Guidelines for the Selection, Use, and Handling of High Temperature Insulation

TR-108622

Final Report, October 1997

Prepared by
Northern States Power Company
1518 Chestnut Avenue North
Minneapolis, Minnesota 55403-1292

Authors
E. Fore
J. Meier

Consultant
I. Zenker

Prepared for
Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, California 94304

EPRI Project Manager
J. L. Tsou
Generation Group

ORGANIZATION(S) THAT PREPARED THIS REPORT

Northern States Power Company

ORDERING INFORMATION

Requests for copies of this report should be directed to the EPRI Distribution Center, 207 Coggins Drive, P.O. Box 23205, Pleasant Hill, CA 94523, (510) 934-4212.

REPORT SUMMARY

This guide addresses design considerations for selecting replacement materials based on reviewing acceptable operating experience; handling new and used insulating materials safely; and identifying training criteria for personnel that come in contact with insulation. The user can complete an economically sound, energy conserving, and safe insulation maintenance project by applying this guide.

Background

A typical utility has multiple operating units that vary in age from new to decades old. Each unit has systems operating at temperatures ranging up to and in excess of 1,000°F (537° C). A portion of system insulation is removed and replaced each year, with little thought given to its effect on plant operation, or the options that may be available. With asbestos use limited, various materials have been tried as replacements. While no single material has been found to equal the durability, workability, or the general load carrying capacity of asbestos, some of the new materials have held up well at lower to midrange termperatures. Most, however, have experienced some form of failure at elevated temperatures.

The guide is based on utility experience at coal-fired sites that are operated with a mix of insulation types found under typical plant conditions. Plant systems include boilers, piping, wet and dry scrubbers, bag houses, hydraulically ponded slurry, and pneumatically conveyed ash. The report draws much of its information from the experience and practices of Northern States Power Company insulators working at the Sherburne County Generating Station, which was under construction during a period that coincided with asbestos prohibition.

Objective

- To develop a practical guideline for the selection, use, and handling of high temperature insulation

Approach

The project team reviewed the information gathered from the experience and practices of insulators working at the Sherburne County Generating Station. The team also reviewed manufacturer's literature, insulation trade workers' manuals, and other related industry sources. They developed guidelines on insulation removal, insulation material selection, insulation system design, and general installation practices. They

also addressed monitoring and air quality concerns and personnel training needs for removal and reinstallation of insulation material.

Results

Insulation used on high temperature steam generators, boilers, turbines, and related power piping systems are generally expected to function continuously at temperatures of 700° F (370°C) to more than 1,000°F (537°). These materials typically include mineral wool, calcium silicates, ceramic wool, and expanded perlite. Perlite has demonstrated good durability and thermal characteristics but has the least historical data of the group. Ceramic wool, while exhibiting good insulating properties, has been found to have durability problems. There are a number of other materials that could be used, all with their pros and cons, but the major factor that limits the choice is installed cost. The material selection and installation should take operating and maintenance foot traffic, gravity, and vibration into consideration. The report suggests placing higher density material, such as calcium silicate, on the top 180° of the pipe, and lower density material, such as mineral wool, on the lower 180°. Also critical, is providing adequate support to prevent sagging.

Perspective

This guide explained the values and short comings of several types of insulating materials and how to utilize their best physical and economic properties. The guide's intent is to help utility users evaluate and maintain high temperature insulation systems. New techniques continue to be developed by insulation manufacturers. Additionally, other organizations, including ASTM and ISO are developing practices and guidelines for the industrial designer and user.

TR-108622

Interest Categories

Fossil steam plant performance optimization
Fossil steam plant O&M cost reduction
Plant maintenance assistance
Plant support engineering

Key Words
Thermal insulation
Asbestos
Maintenance
Steam pipes
Life extension
Air monitoring

ABSTRACT

A typical utility has multiple operating units that vary in age from new to decades old. Each unit has systems operating at temperatures ranging up to and in excess of 1000 degrees Fahrenheit (537C). Portions of system insulation is removed and replaced each year without much thought about its affect on plant operation or the options that may be available.

The intent of this guide is to help utility users evaluate and maintain high temperature insulation systems. Information is based on power house experience in Minnesota over the past twenty years and a balanced perspective providing for continued equipment operation, maintenance of insulation properties and worker safety. These views are based on work within multiple power houses, but should not exclude other reasonable insulation options.

This guide addresses design considerations for selecting replacement materials based on acceptably operating experience; handling new and used insulating materials safely; and identifying training criteria for personnel that come in contact with insulation.

ACKNOWLEDGMENTS

Black and Veatch, the design engineer for Northern States Power Company's three Sherburne County generating plants.

National Commercial and Industrial Insulation Standards, published by Midwest Insulation Contractors Association, 1979 edition.

United States Department of Energy publication number ORNL/M - 4678, Industrial Insulation for Systems Operating Above Ambient Temperature.

ASTM publication number 04.06, Thermal Insulation, 1995 edition; PCN 01-040695-61.

Stephen S. Miller, Long Island Lighting Company, Power Engineering, August 1985, computer program to calculate heat loss for insulating materials.

United Nations World Health Organization, Red Book Monogram Series, International Conference on Manmade Mineral Fibers; publication NR-77, 1988 edition.

Refractory Ceramic Fibers Coalition , an insulation manufactures group.

Power Engineering, August 1995, Stephen S. Miller, Long Island Lighting Company, computer program to calculate heat loss for insulating materials.

SUMMARY

This guide is based on utility experience at coal fired sites operated with a mix of insulation types and operating under typical plant conditions. Plant systems include boilers, piping, wet scrubbers, dry scrubbers, bag houses, hydraulically ponded slurry and pneumatically conveyed ash.

Every capital and maintenance project provides opportunities to apply sound engineering principles, economics and energy conservation during the selection and installation of insulating material. The practices and suggestions of this guide have been successfully demonstrated, but should not be viewed as a limiting other creative uses or maintenance of insulation.

It remains the responsibility of each owner and user to ensure adequate training of their operations, maintenance and engineering personnel to ensure public health and safety.

It should be recognized that new techniques and applications continue to be developed by the producers of the insulation products. Additionally, other organizations including ASTM and ISO are developing practices and guide documents for the industrial designer and user.

CONTENTS

LIST OF FIGURES

1

HISTORICAL BASIS

This report draws much of its information from the experience and practices of Northern States Power Company insulators working at the Sherburne County generating station. The Sherburne plant is located in central Minnesota and is a three unit station designed by Black & Veatch and built during the seventies and early eighties. The combined capacity of the three coal fired units is 2400 MW net.

Sherburne County's construction happened at a period of time when asbestos was newly prohibited and there was a scramble to find the right combination of materials needed to replace it. Some of the new materials have held up well at lower to midrange temperatures, but most have experienced some form of failure at elevated temperatures. This guide provides a general insight into the selection, application technique and disposal of insulating materials.

During the intervening years since the use of asbestos has been limited, a variety of materials have been tried as asbestos replacements. No single material has been found to equal the durability, workability or the general load carrying capacity of asbestos. This guide discusses the values and short comings of several types of insulating materials and how to utilize their best physical and economic properties.

Most insulating materials placed in 1000F (537C) environments have a sacrificial contact zone where some original design properties are compromised. It is important to provide for this sacrificial zone during preparation of engineering and maintenance specifications so that thermal parameters are maintained within system tolerances. A benefit of maintaining thermal characteristics is the assurance it provides for personnel and equipment safety, and process integrity.

2

UTILITY INSULATION

Insulation used on high temperature steam generators, boilers, turbines and related power piping systems are generally expected to function continuously at temperatures of 700F (370C) to more than 1000F (537C). These materials typically include mineral wool, calcium silicates, ceramic wool and expanded perlite. Perlite has demonstrated good durability and thermal characteristics, but has the least historical data of the group. Ceramic Wool, while exhibiting good insulating properties, has been found to have durability problems. There are a number of other materials that could be used, all with their pros and cons, but the major factor that limits the choice is installed cost. All applications do include economic considerations as well as the obvious need for adequate workmanship.

Application techniques are compiled from experience, manufacturer’s literature, insulation trade worker’s manuals and other related industry sources. The described techniques have been used, practiced and altered to reflect the changing requirements of the design and to ensure the best results within the limitations of each material. Many techniques described by this paper have been used since the early 1930s and are as applicable today as they were 60 years earlier.

Reference is made throughout the paper about burn out of insulation binders in mineral wool and fiberglass. The burn out process involves the vaporization at 450F (232C) of the common binder urea formaldehyde. The burn out process occurs at different times within an insulation dependent on the gradient temperature across the insulation. Burn out is normally accompanied by an ammonia smell as the binder breaks down.

In the past, the disposal of non asbestos insulation has not been considered a major environmental or social problem. But, with changing social consciousness, laws and the ongoing environmental testing of materials, it has become more important to consider the best near and long term options for disposing of insulation material. The World Health Organization has classified several insulation materials as possibly being carcinogenic. There is a growing concern in the insulation industry that someday all insulating material will require handling similar to that of asbestos. Well thought out and adequately documented programs implemented today, which describe good handling and disposal practices, may save future dollars in rework or reclamation.

Most used insulation will be scrapped, but consider using this material as filler or as a sacrificial layer in reworked areas. A problem with reuse of material is its storage and handling versus actual value. Used items generally should have a short or nonexistent shelf life since their value is equated against storage costs, and may have handling problems due to dusting from binder breakdown, or contain potentially unacceptable contamination from its previous service location. Near term considerations should include adequately trained and protected workers, good records, documented disposal methods and an accounting of disposal locations.

3

INSULATION REMOVAL

A best practice consideration for removal of insulation involves pulling off full sections of material. Use of full sections minimizes reinstallation time and material cutting requirements. If material is removed between specific points without consideration of existing seams you are likely to end up with circumferential gaps, material to dispose of and settling of material because of shifting of vertical runs. The bottom line, it is best to remove from seam to seam. Another insulation consideration should be what pipe or component is most likely to require inspection or maintenance. Consider a branch line off of a main piping run that is known to require periodic inspection, the insulation covers and material should be installed so that removal can begin on the branch line.

Insulation may be removed by hand or with the aid of a machine. Work often requires that insulation be removed when equipment and systems are still at high temperatures or the system is in service. Platforms, personnel protection and equipment covers should be provided to ensure worker contact is limited.

Manual removal should include the use of poly trash bags for cold material or cardboard boxes for hot materials, and the appropriate gloves, clothing and respiratory protection. Tools required are hand saw, wire cutter, knife and screw gun with 1/4 inch (6.3mm) bit. Hot materials are collected in cardboard boxes, but should be bagged in poly after they have cooled. Cool materials can be handled with disposable rubber gloves to better protect the occasional worker from dermatitis and to minimize the spread of fibers. Respirator requirements are generally a half mask, with a HEPA filter when dust and fiber removal is a concern. Disposable coveralls are recommended for larger jobs to avoid contaminating the personal clothing or the possibility of the worker’s home laundry.

Blankets that are still hot should be carefully laid out after their removal to prevent “contraction pinching” during cool down. Hot removal of blankets will cause an increase in airborne dust from convection around the exposed equipment, and should be performed gently to minimize this problem. Hot blankets are more easily torn and the lacing hooks, generally too hot to the touch, are susceptible to pulling through the blanket.

