ERDC/CERL TR-15-5

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DoD Corrosion Prevention and Control Program (CPC)

Demonstration and Validation of Corrosion-Mitigation Technologies for Mechanical Room Utility Piping and Cooling-Tower Pumps

Final Report on Project F07-ARCTC01

Robert B. Mason, Kevin L. Klug, Richard G. Lampo,
Alfred D. Beitelman, Susan A. Drozdz, and Vincent F. Hock

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Final report

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Abstract

Two critical infrastructure corrosion issues at Fort Bragg, NC, are the corrosion of steel utility piping union joints in mechanical rooms and the corrosion of steel pump housings in cooling tower systems. Reliable operation of these components is essential to the Fort Bragg mission. Pump corrosion in particular can lead to system failure, causing disruptions in facility operation and incurring considerable expense for emergency repair labor and parts. This project demonstrated reliable corrosion prevention technologies, including high-performance coatings, materials, insulation, water treatment, and dehumidification — as applied to mechanical room pipes and cooling tower housings. The performance of the technologies was monitored, along with the overall corrosivity of the environment, from January – December 2008. Then, in mid-2010, coating condition in both the mechanical rooms and on the cooling-tower pumps was inspected and reassessed. This report presents corrosion data spanning approximately 30 months of service and evaluates the performance of each technology in terms of cost effectiveness, system reliability, and safety.

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Preface

This demonstration was performed for the Office of the Secretary of Defense under the Corrosion Control and Prevention Program, Project F07-ARCTC01, “Demonstration and Validation of Technologies to Mitigate Corrosion on Mechanical Room Utility Piping and Cooling-Tower pumps at Fort Bragg, NC.” The proponent was the U.S. Army Office of the Assistant Chief of Staff for Installation Management (ACSIM) and the stakeholder was the U.S. Army Installation Management Command (IMCOM). The technical monitors were Daniel J. Dunmire (OUSD(AT&L)), Bernie Rodriguez (IMPW-FM), and Valerie D. Hines (DAIM-ODF).

The project was executed by the Materials and Structures Branch (CEERD-CFM), Facilities Division (CF), U.S. Army Engineer Research Center, Construction Engineering Research Laboratory (ERDC-CERL). The work was conducted by Concurrent Technologies Corporation (CTC), utilizing personnel in Largo, FL, and Fayetteville, NC. At the time of publication, Vicki L. Van Blaricum was Chief, CEERD-CFM; L Michael Golish was Chief, CEERD-CF; and Kurt Kinnevan, was the Technical Director for Adaptable and Resilient Installations. The Deputy Director of ERDC-CERL was Dr. Kirankumar Topudurti, and the Director was Dr. Ilker Adiguzel.

The following Fort Bragg personnel are gratefully acknowledged:

- Judi Hudson – Deputy Director of Public Works, DPW
- Jason Lyons – Acting Chief, Facility Maintenance Division, DPW
- Brenda Audette – Water Resources Chief, DPW
- Robert Mullen – Chief of Utilities, DPW
- Russell Hayes – DPW

The assistance of John Schlesinger, Honeywell Fort Bragg, was instrumental in obtaining access to the cooling towers and is greatly appreciated. Also, CTC Senior Materials Engineer Michael Miller is gratefully acknowledged for preparing the final economic analysis for Chapter 4.

The Acting Commander of ERDC was LTC John T. Tucker III, and the Director was Dr. Jeffery P. Holland.

Executive Summary

This demonstration/validation project assessed the effectiveness of several market-available corrosion-mitigation technologies selected for application to susceptible mechanical room piping and cooling-tower pump housings at Fort Bragg, NC. High-performance coating systems and materials, insulation, water-treatment technologies, and dehumidification equipment were installed in January 2008. Technology performance and the corrosivity of the demonstration-site environments were monitored from January through December 2008.

In general, both of the high-performance coating systems performed adequately in the mechanical rooms during the first year of service by inhibiting corrosion on pipe union joints as compared with uncoated joints, although not completely or consistently. Dehumidification and removable insulation products were far less effective in arresting the corrosion of pipe fittings because they did not prevent the formation of condensation on the cold-water joints. For the cooling-tower pumps, a stainless steel alloy and a high-performance epoxy coating system incorporating a zinc-rich primer were both observed to be more effective during the first year of service than a standard pump-manufacturer coating system.

In mid-2010, after approximately 30 months of service, additional data were collected on the condition of the coatings in both the mechanical rooms and on the cooling-tower pumps. By that time, the stainless steel pump had failed due to off-specification dry storage during a period of seasonal dormancy. The pump was easily repaired and ran well afterward, but the issue underscored the need for the user to closely follow manufacturer instructions about equipment operation and storage.

Based on the data collected during this demonstration, the return-on-investment was calculated to be 37.8 for the use of high-performance coating systems in mechanical rooms; 6.2 for the use of stainless steel cooling pumps, and 7.4 for the use of high-performance coating materials on cooling-tower pump housings. Recommendations are offered for updating Unified Facilities Guide Specifications to promote appropriate implementation of these technologies.

Unit Conversion Factors

Multiply	By	To Obtain
degrees Fahrenheit	(F-32)/1.8	degrees Celsius
feet	0.3048	meters
gallons (U.S. liquid)	3.785412 E-03	cubic meters
inches	0.0254	meters
mils	0.0254	millimeters
square feet	0.09290304	square meters

1 Introduction

Accelerated corrosion of critical steel infrastructure components has been evident for years at Fort Bragg, NC. Problems include the corrosion of steel utility piping in mechanical rooms and steel pump housings used in cooling-tower systems. A prime example of a serious problem surfaced as accelerated corrosion of exposed union joints in the mechanical rooms at Fort Bragg's newly constructed 16th Military Police Barracks. The environmental conditions in the mechanical rooms resulted in heavy amounts of condensation accumulating on the supply line insulation and metal brackets that support the pipes. In addition to causing accelerated corrosion, there is also concern about the potential for the growth of mold, creating health hazards in addition to safety issues.

Accelerated corrosion is also damaging a relatively new central cooling plant at Fort Bragg, which first went online in 1996. The vertical cooling towers and pumps there have corroded at an alarming rate, causing total pump failure within 2 – 4 years of operation. These problems can be attributed to use of a corrosion-vulnerable mild steel alloy in the lower pump housings. These housings are typically exposed to highly oxygenated turbulent water, which effectively consumes the metal through extensive pitting and flaking. Ineffective or improper system water treatment may also contribute to the accelerated corrosion of these pump components, further aggravating the problem. Corrosion damage can cause considerable system downtime, which disrupts the use of facilities and increases the life-cycle cost of operation in terms of repair expenses.

The U.S. Army Engineer Research Center, Construction Engineering Research Laboratory (ERDC-CERL) collaborated with personnel of the Fort Bragg Department of Public Works (DPW) to demonstrate and validate a number of promising, market-available corrosion-mitigation technologies under the Department of Defense Corrosion Prevention and Control Program. Technologies were selected to address examples of highly aggressive corrosion and the ambient conditions contributing to it.

1.1 Objectives

For mechanical room piping and union joints, the objectives were to demonstrate

- at least two different coating systems (including one innovative ceramic-filled coating) to prevent corrosion on exposed pipes and joints
- removable insulation to thermally isolate cold surfaces of exposed steel pipes and joints to prevent condensation on them
- industrial-grade dehumidification equipment to remove moisture from mechanical room air in order to suppress corrosion processes and potential mold growth.

For cooling-tower pump housings, the objectives were to

- investigate and compare the use of high-performance coatings to original equipment manufacturer (OEM) coatings used on pump housings
- investigate and compare the use of alternative materials for the lower pump housing to the demonstrated high-performance coatings
- assess the need for different water treatment chemistry in the cooling tower systems.

1.2 Approach

A commercially available removable/replaceable insulation system, two different coating systems, and one dehumidification system were identified and evaluated in terms of cost, performance, and availability. Candidate technologies were reviewed by ERDC-CERL, and the most promising examples were procured and installed is selected Fort Bragg mechanical rooms. The technologies were monitored January through December 2008. Their condition was documented photographically. Where applicable, the performance of the technologies was rated on a monthly basis in accordance with the American Society for Testing and Materials (ASTM) Test Method D1654, *Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments* [1].

For the cooling tower applications, two commercially available coating systems and one alternative corrosion-resistant material were identified, evaluated, and approved in cooperation with ERDC-CERL. After being installed, they also were monitored from January through December 2008, documented photographically and, where possible, rated monthly in accordance with ASTM D1654 [1]. Water samples were collected monthly during this period to assess system water chemistry.

Two types of coupon test racks also were located in the mechanical rooms and cooling tower sumps for controlled, longer-term comparison of demonstrated materials. Large test coupons were coated with the selected coatings at the time of installation, mounted in the same locations where the demonstrations were being conducted, and rated monthly in accordance with ASTM D1654 [1]. Smaller, uncoated test coupon racks, procured from Battelle[1], were placed in the mechanical rooms and outdoors near the rooms. These racks were returned to Battelle for analysis at three-month intervals during the evaluation period. The analyses were conducted outside the scope of demonstration support, but the results are reported here.

Also, corrosion rate sensors were placed in the cooling-tower sumps and read on a monthly basis during the evaluation period.

The Project Management Plan (PMP) for this demonstration (Appendix A) provides the full scope of work.

[1] Battelle Memorial Institute, Columbus, OH.

2 Technical Investigation

2.1 Project overview

2.1.1 Mechanical room piping

High-performance coatings, removable insulation, and dehumidification technologies were evaluated for their applicability to the Fort Bragg facilities and equipment described in Chapter 1. Candidate technologies were identified and evaluated from the perspective of cost, performance, and availability. This information was compiled into a technology matrix to ascertain the most viable candidates. Table 1 shows the matrix of technologies considered for demonstration and validation. The most promising technologies were reviewed and approved for the test applications by ERDC-CERL before procurement and installation.

One of the coating systems consisted of Sherwin-Williams (Cleveland, OH) Corothane MIO-Aluminum primer (a moisture-cure polyurethane pigmented with aluminum and micaceous iron oxide) and Sherwin-Williams Corothane 1 Moisture-Cure Urethane (MCU) topcoat. The second coating was a ceramic-filled insulating coating, which was evaluated both for corrosion-prevention capabilities and suppression of condensation on cold-water piping. This product, TC Ceramic (Capstone Manufacturing, Seattle, WA), is a water-thinable acrylic paint that is heavily pigmented with ceramic particles, which was used in previous ERDC-CERL work to mitigate corrosion for manholes, piping, and appurtenances at Fort Jackson, SC [2, 3].

Both of the selected coatings were applied by a subcontractor, M&T Machine, to exposed, uncoated steel piping, union joints, and utility hangers in a single mechanical room (hereinafter referred to as Mechanical Room A). Surface preparation and application complied with the respective manufacturer's recommendations, industry best practices, and the environmental safety and health policies at Fort Bragg (see Appendix B).

Table 1. Technology matrix for mechanical room applications.

Requirement (per SOW)	Proposed Technology	Manufacturer	Product Description	Advantages	Disadvantages	Product Characteristics	Performance Characteristics
"commercial off-the-shelf (COTS) white-pigmented, moisture-cure polyurethane coating suitable for the expected high-humidity exposures"	***Corothane Mio-Aluminum (Primer), Corothane 1 MCU (topcoat)***	**Sherwin-Williams Company, Cleveland. OH**	PRIMER: Single component, VOC compliant, moisture curing, aluminum and Micaceous Iron Oxide (MIO) filled urethane primer. TOPCOAT: Single component, VOC compliant, moisture curing urethane designed for low temperature/high humidity applications while providing UV resistance and chemical resistance equivalent to two part urethane coatings.	Both primer and topcoat COTS, readily available, can be sprayed, brushed, or rolled. Primer compatible with topocat.	Both primer and topcoat have moderate VOC content (<340g/L for primer, <420 g/L for topcoat). Needs "Reducer" to clean up.	Both primer and topcoat: low temperature application (down to 20 °F). Primer dries to touch in 1-4 hrs, recoat in 3-16 hrs.	PRIMER: Adhesion 1000 psi per ASTM D4541, dry heat resistance 300°F per ASTM D2485, flexibility passes per ASTM D522, moisture condensation passes per ASTM D4585, pencil hardness 2B per ASTM D3363, corrosion ratings 9 per ASTM D5894, 10 per ASTM B117 (2300 hours). TOPCOAT: Abrasion 24 mg per ASTM D4060, adhesion 946 psi per ASTM D4541, dry heat resistance 280°F per ASTM D2485, flexibility passes per ASTM D522, moisture condensation passes per ASTM D4585, pencil hardness 2H per ASTM D3363, corrosion ratings 9/10 per ASTM D5894, 9/10 per ASTM B117 (3000 hours)
"ceramic-filled, insulating coating suitable for the high-humidity exposures"	***TC Ceramic (also known as Thermal Coat)***	**Capstone Manufacturing, Seatte, WA**	Single component, waterborne acrylic polymer with silicon microspheres. "Liquid insulation," consisting of a mixture of various silicon and ceramic beads blended into a high quality acrylic polymer.	Radiant reflectivity and emissivity properties – significantly reduces radiant energy gain. Reduces or eliminates condensation. CERL is familiar with this product and has specified it	VOC content 80.5 % solids by volume	Dry to touch 3 hrs, recoat 12 hrs.	Withstands up to 500 °F.
"removable/replaceable insulation material system"	***SpeedWrap***	**SpeedTech Inc., River Falls, WI**	Removable insulation suitable for various pipe configurations.	COTS, readily available. Easily applied, removed and, reapplied after testing or maintenance. Ideal for insulating exposed fittings, valves, piping and tubing. Shipped ready to install using standard scissors.	TBD	Manufactured from silicone impregnated woven fiberglass cloth. Fits standard pipe and tubing sizes up to 3" diameter. Service temperature for 1/8" insulation is ambient to 400 °F; for 1/4" insulation, ambient to 600 °F.	Hook and loop fasteners, easily applied, installs in minutes.
"some form of dehumidification. The proposed solution must be cost-effective and require minimal maintenance."	***Ebac CD35-P Dehumidifier***	**Applied Dehumidification Inc., Tampa, FL**	Portable dehumidifier. Self-contained and automatic.	Standard 115 V, internal adjustable humidistat, ductable, extra long power cord. Heavy duty steel chassis, powder coated. 1 year warranty. CD35P features internal condensate pump and ground fault interrupter.	Need to determine required maintenance.	Compressor: High Efficiency reciprocating, 1/3 HP. Refrigerant: R-134a CFM: 170. 115 V, 2.5 amps. Capacity: 17ppd@AHAM, 6 Gallons per day@saturation. Height: 22", Width: 12", Depth: 12"	At 80 °F and 60% RH, unit will remove more than 17 pints water vapor per day (nearly 6 gallons in severe environments).

In a second mechanical room (hereinafter referred to as Mechanical Room B), no coatings were applied; instead, industrial-grade dehumidification equipment was specified. A suitable system, the Ebac CD35-P Dehumidifier, was sized on the basis of Mechanical Room B dimensions; procured from Applied Dehumidification Inc., Tampa, FL; and installed. The humidity level of the room was monitored and electronically recorded with a humidistat device (HOBO U12 Temperature/Relative Humidity data logger and HOBOware Pro for Windows software, Onset Computer Corporation, Bourne, MA). The dehumidifier was installed in January 2008, after temperature and humidity data collection had been initiated. The dehumidification level was initially set to 8 on a scale of 10.

A third mechanical room (hereinafter referred to as Mechanical Room C) was designated for experimental control purposes, and was not outfitted with any of the above technologies.

Also, a removable/replaceable insulation material (SpeedWrap ES) was used on coated union joints (Mechanical Room A) and uncoated, exposed union joints (Mechanical Room C). The selected insulation system was incorporated into this effort at the request of Fort Bragg personnel to test whether it could control the condensation of moisture at the pipe component/insulation interface. The insulation material was procured from SpeedTech, Inc., River Falls, WI. It is noted that this technology was relatively new to the market, and its full spectrum of capabilities was unknown; thus, in Table 1, the disadvantages are listed as "to be determined."

In all three mechanical rooms, two types of coupon test racks were installed. Large test coupons were coated with the subject coatings at the time of installation, installed within the subject mechanical rooms, and rated in accordance with ASTM D1654 [1]. One coated test panel for each coating system was scribed to base metal in accordance with ASTM D1654, while the other duplicate for each coating system was left unscribed. Smaller, uncoated test coupon racks were supplied by Battelle and were placed in the mechanical rooms, as well as outside. These racks were returned to Battelle for analysis every 3 months during the evaluation period. The analysis of these test coupons was conducted outside the scope of this effort, but the data are relevant and therefore provided in this report.

Available technical data sheets and material safety data sheets for the coating technologies described above can be found in Appendix C.

2.1.2 Cooling-tower pumps

Coating systems and corrosion-resistant materials that could be used in the cooling towers at Fort Bragg were identified and evaluated from a cost, performance, and availability standpoint. The technology matrix employed to identify the most promising candidates for this application is presented in Table 2. The identified technologies were reviewed by ERDC-CERL, and the most promising candidates were approved for the demonstration.

There are five cooling-tower pumps at the central cooling plant at Fort Bragg. Two of these pumps—one recently purchased replacement pump and one recently refurbished pump (both with standard OEM coatings on the lower steel housings)—served as controls. Two of the remaining pumps were refurbished using two different selected high-performance coatings suitable for the application and anticipated environment. The first coating system selected was Corps of Engineers Paint System 21-A-Z, consisting of MIL-DTL-24441/19B (also called Formula 159) zinc-rich epoxy primer and MIL-DTL-24441 Formula 151 topcoat. The second coating system selected was Sherwin-Williams Macropoxy 646 Fast Cure Epoxy primer and Sherwin-Williams Tile-Clad High Solids Epoxy-Polyamide topcoat. Removal, surface preparation, coating, and reinstallation of all system components as required to execute this task was conducted by M&T Machine. Surface preparation and application of the selected coatings was conducted in accordance with the respective coatings manufacturer's recommendations, industry best practices, and applicable environmental safety and health policies (Appendix B).

Available technical data sheets and material safety data sheets for the coating technologies discussed above can be found in Appendix C.

The fifth pump was replaced with a pump that incorporated components made from a corrosion-resistant alloy (stainless steel 316) suitable for the application and anticipated environment. (For brevity, this pump is hereinafter referred to as "the stainless steel" pump even though only a portion of the pump is made of stainless steel.) The replacement pump was comparable in size, capacity, and connection with the existing system. To this end, the following items were procured and installed under this effort:

- Flowserve Model 12ENH-1 stage pump bowl and impeller assembly
- 316 stainless steel pump shaft and line shaft
- 316 stainless steel column pipe.

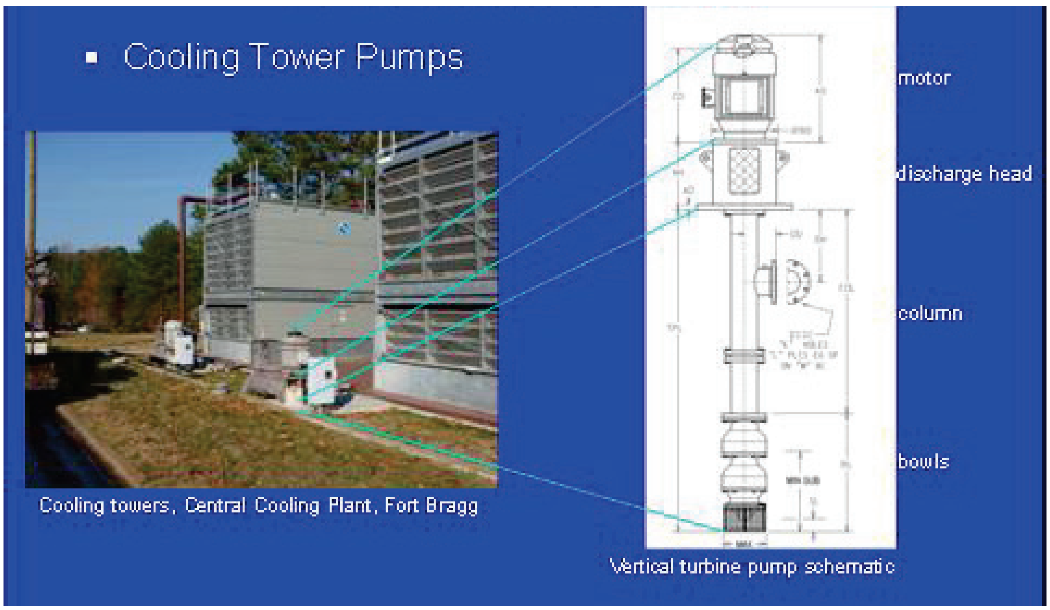
Table 2. Technology matrix, cooling-tower pump components.

Requirement (per SOW)	Proposed Technology	Manufacturer	Product Description	Advantages	Disadvantages	Product Characteristics	Performance Characteristics
"standard coating for cooling pump shafts"	***System No. 21-A-Z***	**Mobile Paint Manufacturing, Theodore, AL**	PRIMER: MIL-DTL-24441/19B (also called Formula 159) zinc rich epoxy. TOPCOAT: MIL-DTL-24441 Formula 151 or 152 depending on color desired.	Recommended by CERL. CERL is familiar with this product and has specified it previously.	Cost - zinc rich primer reported to be $1K per gallon	Requires white metal grit blast (not shot). From CERL specification: "The epoxy zinc-rich paint 19B shall be applied in two single half-lapped spray coats to an average dry film thickness of a minimum of 4.0 mils, and a thickness at any point of not less than 2.5 mils or greater than 8.0 mils. After a drying period of not less than 6 hours nor more than 96 hours, at least two coats of epoxy polyamide paint shall be applied to produce an average dry film thickness totaling 12 mils. If the epoxy zinc-rich paint has been applied in the shop or otherwise has been permitted to cure for longer than 96 hours, it shall be abraded and recoated with an additional thin tack coat of the zinc-rich paint, which in turn shall be overcoated within 96 hours with the first coat of the epoxy polyamide paint. When applying MIL-DTL-24441, the type of thinner, amount of thinning, and required induction time shall be as recommended by the manufacturer. The drying time between non-zinc coats shall not be less than 12 hours nor more than 96 hours."	None reported for either primer or topcoat on Product Data Sheets.
"advanced coating for cooling pump shafts"	***Macropoxy 646 Fast Cure Epoxy (Primer), Tile-Clad High Solids Epoxy-Polyamide (Topcoat)***	**Sherwin-Williams Company, Cleveland, OH**	PRIMER: High solids, high build, fast drying polyamide epoxy. TOPCOAT: VOC-compliant, two-package, epoxy-polyamide for use in industrial maintenance environments.	Proposed by SW representative for M&T. Macropoxy 646 alone is on the refurbished pump at Fort Bragg. Topcoat is formulated for immersion and atmospheric service in marine and industrial environments. Low temperature application.	Epoxy coatings may darken or discolor following application and curing. Coatings may chalk if exposed to sunlight for long periods.	Requires properly prepared surfaces. For recoating: primer min 8 hours, topcoat min 2 hours (@77°F). Cure for immersion (primer) is 7 days (@77°F).	PRIMER: Abrasion Resistance 84 mg loss per ASTM D4060, Accelerated Weathering QUV passes per ASTM D4587 (QUV-A 12,000 hours), Adhesion 1,037 psi per ASTM D4541, Corrosion Weathering Rating 10 per ASTM D714 for blistering 9 per ASTM D610 for rusting per ASTM D5894 (36 cycles, 12,000 hours), Direct Impact Resistance 30 in. lb. per ASTM D2794, Humidity Resistance no blistering, cracking, or rusting per ASTM D4585 (6000 hrs), Immersion passes with no rusting, blistering, or loss of adhesion after 1 year fresh and salt water, Pencil Hardness 3H per ASTM D3363, Salt Fog Resistance 10 per ASTM D610 for rusting and 9 per ASTM D1654 for corrosion per ASTM B117 (6,500 hours). TOPCOAT: Abrasion Resistance 80 mg loss per ASTM D4060 (CS17 wheel, 1000 cycles, 1 kg load), Adhesion 1050 psi per ASTM D4541, Corrosion Weathering Rating 10 per ASTM D714 for blistering 9 per ASTM D610 for rusting per ASTM D5894 (10 cycles, 3,336 hours), Direct Impact Resistance 95 in lb per ASTM D2794, Pencil Hardness F-H per ASTM D3363, Salt Fog Resistance 10 per ASTM D610 for rusting and 10 per ASTM D714 for blistering per ASTM B117 (2,500 hours).
"advanced material for cooling pump shafts"	***Stainless steel (316 or 416)***	**Floway Pump Company, Fresno, CA**	316 or 416 stainless steel shafts to replace existing shafts.	Enhanced corrosion protection	Cost considerably higher.	TBD	TBD

It is noted that the stainless steel pump components were not available off the shelf, but were specially fabricated for this project. Because the full spectrum of capabilities was unknown, the product and performance characteristics were listed "to be determined" in Table 2.

The submerged portions of the pumps are composed of two sections: the upper housing, which protects the shaft (i.e., column) and the lower housing, which protects the impellers (i.e., bowls). A schematic showing these sections of the pumps is presented in Figure 1.

Figure 1. Cooling-tower pump at Fort Bragg and schematic.



The two pump coating systems covered the column and bowl sections, as well as the discharge head; however, the stainless steel was used only for the column section, and a one-coat system was applied to the bowl section of that pump.

The demonstrated coatings were applied to large test coupons at the time of installation. The coupons were mounted in the three subject pump sumps and rated monthly in accordance with ASTM D1654 [1]. One coated test panel for each system was scribed to base metal in accordance with ASTM D1654, while the other duplicate for each coating system was left unscribed. The condition of these test panels was documented and photographed upon installation.

The corrosivity of the water system was measured and monitored using Rohrback Cosasco Systems (Santa Fe Springs, CA) corrosion sensor probes with Checkmate data logger and Corrdata Plus software in each of the three sumps in which the exposure test racks were placed. Data were collected and recorded monthly for 1 year under this effort.

Water samples were collected on a monthly basis from each of the five pump sumps, dispensed into 1 qt laboratory-grade plastic bottles, and sent for analysis in order to assess the water treatment chemicals relative to their influence on the overall corrosivity within the system.

2.1.3 Monitoring

The panels and components in the mechanical rooms were visually inspected and photographed at monthly intervals. (The project plan specified three-month intervals, but Fort Bragg personnel asked for monthly evaluations, and the project team was able to accommodate this request at no additional cost.) Where possible, coating performance was rated in accordance with ASTM D1654 [1]. The performance of the insulation and dehumidifier was evaluated visually on a monthly basis.

In Mechanical Room B, dehumidifier performance appeared to be marginal, and so the dehumidification setting was increased for the summer months — from 8 to 9 (out of 10) in June 2008, and from 9 to 10 in July 2008.

The performance of the coatings on the pumps and test panels was also assessed and photographed at monthly intervals under this effort (the SOW for this effort specified three-month intervals. Where possible, the coating performance was rated in accordance with ASTM D1654 [1]. The results of the water sample analyses were also reviewed and correlated to the findings.

2.2 Installation of the technologies

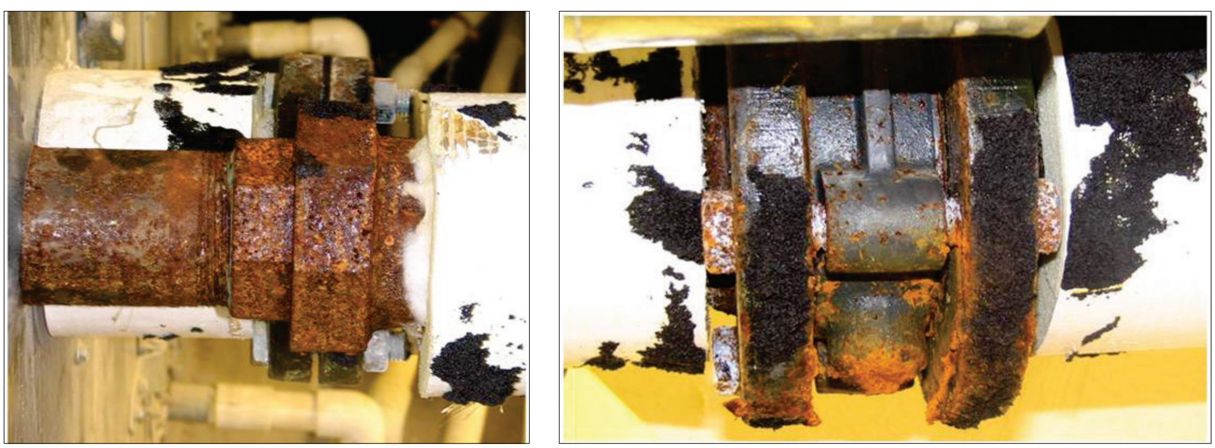
2.2.1 Mechanical room piping

The coatings work began in January 2008. Work was performed in the three subject mechanical rooms on the third floor of Building 2-5506. The list below summarizes the settings and tasks:

- Mechanical Room A, in the southwest corner, was used for the evaluation of coatings and removable insulation with coatings.
- Mechanical Room B, in the northwest corner, was used for the evaluation of dehumidification.
- Mechanical Room C, in the northeast corner, was used as the control location, but a small number uncoated fittings were selected to evaluate a variety of removable insulation of interest to DPW personnel.

The as-built drawings of Mechanical Rooms A and B were dated 29 November 2004 and 20 April 2006, respectively. Mechanical Room C was reported to be 9 months old. Most of the piping systems in all three rooms were covered with black insulation; some also incorporated a hard white plastic jacket over this insulation. While this system completely encloses each item, large air cavities were noted within the insulation. Humidity apparently infiltrated the cavities and condensed, as indicated by considerable volumes of water released where some of the foam was removed. As would be expected, there was more condensation on the chilled lines than on the hot, and the union joints on the cold lines revealed significant corrosion when exposed. Figure 2 shows the appearance of two such joints.

Figure 2. Union joint in Mechanical Room A, before cleaning.

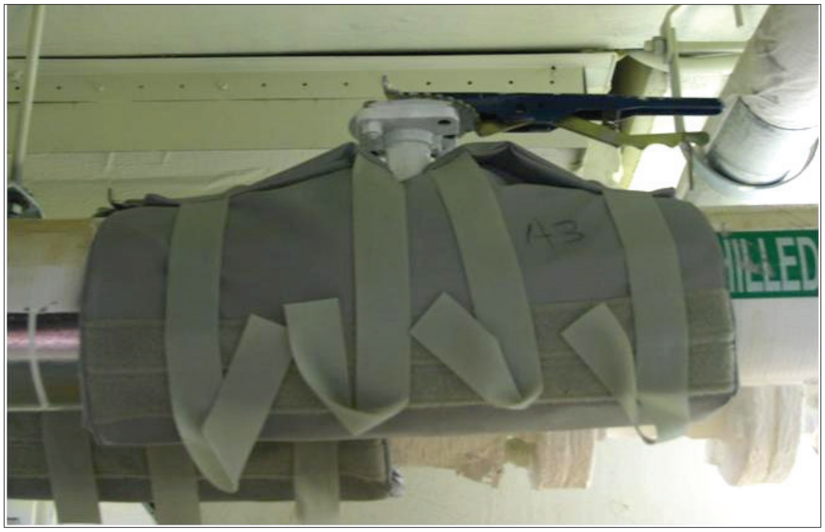


In Mechanical Room A, the foam insulation was removed from a number of union joints and other items. The condition of each item was documented and photographed. Wire brushes, jackknives, and rags were used to remove corrosion products and dirt as needed. The quality of cleaning met the requirements of SSPC Surface Preparation Specification No. 2 (SP2), *Hand Tool Cleaning* [4]. Immediately before applying the paint, each item was again wiped dry with a cloth. All items were brush-coated with Sherwin-Williams Corothane MIO-Aluminum primer. On one large pump, the application consisted of wiping and coating small areas in order to maintain a dry substrate. The following day, thickness measurements were taken from all painted items. Measurements ranged from 1.6 to 5.0 mils, with most in the 2.0–3.0 mil range. Selected items were dried with a cloth and then coated with Sherwin-Williams Corothane I Aliphatic (white) topcoat. Final thickness measurements on these items ranged from 5.0–8.0 mils, with most in the 5.0–6.0 mil range. The remaining primed items were brush-coated with Capstone TC Ceramic. Due to the high viscosity of the product, the initial coat went on very rough, and a second coat was deemed necessary. The second coat was applied after a 3 hour dry time and produced a more acceptable coating appearance. Final system thickness ranged from 30–80 mils, with most measurements in the 30–40 mil range. Two coated fittings, one with the Sherwin-Williams Corothane system and one with TC Ceramic, are shown in Figure 3.

Figure 3. Union joints in Mechanical Room A, coated with Sherwin-Williams Corothane System (A7, on left) and TC Ceramic (A8, on right).

Several items coated with the Corothane I White topcoat in Mechanical Room A were also covered with SpeedWrap ES removable insulation in accordance with manufacturer's recommendations. The appearance of a wrapped union joint is shown in Figure 4.

Figure 4. Union joint in Mechanical Room A, coated and wrapped in SpeedWrap.



Wire brushes were used to clean exposed items in Mechanical Room B. The quality of cleaning met the requirements of SSPC SP2 [4]. The condition of these items was documented and photographed. The items remained uncovered and the dehumidification equipment was installed.

Control union joints and fittings were identified in Mechanical Room C. Temperatures were recorded. The items remained covered with existing black insulation used at this location, and they were not uncovered until the conclusion of the test period.

In conjunction with the work in Mechanical Room A, 24 large panels were prepared. These panels were 3 x 6 in. steel Q-Panels. No surface preparation was performed. Coating types and thicknesses were the same as those recorded for the other work. Following the work, three panel racks, each consisting of two panels of each coating system (one scribed and one unscribed), along with two uncoated panels, were assembled and suspended above the heat exchanger in each of the three mechanical rooms. A corrosion coupon box with standard Battelle corrosion coupons was also suspended near each panel rack, and a data recorder was placed on each coupon box.

A summary of the coatings applied to the three mechanical rooms is shown in Table 3.

Table 3. Summary of items and coatings applied in mechanical rooms.

Designation	Item Painted	Temp (F) 8 Jan 08	Temp (F) 10 Jan 08	System
A1	CWR	48	76	MCA + MCW + Wrap
A2	CWR	46	77	MCA + TCC
A3	CWS	45	64	MCA + MCW + Wrap
A4	CWS	46	75	MCA + MCW + Wrap
A5	CWS	46	106	MCA + TCC
A6	CWR	61	103	MCA + TCC
A7	HWR	77	155	MCA + MCW + Wrap
A8	HHWS	130	135	MCA + TCC
A9	HWR	69	70	MCA + TCC
A10	HHWS	68	70	MCA + TCC
A11	CWP	60	60	MCA + TCC
A12	CWP	60	60	MCA + TCC
A13	HHWS	66	69	MCA + MCW + Wrap
A14	HHWS	69	71	MCA + TCC
B1	CWR		57	Dehumidification
B2	CWS		57	Dehumidification
B3	CWR		57	Dehumidification
B4	VWS		57	Dehumidification
B5	HWR		64	Dehumidification
B6	HWS		147	Dehumidification
B7	CWR		62	Dehumidification
B8	CWS		62	Dehumidification
B9	CWS		72	Dehumidification
B10	CWR		72	Dehumidification
C1	CWS		70	Control
C2	CWR		70	Control
C3	CWR		70	Control
C4	CWS		70	Control
C5	HWR		83	Control
C6	HWS		132	Control
C7	HWS		91	Control
Codes				
CWS	Chilled Water Supply			
CWR	Chilled Water Return			
HWS	Heating Water Supply			
HWR	Heating Water Return			
HHWS	Heating Hot Water Supply			
CWP	Chilled Water Pump			
MCA	Corothane I Moisture Cure Aluminum			
MCW	Corothane I Moisture Cure White			
TCC	Capstone TC Ceramic			
Wrap	SpeedWrap			

2.2.2 Cooling-tower pumps

As previously stated, five cooling-tower pumps at the central plant were used in this project. Two of these pumps — one recently purchased replacement pump and one recently refurbished pump (both with standard OEM coatings on the lower steel housings) — served as controls. Two other pumps were refurbished using two different commercial high-performance coatings suitable for the application and environment. The remaining pump was replaced with a 316 stainless steel pump. The pump designations and uses are summarized in Table 4. The pump numbers are presented from right to left, as facing the five towers from the back of the building. For example, the pump to the far right is 0495801, with 0495802 on its left, etc. For purposes of clarity in text, the pump inventory numbers are shortened to 1, 2, 3, 4, and 5 (see Table 4).

Table 4. Utilization of five cooling-tower pumps.

Pump Inventory Number	Abbreviated Pump Number	Utilization
0495801	1	Control – new pump
0495802	2	Control – refurbished pump
0495803	3	Coating 1 - Sherwin-Williams Macropoxy (gray)
0495804	4	Coating 2 - System No. 21-A-Z (white)
0495805	5	316 stainless steel replacement pump

The column and bowl sections of the two control pumps were painted with one of the selected commercial primers (Macropoxy 646 Fast Cure Epoxy). Based on the information provided by the personnel who installed these pumps (M&T Machine), no topcoat was applied.

In December 2007 the three demonstration pumps were removed. The column and bowl sections of all three pumps were found to be heavily corroded. The internal mechanisms did not show any corrosion, however. The condition of each pump at the time of its removal is presented in Figure 5 through Figure 8.

Figure 5. Pump 3 being removed from sump.

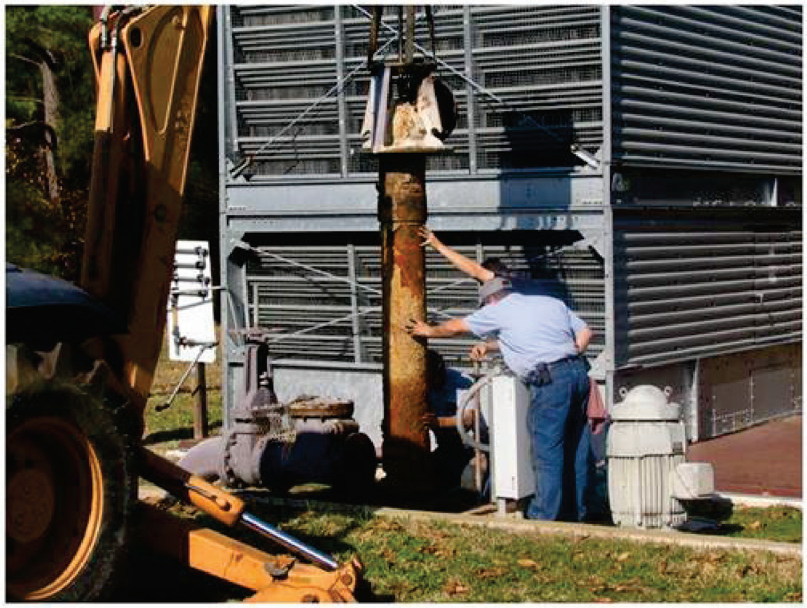


Figure 6. Condition of pump housing 3, after removal from sump.

Figure 7. Condition of pump housing 4, after removal from sump.

Figure 8. Condition of pump housing 5 after removal from sump.

Column and bowl sections for pumps 0495803 and 0495804 were abrasive-blasted and recoated. The column and bowl sections of pump 0495803 were coated with Macropoxy 646 Fast Cure Epoxy primer, followed by Tile-Clad High Solids Epoxy-Polyamide topcoat. The coated, refurbished pump is shown in Figure 9, and the reinstallation of this pump is presented in Figure 10.

Figure 9. Pump 3, after coating.

Column and bowl sections of pump 0495804 were coated with System No. 21-A-Z, which consisted of MIL-DTL-24441/19B (Formula 159) zinc-rich epoxy primer followed by MIL-DTL-24441 Formula 151 topcoat. Figure 11 shows the condition of this coated, refurbished pump as it is being reinstalled.

Figure 10. Pump 3 being reinstalled.

Figure 11. Pump 4 being reinstalled.

The fifth pump was replaced with an entirely new pump incorporating a corrosion-resistant alloy, 316 stainless steel. As stated previously, only the column section was made of 316 stainless steel; the lower half was cast iron painted by the manufacturer prior to shipment with a cycloaliphatic amine epoxy, Carboguard 890. Based on the information provided from the manufacturer, no topcoat was applied. The new pump is shown in Figure 12, and its installation is depicted in Figure 13.

Figure 12. New pump 5 incorporating 316 stainless steel housing.

Figure 13. New pump 5 being installed.

