RADIANT HEAT BARRIER CORROSION RESISTANT COATING WITH INSULATION PROPERTIES

ABSTRACT
Hot liquor and other process vessels including piping create an unsafe environment due to emission of radiant heat. Insulating the vessel creates a potential corrosion environment under the insulation. This paper will discuss a unique coating that provides protection from corrosion and virtually eliminates radiant heat loss.

INTRODUCTION
As is true in most industries, the pulp and paper industry also encounters corrosion under thermal insulation. Most tanks, process vessels and piping are insulated with fiberglass or foam with aluminum or 304 stainless steel jacketing. Breaches in the jacket allow permeation of liquid process chemicals and moist ambient air causing potential corrosion to the substrate. This problem is exacerbated by the wicking of the liquid along the insulation. In addition to the corrosion problem, wet insulation also loses its insulating properties. An insulating spray applied coating has been developed which virtually eliminates the corrosion under insulation problem while providing the necessary insulating properties for the specific environment. This product is formulated with a special acrylic resin blend with specific ceramic compounds added to provide a non-conductive block against heat transfer. It is environmentally friendly, cost competitive and easy to apply.

WHY INSULATING COATING SHOULD BE CONSIDERED VERSUS CONVENTIONAL INSULATION
Corrosion of carbon and stainless steel under conventional insulation on process equipment requires maintenance and repair costs; with safety risks to personnel and the environment. Using the insulating coating will reduce the risk of corrosion to the substrate to which it is applied by resisting movement of moisture and contaminates to the surface which causes the substrate to corrode. This material is a monolithic film having no fasteners or joints thus eliminating the potential moisture intrusion problem.

The Issues Affecting Corrosion of Carbon Steel under Conventional Insulation
The rate carbon steel will corrode under insulation is influenced by first; the wet exposure cycle, the duration and frequency; second, the corrosivity of the moisture and third, the lack of or failure of the barrier protection between the insulation and the carbon steel. Although, there are many factors contributing to corrosion under conventional insulation, the seven main factors, along with how the insulating coating can help mitigate the problem, are as follows:

1. Equipment design
2. Service temperatures
3. Insulation selection
4. Protective coatings
5. Weather barriers
6. Climate control
7. Maintenance procedures

Mastering an understanding of these issues will help to reduce the failure of insulation systems and reduce costs in these areas. When properly used the insulating coating offers some fixes with lower costs and better performance. It only takes mils not inches.

Equipment design
Care in equipment design and support layout is a key to providing space for the insulation system used. Pipes, pressure vessels and tanks are the main items involved with process equipment. Simplifying the surface to be insulated makes these tasks easier, more cost effective and provides longer life. The spray applied insulating coating is more conforming to the surface than conventional systems, and it does not require studs and lagging to support and seal the insulation from moisture. Building structures and roofs require their own specially designed *coating system* to cope with higher levels of weather proofing required due to exposure.

Service temperatures
The warmer the insulated equipment the less effect moisture will have on the insulated surface. Corrosion rates will be increased with the number of cycles the equipment goes through and the contaminants in the moisture. The better the weatherproofing the less the corrosion rate will be. The insulating coating resists the movement of moisture more so than conventional insulation systems.

Insulation selection

Corrosion under the insulation system is directly related to moisture absorbency, chemicals and insulation breeches, consequently selection of an insulating material fitting the service application is a key to minimizing the risk of under insulation corrosion. Non-wicking materials rate the best choice for high exposure areas to wet service areas. Insulation is normally selected based on installed cost versus energy cost saved; unfortunately maintenance costs don't enter the picture until later. Without the lagging requirement and being a water based system, which can be applied to most surface's while the operation is in progress, makes the insulating coating product an easily maintained system. Polyurethane foam absorbs water readily; whereas the insulating coating does not. A wet insulation system does not give the energy savings and is a corrosion liability.