Insulation removal from walls and flat surfaces has a few additional handling concerns related to fiber dusting. Vertical wall panels fall apart easily without chicken wire to retain them and for this reason are best worked from the top down. Dusting from overhead panels is even worse. Cut and fold back chicken wire for reuse. On multiple layer applications try to stagger material removal to maintain seam integrity. Bulk removal using a vacuum truck is the preferred method of handling any dusty insulation.

Cold removal of pipe and valve insulation is preferred because it reduces the amount of airborne fiber. Jacketing can be scored using a utility knife and peeled back in partial sections to minimize area of removal. When insulation is very burned out, it may be best to remove any chicken wire retainer and insulation as a unit. Remove complete sections when possible to minimize cutting of replacement material. Use a knife or a saw to cut for removal since tearing or breaking only creates dust and increases replacement labor. If material is removed hot, use the boxes the replacement material came in or the removed system jacketing to catch the insulation debris.

Machine removal includes the suction and wet down of the material to help speedup insulation removal, control dust conditions and minimize hot material contact and reduce the required cool down time. There is less airborne fiber if wet down is done on cool insulating materials. NSP uses truck mounted vacuums and permanently installed plant vacuum systems to aid in insulation removal. A 6 inch (15.2cm) line is the minimum vacuum feed to the work area, where two 4 inch (10.2cm) connections are wyed from the 6 inch (15.2cm) feed. A waterline is inserted into one of the two 4 inch (10.2cm) lines to wet and cool the removed insulation. The vacuum system's filter is run in the bypass mode to prevent its 'blinding' and loss of suction. Most wool materials easily shred and are unlikely to clog the removal system, but Calcium Silicate and similar products may need a little extra care to ensure they're in small enough sizes. Machine removed materials are normally directed to a controlled landfill, often on site.

Wool insulation, even with binder burnout, can be reinstalled on smaller diameter systems simply to improve that system's overall thermal efficiency. Undamaged calcium silicates are always reused. Damaged calcium silicates may be used as void fillers, with the remaining disposed of to a solids disposal area. Other products such as Styrofoam's, low temperature fiberglass, foam rubbers and others that retain their properties can be set aside for reuse. A rule of thumb is that salvaged insulation should be at least 3 foot (0.91m) in its major dimension. Boiler wall material is not usually salvageable, but works well as a fill-in for areas such as ducts and building walls. Most turbine insulation is either blankets, calcium silicate or spray on. Because of turbine temperature, vibration and maintenance foot traffic, blankets are normally the only salvageable item.

Handling and disposal of insulation should recognize that free silica (crystalline quartz) may exist in some used materials where the binder has burned out or the material has experienced mechanical degradation. Airborne and surface contamination protection should be specifically addressed in a site maintenance and safety programs. For large scope removals or jobs of extended duration, air sampling of the area and the insulation worker may be the most effective way to establish the safety program's base line for your formal protection plan. Disposal should be to areas that do effectively control free silica. One possible location for used insulation is to place it in a controlled ash pond. Some studies have been done on the use of insulation as an additive to asphalt and concrete, todate these studies have not resulted in a recommendation. The currently unregulated disposal of insulating material should be treated as a potential future regulation issue. At a minimum, annual records should be maintained of which employees and contracting companies were involved in providing insulating activities for each unit. These records should include where the bulk of the disposal was directed and what handling programs were in place at that time. Additionally, it would be useful to note what permits or pollution control standards were in place during any particular period.

4

GENERAL INSTALLATION PRACTICES

Operating and maintenance foot traffic, gravity and vibration need to be considered for all installations. Sag results when an insulation material loses a portion of its cross section on top or vertical surfaces, resulting in a gap between the object's lower surface and the insulation. Sag on horizontal runs can be minimized with additional strapping and reinforcement. Gravitational drift on vertical runs can be minimized with closer spacing of support rings. Loss of cross section due to foot traffic should be addressed through the use of denser material on the traffic surfaces.

Wool type insulation comes in pre-formed half sections for pipe 1/2 through 24 inches (1.3 - 60.9cm) . As with any low density pipe insulation, the best economics for loaded horizontal runs is to place higher compressive material on the top 180 degrees for pipe up to 12 inch (30.5cm) diameter, the top 90 degrees for pipe sizes 14 through 24 inch (35.6 - 60.9cm) diameter, and for pipe over 24 inch(60.9cm) diameter it should be that area that lays nearly horizontal between the vertical members of any 'U' bolt type pipe hanger. Refer to figure A-1 and A-2.

Insulation sag in vertical pipe runs can be reduced through proper support ring sizing and spacing. Support rings that previously were satisfactory for asbestos are not wide enough to support wool insulation. Similarly, wool insulation is less rigid than several other types of insulation and must be supported more frequently to minimize crushing. The use of intersecting pipe to support vertical insulation is not considered adequate unless the surface contact is at least equal to 90 degrees of the insulation outer circumference. Support rings should be considered adjacent to pipe butt welds when periodic inspection of the welds is anticipated. Additional support ring design specifications are described in figure A-4 and A-5.

On flat surfaces, such as boiler walls, insulation boards should be supported by a minimum of two rows of weld pins. This would require that weld pins be placed on 12 by 12 inch (30.5x30.5cm) centers instead of the industry convention of 12 vertical by 18 inch (30.5x45.7cm) horizontal. Standard board size is 24 by 48 inch (60.9x121.9cm) and use of a 12 x 18 (30.5x45.7cm) pin configuration can result in some board material being supported by a single row of pins. Figure A-12 represents a typical multi-layer boiler wall insulation system, while figure A-6 and A-7 give additional placement detail for boiler and duct surfaces. Proper lap and pinning will minimize any loss of energy from open joints or chimney effects. The use of Weld pins to hold insulation is particularly good where there is high frequency vibration. Most heavy component shells have welded nuts attached for bolting insulation permanently into place. When a component is brought out of service for maintenance it is helpful, when needed, to replace these bolts with weld pins fabricated from set screw or allen head screw studs. The fabricated pin, figure A-10, can be looped on the top side for firmer application of blanket systems by creating a wire tie point, and on the bottom either by penetration or loop and tie. Penetration and clip works well on the bottom applications where the blankets are seldom removed. An additional benefit of fabricated pins is they aren't as likely to be used as a foot support, often resulting in a broken welded nut to a casing.

Chicken wire has been used to retain insulation for many years. It has been recognized that galvanized wire is not suitable for working temperatures over 350F because of zinc embrittlement. Stainless steel chicken wire is a little more expensive but appears to be the required solution to higher temperature installations.

Equipment with irregular surfaces, such as turbine shells and boiler feed pumps, generally use a combination of materials dependent upon the frequency of expected maintenance. Typical insulation methods include removable flexible blankets, hard blocking with calcium silicate or spraying with loose filler material held in place with chicken wire. Spray insulation's have been found to loosen and settle under vibration. Blanket materials exposed to temperatures between 800F and 1050F (426 - 565C) have experienced fabric break down, with stainless steel mesh over fabric and vermiculite coated cloth having faired no better than fabric blankets. The use of a stainless steel foil for blankets has demonstrated better durability. Figure A-13 shows insulation placement practices for turbine shells or similar large equipment with traffic and access requirements. The figures do not show the solution to interfacing piping, instrumentation and the like. The concept of 'sacrificial insulation' has proven valuable where turbine surfaces and integral piping are used for climbing to gain access by maintenance. Wrapping pipe with amorphous fiberglass insulation blankets such as "Temp-mat" and then covering it with aluminum or stainless foils provides a semi durable surface that can also be used to contain the insulation during its removal and disposal. Very small lines should be covered with ceramic wool and foil for its economy and ease of disposal. Often equipment piping is insulated without coverings when clearances between pipe are small or it is better to have the insulation breathe. Even blankets and jacketing do eventually tear and fail under severe maintenance foot traffic. Additionally, blankets should not be used on equipment where lubrication from leaking bearings could cause the blankets to become a fire hazard. If blankets are the only option and lubricants are present, stainless steel blankets are considered the better material. Blanketing use is generally preferred over hard blocking where access to bolting, instrumentation or frequent maintenance is expected.

5

DESIGN CONSIDERATIONS

SINGLE LAYER

Horizontal pipe runs are covered with mineral wool, calcium silicates or expanded perlite. Mineral wool is supplied in pre-split full sections and calcium silicate or perlite are supplied in half sections. Longitudinal seams should be placed at 3 o'clock and 9 o'clock to avoid the creation of convection paths. Prefabricated insulation elbows are the best choice for pipe larger than 4 inches (10.2cm). For small pipe, it is more economical to cut straight lengths at 45 degrees, shave the heel area and install a metal elbow jacket. For pipe 14 inch (35.6cm) and larger, mitered and gored elbows are used. When binder burn out is a concern, top surfaces of pipe should be insulated with calcium silicate or perlite. Other surfaces of the pipe may not require calcium silicate or perlite where crushing may not be an issue. The system designer should be made aware when denser insulation materials are used so that proper pipe hanger spacing and settings can be verified for the increased load. Refer to figure A-1.

Vertical pipe runs are similar to horizontal types except for the concerns for convection and support. The issue of support is particularly important for long runs of pipe and is addressed by support rings described by figure A-4 and A-5.

Boiler walls and high temperature duct walls should have board edges lapped (stepped) a minimum of 1/2 their thickness. Steps are made as part of the field installation, and may be omitted on lower temperature applications with minor loss of insulation integrity. Bottom applications of insulation board are held in place with chicken wire, and by weld pins placed on 12 inch (30.5cm) centers. The use of chicken wire on the top surfaces is optional and is good practice when vibration or insulation movement is a concern. Sides should have chicken wire except when lagging rests directly against the insulation. Corner laps of the insulation board are accomplished by over hanging the top and bottom panels past the vertical surfaces the thickness of the insulation board. Refer to application figure A-6 and A-7.

MULTIPLE LAYERS

Multiple layer horizontal pipe runs are basically the same as single layer, except that seams between layers should not line up. The outer most longitudinal seam should be at 3 o'clock and 9 o'clock to avoid the creation of convection paths. When denser insulation material is used for top face reinforcement its longitudinal seams should be at 10 o'clock and 2 o'clock. Some staggering between layers needs to occur to minimize heat loss through the insulation's circumferential joints. See examples of figure A-2.

Multiple layer vertical pipe runs are similar to horizontal types, except for the concerns for convection and support. Support rings should be wide enough to contact insulation over 2/3 of its cross-sectional surface. Support ring spacing needs to be designed to carry the insulation load without crushing or deforming the lower portion of an insulation run. Supporting vertical insulation on intersecting pipe often can result in crushed or torn insulation and lagging. It is best to add a support ring when the vertical pipe is larger than the intersecting horizontal line. Because of thermal growth, an expansion area needs to be provided on the top of each run of insulation material, just beneath the next support ring. Examples of support rings are shown as figure A-4 and A-5.

Boiler walls and high temperature duct walls should have seams staggered between layers to avoid convection paths and hot spots. The minimum joint stagger should be the total depth of all insulation material on that surface. Attachment criteria are the same as for single layer applications. Corner laps of the insulation board are accomplished by over hanging the top and bottom panels past the vertical surfaces the thickness of the insulation board, and progressively extending the over hang for each successive layer. Refer to figure A-7 and A-12.

GENERAL DESIGN CRITERIA

The following criteria should be considered during the designer's selection of an insulation system.