Eighteen test panels and three test racks were prepared. Each of the three test racks contained two panels for each of the two coating systems (one panel scribed, the other unscribed), two additional panels with primer only (Macropoxy 646, representative of the painted control pump), and two bare panels. In each of the three test sumps, one rack was suspended by means of a rope. A test rack suspended in the sump is shown in Figure 14.

Figure 14. Test panel rack suspended from far edge of sump.

Corrosion sensor probes were also installed in each of the three experimental pump sumps.

2.3 Performance and environment monitoring

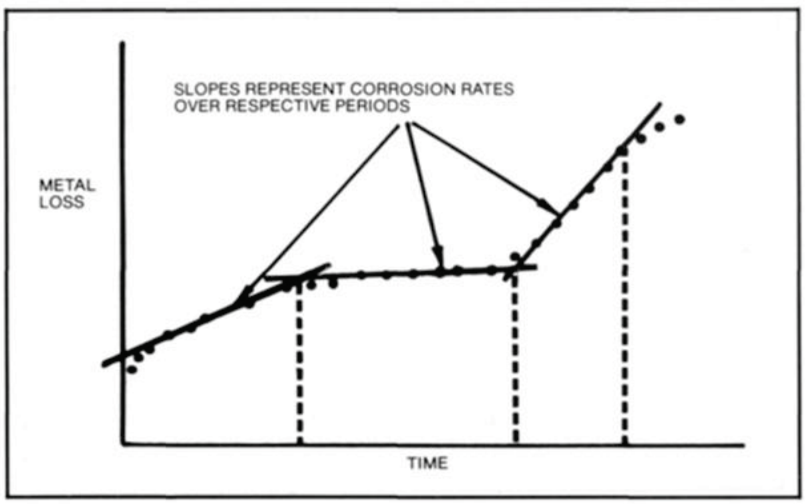
The applied technologies were monitored through monthly sensor and panel readings and onsite inspection. Photographs were taken of all subject pipe union joints and test panels. The humidity and temperature of each of the three mechanical rooms also were measured.

The coated test racks in the three subject cooling-tower pump sumps were evaluated during monthly site visits. The pump housings were located deep in the sumps, and were usually completely submerged during the monthly site visits (particularly in the summer months). Therefore, the corrosion processes were tracked through evaluation of the painted test coupons. The actual pump housings were evaluated directly in January

2009, at which time the water level in the sumps was low enough to see the condition of the housings. Updates on the condition of the pumps were not available during the June 2010 visit as the pumps were once again submerged and in operation.

The corrosivity of the water in the sumps was measured with the corrosion sensors on a monthly basis. The corrosion probes and associated instrumentation employed for this study determined metal loss through changes in electrical resistance. The resulting metal loss was then plotted as a function of time, permitting the corrosion rate to be determined. A representative notional plot, as seen in Figure 15 [5], demonstrates that the slope of the curve represents the average corrosion rate over the selected interval.

Figure 15. Test panel rack suspended in sump.



For each measurement, the probe had to be temporarily removed from the water to facilitate connection with the data acquisition system. The probe was placed back in water and held for 30–60 seconds before taking the first reading.

2.4 Completion of field work

The field work was completed in February 2008 with the installation of the stainless steel pump housing. The subject coatings, materials, and technologies were monitored for a full calendar year (January 2008 through December 2008). After December 2008, all technologies were left in place so that long-term corrosion-resistance benefits could continue to be assessed. In June 2010, an additional inspection of the mechanical room fittings and all test coupons was made.

3 Discussion

3.1 Metrics

The performance of the coatings on the installed test panels and on the piping components was evaluated visually on a monthly basis. Where possible, specimens were rated in accordance with ASTM D1654. This method assigns a rating number of 0–10 for both scribed and unscribed areas, as presented in Table 5 and Table 6 [1, 3].

Table 5. ASTM D1654 rating of coating performance at scribed areas.

Creepage from Scribe (mm)	Rating Number
Zero	10
0 to 0.5	9
Over 0.5 to 1.0	8
Over 1.0 to 2.0	7
Over 2.0 to 3.0	6
Over 3.0 to 5.0	5
Over 5.0 to 7.0	4
Over 7.0 to 10.0	3
Over 10.0 to 13.0	2
Over 13.0 to 16.0	1
Over 16.0	0

Table 6. ASTM D1654 rating of coating performance at unscribed areas.

Area Failed (%)	Rating Number
No failure	10
0–1	9
2–3	8
4–6	7
7–10	6
11–20	5
21–30	4
31–40	3
41–55	2
56–75	1
Over 75	0

Scribed test panels were evaluated using the criteria in Table 5, in accordance with Procedure A, Method 2, and with Procedure B. The performance of the coatings on unscribed panels, the piping components, and the cooling-tower pumps was evaluated using the criteria in Table 6, in accordance with Procedures B and D. The performance of the insulation and dehumidification technologies was visually evaluated.

The cooling-tower pumps could not be evaluated on a monthly basis as they were submerged in cooling water during the year-long exposure period. They were evaluated at the end of the evaluation period. The pumps were once again submerged and in operation during the June 2010 visit, and therefore updates on their conditions were not available at that time.

Corrosion sensors were placed in the sump areas of the cooling towers. When interrogated, the sensors provide two readings, a Div reading and a Chk reading. The Div reading represents the cumulative metal loss (corrosion) on the probe element, on a scale of 1,000 divisions. For example, a Div reading of 138 means that 138 one-thousandths (i.e., 13.8%) of the element has been consumed by corrosion. The Chk reading is a self-check of probe integrity, and should not vary by more than 1% from the initial reading.

3.2 Results

Data were collected on the mechanical room pipes and coupons. The ASTM D1654 ratings for the mechanical room piping and union joints are summarized in Table 7. The ASTM D1654 ratings for the mechanical room panels are summarized in Table 8.

Table 7. ASTM d1654 ratings, mechanical room pipes and union joints.

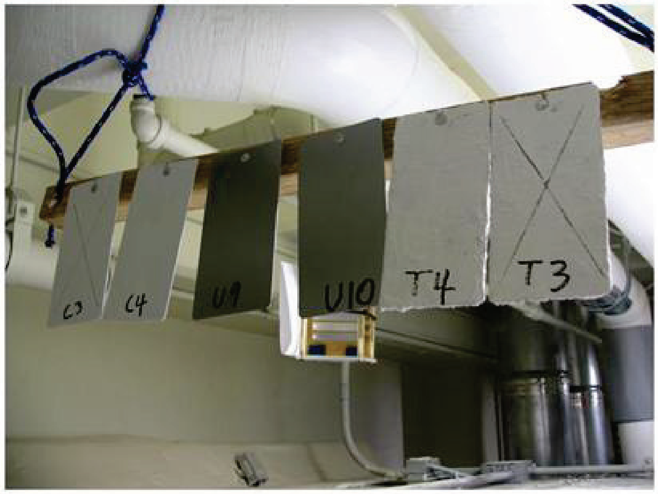
Mechanical Room	Specimen Designation	Piping Type	Coating/ Technology Applied	Rating, Jan 2008	Rating, Feb 2008	Rating, March 2008	Rating, April 2008	Rating, May 2008	Rating, June 2008	Rating, July 2008	Rating, August 2008	Rating, September 2008	Rating, October 2008	Rating, November 2008	Rating, December 2008	Rating, June 2010	NOTES
	A1	CWR	*MCA+MCW+Wrap*	10	10	10	*	*	*	*	*	*	*	*	7		
	A2	CWR	*MCA+TCC*	10	10	9	9	9	8	7	4	3	3	2	2	2	* Not unwrapped
	A3	CWS	*MCA+MCW+Wrap*	10	9	8	*	*	*	*	*	*	*	*	6		* Not unwrapped
	A4	CWS	*MCA+MCW+Wrap*	10	9	8	*	*	*	*	*	*	*	*	6	6	* Not unwrapped
	A5	CWS	*MCA+TCC*	10	10	10	10	5	4	4	2	2	2	2	2	2	
	A6	CWR	*MCA+TCC*	10	10	10	10	10	10	10	10	9	9	9	9	9	
A	A7	HWR	*MCA+MCW+Wrap*	10	9	9	*	*	*	*	*	*	*	*	9	9	* Not unwrapped
	A8	HHWS	*MCA+TCC*	10	10	10	10	10	10	10	10	10	10	10	10	10	
	A9	HWR	*MCA+TCC*	10	10	10	10	10	10	10	10	10	10	10	10	10	
	A10	HHWS	*MCA+TCC*	10	10	10	10	10	10	10	10	10	10	10	10	10	
	A11	CWP	*MCA+TCC*	10	10	10	10	9	9	7	6	6	6	4	4	3	
	A12	CWP	*MCA+TCC*	10	10	10	10	10	9	8	6	6	6	4	4	3	
	A13	HHWS	*MCA+MCW+Wrap*	10	10	10	*	*	*	*	*	*	*	*	9	9	* Not unwrapped
	A14	HHWS	*MCA+TCC*	10	9	8	8	8	8	8	8	8	6	6	6	4	
	B1	CWR	*Dehumidification*	10	0	0	0	0	0	0	0	0	0	0	0	0	
	B2	CWS	*Dehumidification*	10	0	0	0	0	0	0	0	0	0	0	0	0	
	B3	CWR	*Dehumidification*	10	0	0	0	0	0	0	0	0	0	0	0	0	
	B4	VWS	*Dehumidification*	10	0	0	0	0	0	0	0	0	0	0	0	0	
	B5	HWR	*Dehumidification*	10	10	10	10	10	10	10	10	10	10	10	10	7	Made of brass, not steel
B	B6	HWS	*Dehumidification*	10	10	10	10	10	10	10	10	10	10	10	10	7	Made of brass, not steel
	B7	CWR	*Dehumidification*	10	5	4	2	1	1	1	1	1	1	1	1	1	
	B8	CWS	*Dehumidification*	10	0	0	0	0	0	0	0	0	0	0	0	0	
	B9	CWS	*Dehumidification*	10	3	3	2	1	1	1	1	1	1	1	1	0	
	B10	CWR	*Dehumidification*	10	3	3	2	1	1	1	1	1	1	1	1	1	
	B11		*Dehumidification*	10	3	3	2	0	0	0	0	0	0	0	0	0	
	C1	CWS	*Control*	10	*	*	*	*	*	*	*	*	*	*	*	*	* Not unwrapped
	C2	CWR	*Control*	10	*	*	*	*	*	*	*	*	*	*	*	*	* Not unwrapped
	C3	CWR	*Control*	10	*	*	*	*	*	*	*	*	*	*	*	*	* Not unwrapped
C	C4	CWS	*Control*	10	*	*	*	*	*	*	*	*	*	*	*	*	* Not unwrapped
	C5	HWR	*Control*	10	*	*	*	*	*	*	*	*	*	*	*	*	* Not unwrapped
	C6	HWS	*Control*	10	10	10	*	*	*	*	*	*	*	*	9	9	* Not unwrapped
	C7	HWS	*Control*	10	10	10	*	*	*	*	*	*	*	*	8	8	* Not unwrapped

Table 8. ASTM D1654 ratings, mechanical room panels.

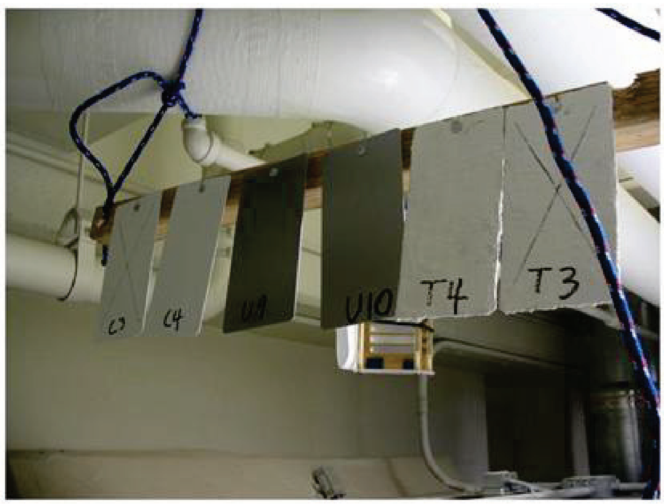
Mechanical Room	Panel Designation	Coating/ Technology Applied	Condition	Rating, Jan 2008	Rating, Feb 2008	Rating, March 2008	Rating, April 2008	Rating, May 2008	Rating, June 2008	Rating, July 2008	Rating, August 2008	Rating, September 2008	Rating, October 2008	Rating, November 2008	Rating, December 2008	Rating, June 2010	NOTES
A	U9	uncoated	uncoated	10	10	10	10	10	5	0	0	0	0	0	0	0	Slight flash rust observed in June, very heavy in July
	U10	uncoated	uncoated	10	10	10	10	10	10	3	1	0	0	0	0	0	Heavy rust in July
	C3	SW Corothane Primer, Corothane 1 topcoat	scribed	10	10	10	10	10	10	10	10	10	10	10	10	10	
	C4	SW Corothane Primer, Corothane 1 topcoat	unscribed	10	10	10	10	10	10	10	10	10	10	10	10	10	
	T3	SW primer, TC Ceramics topcoat	scribed	10	10	10	10	10	10	10	10	10	10	10	10	10	
	T4	SW primer, TC Ceramics topcoat	unscribed	10	10	10	10	10	10	10	10	10	10	10	10	10	
B	U7	uncoated	uncoated	10	10	10	10	10	5	5	0	0	0	0	0	0	Slight flash rust observed in June, very heavy in July
	U8	uncoated	uncoated	10	10	10	10	7	7	7	5	0	0	0	0	0	Heavy rust in August
	C1	SW Corothane Primer, Corothane 1 topcoat	scribed	10	10	10	10	10	10	10	10	10	10	10	10	10	
	C2	SW Corothane Primer, Corothane 1 topcoat	unscribed	10	10	10	10	10	10	10	10	10	10	10	10	10	
	T1	SW primer, TC Ceramics topcoat	scribed	10	10	10	10	10	10	10	10	10	10	10	10	10	
	T2	SW primer, TC Ceramics topcoat	unscribed	10	10	10	10	10	10	10	10	10	10	10	10	10	
C	U11	uncoated	uncoated	10	10	8	4	4	0	0	0	0	0	0	0	0	
	U12	uncoated	uncoated	10	10	8	4	4	0	0	0	0	0	0	0	0	
	C5	SW Corothane Primer, Corothane 1 topcoat	scribed	10	10	10	10	10	10	10	10	10	10	10	10	10	
	C6	SW Corothane Primer, Corothane 1 topcoat	unscribed	10	10	10	10	10	10	10	10	10	10	10	10	10	
	T5	SW primer, TC Ceramics topcoat	scribed	10	10	10	10	10	10	10	10	10	10	10	10	10	
	T6	SW primer, TC Ceramics topcoat	unscribed	10	10	10	10	10	10	10	10	10	10	10	10	10	

In Mechanical Room A, neither the TC Ceramic-coated coupons nor the Corothane-coated coupons demonstrated any signs of corrosion during the entire evaluation period. All panels received D1654 ratings of 10 throughout the evaluation period (Table 8). Figure 16 demonstrates the pristine nature of the Corothane-coated coupons (C3 and C4) and the TC Ceramic coated coupons (T3 and T4) in Mechanical Room A at 3, 6, 9, 12, and 30 month intervals. As a means of comparison, severe corrosion can be seen on the two uncoated panels (U9 and U10) from the ninth month and onward.

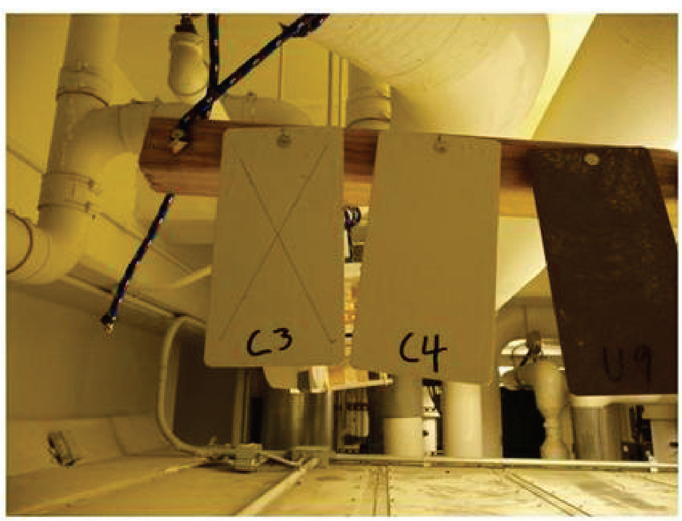
Figure 16. Test coupons in Mechanical Room A exposures at 3 months (a), 6 months (b), 9 months (c), 12 months (d), and 30 months (e).



(a)



(b)



(c)

(d)

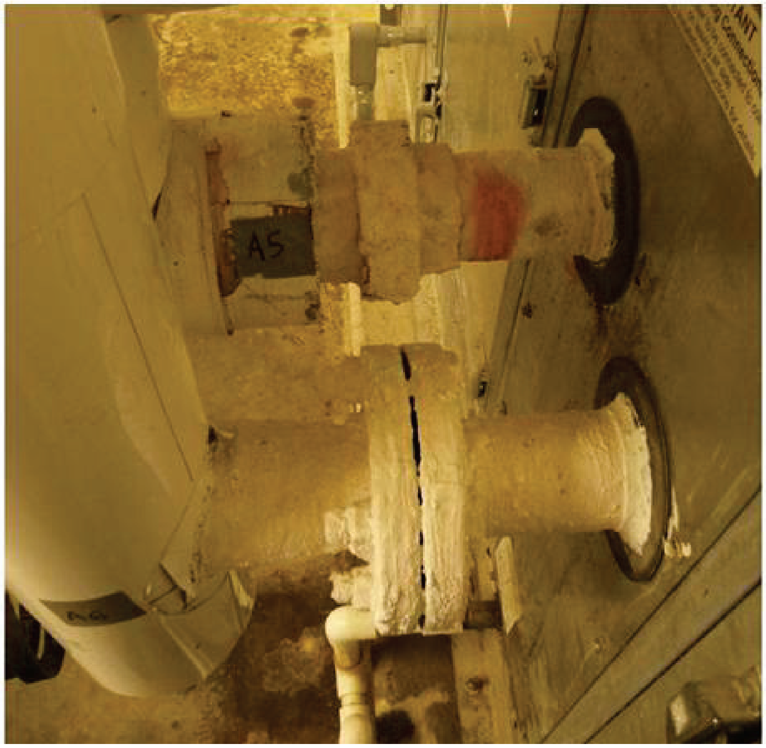
(e)

Minimal differences in coating performance were also seen on the coated pipe components in Mechanical Room A. Corrosion was observed only in special cases. For example, two cold-water-line fittings in very close proximity that were coated with TC Ceramic (designated A5 and A6) behaved differently: A5 exhibited rusty discoloration by 3 months of exposure, while A6 did not corrode at all up to 12 months. The rusty discoloration observed on A5 was caused by rusty water dripping down from another fitting. Otherwise, performance was very similar to that of A6, which had nothing dripping down onto it. By June 2010, the wet, rough surface of both fittings had accumulated mold on their rough, damp exteriors, but this did not influence corrosion ratings. These fittings were damp during this evaluation (Figure 18e), with considerable condensation (but not enough to drip or cause significant corrosion). The insulating properties of the TC Ceramic coating were apparently unable to impede condensation on these fittings. The performance of these fittings (A5 is in the rear, A6 is in front) throughout the evaluation period is presented in Figure 17.

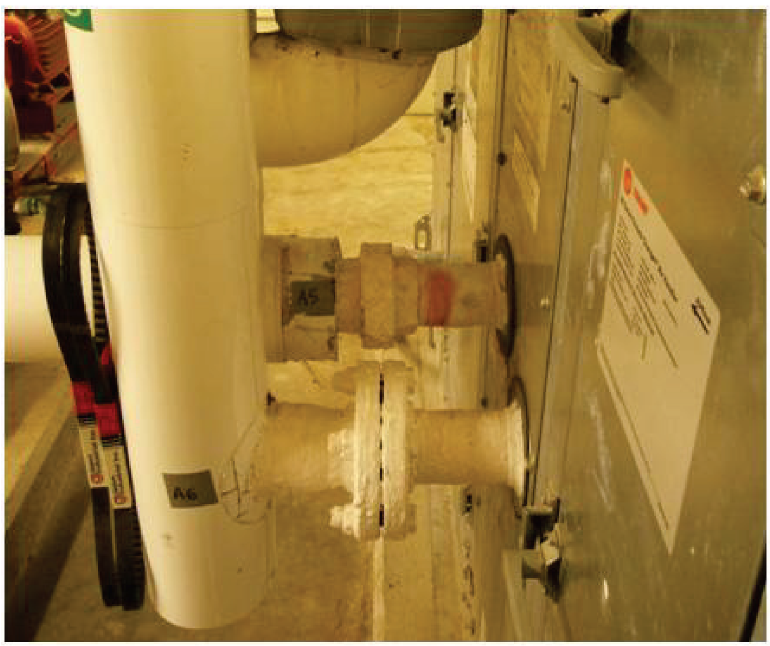
Figure 17. Two cold water line fittings coated with TC Ceramic in Mechanical Room A exposures at 3 months (a), 6 months (b), 9 months (c), 12 months (d), and 30 months (e).

(a)

(b)



(c)



(d)

(d)

Neither the dehumidification system (Mechanical Room B) nor the removable insulation (Mechanical Rooms A and C) appeared to be effective in arresting corrosion on the fittings in the mechanical rooms. The performance of the dehumidification unit was found to be questionable throughout the entire evaluation period, based on the evidence of the data collected. The temperature and humidity readouts from the data loggers in Mechanical Rooms A, B, and C throughout the one year evaluation period are presented in Figure 18 through Figure 20. (Updates were not available for June 2010.)

Figure 18. Temperature and humidity data, Mechanical Room A.

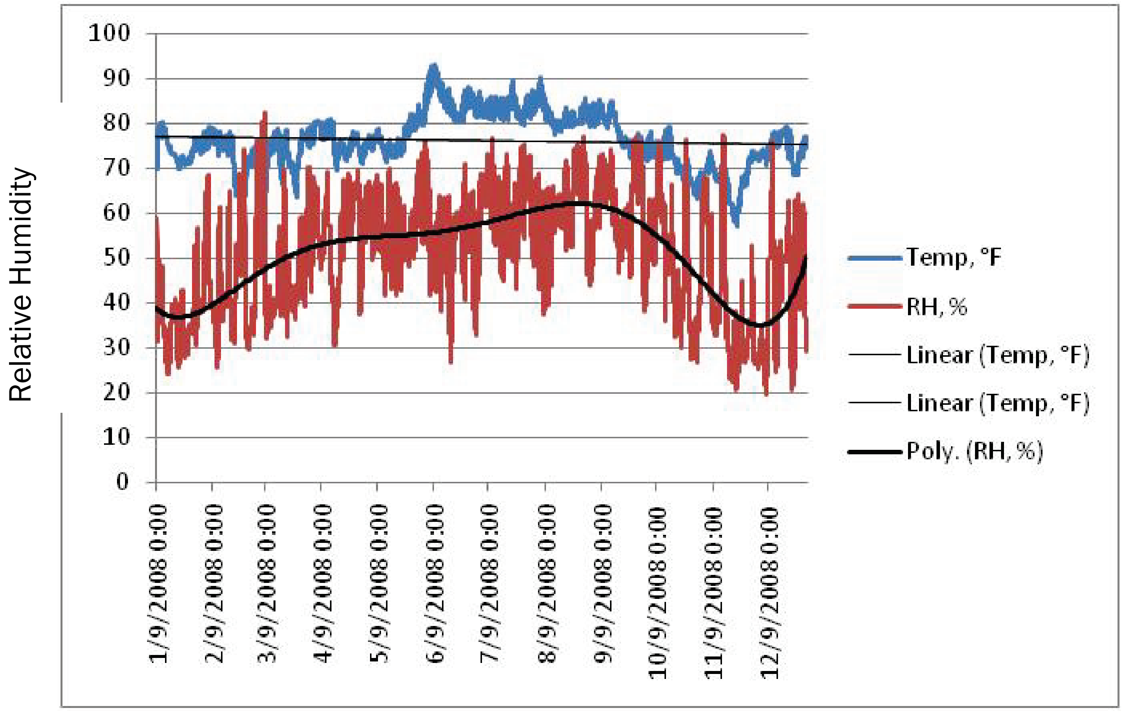


Figure 19. Temperature and humidity data, Mechanical Room B.

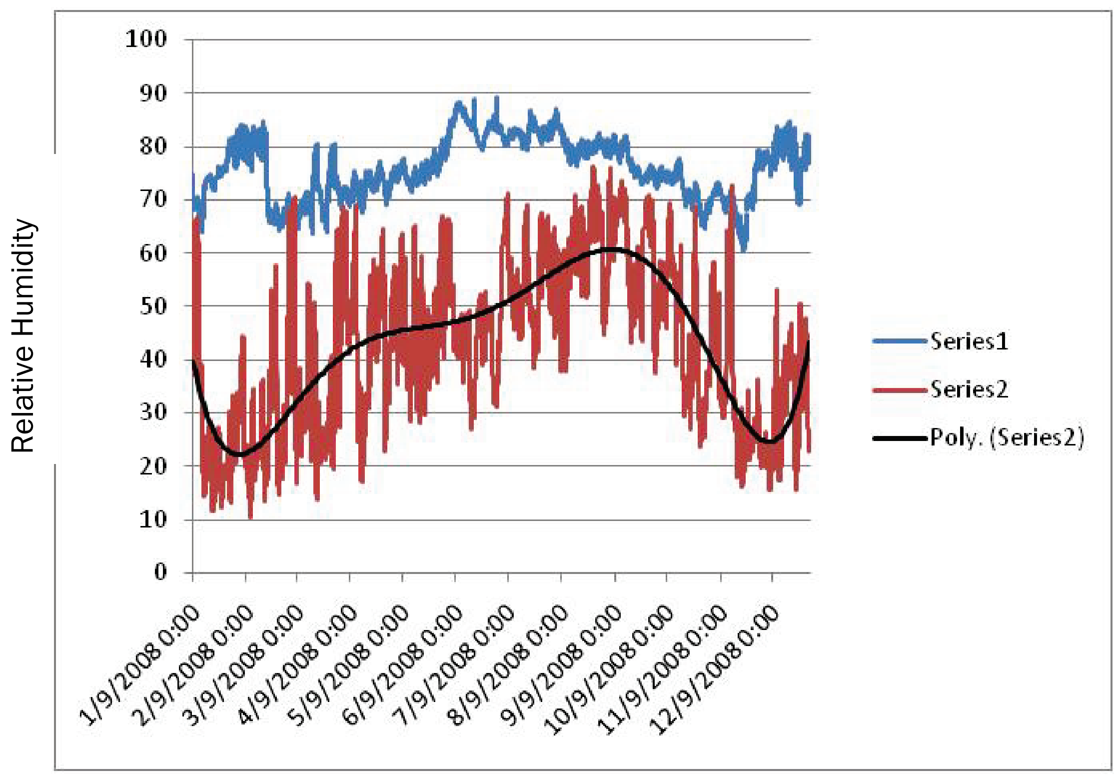
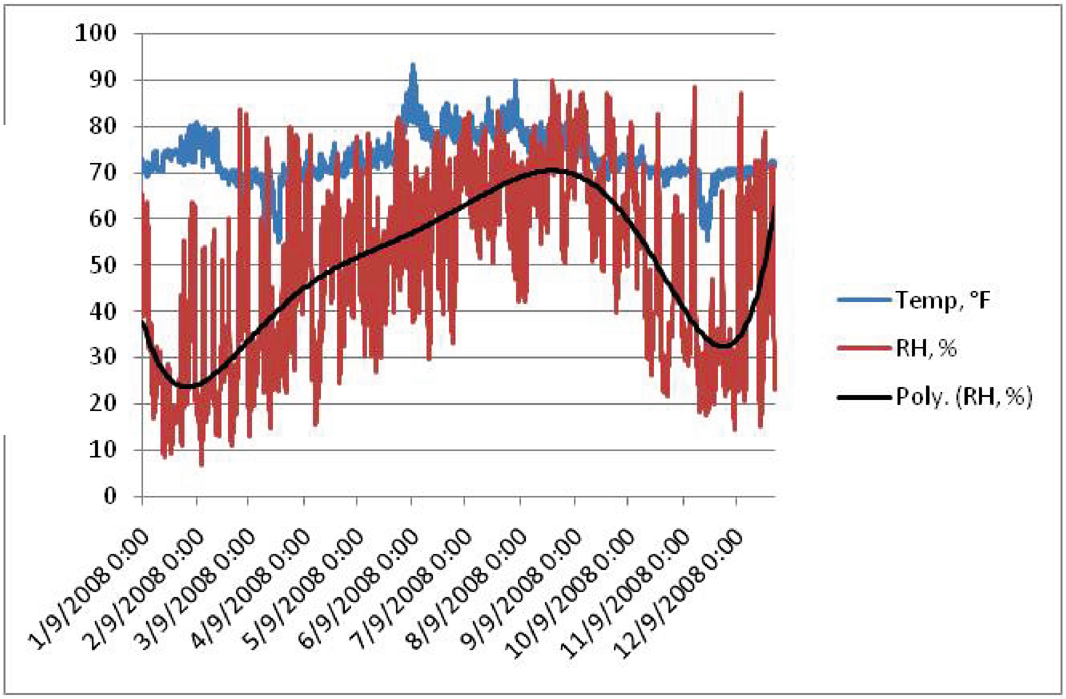
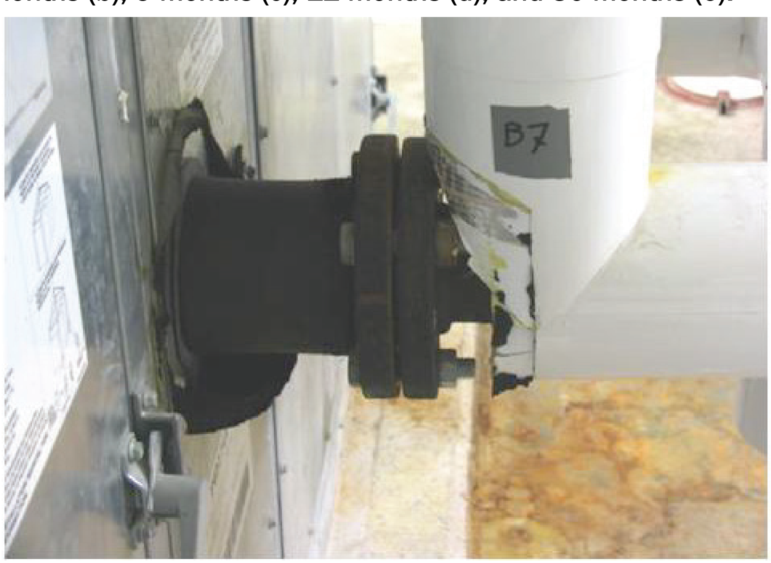


Figure 20. Temperature and humidity data, Mechanical Room C.

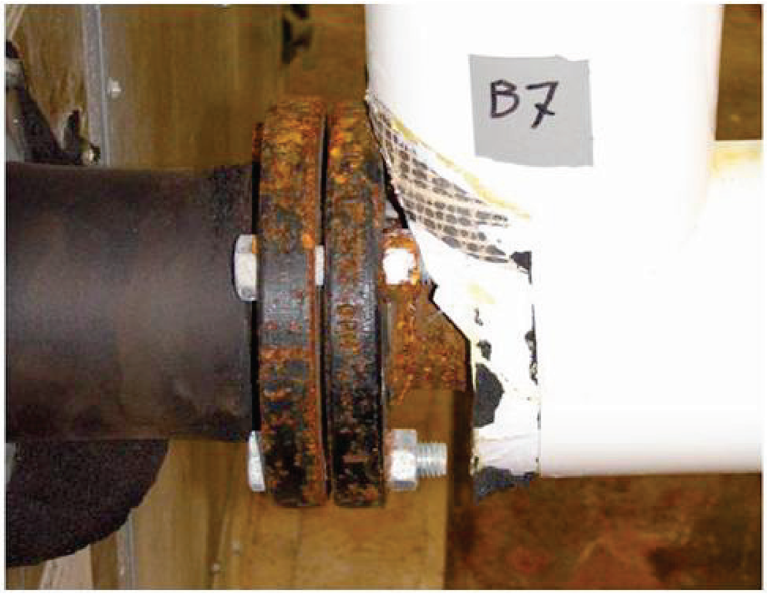


As seen by comparing these three figures, the humidity data from Mechanical Room B (Figure 19), where the dehumidifier was installed, appears to be very similar to the data for Mechanical Room A (Figure 18). Thus it is not surprising that significant corrosion was observed in Mechanical Room B. The performance of a cold water line fitting in Mechanical Room B is depicted in Figure 21a – 21e.

Figure 21. Cold water line fitting in Mechanical Room B exposures at 3 months (a), 6 months (b), 9 months (c), 12 months (d), and 30 months (e).

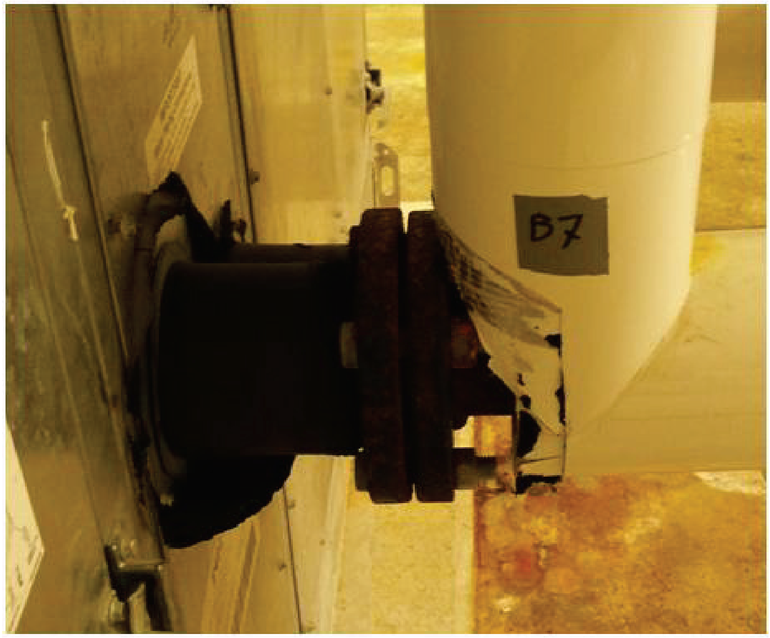


(a)



(b)

(c)



(d)

(e)

It was noted that the SpeedWrap insulation was difficult to attach to the lines. The team worked with the manufacturer to custom-fit pieces to specific joints, but the resulting fit was still loose and evidently not effective in controlling corrosion. Water was observed accumulating in wrapped portions of the line to the extent that it dripped out the ends of the insulation. Figure 22 shows two loosely wrapped fittings at 9 months exposure.

Figure 22. SpeedWrap on fittings, Mechanical Room A, 9 months exposure.

When the insulation was removed after 12 months, a moderate degree of corrosion was observed (Figure 23). The reduced corrosion was probably attributable the Corothane coating. Most of the corrosion on the union joint appeared at the gap where paint could not be applied evenly.

Figure 23. Condition of fitting after removal of SpeedWrap, Mechanical Room A, 12 months exposure.

As mentioned previously, smaller, uncoated test coupon racks were supplied by Battelle and were placed in the mechanical rooms, as well as outside. These racks were returned to Battelle for analysis every 3 months over a one year period. The results of this study [6] revealed that all of the indoor locations may be considered benign as measured by corrosion rates on the metal coupons. In many cases, there was not even the first indication of rust formation on the steel coupons. Although it is noted that the uncoated steel panels that were exposed with the coated panels, which were exposed for a longer time period, corroded severely in as little as five months. Corrosion was found on the outdoor samples, and it must be mentioned that the locations of both of these bases are still considered to be relatively mild.

Data were collected on the cooling tower coupons and the corrosion probes on a monthly basis during the period of performance; corrosion probe readouts were not available in June 2010. The ASTM D1654 ratings for the cooling tower sump panels are presented in Table 9.

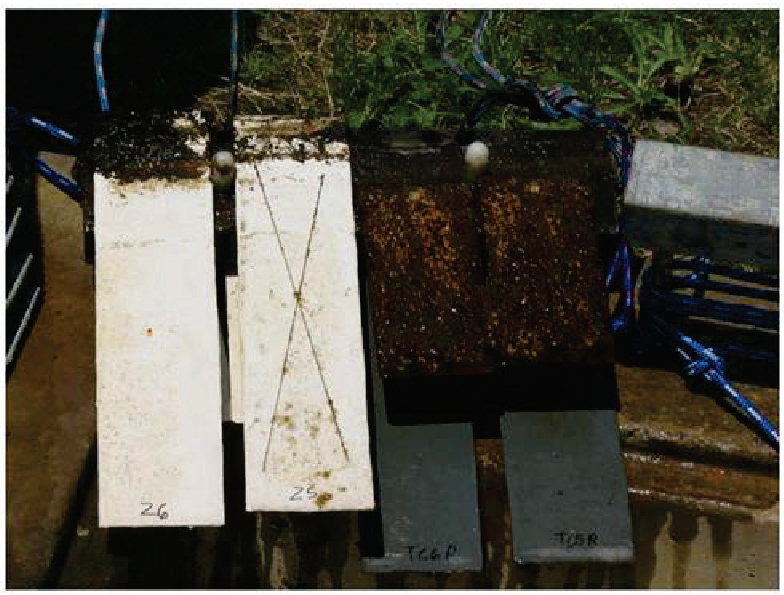
Table 9. ASTM D1654 ratings, cooling-tower pump sump panels.

Pump	Panel Designation	Coating/ Technology Applied	Condition	Rating, Month 1 (Jan 2008)	Rating, Month 2 (Feb 2008)	Rating, Month 3 (March 2008)	Rating, Month 4 (April 2008)	Rating, Month 5 (May 2008)	Rating, Month 6 (June 2008)	Rating, Month 7 (July 2008)	Rating, Month 8 (August 2008)	Rating, Month 9 (September 2008)	Rating, Month 10 (October 2008)	Rating, Month 11 (November 2008)	Rating, Month 12 (December 2008)	Rating, Month 30 (June 2010)	NOTES
495803	U5	uncoated	uncoated	0	0	0	0	0	0	0	0	0	0	0	0	0	
	U6	uncoated	uncoated	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Z5	System No. 21-A-Z	scribed	10	10	10	10	10	10	10	10	9	9	9	9	9	Panel partly obscured by green sludge in Dec
	Z6	System No. 21-A-Z	unscribed	10	10	10	10	10	10	10	10	10	10	10	10	10	
	TC5	SW 646 Epoxy Primer w/Topcoat	scribed	10	10	10	10	8	8	8	8	6	4	3	3	2	Blisters apparent along scribe in August, heavily blistered by Sept
	TC6	SW 646 Epoxy Primer w/Topcoat	unscribed	10	10	10	10	10	10	10	10	10	10	9	9	9	
	P5	SW 646 Epoxy Primer only	scribed	10	10	10	9	8	8	8	7	7	7	6	4	lost	
	P6	SW 646 Epoxy Primer only	unscribed	10	10	10	10	10	10	10	10	5	4	2	2	0	Piece of coating off (corner), many blisters in Oct
495804	U3	uncoated	uncoated	0	0	0	0	0	0	0	0	0	0	0	0	lost	
	U4	uncoated	uncoated	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Z3	System No. 21-A-Z	scribed	10	10	10	10	10	10	10	9	9	8	8	8	8	Panel partly obscured by green sludge in Dec
	Z4	System No. 21-A-Z	unscribed	10	10	10	10	10	10	10	10	10	10	10	10	10	Panel partly obscured by green sludge in Dec
	TC3	SW 646 Epoxy Primer w/Topcoat	scribed	10	10	10	10	9	8	7	6	6	6	5	4	3	Blisters apparent along scribe in June, heavily blistered by Sept
	TC4	SW 646 Epoxy Primer w/Topcoat	unscribed	10	10	10	10	10	10	10	10	10	10	10	10	10	
	P3	SW 646 Epoxy Primer only	scribed	10	10	9	8	8	8	8	7	7	7	6	6	0	Blisters apparent along scribe in July
	P4	SW 646 Epoxy Primer only	unscribed	10	10	10	10	10	10	10	9	8	8	4	4	0	Blisters apparent in Aug
495805	U1	uncoated	uncoated	0	0	0	0	0	0	0	0	0	0	0	0	lost	
	U2	uncoated	uncoated	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Z1	System No. 21-A-Z	scribed	10	10	10	10	10	10	9	9	9	9	9	9	9	Panel partly obscured by green sludge in Dec
	Z2	System No. 21-A-Z	unscribed	10	10	10	10	10	10	10	10	10	10	10	10	10	Panel partly obscured by green sludge in Dec
	TC1	SW 646 Epoxy Primer w/Topcoat	scribed	10	10	10	8	8	8	8	7	6	4	4	4	3	Blisters apparent along scribe in July
	TC2	SW 646 Epoxy Primer w/Topcoat	unscribed	10	10	10	10	10	10	10	9	8	8	8	8	8	2 blisters in Sept
	P1	SW 646 Epoxy Primer only	scribed	10	10	9	8	8	8	8	8	8	6	6	6	0	
	P2	SW 646 Epoxy Primer only	unscribed	10	10	10	10	10	10	9	9	7	3	3	3	0	

As indicated in the table, the System 21-A-Z candidate clearly outperformed the Macropoxy candidate. This performance was observed on both panels and pump components. While a great deal of dirt and algae was accumulated on the panels, the integrity of the coating could still be observed and recorded. The performance of the System 21-A-Z coated panels and the uncoated panels in pump 3 throughout the evaluation period is presented in Figure 24; the performance of the Macropoxy-coated panels and the primer-only panels are presented in Figure 25.