Protective coatings

A protective coating under the insulation provides corrosion protection; however, it must meet immersion service conditions. The combination of moisture and heat along with chemical concentrations requires a coating system with a high resistance to permeability. With no access to maintain the coating system it needs to perform for 15 to 20 years. With an insulation system holding moisture to the surface longer than a non-insulated surface the need for the added protection of coating reduces the corrosion rate significantly. Zinc rich primers and/or conventional coatings do not perform well in immersion service and/or under insulation. In certain applications the coating is only done on the last four to six feet of the tank wall at the foundation, this being the zone where spills and splashing occur. Welds and insulation rings must be seal welded or caulked with material compatible with the coating system. Coating under the insulating coating would only be required in high risk areas, example a storage tank containing chilled solution. With high humidity a chilled tank will draw moisture to it like a magnet. The insulation coating is water based; top coating may be done to meet color requirements. The top coating must be tested for compatibility with the water based system, so it does not impact adhesion or insulation values. **Be careful!**

Weather barriers

For conventional insulation the lagging is critical to the success and life of the system. The barrier provides both a liquid and a vapor block to protect the insulation system from contamination and from moisture and chemicals. The barrier allows moisture to flow from the equipment out of the insulation system. Trapped moisture increases the corrosion damage. Screws and other fasteners must not be on the top of the system, this will allow moisture in around the screw holes; they should be located on high spots and on the sides of pipes. This reduces the risk of leakage. While insulation systems are designed to last 25 to 30 years, the lagging will require maintenance to keep the integrity of the system in place. It should be placed on a preventive maintenance program. The insulation coating does not require a vapor barrier, as it resists moisture movement as is. It, like conventional insulation will suffer from mechanical damage and requires maintenance over the life of the system. It being spray (or brush applied) and coming in a can allows full use of the product and is maintenance friendly.

Climate control

The climate and the micro climate within buildings and/or processes are factors to be taken in the planning stage of what system to use. In a high humidity process moisture will come at the insulation system from both sides. Equipment located next to or downwind from cooling towers or vents will see more moisture than other equipment. This would require more weather proofing than would normally be used. The insulating coating handles moisture without added protection in most applications (it is UV stable). One clear advantage is the insulating coating does not allow moisture or chemicals to migrate to one location to set up a more active corrosion cell at the tank bottom, insulation rings or pipe elbows.

Maintenance procedures

With the current use of maintenance planning and computer controlled schedules for inspection of process equipment and facility structures; the insulation systems are simply included in the inspection process. Visual inspection for insulation integrity is 90% of what is required. The area of greatest risk occurs when mechanical maintenance takes place on the process equipment (opening the insulation.) Those crews are usually not responsible for re-insulation of the equipment. After the mechanical repair is complete, a policy of prompt repair is required so the insulation system is not compromised. Low points and other natural moisture traps are high on the inspection list. Various codes require inspection of vessels and tanks every five years or based on a risk assessment depending on type of service and history. These inspections require the insulation be removed to measure shell or wall thickness for material loss. The insulation system then has to be replaced or plugs fitted to the inspection areas. On some types of vessels removable blankets or bats are used for ease of replacement. Repair with the spray on or brush applied insulating coating will meet this need in a cost effective manner. One major area of concern is in personnel protection. Some tanks are only insulated up 8' to protect personnel from burns. This requires a weatherproof seal where the system terminates on the tank wall. If the seal breaks down then moisture compromises the system. The insulating coating will help to eliminate this risk of moisture intrusion and later the corrosion of the process equipment. Planned maintenance is the key to cost effective insulation and reduced corrosion. The insulation coating resists undercutting.

STRESS CORROSION CRACKING OF AUSTENITIC STAINLESS UNDER INSULATION

External stress corrosion cracking or environmental stress corrosion cracking (ESCC) refers to stress corrosion cracking of austenitic stainless steel (304L, 316L and 317L) in general. The product in the vessel, tank or pipe is only supplying the heat to promote the cracking mechanism. Process spills or leaks would add to the problem but usually the normal moisture penetrating conventional insulation systems containing chlorides will cause cracking. Temperatures from 140ºF to 250ºF (60ºC to 12 1ºC) seem to be the range where the ESCC normally occurs.