Location

System components which are located close to each other may affect the thickness of the material that can be applied. Close bundling of piping in an area may also affect the design of an insulation system. Some equipment insulation may require protection from localized vibration or excessive ambient temperature. Other location factors could include access to equipment for maintenance such as boiler penthouse areas, exposure to foot traffic, or how an adjacent area is used (e.g.: in a machine shop steel storage area there is potential for frequent impact abrasion to adjacent insulation).

Environment

An insulation system's longevity can be affected by its exposure to natural conditions of weathering or from adjacent processes, including the use of caustics and acids or exposure to system leaks and spills. The insulation material may even contribute to the problem through its reaction with a spilled material, such as wicking of a liquid or the corrosion of the item the insulation was installed to protect. Water proofing is commonly provided for otherwise unprotected exterior applications. Differential thermal conditions can cause loss in the effective insulating values, often as a result of system location within a plant such as proximity to vents, louvers or doors.

System Temperature

Generally systems are insulated to keep temperature in, although there are applications such as molten glass furnaces where a calculated loss is desirable. A United States Department of Energy Guide line recommends 6 inches (15.2cm) of insulation as the minimum required to protect personnel when surface temperatures are between 800 and 1200F (426 - 648C). The DOE allows the thickness to be reduced to 5 inches (12.7cm) when the area is not readily accessible and warning signs are posted.

Insulation Material

Besides concerns for environment and location, material selection should the consider insulation strength requirements for service conditions affected by gravity, maintenance rigging and the direct physical support of the insulation. High compressive strength materials can, in some instances, be replaced with lower strength materials to create a cost savings of both material and labor. The addition of cradling support for low strength material can minimize the effects from gravity and vibration, and can be economic choices for out of the way locations.

Jacketing

The standard material for covering insulation continues to be aluminum, with others being stainless steel and cloth. Jacketing needs to be selected based on required durability and the known environmental exposure. Roll aluminum of 0.016 inches (.41mm) works well on piping 12 inches (30.5cm) and smaller, with 0.020 (.51mm) of an inch used on piping up to 24 inches (60.9cm). Over 24 inches (60.9cm) thickness should be 0.024 to 0.028 inches (0.61 - .71mm), with any thickness' greater than this requiring flat sheet material. Cloth was the traditional jacketing material through the middle of the 1940's, with most plants using 4 or 6 ounce (113 - 170 gram) gauze or blanket type of cloth. The more durable fiberglass cloth is now the common material. Cloth jacketing does not withstand moderate to severe abuse. Where long service life is needed, stainless steel is the best economic choice.

Removable systems can be either of the rigid or flexible style. Rigid systems of lagging involves the prefabrication of metal boxes and shapes that can withstand repeated handling without losing their shape. Flexible systems involve the use of blankets or foils on equipment of irregular shape.

When jacketing components or piping intersections the use of scalloping versus tabs should be considered. Scalloped branch line jackets can be removed without taking apart the main run. This idea works well on bonnet valves where the bonnet can be removed without disturbing the body jacketing or insulation. Another consideration for bonnet valves is the use of a blanket over the bonnet rather than lagging. A general rule to follow is use a blanket when you expect to remove the lagging and insulation more than twice. Refer to figure A-3.

Accessories

Elbow covers, banding, color coding and wire are necessary to complete a structurally neat and workman like installation. Selecting accessories should consider issues of required durability, environmental exposure and for wire its design temperature. Elbow covers include a universal type for smaller size pipe that use short radius butt and socket welded elbows, or specific style preforms available up to 24 inches (60.9cm). Hand fabricated gores are usually used for pipe runs over 16 inches (40.6cm) in diameter. The larger radius sweeps on large diameter pipe can be made from straight sheet metal pieces.

Some wire and banding products can not maintain their integrity when subjected to high temperatures for extended periods. This is particularly true of galvanized chicken wire, which breaks down when temperatures are consistently over 350F (176C). Eighteen gauge wire is used for piping insulation less than 12 inches (30.5cm) in diameter and 14 gauge for piping between 12 and 24 inches (30.5 & 60.9cm) in diameter. Banding is always used for pipe diameters greater than 24 inches (60.9cm). Experience has shown that stainless steel wire used for calcium silicate products will fail due to stress corrosion when moisture is present, or when a system experiences many thermal cycles. Failure of Stainless steel wire is usually remedied by replacing it with aluminum banding.

Care should be exercised when wiring calcium silicate sections together because of insulation cracking due to over tightening. Banding pressures are easier to control than those of wire, but it can still be over tightened causing insulation fracture.

Banding comes in a variety of styles and can help identify a system much like a label or tag.

Maintenance

When designing a system's insulation, worker access is an important factor. Permanent insulation can be provided with access windows or ports when systems are frequently worked on or require on-line inspection. Most maintenance is typically performed during outages with the permanent insulation fully removed. It is generally more economical to group infrequent inspections and fully remove permanent insulation. Removable lagging is often cumbersome and presents its own access problem for removal and reinstallation, and needs to be protect while stored.

Replacement of insulation and lagging should consider future and past maintenance access. Figure A-8 details typical solutions for insulating flush valve bodies, elevated bonnet valves, flanged piping intersections and angle valves. Maintenance access should include sufficient insulation cut back to allow for required seal welds. Boilers, vessels and other components may have bolted access doors that are flush, raised or over extended. Insulation systems and man-way covers need to provide for access to both the bolt heads and their nutted surfaces. Refer to figure A-9.

ECONOMIC THICKNESS

The most economic thickness of insulation is that amount that meets energy conservation criteria without exhibiting an over kill in the design thickness. Included parameters are the cost of energy saved versus the cost of the insulation system, and the related time it takes to recover insulation costs.

The United States Department of Energy has established economic guidelines for insulation as a result of the 1992 Energy Act. Figure A-15 represents a set of economic thickness' that are based on environmental values of ambient temperatures equal to 70F (21C) and a steady air movement of 10 mph (16kph). The insulation surface was assigned a value of 0.1 since most industrial insulation is jacketed. The reflected strategy is to minimize annual costs while projecting a seven year life for an insulation system. The cost of energy was assigned variable rates of $3 to $10 per million BTU. Cost estimates have included considerations for energy conversion efficiency and related thermal operating losses. Calculations were limited to insulation of 10 inches (25.4cm) and less.

An article from Power Engineering, August 1995, provides a graphical presentation for selecting an economic thickness of insulation. Most programs relate the insulation 'K' factor in the format of a sine curve based on a some what difficult to use formula. Figure A-14 graphs a straight line of information in a much easier to use format. Points on the line were determined from two criteria, first by increasing the thickness of a given material until there is no appreciable reduction in BTU loss and second by interpolation due to the rounding of thickness values. Insulation comes in 1/2 inch (1.27cm) increments and the attached program either rounds up or provides a value that does require rounding. The straight line graph falls within acceptable bounds for an economic thickness. Consider, that it's always better to round up to the next standard thickness to allow for material degradation or settling. The program, written in a basic language, describes the attached Straight Line Graph of Figure A-14 for 8# (3.6 kg) mineral wool.

6

MONITORING AND AIR QUALITY CONCERNS

The United Nations World Health Organization's International Conference on Manmade Mineral Fibers has expressed concern with the exposure of workers to respirable dusts. The Refractory Ceramic Fibers Coalition has established several insulation industry standards for exposure to air borne fibers. While our test samples did not reveal problems with respirable quarts or cristobalite, we found it prudent for the insulation worker to use 1/2 mask HEPA respirators.

Air monitoring tests were taken for insulation workers and the adjoining plant areas. Completed sampling indicates that the areas of concern do not extend very far beyond the insulation worker.

Most insulation particles, because of their size and density, will not travel any substantial distance except in heavy air currents. Personnel monitors showed significantly higher values than area monitors only ten feet away. Monitoring of personnel performing insulation removal and the monitoring of adjacent areas supports the conclusion that isolation of work and effective handling practices are the best methods to protect area personnel.

Insulation manufactures meet industry standards during manufacturing, but their individual products do have differing life and break down characteristics. Monitoring should consider the brand as well as the product form, so as to establish the pattern of break down and the appropriate removal method and protection.

Personnel training should be established for both the seasoned insulator performing schedule work and those individuals required to perform unscheduled 'emergency' removal.

The application of new materials, with their fibers locked in their binder, do not require air monitoring. Work practices, to minimize general exposure to fibers, should be implemented that reduce excessive material cutting and provide for continuous area housekeeping.

Materials that degrade from extended exposure to temperature can be generally grouped as wool's and calcium silicates. Wool fibers break down across their long axis until they become granular in nature. Finely spun fibers become dusty and cotton like under severe heat and vibration. Calcium silicate products contain fiberglass or other wool material as a binder, and will contribute to dust levels as they experience burn out. The worst insulation exposure problem comes from free silica (cristobalite) formed at very high temperatures. Sampling performed at the Sherburne facilities did not find cristobalite, indicating that insulation temperatures at this site didn't reach the critical temperature of 1800F (981C), as established by the Refractory Ceramic Fibers Coalition. However, a less toxic form of free silica (quartz) does exist in some insulation and becomes available as their binders break down.

Air monitoring reports, figure B-1 through B-13, are included for comparison with the data gathered by others. Sherburne unit 2 insulation is up to 20 years old, while that of unit 3 insulation is generally less than 10 years old. The monitoring report summarizes the respirable dust levels as being within acceptable limits, and requiring only reasonable precautions during handling of insulation materials.

7

PERSONNEL TRAINING

All persons who will be exposed to insulation systems should be given training so that they recognize area requirements and are properly protected. In house programs should address respirator training, plant layout, and related safety manuals.

Craft personnel working with the insulation should be provided training in the suit-up requirements and appropriate respirator protection for the various type of insulation found at a facility. Suit-up training should include foot, hand and head protection including the proper selection of garment based on the temperature or other relevant condition of the insulation. Training should include the appropriate requirements for donning, removal, laundering or disposal for all regularly used protective garments.

Insulation removal training should include standard practices for application and fastening, area protection and draping, storage and disposal of removed material, and general housekeeping requirements.