Figure 24. System 21-A-Z and uncoated panels for pump 3 exposures at 3 months (a), 6 months (b), 9 months (c), 12 months (d), and 30 months (e).

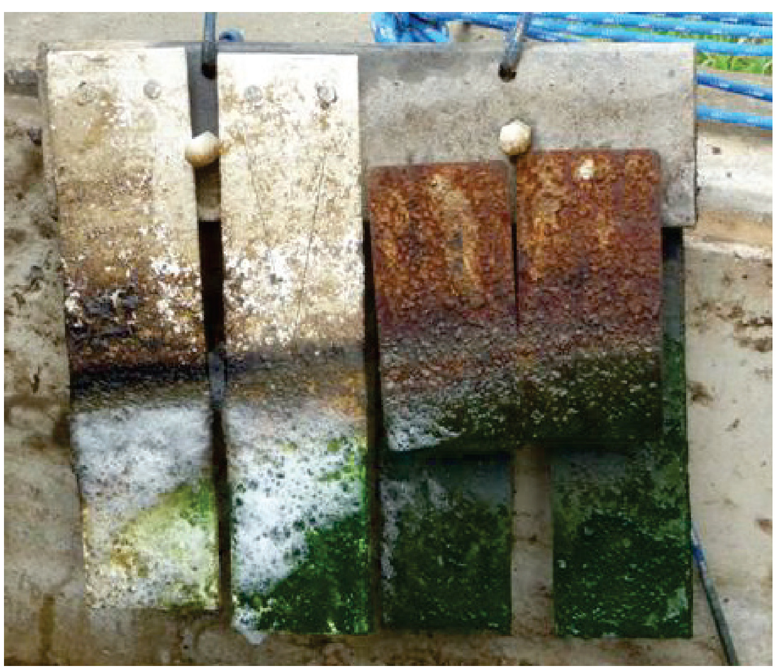
(a)



(b)

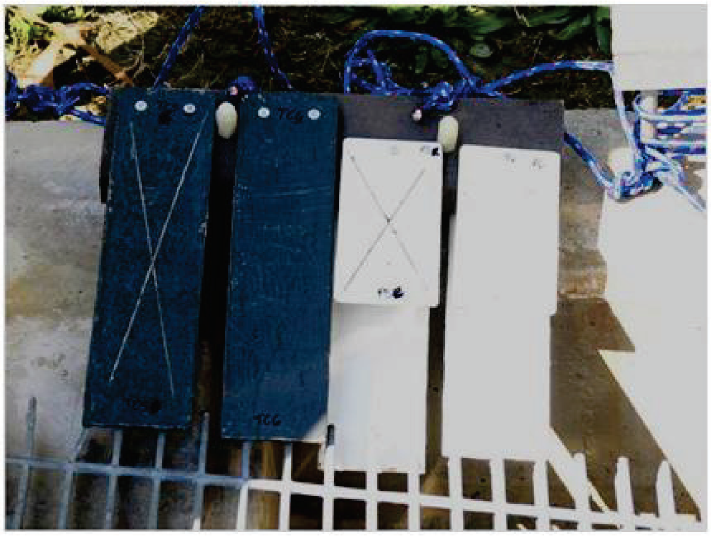
(c)

(d)



(e)

Figure 25. Macropoxy primer-topcoat and primer-only panels for pump 3 exposures at 3 months (a), 6 months (b), 9 months (c), 12 months (d), and 30 months (e).

(a)


(b)


(c)

(d)

(e)

It is noted that the Macropoxy primer-only panels performed similarly to the Macropoxy primer-topcoat system panels for the first 12 months, which seemed to demonstrate that the application of the topcoat did not provide a noteworthy degree of additional protection.

However, evaluations after an additional 18 months revealed a sharp difference between the two types of Macropoxy specimens: the coatings on the primer-only panels had failed completely (see Figure 26e), and one primer-only specimen (the scribed coupon) had entirely corroded and fallen off the rack; even the uncoated panels (see Figure 25e) were less corroded than the primer-only panels. Hindsight reveals early signs of this performance at 12 months (see Figure 26d), as the unscribed panel had begun peeling early at its lower-right corner. This behavior was also observed on the primer-only panels in pumps 4 and 5, where the primer-only panels had only small scraps of loose coating still in place.

The condition of the pumps after 12 months of exposure is presented in Figure 26 through Figure 28. The pump sumps were filled with water and could not be evaluated until January 2009. The results shown in the photos below echo those of the coupons, in that the System 21-A-Z coating outperformed the Macropoxy system. The stainless steel upper housing performed well through January 2009, but the cast iron pump bowls (painted with Carboguard 890) showed extensive corrosion, as seen in Figure 28.

Figure 26. Pump 3 (Macropoxy primer-topcoat), 12 months.

Figure 27. Pump 4 (System 21-A-Z), 12 months.

Note: The wavy appearance of the System 21-A-Z coating was evidently caused by surface soiling, not blistering. The coating did not flake off when brushed.

Figure 28. Pump 5 (316 Stainless Steel), 12 months exposure.

While the significant corrosion of the pump bowls on pump 5 did not impede the performance of the pump during the original effort, issues arose after the original project had concluded. In May 2009, Fort Bragg personnel reported that pump 5 (the stainless steel pump) had failed. The impellers would not move, presumably due to corrosion inside the bowls. Before an investigation on the specific causes of failure could be conducted, Fort Bragg maintenance personnel repaired the pump by banging the bowls with a wrench. They reported that significant corrosion products fell out of bowls when this was done, and that the pump started up and ran well thereafter. This issue and its resolution underscores the need for users to closely follow the equipment manufacturer's instructions on pump operation and storage.

The corrosion sensor data presented in Table 10 demonstrates the corrosive nature of the water in the pump sumps. The Chk readings were consistently within 1% of their original values, which, per Section 3.1, confirms that the three probes operated correctly for the measurement period of 26 March 2008 through 30 December 2008. The Div readings on Table 10, which translate directly into mils of mild steel lost to corrosion, show that the sensor in pump 3 lost about 18 mils; the sensor in pump 4 lost about 24 mils; and the sensor in pump 5 lost about 69 mils. This suggests that for some reason the water in the sump containing the stainless steel pump (pump 5) was considerably more aggressive than those of the other pumps.

Table 10. Corrosion probe readings, cooling-tower pump sump panels.

			26-Mar-08		30-Apr-08		4-Jun-08		25-Jun-08		23-Jul-08		23-Jul-08		21-Aug-08		30-Sep-08		23-Oct-08		30-Dec-08*	
Probe ID	Probe Tag/Cooling Tower Number	Reading #	Div	Chk	Div	Chk	Div	Chk	Div	Chk	Div	Chk	Div	Chk	Div	Chk	Div	Chk	Div	Chk	Div	Chk
201	0495805	1	74.2	778	97.1	777	96.5	777	96.3	778	99.3	777	98.6	778	98.6	778	108.8	777	129.3	777	142.2	778
		2	73.7	778	98.1	776	95.9	777	95.8	778	98.3	777	98.5	778	98.6	777	108.4	777	127.7	778	143.7	777
		3	N/A	N/A	96.3	777	96.5	777	96.6	778	98.4	777	98.9	778	99.7	777	108.4	777	127.8	778	146.2	776
		4	N/A	N/A	N/A	N/A	N/A	N/A	95.0	779	98.5	778	99.3	777	98.7	777	108.3	777	128.1	778	143.7	777
		5	N/A	N/A	N/A	N/A	N/A	N/A	95.4	779	98.3	778	98.4	778	98.6	777	111.1	777	128.4	778	144.1	777
		6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	107.2	777	128.3	778	143.4	777
		7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	111.8	777	127.5	778	143.6	777
202	0495804	1	113.9	770	125.2	771	129.6	770	130.1	772	132.0	770	Note: A large amount of organic growth covered the 0495805 probe. That growth was gently removed with a towel and five additional readings (above) were taken.		133.1	770	135.2	770	134.5	771	138.2	771
		2	116.0	770	126.2	770	130.1	770	130.5	772	131.7	770			133.6	770	134.6	770	135.4	771	138.7	771
		3	115.9	770	126.6	770	129.1	770	129.3	772	131.5	770			132.7	770	140.8	767	134.4	772	138.9	771
		4	N/A	N/A	N/A	N/A	N/A	N/A	129.6	772	131.6	770			133.9	770	133.1	769	135.9	771	138.2	771
		5	N/A	N/A	N/A	N/A	N/A	N/A	130.2	772	131.2	770			133.4	770	136.9	770	134.4	772	138.5	771
203	0495803	1	140.0	782	149.5	782	149.4	781	148.0	784	148.9	781			151.1	782	155.4	781	154.8	783	157.5	782
		2	139.4	782	148.7	782	149.4	782	147.4	784	149.2	781			151.1	782	154.7	782	155.5	783	157.0	782
		3	139.8	782	149.1	782	148.1	782	148.3	784	149.0	782			151.6	782	151.8	782	155.1	783	157.1	782
		4	N/A	N/A	N/A	N/A	N/A	N/A	148.7	783	149.1	782			151.5	782	155.4	782	155.9	783	156.9	782
		5	N/A	N/A	N/A	N/A	N/A	N/A	148.8	784	149.4	781			151.1	782	156.9	781	155.1	783	157.9	782

The water chemistry within the sumps of the five towers was sampled and analyzed on a monthly basis, from April to December 2008. The detailed results are provided in Appendix D of this report. The results of the analyses of the water in the sumps were compared to baseline samples of Fort Bragg tap water that were taken in June 2009 (represented by the first two analyses after the summary in Appendix D). The corrosivity of fresh water is known to depend upon oxygen content, impurities, hardness, chloride content, sulfur content, and other factors [7]. The Illinois State Water Survey performed the water testing on the tap water samples and the supervising chemist's comment was, "This is some of the most corrosive water I have seen." (the pump water received subsequent treatments). The highly corrosive nature of the sump water was observed on both the pump components and the test panels. Pump 5 samples showed particularly high pH readings (alkaline) and generally high conductivity (an indirect measure of Total Dissolved Solids) during the pumps operating months. The water samples also exhibited low water hardness, which might have prevented the formation of a protective scale that could have impeded corrosive attack [7]. It is also noted that Total Dissolved Solids was consistently high in this sump (readings ranging from 318 to 610 mg/L), as compared to the readings from the other sumps (readings ranging from 62 to 750 mg/L). While this does not quantitatively support the data from the corrosion probes (which found that that the corrosivity of the water in pump 5 was several times higher than those of other pumps), it is indicative of elevated corrosivity compared to the other pumps. This is supported by the performance of the panels and the pump components within the sump (both of which corroded severely). Finally, it was noted that inhibitor levels were consistently low in many sample readings; the copper corrosion inhibitor, triazole, was either very low or not detected in all of the samples. Either the inhibitor levels were low during the sampling, or the test methodology was unable to detect the inhibitors in the sample.

3.3 Lessons learned

3.3.1 Site selection

Fort Bragg was selected for this project due to the particular needs of the barracks mechanical room piping and cooling tower shafts. The specific needs of Fort Bragg required constant communication and coordination with relevant on-site personnel. It was advantageous to have access to all key personnel involved in the effort (e.g. Fort Bragg Science Advisor, DPW) as well as other necessary personnel (e.g. Honeywell Fort Bragg, the contractor for maintaining the cooling towers). For example, personnel provided access to the mechanical rooms that was critical during the evaluation effort. Constant communication ensured that information was disseminated along the correct chain of command and that the appropriate permissions to access the facilities were obtained in a timely manner.

3.3.2 Application

Technology application was somewhat challenging, especially with respect to the removal, coating, and re-installation of the cooling-tower pumps. This portion of the effort required heavy lifting equipment and particular expertise. In addition, some minor work had to be done to install the new pump into the sump. The subcontractor, M&T Machine, was specifically selected to conduct this portion of the effort because the key personnel at M&T have unique experience in doing this type of work. In fact, M&T had previously refurbished at least one of the control cooling-tower pumps in question (pump 2). Therefore, M&T had existing relationships with Fort Bragg personnel, were familiar with the facility, and had been conducting similar work on site for several years. Selecting a subcontractor with these attributes was found to be critical to the success of the effort, and should be considered as a template for future efforts of a similar nature.

The new pump procured for this effort had to be specifically sized for the cooling tower, because the company that made the original pumps was no longer in business. It is suggested that maintenance personnel should be mindful of potential obsolescence issues regarding large pieces of equipment, and should have both spare parts and alternate sources readily available.

There were additional challenges related to the application of some of the selected technologies. The TC Ceramic product is highly loaded with ceramic particles, giving the coating a very high viscosity that made it difficult and time consuming to apply. So this product required two coats. It is suggested that future efforts involving this product should take this application property into account.

In addition, in union joints coated with either coating, corrosion would often initiate in hard-to-reach areas that were not coated. It is suggested that the coating of these fittings be considered for maintenance operations that include taking them apart, rather than trying to coat all areas of the joints while in place.

The dehumidification system, although sized for the room by the manufacturer, was unable to consistently keep the humidity in Mechanical Room B low enough to impede corrosion of the union joints. Eventually, it became difficult to confirm that the unit was working properly; the team evaluated the humidity readouts from the data logger (Figure 18 through Figure 20) on a monthly basis to confirm functioning. It is noted that air circulation was minimal in this mechanical room. The fan that was meant to ventilate the room with external air was broken, though the ventilation grating remained open. Humidity control in an interior space is significantly affected by air circulation. If the only circulation was provided by the dehumidifier, and the major source of humidity was condensation, then this would account for the poor humidity control. It is suggested that future efforts involving small dehumidification devices establish a means to confirm proper functioning of the unit over the evaluation period, and also confirm that sufficient air circulation exists within the room to allow the dehumidification unit to function properly.

3.3.3 Operational issues

As mentioned previously, coordination with all required personnel on-site was a critical element of the success of the project. These personnel played an active part in the installation and monitoring of the selected technologies. For example, the subject mechanical rooms were locked at all times, and DPW personnel were needed to provide access to the mechanical rooms during the one year evaluation period.

The Battelle corrosion coupons provided useful data at the conclusion of the project. Specifically, the lack of atmospheric corrosion observed on the coupons corresponded with similar conditions on the coated coupons, and demonstrates that condensate collecting on the fittings may be responsible for the accelerated corrosion attack in the mechanical rooms.

Perhaps the most significant lesson learned from an operational standpoint was the importance of carefully following the manufacturer's operation and storage instructions for new technologies or technologies acquired from new vendors. The stainless steel pump performed well over the period of performance (approximately 1 year). But 3 months later, this pump failed on attempted startup after a period of seasonal shutdown. In this case, the pump was drained after shutdown whereas the manufacturer recommends that a dormant stainless steel pump be kept wet. After removing corrosion products that had accumulated during dry storage, the pump worked well again, so there appears to have been no inherent design or manufacturing problem with the pump.

Also, as mentioned previously, at 30 months of exposure, the dual-coating systems clearly outperformed the single-primer system on the coated coupons in the sumps, a trend that was not clearly evident after only 1 year of service. This finding indicates that, optimally, observations of performance should continue as long as feasible to obtain the most reliable validation result.

4 Economic Summary

Two separate return on investment (ROI) analyses were generated for the technologies implemented under this contract: one for the mechanical room pipes and the other for the cooling-tower pumps. The ROI estimates developed as part of the original project plan established by ERDC-CERL and the Fort Bragg Directorate of Public Works (DPW) were used as a starting point. Pertinent data and facts used in the ROI computations included, but were not limited to (1) the actual costs and quantities of each specific coating or material used, and (2) the costs of equipment and mobilization. The actual person-hours required to implement the technologies, by trade, were captured as labor under the overall task of applying the technologies.

All ROI ratios discussed in this chapter encompass the costs of installing the subject technologies and performing the demonstration/validation study. The original ROI estimates included in the project PMP (Appendix A) are provided first for comparison with final calculated values.

Using the required spreadsheet [8] and methods prescribed in OMB Circular A-94 [9], an estimated ROI of 11.6 was calculated for technologies applied to mitigate the mechanical room utility corrosion problem. An estimated ROI of 8.2 was calculated for cooling-tower pump corrosion mitigation. These ROI values assume the application of current costs and best practices for operations, maintenance, and rehabilitation.

4.1 Mechanical room assumptions

Three technologies were examined for the mechanical rooms: insulation, dehumidification, and advanced coatings. Based on 1 year of observations, insulation and dehumidification did not significantly reduce corrosion, so they produced no reduction in maintenance requirements. The costs of acquiring and installing these options are included in the analysis as demonstration project costs, but they produced no economic benefit accountable in the ROI calculations.

The demonstrated coatings were observed to have largely prevented corrosion where they were applied, so a final ROI calculation was based on the utility of applying coatings to vulnerable joints in mechanical rooms. The following assumptions were used for the baseline circumstances in mechanical rooms:

- Per the PMP, Appendix 1, Task 1, Assumption a, it was assumed that the replacement cost of the corroded piping and joint components was approximately $500,000 for 1,000 mechanical rooms; that replacement was needed immediately; and that with no corrective actions replacement would be required every 12 years. Based on the work conducted under this effort, as well as discussions with Fort Bragg personnel, these assumptions seemed reasonable except for the overall cost of $500,000 to replace the pipes in 1,000 mechanical rooms. On further analysis, that estimate (i.e., $500 per room) was determined to be unrealistically low. A more realistic average cost is $6,000 per room, so the figure of $6,000,000 for 1,000 rooms was used.
- It was assumed that there was a $5,000 annual maintenance cost (PMP Appendix 1, Task 1, Assumption c). Given the costs to coat the fittings in the rooms (see below), this assumption seemed reasonable.
- Even with routine maintenance, failures of the mechanical room systems due to corrosion were assumed to occur with direct (emergency repairs) and indirect (loss of mission capability) cost impacts of $200,000 on a periodic basis of every 5 years (per the PMP under Appendix 1, Task 1, Assumption b) after full replacement. Based on the work conducted under this effort, as well as discussions with Fort Bragg personnel, these assumptions seemed reasonable and were adopted.

The following assumptions were made for the application of coatings as part of this project:

- The cost to paint the mechanical rooms was not initially separated from the cost to repair the cooling-tower pumps in the CTC purchase order (PO) of $36,000 to the subcontractor, M&T Machine, for labor only.
    - However, discussion and review with M&T of the PO provided a detailed breakdown of labor between the mechanical room and pump activities sufficient for an engineering estimate of the labor of the mechanical room: $7,200 for all three mechanical rooms.
    - Based on firsthand observations of the painting process and assuming that no more than one or two coating systems are used (vs. the multitude of experimental coatings and sample coupon prepara-

tion), then a cost to treat three rooms (the same number of rooms in this project) is estimated at $3,500.
  - Treating all 1,000 mechanical rooms (at $3,500 per three rooms) would then be estimated as $1,167,000 (rounding up to the nearest thousand). This is the first-year investment as determined from original M&T Machine PO from CTC purchasing records, interview with M&T dated 28 July 2010, first-hand observations, and assistance in painting process by CTC personnel.
  - $1,167,000 is likely to be conservatively high, as an organized painting program across Fort Bragg would benefit from economy of scale in the operation, increased worker experience in the operation, and the fact that some mechanical rooms are smaller than those examined in this project. Furthermore, less work is involved in cleaning and repainting joints than replacing them, which is now estimated at $6,000,000 (discussed above).
- From CTC's receipts of paints purchased, the cost of the Corothane primer that was used on all joints was $141.00, the cost of the Corothane 1 MCU topcoat that was used on some of the joints was $180.06, and the cost of the TC Ceramic topcoat that was used on the remaining joints was $315.00. Because of the difficulty in working with the TC Ceramic topcoat and the nearly equal performance of the two systems, the use of the Corothane primer/topcoat system was assumed. It is noted that there was sufficient leftover paint for numerous other mechanical rooms; for the purposes of the ROI computation, it was conservatively assumed that $321.06 in paint is required for every five mechanical rooms, resulting in a capital investment material cost of $64,000 (rounding up to the nearest thousand) for 1,000 rooms. Note this paint cost is not included in the $1,167,000 listed in the preceding point because the paint cost was separate of M&T's invoice.
- Because the pipes are already corroded from service, it was assumed that a $6,000,000 immediate-replacement cost applies; this is above and beyond the cost of painting the mechanical rooms. Again, it also assumed that annual maintenance remains at $5,000 (per the PMP under Appendix 1, Task 1, Assumptions a and c), as the pipes and joints are already corroded from service.
- However, it was assumed that the suggested $200,000 emergency repairs conducted every five years are avoided (per the PMP, "Because of the increased durability of the high-performance coatings, repair/replacement costs are assumed to be negligible for twenty (20) years with inspection every five (5) years in between replacement").

That also indicates the annual maintenance fee of $5,000 would be changed to $5,000 every 5 years, reflecting the much-reduced corrosion with the new paint systems.
- It was assumed there would be one major system overhaul or replacement (costing $500,000, per the PMP under Appendix 1, Task 1, Assumption a) after 20 years, per the preceding bullet ("…negligible for twenty years…").
- The cost of the project (or Investment Required) as applied to mechanical rooms had to be inferred as the work was not budgeted by topics investigated, but by labor, travel, materials, etc. The effort in the mechanical rooms was estimated as being proportional to the amount M&T spent in the rooms. M&T spent $7,200 (20%) of a $36,000 budget on the rooms, so it is estimated the project cost for the rooms was $72,000 (20% of $360,000).

No base benefits and savings or new system benefits and savings were explicitly separated from the baseline system and new system costs. Rather, benefits were computed directly from the lower costs of the new system.

Based on the above assumptions, the costs summaries are:

- Baseline costs include a $6,000,000 replacement cost in years 1, 13, and 25 (every 12 years); $200,000 in emergency repairs every 5 years (6, 11, 16, 21, and 26); and annual maintenance costs of $5,000 every year, even in years with replacement or emergency repairs.
- The new system would include a year 1 installment cost of $7,231,000 (including $1,167,000 to clean and paint 1,000 mechanical rooms and $64,000 for paint supplies during that initial painting); a repair/replacement cost of $500,000 in year 21; and $5,000 every 5 years (years 6, 11, etc.) for maintenance.

4.2 Cooling-tower pump assumptions

Two technologies were examined for protecting pump housings: coatings and stainless steel substitution.

The following assumptions were applied to the ROI calculation for the baseline circumstances in pumps:

- Per the PMP, Appendix 1, Task 2, Assumption a, it was assumed that 30 pumps at Fort Bragg are subject to repair and replacement separate of any repainting or replacement by stainless steel. Replacement costs are assumed to be $30,000 per pump, and replacement for all pumps is required immediately for $900,000 total. Based on the work conducted under this effort, as well as discussions with Fort Bragg personnel, these assumptions seemed reasonable and were adopted.

- Current technology results in pump failure every five years, necessitating complete replacement (per the PMP, Appendix 1, Task 2, Assumption b). Based on the work conducted under this effort, as well as discussions with Fort Bragg personnel, these assumptions seemed reasonable and were adopted.
- Also assumed was a $5,000 annual inspection and maintenance cost (per the PMP, Appendix 1, Task 2, Assumption c). Based on the work conducted under this effort, as well as discussions with Fort Bragg personnel, these assumptions seemed reasonable and were adopted.
- Even with routine inspection and maintenance, failures of the pumps will still occasionally occur with a direct (emergency repairs) and indirect (loss of mission capability) cost impact ($200,000) figured on a periodic basis of every 3 years (per the PMP, Appendix 1, Task 2, Assumption b). Based on the work conducted under this effort, as well as discussions with Fort Bragg personnel, these assumptions seemed reasonable and were adopted.

The following assumptions were made for the application of coatings to cooling-tower pumps:

- The cost to repair and repaint the pumps was not initially separated from the cost to repair the mechanical rooms in the CTC PO of $36,000 for M&T's labor.
  - However, discussion and review with M&T of the PO provided a detailed breakdown of labor between the mechanical room and pump activities sufficient for an engineering estimate of the labor of the mechanical room: $28,800 for all three pumps. The labor to remove, clean, paint and repair, and reinstall each pump was thus $9,600.
  - Removal and reinstallation of each pump were estimated at 20% of the labor ($1,920 for each operation); cleanup and preparation (such as sand blasting) was 15% of the labor ($1,440); and painting (or retrofitting, in the case of the stainless steel column) was the balance ($4,320). (Reference: interview with M&T dated 28 July 2010.)

  - The material cost for recoating the two pumps was $795 (System 21-A-Z) and $188.76 (Macropoxy). Based on the superior coupon performance of System 21-A-Z (see Table 9), material costs are based on System 21-A-Z and, to be conservative, are rounded up to $1,000 total per pump.
  - The overall repair and repainting process for two pumps is thus estimated as $10,600 per pump, based on the CTC PO, CTC's paint receipts, and interview with M&T.
  - Coating 30 pumps would thus be $318,000, the first year installment costs for the technology. Note that this cost is based on the assumption that pump removal, cleaning, and painting are not included in the $900,000 immediate replacement cost, and thus is quite conservative. Stipulating painting during the procurement of replacement pumps could greatly reduce this cost.
  - If stipulating up front the use of System 21-A-Z in place of a standard OEM coating system, a cost of $400 is assumed (half of the $795 needed for two pumps in a repainting operation). Then the cost of 30 pumps with the 21-A-Z system applied is conservatively estimated at $912,000.
- It is assumed that the $900,000 immediate replacement cost (per the PMP, Appendix 1, Task 2, Assumption a) for 30 pumps remains despite the new technology, because the new technology would be applied to in-service (and thus currently corroded) pumps.
- Per the PMP, Appendix 1, Task 2, Assumption d, it was assumed that a $5,000 inspection and maintenance fee applied every 5 years, and because of PMP Task 2, Assumption d, "virtually maintenance free for 15 years," a $200,000 repair cost (from Assumption b) was assumed to apply every 15 years for all 30 pumps. Based on the work conducted under this effort, as well as discussions with Fort Bragg personnel, these assumptions seemed reasonable and were adopted.

The cost of the project as applied to mechanical rooms had to be inferred as the work was not budgeted by topics investigated, but by labor, travel, materials, etc. The effort in the mechanical rooms was estimated as being proportional to the amount M&T spent in the rooms. M&T spent $28,800 (80%) of a $36,000 budget on the rooms, so it is estimated the project cost (i.e., investment required) for the cooling pumps is $288,000 (80% of $360,000).

Based on the above assumptions, the costs for coating cooling tower pumps are as follows:

- Baseline costs are $900,000 for pump replacement (with the EOM coating system) on the first year and every fifth year thereafter (years 6, 11, 16, etc.); $200,000 in repairs every three years after replacement (years 3, 6, 9, etc.); and $5,000 in annual inspection and maintenance.
- The costs for coated pumps (new pumps with coatings as demonstrated in this project) include $900,000 in replacements costs on the first year only; $200,000 in repairs every 15 years (years 16 and 31) instead of every five years; and $5,000 in inspection and maintenance every five years (years 6, 11, etc.).

The following assumptions were made for the use of stainless steel components:

- The cost to repair and repaint the pumps was not initially separated from the cost to repair the mechanical rooms in the CTC PO of $36,000 for M&T's labor.
  - However, discussion and review with M&T of the PO provided a detailed breakdown of labor between the mechanical room and pump activities sufficient for an engineering estimate of the labor of the mechanical room: $28,800 for all three pumps. The labor to remove, clean, paint and repair, and reinstall each pump was thus $9,600.
  - The installation process of the stainless pump did differ from painting the other two pumps, but was approximately of the same difficulty, so the same value of $9,600 in labor is used.
  - Removal and reinstallation of the pump were each estimated at 20% of the labor ($1,920 for each operation); cleanup and repair (such as of the motor mount) was 15% of the labor ($1,440); and modifying the stainless pump to fit in the well was the balance ($4,320). (Reference: interview with M&T dated 28 July 2010.)
  - The material cost for replacing the pump with a stainless steel stem was $12,922 based on the CTC purchase order to Diversified Drilling Corporation, Tampa, FL. Note that this includes the cost of building and assembling the custom stainless steel pump, as well as shipping the completed assembly to Fort Bragg.

- The overall replacement cost for one existing pump with a stainless steel pump is thus estimated as $22,522, based on CTC POs and interview with M&T.

- Replacement of 30 existing pumps would thus be $675,660. A year 1 replacement of 30 existing pumps with new pumps fitted with stainless steel would be approximately $1,288,000 ($900,000 for the pumps and $388,000 for the stainless steel components).
- Per the PMP, Appendix 1, Task 2, Assumption d, it was assumed that a $5,000 maintenance fee applied every five years per pump, and because of the PMP guidance Task 2, Assumption d, "virtually maintenance free for 15 years," a $200,000 repair cost (from Assumption b) was assumed to apply every 15 years for all pumps. Based on the work conducted under this effort, as well as discussions with Fort Bragg personnel, these assumptions seemed reasonable and were adopted.

Finally, no base benefits and savings or new system benefits and savings were explicitly separated from the baseline system and new system costs. Instead, any benefits were computed directly from the lower costs of the new system.

4.3 Return on investment

Under the assumptions and references given in sections 4.1 and 4.2 above, the estimated ROIs for the three systems are as follows:

- 37.8 for the use of high-performance coatings in mechanical rooms
- 6.2 for the use of stainless steel on cooling tower pumps
- 7.4 for the use of high-performance coatings on cooling tower pumps (instead of using stainless steel)

These ROI computations include 30 years of recurring maintenance costs shown in Table 11–Table 13.

Table 11. Mechanical room ROI computation, coatings.

Return on Investment Calculation

Investment Required			72,000
Return on Investment Ratio	37.84	Percent	3784%
Net Present Value of Costs and Benefits/Savings	6,888,312	9,613,095	2,724,783

A Future Year	B Baseline Costs	C Baseline Benefits/Savings	D New System Costs	E New System Benefits/Savings	F Present Value of Costs	G Present Value of Savings	H Total Present Value
1	6,000,000		7,231,000		6,758,093	5,607,600	-1,150,493
2	5,000					4,367	4,367
3	5,000					4,082	4,082
4	5,000					3,815	3,815
5	5,000					3,565	3,565
6	205,000		5,000		3,332	136,592	133,260
7	5,000					3,114	3,114
8	5,000					2,910	2,910
9	5,000					2,720	2,720
10	5,000					2,542	2,542
11	205,000		5,000		2,376	97,396	95,020
12	5,000					2,220	2,220
13	6,000,000					2,490,000	2,490,000
14	5,000					1,939	1,939
15	5,000					1,812	1,812
16	5,000		5,000		1,694	1,694	
17	5,000					1,583	1,583
18	205,000					60,660	60,660
19	5,000					1,383	1,383
20	5,000					1,292	1,292
21	5,000		505,000		121,958	1,208	-120,750
22	5,000					1,129	1,129
23	205,000					43,235	43,235
24	5,000					986	986
25	6,000,000					1,105,200	1,105,200
26	5,000		5,000		861	861	
27	5,000					805	805
28	5,000					752	752
29	5,000					703	703
30	205,000					26,937	26,937

Table 12. Cooling pump ROI computation, coatings.

Return on Investment Calculation

Investment Required			288,000
Return on Investment Ratio	7.42	Percent	742%
Net Present Value of Costs and Benefits/Savings	918,349	3,055,222	2,136,873

A Future Year	B Baseline Costs	C Baseline Benefits/Savings	D New System Costs	E New System Benefits/Savings	F Present Value of Costs	G Present Value of Savings	H Total Present Value
1	900,000		900,000		841,140	841,140	
2	5,000					4,367	4,367
3	5,000					4,082	4,082
4	205,000					156,395	156,395
5	5,000					3,565	3,565
6	900,000		5,000		3,332	599,670	596,339
7	5,000					3,114	3,114
8	5,000					2,910	2,910
9	205,000					111,500	111,500
10	5,000					2,542	2,542
11	900,000		5,000		2,376	427,590	425,215
12	5,000					2,220	2,220
13	5,000					2,075	2,075
14	205,000					79,499	79,499
15	5,000					1,812	1,812
16	900,000		205,000		69,434	304,830	235,397
17	5,000					1,583	1,583
18	5,000					1,480	1,480
19	205,000					56,683	56,683
20	5,000					1,292	1,292
21	900,000		5,000		1,208	217,350	216,143
22	5,000					1,129	1,129
23	5,000					1,055	1,055
24	205,000					40,406	40,406
25	5,000					921	921
26	900,000		5,000		861	154,980	154,119
27	5,000					805	805
28	5,000					752	752
29	205,000					28,823	28,823
30	5,000					657	657

Table 13. Cooling pump ROI computation, stainless steel components.

Return on Investment Calculation

Investment Required			288,000
Return on Investment Ratio	6.16	Percent	616%
Net Present Value of Costs and Benefits/Savings	1,280,974	3,055,222	1,774,248

A Future Year	B Baseline Costs	C Baseline Benefits/Savings	D New System Costs	E New System Benefits/Savings	F Present Value of Costs	G Present Value of Savings	H Total Present Value
1	900,000		1,288,000		1,203,765	841,140	-362,625
2	5,000					4,367	4,367
3	5,000					4,082	4,082
4	205,000					156,395	156,395
5	5,000					3,565	3,565
6	900,000		5,000		3,332	599,670	596,339
7	5,000					3,114	3,114
8	5,000					2,910	2,910
9	205,000					111,500	111,500
10	5,000					2,542	2,542
11	900,000		5,000		2,376	427,590	425,215
12	5,000					2,220	2,220
13	5,000					2,075	2,075
14	205,000					79,499	79,499
15	5,000					1,812	1,812
16	900,000		205,000		69,434	304,830	235,397
17	5,000					1,583	1,583
18	5,000					1,480	1,480
19	205,000					56,683	56,683
20	5,000					1,292	1,292
21	900,000		5,000		1,208	217,350	216,143
22	5,000					1,129	1,129
23	5,000					1,055	1,055
24	205,000					40,406	40,406
25	5,000					921	921
26	900,000		5,000		861	154,980	154,119
27	5,000					805	805
28	5,000					752	752
29	205,000					28,823	28,823
30	5,000					657	657

5 Conclusions and Recommendations

5.1 Conclusions

5.1.1 Mechanical room piping

In Mechanical Room A, both coatings performed well on the test coupons, in that neither the TC Ceramic-coated coupons nor the Corothane-coated coupons demonstrated any signs of corrosion during the one-year evaluation period. It is noteworthy, but not unexpected, that both coatings performed considerably better on the hot water lines (supply and return) than on the cold water lines, as the cold water lines experienced considerable standing condensation, which is the primary source of corrosion on these lines. Because condensation occurs when moisture-laden air comes into contact with a cold surface, the cold-water fittings will naturally collect condensation while the hot water fittings will not.

Neither the dehumidification system (Mechanical Room B) nor the removable insulation (Mechanical Rooms A and C) appeared to be effective in arresting corrosion on the fittings in the mechanical rooms. The dehumidification unit was simple to operate but it was difficult to confirm whether it was performing properly. The proper functioning of this unit throughout the entire one-year evaluation period was considered questionable based on the corrosion results. It was concluded that the dehumidifier, although sized for the room by the manufacturer, was unable to reduce the humidity to the level that would eliminate condensation on the exposed union joints, at least not without supplementary air circulation.

While the two coating systems were able to reduce the amount of corrosion on the fittings in the mechanical rooms, as compared with uncoated fittings, neither was able to fully eliminate corrosion consistently during the one-year evaluation period. Because this corrosion is attributed to continual condensation on the cold-water lines, it appears that effective dehumidification with constant air circulation to remove humidity uniformly throughout the rooms and either of the coatings could be combined to cost-effectively arrest corrosion on mechanical room union joints and pipe fittings.

The SpeedWrap removable insulation was found to be challenging to attach to the lines. It was very loose when it was finally attached even though the team worked with the manufacturer to specially design the applied pieces for the fittings in question). This product seemed to accumulate water within the wrapped portion, which would drip out of the ends. For these reasons, this insulation was found unsuitable as a stand-alone solution.

Based on the results of the studies of the Battelle coupons at both locations, it is concluded that there was no atmospheric corrosion problem to be addressed. This result supports the inference that corrosion on the fittings may be directly related to the presence of condensation on the fittings, which explains why the corrosion performance of the coated fittings (see Table 7) was worse than that of the coated panels (see Table 8).

5.1.2 Cooling-tower pumps

For the pump housings, the System 21-A-Z clearly outperformed the Macropoxy candidate on both the panels and the pump components. It is noted that the Macropoxy primer-only panels performed similarly to the Macropoxy primer-topcoat system panels for the first 12 months, which seemed to demonstrate that the application of the topcoat did not provide a noteworthy degree of additional protection. However, evaluations after an additional 18 months revealed a sharp difference between the two types of Macropoxy specimens: the coatings on the primer-only panels had failed completely, and one primer-only specimen had corroded off the rack entirely—even the uncoated panels were less corroded than the primer-only panels. This result was also observed on the primer-only panels in pumps 4 and 5, where the primer-only panels were coated only with small scraps of loose coating.

Based on discussions that were generated when these results were presented in open technical forums [10, 11], it is believed that the corrosion of the pump bowls may not be due to galvanic effects, as the stainless steel column was sufficiently isolated from the cast iron bowls by the bearings. Rather, the single coat of primer applied to the bowls may have been insufficient to protect them from the corrosive environment. This hypothesis is supported by the conditions of the primer-only panels mentioned above.

It is further noted that corrosion may have been aggravated by leaving the pump dry (i.e., with no water in the sumps) during seasonal shutdown. The manufacturer suggests that these stainless steel pumps be left with water in the sumps during the off season as much as possible. Possibly as a result of following this guidance, in May 2010 Fort Bragg personnel reported that pump 5 started up with no problems.

5.2 Recommendations

5.2.1 Applicability

Based on the results derived from this study, it is suggested that either the TC Ceramic or the Sherwin-Williams Corothane system would be suitable to reduce corrosion on the mechanical room pipe fittings. The Corothane system may be slightly more protective and cost-effective than the TC Ceramics system, and would be easier to apply (thus reducing labor costs). Either coating system, used in combination with dehumidification and continuous air circulation to stabilize humidity levels throughout the mechanical rooms, should be considered to mitigate corrosion. The potential benefits of combining these technologies should be considered in future demonstration efforts.

For the cooling-tower pump components, both the stainless steel alloy and the System 21-A-Z coating performed very well during the initial evaluation. Based on those results alone, either would be suggested for this application. However, performance issues became more apparent over a longer period of time. Specifically, the stainless steel pump failed shortly after the conclusion of the original project. While the specific cause has yet to be determined, both the condition of the pump at 12 months and the condition of the primer-only panels at 30 months suggest that the single-coat system is insufficient to protect the cast-iron bowls from corrosion in this environment. With this in mind, and considering the significant extra time and expense needed to procure and install the stainless steel pump, coating the existing pumps with the multi-coat System 21-A-Z coating system is clearly suggested. Finally, it is recommended that Fort Bragg DPW personnel review the results of the water sample analyses and the test methodology used for verifying the inhibitor levels with the contractor operators of the cooling plant to determine if the test is adequate for detecting the inhibitor levels. Addition of inhibitors to the cooling tower water should be adjusted accordingly.

5.2.2 Implementation

Given the successes of the different technologies demonstrated under this project, the following changes to existing Unified Facilities Guide Specifications (UFGS) are suggested for the corrosion protection of mechanical room piping components and cooling tower pumps.

