

Ceramic Insulation Coating Products- Facts and Certified Testing Performance

Delta T and Protective
Products

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This document outlines the properties, uses and Laboratory tests performed on our Ceramic Insulation Industrial Coating.

Ceramic Insulation Key Properties and Test Results

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Protection from UV Rays

The "Ceramic Insulation Coating "Product" can be applied directly over composites with 100% adhesion and no chemical adverse effect (i.e. tar roofing, asphalt shingles, paint, etc.) providing protection against UV Rays as well as insulating. A certified testing laboratory "reported" the coating material was found to be extremely durable and a high quality, "heat barrier" that reflected 96% to 97% of all radiant heat. Additional tests were performed on 1 inch of foam coated with 16 mils of the "Ceramic Insulation Coating Product". Conventional foam sheet insulation has a tendency to crumble and split when exposed to ultra rays. However when the foam was covered with a thin coat of "Ceramic Insulation Coating" and tested, the conclusion reported: The coating offers protection against the normal problems of the foam insulation, therefore, it preserves the effectiveness of such insulating materials. The coatings were also found to remain flexible at temperatures as low as -30 degrees F. This additional coating of 1.00 pcf density foam provides the dimensional stability and compressive strength normally found in the higher cost 3.0 pcf density, without paying the higher price.

Adhesion

The "Ceramic Insulation Coating "product" has been tested for adhesion conforming to testing methods corresponding to ASTM D-3359, a cross hatch adhesion test, resulted in a score of 100 % (the highest on a scale of 1 to 100) The coating was spray applied using air assisted airless equipment. The coating thickness ranges from 45 mils to 75 mils across the tested coupon on tightly adhered mil scale. The initial test was performed 20 days after application. The result was a pull strength of 210 psi at 75 mils dft The coating was disbonded from itself leaving 3-6 mils intact to the substrate. The final pull test was performed about 30 days after final cure. The result was a pull strength of 210 psi at 45 mils dft. The coating again disbonded leaving 3 to 4 mils intact on the substrate. The "Ceramic Insulation Coating product" has been tested under ASTM 04541 Test Method for pull strength of Coating using portable adhesion testers. The conclusions are that the "Ceramic Insulation Coating "product" reaches full adhesive strength prior to final cure. Further conclusion based on disbandment within the coating shows an actual stronger bond to the substrate surface.

Flame Resistant

The "Ceramic Insulation Coating" Flame spread is rated 5 out of 100 according to the certified testing laboratories. Therefore the, "Ceramic Insulation Coating Product" can be applied directly to "hot" surfaces in a wide temperature range from 34 to 400 degrees F without and operating shutdown. In addition the "Ceramic Insulation Coating "product" was tested for toxic smoke, "All exposed animals survived without sickness or irritation" concluding that the "Ceramic Insulation Product" has no effects from smoke inhalation.

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Corrosion Protection

Insulating properties of fiberglass, wools, etc. are largely a result of the air entrapped between fibers but are reduced markedly when the material becomes wet. Moisture reduces the performance of air-filled insulators because the heat conduction of water at atmospheric temperature is more than 20 times that of air. Because the "Ceramic Insulation Coating" "product" has no air pockets, it impedes condensation, stops corrosion and has no loss of insulation properties when wet. A testing laboratory rated the "Ceramic Insulation Coating Product" by ASTM D-1653 standards as a moisture barrier. A pipe-coating company completed a hot water soak at 95⁰C or 203⁰ F for 48 hours with excellent results against penetration and no breakdown.

Condensation

A 40 mil application of the "Ceramic Insulation Coating" on a 38⁰F water line eliminated the condensation caused by the ambient temperature of 74⁰ F. Also a pulp and paper plant in the mid south applied 40 mils of the "Ceramic Insulation Coating Product" to a 48⁰F. CLO/2 tank (40 ft diameter x 50 ft height) top coated with polyurethane mastic to eliminate condensation and maintain a consistent temperature. In addition the "Ceramic Insulation Coating" has properties that are impervious to the environment such as a fungal pesticide resistance, rating 10 on a scale of 1 to 10 (10 being the highest.) Additional tests have been administered: wind driven rain, hot / cold cycling, and chemical resistance. In each test and analysis the "Ceramic Insulation Coating Product" tested in the highest percentiles of the available products.