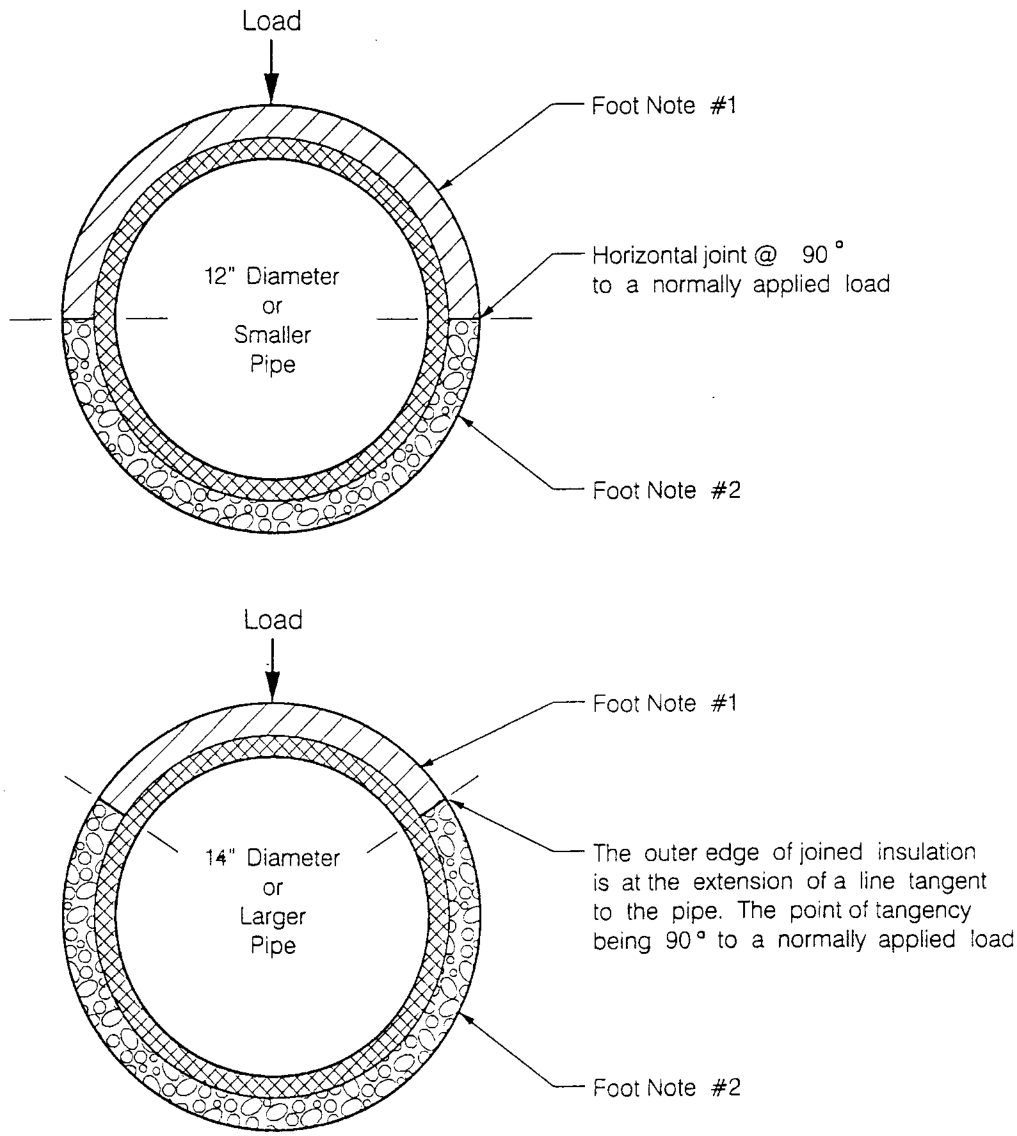
Personal protective clothing includes eye protection, rubber gloves and disposable suits for cool material or leather gloves and cotton coveralls for hot removal of material. Respirators found effective are the 1/2 mask with HEPA filter for all around work, and the PAPR for hot removal for the additional cooling they provide.

Insulators should be trained in the tools and equipment they can be expect to use including saws, drills, wire cutters, knives, scaffolds, and vacuums. The vacuum, as an example, should have three filters in the tank when cleaning up insulation debris. Training for use of Vacuum trucks and systems should include bypass mode operation during water injection for hot material removal.

Other training considerations should be area posting for respirator use, and control of work area drafts and air movers. There are asbestos worker courses that, aside from safety factors, would be applicable to all insulation since the principles, equipment and procedures that apply to asbestos also apply to other insulation material.

A

FIGURES

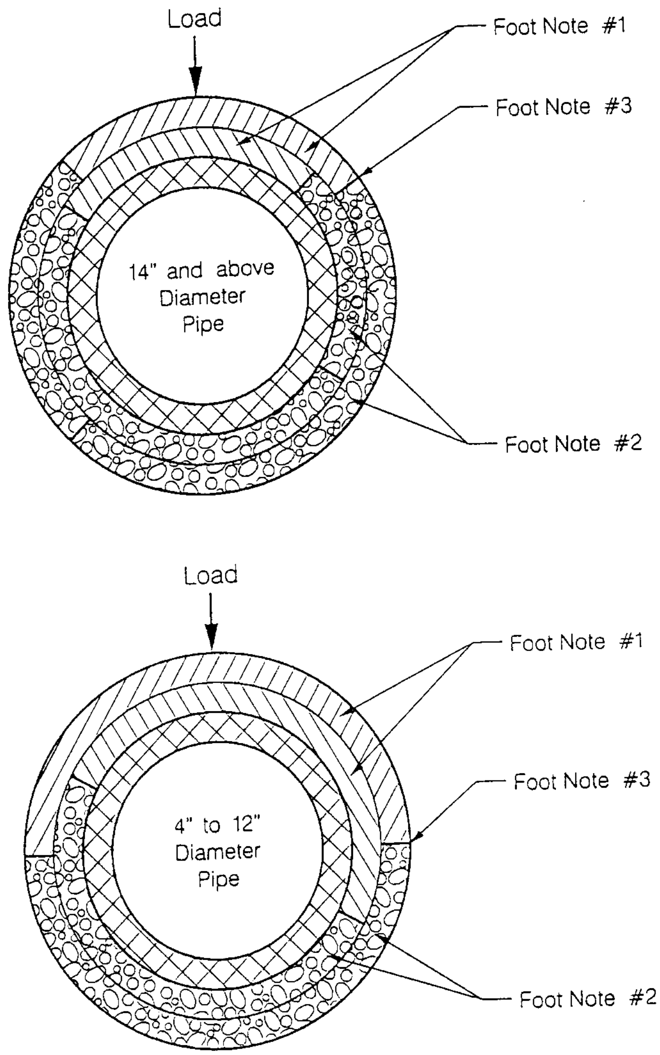


Foot Notes:

#1 Calciun Silicate or other dense material selected for load carrying capabilities.

#2 Mineral Wool or Equivalent.

Figure A-1
Single Layer - Horizontal Pipe



Foot Notes:

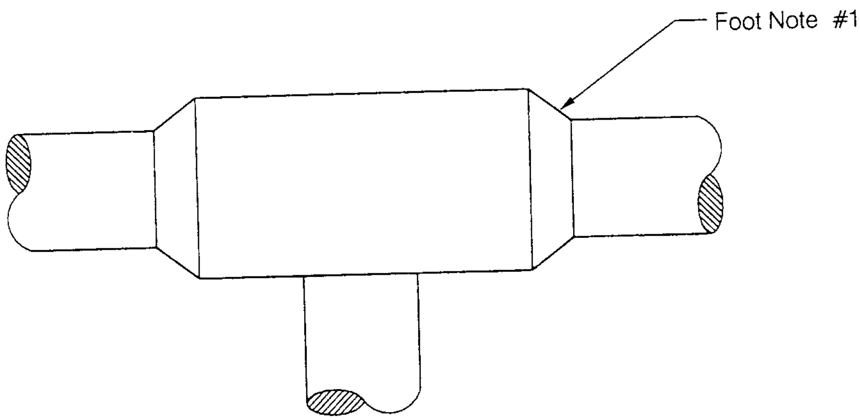
#1 Use 1/2 of 1/2 section Calciun Silicate or Mitered block (over 24") to carry load. Pipe smaller than 24", use 1/2 section of Calcium Silicate.

#2 Mineral Wool or Equivalent.

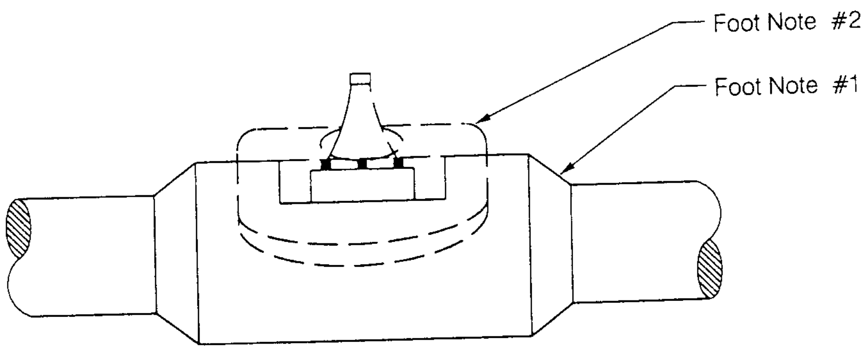
#3 All joints between layers are staggered at least the thickness of the thinner insulation layer.

#4 Wool is used at intersections of pipe or valves for ease of application.

Figure A-2
Multiple Layer - Horizontal Run Pipe



Pipe Intersection



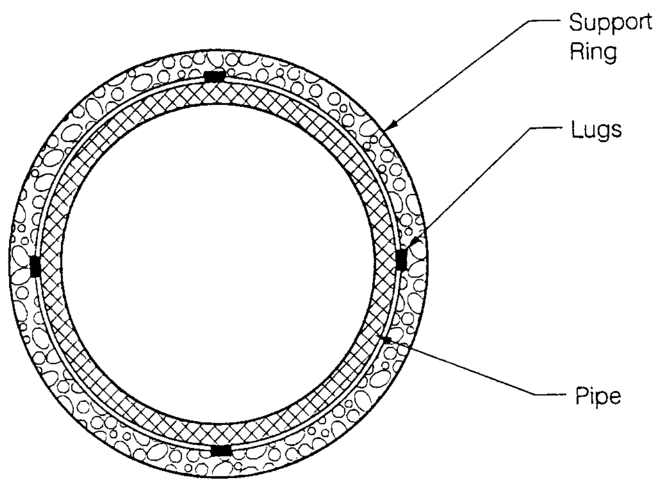
Inline Bonnet Valve

Foot Notes:

#1 To make insulation covers stronger, minimize sag of wool insulation and to center all material, cone shape caps are recommended.

#2 Bonnet valves can be repaired without removing lagging. A simple blanket is made to cover the cut.

Figure A-3
Insulation 'Jump ups' at Pipe and Valve Intersections



Foot Notes:

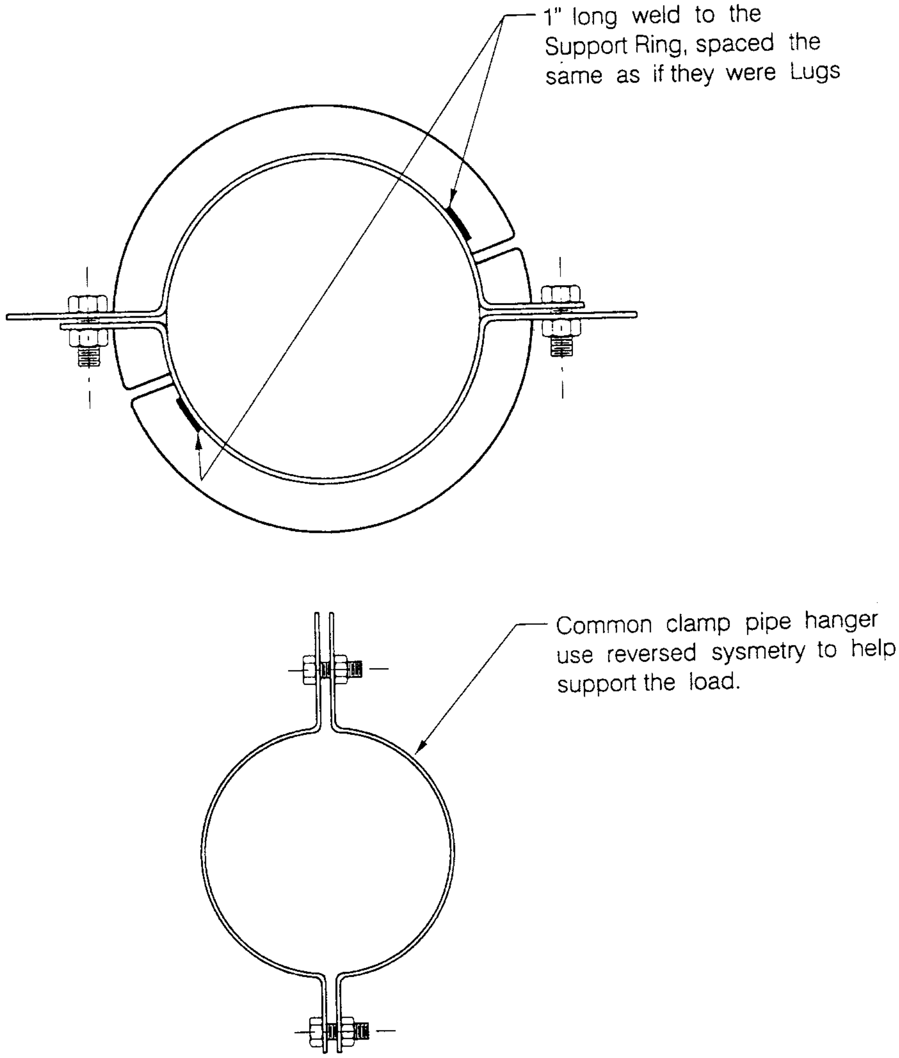
#1 Support ring may be one or two piece, depending on pipe installation. The ring diameter should be sized 1/2" bigger than pipe and 1/2" smaller than insulation.