Sources of chlorides

Insulation material itself will contain chlorides ranging from 10 ppm to close to 1000 ppm; the problems really occur when moisture moves the chlorides from the material to the surface of the stainless equipment. The coastal regions have more problems due to atmospheric chlorides and these may be deposited on the surface before the insulation system is ever applied. The chlorides may be related to the chemical process at the site. Inhibitors may be used to reduce the leach ability of chlorides in the insulation system. The pH, if less than 5.5, will tend to increase the corrosion rate rapidly with the chlorides present.

Controlling the cracking

History shows that in austenitic stainless steel, presence of chlorides and time, ESCC will occur. Concentrations and stresses in the fabricated vessel will dictate the rate at which it will occur. Gland water, on shaft packing, flowing at 3-5 gal/hr. (11.4-19 liters/hr.) containing 50 to 70 ppm chlorides and penetrating the insulation jacket caused a $500,000 mixing vessel to fail in three years' time. Low chloride insulation was used, but time, temperature, chloride and concentration with the stresses in the equipment caused the untimely failure. Other cases may take much longer. The main difference between the stainless and carbon steels is the cracking cannot be effectively repaired without replacing major sections of the vessel or tank. Weld repair to the cracks does not work or does not work long. Protecting the stainless steel surface with coating is the safest approach to use in the 140ºF to 250ºF (60ºC to 121ºC). Immersion service coatings are the only ones to use. The key is to remove one or more of the elements causing the corrosion mechanism to develop. Coating does this well. The insulating coating has low chlorides and provides the insulation as well as serving the function as a coating.

SOME OF THE BENEFITS OF THE INSULATING COATING ARE:

1. Unaffected by UV rays (has passed 1300 hours of accelerated aging by exposure to salt fog and UV).
2. Non-combustible during application and after installation and cure, extremely low flame spread and smoke contribution ratings.
3. Due to the low thermal conduction and other insulating properties, the coating will reduce surface temperatures low enough to allow the application of color top coats while providing safety from burns by incidental contact.
4. With the exception of cold wet applications the coating can be applied without operation shut down.
5. Superior radiant heat barrier averaging 0.063 W/mK Thermal Conductivity, thus eliminating the majority of heat penetration.
6. Low chloride content, i.e., less than 23 ppm and less than 19 ppm halogen. This allows the coating to be used over stainless steel.
7. Dry fall during application is 5' to 7'.
8. Cleans up with soap and water.
9. Remains flexible to -30ºF (-35ºC).
10. Contains no solvents.
11. Contains no hazardous fiber.
12. Removal is not a hazardous waste (it does not absorb chemicals).
13. Does not require special equipment and handling.
14. Requires no solvents.

CONCLUSION

Process vessels, tanks and piping requiring insulation where the corrosion risk from process or the environment is high are good candidates for the insulating coating. If the surface is too hot for paint systems then the insulating coating maybe applied to the equipment, while in operation. Water or chemicals have little effect on the insulating coating, as there is no wicking or migration of chlorides to the substrate being insulated. If the insulation skin is damaged the insulating coating only exposes the substrate where the breach occurs. The history with the product is short thus making the engineering of the systems more important because the insulation factors between conventional systems and the insulating coating are not direct. One deals in inches (cm) thickness and the other deals in mils (mm) of thickness. Conventional insulation when wetted promotes energy loss and corrosion; the key advantage of the insulating coating is it does neither. If you have insulated equipment, corrosion will occur to some degree. By using proper materials, specifications, engineering design, inspection and maintenance methods, the costs can be kept to a minimum. The problem will most likely never go away but it can be controlled. The insulating coating offers answers to some of the challenges faced by the other insulation systems. Just like all systems it needs proper design and application along with good product to be successful.