Chemical Resistance

The "Ceramic Insulation Coating Product" is 58% solids, single component based medium density material, low in viscosity with high insulating properties and chemical resistance. Delta T. Control has worked with the industries utilizing and testing all of the known "Ceramic Coating Products" available on the market to date. Over the years we have eliminated the usage of all the various brands of "Ceramic Coating Products" that do not meet the standards as claimed by the specific manufacturer and their products associated there to. My experience over the last 15 years have identified the quality products that meet or exceed their specified claims, and will continue to utilize those products that meet the highest stringent standards of product quality available.

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Chemical Content

The laboratories reports that the "Ceramic Insulation Coatings Product" as having 0 (zero) grams of volatile organic compounds (VOC's), less water per liter, and is a compliant coating with regard to VOC content requirement of the Bay Area, "Air Quality Management District", one of the most strictly controlled air quality management districts in the United States. The "Ceramic Insulation Coating Product" contains no solvents or hazardous chemical elements such as fluorides, chlorines or iodine's. Laboratories have tested the chemical compound of the "Ceramic Insulation Coating Product" for chlorides and halogens with excellent results.

| Analytical | Water Soluble Chloride Cl mg/ kg (ppm) | Total Halogen TX mg/ kg (ppm) |
|------------|--|-------------------------------|
| Lab Code | As-Rec'd Basis | As-Rec'd Basis |
| 6379 | 22.5 | 5800 |
| 63749D | 19.1 | 8800 |

Certified ASTMT Testing:

| FLAMMABILITY | RESULTS | TEST METHOD |
|---|----------------|-----------------|
| Flame Spread (SW Research) | 5 out of 100 | ASTM E-84 |
| Smoke Developed | 5 | |
| MECHANICAL PROPERTIES | | |
| Cross Hatch Adhesion | 100 % | ASTM D-3359 |
| Tensile Strength (lb/in) | 66.7 % | ASTM D-882 |
| PHYSICAL PROPERTIES | | |
| Accelerated Aging. | PASSED 200 Hrs | ASTM G-53 |
| | 7347 HOURS | ASTM D-5894 |
| Moisture vapor barrier (Action Testing) | PASSED | ASTM D-1653 |
| Water vapor transmission (Corrosion Probe) | (Probe) PASSED | ASTM E-96 D4708 |
| Thermal Conductivity (OCM Test Lab) | | ASTM C-158 |
| Thermal Resistance (Action Testing) | | ASTM C-177-85 |

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| | | |
|---|-----------------|--------------|
| Pull-Off Strength (Corrosion Probe) | PASSED 250psi | ASTM D-4541 |
| Radiant Heat Burner | REFLECTS 100 UV | Rays GA TECH |
| Surface Flammability of Bulkhead | PASSED | ASTM D-792 |
| Weight Per Gallon | 5.94 | |
| Weight Non-Volatiles | 43%0 | |
| Brookfield Viscosity #3 Spindle @ 30 RPM, | 3564 | |
| Centipoise | | |
| USDA | ACCEPTED | |
| FDA | ACCEPTED | |

Temperature vs Thickness Comparisons

Test results have proven that one coat or 20 mil of “Ceramic Insulation Coating Product” eliminates radiant heat and significantly reduces temperature (60° F to 80° F) on hot surfaces. Additional coats contribute a reduction in temperature of 40° F to 50° F.