#2 Lugs are welded to the pipe per the prevailing pipe code requirements. Lugs should be 1/4" thick and at least one inch radially. Spacing should be evenly around pipe circumference.

#3 Number of Support lugs is dependent upon pipe size.
- 36" and larger – 1 lug / 2 ft circumference (minimum of 5)
- 25" to 36" – 4 lugs
- 14" to 25" – 3 lugs
- up to 14" – 2 lugs

#4 Distance between support rings is 15 feet for 14" and larger pipe, and 21 feet for pipe less than 14".

Figure A-4
Insulation Support Rings - Vertical Run Pipe - Lug Support



Foot Notes:

#1 See foot notes of Diagram Number – 04.

#2 When possible, place clamp above crown of weld on elbows changing direction of pipe run from horizontal to verticle. This allows additional support and access to weld for future inspection.

Figure A-5
Insulation Support Rings - Vertical Run Pipe - Clamp Support

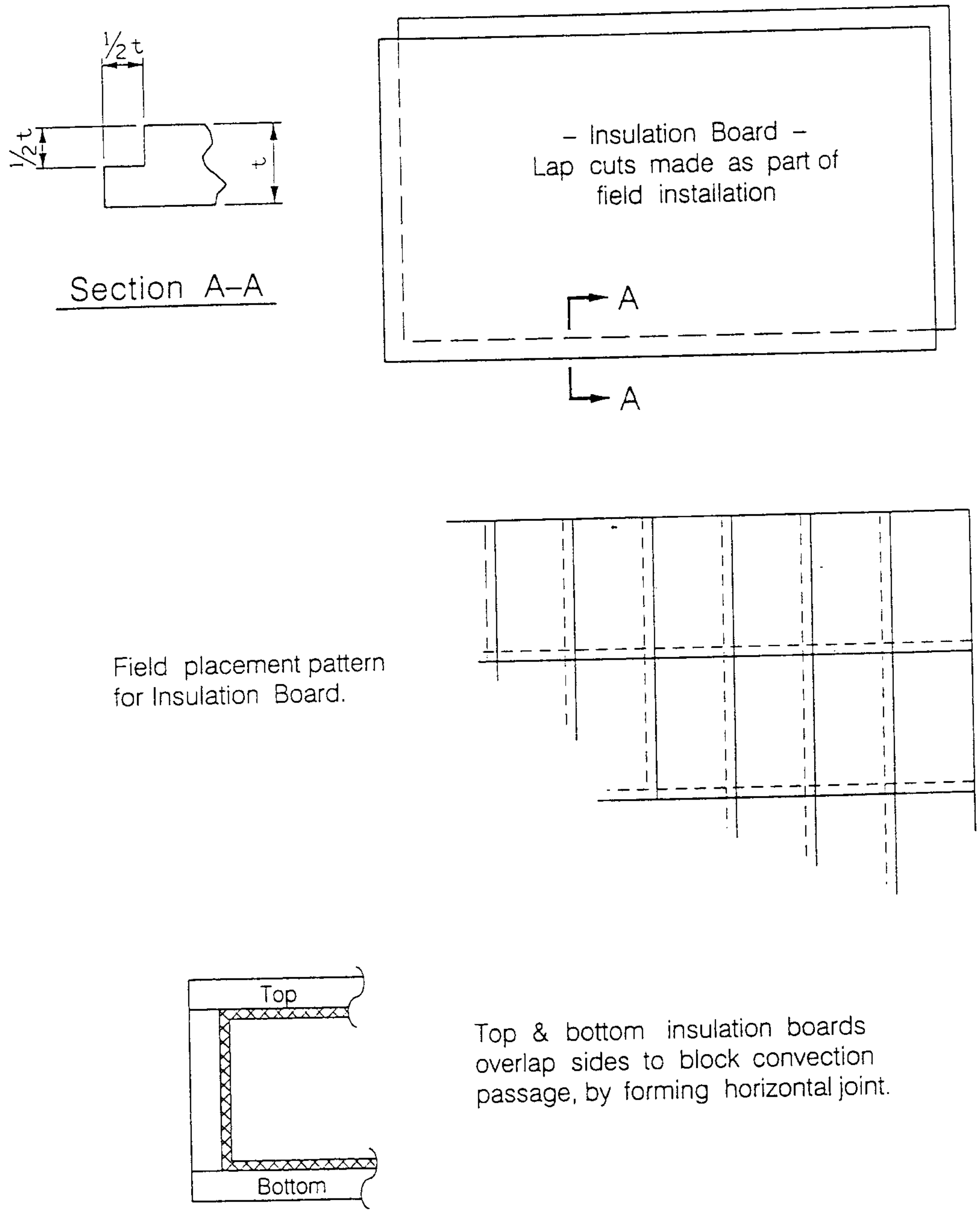
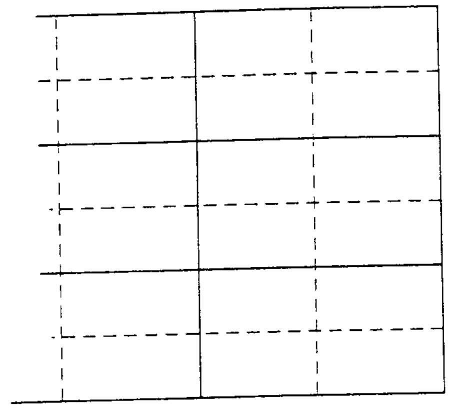
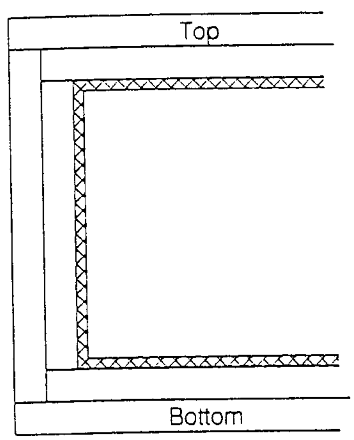


Figure A-6
Single Layer - Boilers and Ducts

Dotted lines represent stagger between layers. Minimun stagger is the total of all insulation thickness on that surface.

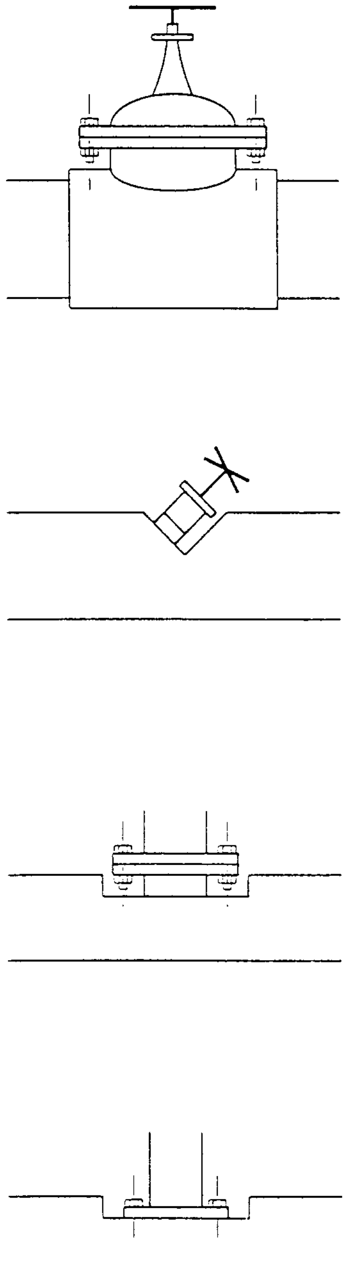
Example: 3 four inch layers require stagger of 12 inches each layer.





- Top & bottom insulation boards overlap sides to block convection passage, by forming horizontal joint.
- Verticle joints have same stagger, but orientation does not matter.

Figure A-7
Multiple Layer - Boilers and Ducts



Valves with elevated bonnets.

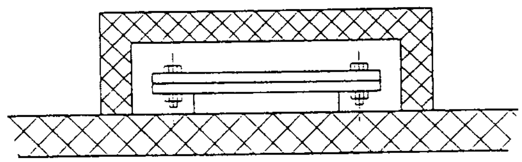
Angle valve – Often with seal welds.

Flanged intersections including valves, pipe snubbers, or access covers.

Valves with bonnet flanges flush with their body.

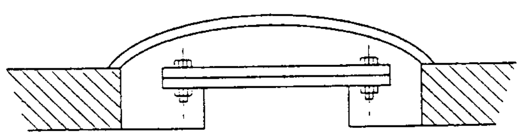
Figure A-8
Maintenance Access - Bolts and Seal Welds

– Over Extended Manway –



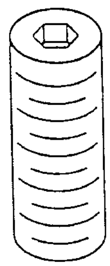
- Use either prefabricated metal cover or blanket for manway cover.

– Flush or Shallow Manway –

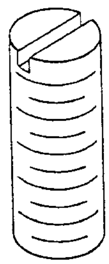


- Hold back insulation to allow access to nutted surface.
- Attaching cover blanket with hooks and lacing is preferred for temperatures of 800°F plus.

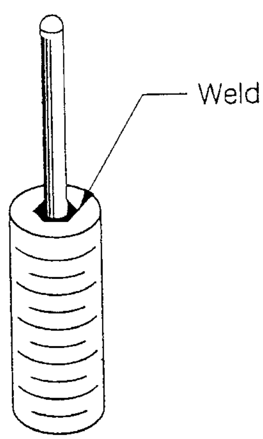
Figure A-9
Maintenance Access - Manway Bolts and Nuts



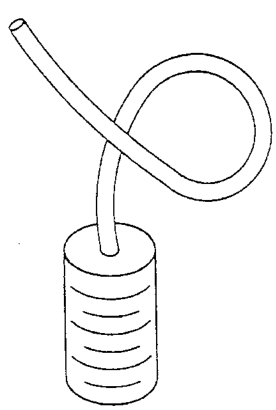
- Allen head set screw; 1⁄2" NC or as used on casing.