REFERENCES

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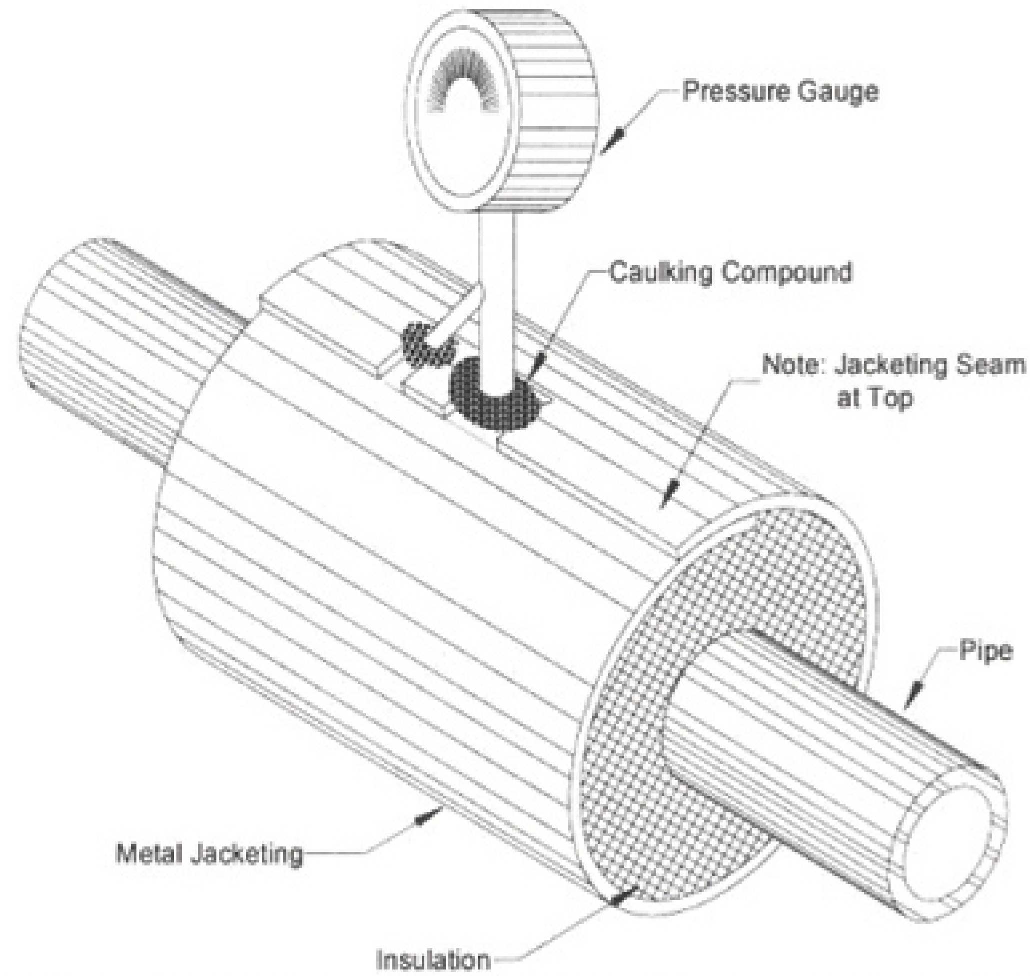
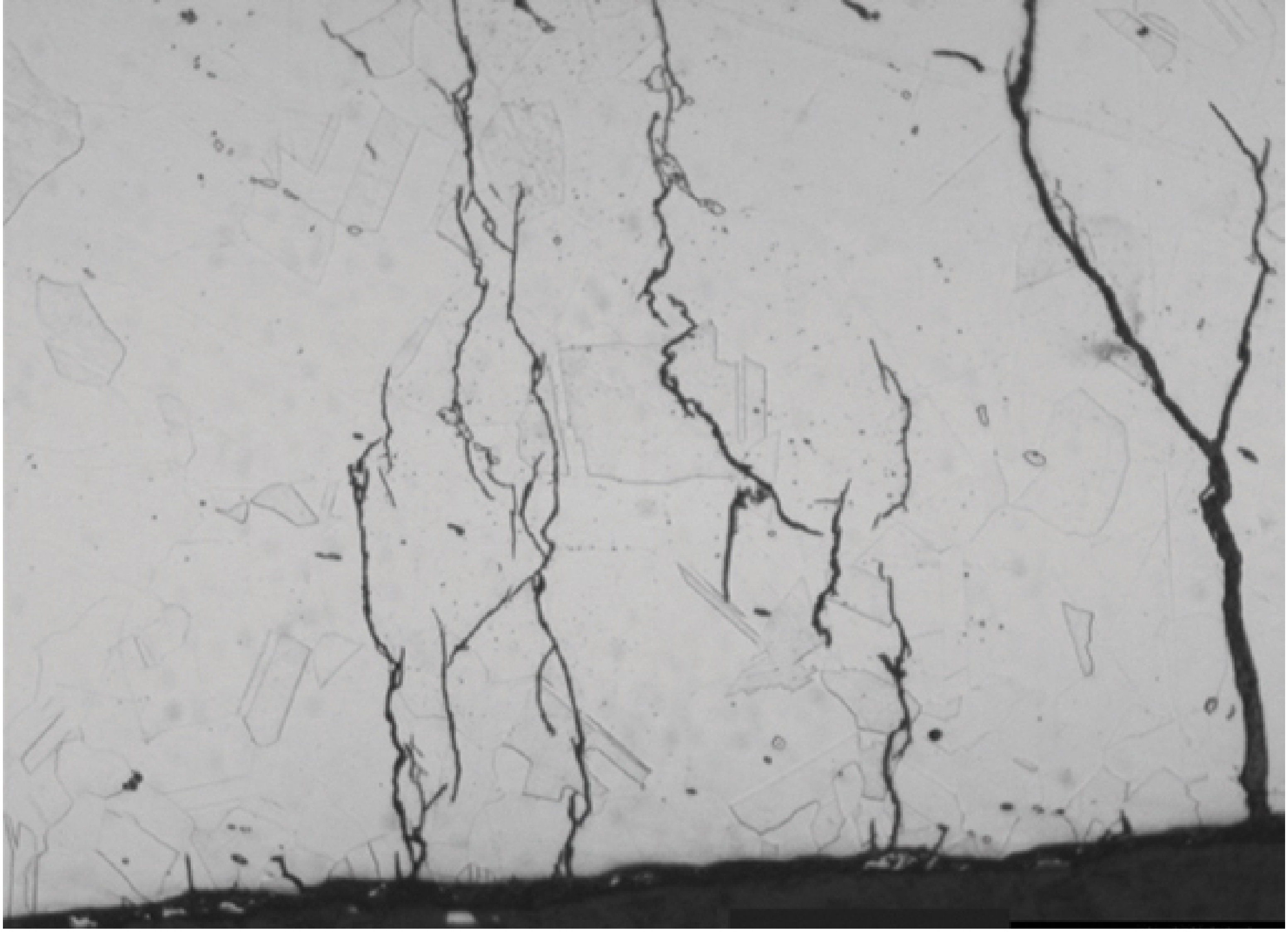