Recommended coating thickness based on surface temperatures

| Degrees F | Coats | Mil Thickness | DFT/per in |
|------------|-------|---------------|------------|
| 100 to 120 | 1 | 16 to 20 | 1/64 |
| 120 to 160 | 2 | 32 to 40 | 1/32 |
| 160 to 200 | 3 | 48 to 60 | 3/64 |
| 220 to 260 | 4 | 64 to 80 | 5/64 |
| 260 to 300 | 5 | 80 to 100 | 3/32 |
| 300 to 340 | 6 | 96 to 120 | 7/64 |
| 340 to 400 | 8+ | 140 to 200 | 9/64 |

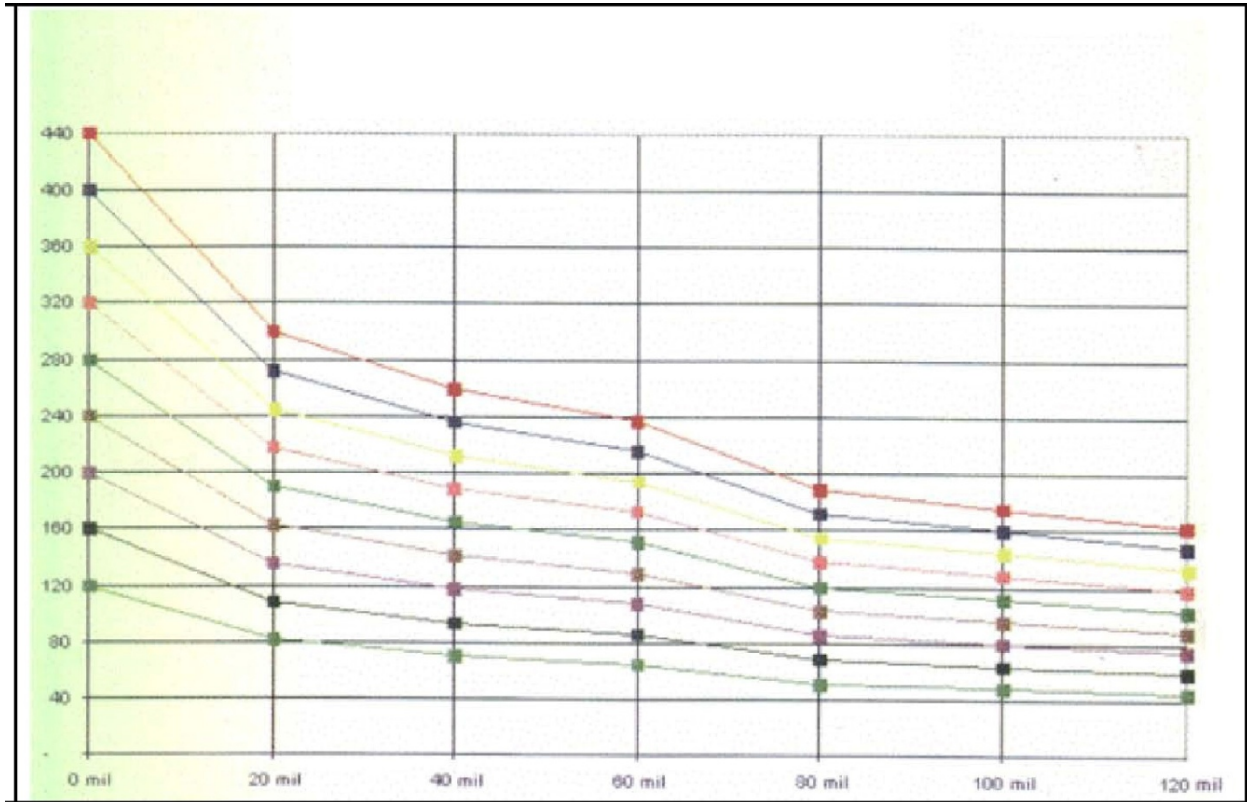
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Temperature Reduction versus CCC-100 product applied thickness

(temperature units in Fahrenheit)