- Slotted head set screw; 1⁄2" NC or as used on casing.

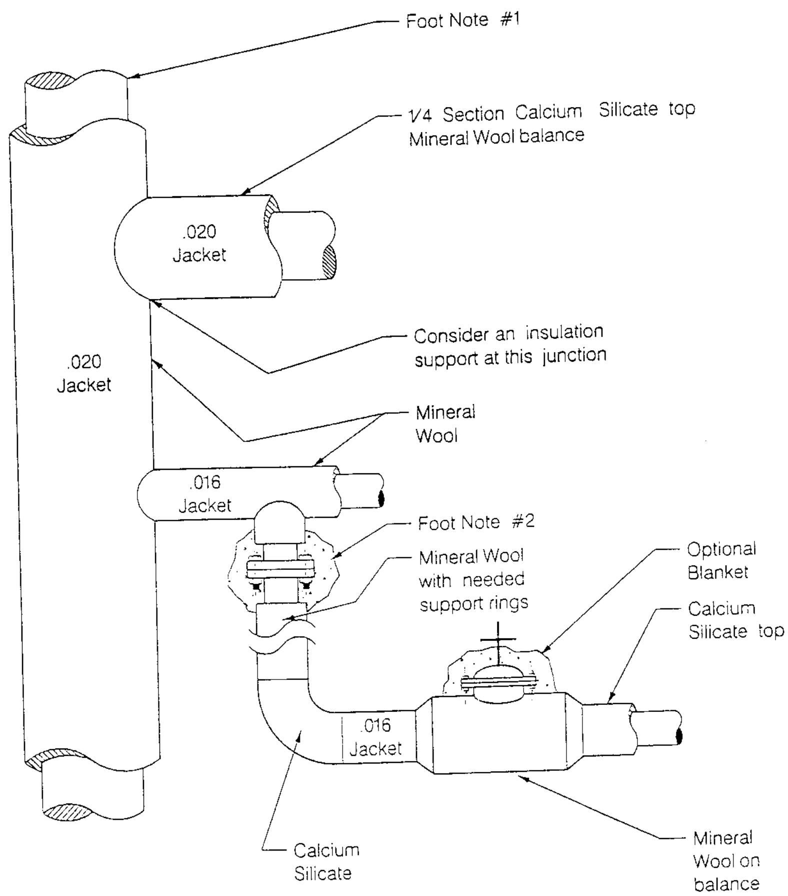


- Insulation pin brazed to allen head or slotted head set screw, or by pin weld machine for slotted head set screw.
- Generally used with clips.



- Looped insulation pin to provide for ties and lacing.
- or use with clips.

Figure A-10
Fabricated Insulation Pins

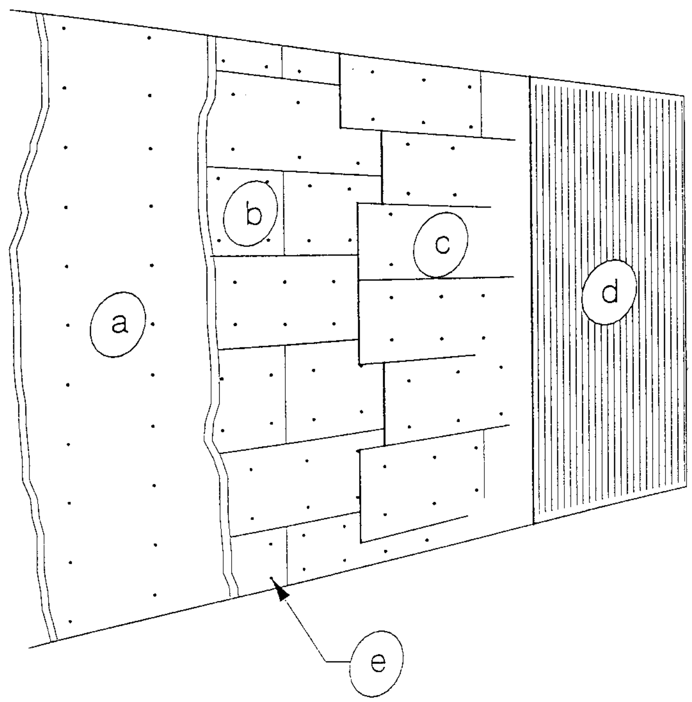


Foot Notes:

#1 Large diameter pipe, use aluminum foil backing on pipe wrap if temperatures exceed 600 degrees F.

#2 Insulation hang back sufficient to remove bolt or studs. Consider access for required impact tools.

Figure A-11
Typical Insulation System - General Piping



Foot Notes:

A. 1/2" Ceramic Wool.

B. 4" Mineral Wool boards #8.

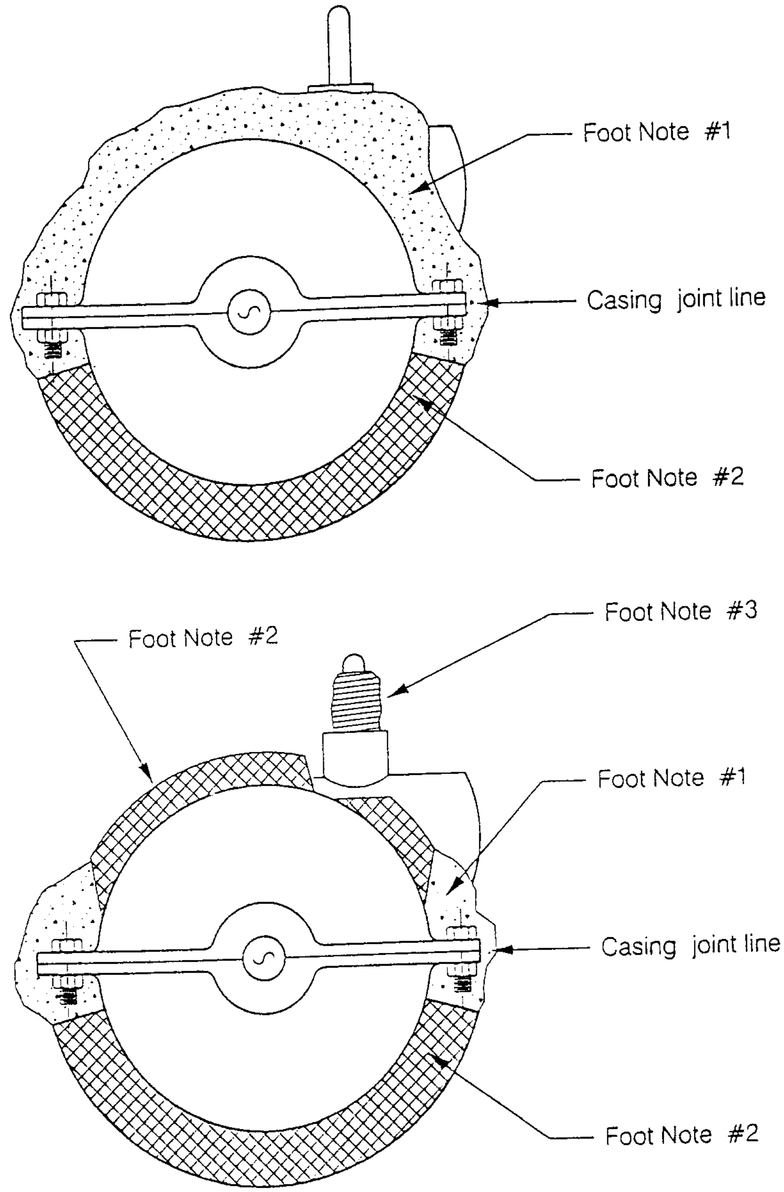
C. Second layer of 4" Mineral Wool boards #8.
Stager all joints with first layer.

D. 0.040 inch 4" corrugated aluminum lagging.

E. Weld pins - all on 12" centers.

1. Place optional aluminum foil between first and second layer of mineral wool for efficiency and as an aid in future disposal.

Figure A-12
Typical Insulation System - Boiler Walls



FOOT NOTES:

#1 Blanket Material, such as "Temp–Mat".

#2 Hard block insulation recommended. Spray insulation or blanket Not recommended on lower casing.

#3 Small lines & instrumentation cover with ceramic wool & foil.

Figure A-13
Typical Insulation System - Turbine and Large Equipment

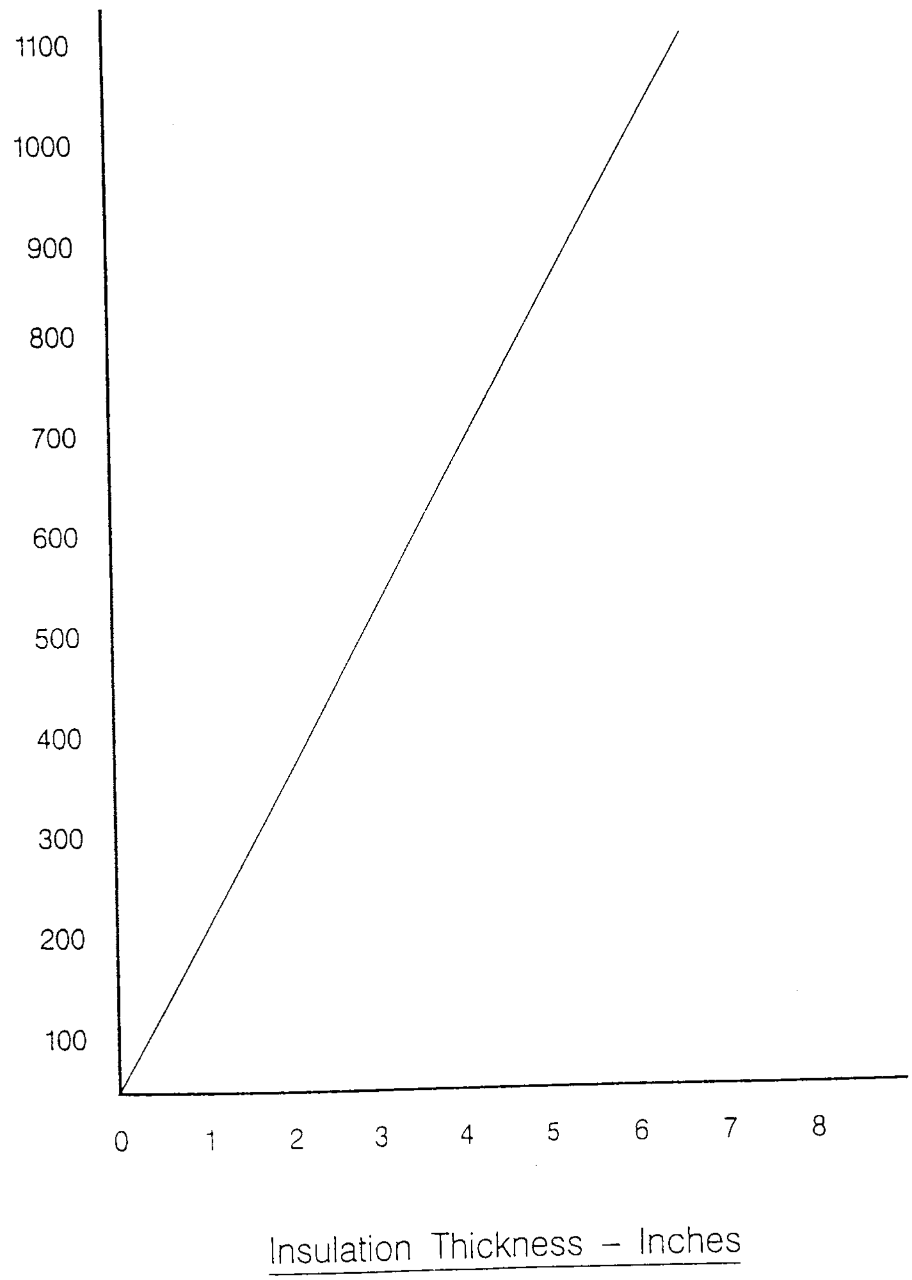


Figure A-14
Insulation Thickness - 8# Wool

```
Run
Pipe heat loss calculation
Pipe surface temperature = ?              300
Ambient temperature = ?                   75
Insulation thickness = ?                  2
Wind velocity - FPM = ?                   440
Pipe diameter - outer - inches = ?        4.5


Temperature 1 =          from K factor scale of product
Condition 1 =            from K factor scale of product
Temperature 2=           100
Conductivity - 2 =?      0.4
Emissivity =?            0.85


Results - Insulation Calculation

Insulation thickness =                 2
Pipe diameter - Inches =               4.5
Thermal conductivity - K =             0.325 @ average temperature - F  192.9
Surface temperature - F =              85.8
Heat loss - BTU /HR - FT of pipe       57.3
0


1List  2Run  3Load  4Save  5Cont  6lpt1  7Tron  8Troff  9Key  0Screen
```

Note: This program may be modified by the user. Certain parameters are constants.