5.2.2.1 Mechanical room pipes

For mechanical room piping, possible updates to UFGS-23 82 02.00 10, Unitary Heating and Cooling Equipment are proposed as follows.

Paragraph 3.2.4, "Field Painting," states that "painting required for surfaces not otherwise specified and finish painting of items only primed at the factory are specified in Section 09 90 00, "Paints and Coatings." However, the Corothane I Mio-Aluminum and TC Ceramic coatings used in this demonstration for the mechanical room piping are not covered by existing MPI (Master Painters Institute) or SSPC (Society for Protective Coatings) standard specifications referenced in UFGS 09 90 00. The Corothane I Aliphatic Topcoat does conform to AWWA (American Waterworks Association) D103, *Coating Steel Water Storage Tanks*, "Outside Coating System (OCS) #2," but no AWWA specifications are referenced in UFGS 09 90 00.

Corothane I MIO-Aluminum, as used in this project, can be used as a primer, intermediate coating, or finish coating. It is similar to SSPC Paint 41, "Moisture-Cured Polyurethane Primer or Intermediate Coat, Micaceous Iron Oxide Reinforced." Also, the Corothane I Aliphatic Topcoat is similar to SSPC Paint 38, "Single Component, Moisture-Cure Weatherable Aliphatic Polyurethane Topcoat." Both SSPC Paint 38 and Paint 41 are used in coating systems listed in UFGS-09 97 02, *Painting, Hydraulic Structures*. System 23-D and System 23-E use Paint 41 as primer and topcoats. Paint 41 is also used in System 23-A-Z which uses a zinc-rich urethane primer (SSPC Paint 40). Paint 41 is the intermediate coating and Paint 38 is the topcoat for this system.

Given the above observations, it is recommended that either UFGS-09 97 02 be referenced in UFGS 23 82 02.00 10, or coating systems 23-D, 23-E, and 23-A-Z be added to UFGS-09 90 00. As mentioned above, the TC Ceramic coating is not covered by any existing MPI or SSPC specifications. This coating, like other similar, ceramic-filled coatings available on the market, is advertised as a liquid-applied insulation. No thermal measurements were taken during this demonstration to verify the claimed insulation properties of the coating. While the TC Ceramic provided protection against corrosion equal to the Corothane system, it was more difficult to apply. It is recommended that inclusion of ceramic insulation coatings in UFGS-09 90 00 should be deferred until independent studies verify the thermal insulation benefits of these coatings and an industry-consensus specification is developed.

5.2.2.2 Cooling-tower pumps

The following specific updates are proposed for UFGS 43-21-39, *Pumps: Water, Vertical Turbine* (April 2008).

1. Paragraph 2.4.4.3: insert the following NOTE at the beginning of this paragraph: "If the pump will be subjected to corrosive water conditions, it is recommended that the column enclosing the pump lineshaft also be stainless steel. Alternatively, if using a standard ferrous metal column in corrosive water conditions, the column shall be coated with a system consisting of MIL-DTL-24441/19B primer and MIL-DTL-24441 topcoats. The surface shall be prepared and the coatings applied in accordance with the manufacturer's written instructions." If included, these MIL specifications will need to be added to the References under paragraph 1.1.
2. Paragraph 2.5.2.3: insert the following NOTE at the beginning of this paragraph: "If the pump will be subjected to corrosive water conditions, it is recommended that the column enclosing the pump lineshaft also be stainless steel. Alternatively, if using a standard ferrous metal column in corrosive water conditions, the column shall be coated with a system consisting of MIL-DTL-24441/19B primer and MIL-DTL-24441 topcoats. The surface shall be prepared and the coatings applied in accordance with the manufacturer's written instructions." If included, these MIL specifications will need to be added to the References under paragraph 1.1.
3. Paragraph 2.11.2: After the first sentence, add the following: "Ferrous metal components that will come into contact with highly corrosive water or that will be exposed to high humidity or other corrosive atmospheric conditions shall be coated with a system consisting of MIL-DTL-24441/19B primer and MIL-DTL-24441 topcoats. The surface shall be prepared and the coatings applied in accordance with the manufacturer's written instructions." If included, these MIL specifications will need to be added to the References under paragraph 1.1.

References

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[3] Mason, R., Gintert, L., Singleton, M., Hock, V., and Lampo, R. 2008. Evaluation of Corrosion Mitigation Technologies for Mechanical Room Plumbing and Union Joints at Military Facilities. *NACE Corrosion 2008 Conference*.

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[10] Mason, R., Gintert, L., Klug, K., Hock, V., and Lampo, R. Coating Technologies to Mitigate Corrosion on Infrastructure Components at Fort Bragg. SUR/FIN 2010.

[11] Mason, R., Gintert, L., Klug, K., Hock, V., and Lampo, R. Demonstration and Validation of Technologies to Mitigate Corrosion on Infrastructure Components at Fort Bragg: One Year Results. 2009 DoD Corrosion Conference.

Appendix A: Project Management Plan

OSD CORROSION PREVENTION AND CONTROL (CPC) PROGRAM

FY07 TRI-SERVICE / ARMY FACILITIES CPC PROJECT MANAGEMENT PLAN

Demonstrate and Validate Technologies to Mitigate Corrosion on Mechanical Room Utility Piping and Cooling-Tower Pumps at Fort Bragg (OMA)

29 May 2007

Submitted By: Vincent Hock

U.S. Army Engineer Research & Development Center (ERDC)

Construction Engineering Research Laboratory (CERL)

Comm: 217-373-6753

F07ARCTC01

1. **STATEMENT OF NEED**

PROBLEM STATEMENT: A number of critical issues related to accelerated corrosion of infrastructure components are evident at Fort Bragg, NC. These include corrosion of steel utility piping in mechanical rooms and steel pump housing as part of cooling tower systems.

a. Mechanical Rooms: Steel piping in mechanical rooms with high humidity will readily corrode unless appropriately protected. Accelerated corrosion of exposed union joints in the mechanical rooms at the newly constructed 16th Military Police Barracks at Fort Bragg is a prime example of such corrosion (Fig. 1). The environmental conditions within the mechanical rooms have also resulted in a significant amount of condensate building up on the insulation covering the supply lines, with the metal brackets that support them also collecting moisture. Aside from resulting in accelerated corrosion, there is concern about the potential for organic growth (e.g., mold) under these conditions.

Figure A1. Corroding steel utility piping in high-humidity mechanical room at Fort Bragg.

b. Cooling-tower pumps: Accelerated corrosion is also occurring at a relatively new (put on line in 1996) central cooling plant at Fort Bragg. The vertical cooling towers and pumps at this central plant have corroded at an alarming rate, with the pumps reaching total failure due to corrosion within 2-4 years of operation (Fig.

2). These problems can be attributed to the lower housing of the pumps being made of mild steel and exposed to highly oxygenated, turbulent water which effectively consumes the metal, resulting in extensive pitting and flaking of the steel. Ineffective or improper system water treatment may also be contributing to an accelerated rate of corrosion to the pumps.

Figure A2. Corroding pumps bodies at central heating plant at Fort Bragg.

Special high-performance coatings, insulation, water treatment, and/or dehumidification technologies are needed to mitigate the corrosion that is occurring on the mechanical room utility piping and the cooling-tower pumps.

IMPACT STATEMENT: Operation of the cooling systems within the mechanical rooms and the central plant are critical to the ongoing mission of Fort Bragg. The corrosion problem in the mechanical rooms is considered both a safety problem (should a leak develop or a pipe to burst due to corrosion of the components) as well as a potential health-related problem, with the possibility of mold or mildew growth developing in the damp environment. The pump corrosion problem is a cause for considerable system down time that in turn disrupts the use of facilities and requires increased labor and expense to repair or replace. The proposed (see next section for further details) innovative high-performance coatings, insulation, water treatment, and/or dehumidification solutions will provide enhanced long-term system reliability and safety at reduced costs compared to current practices.

2. **PROPOSED SOLUTION**

TECHNICAL DESCRIPTION: A combination of high-performance coatings, removable/replaceable insulation, water treatment, and dehumidification technologies will be used to address the corrosion problems described above. The technologies to be applied to the mechanical room piping and joints and the cooling-tower pumps and system will be addressed separately in more detail below as two tasks.

a. Task 1. Mechanical Room Piping and Joints: Removable/replaceable insulation and at least two different coating systems will be used on the mechanical room exposed piping and joints as a means to control corrosion of these components. One of the coatings will be a liquid-ceramic, high-performance coating that is expected to not only provide the needed corrosion resistance but thermal insulation as well. Application of special dehumidification techniques to remove the excess moisture (leading to corrosion of the exposed steel utility system components and possible mold/mildew growth) will also be explored and demonstrated.

Task 1 Objectives: The objectives of this task concerning the corrosion problems in the mechanical rooms are to: (1) identify, demonstrate, and validate at least two different coatings (one coatings to be a liquid ceramic) to prevent corrosion on the exposed piping and union joints; (2) identify, demonstrate, and validate removable insulation to be used to provide the required thermal insulation and stop the condensation on the exposed steel piping; and (3) identify, demonstrate, and validate the use of dehumidification techniques to control the humidity in the mechanical rooms which enables the corrosion and possible mold/mildew growth. Coupon test racks will be located in the mechanical rooms for further (including long-term) comparison and validation of the different solutions.

Implementation of the technologies in the Fort Bragg mechanical rooms (Task 1) is projected to have an ROI of 11.6, and a total savings of $1.2M.

b. Task 2. Cooling-tower pumps: There are five cooling-tower pumps to be used in this project. A recently purchased replacement pump and a recently refurnished pump, both with standard OEM coatings on the lower steel housings, will act as controls. Two of the other pumps will be replaced/refurbished using selected high-performance coatings. The fifth pump will be replaced with an alternative corrosion-resistant alloy or non-metallic housing. The condition of the five pumps will periodically be assessed and documented. The water chemistry will be analyzed and the currently used water treatment chemicals will be assessed relative to their influence on the overall corrosion of the system. Suggested adjustments to the water treatment chemicals will be made as determined by this assessment.

Task 2 Objectives: The objectives of this task are to extend the life of cooling tower components and pumps, thus reducing the replacement and lifecycle costs of the system, will be to: (1) investigate and compare the use of high-performance coatings to standard OEM coatings for the pump housing; (2) investigate and compare the use of alternative materials for the lower pump housing; and (3) assess the need for modified water treatment in the system. Coupon test racks will be placed in the pump sumps for further (including long-term) comparison and validation of the different coatings and alternative material solutions.

Implementation of the technologies in the Fort Bragg cooling-tower pumps (Task 2) is projected to have an ROI of 8.2, and a total savings of $2.1M.

<u>Technology Maturity</u>:

The coatings, alternative materials, insulation, water treatment chemicals and dehumidification technologies to be implemented in this project are all commercially available products that are not currently being effectively utilized by the Army to prevent corrosion as being experienced on the mechanical room piping and joints and the cooling-tower pumps at Fort Bragg. A primary objective of this project is to determine best selection and best practices for the use of these coatings, insulation, water treatment chemicals and dehumidification technologies to mitigate the subject corrosion problems.

RISK ANALYSIS: This is a relatively **<u>low-risk</u>** project as the technologies to be demonstrated are readily available and have been successfully field tested in similar applications. The site for implementation of this project at Fort Bragg and plans for implementation of this project have been coordinated with Ms. Judi Hudson, Deputy Director, DPW at Fort Bragg. The project will not be parsed into phases.

EXPECTED DELIVERABLES AND RESULTS/OUTCOMES: The previously described technologies will be implemented in mechanical rooms and cooling towers at Fort Bragg. These innovative technologies will be compared to current existing practice and evaluated for durability and cost benefits using a mutually agreed upon matrix of performance criteria. The economics and performance benefits of the coatings, alternative materials, insulation, water treatment chemicals, and dehumidification technologies will be analyzed and documented. The project design and benefits analyses will be used to develop or modify existing engineering guidance (e.g., Unified Facilities Guide Specifications – UFGS and Unified Facilities Criteria – UFC) for the corrosion protection of mechanical room piping components and cooling-tower pumps. Lessons-learned and guidance developed as part of this project will be implemented in ACSIM's Installation Design Standards Process. Standard operating procedures (SOP) will be developed for use by Installation personnel as may be required for maintenance of the technologies implemented in this project. A final report describing the details of the project including lessons learned will be developed and placed on the Office of the Secretary of Defense (OSD) Corrosion Exchange website under "Specs & Standards" and "Facilities SIG."

PROGRAM MANAGEMENT: The Project Manager will be: Mr. Vincent Hock (ERDC-CERL Senior Researcher and Materials Engineer). The Associate Project Manager will be: Mr. Richard Lampo (Materials Engineer). Mr. Steve Sweeney is the acting ERDC-CERL Branch Chief. The stakeholders will be: Ms. Judi Hudson (Fort Bragg DPW POC), Dr. Gay Kendall (Fort Bragg Science Advisor), Mr. Theodore Kientz (Fort Bragg Installation Support, Savannah Dist.), Ms. Kristen Thomas (IMCOM-SERO), Paul Volkman (HQ-IMCOM), David Purcell (HQ-ACSIM), as well as Tri-services WIPT representatives, Mr. Dan Zarate (NFESC), and Mr. Michael Zapata (AFCESA/CESM). The initial customer is: Ms. Judi Hudson, Deputy Director of Public Works, Fort Bragg, NC. The technology has been requested by Fort Bragg to help reduce their maintenance and replacement costs of mechanical room utility piping and cooling-tower pumps. Coordination with the Army Corrosion Program Office will be through Mr. Hilton Mills (HQ-AMC) and with OSD will be through Mr. Richard Kinzie.

Project Team Roles and Responsibilities: For this particular project, contracting will be done through OSD's Indefinite Delivery Order (IDIQ) Contract with Mandaree Enterprises Corporation (MEC). Mr. Richard Kinzie, is the primary POC at OSD regarding this project. Mr. Dan Dunmire, OSD, is the Contracting Officer's Representative (COR) for the IDIQ to MEC. MEC will subcontract for the on-site work at Fort Bragg using the Statement of Work (SOW) provided to OSD by ERDC-CERL.

a. OSD Roles and Responsibilities: OSD will act as the liaison between ERDC-CERL and MEC for the contracting action required for this project. Mr. Dunmire (primary COR) will not approve payment of invoices associated with this project without written concurrence of Mr. Richard Lampo, ERDC-CERL.

b. Fort Bragg DPW Roles and Responsibilities: Fort Bragg DPW will provide access to the facilities on which to implement the technologies to be demonstrated and validated by this project. Mr. Russell Hayes, DPW Office, will act as a liaison between the operators and/or responsible persons of the mechanical rooms and the cooling towers and the contractor(s) conducting the on-site work. Dr. Gay Kendall, Fort Bragg Science Advisor, will provide technical review of reports and address other technical issues as needed.

c. ERDC-CERL Roles and Responsibilities: Overall project management and technical oversight of the on-site work will be provided by ERDC-CERL. Mr. Lampo has this primary responsibility of overall project management and technical oversight using a CERL Team that includes Mr. Al Beitelman (coatings) and Ms. Susan Drozdz (coatings and water treatment). The SOW for the Mandaree subcontract will be developed and coordinated between Fort Bragg DPW and CERL. The SOW will detail the work requirements for the Mandaree subcontractor relative to the two Tasks defined within this PMP including, but not limited to, the development of a detailed Work & Schedule Plan, a Health & Safety Plan, and an Environmental Protection & Compliance Plan. Mr. Lampo will be designated as the Alternate Contracting Officer's Technical Representative for this Mandaree Subcontract. All deliverables (including monthly progress reports) shall be submitted through and approved by Mr. Lampo (in coordination and approval of Fort Bragg DPW) before concurrence will be given to OSD for payment of incremental invoices. On all OSD funded Corrosion Prevention and Control Projects, ERDC-CERL is responsible for providing Progress Reports (in the form of quad charts) on a bi-monthly basis to OSD. ERDC-CERL will coordinate with the Fort Bragg DPW before these Bimonthly's are submitted to OSD. Mr. Lampo will immediately inform the Fort Bragg DPW of any problem that arises in the performance of this project. ERDC-CERL will coordinate with Fort Bragg DPW when preparing the final project ROIs and Technical Report.

Contact Information for Key Personnel

Name	Organization	Phone #	E-Mail
Richard Lampo	ERDC-CERL	217-373-6765	r-lampo@cecer.army.mil
Susan Drozdz	ERDC-CERL	217-373-6767	s-drozdz@cecer.army.mil
Al Beitelman	ERDC-CERL	217-373-7237	a-beitelman@cecer.army.mil
Russell Hayes	Fort Bragg DPW	910-432-5093	russ.hayes@us.army.mil
Gay Kendall	Fort Bragg	910-396-2522	gay.kendall@us.army.mil
Richard Kinzie	OSD	478-714-8853	richard.kinzie@gmail.com

3. COST/BENEFITS ANALYSIS

a. Funding ($K):

Funding Source	OSD
Labor	15*
Contracts	360**
Travel	10*
Report	5*
TOTAL ($K)	**390**

* ERDC-CERL

** Approximately $100K for the mechanical room tasks and $260K for the cooling-tower pump tasks.

Development Project Budget

The $390K budget is realistic and adequate for the scope of the project. This budget has been based on a needs assessment of the candidate materials and costs for implementation.

b. Return-On-Investment Computation:

Using the required OMB spreadsheet, and in accordance with OMB Circular A-94, a **return-on-investment (ROI) of 11.6** was calculated (see Appendix 1 below for assumptions made in this calculation) for the mechanical room utility corrosion problem. The **associated savings were $1.2M**. A **return-on-investment (ROI) of 8.2** was calculated (see Appendix 1 below for assumptions made in this calculation) for the cooling-tower pump corrosion problem. The **associated savings were $2.1M**. These ROI values are based on current best practices, as well as projected maintenance and rehabilitation practices and costs.

c. Mission Criticality:

Corrosion protection for mechanical room components and cooling-tower pumps will ensure that these facilities remain operable. Providing climate control for Soldiers is critical for health and wellbeing. Wide-spread implementation of these technologies across Fort Bragg will ensure that all buildings which support Unit activities, to include critical training, are maintained at optimum temperature. Due to a lack of maintenance personnel and limited operational funding in DPW, it is not uncommon to have some buildings at Fort Bragg, including barracks and classrooms, uncooled during the hot summer months. Often this is due to catastrophic failure of piping components or pumps, as little or no preventative measures have been taken to protect and maintain them. The success of this project will help Fort Bragg ensure readiness by ensuring the ability to house and train Soldiers in a healthy and comfortable environment. The same would be true at other Army and DoD Installations that house and train personnel for mission readiness.

4. **SCHEDULE**

MILESTONE CHART	
EVENT	TIME
Project Coordination Meeting	May 2007
Subcontract Awarded / Pre-Work Conference	July 2007
Technologies Selected for Implementation in Mechanical Rooms	August 2007
Technologies Selected for Implementation in Cooling Towers	August 2007
Selected Technologies Implemented in Mechanical Rooms	September 2007
Selected Technologies Implemented in Cooling Towers	September 2007
Perform Initial Assessment of Performance	January 2008
Perform Additional Performance Assessments	July 2008
Complete ROI Validation	August 2008
Complete Interim Technical Report	September 2008
Complete Documentation (includes Interim Tech Report, Procurement Specification, etc.)	September 2008

a. ***Bi-monthly status reports will be submitted to OSD*** (i.e. starting the first week of the second month after contract award and every two months thereafter until final report is completed). This report will be submitted to the DoD CPC Policy & Oversight office. Report will include project number, progress summary (and/or any issues), performance goals and metrics and upcoming events.

b. Examples of performance goals and metrics: include achieving specific milestones, showing positive trend toward achieving the forecasted ROI, reaching specific performance quality levels, meeting test and evaluation parameters, and/or successfully demonstrating a new system.

Development Project Schedule

This project to select and install coatings, insulation, and dehumidification technologies for piping and joints in humid mechanical rooms and to select and install coatings, alternative materials, and water treatment chemicals for central plant cooling towers will be completed, including an interim technical report, within 18 months. Performance, economic, and environmental benefits of the implemented and demonstrated technologies will be documented. Engineering guidance documents will be developed to enable others to use the innovative systems. Site work will be done by contractors. ERDC-CERL will provide overall project management and technical oversight including provide the bi-monthly progress reports to OSD. The schedule has been coordinated with Fort Bragg DPW. Overall project milestones are shown in the Table above. Potential contractors have been identified. Contract award will be completed through the Air Force Corrosion Program Office in coordination with CERL and Fort Bragg responsible persons.

5. **IMPLEMENTATION**

a. **Transition approach:** The project design and benefits analyses will be used to develop engineering guidance (e.g., Unified Facilities Guide Specifications – UFGS and Unified Facilities Criteria – UFC) for the design, construction, and use of coatings or insulation in mechanical room piping and use of coatings and/or water treatment for cooling-tower pumps and other components. Lessons-learned and guidance developed as part of this project will also be implemented in ACSIM's Installation Design Standards Process. A final report describing the details of the project will be developed and placed on the OSD Corrosion Exchange website under "Specs & Standards" and "Facilities SIG." In addition, the draft documents will be posted on the ERDC-CERL Corrosion Control Technology Program (CCTP) website.

b. **ROI validation**. Potential ROIs will be validated by comparison of performance of the implemented technologies to currently used materials and practices. The calculated ROIs for this project, which is based on current best practices, projected maintenance and rehabilitation cost, has the potential to increase over the multiple year implementation due to the reduction in down time, which will result in increased indirect savings.

c. Final Report:

A draft technical report to be presented to OSD will be completed on or before December 2008. The report will reflect the project plan format as implemented and will include lessons learned.

Projected Benefits

The immediate benefits of this project are the reduction in operating costs and increased service life of mechanical rooms in the new multimillion dollar barracks complex at Fort Bragg, which is already experiencing corrosion problems and the reduction in operating and replacement costs and increased service life of cooling pumps at the 82nd Airborne central cooling plant at Fort Bragg, which have been experiencing severe corrosion problems, leading to catastrophic failure of cooling pumps. Longer term benefits will be realized when the identified solutions are successfully adopted at other Army and DoD facilities.

Management Support

This project is supported by the Deputy Director, Fort Bragg DPW Office as well as the IMCOM-SERO Region (see coordination sheet signatures).

6. **COORDINATION SHEET**

ORGANIZATION	SIGNATURE	DATE
Associate Project Manager	____________	______
Project Manager	____________	______

ERDC-CERL Branch Chief, CF-M	____________	______
Installation Support, Savannah Dist.	____________	______
Fort Bragg Science Advisor	____________	______
Fort Bragg DPW	____________	______
OSD Corrosion Program POC	____________	______
IMCOM Southeast Region	____________	______
HQ IMCOM	____________	______
HQ ACSIM	____________	______
HQ AMC	____________	______
Tri-Service Facilities WIPT Chair	____________	______

6. **COORDINATION SHEET**

ORGANIZATION	**SIGNATURE**	**DATE**
Associate Project Manager	[illegible]	5/24/07
Project Manager	[illegible]	5/29/07
ERDC-CERL Branch Chief, CF-M	[illegible]	5/29/07
Installation Support, Savannah Dist.		
Fort Bragg Science Advisor		
Fort Bragg DPW		
OSD Corrosion Program POC		
IMCOM Southeast Region		
HQ IMCOM		
HQ ACSIM		
HQ AMC		
Tri-Service Facilities WIPT Chair		

6. COORDINATION SHEET

ORGANIZATION	SIGNATURE	DATE
Associate Project Manager		
Project Manager		
ERDC-CERL Branch Chief, CF-M		
Installation Support, Savannah Dist.		
Fort Bragg Science Advisor		
Fort Bragg DPW		
OSD Corrosion Program POC	Richard C. Kinzie, Jr.	24 May 07
IMCOM Southeast Region		
HQ IMCOM		
HQ ACSIM		
HQ AMC		
Tri-Service Facilities WIPT Chair		

7. **APPENDICES**

APPENDIX 1: Return on Investment (ROI) Calculations based on OMB Circular A-94

Task 1. Mechanical Room Utility Piping

Assumptions:

a. Assume implementation of the technologies in 1,000 mechanical rooms at Fort Bragg. Estimated replacement of the corroded piping and joint components is approximately $500K. Assume replacement is needed immediately. Under current conditions and practice (that is, no protective coatings and/or insulation), assume replacement every 12 (12) years.

b. Even with routine maintenance, failures of the mechanical room systems due to corrosion will occur with a direct (emergency repairs) and indirect (loss of mission capability) cost impact of $200K figured on a periodic basis of every five (5) years.

c. The mechanical rooms are currently inspected every year at $5K total per year.

d. Because of the increased durability of the high-performance coatings, repair/replacement costs are assumed to be negligible for twenty (20) years with inspection every five (5) years in between replacement.

Return on Investment Calculation

Investment Required			100,000
Return on Investment Ratio	11.62	Percent	1162%
Net Present Value of Costs and Benefits/Savings	37,664	1,200,035	1,162,371

A Future Year	B Baseline Costs	C Baseline Benefits/Savings	D New System Costs	E New System Benefits/Savings	F Present Value of Costs	G Present Value of Savings	H Total Present Value
1	500,000		25,000		23,365	467,300	443,935
2	5,000					4,367	4,367
3	5,000					4,082	4,082
4	5,000					3,815	3,815
5	5,000					3,565	3,565
6	5,000		5,000	200,000	3,332	136,592	133,260
7	5,000					3,114	3,114
8	5,000					2,910	2,910
9	5,000					2,720	2,720
10	5,000					2,542	2,542
11	5,000		5,000	200,000	2,376	97,396	95,020
12	5,000					2,220	2,220
13	500,000					207,500	207,500
14	5,000					1,939	1,939
15	5,000					1,812	1,812
16	5,000		5,000	200,000	1,694	69,434	67,740
17	5,000					1,583	1,583
18	5,000					1,480	1,480
19	5,000					1,383	1,383
20	5,000					1,292	1,292
21	5,000		25,000	200,000	6,038	49,508	43,470
22	5,000					1,129	1,129
23	5,000					1,055	1,055
24	5,000					986	986
25	500,000					92,100	92,100
26	5,000		5,000	200,000	861	35,301	34,440
27	5,000					805	805
28	5,000					752	752
29	5,000					703	703
30	5,000					657	657

Task 2. Cooling-tower pumps

Assumptions:

a. Assume implementation of the technologies on 30 (30) pumps at Fort Bragg. Replacement costs are assumed to be $30,000 (materials and labor) per pump or $900K total. Assume replacement is needed immediately. Pumps are basically completely failed within five (5) years using current technology.

b. Even with routine inspection and maintenance, failures of the pumps will still occasionally occur with a direct (emergency repairs) and indirect (loss of mission capability) cost impact ($200K) figured on a periodic basis of every 3 years.

c. Cooling-tower pumps currently require annual inspection and repair at $5K total per year.

d. The pumps coated with the high performance coatings are expected to be virtually maintenance-free for a minimum fifteen (15) years with inspection every five (5) years in between replacement. (This technology may also be applicable to 700 smaller cooling-tower pumps which are not being considered in the calculations at this time.)

Return on Investment Calculation

Investment Required			260,000
Return on Investment Ratio	8.22	Percent	822%
Net Present Value of Costs and Benefits/Savings	1,153,746	3,290,342	2,136,596

A Future Year	B Baseline Costs	C Baseline Benefits/Savings	D New System Costs	E New System Benefits/Savings	F Present Value of Costs	G Present Value of Savings	H Total Present Value
1	900,000		900,000		841,140	841,140	
2	5,000					4,367	4,367
3	5,000					4,082	4,082
4	5,000			200,000		156,395	156,395
5	5,000					3,565	3,565
6	900,000		5,000		3,332	599,670	596,339
7	5,000			200,000		127,654	127,654
8	5,000					2,910	2,910
9	5,000					2,720	2,720
10	5,000			200,000		104,202	104,202
11	900,000		5,000		2,376	427,590	425,215
12	5,000					2,220	2,220
13	5,000			200,000		85,075	85,075
14	5,000					1,939	1,939
15	5,000					1,812	1,812
16	900,000		900,000	200,000	304,830	372,570	67,740
17	5,000					1,583	1,583
18	5,000					1,480	1,480
19	5,000			200,000		56,683	56,683
20	5,000					1,292	1,292
21	900,000		5,000		1,208	217,350	216,143
22	5,000			200,000		46,269	46,269
23	5,000					1,055	1,055
24	5,000					986	986
25	5,000			200,000		37,761	37,761
26	900,000		5,000		861	154,980	154,119
27	5,000					805	805
28	5,000			200,000		30,832	30,832
29	5,000					703	703
30	5,000					657	657

8. **METRICS / TRACKING**

Costs for replacement of the mechanical room piping and joints and cooling-tower pumps and will be developed and compared to the actual costs to implement the coatings, insulation, water treatment, and/or dehumidification technology solutions. Typical costs for maintenance and replacement of the pumps will be collected from the DPW. Maintenance costs for the implemented technologies will compiled and compared and used to develop a projection of long-term benefits and corrosion-resistant performance that will then be documented in the project interim technical report.

Appendix B: Contractor Planning and Safety Documents

WORK PLAN

Corrosion Technologies for Defense Systems and Infrastructure (CTDSI)

Task 2.1 Demonstrate and Validate Technologies to Mitigate Corrosion on Mechanical Room Utility Piping and Cooling-Tower Pumps at Fort Bragg

SCHEDULE

The CTDSI task, "*Demonstrate and Validate Technologies to Mitigate Corrosion on Mechanical Room Utility Piping and Cooling-Tower pumps at Fort Bragg*," has the following notable milestones and procurement, testing, and closeout activities:

MILESTONE CHART	
EVENT	TIME
Project Coordination Meeting	May 2007
Subcontract Awarded / Pre-Work Conference	July 2007
Pre-Job Meeting (scheduling contingent on key personnel availability)	October 2007
Technologies Selected for Implementation in Mechanical Rooms	October 2007
Technologies Selected for Implementation in Cooling Towers	October 2007
Selected Technologies Implemented in Mechanical Rooms	November 2007
Selected Technologies Implemented in Cooling Towers	November 2007
Perform Initial Assessment of Performance	January 2008
Perform Additional Performance Assessments	July 2008
Complete ROI Validation	August 2008
Complete Interim Technical Report	September 2008
Complete Documentation (includes Interim Tech Report, Procurement Specification, etc.)	September 2008

Note that for billing purposes, this MANDAREE contract has established a monthly billing schedule.

HEALTH AND SAFETY PLAN

CTC is an ISO 14001-certified company, with an extant system for monitoring environmental, health, and safety issues. As part of this ISO system, CTC evaluates and summarizes a project's physical risks and legal implications, including any activities performed by subcontractors, prior to initiation of work.

Program Management

CTC's Environmental, Health, and Safety Management System (EMS) encompasses employee training, physical qualification, accident reporting and recordkeeping, emergency plans, and daily safety briefings. The system also extends to subcontractors operating under CTC oversight.

CTC will maintain and operate the health and safety aspects of this effort in compliance with the ISO 14001 EMS. While it is recognized that the aspects of the ISO 9001 EMS may differ from those of Fort Bragg, they will serve as a baseline for the Health and Safety Plan for this effort.

CTC will provide the necessary personnel, materials and all other items essential to this aspect of the assigned tasks. All selected technologies to be implemented will be presented to and approved by the relevant Fort Bragg personnel before being implemented on site. Technical Data Sheets, Material Safety Data Sheets, and any other relevant materials describing the potential for safety and/or health hazards will be provided to all parties before work is initiated.

Sanitation

The worksite is an active U.S. military facility with appropriate sanitary facilities. If such sanitation facilities (e.g., drinking water and toilets) are not available within a reasonable distance of the worksite itself, then the contractor and/or relevant subcontractors will supply appropriate portable alternatives.

Medical and First-Aid Requirements

Prior to start of work, arrangements shall be made for medical facilities and personnel to provide prompt attention to the injured, should such occur, and for consultation on occupational safety and health matters as needed.

Emergency phone numbers appropriate for Fort Bragg will be prominently displayed at each work location, and the workers will have a first aid kit (with supplies appropriate to the type of work) at the worksite or conveniently nearby (See Table 3-1 of EM 385-1-1).

Personal Protective and Safety Equipment, and Hazardous Substances, Agents, and Environments

Based on hazard evaluations (conducted by supervisors), the contractor and/or relevant subcontractors shall select, and have each affected worker use, the appropriate personal protective equipment (PPE) that will protect the worker from hazards. The contractor and/or relevant subcontractors shall communicate PPE decisions to each affected worker and select PPE that properly fits each affected worker. Workers shall use all PPE that may be required to maintain their exposure within acceptable limits.

Hazardous substances such as those involved in working with chemicals, coatings, paint thinners, adhesives, etc. will be handled and disposed of properly, as required by CTC's ISO 14001 system and relevant local and federal regulations.

Signs

Signs, tags, and labels will be provided to give adequate warning and caution of hazards and instruction and directions to workers and the public.

Fire Prevention and Protection

The existing facilities should have extant fire prevention and response plans, which will be consulted. Available on-site fire suppression equipment will be noted. The CTC ISO 14001 system covers appropriate oversight and planning for fire prevention, suppression, and protection on the worksite through proper scrutiny of subcontractor procedures, capabilities, prior experience, and training as required.

If required, adjustments to existing fire prevention plans will be written for facilities and project sites. The revised Plan will update a list of the major workplace fire hazards, potential ignition sources, the types of fire suppression equipment or systems appropriate to the control of fire, assignments of responsibilities for maintaining the equipment and systems, personnel responsible for controlling the fuel source hazards, and housekeeping procedures, including the removal of waste materials. It shall be used to brief employees and emergency first responders on the fire hazards, the materials and processes to which they are exposed, and the emergency evacuation procedures.

Welding and Cutting, Hand and Power Tools

It is not anticipated that the installation of the equipment at the different facilities will entail the use of welding and cutting tools. If it becomes necessary to employ such tools, the CTC ISO 14001 system covers use of dangerous tools, including planning for injuries and fires that might be caused by welding and cutting tools. In addition, personnel will be trained in safe operation and first aid as part of the system.

Welders, cutters, and their supervisors will be trained in the safe operation of their equipment, safe welding/cutting practices, and welding/cutting respiratory and fire protection. Review of the American Industrial Hygiene Association (AIHA) publication "Welding Health and Safety: A Field Guide for OEHS Professionals" is recommended.

Material Handling, Storage, and Disposal

As governed by the CTC ISO 14001 system, due care will be taken during work activities involving the handling and storage of heavy and bulky materials.

Further, work sites will be maintained in a neat and orderly fashion. Work areas will be inspected at the end of the day for adequate housekeeping and findings shall be reported. Inadequate conditions will be corrected.

Contractor Quality Control (CQC) Plan

CTC's quality control system addresses the following requirements:

- CTC will perform all inspection and/or testing required by this contract per its existing ISO 9001 quality control system. (Unless the inspection and testing is specifically designated to be performed by the Government to ensure compliance to all contract requirements.)
- CTC's ISO 9001 system tracks plans, procedures, and organization necessary to provide the required materials, equipment, workmanship, fabrication, installation, and operations. The CTC ISO 9001 system is able to cover installation operations, including fabrication onsite and offsite, and takes into account the work schedule/installation plan.
- After award and before any site work is to proceed under the contract, CTC will hold a Pre-Job Meeting at Fort Bragg with the ERDC-CERL PM and Fort Bragg personnel to discuss the Work Plan (including the CQC system). During the meeting, a mutual understanding of the plan details shall be developed including the forms for recording the CQC operations, control activities, testing, administration of the system, including fabrication onsite and offsite, and the interrelationship of CTC and Government control and surveillance.
- Minutes of the Pre-Job Meeting will be prepared and signed by CTC, the ERDC-CERL PM, and Fort Bragg DPW and will become a part of the contract file.
- In addition to the application of the corporate-wide Quality/Environmental, Health and Safety Management System (QMS/EMS), CTC will utilize the Daily Quality Control Report form that was provided with the Task Order, as shown below.
- An overview of CTC's ISO 9001 and 14001 management systems are provided below, following the Daily Quality Control Report form, in the section, "CTC QMS/EMS Overview."

DAILY QUALITY CONTROL REPORT

Contract Number: ______________________ Date:
__________ Rpt No.____________

Contract Title: ______________________________

Location:____________________

Weather: Clear __ P.Cloudy __ Cloudy __ Rainfall __
(__% of workday)

Temperature during workday: High ____ degrees F. Low
___ degrees F.

1. WORK PERFORMED BY CONTRACTOR/SUBCONTRACTOR(S):

Contractor Name No. of Workers Crafts/Hours Work performed

____

____

____

____

2. EQUIPMENT DATA:

Type, Size, Etc. Owned/Rented Hours Used Hours Standby

____

____

____

____

3. QUALITY CONTROL INSPECTIONS AND RESULTS: (Include a description of preparatory, initial, and/or follow up inspections or meetings; check of subcontractors work and materials delivered to the site compared to submittals and/or specifications; comments on the proper

storage of materials; include comments on corrective actions to be taken):

____

____

____

____

4. QUALITY CONTROL TESTING AND RESULTS (comment on tests and attach test reports):

____

____

____

5. DAILY SAFETY INSPECTIONS (Include comments on new hazards to be added to the Hazard Analysis and corrective action of any safety issues):

____

____

____

6. REMARKS (Include conversations with or instructions from the Government representatives; delays of any kind that are impacting the job; conflicts in the contract documents; comments on change orders; environmental considerations; etc.):

____

____

____

____

____

CONTRACTOR'S VERIFICATION: The above report is complete and correct. All material, equipment used, and work performed during this reporting period are in compliance with the contract documents except as noted above.

____

CONTRACTOR QC REPRESENTATIVE

APPENDIX A1: CTC QMS/EMS Overview

CTC has a corporate wide Quality/Environmental, Health and Safety Management System (QMS/EMS) that is comprised of industry best models including ISO 9001 (Quality) and 14001 (Environmental), AS9100 (Aerospace) and CMMI-SE/SW®, Version 1.1 (Systems/Software Engineering).

CTC was one of the first nonprofit research and development organizations to simultaneously certify to both the ISO 9001 and 14001 international standards, doing so in 1998. All CTC locations conform to the requirements of these international management system standards, and they provide the foundation for all of our business processes. Additional quality benchmarks such as CMMI and AS9100 have been adopted to guide and support those activities that require more stringent quality controls. Surveys are sent to every client on every project to assess client satisfaction.

Professional Certification	Certification/Registration Entity	Date of Original Certification	Renewal Date
ISO 9001/ANSI/ASQC Q9001:2000	SGS SSC (Systems and Services Certification)	August 1998	August 2009
ISO 14001:2004	SGS SSC (Systems and Services Certification)	August 1998	August 2009
AS9100:2004	SGS SSC (Systems and Services Certification)	April 2005	April 2008
Capability Maturity Model Integrated for Systems Engineering/Software Engineering (CMMI-SE/SW) Version 1.1© Maturity Level 3	Abelia Corp/MultiDimensional Maturity (SEI Authorized Lead Assessor)	March 2003	There is no recurring certification/ required “Renewal” period under the CMMI assessment system.

Key Components of CTC's Quality Management System (QMS)

Standard Operating Procedures

CTC's quality efforts reduce variability and minimize project risks through standardized operating procedures that include detailed responsibilities for project personnel, line management, and corporate support functions (e.g. contracts, procurement, finance, human resources) covering key elements of project planning and execution. All aspects of project management, from contract/solicitation review through product/service delivery, are controlled via these documented procedures and periodic conformance assessments (i.e., audits). The result is reduced risk (cost, schedule, technical), cost savings/avoidance, and improved efficiency for our clients.

Performance Objectives

Monthly tracking of key performance indicators ensures early detection of potential issues and subsequent initiation of corrective/preventive action prior to customer impact. CTC measures itself against the same criteria the government uses, and asks its clients to do the same (client surveys). Broader program metrics allow for thoughtful and strategic decisions on program direction and objectives. Lastly, functional area metrics such as procurement response time, information services, and corrective action efficiency measure the effectiveness of our business processes. The Quality Committee reviews performance against a set of Quality Objectives, and takes action as necessary when trends and statistical analyses indicate potential areas of concern. CTC's quality program assures that customers receive the highest product quality and service performance in the most cost effective manner.

Regular client interactions and the use of a common set of performance metrics ensures our responsiveness, reduces program risk, and provides the client with full visibility for all resources.