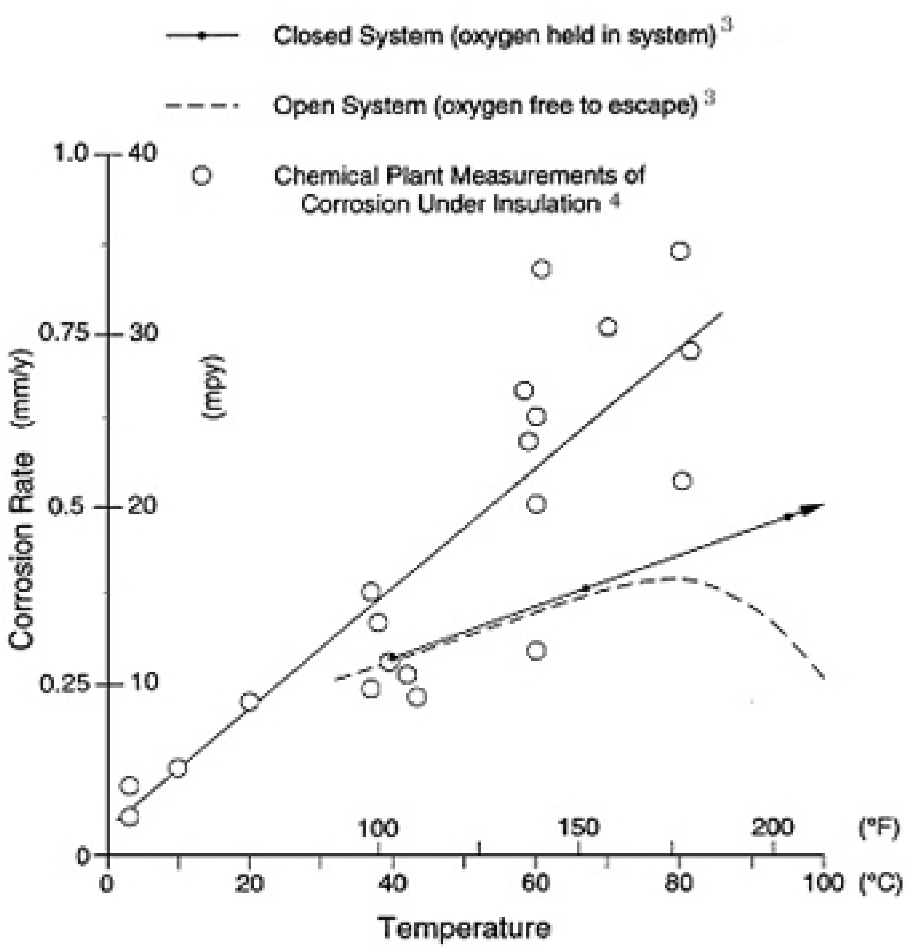
3. Preventing Corrosion Under Insulation in chemical Manufacturing Facilities.” Bruce Rutherfor, JPCL, July, 1998.
4. “The Control of Corrosion Under Thermal Insulation and Fire Proofing Materials – A Systems Approach.” NACE RPO 198-98, Item No. 21084 NACE International 1998