Figure A-15
Temperature and Heat Loss, Computer Calculations - 8# Mineral Wool

B

AIR MONITORING REPORTS

Date **April 16, 1996**

From Location

To Location

Subject **AIR MONITORING FOR DUST AND FIBROUS MATERIAL FOR UNIT 3**

Background

As a result of our earlier meetings, we devised a sampling plan to assess the general background exposure to airborne dust and fiber for unit #3. The plan basically called for sampling of respirable dust (including quartz and cristobalite forms of free silica) and total fibers from non-asbestos vitreous insulation. Sampling would be done at several locations adjacent to the unit #3 boiler to monitor material that may be sloughed off of the boiler insulation, and /or pipe lagging. These locations ranged from the 1st to 21st floor.

This sampling was done in three phases: during static conditions with all three units on-line; during the initial shutdown of the Unit #3 boiler when it was cooling off; and when the Unit #3 boiler was fired and was in the process of coming back on line. The purpose of the sampling during shutdown and startup was to cover the highest potential for thermal contraction/expansion and hence vibration that could lead to higher dust and fiber levels.

Additionally, sampling would be done in conjunction with certain work done by the insulator to determine personal exposure and respiratory protection requirements during insulation blanket removal and reattachment. Sampling would also be done in the adjacent “downwind” area to check for contaminant levels as a result of thermal drift.

Results

The results of all of the sampling are in the attached tables.

1. Overall there was no respirable dust including respirable quartz and cristobalite above detection limits found in any of the background samples taken near the Unit #3 boiler. The airborne fiber levels were also below detection limits for these areas. This was true for background static conditions on 1-30-96 as well as during the time the boiler came on line and heated up on 3-15 and 3-16-96.

2. The personal sample for fibers taken on the insulator on 2-16 and 2-17-96 removing insulating blankets indicated a heavy loading of large fiber material that precluded the sample from being analyzed. At the same time the personal sample for respirable dust and free silica (including quartz and cristobalite) was below detection limit. The corresponding area samples for dust and fiber were also below detection limits. This indicates two probabilities; first that the material is quite large and not in the respirable size range (<10 micrometers in diameter) and second that the material falls out fairly close to the work and doesn't stay airborne very long.

3. Shorter term samples for fibers (to attempt to alleviate overloading) taken on two insulators reinstalling the blankets on 3-13-96 indicated total fiber counts in the range of 0.344 to 0.674 fibers/cc of air. Recommended exposure standards are set at 1.0 fiber/cc. In an effort to measure dust including free silica, <u>total dust</u> samples were also taken on the insulators while reattaching blankets. These samples indicated total dust exposures of 3670 to 5460 ug/M^3 and quartz exposures of 240 to 340 ug/M^3. No cristobalite was detected. The recommended exposure standard for total dust (not containing free silica or asbestos) is 10 mg/M^3 or 10,000 ug/M^3. No current standard exists for total quartz - the respirable standard is 100 ug/M^3.

4. The air samples taken on insulators putting blankets on indicate exposure to total dust at about half of the current standard. In addition, exposure to total quartz in the 240 to 340 ug/M^3 range would indicate the prudent use of 1/2 mask respirators with HEPA type cartridges.

5. The lab analysis of the air samples for quartz did indicate some question as to the positive identification of quartz as the contaminant. Sometimes very small particle size (not the case here) or the heating of material to a high temperature can lead to the breakdown of crystalline silica to amorphous silica.

6. Bulk samples taken on several insulation could not be analyzed for particle size the size would be dependent on the amount of grinding done preceding analysis. Three of the samples, however, were analyzed for the presence of free silica. The SPF-1000 fiberglass and the ceramic fiber used in blankets as identified by Insulator #1 did not contain free silica. The Ceramo Spray insulation did contain 1% quartz and no cristobalite.

7. Cristobalite formation is <u>not</u> happening to heated insulation on the exterior of the boiler. This would not be expected to happen as the manufacture's association RCFC does not identify this as a possible hazard until temperatures reach 1,800^0 F. (See attached)

Recommendations

1. At the next opportunity we should set up more sampling on the removal and reinstallation of insulating blankets. I would recommend taking both respirable and total dust samples looking for quartz and at particle sizing.

2. We should not need to repeat any general background sampling for fiber and dust. Up to 18 sets of samples taken at 6 different locations under several operating parameters failed to detect any fibers or respirable dust above detection limits.

3. All types of insulation should be cataloged and MSDS sheets secured for each different type. A careful review should be done of these sheets to look for ones that contain quartz (generally as a minor contaminant). These insulation should be inspected after use to determine if the quartz tends to migrate to a surface and collect (perhaps due to vibration of the product over time). These insulation should then be analyzed at the laboratory for the presence of quartz.

4. Have insulators that remove and reattach blankets wear a minimum of 1/2 mask respirator with a silicone rubber face seal and HEPA types cartridges and eliminate the use of paper dust masks for this work.

5. Study the work practices of blanket removal and incorporate any appropriate wetting that could be done to minimize the material from becoming airborne. See copy of RCFC recommendations (attached).

Should you have any questions concerning this report, please feel free to contact me.

AREA SAMPLES
January 30, 1996

Unit #3 Background Samples - Static Conditions (Units 1, 2, 3 On Line)

Location	Activity	Total Fiber Fibers/cc	Respirable Dust (ug/M^3)	Quartz (ug/M^3)	Cristobalite (ug/M^3)
21st floor (boiler roof), South side on top of boiler	Looking for material deposited from updrafts	< 0.010	< 180	< 18	< 18
16th floor (retract blower), catwalk south side, middle col.	Looking for material in updraft	< 0.008	< 180	< 18	< 18
7th floor (3rd burner), South side overlooking turbine floor	Looking for material in downdraft	< 0.008	< 180	< 18	< 18
3rd floor (operating), east end pipe chase	Looking for material from pipe lagging	< 0.008	< 190	< 19	< 19
3rd floor (operating), west end pipe chase	Looking for material from pipe lagging	<0.008	< 190	< 19	< 19
1st floor (ground), by west recirc discharge, near 307 mill	Looking for material entrained in recirc ventilation	< 0.008	No sample	No sample	No sample
OSHA PEL, 8 hour time-weighted-average (TWA)		None	5,000	100	50
ACGIH TLV, 8 hour TWA		1 (RCF)*	3,000	100	50

* RCF = refractory ceramic fiber, standard is an industry recommendation from the Refractory Ceramic Fiber Coalition (RCFC) member companies and proposed by OSHA in 1992.

PEL = Permissible Exposure Limit TLV = Threshold Limit Value

No sample due to restricted number of sampling pumps.

AREA SAMPLES
February 16-17, 1996
Unit #3 Background Samples - Cooling Conditions (Units 1, 2 On Line)

Location	**Activity**	**Total Fiber Fibers/cc**	**Respirable Dust (ug/M^3)**	**Quartz (ug/M^3)**	**Cristobalite (ug/M^3)**
21st floor (boiler roof), South side on top of boiler	Looking for material deposited from updrafts	< 0.006	< 130	< 13	< 13
16th floor (retract blower), catwalk south side, middle col.	Looking for material in updraft	< 0.005	< 130	< 13	< 13
7th floor (3rd burner), South side overlooking turbine floor	Looking for material in downdraft	< 0.005	< 130	< 13	< 13
3rd floor (operating), east end pipe chase	Looking for material from pipe lagging	< 0.005	< 130	< 13	< 13
3rd floor (operating), west end pipe chase	Looking for material from pipe lagging	<0.005	No sample	No sample	No sample
1st floor (ground), by west recirc discharge, near 307 mill	Looking for material entrained in recirc ventilation	< 0.005	< 220	< 22	< 22
OSHA PEL, 8 hour time-weighted-average (TWA)		None	5,000	100	50
ACGIH TLV, 8 hour TWA		1 (RCF)*	3,000	100	50

* RCF = refractory ceramic fiber, standard is an industry recommendation from the Refractory Ceramic Fiber Coalition (RCFC) member companies and proposed by OSHA in 1992.

PEL = Permissible Exposure Limit TLV = Threshold Limit Value

No sample due to restricted number of sampling pumps.

AREA SAMPLES
March 15-16, 1996
Unit #3 Background Samples - Heating Conditions (Units 1, 2 On Line)

Location	Activity	Total Fiber Fibers/cc	Respirable Dust (ug/M^3)	Quartz (ug/M^3)	Cristobalite (ug/M^3)
21st floor (boiler roof), South side on top of boiler	Looking for material deposited from updrafts	< 0.012	< 130	< 13	< 13
16th floor (retract blower), catwalk south side, middle col.	Looking for material in updraft	< 0.012	< 130	< 13	< 13
7th floor (3rd burner), South side overlooking turbine floor	Looking for material in downdraft	< 0.012	< 130	< 13	< 13
3rd floor (operating), east end pipe chase	Looking for material from pipe lagging	< 0.012	< 130	< 13	< 13
3rd floor (operating), west end pipe chase	Looking for material from pipe lagging	< 0.012	< 130	< 13	< 13
1st floor (ground), by west recirc discharge, near 307 mill	Looking for material entrained in recirc ventilation	< 0.012	< 130	< 13	< 13
OSHA PEL, 8 hour time-weighted-average (TWA)		None	5,000	100	50
ACGIH TLV, 8 hour TWA		1 (RCF)*	3,000	100	50

* RCF = refractory ceramic fiber, standard is an industry recommendation from the Refractory Ceramic Fiber Coalition (RCFC) member companies and <u>proposed</u> by OSHA in 1992.