Chemical Reaction Tests

Ceramic Insulation Coating Products" tested for reaction against the following

| Chemical Tested | Test Description | Results |
|--|-------------------|---|
| Ethylene Glycol (HOCH ₂ CH ₂ OH) | immersion 300 hrs | Excellent, the CCC-100 is not affected, no softening or discoloration is observed. |
| Ethylene Glycol+.03 Sulfuric Acid (HOCH ₂ CH ₂ OH) (H ₂ SO ₄) | immersion 300 hrs | Excellent, there is some metal strip corrosion, but CCC-100 stability is in-tact. The metal under the coating shows no corrosion. |
| Sulfuric Acid (93%) (H ₂ SO ₄) | immersion 300 hrs | Excellent, there is some metal strip corrosion, but CCC-100 stability is in-tact. The metal under the coating shows no corrosion. |
| Hydrochloric Acid (53%) (HCl) | immersion 300 hrs | The Acid softens the material but there is no adverse affect or break down of the CCC-100. |

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| | | |
|---|-------------------------|---|
| Methanol (98%) (CH4O) | immersion 300 hrs | The material is softened but there is no adverse affect or break down of the CCC-100. |
| Chemical Tested | Test Description | Results |
| Acidic Acid (50%) | immersion 300 hrs | The Acid softens the material but no breakdown |
| Sodium Hydroxide (NaHCO) | immersion 300 hrs | Excellent results, CCC-100 is not affected, no softening or discoloration is noted. The aluminum strip showed no sign of corrosion. |
| <p><i>**An environmental laboratory uses sodium hydroxide for removal of contaminates in water. Sodium hydroxide violently attacks the aluminum mixing paddles accelerating corrosion. Tests of the "Ceramic Insulation Coating CCC-100 " are noted in the above chart.</i></p> | | |

Example of Insulation properties - Ceramic Insulation CCC-100

Two large hot water Tanks in the mid south of the US were tested with CCC-100. The first hot water tank had a 40 ft. diameter and was 30 ft. high with a mean operating temperature of 140⁰ F. The second tank was the same diameter but 10ft. higher, and ran at 195⁰ F. Each of the tanks has the fiberglass insulation removed and was pressure washed. Two coats of Ceramic Insulation CCC-100 was applied, at approximately 40 mils thickness. The CCC-100 was only applied to a 10 ft. height on each tank. The 40 mil coating of CCC-100 produced astounding results by reducing the mean operating temperature on both tanks to 107⁰ F.

Corrosion issues on carbon Steel and Stainless Steel

Corrosion of carbon steel and stainless steels under conventional insulation on commercial and industrial process equipment costs our economy millions of dollars per year to repair costs; with safety risks to personnel and our environment, as well. These dollars would do better as profit and/or reinvestment into our economy, not spent on avoidable corrosion. The use of Ceramic Coatings will reduce the risk of corrosion to the substrates to which it is applied by resisting movement of moisture and contaminates to the surface. The moisture and contaminates cause the substrate to corrode with oxygen present.

Corrosion of carbon steel under conventional insulation.

The rate carbon steel will corrode under insulation is influenced by three factors. First is the wet exposure cycle with a duration and frequency. Second is the corrosivity of the moisture. Third is the lack of or failure of the barrier protection between the insulation and the carbon steel. There are many

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factors contributing to corrosion under conventional insulation and these may be offset by the use of Ceramic Coatings in certain applications.

There are seven main factors that will help control this process. These are equipment design, surface temperatures, insulation selection, protective coatings, weather barriers, climate control, and maintenance procedures. Mastering and understanding these issues well help to reduce the failure of insulation systems and *reduce costs* in these areas. Ceramic Coatings offers some fixes with lower costs and better performance. Properly used Ceramic Insulation only takes mils not inches.

Equipment Design

Care in equipment design and support layout is key to providing space for the insulation system used. Pipes, pressure vessels and tanks are the main items involved with process equipment. Building structures and roofs require their own special design to cope with higher levels of weather proofing required due to exposure. Simplifying the surface to be insulated makes these tasks easier, more cost effective and provides longer life.