Pressure Gauge
Caulking Compound
Note: Jacketing Seam
at Top
Pipe
Metal Jacketing
Insulation





Closed System (oxygen held in system) 3
Open System (oxygen free to escape) 3
Chemical Plant Measurements of Corrosion Under Insulation 4
Corrosion Rate (mm/y)
(mpy)
1.0
0.75
0.5
0.25
0
40
30
20
10
100
150
200
(°F)
0
20
40
60
80
100
(°C)
Temperature

For an insulation system to be considered reliable the maintenance cost and inspection costs should be eliminated. This is done by using life cycle cost analysis and the use of good CUI prevention tools.

- Thermal Spray Aluminum Coating (TSA) of carbon steel (especially 4 inches and above).
- High performance coating of carbon steel
- Replace personnel protection insulation with wire cages
- Stainless steel for small diameter pipe instead of carbon steel
- Electrochemical protection using aluminum foil as a sacrificial anode in a galvanic reaction on stainless steel.

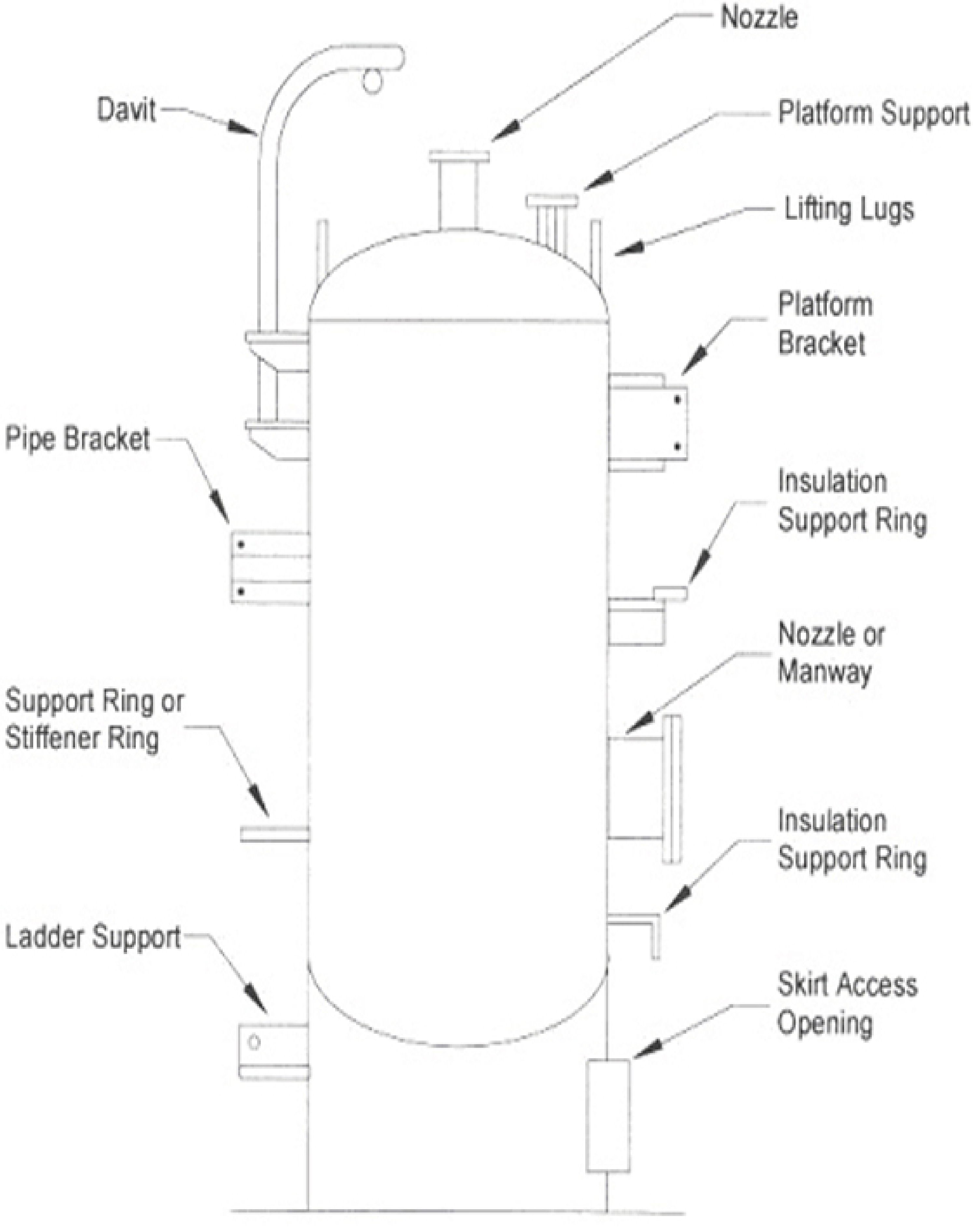
Insulation Properties Important To Reduce CUI

- Low permeability
- Protection against water intrusion and retention
- Thermal expansion properties should be similar to carbon steel and stainless steel to reduce seal breakage.
- Consistent thermal properties—avoid products whose insulation values change with age; this can lead to dew point issues and therefore CUI
- Product should be benign—no acidic species leaching

Table 1 Typical Service Temperatures for Thermal Insulation Materials

Thermal Insulation Material	Recommended Service Temperature (°C)
Polystyrene foam	-71 to 60
Polyurethane foam—rigid	-73 to 82
Polyisocyanurate foam—rigid	-73 to 120*
Flexible Foamed Elastomer	-40 to 104
Cellular Glass	-240 to 121
Glass Fiber	27 to 343
Mineral Wool	27 to 982
Calcium Silicate	27 to 649
Pearlite-Silicate	27 to 593

* Although some manufacturers' literature shows upper temperature limits approaching 149°C, experience indicates that polyisocyanurate foam begins to degrade at about 93°C in the presence of moisture. A suggested practical upper limit is 66°C.


Nozzle
Davit
Platform Support
Lifting Lugs
Platform Bracket
Pipe Bracket
Insulation Support Ring
Nozzle or Manway
Support Ring or Stiffener Ring
Insulation Support Ring
Ladder Support
Skirt Access Opening