PEL = Permissible Exposure Limit   TLV = Threshold Limit Value

PERSONAL AND AREA SAMPLES
FEBRUARY 16-17, 1996
Unit #3 Removing Insulating Blankets #33 Boiler Feedwater Pump

Employee/Location SSN #	Sample Time	Total Fiber (Fibers/cc)	Sample Time	Respirable Dust (ug/M^3)	Quartz (ug/M^3)	Cristobalite (ug/M^3)
Insulator #1	125 Min.	Too Dusty To Count	125 Min.	< 470	< 47	< 47
At west end of Unit #3 turbine check for particle dispersion “downwind”	386 Min.	< 0.006	386 Min.	< 150	< 15	< 15
Removing Blankets on Main Control Valve (Mezz)	93 Min.	< 0.027	91 Min.	< 650	< 65	< 65
OSHA PEL, 8 hour time-weighted-average (TWA)		None		5,000	100	50
ACGIH TLV, 8 hour TWA		1 (RCF)*		3,000	100	50

* RCF = refractory ceramic fiber, standard is an industry recommendation from the Refractory Ceramic Fiber Coalition (RCFC) member companies and proposed by OSHA in 1992.

PEL = Permissible Exposure Limit TLV = Threshold Limit Value

PERSONAL SAMPLES
MARCH 13, 1996
Unit #3 Replacing Insulating Blankets #32 Boiler Feedwater Pump

Employee/Location SSN #	Sample Time	Total Fiber (Fibers/cc)	Sample Time	Total Dust (ug/M^3)	Quartz (ug/M^3)	Cristobalite (ug/M^3)
Insulator #1 12:40PM-1:26 PM 301-54-1865	46 Min.	0.610	See Below	-------	-------	----------
Insulator #1 1:30PM-2:00PM & 2:30PM-3:25PM 301-54-1865	85 Min.	0.674	See Below	-------	-------	----------
Insulator #1 12:40PM-3:25PM Composite 301-54-1865	131 Min.	0.652	135 Min. Full Job	3,670	240	< 13
Insulator #2 12:43PM-2:00PM 552-72-9449	77 Min.	Too Dusty To Count	See Below	-------	-------	----------
Insulator #2 2:27PM-3:25PM 552-72-9449	58 Min.	0.344	See Below	-------	-------	----------
Insulator #2 12:43PM-3:25PM 301-54-1865	-------	-------	135 Min. Full Job	5,460	340	< 13
OSHA PEL, 8 hour time-weighted-average (TWA)		None		15,000	100 Respirable Only	50 Respirable Only
ACGIH TLV, 8 hour TWA		1 (RCF)*		10,000	100 Respirable Only	50 Respirable Only

* RCF = refractory ceramic fiber, standard is an industry recommendation from the Ceramic Fiber Coalition (RCFC) member companies and proposed by OSHA in 1992.

PEL = Permissible Exposure Limit TLV = Threshold Limit Value

Figure B-1
April 16, 1996, Report

Date **May 9, 1997**

From Location

To Location

Subject **AIR MONITORING FOR DUST AND FIBROUS MATERIAL FOR UNIT 2**

Background

In 1996 we devised a sampling plan to assess the general background exposure to airborne dust and fiber for unit #3. The plan basically called for sampling of respirable dust (including quartz and cristobalite forms of free silica) and total fibers from non-asbestos vitreous insulation. Sampling would be done at several locations adjacent to the unit #3 boiler to monitor material that may be sloughed off of the boiler insulation, and /or pipe lagging. These locations ranged from the 1st to 21st floor.

Additionally, sampling would be done in conjunction with certain work done by the insulator to determine personal exposure and respiratory protection requirements during insulation blanket removal and reattachment. Sampling would also be done in the adjacent "downwind" area to check for contaminant levels as a result of thermal drift.

The results of the 1996 sampling were reported in a memo to you dated April 16, 1996.

Summary of 1996 Sampling

Overall there was no respirable dust including respirable quartz and cristobalite above detection limits found in any of the background samples taken near the Unit #3 boiler. The airborne fiber levels were also below detection limits for these areas. This was true for background static conditions, as well as during the time the boiler came off line and cooled down and also when the boiler came back on line and heated up.

Personal samples for fibers taken on the insulators removing insulating blankets indicated a heavy loading of large fiber material. Some of the samples could not be analyzed and others that could be analyzed indicated total fiber counts in the range of 0.344 to 0.674 fibers/cc of air. In an effort to measure dust including free silica, total dust samples were also taken on the insulators while reattaching blankets. These samples indicated total dust exposures of 3670 to 5460 ug/M^3 and quartz exposures of 240 to 340 ug/M^3. No cristobalite was detected.

1996 Recommendations

1. At the next opportunity we should set up more sampling on the removal and reinstallation of insulating blankets. I would recommend taking both respirable and total dust samples looking for quartz and at particle sizing.

2. We should not need to repeat any general background sampling for fiber and dust. Up to 18 sets of samples taken at 6 different locations under several operating parameters failed to detect any fibers or respirable dust above detection limits.

3. All types of insulation should be cataloged and MSDS sheets secured for each different type. A careful review should be done of these sheets to look for ones that contain quartz (generally as a minor contaminant). These insulation should be inspected after use to determine if the quartz tends to migrate to a surface and collect (perhaps due to vibration of the product over time). These insulation should then be analyzed at the laboratory for the presence of quartz.

4. Have insulators that remove and reattach blankets wear a minimum of 1/2 mask respirator with a silicone rubber face seal and HEPA types cartridges and eliminate the use of paper dust masks for this work.

5. Study the work practices of blanket removal and incorporate any appropriate wetting that could be done to minimize the material from becoming airborne. See copy of RCFC recommendations (attached).

In 1997 we followed up with Recommendation #1 to sample two insulators removing blankets in the Unit #2 outage as well as during boiler wall insulation removal. Additionally, recommendation #4 was followed as the insulators switched to a new comfortable 1/2 mask, the 3M 6000. Recommendation #2 required no follow-up. Recommendations #3 & #5 are left up to the plant to carryout if they wish.

1997 Sampling Results

Boiler Wall Insulation The 1997 sampling results of the boiler wall insulation removal ranged from 52,240 to 71,140 ug/M^3 total dust and 164 to 192 ug/M^3 quartz. This showed once again that respirators are required for this operation and the permanent 1/2 masks worn (3M 6000 with HEPA cartridge) would be adequate with its protection factor of 10. You would be allowed an exposure up to 150,000 ug/M^3 of total dust and 1000 ug/M^3 of respirable quartz.

Many of the airborne fiber samples that were taken were overloaded even though short sampling times were used (20 - 30 minutes). Of the ones that were analyzed airborne fiber ranged from 1.289 f/cc to 3.068 f/cc above the recommended standard put out by the Refractory Ceramic Fiber Coalition. This again indicated the prudent use of I/2 mask HEPA respirators.

Feedwater Pump Blankets The total dust levels were much lower on this work. These samples ranged from 1,280 ug/M^3 to 2,590 ug/M^3 with quartz ranging only to a high of 133 ug/M^3. Only one sample had fiber counts above background with O.118 f/cc. This work is much less dusty that the boiler wall work but still warrants the use of 1/2 mask HEPA respirators due to the variability of the work and the potential exposure to insulators.

Area Samples Samples were taken in the surrounding area to both the boiler wall removal and the blanket removal and no airborne fiber, total dust or quartz was detected on the samples. This again confirms our hypothesis that the material is too large to remain airborne very long and that employee exposure away from the work is not a concern under the conditions that were sampled.

AREA SAMPLES
TO CHECK DRIFT FROM WORK
April 5 and 6, 1997
Unit #2

Location	Sample Time	Total Fiber (Fibers/cc)	Sample Time	Total Dust (ug/M^3)	Quartz (ug/M^3)
10th Floor Monorail, On Buckstays above boiler wall insulation removal	181 Min.	< 0.014	182 Min.	< 275	< 27
At east end of #22 Boiler Feed Pump, Blanket removal	84 Min.	< 0.029	85 Min.	< 588	< 59
OSHA PEL, 8 hour time-weighted-average (TWA)	480	None	480	5,000	100
ACGIH TLV, 8 hour TWA	480	1 (RCF)*	480	3,000 Respirable Only	100 Respirable Only

* RCF = refractory ceramic fiber, standard is an industry recommendation from the Refractory Ceramic Fiber Coalition (RCFC) member companies and proposed by OSHA in 1992.

PEL = Permissible Exposure Limit   TLV = Threshold Limit Value

PERSONAL SAMPLES
April 5, 1997
Unit #2 Removing Boiler Wall Insulation 9th & 10th Floors

Employee/SSN #	Sample Time/ Location	Total Fiber (Fibers/cc)	Sample Time	Total Dust (ug/M^3)	Quartz (ug/M^3)
Insulator #1 10:01AM-10:29AM	28 Min. 9thFloor	Too Dusty	See Below	-------	-------
Insulator #1 10:45AM-11:21AM	36 Min. 10th Flr.	Too Dusty	See Below	-------	-------
Insulator #1 13:11PM-13:54PM	43 Min. 10th Flr.	1.289	See Below	-------	-------
Insulator #1 10:01AM-13:54PM (Composite)	107 Min.	Too Dusty	127 Min. Full Job	71,140	192
Insulator #2 10:08AM-10:30AM	22 Min. 9thFloor	Too Dusty	See Below	-------	-------
Insulator #2 10:53AM-11:18AM	25 Min. 10th Flr.	2.805	See Below	-------	-------
Insulator #2 13:08PM-13:51PM	43 Min. 10th Flr.	3.068	See Below	-------	-------
Insulator #2 07:41AM-09:03AM (Composite)	90 Min.	Too Dusty	116 Min. Full Job	52,240	164
OSHA PEL, 8 hour time-weighted-average (TWA)	480	None	480	15,000	100 Respirable Only
ACGIH TLV, 8 hour TWA	480	1 (RCF)*	480	10,000 Inhalable Only	100 Respirable Only

* RCF = refractory ceramic fiber, standard is an industry recommendation from the Refractory Ceramic Fiber Coalition (RCFC) member companies and proposed by OSHA in 1992.

PEL = Permissible Exposure Limit   TLV = Threshold Limit Value

PERSONAL SAMPLES
April 6, 1997
Unit #2 Removing Insulating Blankets #22 Boiler Feedwater Pump

Employee/SSN #	Sample Time	Total Fiber (Fibers/cc)	Sample Time	Total Dust (ug/M^3)	Quartz (ug/M^3)
Insulator #1 07:34AM-08:31PM	57 Min.	<0.086	See Below	-------	-------
Insulator #1 08:33PM-09:08PM	35 Min.	<0.014	See Below	-------	-------
Insulator #1 07:34AM-09:08AM (Composite)	92 Min.	<0.059	94 Min. Full Job	1,280	< 53
Insulator #2 07:41AM-08:35AM	54 Min.	0.118	See Below	-------	-------
Insulator #2 08:36AM-09:03AM	27 Min.	< 0.182	See Below	-------	-------
Insulator #2 07:41AM-09:03AM (Composite)	81 Min.	<0.139	83Min. Full Job	2,590	133
OSHA PEL, 8 hour time-weighted-average (TWA)	480	None	480	15,000	100 Respirable Only
ACGIH TLV, 8 hour TWA	480	1 (RCF)*	480	10,000	100 Respirable Only

* RCF = refractory ceramic fiber, standard is an industry recommendation from the Refractory Ceramic Fiber Coalition (RCFC) member companies and proposed by OSHA in 1992.

PEL = Permissible Exposure Limit TLV = Threshold Limit Value

Figure B-2
May 9, 1997, Report