Surface 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 contaminates in the moisture. The better the weatherproofing the less the corrosion rate will be. Ceramic Coatings 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 process breaches, consequently selection of an insulating material fitting the service application is key to minimizing the risk of under insulation corrosion. Non-wicking materials are 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 tagging requirement and being a water based system, which can be applied to most surface's while the operation is in progress, makes the Ceramic Coatings an easily maintained system. Polyurethane foam absorbs water readily, whereas the Ceramic Coatings does not. A wet insulation system does not give the energy savings the Ceramic Insulation provides and is a corrosion liability.

Protective Coatings

Protective coatings under insulation provide corrosion protection; however, it must meet immersion service conditions. The combination of moisture and heat along with chemical concentrations requires a coating system with 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 an un-insulated surface the need for the added protection of coating reduces the corrosion rate, significantly. Zinc rich primers and/or 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 occurs. Welds and insulation rings must

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be seal welded or caulked with material comparable with the coating system. Coating with Ceramic Coatings may only be required in high risk areas. For example: a storage tank containing a chilled solution. With high humidity a chilled tank will draw moisture to it like a magnet. Ceramic Coatings is water based. The product may be tinted. Top coating may also be done to meet color requirements. The top coat 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 or outer covering 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, 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 in 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. Ceramic Coatings does not require a vapor barrier, as it resists moisture movement. Ceramic Coatings like conventional insulation will suffer from mechanical damage and requires maintenance for the life of the system. Ceramic Coatings being spray applied and coming in containers allows full use of the product, whereas with conventional systems being pieced together, all material is not useable. But it still goes on the bill.

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. Ceramic Coatings will handle moisture without added protection in most applications. It is UV stable. One clear advantage is Ceramic Coatings does not allow moisture or chemicals to migrate to one location to set up a more active corrosion cell at the tank bottom, insulation ring or pipe elbow.

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

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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 spray application or brush applied, Ceramic Coatings will meet this need in a cost effective manner. One major area of concern is in personnel protection. Some tanks are only insulated to a height of eight feet to protect personnel from burns. There should be a weatherproof seal where the system terminates on the tank wall as the caulking breaks down and moisture can compromise the system. Ceramic Coatings will help to eliminate this risk of moisture intrusion and corrosion. Planned maintenance is the key to cost effective insulation and reducing corrosion.

Conclusion

The key to the success of maintaining cost effective life cycle costs with insulation systems in wet and corrosive environments is controlling the moisture in the insulation system. Simplifying the design with a monolithic insulation application reduces the risk for corrosion to the carbon steel.

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 140°F to -50°F seem to be the range where the ESCC normally occurs. When stress corrosion will occur in the life of the unit is difficult to predict and more so to control over time.

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 in the surface of the stainless equipment. The coastal regions have more of problem 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 of less than 5.5 will tend to increase the corrosion rate, rapidly with the chlorides present.

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Controlling the Cracking

Concentrations and stresses in the fabricated vessel will dictate the rate at which ESCC will occur. Gland water, on shaft packing, flowing at 3-5 gal/hr containing 50-70 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 to the equipment ultimately caused the failure. In other cases it may take much longer. The main difference between the stainless and carbon steels is that the cracking can't 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 Ceramic Coatings is the safest approach to use in the 140°F to 250°F range. 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. Ceramic Coatings does this well, because the material has low chlorides, provides insulation, and serves as a protective coating.