Internal/External Audits and Assessments

Regularly scheduled audits (both internal and third-party) are a key component of the QMS/EMS in evaluating conformance against requirements and identifying additional opportunities for improvement. Several internal system audits are conducted annually along with annual and semi-annual third-party audits (depending on office size). This robust "inspection" process monitors project management activities, support service performance, and the overall quality of products/services on an on-going basis. Clients can rest assured that potential issues will be identified before problems surface, the appropriate improvement measures instituted, and the effectiveness of those measures evaluated. Additional benefits can be obtained for clients requiring on-site vendor assessments or quality inspections as CTC's quality certifications and/or audit program often meets those requirements. This provides additional cost and schedule savings to our clients.

Process Improvement Monitoring System

CTC's most significant quality system improvement initiatives have been a result of its process improvement monitoring system. Two key components of this system are Action Requests – dealing specifically with issues that need to be corrected or preventive measures that need to be instituted to avert potential problems, and System Improvements – dealing with process enhancements related to quality, efficiency, cost, or Environmental, Health and Safety (EHS) performance.

For corrective and preventive actions, root causes are recognized and "fixes" are identified, assigned, tracked, implemented, and verified for effectiveness. Actions taken on one program can have a direct impact on other programs.

In terms of System Improvements, each and every employee has a responsibility to identify opportunities for process improvements. On average, nearly 40% of all system improvement process changes are initiated by CTC employees and designed specifically to reduce waste and variability in our processes. System improvements have lowered costs and enhanced the quality of our products and services – directly benefiting our customers. These practices ensure that the client gains continual process improvement through best practices and lessons learned.

Appendix C: Coating System Technical Data

SHERWIN WILLIAMS.

Industrial & Marine Coatings

5.10

COROTHANE® I MIO-ALUMINUM

B65S14

PRODUCT INFORMATION

Revised 11/06

PRODUCT DESCRIPTION

COROTHANE I MIO-ALUMINUM is a single component, VOC compliant, moisture curing, aluminum and Micaceous Iron Oxide (MIO) filled, urethane primer, intermediate coating, or finish. It has excellent surface wetting properties and provides extended recoatability.

- Excellent adhesion to most substrates
- Low temperature application - down to 20°F
- Excellent durability
- Outstanding abrasion resistance
- Excellent corrosion and chemical resistance
- Recoat up to 30 days

RECOMMENDED USES

For use over prepared surfaces in industrial environments:

- Heavy duty interior and exterior structural coating
- High performance, one coat or multiple coat, coating for steel, aluminum, concrete, and most plastics in industrial and marine environments
- Universal primer for poorly prepared surfaces, old paint, tightly adherent rust, weathered galvanized steel, and concrete
- Excellent intermediate coat providing superior adhesion of subsequent coats

PRODUCT CHARACTERISTICS

Finish: Matte

Color: Aluminum

Volume Solids: 65% ± 2%

Weight Solids: 77% ± 2%

VOC (EPA Method 24): <340 g/L; 2.80 lb/gal

Recommended Spreading Rate per coat:
Wet mils: 3.0 - 4.5
Dry mils: 2.0 - 3.0
Coverage: 348 - 521 sq ft/gal approximate

Drying Schedule @ 3.5 @ mils wet @ 50% RH:

	@ 40°F	@ 77°F	@ 100°F
To touch:	4 hours	2 hours	1 hour
To recoat			
minimum:	16 hours	7 hours	3 hours
maximum:	30 days	30 days	30 days
To cure:	5 days	3 days	1 day

Drying time is temperature, humidity, and film thickness dependent.
Abrade surface if maximum recoat time is exceeded.

Shelf Life: 12 months, unopened
Store indoors at 40°F to 100°F.

Flash Point: 103°F, PMCC

Reducer/Clean Up:
Spray: Reducer #15, R7K15
Brush and Roll: Reducer #100, R7K100
VOC Exempt: Reducer R7K111

PERFORMANCE CHARACTERISTICS

System Tested: (unless otherwise indicated)
Substrate: Steel
Surface Preparation: SSPC-SP6
1 ct: Corothane I MIO-Aluminum @ 3.0 mils dft
1 ct: Corothane I IronOx B @ 4.0 mils dft
1 ct: Corothane I Aliphatic @ 3.0 mils dft

Adhesion:
Method: ASTM D4541
Result: 1000 psi

Corrosion Weathering:
Method: ASTM D5894, 1700 hours, 5 cycles
Result: Rating 9 per ASTM D714 for blistering
Rating 9 per ASTM D610 for rusting

Direct Impact Resistance:
Method: ASTM D2794
Result: 140 in lb

Dry Heat Resistance:
Method: ASTM D2485
Result: 300°F

Flexibility:
Method: ASTM D522, 180° bend, 1/8" mandrel
Result: Passes

Moisture Condensation Resistance:
Method: ASTM D4585, 100°F, 300 hours
Result: Passes

Pencil Hardness: Corothane I MIO-Aluminum only
Method: ASTM D3363
Result: 2B

Salt Fog Resistance:
Method: ASTM B117, 2300 hours
Result: Rating 10 per ASTM D610 for rusting
Rating 10 per ASTM D714 for blistering

Polyurethane 5.10 continued on back

Industrial & Marine Coatings

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COROTHANE® I MIO-ALUMINUM

B65S14

PRODUCT INFORMATION

Recommended Systems

Steel:
1 ct. Corothane I MIO-Aluminum @ 2.0 - 3.0 mils dft/ct
1 ct. Corothane I IronOx B @ 3.0 - 5.0 mils dft
1 ct. Corothane I Aliphatic Finish Coat @ 2.0 - 3.0 mils dft/ct
or Corothane I HS @ 2.0 - 3.0 mils dft
or Corothane I Ironox A HS @ 2.5 - 3.5 mils dft

Steel:
2 cts. Corothane I MIO-Aluminum @ 2.0 - 3.0 mils dft/ct

Steel: (Zinc Primer)
1 ct. Corothane I GalvaPac Zinc Primer @ 3.0 - 4.0 mils dft
2 cts. Corothane I MIO-Aluminum @ 2.0 - 3.0 mils dft/ct

Concrete: (Smooth)
2 cts. Corothane I MIO-Aluminum @ 2.0 - 3.0 mils dft/ct

Concrete: (Rough)
1 ct. Kem Cati-Coat HS Epoxy Filler/Sealer @ 10.0 - 30.0 mils dft/ct, as required to fill voids and provide a continuous substrate.
2 cts. Corothane I MIO-Aluminum @ 2.0 - 3.0 mils dft/ct

Galvanized:
1-2 cts. Corothane I MIO-Aluminum @ 2.0 - 3.0 mils dft/ct (Check Compatibility)

Aluminum:
1-2 cts. Corothane I MIO-Aluminum @ 2.0 - 3.0 mils dft/ct (Check Compatibility)

Previously Painted Surfaces:
1-2 cts. Corothane I MIO-Aluminum @ 2.0 - 3.0 mils dft/ct (Check Compatibility)

The systems listed above are representative of the product's use. Other systems may be appropriate.

Surface Preparation

Surface must be clean, dry, and in sound condition. Remove all oil, dust, grease, dirt, loose rust, and other foreign material to ensure adequate adhesion.

Refer to product Application Bulletin for detailed surface preparation information.

Minimum recommended surface preparation:

Iron & Steel:	SSPC-SP2/3
Concrete:	SSPC-SP13/NACE 6, or ICRI 03732, CSP 1-3
Galvanized:	SSPC-SP1
Aluminum:	SSPC-SP1
Previously Painted	SSPC-SP2 or SP3

Tinting

Do not tint.

Application Conditions

Temperature:	
air and surface:	20°F minimum, 100°F maximum
material:	45°F minimum Do not apply over surface ice
Relative humidity:	Can be applied at relative humidities up to 95%.

Refer to product Application Bulletin for detailed application information.

Ordering Information

Packaging:	1 and 5 gallon containers
Weight per gallon:	10.5 ± 0.2 lb

Safety Precautions

Refer to the MSDS sheet before use.

Published technical data and instructions are subject to change without notice. Contact your Sherwin-Williams representative for additional technical data and instructions.

Disclaimer

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Warranty

The Sherwin-Williams Company warrants our products to be free of manufacturing defects in accord with applicable Sherwin-Williams quality control procedures. Liability for products proven defective, if any, is limited to replacement of the defective product or the refund of the purchase price paid for the defective product as determined by Sherwin-Williams. NO OTHER WARRANTY OR GUARANTEE OF ANY KIND IS MADE BY SHERWIN-WILLIAMS, EXPRESSED OR IMPLIED, STATUTORY, BY OPERATION OF LAW OR OTHERWISE, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

SHERWIN WILLIAMS.

Industrial & Marine Coatings

5.10A
COROTHANE® I MIO-ALUMINUM
B65S14

APPLICATION BULLETIN
Revised 11/06

Surface Preparation

Surface must be clean, dry, and in sound condition. Remove all oil, dust, grease, dirt, loose rust, and other foreign material to ensure adequate adhesion.

Iron & Steel
Remove all oil and grease from surface by Solvent Cleaning per SSPC-SP1. Minimum surface preparation is Hand/ Power Tool per SSPC-SP2/3. For better performance, use Near White Metal Blast Cleaning per SSPC-SP10/ NACE 2. Coat any bare steel the same day as it is cleaned or before flash rusting occurs.

Aluminum
Remove all oil, grease, dirt, oxide and other foreign material by Solvent Cleaning per SSPC-SP1.

Galvanized Steel
Allow to weather a minimum of six months prior to coating. Remove all oil, grease, dirt, oxide and other foreign material by Solvent Cleaning per SSPC-SP1. When weathering is not possible, or the surface has been treated with chromates or silicates, first Solvent Clean per SSPC-SP1 and apply a test patch. Allow paint to dry at least one week before testing adhesion. If adhesion is poor, brush blasting per SSPC-SP7 is necessary to remove these treatments. Rusty galvanizing requires a minimum of Hand Tool Cleaning per SSPC-SP2, prime the area the same day as cleaned.

Poured Concrete
New
For surface preparation, refer to SSPC-SP13/NACE 6, or ICRI 03732, CSP 1-3. Surface must be clean, dry, sound, and offer sufficient profile to achieve adequate adhesion. Minimum substrate cure is 28 days at 75°F. Remove all form release agents, curing compounds, salts, efflorescence, laitance, and other foreign matter by sandblasting, shotblasting, mechanical scarification, or suitable chemical means. Refer to ASTM D4260. Rinse thoroughly to achieve a final pH between 8.0 and 10.0. Allow to dry thoroughly prior to coating.

Old
Surface preparation is done in much the same manner as new concrete; however, if the concrete is contaminated with oils, grease, chemicals, etc., they must be removed by cleaning with a strong detergent. Refer to ASTM D4258. Form release agents, hardeners, etc. must be removed by sandblasting, shotblasting, mechanical scarification, or suitable chemical means. If surface deterioration presents an unacceptably rough surface, Kem Cati-Coat HS Epoxy Filler/Sealer is recommended to patch and resurface damaged concrete.
Fill all cracks, voids and bugholes with ArmorSeal Crack Filler.

Always follow the standard methods listed below:
ASTM D4258 Standard Practice for Cleaning Concrete.
ASTM D4259 Standard Practice for Abrading Concrete.
ASTM D4260 Standard Practice for Etching Concrete.
ASTM F1869 Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete.
SSPC-SP 13/Nace 6 Surface Preparation of Concrete
ICRI 03732 Concrete Surface Preparation

Previously Painted Surfaces
If in sound condition, clean the surface of all foreign material. Smooth, hard or glossy coatings and surfaces should be dulled by abrading the surface. Apply a test area, allowing paint to dry one week before testing adhesion. If adhesion is poor, or if this product attacks the previous finish, removal of the previous coating may be necessary. If paint is peeling or badly weathered, clean surface to sound substrate and treat as a new surface as above.

Application Conditions

Temperature:
- air and surface: 20°F minimum, 100°F maximum
- material: 45°F minimum

Do not apply over surface ice

Relative humidity: Can be applied at relative humidities up to 95%.

Application Equipment

The following is a guide. Changes in pressures and tip sizes may be needed for proper spray characteristics. Always purge spray equipment before use with listed reducer. Any reduction must be compliant with existing VOC regulations and compatible with the existing environmental and application conditions.

Reducer/Clean Up
- Spray .... Reducer #15, R7K15
- Brush and Roll .... Reducer #100, R7K100
- VOC Exempt .... Reducer R7K111

Airless Spray
- Pump 30:1
- Pressure .... 1800 - 2000 psi
- Hose .... 1/4" ID
- Tip .... .015" - .019"
- Filter .... 60 mesh
- Reduction .... As needed up to 10% by volume

Conventional Spray

Unit	Graco	Binks
Gun	900	95
Fluid Nozzle	070	66/65
Air Nozzle	947	66PR
Atomization Press	60-70 psi	60-70 psi
Fluid Pressure	15-20 psi	15-20 psi
Reduction	As needed up to 10% by volume	

Brush
- Brush .... Natural bristle
- Reduction .... As needed up to 10% by volume

Roller
- Cover .... 1/4" natural or synthetic with phenolic core
- Reduction .... As needed up to 10% by volume

If specific application equipment is not listed above, equivalent equipment may be substituted.

continued on back

Industrial & Marine Coatings

5.10A
COROTHANE® I MIO-ALUMINUM
B65S14

APPLICATION BULLETIN

Application Procedures

Surface preparation must be completed as indicated.

Stir material thoroughly prior to use with a power agitator. Filter slowly through a 55 mesh screen.

Apply paint at the recommended film thickness and spreading rate as indicated below:

Recommended Spreading Rate per coat:

Wet mils:	3.0 - 4.5
Dry mils:	2.0 - 3.0
Coverage:	384 - 521 sq ft/gal approximate

Drying Schedule @ 3.5 @ mils wet @ 50% RH:

	@ 40°F	@ 77°F	@ 100°F
To touch:	4 hours	2 hours	1 hour
To recoat			
minimum:	16 hours	7 hours	3 hours
maximum:	30 days	30 days	30 days
To cure:	5 days	3 days	1 day

Drying time is temperature, humidity, and film thickness dependent. Abrade surface if maximum recoat time is exceeded.

Application of coating above maximum or below minimum recommended spreading rate may adversely affect coating performance.

Performance Tips

Stripe coat all crevices, welds, and sharp angles to prevent early failure in these areas.

When using spray application, use a 50% overlap with each pass of the gun to avoid holidays, bare areas, and pinholes. If necessary, cross spray at a right angle.

Spreading rates are calculated on volume solids and do not include an application loss factor due to surface profile, roughness or porosity of the surface, skill and technique of the applicator, method of application, various surface irregularities, material lost during mixing, spillage, overthinning, climatic conditions, and excessive film build.

Excessive reduction of material can affect film build, appearance, and adhesion.

In order to avoid blockage of spray equipment, clean equipment before use or before periods of extended downtime with Reducer #15, R7K15.

Pour a small amount of Reducer #15, R7K15 over the top of the paint in the can to prevent skinning or gelling.

Place a temporary cover over the pail to keep excessive moisture, condensation, fog, or rain from contaminating the coating.

Corothane KA Accelerator is acceptable for use. See data page 5.98 for details.

It is recommended that partially used cans not be sealed/closed for use at a later date.

Refer to Product Information sheet for additional performance characteristics and properties.

Clean Up Instructions

Clean spills and splatters immediately with Reducer #15, R7K15. Clean tools immediately after use with Reducer #15, R7K15. Follow manufacturer's safety recommendations when using any solvent.

Safety Precautions

Refer to the MSDS sheet before use.

Published technical data and instructions are subject to change without notice. Contact your Sherwin-Williams representative for additional technical data and instructions.

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MATERIAL SAFETY DATA SHEET

B65S14
08 00

Section 1 -- PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NUMBER	DATE OF PREPARATION	HMIS CODES	
		Health	3*
B65S14	30-SEP-07	Flammability	2
		Reactivity	1

PRODUCT NAME
COROTHANE® I - Aliphatic Finish Coat, MIO/Aluminum

MANUFACTURER'S NAME
THE SHERWIN-WILLIAMS COMPANY
101 Prospect Avenue N.W.
Cleveland, OH 44115

TELEPHONE NUMBERS and WEBSITES
Product Information
www.sherwin-williams.com
Regulatory Information
(216) 566-2902 www.paintdocs.com
Medical Emergency
(216) 566-2917
Transportation Emergency for Chemical Emergency ONLY (spill, leak,
(800) 424-9300 fire, exposure, or accident)

Section 2 -- COMPOSITION/INFORMATION ON INGREDIENTS

% by WT	CAS No.	INGREDIENT		UNITS	VAPOR PRESSURE
3	64742-88-7	Mineral Spirits			
		ACGIH TLV	100	ppm	2 mm
		OSHA PEL	100	ppm	
0.4	100-41-4	Ethylbenzene			
		ACGIH TLV	100	ppm	7.1 mm
		ACGIH TLV	125	ppm STEL	
		OSHA PEL	100	ppm	
		OSHA PEL	125	ppm STEL	
2	1330-20-7	Xylene			
		ACGIH TLV	100	ppm	5.9 mm
		ACGIH TLV	150	ppm STEL	
		OSHA PEL	100	ppm	
		OSHA PEL	150	ppm STEL	
3	64742-95-6	Light Aromatic Hydrocarbons			
		ACGIH TLV	Not Available		3.8 mm
		OSHA PEL	Not Available		
4	108-67-8	1,3,5-Trimethylbenzene			
		ACGIH TLV	25	ppm	2 mm
		OSHA PEL	25	ppm	
6	95-63-6	1,2,4-Trimethylbenzene			
		ACGIH TLV	25	ppm	2.03 mm
		OSHA PEL	25	ppm	
2	64742-94-5	Medium Aromatic Hydrocarbons			
		ACGIH TLV	Not Available		0.12 mm
		OSHA PEL	Not Available		

Continued on page 2

0.4	91-20-3	Naphthalene				
		ACGIH TLV	10	ppm		1 mm
		ACGIH TLV	15	ppm STEL		
		OSHA PEL	10	ppm		
		OSHA PEL	15	ppm STEL		
1	110-43-0	Methyl n-Amyl Ketone				
		ACGIH TLV	50	ppm		3.855 mm
		OSHA PEL	100	ppm		
3	101-68-8	4, 4'-Diphenylmethane Diisocyanate				
		ACGIH TLV	0.005	ppm		
		OSHA PEL	0.02	ppm CEILING		
3	26447-40-5	Diphenylmethane Diisocyanate				
		ACGIH TLV	Not Available			
		OSHA PEL	Not Available			
20	9016-87-9	Diphenylmethane Diisocyanate Polymer				
		ACGIH TLV	Not Available			
		OSHA PEL	Not Available			
14	Proprietary	Toluene Diisocyanate Polymer				
		ACGIH TLV	Not Available			
		OSHA PEL	Not Available			
9	14807-96-6	Talc				
		ACGIH TLV	2	mg/m3 as Resp. Dust		
		OSHA PEL	2	mg/m3 as Resp. Dust		

Section 3 -- HAZARDS IDENTIFICATION

ROUTES OF EXPOSURE
INHALATION of vapor or spray mist.
EYE or SKIN contact with the product, vapor or spray mist.
EFFECTS OF OVEREXPOSURE
EYES: Irritation.
SKIN: Prolonged or repeated exposure may cause irritation.
INHALATION: Irritation of the upper respiratory system.
May cause nervous system depression. Extreme overexposure may result in unconsciousness and possibly death.
Prolonged overexposure to solvent ingredients in Section 2 may cause adverse effects to the liver, urinary and reproductive systems.
SIGNS AND SYMPTOMS OF OVEREXPOSURE
Headache, dizziness, nausea, and loss of coordination are indications of excessive exposure to vapors or spray mists.
Redness and itching or burning sensation may indicate eye or excessive skin exposure.
MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE
May cause allergic respiratory and/or skin reaction in susceptible persons or sensitization. This effect may be delayed several hours after exposure.
Persons sensitive to isocyanates will experience increased allergic reaction on repeated exposure.
CANCER INFORMATION
For complete discussion of toxicology data refer to Section 11.

Section 4 -- FIRST AID MEASURES

EYES:	Flush eyes with large amounts of water for 15 minutes. Get medical attention.
SKIN:	Wash affected area thoroughly with soap and water. Remove contaminated clothing and launder before re-use.
INHALATION:	If any breathing problems occur during use, LEAVE THE AREA and get fresh air. If problems remain or occur later, IMMEDIATELY get medical attention.
INGESTION:	Do not induce vomiting. Get medical attention immediately.

Section 5 -- FIRE FIGHTING MEASURES

FLASH POINT	LEL	UEL
105 F PMCC	0.7	7.9

FLAMMABILITY CLASSIFICATION
Combustible, Flash above 99 and below 200 F
EXTINGUISHING MEDIA
Carbon Dioxide, Dry Chemical, Foam
UNUSUAL FIRE AND EXPLOSION HAZARDS
Closed containers may explode when exposed to extreme heat.
Application to hot surfaces requires special precautions.
During emergency conditions overexposure to decomposition products may cause a health hazard. Symptoms may not be immediately apparent. Obtain medical attention.
SPECIAL FIRE FIGHTING PROCEDURES
Full protective equipment including self-contained breathing apparatus should be used.
Water spray may be ineffective. If water is used, fog nozzles are preferable. Water may be used to cool closed containers to prevent pressure build-up and possible autoignition or explosion when exposed to extreme heat.

Section 6 -- ACCIDENTAL RELEASE MEASURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
Remove all sources of ignition. Ventilate the area.
All personnel in the area should be protected as in Section 8.
Cover spill with absorbent material. Deactivate spilled material with a 10% ammonium hydroxide solution (household ammonia). After 10 minutes, collect in open containers and add more ammonia. Cover loosely. Wash spill area with soap and water.

Section 7 -- HANDLING AND STORAGE

STORAGE CATEGORY
DOL Storage Class II
PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE
Contents are COMBUSTIBLE. Keep away from heat and open flame.
Consult NFPA Code. Use approved Bonding and Grounding procedures.
Keep container closed when not in use. Transfer only to approved containers with complete and appropriate labeling. Do not take internally. Keep out of the reach of children.

Continued on page 4

Section 8 -- EXPOSURE CONTROLS/PERSONAL PROTECTION

PRECAUTIONS TO BE TAKEN IN USE

NO PERSON SHOULD USE THIS PRODUCT, OR BE IN THE AREA WHERE IT IS BEING USED, IF THEY HAVE CHRONIC (LONG-TERM) LUNG OR BREATHING PROBLEMS OR IF THEY EVER HAD A REACTION TO ISOCYANATES.

Use only with adequate ventilation.

Avoid contact with skin and eyes. Avoid breathing vapor and spray mist.

Wash hands after using.

This coating may contain materials classified as nuisance particulates (listed "as Dust" in Section 2) which may be present at hazardous levels only during sanding or abrading of the dried film. If no specific dusts are listed in Section 2, the applicable limits for nuisance dusts are ACGIH TLV 10 mg/m3 (total dust), 3 mg/m3 (respirable fraction), OSHA PEL 15 mg/m3 (total dust), 5 mg/m3 (respirable fraction).

VENTILATION

Local exhaust preferable. General exhaust acceptable if the exposure to materials in Section 2 is maintained below applicable exposure limits. Refer to OSHA Standards 1910.94, 1910.107, 1910.108.

RESPIRATORY PROTECTION

Where overspray is present, a positive pressure air supplied respirator (TC19C NIOSH/MSHA approved) should be worn. If unavailable, a properly fitted organic vapor/particulate respirator approved by NIOSH/MSHA for protection against materials in Section 2 may be effective. Follow respirator manufacturer's directions for use. Wear the respirator for the whole time of spraying and until all vapors and mists are gone. NO PERSONS SHOULD BE ALLOWED IN THE AREA WHERE THIS PRODUCT IS BEING USED UNLESS EQUIPPED WITH THE SAME RESPIRATOR PROTECTION RECOMMENDED FOR THE PAINTERS.

When sanding or abrading the dried film, wear a dust/mist respirator approved by NIOSH/MSHA for dust which may be generated from this product, underlying paint, or the abrasive.

PROTECTIVE GLOVES

To prevent skin contact, wear gloves which are recommended by glove supplier for protection against materials in Section 2.

EYE PROTECTION

Wear safety spectacles with unperforated sideshields.

OTHER PROTECTIVE EQUIPMENT

Use barrier cream on exposed skin.

OTHER PRECAUTIONS

Intentional misuse by deliberately concentrating and inhaling the contents can be harmful or fatal.

Section 9 -- PHYSICAL AND CHEMICAL PROPERTIES

PRODUCT WEIGHT	10.54 lb/gal	1263 g/l
SPECIFIC GRAVITY	1.27	
BOILING POINT	281 - 415 F	138 - 212 C
MELTING POINT	Not Available	
VOLATILE VOLUME	34 %	
EVAPORATION RATE	Slower than ether	
VAPOR DENSITY	Heavier than air	
SOLUBILITY IN WATER	N.A.	

Continued on page 5

VOLATILE ORGANIC COMPOUNDS (VOC Theoretical - As Packaged)
2.45 lb/gal 294 g/l Less Water and Federally Exempt Solvents
2.45 lb/gal 294 g/l Emitted VOC

Section 10 -- STABILITY AND REACTIVITY

STABILITY -- Stable
CONDITIONS TO AVOID
None known.
INCOMPATIBILITY
Contamination with Water, Alcohols, Amines and other compounds which react with isocyanates, may result in dangerous pressure in, and possible bursting of, closed containers.
HAZARDOUS DECOMPOSITION PRODUCTS
By fire: Carbon Dioxide, Carbon Monoxide, Oxides of Nitrogen, possibility of Hydrogen Cyanide
HAZARDOUS POLYMERIZATION
Will not occur

Section 11 -- TOXICOLOGICAL INFORMATION

CHRONIC HEALTH HAZARDS
Reports have associated repeated and prolonged overexposure to solvents with permanent brain and nervous system damage.
Ethylbenzene is classified by IARC as possibly carcinogenic to humans (2B) based on inadequate evidence in humans and sufficient evidence in laboratory animals. Lifetime inhalation exposure of rats and mice to high ethylbenzene concentrations resulted in increases in certain types of cancer, including kidney tumors in rats and lung and liver tumors in mice. These effects were not observed in animals exposed to lower concentrations. There is no evidence that ethylbenzene causes cancer in humans.

TOXICOLOGY DATA

CAS No.	Ingredient Name				
64742-88-7	Mineral Spirits				
		LC50	RAT	4HR	Not Available
		LD50	RAT		Not Available
100-41-4	Ethylbenzene				
		LC50	RAT	4HR	Not Available
		LD50	RAT		3500 mg/kg
1330-20-7	Xylene				
		LC50	RAT	4HR	5000 ppm
		LD50	RAT		4300 mg/kg
64742-95-6	Light Aromatic Hydrocarbons				
		LC50	RAT	4HR	Not Available
		LD50	RAT		Not Available
108-67-8	1,3,5-Trimethylbenzene				
		LC50	RAT	4HR	Not Available
		LD50	RAT		Not Available
95-63-6	1,2,4-Trimethylbenzene				
		LC50	RAT	4HR	Not Available
		LD50	RAT		Not Available
64742-94-5	Medium Aromatic Hydrocarbons				
		LC50	RAT	4HR	Not Available
		LD50	RAT		Not Available
91-20-3	Naphthalene				
		LC50	RAT	4HR	Not Available
		LD50	RAT		Not Available
110-43-0	Methyl n-Amyl Ketone				
		LC50	RAT	4HR	Not Available
		LD50	RAT		1670 mg/kg
101-68-8	4, 4'-Diphenylmethane Diisocyanate				
		LC50	RAT	4HR	Not Available
		LD50	RAT		Not Available
26447-40-5	Diphenylmethane Diisocyanate				
		LC50	RAT	4HR	Not Available
		LD50	RAT		Not Available
9016-87-9	Diphenylmethane Diisocyanate Polym				
		LC50	RAT	4HR	Not Available
		LD50	RAT		Not Available
Proprietary	Toluene Diisocyanate Polymer				
		LC50	RAT	4HR	Not Available
		LD50	RAT		Not Available
14807-96-6	Talc				
		LC50	RAT	4HR	Not Available
		LD50	RAT		Not Available

Section 12 -- ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL INFORMATION
No data available.

Section 13 -- DISPOSAL CONSIDERATIONS

WASTE DISPOSAL METHOD
Waste from this product may be hazardous as defined under the Resource Conservation and Recovery Act (RCRA) 40 CFR 261.
Waste must be tested for ignitability to determine the applicable EPA hazardous waste numbers.
Incinerate in approved facility. Do not incinerate closed container. Dispose of in accordance with Federal, State/Provincial, and Local regulations regarding pollution.

Section 14 -- TRANSPORT INFORMATION

US Ground (DOT)
May be Classed as a Combustible Liquid for U.S. Ground.
UN1263, PAINT, 3, PG III, (ERG#128)

DOT (Dept of Transportation) Hazardous Substances & Reportable Quantities
Naphthalene 100 lb RQ
Xylenes (isomers and mixture) 100 lb RQ

Bulk Containers may be Shipped as (check reportable quantities):
UN1263, PAINT, COMBUSTIBLE LIQUID, PG III, (ERG#128)

Canada (TDG)
May be Classed as a Combustible Liquid for Canadian Ground.
UN1263, PAINT, CLASS 3, PG III, (ERG#128)

IMO
UN1263, PAINT, CLASS 3, PG III, (41 C c.c.), EmS F-E, S-E

Section 15 -- REGULATORY INFORMATION

SARA 313 (40 CFR 372.65C) SUPPLIER NOTIFICATION

CAS No.	CHEMICAL/COMPOUND	% by WT	% Element
100-41-4	Ethylbenzene	0.3	
1330-20-7	Xylene	2	
95-63-6	1,2,4-Trimethylbenzene	6	
91-20-3	Naphthalene	0.3	
101-68-8	4, 4'-Diphenylmethane Diisocyanate	3	
9016-87-9	Diphenylmethane Diisocyanate Polymer	20	

CALIFORNIA PROPOSITION 65
WARNING: This product contains chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.
TSCA CERTIFICATION
All chemicals in this product are listed, or are exempt from listing, on the TSCA Inventory.

Section 16 -- OTHER INFORMATION

This product has been classified in accordance with the hazard criteria of the Canadian Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

Technical data for Sherwin-Williams Corothane I Topcoat

SHERWIN WILLIAMS.

Industrial & Marine Coatings

5.05

COROTHANE® I ALIPHATIC FINISH COAT

B65-10 Series

PRODUCT INFORMATION

Revised 11/05

Product Description

COROTHANE I ALIPHATIC FINISH COAT is a single component, VOC compliant, moisture curing urethane designed for low temperature or high humidity applications while providing UV resistance and chemical resistance equivalent to two part urethane coatings.

- Low temperature application - down to 20°F
- Excellent resistance to yellowing, chalking, or degradation by sunlight
- Excellent adhesion to most surfaces
- Superior abrasion resistance
- Excellent adhesion directly to clean concrete
- Outstanding chemical resistance

Recommended Uses

- Color coat for where maximum color and gloss retention are required
- Chemical resistant coating for metallized surfaces and tanks
- Chemical resistant floor coating
- Marine applications
- Suitable for use in USDA inspected facilities
- Conforms to AWWA D102-03 OCS #2

Product Characteristics

Finish: Gloss

Color: Wide range of colors available

Volume Solids: 52% ± 2%, may vary by color

VOC (calculated): <420 g/L; 3.5 lb/gal

Recommended Spreading Rate per coat:

Wet mils: 4.0 - 6.0
Dry mils: 2.0 - 3.0
Coverage: 278 - 417 sq ft/gal approximate

Drying Schedule @ 4.0 mils wet @ 50% RH:

	@40°F	@77°F	@100°F
To touch:	4 hours	1 hour	40 minutes
To recoat			
minimum:	18 hours	4 hours	4 hours
maximum	30 days	14 days	14 days
To cure:	8 days	3 days	3 days

Drying time is temperature, humidity, and film thickness dependent.

Shelf Life: 12 months, unopened
Store indoors at 40°F to 100°F.
(Tinted colors must be used within 7 days after tinting)

Flash Point: >93°F, PMCC

Reducer/Clean Up: Reducer #15, R7K15
Reducer 100, R7K100

Performance Characteristics

System Tested: (unless otherwise indicated)
Substrate: Steel
Surface Preparation: SSPC-SP6
1 ct. Corothane I GalvaPac Zinc Primer @ 3.0 mils dft
1 ct. Corothane I Aliphatic @ 2.0 mils dft

Abrasion Resistance:
Method: ASTM D4060, CS17 wheel, 1000 cycles, 1 kg load
Result: 24 mg loss

Adhesion:
Method: ASTM D4541
Result: 946 psi

Corrosion Weathering: (Zinc Primer/Mastic/Aliphatic Finish)
Method: ASTM D5894, 3024 hours, 9 cycles
Result: Rating 10 per ASTM D714 for blistering
Rating 9 per ASTM D610 for rusting

Direct Impact Resistance:
Method: ASTM D2794
Result: 160 in. lbs.

Dry Heat Resistance:
Method: ASTM D2485
Result: 280°F

Flexibility:
Method: ASTM D522, 180° bend, 1/8" mandrel
Result: Passes

Moisture Condensation Resistance:
Method: ASTM D4585, 100°F, 1000 hours
Result: Passes

Pencil Hardness:
Method: ASTM D3363
Result: 2H

Salt Fog Resistance: (Zinc Primer/Mastic/Aliphatic Finish)
Method: ASTM B117, 3000 hours
Result: Rating 10 per ASTM D714 for blistering
Rating 9 per ASTM D610 for rusting

Wet Heat Resistance:
Method: Non-immersion
Result: 180°F

Meets requirements of SSPC Paint 38, Level II.

Polyurethane 5.05

continued on back

Industrial & Marine Coatings

SHERWIN WILLIAMS.

5.05 COROTHANE® I ALIPHATIC FINISH COAT

B65-10 SERIES

PRODUCT INFORMATION

RECOMMENDED SYSTEMS

Steel:
1 ct. Corothane I GalvaPac Zinc Primer @ 3.0 - 4.0 mils dft
1-2 cts. Corothane I Aliphatic Finish Coat @ 2.0 - 3.0 mils dft/ct

Steel:
1 ct. Corothane I GalvaPac Zinc Primer @ 3.0 - 4.0 mils dft
1 ct. Corothane I Ironox B @ 3.0 - 5.0 mils dft
1 ct. Corothane I Aliphatic Finish Coat @ 2.0 - 3.0 mils dft

Steel:
1 ct. Corothane I PrePrime @ 1.0 - 1.5 mils dft
1 ct. Corothane I MIO-Aluminum @ 2.0 - 3.0 mils dft
1 ct. Corothane I Ironox B @ 3.0 - 5.0 mils dft
1 ct. Corothane I Aliphatic Finish Coat @ 2.0 - 3.0 mils dft

Steel (Epoxy Primer):
1 ct Dura-Plate MT @6.0 - 8.0 mils dft
1-2 cts Corothane I Aliphatic Finish Coat @ 2.0 - 3.0 dft/ct

Concrete, smooth:
1 ct. Corothane I PrePrime @ 1.0 - 1.5 mils dft
1 ct. Corothane I Aliphatic Finish Coat @ 2.0 - 3.0 mils dft

Concrete, smooth:
2 cts. Corothane I Aliphatic Finish Coat @ 2.0 - 3.0 mils dft/ct

Concrete Floors, rough:
On deeply profiled or damaged concrete floor:
1 ct. Kem Cati-Coat HS Epoxy Filler/Sealer @ 10.0 - 30.0 mils dft/ct, as required to fill voids and provide a continuous substrate.
1-2 cts. Corothane I Aliphatic Finish Coat @ 2.0 - 3.0 mils dft/ct

Previously Painted Surfaces:
Spot prime bare steel with 1 coat of Corothane I GalvaPac Zinc Primer
2 cts. Corothane I Aliphatic Finish Coat @ 2.0 - 3.0 mils dft/ct
or
1 ct. Corothane I Ironox B @ 3.0 - 5.0 mils dft
1 ct. Corothane I Aliphatic Finish Coat @ 2.0 - 3.0 mils dft
(Check compatibility)

The systems listed above are representative of the product's use. Other systems may be appropriate.

SURFACE PREPARATION

Surface must be clean, dry, and in sound condition. Remove all oil, dust, grease, dirt, loose rust, and other foreign material to ensure adequate adhesion.

Refer to product Application Bulletin for detailed surface preparation information.

Minimum recommended surface preparation:

* Iron & Steel:	SSPC-SP6/NACE 3
Concrete:	SSPC-SP13/NACE 6, or ICRI 03732, CSP 1-3
Previously Painted	SSPC-SP2 or SP3

* Primer required

TINTING

Tint B65W16 and B65T14 only with 844 colorants, 100% tint strength. Must be used within 7 days after tinting.

APPLICATION CONDITIONS

Temperature:

air and surface:	20°F minimum, 100°F maximum
material:	45°F minimum
	Do not apply over surface ice
Relative humidity:	Can be applied at relative humidities up to 99%.

Refer to product Application Bulletin for detailed application information.

ORDERING INFORMATION

Packaging:	1 and 5 gallon containers
Weight per gallon:	9.0 to 11.0 ± 0.2 lb may vary by color

SAFETY PRECAUTIONS

Refer to the MSDS sheet before use.

Published technical data and instructions are subject to change without notice. Contact your Sherwin-Williams representative for additional technical data and instructions.

DISCLAIMER

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WARRANTY

The Sherwin-Williams Company warrants our products to be free of manufacturing defects in accord with applicable Sherwin-Williams quality control procedures. Liability for products proven defective, if any, is limited to replacement of the defective product or the refund of the purchase price paid for the defective product as determined by Sherwin-Williams. NO OTHER WARRANTY OR GUARANTEE OF ANY KIND IS MADE BY SHERWIN-WILLIAMS, EXPRESSED OR IMPLIED, STATUTORY, BY OPERATION OF LAW OR OTHERWISE, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

Industrial & Marine Coatings

SHERWIN WILLIAMS.

5.05A

COROTHANE® I ALIPHATIC FINISH COAT

B65-10 SERIES

APPLICATION BULLETIN

Revised 11/05

SURFACE PREPARATION

Surface must be clean, dry, and in sound condition. Remove all oil, dust, grease, dirt, loose rust, and other foreign material to ensure adequate adhesion.

Iron & Steel
Remove all oil and grease from surface by Solvent Cleaning per SSPC-SP1. Minimum surface preparation is Commercial Blast Cleaning per SSPC-SP6/NACE 3. For better performance, use Near White Metal Blast Cleaning per SSPC-SP10/NACE 2. Blast clean all surfaces using a sharp, angular abrasive for optimum surface profile (2 mils). Prime any bare steel the same day as it is cleaned.

Poured Concrete

New
For surface preparation, refer to SSPC-SP13/NACE 6 or ICRI 03732, CSP 1-3. Surface must be clean, dry, sound, and offer sufficient profile to achieve adequate adhesion. Minimum substrate cure is 28 days at 75°F. Remove all form release agents, curing compounds, salts, efflorescence, laitance, and other foreign matter by sandblasting, shotblasting, mechanical scarification, or suitable chemical means. Refer to ASTM D4260. Rinse thoroughly to achieve a final pH between 8.0 and 10.0. Allow to dry thoroughly prior to coating.

Old
Surface preparation is done in much the same manner as new concrete; however, if the concrete is contaminated with oils, grease, chemicals, etc., they must be removed by cleaning with a strong detergent. Refer to ASTM D4258. Form release agents, hardeners, etc. must be removed by sandblasting, shotblasting, mechanical scarification, or suitable chemical means. If surface deterioration presents an unacceptably rough surface, Kem Cati-Coat HS Epoxy Filler/Sealer is recommended to patch and resurface damaged concrete.
Fill all cracks, voids and bugholes with ArmorSeal Crack Filler.

Always follow the industry standards listed below:
ASTM D4258 Standard Practice for Cleaning Concrete.
ASTM D4259 Standard Practice for Abrading Concrete.
ASTM D4260 Standard Practice for Etching Concrete.
ASTM F1869 Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete.
SSPC-SP13/NACE 6 Surface Preparation of Concrete
ICRI 03732 Concrete Surface Preparation

Previously Painted Surfaces
If in sound condition, clean the surface of all foreign material. Smooth, hard or glossy coatings and surfaces should be dulled by abrading the surface. Apply a test area, allowing paint to dry one week before testing adhesion. If adhesion is poor, or if this product attacks the previous finish, removal of the previous coating may be necessary. If paint is peeling or badly weathered, clean surface to sound substrate and treat as a new surface as above.

