is started flush with the lower edge of the sheet metal and carried upward without restraining the possible motion in the joint. It should be noted that the glass fabric and weathercoating is carried up to the top of the insulation just below the joint before attaching the metal strip. This permits vertical motion of the metal strip without exposing any insulation to weather.

If staggered block construction is used, the blocks are installed beyond the planned expansion joint, and each block above the joint attached with welding studs. Then the alternate blocks which span the joint are sawed completely through and the metal strip attached as mentioned.

Requisitioning Insulation Materials

With this system of insulating a more carefully organized material take-off is required. However, with the proper factors and tables the amount of each material can be arrived at readily with little more effort than heretofore.

It should be noted that there is no doubt as to the exact quantities of each material needed when the take-off is completed, because the surface areas, length of pipe insulation and number of fittings have been specified. This more positive estimate of quantities is possible because it is known where each type of insulation begins and ends, which had not been true in the past when builtup fittings overlapped pipe insulation.

Therefore, it is no longer necessary to purchase excess material in large quantities to make certain there is sufficient quantity at the job site for completion. For the application procedure described, no material is ordered in excess of 1½ to 3 per cent above the take-off quantities. On foreign projects, these excess quantities are increased slightly.

Specifications . . . Under this system, the designing engineers indicate sizes and lengths of all units, and the thickness of insulation required. Since the demarcation between single and shiplapped layers is 700° F., expected operating temperatures are indicated merely as above or below this temperature. By limiting the specification to such simple notation, the designing engineers have not placed in the hands of the manufacturer of insulation valuable data on expected operating temperatures which they may wish to keep confidential.

From the writers' experience, this system involves some added engineering time. The insulation manufacturer determines quantities required to insulate irregular shapes since these quantities can best be determined by the manufacturer, who adjusts quantities to the dimensions of the pieces of insulation he makes.

Simplifications . . . In order to simplify taking off and summarizing insulation materials for requisitioning, standard sketches and tables have been developed for use with equipment drawings, insulation design specifications and to-scale single line isometric drawings. The procedure serves as a quick means for determining the shape, securement, reinforcement, weathercoating, and joint requirements for any given piece of equipment and pipe size for any temperature and insulation thickness.

Identification marks for the various insulation shapes are also obtained, partially by codes. It should be noted that this procedure in quantity survey gives the quantities of piping and fittings at the same time that it gives quantities of insulation. Final quantities to be ordered are obtained by multiplying the square feet of areas or the lineal feet of piping by factors. It is emphasized that this includes the quantities of auxiliary materials as well.

Identification System for Insulation Material

Because all materials are "tailor made" pieces, and each piece has a definite place in the over-all erection scheme, the manufacturer marks each piece and the carton in which it is shipped to identify its use. When items are interchangeable for dimensions on several pieces of equipment, for example, all interchangeable identifications are used.

Sample of marking:

"A tower 80 ft. high on the shell and 10 ft. in diameter with 2-in. thick insulation, having ellipsoidal heads, designated E-101, would have each shell insulation piece marked 120 x 2, with the cartons marked 36 sq. ft., 120 x 2 E-101, and each piece of head insulation marked, Hinged Block 2, with cartons marked 36 sq. ft. Hinged Block 2 E-101. For five 6-in. butt-weld elbow insulation, 2 in. thick, shop-coated with weathercoating, each piece would be marked 6 x 2 BWL and cartons marked 5 Butt weld Ell Coated 6 x 2."

Detailing special insulation . . . Because it is impractical at this time to standardize all insulating materials including special shapes or dimensions, it becomes necessary to detail either new pieces of insulation for shop fabrication or to use combinations of standard pieces. The decision must be made on the economics of shop or field fabrication, taking into account the cost of possible added engineering, manufacturing and shipping difficulties and handleability in the field. When the decision is in favor of field manufacture, the proper pieces must be requested for easy assembly, and instruction for erection forwarded to the field.

Storage Arrangement

The storing or warehousing of any kind of material on any size project is always a problem, with its major difficulty the easy withdrawal of specific items. To avoid rehandling of materials in finding specific items, or due to errors in selection, the markings described permit predetermined locations in the storage area to be used immediately upon removal of shipments from railroad car or truck.

More care in locating items upon receipt at the warehouse has been found to save an appreciable time when withdrawals are made. However, the keeping of records of receipts and withdrawings accompanying the actual moving of the materials, enables an accurate running record to be kept available at all times. This is particularly desirable when partial shipments from the manufacturer are being handled.