Summary of Corrosion under Insulation

If you have insulated equipment, corrosion will occur to fine degree. By using proper materials, specification, engineering design inspection and maintenance methods the costs can be kept to a minimum. The problem will most likely never go away, but like blood pressure and taxes; it can be controlled. Ceramic Coatings offers answers to some of the challenges faced by the other insulation systems. Just like all systems it needs proper specification and application along with good product knowledge to be successful

Technical Information Bulletin

Target:

INSULATION AND MAINTENANCE ON SMALL PROJECTS

Product: Ceramic Insulation Coatings

Summary

IN LOOKING FOR NEW PRODUCTS TO INCREASE PERFORMANCE. REDUCE COSTS AND REDUCE RISKS TO THE ENVIRONMENT, WE (Delta T Control and Protective Products) HAVE STUDIED AND TESTED THE (CERAMIC INSULATION COATING PRODUCTS) . THE MATERIAL HAS BEEN IN SERVICE FOR ABOUT 18 YEARS (WE LOCATED AN APPLICATION ON A MOLTEN SULFUR STORAGE TANK IN ONE OF OUR COASTAL MILLS IN SUCCESSFUL SERVICE SINCE 1988). AS REPAIRS ARE MADE TO EXISTING TANKS AND PIPEING SYSTEMS REINSULATION 1S REQUIRED.

THE CERAMIC BASED SPRAY APPLIED SYSTEM 1S LATEX BASED AND MAY BE APPLIED TO HOT SERVICES. THE KEY ADVANTAGE HERE IS FOR SAFETY AND THE CONTRACTORS CAN PERFORM THE WORK WITH THE PROCESS IN OPERATION. THE NATURE OF THE PRODUCT DOES NOT ALLOW MOISTURE TO MIGRATE; THIS IS AN IMPROVEMENT OVER OTHER TYPES OF SPRAY APPLIED INSULATION, WHICH HAS HAD A HISTORY OF

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PROMOTING CORROSION UNDER INSULATION DUE TO MOISTURE RELATED ISSUES. THE PROCESS WE USED IN TESTING INCLUDED TEAMING OR PARTNERING WITH THE EXISTING PAINTING CONTRACTORS WE ARE CURRENTLY USING AT OUR VARIOUS MILL SITES. THIS METHOD REDUCED THE UNKNOWN OF THE QUALITY OF THE APPLICATOR AND ALLOWED US TO FOCUS ON THE PRODUCT ITSELF. WE FEEL OUR CONTRACTORS WOULD NOT PLACE THEIR REPUTATIONS WITH A NEW PRODUCT UNLESS THERE WAS A GOOD CHANCE FOR SUCCESS TECHNICALLY AND FINANCIALLY. THE ONE ISSUE DELTA T CONTROL AND PROTECTIVE PRODUCTS WILL STRESS IS CERTIFICATION OF THE CONTRACTOR. THIS IS IMPORTANT TO THE SUCCESSFUL USE OF THE PRODUCT.

LIKE MANY NEW MATERIALS " THEY ARE NOT ALL THE SAME" AS WE ARE LED TO BELIEVE. HENCE THE NEED FOR EDUCATION ON APPLICATION OF THE PRODUCT UNDER PROCESS CONDITIONS.

RECOMMENDATIONS

CERAMIC COATINGS (0 FLAME SPREAD) MAY BE USED ON PROCESS AND STORAGE TANKS AND FOR INSULATION PERSONELLE PROTECTION; APPLICATIONS TO DATE INCLUDE TEMPERATURES UP TO 285 DEGREES F.

NOTE: AFTER THE TANK SURFACE HAS BEEN INSULATED IT MAY BE COATED WITH A COLOR OF THE OWNERS CHOICE AS THE SURFACE TEMPERATURE IS LOW ENOUGH FOR CONVENTIONAL COATING SYSTEMS TO BE USED. URETHANES ARE RECOMMENDED OVER THE EPOXIES (WORK WITH YOUR CURRENT SUPPLIERS)

CERAMIC COATINGS MAY BE USED ON PIPING AND DUCTWORK TO CONTROL HEAT LOSS OR GAIN AS REQUIRED. SURFACE PREPARATION REQUIREMENTS ARE CLEAN, DRY. SURFACE (NO OIL OR LOOSE RUST) IT MAY BE USED ON STAINLESS STEEL AS IT CONTAINS LESS THAN 25 PPM. OF WATER SOLUABLE CHLORIDE