APPLICATION CONDITIONS

Temperature:
air and surface: 20°F minimum, 100°F maximum
material: 45°F minimum
Do not apply over surface ice

Relative humidity: Can be applied at relative humidities up to 99%.

APPLICATION EQUIPMENT

The following is a guide. Changes in pressures and tip sizes may be needed for proper spray characteristics. Always purge spray equipment before use with listed reducer. Any reduction must be compliant with existing VOC regulations and compatible with the existing environmental and application conditions.

Reducer/Clean Up .... Reducer #15, R7K15 (Spray)
Reducer #100, R7K100 (Brush and Roller)

Airless Spray
Pump 30:1
Pressure .... 1800 - 2000 psi
Hose .... 1/4" ID
Tip .... .011" - .015"
Filter .... 60 mesh
Reduction .... Reducer R7K15, as needed up to 10% by volume

Conventional Spray

Unit	Graco	Binks
Gun	900	95
Fluid Nozzle	070	66/65
Air Nozzle	947	66PR
Atomization Pressure	60-70 psi	60-70 psi
Fluid Pressure	15-20 psi	15-20 psi
Reduction	Reducer R7K15, as needed up to 10% by volume	

Brush
Brush .... Natural bristle
Reduction .... Reducer R7K100 as needed up to 10% by volume

Roller
Cover .... 1/4" natural or synthetic with phenolic core
Reduction .... Reducer R7K100 as needed up to 10% by volume

If specific application equipment is not listed above, equivalent equipment may be substituted.

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Industrial
&
Marine
Coatings

5.05A
COROTHANE® I ALIPHATIC FINISH COAT
B65-10 SERIES

APPLICATION BULLETIN

APPLICATION PROCEDURES

Surface preparation must be completed as indicated.

Stir paint thoroughly prior to use with a power agitator. Filter slowly through a 55 mesh screen.

Apply paint at the recommended film thickness and spreading rate as indicated below:

Recommended Spreading Rate per coat:

Wet mils:	4.0 - 6.0
Dry mils:	2.0 - 3.0
Coverage:	278 - 417 sq ft/gal approximate

Drying Schedule @ 4.0 mils wet @ 50% RH:

	@40°F	@77°F	@100°F
To touch:	4 hours	1 hour	40 minutes
To recoat			
minimum:	18 hours	4 hours	4 hours
maximum	30 days	14 days	14 days
To cure:	8 days	3 days	3 days

Drying time is temperature, humidity, and film thickness dependent.

Application of coating above maximum or below minimum recommended spreading rate may adversely affect coating performance.

PERFORMANCE TIPS

Stripe coat all crevices, welds, and sharp angles to prevent early failure in these areas.

When using spray application, use a 50% overlap with each pass of the gun to avoid holidays, bare areas, and pinholes. If necessary, cross spray at a right angle.

Spreading rates are calculated on volume solids and do not include an application loss factor due to surface profile, roughness or porosity of the surface, skill and technique of the applicator, method of application, various surface irregularities, material lost during mixing, spillage, overthinning, climatic conditions, and excessive film build.

Excessive reduction of material can affect film build, appearance, and adhesion.

In order to avoid blockage of spray equipment, clean equipment before use or before periods of extended downtime with Reducer #15, R7K15.

Pour a small amount of Reducer #15, R7K15 over the top of the paint in the can to prevent skinning or gelling.

Place a temporary cover over the pail to keep excessive moisture, condensation, fog, or rain from contaminating the coating.

When applying White or light colors of Corothane I - Aliphatic over dark colors or porous surfaces, a minimum of 2 coats is required for adequate hide.

Tinted colors must be used within 7 days after tinting.

Corothane KA Accelerator is acceptable for use. See data page 5.98 for details.

E-Z Roll Urethane Defoamer is acceptable for use. See data page 5.99 for details.

It is recommend that partially used cans not be sealed/closed for use at a later date.

Refer to Product Information sheet for additional performance characteristics and properties.

CLEAN UP INSTRUCTIONS

Clean spills and spatters immediately with Reducer #15, R7K15. Clean tools immediately after use with Reducer #15, R7K15. Follow manufacturer's safety recommendations when using any solvent.

SAFETY PRECAUTIONS

Refer to the MSDS sheet before use.

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MATERIAL SAFETY DATA SHEET

B65W15
17 00

Section 1 -- PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NUMBER	DATE OF PREPARATION	HMIS CODES	
		Health	3*
B65W15	30-SEP-07	Flammability	3
		Reactivity	2

PRODUCT NAME
COROTHANE® I-ALIPHATIC Moisture Cure Urethane, White

MANUFACTURER'S NAME
THE SHERWIN-WILLIAMS COMPANY
101 Prospect Avenue N.W.
Cleveland, OH 44115

TELEPHONE NUMBERS and WEBSITES
Product Information
www.sherwin-williams.com
Regulatory Information
(216) 566-2902
www.paintdocs.com
Medical Emergency
(216) 566-2917
Transportation Emergency
(800) 424-9300
for Chemical Emergency ONLY (spill, leak, fire, exposure, or accident)

Section 2 -- COMPOSITION/INFORMATION ON INGREDIENTS

% by WT	CAS No.	INGREDIENT		UNITS	VAPOR PRESSURE
0.7	100-41-4	Ethylbenzene			
		ACGIH TLV	100	ppm	7.1 mm
		ACGIH TLV	125	ppm STEL	
		OSHA PEL	100	ppm	
		OSHA PEL	125	ppm STEL	
4	1330-20-7	Xylene			
		ACGIH TLV	100	ppm	5.9 mm
		ACGIH TLV	150	ppm STEL	
		OSHA PEL	100	ppm	
		OSHA PEL	150	ppm STEL	
2	64742-94-5	Medium Aromatic Hydrocarbons			
		ACGIH TLV	Not Available		0.12 mm
		OSHA PEL	Not Available		
0.3	91-20-3	Naphthalene			
		ACGIH TLV	10	ppm	1 mm
		ACGIH TLV	15	ppm STEL	
		OSHA PEL	10	ppm	
		OSHA PEL	15	ppm STEL	
9	110-43-0	Methyl n-Amyl Ketone			
		ACGIH TLV	50	ppm	3.855 mm
		OSHA PEL	100	ppm	
1	108-94-1	Cyclohexanone			
		ACGIH TLV	25	ppm (Skin)	2 mm
		OSHA PEL	25	ppm (Skin)	

Continued on page 2

4	763-69-9	Ethyl 3-Ethoxypropionate		
		ACGIH TLV	Not Available	1.11 mm
		OSHA PEL	Not Available	
0.1	822-06-0	Hexamethylene Diisocyanate (max.)		
		ACGIH TLV	0.005 ppm	0.05 mm
		OSHA PEL	Not Available	
3	4083-64-1	p-Toluenesulfonyl Isocyanate		
		ACGIH TLV	Not Available	
		OSHA PEL	Not Available	
28	28182-81-2	Hexamethylene Diisocyanate Polymer		
		ACGIH TLV	Not Available	
		OSHA PEL	Not Available	
5	14808-60-7	Quartz		
		ACGIH TLV	0.05 mg/m3 as Resp. Dust	
		OSHA PEL	0.1 mg/m3 as Resp. Dust	
4	14807-96-6	Talc		
		ACGIH TLV	2 mg/m3 as Resp. Dust	
		OSHA PEL	2 mg/m3 as Resp. Dust	
25	13463-67-7	Titanium Dioxide		
		ACGIH TLV	10 mg/m3 as Dust	
		OSHA PEL	10 mg/m3 Total Dust	
		OSHA PEL	5 mg/m3 Respirable Fraction	

Section 3 -- HAZARDS IDENTIFICATION

ROUTES OF EXPOSURE

INHALATION of vapor or spray mist.

EYE or SKIN contact with the product, vapor or spray mist.

EFFECTS OF OVEREXPOSURE

EYES: Irritation.

SKIN: Prolonged or repeated exposure may cause irritation.

INHALATION: Irritation of the upper respiratory system.

May cause nervous system depression. Extreme overexposure may result in unconsciousness and possibly death.

Prolonged overexposure to solvent ingredients in Section 2 may cause adverse effects to the liver, urinary and reproductive systems.

SIGNS AND SYMPTOMS OF OVEREXPOSURE

Headache, dizziness, nausea, and loss of coordination are indications of excessive exposure to vapors or spray mists.

Redness and itching or burning sensation may indicate eye or excessive skin exposure.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE

May cause allergic respiratory and/or skin reaction in susceptible persons or sensitization. This effect may be delayed several hours after exposure.

Persons sensitive to isocyanates will experience increased allergic reaction on repeated exposure.

CANCER INFORMATION

For complete discussion of toxicology data refer to Section 11.

Section 4 -- FIRST AID MEASURES

```
       EYES:  Flush eyes with large amounts of water for 15 minutes.
              Get medical attention.
       SKIN:  Wash affected area thoroughly with soap and water.
              Remove contaminated clothing and launder before re-use.
 INHALATION:  If any breathing problems occur during use, LEAVE THE
              AREA and get fresh air. If problems remain or occur
              later, IMMEDIATELY get medical attention.
  INGESTION:  Do not induce vomiting.
              Get medical attention immediately.
```

Section 5 -- FIRE FIGHTING MEASURES

```
FLASH POINT                         LEL      UEL
    93 F PMCC                       0.8      8.1
FLAMMABILITY CLASSIFICATION
   RED LABEL -- Flammable, Flash below 100 F (38 C)
EXTINGUISHING MEDIA
   Carbon Dioxide, Dry Chemical, Foam
UNUSUAL FIRE AND EXPLOSION HAZARDS
   Closed containers may explode when exposed to extreme heat.
   Application to hot surfaces requires special precautions.
   During emergency conditions overexposure to decomposition products may
cause a health hazard.  Symptoms may not be immediately apparent.  Obtain
medical attention.
SPECIAL FIRE FIGHTING PROCEDURES
   Full protective equipment including self-contained breathing apparatus
should be used.
   Water spray may be ineffective.  If water is used, fog nozzles are
preferable.  Water may be used to cool closed containers to prevent
pressure build-up and possible autoignition or explosion when exposed to
extreme heat.
```

Section 6 -- ACCIDENTAL RELEASE MEASURES

```
STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
   Remove all sources of ignition.  Ventilate the area.
   All personnel in the area should be protected as in Section 8.
   Cover spill with absorbent material.  Deactivate spilled material with a
10% ammonium hydroxide solution (household ammonia).  After 10 minutes,
collect in open containers and add more ammonia.  Cover loosely.  Wash
spill area with soap and water.
```

Section 7 -- HANDLING AND STORAGE

```
STORAGE CATEGORY
   DOL Storage Class IC
```

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE

Contents are FLAMMABLE. Keep away from heat, sparks, and open flame.

During use and until all vapors are gone: Keep area ventilated - Do not smoke - Extinguish all flames, pilot lights, and heaters - Turn off stoves, electric tools and appliances, and any other sources of ignition.

Consult NFPA Code. Use approved Bonding and Grounding procedures.

Keep container closed when not in use. Transfer only to approved containers with complete and appropriate labeling. Do not take internally. Keep out of the reach of children.

Section 8 -- EXPOSURE CONTROLS/PERSONAL PROTECTION

PRECAUTIONS TO BE TAKEN IN USE

NO PERSON SHOULD USE THIS PRODUCT, OR BE IN THE AREA WHERE IT IS BEING USED, IF THEY HAVE CHRONIC (LONG-TERM) LUNG OR BREATHING PROBLEMS OR IF THEY EVER HAD A REACTION TO ISOCYANATES.

Use only with adequate ventilation.

Avoid contact with skin and eyes. Avoid breathing vapor and spray mist.

Wash hands after using.

This coating may contain materials classified as nuisance particulates (listed "as Dust" in Section 2) which may be present at hazardous levels only during sanding or abrading of the dried film. If no specific dusts are listed in Section 2, the applicable limits for nuisance dusts are ACGIH TLV 10 mg/m3 (total dust), 3 mg/m3 (respirable fraction), OSHA PEL 15 mg/m3 (total dust), 5 mg/m3 (respirable fraction).

VENTILATION

Local exhaust preferable. General exhaust acceptable if the exposure to materials in Section 2 is maintained below applicable exposure limits. Refer to OSHA Standards 1910.94, 1910.107, 1910.108.

RESPIRATORY PROTECTION

Where overspray is present, a positive pressure air supplied respirator (TC19C NIOSH/MSHA approved) should be worn. If unavailable, a properly fitted organic vapor/particulate respirator approved by NIOSH/MSHA for protection against materials in Section 2 may be effective. Follow respirator manufacturer's directions for use. Wear the respirator for the whole time of spraying and until all vapors and mists are gone. NO PERSONS SHOULD BE ALLOWED IN THE AREA WHERE THIS PRODUCT IS BEING USED UNLESS EQUIPPED WITH THE SAME RESPIRATOR PROTECTION RECOMMENDED FOR THE PAINTERS.

When sanding or abrading the dried film, wear a dust/mist respirator approved by NIOSH/MSHA for dust which may be generated from this product, underlying paint, or the abrasive.

PROTECTIVE GLOVES

To prevent skin contact, wear gloves which are recommended by glove supplier for protection against materials in Section 2.

EYE PROTECTION

Wear safety spectacles with unperforated sideshields.

OTHER PROTECTIVE EQUIPMENT

Use barrier cream on exposed skin.

OTHER PRECAUTIONS

Intentional misuse by deliberately concentrating and inhaling the contents can be harmful or fatal.

Section 9 -- PHYSICAL AND CHEMICAL PROPERTIES

PRODUCT WEIGHT	11.22 lb/gal 1343 g/l
SPECIFIC GRAVITY	1.35
BOILING POINT	281 - 415 F 138 - 212 C
MELTING POINT	Not Available
VOLATILE VOLUME	40 %
EVAPORATION RATE	Slower than ether
VAPOR DENSITY	Heavier than air
SOLUBILITY IN WATER	N.A.
VOLATILE ORGANIC COMPOUNDS	(VOC Theoretical - As Packaged)
2.92 lb/gal 350 g/l	Less Water and Federally Exempt Solvents
2.92 lb/gal 350 g/l	Emitted VOC

Section 10 -- STABILITY AND REACTIVITY

STABILITY -- Stable

CONDITIONS TO AVOID

None known.

INCOMPATIBILITY

Contamination with Water, Alcohols, Amines and other compounds which react with isocyanates, may result in dangerous pressure in, and possible bursting of, closed containers.

HAZARDOUS DECOMPOSITION PRODUCTS

By fire: Carbon Dioxide, Carbon Monoxide, Oxides of Nitrogen, possibility of Hydrogen Cyanide

HAZARDOUS POLYMERIZATION

Will not occur

Section 11 -- TOXICOLOGICAL INFORMATION

CHRONIC HEALTH HAZARDS

Reports have associated repeated and prolonged overexposure to solvents with permanent brain and nervous system damage.

Ethylbenzene is classified by IARC as possibly carcinogenic to humans (2B) based on inadequate evidence in humans and sufficient evidence in laboratory animals. Lifetime inhalation exposure of rats and mice to high ethylbenzene concentrations resulted in increases in certain types of cancer, including kidney tumors in rats and lung and liver tumors in mice. These effects were not observed in animals exposed to lower concentrations. There is no evidence that ethylbenzene causes cancer in humans.

Crystalline Silica (Quartz, Cristobalite) is listed by IARC and NTP. Long term exposure to high levels of silica dust, which can occur only when sanding or abrading the dry film, may cause lung damage (silicosis) and possibly cancer.

IARC's Monograph No. 93 reports there is sufficient evidence of carcinogenicity in experimental rats exposed to titanium dioxide but inadequate evidence for carcinogenicity in humans and has assigned a Group 2B rating. In addition, the IARC summary concludes, "No significant exposure to titanium dioxide is thought to occur during the use of products in which titanium is bound to other materials, such as paint."

TOXICOLOGY DATA

CAS No.	Ingredient Name				
100-41-4	Ethylbenzene				
		LC50	RAT	4HR	Not Available
		LD50	RAT		3500 mg/kg
1330-20-7	Xylene				
		LC50	RAT	4HR	5000 ppm
		LD50	RAT		4300 mg/kg
64742-94-5	Medium Aromatic Hydrocarbons				
		LC50	RAT	4HR	Not Available
		LD50	RAT		Not Available
91-20-3	Naphthalene				
		LC50	RAT	4HR	Not Available
		LD50	RAT		Not Available
110-43-0	Methyl n-Amyl Ketone				
		LC50	RAT	4HR	Not Available
		LD50	RAT		1670 mg/kg
108-94-1	Cyclohexanone				
		LC50	RAT	4HR	8000 ppm
		LD50	RAT		1535 mg/kg
763-69-9	Ethyl 3-Ethoxypropionate				
		LC50	RAT	4HR	Not Available
		LD50	RAT		5000 mg/kg
822-06-0	Hexamethylene Diisocyanate (max.)				
		LC50	RAT	4HR	Not Available
		LD50	RAT		738 mg/kg
4083-64-1	p-Toluenesulfonyl Isocyanate				
		LC50	RAT	4HR	Not Available
		LD50	RAT		Not Available
28182-81-2	Hexamethylene Diisocyanate Polymer				
		LC50	RAT	4HR	Not Available
		LD50	RAT		Not Available
14808-60-7	Quartz				
		LC50	RAT	4HR	Not Available
		LD50	RAT		Not Available
14807-96-6	Talc				
		LC50	RAT	4HR	Not Available
		LD50	RAT		Not Available
13463-67-7	Titanium Dioxide				
		LC50	RAT	4HR	Not Available
		LD50	RAT		Not Available

Section 12 -- ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL INFORMATION

No data available.

Section 13 -- DISPOSAL CONSIDERATIONS

WASTE DISPOSAL METHOD

Waste from this product may be hazardous as defined under the Resource Conservation and Recovery Act (RCRA) 40 CFR 261.

Waste must be tested for ignitability to determine the applicable EPA hazardous waste numbers.

Incinerate in approved facility. Do not incinerate closed container. Dispose of in accordance with Federal, State/Provincial, and Local regulations regarding pollution.

Section 14 -- TRANSPORT INFORMATION

US Ground (DOT)

1 Gallon and Less may be Classed as CONSUMER COMMODITY, ORM-D
Larger Containers are Regulated as:
UN1263, PAINT, 3, PG III, (ERG#128)

DOT (Dept of Transportation) Hazardous Substances & Reportable Quantities

Naphthalene 100 lb RQ
Xylenes (isomers and mixture) 100 lb RQ

Bulk Containers may be Shipped as (check reportable quantities):

RQ, UN1263, PAINT, 3, PG III, (XYLENES (ISOMERS AND MIXTURE)), (ERG#128)

Canada (TDG)

UN1263, PAINT, CLASS 3, PG III, LIMITED QUANTITY, (ERG#128)

IMO

UN1263, PAINT, CLASS 3, PG III, (34 C c.c.), EmS F-E, S-E

Section 15 -- REGULATORY INFORMATION

SARA 313 (40 CFR 372.65C) SUPPLIER NOTIFICATION

CAS No.	CHEMICAL/COMPOUND	% by WT	% Element
100-41-4	Ethylbenzene	0.6	
1330-20-7	Xylene	4	
91-20-3	Naphthalene	0.3	

CALIFORNIA PROPOSITION 65

WARNING: This product contains chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.

TSCA CERTIFICATION

All chemicals in this product are listed, or are exempt from listing, on the TSCA Inventory.

Section 16 -- OTHER INFORMATION

This product has been classified in accordance with the hazard criteria of the Canadian Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

Technical data for TC Ceramic

TC Ceramic

Technical Data Sheet

CAPSTONE MFG., LLC

PRODUCT DESCRIPTION

CHEMICAL DESCRIPTION: Single Component, Waterborne Acrylic Polymer with Silicon Microspheres

PRODUCT USAGE: ***TC Ceramic*** (previously known as Thermal-Coat) is a liquid insulation, consisting of a mixture of various silicon and ceramic beads blended into a high quality acrylic polymer. ***TC Ceramic*** is designed to provide both thermal and acoustical insulation for a variety of industrial applications, providing an effective, inexpensive alternative to the high cost of typical insulation systems. Due to its excellent reflectivity and emissivity, ***TC Ceramic*** excels at insulating structures and equipment from radiant energy gain. 99% of the radiant energy that comes in contact with ***TC Ceramic*** is either reflected or re-emitted, meaning only 1% of the radiant energy is absorbed. ***TC Ceramic*** also performs very well at protecting personnel from burn hazards on hot or cold structures and equipment. Because it physically adheres to the surface, ***TC Ceramic*** significantly reduces corrosion and rust formation. TC Ceramic is extremely lightweight and pliable, therefore, it expands and contracts with the surface to which it is applied. The use of ***TC Ceramic***, in place of other insulation, reduces both the space and weight for any given structure or piece of equipment.

COLORS: Standard color is white. Special colors available upon request.

PRODUCT CERTIFICATIONS: Passes ASTM C1055-99 standard for protection from burn injuries.

PRODUCT ADVANTAGES

- Excellent radiant reflectivity and emissivity properties – significantly reduces radiant energy gain
- Low thermal conductivity – good conductive insulation properties
- Very good burn safety characteristics – excellent for personnel protection
- Light weight – less weight than other insulations
- Good adhesion – bonds well to a variety of substrates
- Moisture resistant – helps to prevent corrosion and rust formation
- Easy application/installation – installs in much less time than other insulations
- Reduces or eliminates condensation

TYPICAL APPLICATIONS

- Pipe and Valve Insulation
- Tank Insulation
- Roof Coating
- Interior and Exterior Wall Insulation
- Interior and Exterior Ducting

SURFACE PREPARATION

Preparation requirements vary. Contact Capstone Mfg. for assistance.

COATING SYSTEMS

PRIMERS:

Steel: self-priming or corrosion resistant primer
Non-Ferrous Metals and Galvanized Steel: self-priming
Concrete: self-priming
Wood: self-priming

TOPCOATS: Acrylic Latex Compatible Systems: not recommended for burn safety applications.

Capstone Mfg. • 18225-47th Place NE • Seattle, WA 98155 • Phone 206.363.5010 • FAX 206.364.5183 •mlantz@nwlink.com

CAPSTONE MFG., LLC **TC Ceramic**

TECHNICAL DATA

SOLIDS VOLUME
80.5 percent

RECOMMENDED DRY FILM THICKNESS
15-200 mils(0.4mm-5.0mm; 15-30 mils(0.4-0.8mm) per coat, multiple coats required to obtain greater thicknesses. Thickness varies with application. Please consult your designated technical representative for assistance.

DRY TIME (50% R.H.)

Temperature	*Dry To Touch*	*Recoat Time*	*To Normal Use*
75°F	180 min.	12 hrs.	24 hrs.

THEORETICAL COVERAGE
Spray Application: 60 sq. ft/gallon @ 15 mils(0.4mm)

NET WEIGHT PER GALLON
Wet: 5.6 pounds(2.54kg)/gallon, ***Dry:*** 3.2 pounds(1.45kg)/gallon

STORAGE TEMPERATURE
Minimum 40°F/5°C, Maximum 80°F/26°C; cool storage is recommended

SHELF LIFE
12 months at recommended storage temperatures.

HEALTH AND SAFETY
Materials are safe for handling. Consult Material Safety Data Sheet for descriptive handling and safety information.

PHYSICAL PROPERTIES

Cross Hatch Adhesion (ASTM 3359)	100% passed, no failure
Flame Spread (ASTM E84-98)	25
Smoke Developed (ASTM E84-98)	45
Accelerated Aging (ASTM G53), no primer	No discoloration at 200 hours
Brookfield Viscosity, #3 Spindle, 30 rpm	3564 centipoise
Specific Heat (23°C)	1.1120 W·s/gm·K
Thermal Diffusivity (23°C)	0.00239 cm^2/sec
Thermal Conductivity (23°C)	0.00097 W/cm·K 0.0563 Btu/hr·ft·°F
Solar Reflectance (ASTM E903)	0.83
Emittance (ASTM E408-71)	0.94
Service Temperature	Continuous:-40°F/-40°C : 500°F/260°C Maximum Surge: 500°F/260°C

APPLICATION

MIXING
Power mix contents of container using a mud paddle at 300 rpm or less for 3-5 minutes, making sure to blend in all solids on top of container.

SURFACE TEMPERATURE
Minimum 50°F/10°C, Maximum 300°F/150°C. Coating will not dry below 50°F/10°C Prior to applying to substrates at temperatures greater than 150°F/68°C, please contact Capstone Mfg. for assistance.

METHODS & EQUIPMENT
Apply TC Ceramic on a dry, clean, substrate which is free from oil, grease, wax, dirt, rust or corrosion. Use airless sprayer with 3000 PSI, 1.25 GPM, 28:1 ratio with a .021 tip size. An AR-1 Spray Gun using shop air may be used for small applications. Allow product to completely dry between coats. This is a one-coat system with dry time of 12 hours under room temperature conditions. Elevating temperature of substrate will accelerate recoat time. Brush may be used for touch up, but is not recommended for full application, except for under 500 ft^2. (See Application Specifications & Instructions)

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MATERIAL SAFETY DATA SHEET

I. CHEMICAL PRODUCT INFORMATION

PRODUCT NAME: TC Ceramic and TC Ceramic HB

Capstone Manufacturing LLC
18225 - 47th Place NE
Seattle, WA 98155
206-363-5010, FAX 206-364-5183

Effective Date: 01/02/2007

II. HAZARDOUS INGREDIENTS

INGREDIENT(S):	CAS#	OSHA PEL	ACGIH TLV	OSHA STEL	APPROX%
Ammonia	7664-41-7	50 ppm	25 ppm	Unknown	-0.050% / wt.
Acrylate esters	Mixture	Unknown	10 ppm-TWA	Unknown	-0.340% / wt.

This MSDS complies with the OSHA Communication Standard (29 CFR 1910.1200). Unlisted ingredients are not 'Hazardous' per this OSHA Standard and are considered to be trade secrets of Capstone Manufacturing, LLC. Consult Section 12 for the nature of the hazard(s).

III. PRECAUTIONARY INFORMATION

Product not considered hazardous under normal conditions. Direct contact of product with eye can cause irritation. Prolonged or repeated contact with skin may cause irritation.

IV. EMERGENCY AND FIRST AID PROCEDURES

EYE: Flush immediately with water for 15 minutes. Consult a physician if irritation persists.

SKIN: Wash affected area with soap and water. Wash contaminated clothing before reuse.

INHALED: Remove subject to fresh air.

FIRE: Product is non-flammable in the liquid state. Use water spray, foam, dry chemical or carbon dioxide on dried product.

SPILL: Collect and remove using inert absorbent. Contain spill to prevent entering sewers. Notify appropriate agencies.

V. PERSONAL PROTECTION EQUIPMENT

EYE: Wear chemical safety goggles to reduce the potential for eye contact. Eye wash fountain should be available.

SKIN: Impermeable chemical gloves and wear appropriate protective clothing. Launder contaminated clothing before reusing.

RESPIRATORY: Respiratory protection is not normally required. Use NIOSH/MSHA approved respirator if conditions warrant.

VENTILATION: Standard industrial ventilation is recommended.

VI. FIRE PROTECTION

FLASH POINT: Non-flammable

EXTINGUISHING MEDIA: Non-flammable in liquid state: use water spray, foam, dry chemical. Use carbon dioxide on dried product.

UNUSUAL FIRE AND EXPLOSION HAZARD: Personnel exposed to products of combustion should wear self-contained breathing apparatus and full protective equipment. Containers exposed in a fire should be cooled with water to prevent vapor pressure buildup leading to a rupture.

VII. REACTIVITY INFORMATION

STABILITY: Stable.

INCOMPATIBILITY: Not Established.

HAZARDOUS DECOMPOSITION PRODUCTS: Combustion of the dried product can yield low molecular weight hydrocarbons such as carbon monoxide and carbon dioxide.

HAZARDOUS POLYMERIZATION: Will not occur.

VII. EFFECT OF OVEREXPOSURE

EYES: Eye contact with liquid may cause irritation.
SKIN: Repeated or prolonged skin contact with liquid may cause irritation.
INHALATION: No expected effects.
CHRONIC: No anticipated effects. This product does not contain regulated levels of NTP, IARC or OSHA listed carcinogens.
EXISTING HEALTH CONDITIONS AFFECTED BY EXPOSURE: No known effects on other illnesses.

IX. PHYSICAL DATA

PHYSICAL STATE: Liquid
WEIGHT / GALLON: 5.6 lbs.
SOLIDS: 80% +/- 1% by volume
PH: 8.5 - 9.5
VISCOSITY (BROOKFIELD): 3564 +/- 100 cps.
BOILING POINT: >220°F
SOLUBILITY IN WATER: Dilutable

X. SPILL AND DISPOSAL INFORMATION

SMALL SPILLS: Should be contained using absorbent material, such as clay, soil, or any commercially available absorbent. Shovel reclaimed liquid and absorbent into recovery or salvage drums for disposal.
LARGE SPILLS: Should be diked to prevent further movement and reclaim into recovery or salvage drums for disposal.
DISPOSAL: This product does not meet the definition of hazardous waste under the US EPA Hazardous Waste Regulations 40 CFR 261. Consult your state or local authorities for proper disposal in the event more restrictive requirements apply.

XI. STORAGE

Protect from freezing - product stability may be affected.

XII. REGULATORY INFORMATION

TOSCA: This product meets the compositional requirements of the Toxic Substances Control Act and contains only chemical ingredients that are listed on the TOSA inventory.

SARA TITLE III, SECTION 313:
This product does not contain toxic chemical(s) at or above the minimum concentrations subject to the reporting requirements of section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARS) and 40 CFR part 372.

CHEMICAL NAME	CAS NUMBER	PERCENT
NA	NA	NA

ABBREVIATIONS:
NA - Not Applicable, NE - Not Established, NSR - No Special Requirement, ND - Not Determined

XIII. DISCLAIMER

All information appearing herein is based upon data obtained from the manufacturer and/or recognized technical sources. While the information is believed to be accurate, Capstone Manufacturing, LLC makes no representation as to its accuracy or sufficiency. Conditions of use are beyond Capstone Manufacturing, LLC control, and therefore users determine whether the product is suitable for their particular purposes and assume all risks of their use, handling, and disposal of the product, or from the publication, use of or reliance upon information contained herein. This information relates only to the products designated herein.

Technical data for System 21-A-Z Formula 159 Primer

BLP MOBILE PAINTS

PRODUCT DATA

Epoxy Polyamide Zinc Rich Primer
Formula 159 Type III
MIL-DTL-24441/19B(40-DH-6)

Epoxy Polyamide

PRODUCT DESCRIPTION

A two component, high performance epoxy/polyamide zinc rich primer. Meets the requirements of MIL-DTL-24441/19B Type III.

TYPICAL USES

For industrial, commercial and marine use as a protective maintenance coating designed for application directly to properly prepared or sandblasted steel. Suitable for interior or exterior surfaces. For bilges, tanks, underwater hulls, machinery, piping, structural steel and other surfaces requiring a high performance coating system.

PRODUCT ADVANTAGES

MIL-DTL-24441/19B (40-DH-6) Epoxy Polyamide Zinc Rich Primer Coating is formulated to provide a hard, durable, chemically resistant coating on steel structures that receive severe exposure to adverse weather, moisture, corrosive atmospheres and marine environments. It is recommended for use as a Prime Coat normally in a multiple coat system intended for surfaces in tidal zones, surfaces subject to immersion in fresh or salt water, exposures to chemical splash and spillage, and incidental weather exposed areas. Low VOC and lead free.

COLORS

Gray

GLOSS

Matte

PHYSICAL CONSTANTS

Nonvolatile -	By weight - 89.0 ± 2.0% By volume - 63.0 ± 1.0%
VOC (Calculated) -	2.5 lbs./gal. 304 grams/liter
Flash Point -	(A) 99°F minimum (Setaflash) (B) 110°F (Setaflash)
Mixing ratio -	4:1 by volume
Weight per gallon -	(A) 7.7 ± 0.2 lbs. (B) 28.4 ± 0.2 lbs.

APPLICATION

Recommended Film Thickness - 3.0 mils dry, 4.8 mils wet.
Theoretical Coverage @ 3.0 mils dry - 336 sq. ft./gal.
Method - Brush, roll, conventional and airless spray.
Thinner - MoPoxY™ F159 Thinner 43-EF-117 (Refer to thinning on back)

Cure time @ 75°F -	To touch - 2 hours max. To handle - 8 hours max. To recoat - 24 hours
Pot life @ 75°F -	4 hours minimum
Induction time -	1/2 hour @ 75°F (See "Mixing" on back)

SHIPPING & STORAGE

Consists of -	5 Gallon Unit
Part (A)	1 gallon
Part (B)	5 gallons (short filled)
Unit Shipping Weight	125 lbs.

Shelf Life - 12 months minimum from date of manufacture when maintained in protected storage @ 40-100°F (subject to reinspection thereafter).

P.O. BOX 717 • THEODORE, ALABAMA 36590 -0717 • PHONE (251) 443-6110 • FAX (251) 408-0410

APPLICATION INSTRUCTIONS

Consult your Mobile Paint Representative for the protective coating system best suited for your requirements.

Limitations: Apply in good weather when air and surface temperature are above 50°F and surface temperature is at least 5°F above the dew point. For optimum application properties, material should be between 70 to 100°F prior to mixing and application. Maintain unmixed material in closed containers in protected storage at 40-100°F.

Surface Preparation: Good surface preparation is essential to a satisfactory coating system. Surfaces to be coated should be clean and dry. Remove all oil, grease, mildew of other contamination by solvent or detergent cleaning or other effective means.

New or Unfinished Surfaces - Ferrous Metal: For best performance, application to abrasive blasted and primed surface is recommended. "Commercial Blast Cleaning" SSPC-SP6 is recommended as the minimum. For immersion service "Near White Blast Cleaning" SSPC-SP10 is considered minimum. Proper blast media and blasting equipment shall be used to produce an average profile depth of 2.5 mils minimum. Do not reuse abrasive media. Remove blasting dust and grit from surfaces before painting. Blasted surfaces should be coated within 8 hours after blasting or before rusting or other contamination of the surface occurs. If blasting is not feasible, remove rust by "Hand or Power Tool Cleaning" (SSPC-SP2 or -SP3).

Previously Finished Surfaces - Repair all damaged areas. Remove gloss from previous paint by sanding or "Brush Blasting" (SSPC-SP7). Remove rust, corrosion products, heavy chalk and loose or peeling paint by "Hand or Power Tool Cleaning" (SSPC-SP2 or -SP3). Spot prime any bare areas as in new work above. If doubt exists concerning compatibility of this coating with the previous system, apply coating to a representative area (25 square feet minimum) and allow to cure and age several weeks. Then inspect for adhesion failure, wrinkling, lifting, blistering or any other sign of incompatibility. If there are no signs, coating work can proceed.

Mixing: This is a two component coating supplied in two containers as a unit. Always mix a complete unit in the proportions supplied. (1) Mix the contents of Component A thoroughly with a power agitator. (2) Mix the contents of Component B thoroughly with a power agitator.(3) Combine the entire contents of Component A and Component B and mix thoroughly with a power agitator. Allow a 1/2 hour induction time @ 70°F before using the coating. Usable pot life depends on the temperature of the material. Refer to Pot Life section on front page. Agitate at slow speed during use to prevent zinc dust from settling.

Induction time -
@ 50-60°F -- 1½ hours
@ 61-75°F -- 1 hour
@ 76-80°F -- ½ to 1 hour
@ 81-90°F -- ½ hour
above 90°F -- none

Thinning: Material is supplied at airless spray viscosity and should not require thinning. Clean Air Regulations may not allow thinning of this product for certain uses. Do not thin beyond applicable regulations. If thinning is allowed, use MoPoxY™ F159 Thinner 43-EF-117.

Application: Spray application is preferred for proper film build and best performance. Brush application is acceptable for touch up. Roller application may require special care to prevent bubbling and may require more than one coat to attain proper film thickness. Apply at 4.8 mils wet film thickness to achieve 3.0 mils dry film thickness.

Equipment: Conventional spray - DeVilbiss MBC gun with E tip and 30 air cap or equal at 40-45 psi atomizing pressure and 10-15 psi pot pressure, 3/8" ID product hose, double regulated pressure pot with oil and moisture separator. Airless spray - Minimum of 30:1 ratio pump, .017" to .021" tip, 3/8" ID material hose.
NOTE: During lunch, breaks or any period of work stoppage, material should be removed from hoses and equipment. Release pressure from equipment and flush hoses and equipment with MoPoxY™ F159 Thinner 43-EF-117. Do not repressurize equipment until ready to resume work.

Cleanup: Clean all equipment immediately after use with MoPoxY™ F159 Thinner 43-EF-117. Completely flush all spray equipment with this solvent. Occasional flushing of spray equipment during the course of the working day helps prevent buildup and possible clogging.

Safety: Safe storage, handling and use dictate that adequate health and safety precautions be observed with this product and any recommended thinners. User is specifically directed to consult the current Material Safety Data Sheet for this product as well as precautions contained on product labeling.

Notice: The technical data contained herein are true and accurate to the best of our knowledge. All products are offered and sold subject to Mobile Paint Manufacturing Company's Standard Conditions of Sale. Published technical data and instructions are subject to change without prior notice.

40-DH-6(10/03)

LIMITED WARRANTY

The successful performance of this product is highly dependent on many factors beyond our control. Results are highly dependent upon the skill of the operator. This product is manufactured to meet the highest level of consistency and quality for the intended use. Mobile Paint warrants that its products meet the specifications which it sets for them. Should this product be proven to be off-specification within one year from date of shipment, Mobile Paint will, at its sole discretion, either replace the product or issue credit for the original purchase price of the product. The replacement or refund shall be the buyer's sole remedy and Mobile Paint and its affiliates **MAKE NO OTHER WARRANTY OR GUARANTEE, EXPRESS OR IMPLIED, INCLUDING MERCHANTABILITY, DESIGN COMPATIBILITY AND FITNESS FOR A PARTICULAR PURPOSE. LABOR OR COST OF LABOR AND OTHER INCIDENTAL AND/OR CONSEQUENTIAL DAMAGES ARE SPECIFICALLY EXCLUDED**. The technical data contained herein are true and accurate to the best of our knowledge. Published technical data and instructions are subject to change without prior notice.

BLP MOBILE PAINTS

Mobile Paint Mfg. Co., Inc.

MATERIAL SAFETY DATA SHEET

Page 1 of 2

PRODUCT NAME: MoPoxY HZR Organic Epoxy Zinc Rich Primer Component A
PRODUCT CLASS:
PRODUCT CODE: 40-DH-6A

HMIS RATINGS
H2 F2 R0

SECTION I - MANUFACTURER IDENTIFICATION

MANUFACTURER'S NAME: MOBILE PAINT MANUFACTURING CO., INC.
ADDRESS: P.O. BOX 717, THEODORE, AL 36582
DATE PREPARED: 06/18/03
PREPARER: J. Hoagland

EMERGENCY PHONE: 1-800-255-3924
(Chemtel 24 Hour Emergency)
INFORMATION PHONE: 251-443-6110

SECTION II – HAZARDOUS INGREDIENTS

HAZARDOUS COMPONENT	CAS NUMBER	OSHA PEL	ACGIH TLV	VAPOR PRESS mmHg @ TEMP	SARA SEC. 313 *	WT. PERCENT
POLYAMIDE RESIN	PROPRIETARY	NOT ESTB	NOT ESTB	N/A		55
N-BUTYL ALCOHOL	71-36-3	50 PPM		5.5@68	YES	15
AROMATIC HYDROCARBON SOLVENT	64742-95-6	100 PPM	100 PPM	2.0@68		15
1,2,4-TRIMETHYLBENZENE	95-63-6	25 PPM	25 PPM	N/A	YES	10
MINERAL SPIRITS	8052-41-2	100 PPM	100 PPM	2.0@68		<5

* Ingredients marked YES are subject to the reporting requirements of the Superfund Amendments and Reauthorization Act (SARA) Section 313, 40 CFR 372.

SECTION III – PHYSICAL/CHEMICAL CHARACTERISTICS

BOILING POINT: 240°F
VAPOR DENSITY: Heavier than air
VOC TOTAL (lb/gal): 3.39
VOC Less Water and Exempt Solvents (lb/gal): 3.39

APPEARANCE & ODOR: Typical paint solvent odor
SPECIFIC GRAVITY (H20 = 1): 0.9
EVAPORATION RATE: Slower than ether
SOLUBILITY IN WATER: Negligible

SECTION IV – FIRE & EXPLOSION HAZARD DATA

FLASH POINT: 96°F
METHOD USED: Setaflash
UNUSUAL FIRE AND EXPLOSION HAZARDS:
Closed containers may explode when exposed to extreme heat. Application to hot surfaces requires special precautions. Full protective equipment including self-contained breathing apparatus should be used. Water spray may be ineffective. If water is used, fog nozzles are preferable. Water may be used to cool closed containers to prevent pressure build-up.
EXTINGUISHING MEDIA: FOAM, ALCOHOL FOAM, CO2, DRY CHEMICAL

FLAMMABLE LIMITS IN AIR BY VOLUME -
LOWER: 0.9 UPPER: 6.4
SPECIAL FIRE FIGHTING PROCEDURES:
During emergency conditions overexposrue to decomposition products may cause a health hazard. Sypmtoms may not be immediately apparent. Obtain medical attention. Keep containers tightly closed. Isolate from heat, sparks, and open flame.

Mobile Paint Mfg. Co., Inc.

MATERIAL SAFETY DATA SHEET

Product Name: MoPoxY HZR Organic Epoxy Zinc Rich Primer Component A

Product Code: 40-DH-6A

SECTION V – REACTIVITY DATA

STABILITY: Stable

INCOMPATIBILITY (MATERIALS TO AVOID): Oxidizing materials

HAZARDOUS DECOMPOSITION OR BYPRODUCTS: May produce hazardous fumes when heated to decomposition as in welding.

CONDITIONS TO AVOID: High Temperatures

HAZARDOUS POLYMERIZATION: Will not occur.

SECTION VI – HEALTH HAZARD DATA

INHALATION HEALTH RISKS AND SYMPTOMS OF EXPOSURE:
Anesthetic, excessive inhalation can cause irritation of the respiratory tract, or acute nervous system depression characterized by headache, dizziness, staggering gait, confusion, unconsciousness, coma and even asphyxiation.

SKIN & EYE CONTACT HEALTH RISKS AND SYMPTOMS OF EXPOSURE:
Skin: Moderate irritation, defatting, dermatitis. May be a sensitizer in some individuals. Eyes: Severe irritation, redness, tearing, blurred vision. May be a sensitizer in some individuals.

SKIN ABSORPTION HEALTH RISKS & SYMPTOMS OF EXPOSURE:
Liquid can be absorbed through the skin resulting in symptoms similar to the inhalation effects above.

CARCINOGENICITY:
NTP? No IARC MONOGRAPHS? No OSHA REGULATED? No

INGESTION HEALTH RISKS & SYMPTOMS OF EXPOSURE:
Gastrointestinal irritation, nausea, vomiting and diarrhea. Aspiration into the lungs during ingestion or vomiting may cause mild to severe pulmonary injury and possibly even death.

HEALTH HAZARDS (ACUTE AND CHRONIC);
Reports have associated repeated and prolonged occupational overexposure to solvents with permanent brain and nervous system damage. Intentional misuse by deliberately concentrating and inhaling the contents may be harmful or fatal.

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE:
Exposure to petroleum solvents may aggravate preexisting dermatitis.

EMERGENCY AND FIRST AID PROCEDURES:
Skin: Wash affected areas with soap and water. Remove and launder contaminated clothing. Consult a physician if needed. Eyes: flush immediately with large amounts of water for at least 15 minutes. Take to a physician for medical treatment. Ingestion: Drink 1 or 2 glasses of water to dilute. Do not induce vomiting. Get medical help immediately.

SECTION VII – PRECAUTIONS FOR SAFE HANDLING AND USE

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED:
Remove all sources of ignition (flame, hot surfaces, and electrical, static or frictional sparks). Avoid breathing vapors. Ventilate area. Contain and remove with inert absorbent and non-sparking tools.

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING:
Do not store above 120 F. Store large quantities only in buildings designed to comply with OSHA 1910.106. Keep closures tight and container upright to prevent leakage. Do not store or use near heat, sparks or flame. Never use pressure to empty. Drum must not be washed out or used for other purposes. Drums of this material should be grounded when pouring.

WASTE DISPOSAL METHOD:
Dispose of in accordance with local, state and federal regulations. Incinerate in approved facility. Do not incinerate closed containers.

OTHER PRECAUTIONS:
Do not get in eyes. Avoid skin contact. Can cause allergic respiratory reaction. Can cause allergic skin reaction. Prevent prolonged or repeated breathing of vapors or spray mist. Avoid breathing of sanding dust. Wash contaminated clothing thoroughly. Wash skin thoroughly with soap and water after handling. Close container after each use. Do not transfer this product to unlabeled containers. Do not handle until the manufacturer's safety precautions have been read and understood. Keep out of reach of children.

SECTION VIII – CONTROL MEASURES

RESPIRATORY PROTECTION:
Use a NIOSH-approved respirator to prevent overexposure, when exposure exceeds occupational exposure limits (Section II). Use either an atmosphere-supplying respirator or an air-purifying respirator for organic vapors in compliance with 29 CFR 1910.134, with provision for mist removal if conditions so indicate.

PROTECTIVE GLOVES:
Recommended.

OTHER PROTECTIVE CLOTHING OR EQUIPMENT:
Use protective outerwear and prevent prolonged skin contact with contaminated clothing.

VENTILATION:
All application areas should be ventilated in accordance to OSHA regulation 29 CFR 1910.94, 1910.107, 1910.108. Remove decomposition products formed during welding or flame cutting on surface coated with this product. If baking, vent fumes.

EYE PROTECTION:
Safety eyewear including splashguards or side shields recommended.

WORK/HYGIENIC PRACTICES:
Avoid breathing vapors and contact with skin. Wash skin thoroughly before breaks and meals and at end of work period.

SECTION IX – DISCLAIMER

DISCLAIMER: The information provided in this MSDS has been obtained from sources believed to be accurate and reliable. It is furnished without warranty of any kind, express or implied. Recipients should determine that the information is current and suitable for the protection of the environment and the health and safety of your employees and users of this product.

Page 1 of 2

Mobile Paint Mfg. Co., Inc.

MATERIAL SAFETY DATA SHEET

PRODUCT NAME: MoPoxY HZR Organic Epoxy Zinc Rich Primer Component B
PRODUCT CLASS:
PRODUCT CODE: 40-DH-6B

HMIS RATINGS
H1 F2 R0

SECTION I - MANUFACTURER IDENTIFICATION

MANUFACTURER'S NAME: MOBILE PAINT MANUFACTURING CO., INC.
ADDRESS: P.O. BOX 717, THEODORE, AL 36582
DATE PREPARED: 06/18/03
PREPARER: J. Hoagland

EMERGENCY PHONE: 1-800-255-3924
(Chemtel 24 Hour Emergency)
INFORMATION PHONE: 251-443-6110

SECTION II – HAZARDOUS INGREDIENTS

HAZARDOUS COMPONENT	CAS NUMBER	OSHA PEL	ACGIH TLV	VAPOR PRESS mmHg @ TEMP	SARA SEC. 313 *	WT. PERCENT
AROMATIC HYDROCARBON SOLVENT	64742-95-6	100 PPM	100 PPM	2.0@68		<5
1,2,4-TRIMETHYLBENZENE	95-63-6	25 PPM	25 PPM	N/A	YES	<5
MINERAL SPIRITS	8052-41-2	100 PPM	100 PPM	2.0@68		<5
ZINC DUST	7440-66-6	15 MG/M3	10 MG/M3	N/A	YES	80
CALCIUM METASILICATE	13983-17-0	15 MG/M3	10 MG/M3	N/A		<5

* Ingredients marked YES are subject to the reporting requirements of the Superfund Amendments and Reauthorization Act (SARA) Section 313, 40 CFR 372.

SECTION III – PHYSICAL/CHEMICAL CHARACTERISTICS

BOILING POINT: 315°F
VAPOR DENSITY: Heavier than air
VOC TOTAL (lb/gal): 2.36
VOC Less Water and Exempt Solvents (lb/gal): 2.36

APPEARANCE & ODOR: Typical paint solvent odor
SPECIFIC GRAVITY (H20 = 1): 3.4
EVAPORATION RATE: Slower than ether
SOLUBILITY IN WATER: Negligible

SECTION IV – FIRE & EXPLOSION HAZARD DATA

FLASH POINT: 100°F
METHOD USED: Setaflash
UNUSUAL FIRE AND EXPLOSION HAZARDS:
Closed containers may explode when exposed to extreme heat. Application to hot surfaces requires special precautions. Full protective equipment including self-contained breathing apparatus should be used. Water spray may be ineffective. If water is used, fog nozzles are preferable. Water may be used to cool closed containers to prevent pressure build-up.
EXTINGUISHING MEDIA: FOAM, ALCOHOL FOAM, CO2, DRY CHEMICAL

FLAMMABLE LIMITS IN AIR BY VOLUME -
LOWER: 0.9 UPPER: 6.4
SPECIAL FIRE FIGHTING PROCEDURES:
During emergency conditions overexposrue to decomposition products may cause a health hazard. Sypmtoms may not be immediately apparent. Obtain medical attention. Keep containers tightly closed. Isolate from heat, sparks, and open flame.

Mobile Paint Mfg. Co., Inc.
MATERIAL SAFETY DATA SHEET

Product Name: MoPoxY HZR Organic Epoxy Zinc Rich Primer Component B

Product Code: 40-DH-6B

SECTION V – REACTIVITY DATA

STABILITY: Stable

INCOMPATIBILITY (MATERIALS TO AVOID): Oxidizing materials

HAZARDOUS DECOMPOSITION OR BYPRODUCTS: May produce hazardous fumes when heated to decomposition as in welding.

CONDITIONS TO AVOID: High Temperatures

HAZARDOUS POLYMERIZATION: Will not occur.

SECTION VI – HEALTH HAZARD DATA

INHALATION HEALTH RISKS AND SYMPTOMS OF EXPOSURE:
Anesthetic, excessive inhalation can cause irritation of the respiratory tract, or acute nervous system depression characterized by headache, dizziness, staggering gait, confusion, unconsciousness, coma and even asphyxiation.

SKIN & EYE CONTACT HEALTH RISKS AND SYMPTOMS OF EXPOSURE:
Skin: Moderate irritation, defatting, dermatitis. May be a sensitizer in some individuals. Eyes: Severe irritation, redness, tearing, blurred vision. May be a sensitizer in some individuals.

SKIN ABSORPTION HEALTH RISKS & SYMPTOMS OF EXPOSURE:
Liquid can be absorbed through the skin resulting in symptoms similar to the inhalation effects above.

CARCINOGENICITY:
NTP? No IARC MONOGRAPHS? No OSHA REGULATED? No

INGESTION HEALTH RISKS & SYMPTOMS OF EXPOSURE:
Gastrointestinal irritation, nausea, vomiting and diarrhea. Aspiration into the lungs during ingestion or vomiting may cause mild to severe pulmonary injury and possibly even death.

HEALTH HAZARDS (ACUTE AND CHRONIC):
Reports have associated repeated and prolonged occupational overexposure to solvents with permanent brain and nervous system damage. Intentional misuse by deliberately concentrating and inhaling the contents may be harmful or fatal.

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE:
Exposure to petroleum solvents may aggravate preexisting dermatitis.

EMERGENCY AND FIRST AID PROCEDURES:
Skin: Wash affected areas with soap and water. Remove and launder contaminated clothing. Consult a physician if needed. Eyes: flush immediately with large amounts of water for at least 15 minutes. Take to a physician for medical treatment. Ingestion: Drink 1 or 2 glasses of water to dilute. Do not induce vomiting. Get medical help immediately.

SECTION VII – PRECAUTIONS FOR SAFE HANDLING AND USE

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED:
Remove all sources of ignition (flame, hot surfaces, and electrical, static or frictional sparks). Avoid breathing vapors. Ventilate area. Contain and remove with inert absorbent and non-sparking tools.

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING:
Do not store above 120 F. Store large quantities only in buildings designed to comply with OSHA 1910.106. Keep closures tight and container upright to prevent leakage. Do not store or use near heat, sparks or flame. Never use pressure to empty. Drum must not be washed out or used for other purposes. Drums of this material should be grounded when pouring.

WASTE DISPOSAL METHOD:
Dispose of in accordance with local, state and federal regulations. Incinerate in approved facility. Do not incinerate closed containers.

OTHER PRECAUTIONS:
Do not get in eyes. Avoid skin contact. Can cause allergic respiratory reaction. Can cause allergic skin reaction. Prevent prolonged or repeated breathing of vapors or spray mist. Avoid breathing of sanding dust. Wash contaminated clothing thoroughly. Wash skin thoroughly with soap and water after handling. Close container after each use. Do not transfer this product to unlabeled containers. Do not handle until the manufacturer's safety precautions have been read and understood. Keep out of reach of children.

SECTION VIII – CONTROL MEASURES

RESPIRATORY PROTECTION:
Use a NIOSH-approved respirator to prevent overexposure, when exposure exceeds occupational exposure limits (Section II). Use either an atmosphere-supplying respirator or an air-purifying respirator for organic vapors in compliance with 29 CFR 1910.134, with provision for mist removal if conditions so indicate.

PROTECTIVE GLOVES:
Recommended.

OTHER PROTECTIVE CLOTHING OR EQUIPMENT:
Use protective outerwear and prevent prolonged skin contact with contaminated clothing.

VENTILATION:
All application areas should be ventilated in accordance to OSHA regulation 29 CFR 1910.94, 1910.107, 1910.108. Remove decomposition products formed during welding or flame cutting on surface coated with this product. If baking, vent fumes.

EYE PROTECTION:
Safety eyewear including splashguards or side shields recommended.

WORK/HYGIENIC PRACTICES:
Avoid breathing vapors and contact with skin. Wash skin thoroughly before breaks and meals and at end of work period.

SECTION IX – DISCLAIMER

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Technical data for System 21-A-Z Formula 151 Topcoat

SHIPBUILDERS AND MARINE
PAINTS AND COATINGS
by Mobile Paint Mfg. Co. Inc.

PRODUCT DATA SHEET NO.: 40AH086 DATE: 08/24/04 REV: 3

I. GENERIC TYPE AND DESCRIPTION: Epoxy - Polyamide - Haze Gray
Specification Number: MIL-DTL-24441/21A, Type III, F151

II. MANUFACTURER'S DATA:
(a) MANUFACTURER: Mobile Paint Mfg. Co, Inc. (b)PRODUCT DESIGNATION: 40AH086

(c) COLOR(S): Haze Gray (d) USES: Ships, bilges, and hulls.

(e) TECHNICAL SERVICE REPRESENTATIVE - Hank Hays
Telephone No.: 251-443-6110

III. PROPERTIES:

(a) % VOLUME SOLIDS (ASTM D 2697) : 60% (b) FLASH POINT (ASTM D 3278): 100âF

(c) WEIGHT PER GALLON (FTMS141a 4184.1): 10.8 lbs. (d) SHELF LIFE: 12 months minimum

(e) VISCOSITY (FTMS 141a 4281): 82 - 92 KU (f) PACKAGING: 10 gallon kits
5 gallons of A in a metal pail.
5 gallons of B in a metal pail.

(g) NUMBER OF COMPONENTS: 2 (h) GLOSS (ASTM D 523): 30% maximum

(i) STORAGE REQUIREMENTS: Protected storage at temperature of 0°F to 100° maximum

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SPECIAL SAFETY PRECAUTIONS:
Solvents contained in this coating are combustible and may cause irritation. Use extreme caution when applying in enclosed areas. Keep away from heat and sparks or open flame. Always use with adequate ventilation. **See Mobile Paint Mfg.Co. Material Safety Data Sheet for additional information.**

IV. SURFACE PREPARATION MINIMUM REQUIREMENTS :

(a) INITIAL - Near White (SSPC-SP10)

(b) TOUCH-UP - Brush Blast (SSPC-SP7)

(c) PROFILE (Gardner Model 123 Profilometer) - MIN. 2.0 mils MAX. 3.0 mils

(d) SPECIAL INSTRUCTIONS - N/A

(e) PRIMER REQUIREMENTS : MIL-P-24441/20, F150 Primer Green 40CM013

PAGE 1 OF 2
ASTM F718 (Modified)

40AH086 Page 2 of 2

V. MIXING PROCEDURE:

(a) MIXING RATIO BY WEIGHT - 11.1 parts Component A to 10.5 parts Component B
BY VOLUME - 1 part Component A to 1 part Component B

(b) INDUCTION TIME -

Ambient Temp.	Induction Time
<35°F	Do not apply
*35 - 60°F	2 hours
61 - 70°F	1- 1.5 hrs
71 - 90°F	0.5 - 1 hrs
91 - 100°F	15 minutes

* **Note**: For application below 60°F material must be at 60 - 70°F at the time of mixing and remain at 60 - 70°F during the induction period.

(c) RECOMMENDED SOLVENT - CONFINED AREAS - Mopoxy 241 Thinner 43EF094
NON-CONFINED AREAS -Mopoxy241 Thinner 43EF094
CLEAN-UP - Mopoxy 241 Thinner 43EF094

(d) THINNING REQUIREMENTS - Not necessary, (check applicable regulations for VOC limitations). 10% maximum Mopoxy 241 Thinner 43EF094

(e) POT LIFE - 6 hours minimum at 75âF (24âC)
3 hours minimum at 85âF (29.4âC)

(f) SPECIAL INSTRUCTIONS - Components A and B must be mixed 1:1 by volume.

VI. APPLICATION

(a) ENVIRONMENTAL LIMITATIONS - TEMPERATURE - 40°F minimum to 100°F maximum

NOTE - Surface temperature must be at least 5°F above dew point.

(b) FILM THICKNESS - (SSPC PA2-73T)WET FILM - 3.4 mils minimum to 5.1 mils maximum
DRY FILM - 2.0 mils minimum to 3.0 mils maximum

(c) DRY TIMES

Ambient Temp.	Recoat Minimum	Recoat Maximum	For Service Minimum
40 - 60°F	18 hours	10 days	10 days
61 - 80°F	12 hours	7 days	8 days
81 - 100°F	8 hours	5 days	7 days

(d) EQUIPMENT REQUIREMENTS (RECOMMENDED)
Conventional spray - DeVilbliss MBC gun with E tip with 30 air cap or equal. 40-45 psi atomizing pressure.
Airless spray - minimum 30:1 ratio pump, .015" - .017" tip. 3/8" ID material hose.
May be brush or roller applied.

Page 1 of 2

BLP MOBILE PAINTS

Mobile Paint Mfg. Co., Inc.

MATERIAL SAFETY DATA SHEET

PRODUCT NAME: MIL-P-24441/21, Type III F151 Component A
PRODUCT CLASS:
PRODUCT CODE: 40-AH-86A

HMIS RATINGS
H2 F2 R0

SECTION I - MANUFACTURER IDENTIFICATION

MANUFACTURER'S NAME: MOBILE PAINT MANUFACTURING CO., INC.
ADDRESS: P.O. BOX 717, THEODORE, AL 36582
DATE PREPARED: 01/22/02
PREPARER: J. Hoagland

EMERGENCY PHONE: 1-800-255-3924
(Chemtel 24 Hour Emergency)
INFORMATION PHONE: 251-443-6110

SECTION II – HAZARDOUS INGREDIENTS

HAZARDOUS COMPONENT	CAS NUMBER	OSHA PEL	ACGIH TLV	VAPOR PRESS mmHg @ TEMP	SARA SEC. 313 *	WT. PERCENT
POLYAMIDE RESIN	PROPRIETARY	NOT ESTB	NOT ESTB	N/A		20
N-BUTYL ALCOHOL	71-36-3	50 PPM		5.5@68	YES	30
TITANIUM DIOXIDE	13463-67-7	15 MG/M3	10 MG/M3	N/A		10
MAGNESIUM SILICATE	14807-96-6	20 MPPCF	2 MG/M3	N/A		35

* Ingredients marked YES are subject to the reporting requirements of the Superfund Amendments and Reauthorization Act (SARA) Section 313, 40 CFR 372.

SECTION III – PHYSICAL/CHEMICAL CHARACTERISTICS

BOILING POINT: 240°F
VAPOR DENSITY: Heavier than air
VOC TOTAL (lb/gal): 3.34
VOC Less Water and Exempt Solvents (lb/gal): 3.34

APPEARANCE & ODOR: Typical paint solvent odor
SPECIFIC GRAVITY (H20 = 1): 1.3
EVAPORATION RATE: Slower than ether
SOLUBILITY IN WATER: Negligible

SECTION IV – FIRE & EXPLOSION HAZARD DATA

FLASH POINT: 100-103°F
METHOD USED: Setaflash
UNUSUAL FIRE AND EXPLOSION HAZARDS:
Closed containers may explode when exposed to extreme heat. Application to hot surfaces requires special precautions. Full protective equipment including self-contained breathing apparatus should be used. Water spray may be ineffective. If water is used, fog nozzles are preferable. Water may be used to cool closed containers to prevent pressure build-up.
EXTINGUISHING MEDIA: FOAM, ALCOHOL FOAM, CO2, DRY CHEMICAL

FLAMMABLE LIMITS IN AIR BY VOLUME -
LOWER: 1.4% UPPER: N/A
SPECIAL FIRE FIGHTING PROCEDURES:
During emergency conditions overexposrue to decomposition products may cause a health hazard. Sypmtoms may not be immediately apparent. Obtain medical attention. Keep containers tightly closed. Isolate from heat, sparks, and open flame.

Mobile Paint Mfg. Co., Inc.
MATERIAL SAFETY DATA SHEET

Product Name: MIL-P-24441/21, Type III F151 Component A

Product Code: 40-AH-86A

SECTION V – REACTIVITY DATA

STABILITY: Stable INCOMPATIBILITY (MATERIALS TO AVOID): Oxidizing materials	CONDITIONS TO AVOID: High Temperatures
HAZARDOUS DECOMPOSITION OR BYPRODUCTS: May produce hazardous fumes when heated to decomposition as in welding.	HAZARDOUS POLYMERIZATION: Will not occur.

SECTION VI – HEALTH HAZARD DATA

INHALATION HEALTH RISKS AND SYMPTOMS OF EXPOSURE: Anesthetic, excessive inhalation can cause irritation of the respiratory tract, or acute nervous system depression characterized by headache, dizziness, staggering gait, confusion, unconsciousness, coma and even asphyxiation.	INGESTION HEALTH RISKS & SYMPTOMS OF EXPOSURE: Gastrointestinal irritation, nausea, vomiting and diarrhea. Aspiration into the lungs during ingestion or vomiting may cause mild to severe pulmonary injury and possibly even death.
SKIN & EYE CONTACT HEALTH RISKS AND SYMPTOMS OF EXPOSURE: Skin: Moderate irritation, defatting, dermatitis. May be a sensitizer in some individuals. Eyes: Severe irritation, redness, tearing, blurred vision. May be a sensitizer in some individuals	HEALTH HAZARDS (ACUTE AND CHRONIC); Reports have associated repeated and prolonged occupational overexposure to solvents with permanent brain and nervous system damage. Intentional misuse by deliberately concentrating and inhaling the contents may be harmful or fatal.
SKIN ABSORPTION HEALTH RISKS & SYMPTOMS OF EXPOSURE: Liquid can be absorbed through the skin resulting in symptoms similar to the inhalation effects above.	MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE: Exposure to petroleum solvents may aggravate preexisting dermatitis.
CARCINOGENICITY: NTP? No IARC MONOGRAPHS? No OSHA REGULATED? No	EMERGENCY AND FIRST AID PROCEDURES: Skin: Wash affected areas with soap and water. Remove and launder contaminated clothing. Consult a physician if needed. Eyes: flush immediately with large amounts of water for at least 15 minutes. Take to a physician for medical treatment. Ingestion: Drink 1 or 2 glasses of water to dilute. Do not induce vomiting. Get medical help immediately.

SECTION VII – PRECAUTIONS FOR SAFE HANDLING AND USE

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED: Remove all sources of ignition (flame, hot surfaces, and electrical, static or frictional sparks). Avoid breathing vapors. Ventilate area. Contain and remove with inert absorbent and non-sparking tools.	WASTE DISPOSAL METHOD: Dispose of in accordance with local, state and federal regulations. Incinerate in approved facility. Do not incinerate closed containers.
PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING: Do not store above 120 F. Store large quantities only in buildings designed to comply with OSHA 1910.106. Keep closures tight and container upright to prevent leakage. Do not store or use near heat, sparks or flame. Never use pressure to empty. Drum must not be washed out or used for other purposes. Drums of this material should be grounded when pouring.	OTHER PRECAUTIONS: Do not get in eyes. Avoid skin contact. Can cause allergic respiratory reaction. Can cause allergic skin reaction. Prevent prolonged or repeated breathing of vapors or spray mist. Avoid breathing of sanding dust. Wash contaminated clothing thoroughly. Wash skin thoroughly with soap and water after handling. Close container after each use. Do not transfer this product to unlabeled containers. Do not handle until the manufacturer's safety precautions have been read and understood. Keep out of reach of children.

SECTION VIII – CONTROL MEASURES

RESPIRATORY PROTECTION: Use a NIOSH-approved respirator to prevent overexposure, when exposure exceeds occupational exposure limits (Section II). Use either an atmosphere-supplying respirator or an air-purifying respirator for organic vapors in compliance with 29 CFR 1910.134, with provision for mist removal if conditions so indicate.	VENTILATION: All application areas should be ventilated in accordance to OSHA regulation 29 CFR 1910.94, 1910.107, 1910.108. Remove decomposition products formed during welding or flame cutting on surface coated with this product. If baking, vent fumes.
PROTECTIVE GLOVES: Recommended.	EYE PROTECTION: Safety eyewear including splashguards or side shields recommended.
OTHER PROTECTIVE CLOTHING OR EQUIPMENT: Use protective outerwear and prevent prolonged skin contact with contaminated clothing.	WORK/HYGIENIC PRACTICES: Avoid breathing vapors and contact with skin. Wash skin thoroughly before breaks and meals and at end of work period.

SECTION IX – DISCLAIMER

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Page 1 of 2

Mobile Paint Mfg. Co., Inc.
MATERIAL SAFETY DATA SHEET

PRODUCT NAME: MIL-P-24441/21, Type III F151 Component B
PRODUCT CLASS:
PRODUCT CODE: 40-AH-86B

HMIS RATINGS
H1 F2 R0

SECTION I - MANUFACTURER IDENTIFICATION

MANUFACTURER'S NAME: MOBILE PAINT MANUFACTURING CO., INC.
ADDRESS: P.O. BOX 717, THEODORE, AL 36582
DATE PREPARED: 01/22/02
PREPARER: J. Hoagland

EMERGENCY PHONE: 1-800-255-3924
(Chemtel 24 Hour Emergency)
INFORMATION PHONE: 251-443-6110

SECTION II – HAZARDOUS INGREDIENTS

HAZARDOUS COMPONENT	CAS NUMBER	OSHA PEL	ACGIH TLV	VAPOR PRESS mmHg @ TEMP	SARA SEC. 313 *	WT. PERCENT
AROMATIC HYDROCARBON SOLVENT	64742-95-6	100 PPM	100 PPM	2.0@68		15
1,2,4-TRIMETHYLBENZENE	95-63-6	25 PPM	25 PPM	N/A	YES	7
MAGNESIUM SILICATE	14807-96-6	20 MPPCF	2 MG/M3	N/A		25

* Ingredients marked YES are subject to the reporting requirements of the Superfund Amendments and Reauthorization Act (SARA) Section 313, 40 CFR 372.

SECTION III – PHYSICAL/CHEMICAL CHARACTERISTICS

BOILING POINT: 315°F
VAPOR DENSITY: Heavier than air
VOC TOTAL (lb/gal): 2.26
VOC Less Water and Exempt Solvents (lb/gal): 2.26

APPEARANCE & ODOR: Typical paint solvent odor
SPECIFIC GRAVITY (H20 = 1): 1.3
EVAPORATION RATE: Slower than ether
SOLUBILITY IN WATER: Negligible

SECTION IV – FIRE & EXPLOSION HAZARD DATA

FLASH POINT: 100-110°F
METHOD USED: Setaflash
UNUSUAL FIRE AND EXPLOSION HAZARDS:
Closed containers may explode when exposed to extreme heat. Application to hot surfaces requires special precautions. Full protective equipment including self-contained breathing apparatus should be used. Water spray may be ineffective. If water is used, fog nozzles are preferable. Water may be used to cool closed containers to prevent pressure build-up.
EXTINGUISHING MEDIA: FOAM, ALCOHOL FOAM, CO2, DRY CHEMICAL

FLAMMABLE LIMITS IN AIR BY VOLUME -
LOWER: 0.9% UPPER: 6.4%
SPECIAL FIRE FIGHTING PROCEDURES:
During emergency conditions overexposrue to decomposition products may cause a health hazard. Sypmtoms may not be immediately apparent. Obtain medical attention. Keep containers tightly closed. Isolate from heat, sparks, and open flame.

Mobile Paint Mfg. Co., Inc.
MATERIAL SAFETY DATA SHEET

Product Name: MIL-P-24441/21, Type III F151 Component B

Product Code: 40-AH-86B

SECTION V – REACTIVITY DATA

STABILITY: Stable

CONDITIONS TO AVOID: High Temperatures

INCOMPATIBILITY (MATERIALS TO AVOID): Oxidizing materials

HAZARDOUS DECOMPOSITION OR BYPRODUCTS: May produce hazardous fumes when heated to decomposition as in welding.

HAZARDOUS POLYMERIZATION: Will not occur.

SECTION VI – HEALTH HAZARD DATA

INHALATION HEALTH RISKS AND SYMPTOMS OF EXPOSURE:
Anesthetic, excessive inhalation can cause irritation of the respiratory tract, or acute nervous system depression characterized by headache, dizziness, staggering gait, confusion, unconsciousness, coma and even asphyxiation.

INGESTION HEALTH RISKS & SYMPTOMS OF EXPOSURE:
Gastrointestinal irritation, nausea, vomiting and diarrhea. Aspiration into the lungs during ingestion or vomiting may cause mild to severe pulmonary injury and possibly even death.

SKIN & EYE CONTACT HEALTH RISKS AND SYMPTOMS OF EXPOSURE:
Skin: Moderate irritation, defatting, dermatitis. May be a sensitizer in some individuals. Eyes: Severe irritation, redness, tearing, blurred vision. May be a sensitizer in some individuals

HEALTH HAZARDS (ACUTE AND CHRONIC):
Reports have associated repeated and prolonged occupational overexposure to solvents with permanent brain and nervous system damage. Intentional misuse by deliberately concentrating and inhaling the contents may be harmful or fatal.

SKIN ABSORPTION HEALTH RISKS & SYMPTOMS OF EXPOSURE:
Liquid can be absorbed through the skin resulting in symptoms similar to the inhalation effects above.

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE:
Exposure to petroleum solvents may aggravate preexisting dermatitis.

CARCINOGENICITY:
NTP? No IARC MONOGRAPHS? No OSHA REGULATED? No

EMERGENCY AND FIRST AID PROCEDURES:
Skin: Wash affected areas with soap and water. Remove and launder contaminated clothing. Consult a physician if needed. Eyes: flush immediately with large amounts of water for at least 15 minutes. Take to a physician for medical treatment. Ingestion: Drink 1 or 2 glasses of water to dilute. Do not induce vomiting. Get medical help immediately.

SECTION VII – PRECAUTIONS FOR SAFE HANDLING AND USE

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED:
Remove all sources of ignition (flame, hot surfaces, and electrical, static or frictional sparks). Avoid breathing vapors. Ventilate area. Contain and remove with inert absorbent and non-sparking tools.

WASTE DISPOSAL METHOD:
Dispose of in accordance with local, state and federal regulations. Incinerate in approved facility. Do not incinerate closed containers.

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Do not store above 120 F. Store large quantities only in buildings designed to comply with OSHA 1910.106. Keep closures tight and container upright to prevent leakage. Do not store or use near heat, sparks or flame. Never use pressure to empty. Drum must not be washed out or used for other purposes. Drums of this material should be grounded when pouring.

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Do not get in eyes. Avoid skin contact. Can cause allergic respiratory reaction. Can cause allergic skin reaction. Prevent prolonged or repeated breathing of vapors or spray mist. Avoid breathing of sanding dust. Wash contaminated clothing thoroughly. Wash skin thoroughly with soap and water after handling. Close container after each use. Do not transfer this product to unlabeled containers. Do not handle until the manufacturer's safety precautions have been read and understood. Keep out of reach of children.

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VENTILATION:
All application areas should be ventilated in accordance to OSHA regulation 29 CFR 1910.94, 1910.107, 1910.108. Remove decomposition products formed during welding or flame cutting on surface coated with this product. If baking, vent fumes.

PROTECTIVE GLOVES:
Recommended.

EYE PROTECTION:
Safety eyewear including splashguards or side shields recommended.

OTHER PROTECTIVE CLOTHING OR EQUIPMENT:
Use protective outerwear and prevent prolonged skin contact with contaminated clothing.

WORK/HYGIENIC PRACTICES:
Avoid breathing vapors and contact with skin. Wash skin thoroughly before breaks and meals and at end of work period.

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Technical data for Macropoxy 646 Epoxy Primer

Sherwin Williams

Industrial & Marine Coatings

4.53 MACROPOXY® 646 FAST CURE EPOXY

PART A	B58-600	SERIES
PART B	B58V600	HARDENER

PRODUCT INFORMATION

Revised 9/07

PRODUCT DESCRIPTION

MACROPOXY 646 FAST CURE EPOXY is a high solids, high build, fast drying, polyamide epoxy designed to protect steel and concrete in industrial exposures. Ideal for maintenance painting and fabrication shop applications. The high solids content ensures adequate protection of sharp edges, corners, and welds. This product can be applied directly to marginally prepared steel surfaces.

- Low VOC
- Low odor
- Chemical resistant
- Abrasion resistant

RECOMMENDED USES

- Marine applications
- Fabrication shops
- Pulp and paper mills
- Power plants
- Offshore platforms
- Refineries
- Chemical plants
- Tank exteriors
- Water treatment plants
- Mill White and Black are acceptable for immersion use for salt water and fresh water, not acceptable for potable water
- Suitable for use in USDA inspected facilities

Conforms to AWWA D102-03 OCS #5

PRODUCT CHARACTERISTICS

Finish: Semi-Gloss

Color: Mill White, Black and a wide range of colors available through tinting

Volume Solids: 72% ± 2%, mixed
Mill White

Weight Solids: 85% ± 2%, mixed
Mill White

VOC (EPA Method 24): Unreduced: <250 g/L; 2.08 lb/gal
mixed Reduced 10%: <300 g/L; 2.50 lb/gal

Mix Ratio: 1:1 by volume

Recommended Spreading Rate per coat:
Wet mils: 7.0 - 13.5
Dry mils: 5.0 - 10.0*
Coverage: 116 - 232 sq ft/gal approximate

NOTE: Brush or roll application may require multiple coats to achieve maximum film thickness and uniformity of appearance.
*See Recommended Systems

Drying Schedule @ 7.0 mils wet and 50% RH:

	@ 40°F	@ 77°F	@ 100°F
To touch:	4-5 hours	2 hours	1½ hours
To handle:	48 hours	8 hours	4½ hours
To recoat:			
minimum:	48 hours	8 hours	4½ hours
maximum:	1 year	1 year	1 year
Cure for			
service:	10 days	7 days	4 days
immersion:	14 days	7 days	4 days

If maximum recoat time is exceeded, abrade surface before recoating.
Drying time is temperature, humidity and film thickness dependent.

Pot Life:	10 hours	4 hours	2 hours
Sweat-in-time:	30 minutes	30 minutes	15 minutes

Shelf Life: 36 months, unopened
Store indoors at 40°F to 100°F.

Flash Point: 91°F, TCC, mixed

Reducer/Clean Up: Reducer, R7K15
In California: Reducer R7K111 or Oxsol 100

PERFORMANCE CHARACTERISTICS

System Tested: (unless otherwise indicated)
Substrate: Steel
Surface Preparation: SSPC-SP10
1 ct. Macropoxy 646 Fast Cure @ 6.0 mils dft

Abrasion Resistance:
Method: ASTM D4060, CS17 wheel, 1000 cycles, 1 kg load
Result: 84 mg loss

Accelerated Weathering - QUV, Zinc Clad II Plus Primer:
Method: ASTM D4587, QUV-A, 12,000 hours
Results: passes

Adhesion:
Method: ASTM D4541
Result: 1,037 psi

Corrosion Weathering, Zinc Clad II Plus Primer:
Method: ASTM D5894, 36 cycles, 12,000 hours
Result: Rating 10 per ASTM D714 for blistering
Rating 9 per ASTM D610 for rusting

Direct Impact Resistance:
Method: ASTM D2794
Result: 30 in. lb.

Dry Heat Resistance:
Method: ASTM D2485
Result: 250°F

Exterior Durability:
Method: 1 year at 45° South
Result: Excellent, chalks

Flexibility:
Method: ASTM D522, 180° bend, 3/4" mandrel
Result: Passes

Humidity Resistance
Method: ASTM D4585, 6000 hrs
Result: No blistering, cracking, or rusting

Immersion:
Method: 1 year fresh and salt water
Result: Passes, no rusting, blistering, or loss of adhesion

Irradiation-Effects on Coatings used in Nuclear Power Plants
Method: ANSI 5.12 / ASTM D4082-89
Result: Passes

Pencil Hardness:
Method: ASTM D3363
Result: 3H

Water Vapor Permeance:
Method: ASTM D1653, Method B
Result: 1.16 grains/ perms

Salt Fog Resistance, Zinc Clad II Plus Primer::
Method: ASTM B117, 6,500 hours
Result: Rating 10 per ASTM D610 for rusting
Rating 9 per ASTM D1654 for corrosion

Slip Coefficient, Mill White:
Method: AISC Specification for Structural Joints Using ASTM A325 or ASTM A490 Bolts
Result: Class A, 0.36

Epoxy coatings may darken or discolor following application and curing.

Industrial & Marine Coatings

SHERWIN WILLIAMS.

4.53 MACROPOXY® 646 FAST CURE EPOXY

PART A	B58-600	SERIES
PART B	B58V600	HARDENER

PRODUCT INFORMATION

RECOMMENDED SYSTEMS

Immersion and atmospheric:

Steel:
2 cts. Macropoxy 646 @ 5.0 - 10.0 mils dft/ct

Concrete/Masonry, smooth:
2 cts. Macropoxy 646 @ 5.0 - 10.0 mils dft/ct

Concrete Block:
1 ct. Kem Cati-Coat HS Epoxy Filler/Sealer @ 10.0 - 20.0 mils dft, as needed to fill voids and provide a continuous substrate.
2 cts. Macropoxy 646 @ 5.0 - 10.0 mils dft/ct

Atmospheric:
***Steel:**
(Shop applied system, new construction, AWWA D102-03, can also be used at 3 mils minimum dft when used as an intermediate coat as part of a multi-coat system)
1 ct. Macropoxy 646 Fast Cure Epoxy @ 3.0 - 6.0 mils dft
1-2 cts. of recommended topcoat

Steel:
1 ct. Recoatable Epoxy Primer @ 4.0 - 6.0 mils dft
2 cts. Macropoxy 646 @ 5.0 - 10.0 mils dft/ct

***Steel:**
1 ct. Macropoxy 646 @ 4.0 - 6.0 mils dft
1-2 cts. Acrolon 218 Polyurethane @ 3.0 - 6.0 mils dft/ct
or Hi-Solids Polyurethane @ 3.0 - 5.0 mils dft/ct
or SherThane 2K Urethane @ 2.0 - 4.0 mils dft/ct

Steel:
2 cts. Macropoxy 646 @ 5.0 - 10.0 mils dft/ct
1-2 cts. Tile-Clad HS Epoxy @ 2.5 - 4.0 mils dft/ct

Steel:
1 ct. Zinc Clad II Plus @ 3.0 - 6.0 mils dft
1 ct. Macropoxy 646 @ 5.0 - 10.0 mils dft
1-2 cts. Acrolon 218 Polyurethane @ 3.0 - 6.0 mils dft/ct

Steel:
1 ct. Zinc Clad III HS @ 3.0 - 5.0 mils dft
or Zinc Clad IV @ 3.0 - 5.0 mils dft
1 ct. Macropoxy 646 @ 5.0 - 10.0 mils dft
1-2 cts. Acrolon 218 Polyurethane @ 3.0 - 6.0 mils dft/ct

Aluminum:
2 cts. Macropoxy 646 @ 5.0 - 10.0 mils dft/ct

Galvanizing:
2 cts. Macropoxy 646 @ 5.0 - 10.0 mils dft/ct

The systems listed above are representative of the product's use. Other systems may be appropriate.

SURFACE PREPARATION

Surface must be clean, dry, and in sound condition. Remove all oil, dust, grease, dirt, loose rust, and other foreign material to ensure good adhesion.
Refer to product Application Bulletin for detailed surface preparation information.
Minimum recommended surface preparation:

Iron & Steel	
Atmospheric:	SSPC-SP2/3
Immersion:	SSPC-SP10/NACE 2, 2-3 mil profile
Aluminum:	SSPC-SP1
Galvanizing:	SSPC-SP1
Concrete & Masonry	
Atmospheric:	SSPC-SP13/NACE 6, or ICRI 03732, CSP 1-3
Immersion:	SSPC-SP13/NACE 6-4.3.1 or 4.3.2, or ICRI 03732, CSP 1-3

TINTING

Tint Part Awith 844 Colorants at 150% strength. Five minutes minimum mixing on a mechanical shaker is required for complete mixing of color.

Tinting is not recommended for immersion service.

APPLICATION CONDITIONS

Temperature:	40°F minimum, 140°F maximum (air, surface, and material) At least 5°F above dew point
Relative humidity:	85% maximum

Refer to product Application Bulletin for detailed application information.

ORDERING INFORMATION

Packaging:	
Part A:	1 and 5 gallon containers
Part B:	1 and 5 gallon containers
Weight per gallon:	12.9 ± 0.2 lb mixed, may vary by color

SAFETY PRECAUTIONS

Refer to the MSDS sheet before use.

Published technical data and instructions are subject to change without notice. Contact your Sherwin-Williams representative for additional technical data and instructions.

DISCLAIMER

The information and recommendations set forth in this Product Data Sheet are based upon tests conducted by or on behalf of The Sherwin-Williams Company. Such information and recommendations set forth herein are subject to change and pertain to the product offered at the time of publication. Consult your Sherwin-Williams representative to obtain the most recent Product Data Information and Application Bulletin.

WARRANTY

The Sherwin-Williams Company warrants our products to be free of manufacturing defects in accord with applicable Sherwin-Williams quality control procedures. Liability for products proven defective, if any, is limited to replacement of the defective product or the refund of the purchase price paid for the defective product as determined by Sherwin-Williams. NO OTHER WARRANTY OR GUARANTEE OF ANY KIND IS MADE BY SHERWIN-WILLIAMS, EXPRESSED OR IMPLIED, STATUTORY, BY OPERATION OF LAW OR OTHERWISE, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

Sherwin Williams.

Industrial & Marine Coatings

4.53A MACROPOXY® 646 FAST CURE EPOXY

Part A	B58-600	Series
Part B	B58V600	Hardener

APPLICATION BULLETIN

Revised 9/07

Surface Preparation

Surface must be clean, dry, and in sound condition. Remove all oil, dust, grease, dirt, loose rust, and other foreign material to ensure adequate adhesion.

Iron & Steel, Atmospheric Service:
Minimum surface preparation is Hand Tool Clean per SSPC-SP2. Remove all oil and grease from surface by Solvent Cleaning per SSPC-SP1. For better performance, use Commercial Blast Cleaning per SSPC-SP6/NACE 3, blast clean all surfaces using a sharp, angular abrasive for optimum surface profile (2 mils). Prime any bare steel within 8 hours or before flash rusting occurs.

Iron & Steel, Immersion Service:
Remove all oil and grease from surface by Solvent Cleaning per SSPC-SP1. Minimum surface preparation is Near White Metal Blast Cleaning per SSPC-SP10/NACE 2. Blast clean all surfaces using a sharp, angular abrasive for optimum surface profile (2-3 mils). Remove all weld spatter and round all sharp edges by grinding. Prime any bare steel the same day as it is cleaned.

Aluminum
Remove all oil, grease, dirt, oxide and other foreign material by Solvent Cleaning per SSPC-SP1.

Galvanized Steel
Allow to weather a minimum of six months prior to coating. Solvent Clean per SSPC-SP1 (recommended solvent is VM&P Naphtha). When weathering is not possible, or the surface has been treated with chromates or silicates, first Solvent Clean per SSPC-SP1 and apply a test patch. Allow paint to dry at least one week before testing adhesion. If adhesion is poor, brush blasting per SSPC-SP7 is necessary to remove these treatments. Rusty galvanizing requires a minimum of Hand Tool Cleaning per SSPC-SP2, prime the area the same day as cleaned.

Concrete and Masonry, Atmospheric Service:
For surface preparation, refer to NACE 6/SSPC-SP13, or ICRI 03732, CSP 1-3. Surfaces should be thoroughly clean and dry. Concrete and mortar must be cured at least 28 days @ 75°F. Remove all loose mortar and foreign material. Surface must be free of laitance, concrete dust, dirt, form release agents, moisture curing membranes, loose cement and hardeners. Fill bug holes, air pockets and other voids with a cement patching compound. Weathered masonry and soft or porous cement board must be brush blasted or power tool cleaned to remove loosely adhering contamination and to get to a hard, firm surface. Laitance must be removed by etching with a 10% muriatic acid solution and thoroughly neutralized with water.

Concrete and Masonry, Immersion Service:
For surface preparation, refer to SSPC-SP13/NACE 6, Section 4.3.1 or 4.3.2, or ICRI 03732, CSP 1-3.

Previously Painted Surfaces
If in sound condition, clean the surface of all foreign material. Smooth, hard or glossy coatings and surfaces should be dulled by abrading the surface. Apply a test area, allowing paint to dry one week before testing adhesion. If adhesion is poor, or if this product attacks the previous finish, removal of the previous coating may be necessary. If paint is peeling or badly weathered, clean surface to sound substrate and treat as a new surface as above.

Application Conditions

Temperature:	40°F minimum, 140°F maximum (air, surface, and material) At least 5°F above dew point
Relative humidity:	85% maximum

Application Equipment

The following is a guide. Changes in pressures and tip sizes may be needed for proper spray characteristics. Always purge spray equipment before use with listed reducer. Any reduction must be compliant with existing VOC regulations and compatible with the existing environmental and application conditions.

Reducer/Clean Up .... Reducer R7K15
In California .... Reducer R7K111

Airless Spray
Pump 30:1
Pressure .... 2800 - 3000 psi
Hose .... 1/4" ID
Tip .... .017" - .023"
Filter .... 60 mesh
Reduction .... As needed up to 10% by volume

Conventional Spray
Gun .... DeVilbiss MBC-510
Fluid Tip .... E
Air Nozzle 704
Atomization Pressure .. 60-65 psi
Fluid Pressure .... 10-20 psi
Reduction .... As needed up to 10% by volume
Requires oil and moisture separators

Brush
Brush .... Nylon/Polyester or Natural Bristle
Reduction .... Not recommended

Roller
Cover .... 3/8" woven with phenolic core
Reduction .... Not recommended

If specific application equipment is listed above, equivalent equipment may be substituted.

SHERWIN WILLIAMS.

Industrial & Marine Coatings

4.53A
MACROPOXY® 646 FAST CURE EPOXY

PART A	B58-600	SERIES
PART B	B58V600	HARDENER

APPLICATION BULLETIN

APPLICATION PROCEDURES

Surface preparation must be completed as indicated.

Mix contents of each component thoroughly with power agitation. Make certain no pigment remains on the bottom of the can. Then combine one part by volume of Part A with one part by volume of Part B. Thoroughly agitate the mixture with power agitation. Allow the material to sweat-in as indicated prior to application. Re-stir before using.

If reducer solvent is used, add only after both components have been thoroughly mixed, after sweat-in.

Apply paint to the recommended film thickness and spreading rate as indicated below:

Recommended Spreading Rate per coat:

Wet mils:	7.0 - 13.5
Dry mils:	5.0 - 10.0*
Coverage:	116 - 232 sq ft/gal approximate

NOTE: Brush or roll application may require multiple coats to achieve maximum film thickness and uniformity of appearance.
* See Recommended Systems

Drying Schedule @ 7.0 mils wet and 50% RH:

	@ 40°F	@ 77°F	@ 100°F
To touch:	4-5 hours	2 hours	1½ hours
To handle:	48 hours	8 hours	4½ hours
To recoat:			
minimum:	48 hours	8 hours	4½ hours
maximum:	1 year	1 year	1 year
Cure for			
service:	10 days	7 days	4 days
immersion:	14 days	7 days	4 days

If maximum recoat time is exceeded, abrade surface before recoating.
Drying time is temperature, humidity and film thickness dependent.

Pot Life:	10 hours	4 hours	2 hours
Sweat-in-time:	30 minutes	30 minutes	15 minutes

Application of coating above maximum or below minimum recommended spreading rate may adversely affect coating performance.

PERFORMANCE TIPS

Stripe coat all crevices, welds, and sharp angles to prevent early failure in these areas.

When using spray application, use a 50% overlap with each pass of the gun to avoid holidays, bare areas, and pinholes. If necessary, cross spray at a right angle

Spreading rates are calculated on volume solids and do not include an application loss factor due to surface profile, roughness or porosity of the surface, skill and technique of the applicator, method of application, various surface irregularities, material lost during mixing, spillage, overthinning, climatic conditions, and excessive film build.

Excessive reduction of material can affect film build, appearance, and adhesion.

Do not mix previously catalyzed material with new.

Do not apply the material beyond recommended pot life.

In order to avoid blockage of spray equipment, clean equipment before use or before periods of extended downtime with Reducer R7K15. In California use Reducer R7K111.

Tinting is not recommended for immersion service.

Use only Mil White and Black for immersion service.

Quik-Kick Epoxy Accelerator is acceptable for use. See data page 4.99 for details.

Refer to Product Information sheet for additional performance characteristics and properties.

CLEAN UP INSTRUCTIONS

Clean spills and spatters immediately with Reducer R7K15. Clean tools immediately after use with Reducer R7K15. In California use Reducer R7K111. Follow manufacturer's safety recommendations when using any solvent.

SAFETY PRECAUTIONS

Refer to the MSDS sheet before use.

Published technical data and instructions are subject to change without notice. Contact your Sherwin-Williams representative for additional technical data and instructions.

MATERIAL SAFETY DATA SHEET

B58W610
09 00

Section 1 -- PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NUMBER	DATE OF PREPARATION	HMIS CODES	
		Health	3*
B58W610	09-OCT-07	Flammability	3
		Reactivity	0

PRODUCT NAME
MACROPOXY® 646 Fast Cure Epoxy Coating (Part A), Mill White

MANUFACTURER'S NAME
THE SHERWIN-WILLIAMS COMPANY
101 Prospect Avenue N.W.
Cleveland, OH 44115

TELEPHONE NUMBERS and WEBSITES
Product Information
www.sherwin-williams.com
Regulatory Information
(216) 566-2902 www.paintdocs.com
Medical Emergency
(216) 566-2917
Transportation Emergency for Chemical Emergency ONLY (spill, leak,
(800) 424-9300 fire, exposure, or accident)

Section 2 -- COMPOSITION/INFORMATION ON INGREDIENTS

% by WT	CAS No.	INGREDIENT		UNITS	VAPOR PRESSURE
3	100-41-4	Ethylbenzene			
		ACGIH TLV	100	ppm	7.1 mm
		ACGIH TLV	125	ppm STEL	
		OSHA PEL	100	ppm	
		OSHA PEL	125	ppm STEL	
15	1330-20-7	Xylene			
		ACGIH TLV	100	ppm	5.9 mm
		ACGIH TLV	150	ppm STEL	
		OSHA PEL	100	ppm	
		OSHA PEL	150	ppm STEL	
11	68410-23-1	Polyamide			
		ACGIH TLV	Not Available		
		OSHA PEL	Not Available		
9	14807-96-6	Talc			
		ACGIH TLV	2	mg/m3 as Resp. Dust	
		OSHA PEL	2	mg/m3 as Resp. Dust	
31	13463-67-7	Titanium Dioxide			
		ACGIH TLV	10	mg/m3 as Dust	
		OSHA PEL	10	mg/m3 Total Dust	
		OSHA PEL	5	mg/m3 Respirable Fraction	

Section 3 -- HAZARDS IDENTIFICATION

ROUTES OF EXPOSURE
INHALATION of vapor or spray mist.
EYE or SKIN contact with the product, vapor or spray mist.
EFFECTS OF OVEREXPOSURE
EYES: Irritation.
SKIN: Prolonged or repeated exposure may cause irritation.
INHALATION: Irritation of the upper respiratory system.
May cause nervous system depression. Extreme overexposure may result in unconsciousness and possibly death.
Prolonged overexposure to solvent ingredients in Section 2 may cause adverse effects to the liver, urinary and reproductive systems.
SIGNS AND SYMPTOMS OF OVEREXPOSURE
Headache, dizziness, nausea, and loss of coordination are indications of excessive exposure to vapors or spray mists.
Redness and itching or burning sensation may indicate eye or excessive skin exposure.
MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE
May cause allergic skin reaction in susceptible persons.
CANCER INFORMATION
For complete discussion of toxicology data refer to Section 11.

Section 4 -- FIRST AID MEASURES

EYES: Flush eyes with large amounts of water for 15 minutes. Get medical attention.
SKIN: Wash affected area thoroughly with soap and water. Remove contaminated clothing and launder before re-use.
INHALATION: If affected, remove from exposure. Restore breathing. Keep warm and quiet.
INGESTION: Do not induce vomiting. Get medical attention immediately.

Section 5 -- FIRE FIGHTING MEASURES

FLASH POINT	LEL	UEL
85 F PMCC	1.0	7.0

FLAMMABILITY CLASSIFICATION
RED LABEL -- Flammable, Flash below 100 F (38 C)
EXTINGUISHING MEDIA
Carbon Dioxide, Dry Chemical, Foam
UNUSUAL FIRE AND EXPLOSION HAZARDS
Closed containers may explode when exposed to extreme heat.
Application to hot surfaces requires special precautions.
During emergency conditions overexposure to decomposition products may cause a health hazard. Symptoms may not be immediately apparent. Obtain medical attention.

SPECIAL FIRE FIGHTING PROCEDURES

Full protective equipment including self-contained breathing apparatus should be used.

Water spray may be ineffective. If water is used, fog nozzles are preferable. Water may be used to cool closed containers to prevent pressure build-up and possible autoignition or explosion when exposed to extreme heat.

Section 6 -- ACCIDENTAL RELEASE MEASURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED

Remove all sources of ignition. Ventilate the area.

Remove with inert absorbent.

Section 7 -- HANDLING AND STORAGE

STORAGE CATEGORY

DOL Storage Class IC

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE

Contents are FLAMMABLE. Keep away from heat, sparks, and open flame.

During use and until all vapors are gone: Keep area ventilated - Do not smoke - Extinguish all flames, pilot lights, and heaters - Turn off stoves, electric tools and appliances, and any other sources of ignition.

Consult NFPA Code. Use approved Bonding and Grounding procedures.

Keep container closed when not in use. Transfer only to approved containers with complete and appropriate labeling. Do not take internally. Keep out of the reach of children.

Section 8 -- EXPOSURE CONTROLS/PERSONAL PROTECTION

PRECAUTIONS TO BE TAKEN IN USE

Use only with adequate ventilation.

Avoid contact with skin and eyes. Avoid breathing vapor and spray mist.

Wash hands after using.

This coating may contain materials classified as nuisance particulates (listed "as Dust" in Section 2) which may be present at hazardous levels only during sanding or abrading of the dried film. If no specific dusts are listed in Section 2, the applicable limits for nuisance dusts are ACGIH TLV 10 mg/m3 (total dust), 3 mg/m3 (respirable fraction), OSHA PEL 15 mg/m3 (total dust), 5 mg/m3 (respirable fraction).

VENTILATION

Local exhaust preferable. General exhaust acceptable if the exposure to materials in Section 2 is maintained below applicable exposure limits. Refer to OSHA Standards 1910.94, 1910.107, 1910.108.

RESPIRATORY PROTECTION

If personal exposure cannot be controlled below applicable limits by ventilation, wear a properly fitted organic vapor/particulate respirator approved by NIOSH/MSHA for protection against materials in Section 2.

When sanding or abrading the dried film, wear a dust/mist respirator approved by NIOSH/MSHA for dust which may be generated from this product, underlying paint, or the abrasive.

PROTECTIVE GLOVES

Wear gloves which are recommended by glove supplier for protection against materials in Section 2.

EYE PROTECTION
Wear safety spectacles with unperforated sideshields.
OTHER PRECAUTIONS
This product must be mixed with other components before use. Before opening the packages, READ AND FOLLOW WARNING LABELS ON ALL COMPONENTS.
Intentional misuse by deliberately concentrating and inhaling the contents can be harmful or fatal.

Section 9 -- PHYSICAL AND CHEMICAL PROPERTIES

PRODUCT WEIGHT	12.19 lb/gal	1460 g/l
SPECIFIC GRAVITY	1.47	
BOILING POINT	277 - 292 F	136 - 144 C
MELTING POINT	Not Available	
VOLATILE VOLUME	29 %	
EVAPORATION RATE	Slower than ether	
VAPOR DENSITY	Heavier than air	
SOLUBILITY IN WATER	N.A.	
VOLATILE ORGANIC COMPOUNDS	(VOC Theoretical - As Packaged)	
2.11 lb/gal 253 g/l	Less Water and Federally Exempt Solvents	
2.11 lb/gal 253 g/l	Emitted VOC	

Section 10 -- STABILITY AND REACTIVITY

STABILITY -- Stable
CONDITIONS TO AVOID
None known.
INCOMPATIBILITY
None known.
HAZARDOUS DECOMPOSITION PRODUCTS
By fire: Carbon Dioxide, Carbon Monoxide
HAZARDOUS POLYMERIZATION
Will not occur

Section 11 -- TOXICOLOGICAL INFORMATION

CHRONIC HEALTH HAZARDS
Reports have associated repeated and prolonged overexposure to solvents with permanent brain and nervous system damage.
Ethylbenzene is classified by IARC as possibly carcinogenic to humans (2B) based on inadequate evidence in humans and sufficient evidence in laboratory animals. Lifetime inhalation exposure of rats and mice to high ethylbenzene concentrations resulted in increases in certain types of cancer, including kidney tumors in rats and lung and liver tumors in mice. These effects were not observed in animals exposed to lower concentrations. There is no evidence that ethylbenzene causes cancer in humans.
IARC's Monograph No. 93 reports there is sufficient evidence of carcinogenicity in experimental rats exposed to titanium dioxide but inadequate evidence for carcinogenicity in humans and has assigned a Group 2B rating. In addition, the IARC summary concludes, "No significant exposure to titanium dioxide is thought to occur during the use of products in which titanium is bound to other materials, such as paint."

TOXICOLOGY DATA

CAS No.	Ingredient Name				
100-41-4	Ethylbenzene				
		LC50	RAT	4HR	Not Available
		LD50	RAT		3500 mg/kg
1330-20-7	Xylene				
		LC50	RAT	4HR	5000 ppm
		LD50	RAT		4300 mg/kg
68410-23-1	Polyamide				
		LC50	RAT	4HR	Not Available
		LD50	RAT		8000. mg/kg
14807-96-6	Talc				
		LC50	RAT	4HR	Not Available
		LD50	RAT		Not Available
13463-67-7	Titanium Dioxide				
		LC50	RAT	4HR	Not Available
		LD50	RAT		Not Available

Section 12 -- ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL INFORMATION
No data available.

Section 13 -- DISPOSAL CONSIDERATIONS

WASTE DISPOSAL METHOD
Waste from this product may be hazardous as defined under the Resource Conservation and Recovery Act (RCRA) 40 CFR 261.
Waste must be tested for ignitability to determine the applicable EPA hazardous waste numbers.
Incinerate in approved facility. Do not incinerate closed container. Dispose of in accordance with Federal, State/Provincial, and Local regulations regarding pollution.

Section 14 -- TRANSPORT INFORMATION

US Ground (DOT)
1 Gallon and Less may be Classed as CONSUMER COMMODITY, ORM-D
Larger Containers are Regulated as:
UN1263, PAINT, 3, PG III, (ERG#128)

DOT (Dept of Transportation) Hazardous Substances & Reportable Quantities
Ethyl benzene 1000 lb RQ
Xylenes (isomers and mixture) 100 lb RQ

Bulk Containers may be Shipped as (check reportable quantities):
RQ, UN1263, PAINT, 3, PG III, (XYLENES (ISOMERS AND MIXTURE)), (ERG#128)

Canada (TDG)
UN1263, PAINT, CLASS 3, PG III, LIMITED QUANTITY, (ERG#128)

IMO
UN1263, PAINT, CLASS 3, PG III, (29 C c.c.), EmS F-E, S-E

Section 15 -- REGULATORY INFORMATION

SARA 313 (40 CFR 372.65C) SUPPLIER NOTIFICATION

CAS No.	CHEMICAL/COMPOUND	% by WT	% Element
100-41-4	Ethylbenzene	3	
1330-20-7	Xylene	15	

CALIFORNIA PROPOSITION 65
WARNING: This product contains chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.
TSCA CERTIFICATION
All chemicals in this product are listed, or are exempt from listing, on the TSCA Inventory.

Section 16 -- OTHER INFORMATION

This product has been classified in accordance with the hazard criteria of the Canadian Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

The above information pertains to this product as currently formulated, and is based on the information available at this time. Addition of reducers or other additives to this product may substantially alter the composition and hazards of the product. Since conditions of use are outside our control, we make no warranties, express or implied, and assume no liability in connection with any use of this information.

Technical data for Tile-Clad Topcoat

Sherwin Williams

Industrial & Marine Coatings

4.30

TILE-CLAD® HIGH SOLIDS

Part A	B62Z	Series
Part B	B60VZ70	Gloss Hardener
Part B	B60VZ75	Eg-Shel Hardener

PRODUCT INFORMATION

Revised 4/07

Product Description

TILE-CLAD HIGH SOLIDS is a VOC compliant, two-package, epoxy-polyamide coating for use in industrial maintenance environments and high performance architectural applications.

- Chemical resistant
- Dry film resists bacterial attack
- Abrasion resistant
- Low VOC

Recommended Uses

For use over prepared substrates such as steel, galvanizing, and concrete in industrial environments.

- Laboratories
- Masonry surfaces
- Offshore structures
- Storage tanks
- Structural & support steel
- Institutional kitchens
- Lavatories
- Power plants
- Schools
- Marine applications
- Clean rooms
- Nuclear power facilities
- Chemical processing equipment
- Institutional & commercial wall coating
- Suitable for use in USDA inspected facilities

Conforms to AWWA D 102-03, OCS #5

Acceptable for use in high performance architectural applications.

Product Characteristics

Finish: Gloss and Eg-Shel

Color: Wide range of colors available, including safety colors

Volume Solids: 56% ± 2%, mixed, may vary by color

Weight Solids: 70% ± 2%, mixed, may vary by color

VOC (EPA Method 24): mixed — Unreduced: <400 g/L; 3.33 lb/gal; Reduced 10%: <413 g/L; 3.44 lb/gal

Mix Ratio: 1:1 by volume

Recommended Spreading Rate per coat:

Wet mils:	4.0 - 7.0
Dry mils:	2.5 - 4.0
Coverage:	225 - 359 sq ft/gal approximate

NOTE: Brush or roll application may require multiple coats to achieve maximum film thickness and uniformity of appearance.

Drying Schedule @ 4.0 mils wet @ 50% RH:

	@ 55°F	@ 77°F	@ 110°F
To touch:	3 hours	1 hour	20 minutes
Tack free:	6 hours	2 hours	30 minutes
To recoat:			
minimum	6 hours	2 hours	30 minutes
maximum:	30 days	30 days	30 days
To stack:	18 hours	16 hours	3 hours
To cure:	21 days	14 days	7 days
Pot life:	4 hours	4 hours	2 hours
Sweat-in-Time:	1 hour	30 minutes	10 minutes

If maximum recoat time is exceeded, abrade surface before recoating. Drying time is temperature, humidity, and film thickness dependent.

Shelf Life: 36 months, unopened. Store indoors at 40°F to 100°F.

Flash Point: 92°F, PMCC, mixed

Reducer/Clean Up: Reducer #54, R7K54-Spray; R6K25-Brush & Roll

Performance Characteristics

System Tested: (unless otherwise indicated)

Substrate: Steel

Surface Preparation: SSPC-SP6/NACE 3

1 ct. Recoatable Epoxy Primer @ 4.0 - 6.0 mils dft

1 ct. Tile-Clad HS @ 3.0 mils dft

Abrasion Resistance:
Method: ASTM D4060, CS17 wheel, 1000 cycles, 1 kg load
Result: 80 mg loss

Accelerated Weathering - QUV:
Method: ASTM D4587, QUV-A, 5,000 hours
Results: passes

Adhesion:
Method: ASTM D4541
Result: 1050 psi

Corrosion Weathering:
Method: ASTM D5894, 10 cycles, 3336 hours
Result: Rating 9 per ASTM D610 for rusting; Rating 10 per ASTM D714 for blistering

Direct Impact Resistance:
Method: ASTM D2794
Result: 95 in. lbs.

Dry Heat Resistance:
Method: ASTM D2485
Result: 200°F

Exterior Durability:
Method: 1 year 45° South
Result: Excellent, chalks

Flexibility:
Method: ASTM D522, 180° bend, 1/4" mandrel
Result: Passes

Irradiation-Effects on Coatings used in Nuclear Power Plants
Method: ANSI 5.12 / ASTM D4082-89
Result: Passes

Moisture Condensation Resistance:
Method: ASTM D4585, 100°F, 1000 hours
Result: Passes, no blistering, rust, or delamination

Pencil Hardness:
Method: ASTM D3363
Result: F-H

Salt Fog Resistance:
Method: ASTM B117, 2,500 hours
Result: Rating 10 per ASTM D610 for rusting; Rating 10 per ASTM D714 for blistering

Epoxy coatings may darken or yellow following application and curing.

Provides performance comparable to products formulated to federal specification: TT-C-535B

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Industrial & Marine Coatings

4.30

TILE-CLAD® HIGH SOLIDS

PART A	B62Z	SERIES
PART B	B60VZ70	GLOSS HARDENER
PART B	B60VZ75	EG-SHEL HARDENER

PRODUCT INFORMATION

RECOMMENDED SYSTEMS

Steel, epoxy primer:
1 ct. Recoatable Epoxy Primer @ 4.0 - 6.0 mils dft/ct
1-2 cts. Tile-Clad High Solids @ 2.5 - 4.0 mils dft/ct

Steel, universal primer:
1 ct. Kem Bond HS @ 2.0 - 5.0 mils dft/ct
1-2 cts. Tile-Clad High Solids @ 2.5 - 4.0 mils dft/ct

Steel, Acrylic Primer:
1 ct Pro-Cryl WB Universal Primer @ 2.0-4.0 mils dft
1-2 cts. Tile-Clad High Solids @ 2.5 - 4.0 mils dft/ct

Steel, epoxy mastic primer:
1 ct. Epoxy Mastic Aluminum II @ 4.0 - 6.0 mils dft/ct
1-2 cts. Tile-Clad High Solids @ 2.5 - 4.0 mils dft/ct

Aluminum:
1 ct. DTM Wash Primer @ 0.7 - 1.3 mils dft/ct
1-2 cts. Tile-Clad High Solids @ 2.5 - 4.0 mils dft/ct

Concrete Block:
1 ct. Heavy Duty Block Filler @ 10.0 - 18.0 mils dft/ct
1-2 cts. Tile-Clad High Solids @ 2.5 - 4.0 mils dft/ct

Galvanized Metal:
1-2 cts. Tile-Clad High Solids @ 2.5 - 4.0 mils dft/ct

Poured Concrete/Tilt-Up Concrete (including floors):
1-2 cts. Tile-Clad High Solids @ 2.5 - 4.0 mils dft/ct

Wood, including floors:
1-2 cts. Tile-Clad High Solids @ 2.5 - 4.0 mils dft/ct

The systems listed above are representative of the product's use. Other systems may be appropriate.

SURFACE PREPARATION

Surface must be clean, dry, and in sound condition. Remove all oil, dust, grease, dirt, loose rust, and other foreign material to ensure adequate adhesion.

Refer to product Application Bulletin for detailed surface preparation information.

Minimum recommended surface preparation:

* Iron & Steel:	SSPC-SP2
Aluminum:	SSPC-SP1
Galvanizing:	SSPC-SP1
Concrete & Masonry:	SSPC-SP13/NACE 6, or ICRI 03732, CSP 1-3
Wood, interior:	Clean, smooth, dust free

* Primer required

TINTING

Tint Part A with 844 colorants or Blend-A-Color Toner at 200% strength into Part A. Five minutes minimum mixing on a mechanical shaker is required for complete mixing of color.

APPLICATION CONDITIONS

Temperature:	55°F minimum, 110°F maximum (air, surface, and material) At least 5°F above dew point
Relative humidity:	85% maximum

Refer to product Application Bulletin for detailed application information.

ORDERING INFORMATION

Packaging: Parts A & B:	1 and 5 gallon containers
Weight per gallon:	10.78 ± 0.2 lb mixed, may vary by color

SAFETY PRECAUTIONS

Refer to the MSDS sheet before use.

Published technical data and instructions are subject to change without notice. Contact your Sherwin-Williams representative for additional technical data and instructions.

DISCLAIMER

The information and recommendations set forth in this Product Data Sheet are based upon tests conducted by or on behalf of The Sherwin-Williams Company. Such information and recommendations set forth herein are subject to change and pertain to the product offered at the time of publication. Consult your Sherwin-Williams representative to obtain the most recent Product Data Information and Application Bulletin.

WARRANTY

The Sherwin-Williams Company warrants our products to be free of manufacturing defects in accord with applicable Sherwin-Williams quality control procedures. Liability for products proven defective, if any, is limited to replacement of the defective product or the refund of the purchase price paid for the defective product as determined by Sherwin-Williams. NO OTHER WARRANTY OR GUARANTEE OF ANY KIND IS MADE BY SHERWIN-WILLIAMS, EXPRESSED OR IMPLIED, STATUTORY, BY OPERATION OF LAW OR OTHERWISE, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

SHERWIN WILLIAMS.

Industrial & Marine Coatings

4.30A

TILE-CLAD® HIGH SOLIDS

PART A	B62Z	SERIES
PART B	B60VZ70	GLOSS HARDENER
PART B	B60VZ75	EG-SHEL HARDENER

APPLICATION BULLETIN

Revised 4/07

SURFACE PREPARATION

Surface must be clean, dry, and in sound condition. Remove all oil, dust, grease, dirt, loose rust, and other foreign material to ensure adequate adhesion.

Iron & Steel
Minimum surface preparation is Hand Tool Clean per SSPC-SP2. Remove all oil and grease from surface by Solvent Cleaning per SSPC-SP1. For better performance, use Commercial Blast Cleaning per SSPC-SP6/NACE 3, blast clean all surfaces using a sharp, angular abrasive for optimum surface profile (2 mils). Prime any bare steel within 8 hours or before flash rusting occurs. Primer Required.

Aluminum
Remove all oil, grease, dirt, oxide and other foreign material by Solvent Cleaning per SSPC-SP1. Primer Required.

Galvanized Steel
Allow to weather a minimum of six months prior to coating. Remove all oil, grease, dirt, oxide and other foreign material by Solvent Cleaning per SSPC-SP1. When weathering is not possible, or the surface has been treated with chromates or silicates, first Solvent Clean per SSPC-SP1 and apply a test patch. Allow paint to dry at least one week before testing adhesion. If adhesion is poor, brush blasting per SSPC-SP7 is necessary to remove these treatments. Rusty galvanizing requires a minimum of Hand Tool Cleaning per SSPC-SP2, prime the area the same day as cleaned.

Concrete and Masonry
For surface preparation, refer to SSPC-SP13/NACE 6, or ICRI 03732, CSP 1-3. Surfaces must be clean, dry, sound and offer sufficient profile to achieve adequate adhesion. Concrete and mortar must be cured at least 28 days @ 75°F. Remove all loose mortar and foreign material. Surface must be free of laitance, concrete dust, dirt, form release agents, moisture curing membranes, loose cement and hardeners. Fill bug holes, air pockets and other voids with ArmorSeal Crack Filler.

Wood
Surface must be clean, dry and sound. Remove any oils and dirt from the surface using a degreasing solvent or strong detergent. Sand to remove any loose or deteriorated surface wood and to obtain a proper surface profile. Prime with recommended primer and paint as soon as possible. No painting should be done immediately after a rain or during foggy weather. Knots and pitch streaks must be scraped or sanded and spot primed before full coat of primer is applied. All nail holes or small openings must be properly caulked.

APPLICATION CONDITIONS

Temperature:	55°F minimum, 110°F maximum (air, surface, and material) At least 5°F above dew point
Relative humidity:	85% maximum

APPLICATION EQUIPMENT

The following is a guide. Changes in pressures and tip sizes may be needed for proper spray characteristics. Always purge spray equipment before use with listed reducer. Any reduction must be compliant with existing VOC regulations and compatible with the existing environmental and application conditions.

Reducer/Clean Up .... Reducer #54, R7K54, R6K25

Airless Spray
- Pressure .... 2400 psi
- Hose .... 3/8" ID
- Tip .... .019"
- Filter .... 60 mesh
- Reduction .... R7K54 as needed up to 10% by volume

Conventional Spray
- Gun .... Binks 95
- Fluid Nozzle 66
- Air Nozzle .... 69 PB
- Atomization Pressure ... 60 psi
- Fluid Pressure .... 20 psi
- Reduction .... R7K54 as needed up to 10% by volume

Brush
- Brush .... Nylon/Polyester or Natural Bristle
- Reduction .... R6K25 as needed up to 10% by volume

Roller
- Cover .... 1/4"-3/8" " woven with phenolic core
- Reduction .... R6K25 as needed up to 10% by volume

If specific application equipment is not listed above, equivalent equipment may be substituted.

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Industrial & Marine Coatings

4.30A

TILE-CLAD® HIGH SOLIDS

PART A	B62Z	SERIES
PART B	B60VZ70	GLOSS HARDENER
PART B	B60VZ75	EG-SHEL HARDENER

APPLICATION BULLETIN

APPLICATION PROCEDURES

Surface preparation must be completed as indicated.

Mix contents of each component thoroughly with power agitation. Make certain no pigment remains on the bottom of the cans. Then combine one part by volume of Part A with one part by volume of Part B. Thoroughly agitate the mixture with power agitation. Allow the material to sweat-in as indicated. Re-stir before using.

If reducer solvent is used, add only after both components have been thoroughly mixed, after sweat-in.

Apply paint at the recommended film thickness and spreading rate as indicated below:

Recommended Spreading Rate per coat:

Wet mils:	4.0 - 7.0
Dry mils:	2.5 - 4.0
Coverage:	225 - 359 sq ft/gal approximate

NOTE: Brush or roll application may require multiple coats to achieve maximum film thickness and uniformity of appearance.

Drying Schedule @ 4.0 mils wet @ 50% RH:

	@ 55°F	@ 77°F	@ 110°F
To touch:	3 hours	1 hour	20 minutes
Tack free:	6 hours	2 hours	30 minutes
To recoat:			
minimum	6 hours	2 hours	30 minutes
maximum:	30 days	30 days	30 days
To stack:	18 hours	16 hours	3 hours
To cure:	21 days	14 days	7 days
Pot life:	4 hours	4 hours	2 hours
Sweat-in-Time:	1 hour	30 minutes	10 minutes

If maximum recoat time is exceeded, abrade surface before recoating. Drying time is temperature, humidity, and film thickness dependent.

Application of coating below minimum or above maximum recommended spreading rate may adversely affecting coating performance.

PERFORMANCE TIPS

Stripe coat all crevices, welds, and sharp angles to prevent early failure in these areas.

When using spray application, use a 50% overlap with each pass of the gun to avoid holidays, bare areas, and pinholes. If necessary, cross spray at a right angle.

Spreading rates are calculated on volume solids and do not include an application loss factor due to surface profile, roughness or porosity of the surface, skill and technique of the applicator, method of application, various surface irregularities, material lost during mixing, spillage, overthinning, climatic conditions, and excessive film build.

Excessive reduction of material can affect film build, appearance, and adhesion.

Do not apply the material beyond recommended pot life.

Do not mix previously catalyzed material with new.

In order to avoid blockage of spray equipment, clean equipment before use or before periods of extended downtime with Reducer #54, R7K54.

Quik-Kick Epoxy Accelerator is acceptable for use. See data page 4.99 for details.

Refer to Product Information sheet for additional performance characteristics and properties.

CLEAN UP INSTRUCTIONS

Clean spills and spatters immediately with Reducer #54, R7K54. Clean tools immediately after use with Reducer #54, R7K54. Follow manufacturer's safety recommendations when using any solvent.

SAFETY PRECAUTIONS

Refer to the MSDS sheet before use.

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MATERIAL SAFETY DATA SHEET

B62WZ111
20 00

Section 1 -- PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NUMBER	DATE OF PREPARATION	HMIS CODES	
		Health	2*
B62WZ111	09-OCT-07	Flammability	3
		Reactivity	0

PRODUCT NAME
TILE-CLAD® HS High Solids Epoxy (Part A), Extra White

MANUFACTURER'S NAME
THE SHERWIN-WILLIAMS COMPANY
101 Prospect Avenue N.W.
Cleveland, OH 44115

TELEPHONE NUMBERS and WEBSITES
Product Information
www.sherwin-williams.com
Regulatory Information
(216) 566-2902 www.paintdocs.com
Medical Emergency
(216) 566-2917
Transportation Emergency for Chemical Emergency ONLY (spill, leak,
(800) 424-9300 fire, exposure, or accident)

Section 2 -- COMPOSITION/INFORMATION ON INGREDIENTS

% by WT	CAS No.	INGREDIENT		UNITS	VAPOR PRESSURE
2	100-41-4	Ethylbenzene			
		ACGIH TLV	100	ppm	7.1 mm
		ACGIH TLV	125	ppm STEL	
		OSHA PEL	100	ppm	
		OSHA PEL	125	ppm STEL	
13	1330-20-7	Xylene			
		ACGIH TLV	100	ppm	5.9 mm
		ACGIH TLV	150	ppm STEL	
		OSHA PEL	100	ppm	
		OSHA PEL	150	ppm STEL	
1	64742-95-6	Light Aromatic Hydrocarbons			
		ACGIH TLV	Not Available		3.8 mm
		OSHA PEL	Not Available		
2	108-67-8	1,3,5-Trimethylbenzene			
		ACGIH TLV	25	ppm	2 mm
		OSHA PEL	25	ppm	
3	95-63-6	1,2,4-Trimethylbenzene			
		ACGIH TLV	25	ppm	2.03 mm
		OSHA PEL	25	ppm	
1	71-36-3	1-Butanol			
		ACGIH TLV	20	ppm (Skin)	5.5 mm
		OSHA PEL	50	ppm (Skin) CEILING	
2	111-76-2	2-Butoxyethanol			
		ACGIH TLV	20	ppm	0.88 mm
		OSHA PEL	25	ppm	

```
    19    Proprietary  Polyamide
                            ACGIH TLV  Not Available
                            OSHA  PEL  Not Available
    34     13463-67-7  Titanium Dioxide
                            ACGIH TLV     10  mg/m3 as Dust
                            OSHA  PEL     10  mg/m3 Total Dust
                            OSHA  PEL      5  mg/m3 Respirable Fraction
```

Section 3 -- HAZARDS IDENTIFICATION

ROUTES OF EXPOSURE
   INHALATION of vapor or spray mist.
   EYE or SKIN contact with the product, vapor or spray mist.
EFFECTS OF OVEREXPOSURE
         EYES: Irritation.
         SKIN: Prolonged or repeated exposure may cause irritation.
   INHALATION: Irritation of the upper respiratory system.
   May cause nervous system depression. Extreme overexposure may result i unconsciousness and possibly death.
   Prolonged overexposure to solvent ingredients in Section 2 may cause adverse effects to the liver, urinary, blood forming and reproductive systems.
SIGNS AND SYMPTOMS OF OVEREXPOSURE
   Headache, dizziness, nausea, and loss of coordination are indications o excessive exposure to vapors or spray mists.
   Redness and itching or burning sensation may indicate eye or excessive skin exposure.
MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE
   May cause allergic skin reaction in susceptible persons or skin sensitization.
CANCER INFORMATION
  For complete discussion of toxicology data refer to Section 11.

Section 4 -- FIRST AID MEASURES

EYES: Flush eyes with large amounts of water for 15 minutes. Get medical attention.
SKIN: Wash affected area thoroughly with soap and water. If irritation persists or occurs later, get medical attention. Remove contaminated clothing and launder before re-use.
INHALATION: If affected, remove from exposure. Restore breathing. Keep warm and quiet.
INGESTION: Do not induce vomiting. Get medical attention immediately.

Section 5 -- FIRE FIGHTING MEASURES

```
FLASH POINT                         LEL      UEL
    85 F PMCC                       0.7      11.2
```

FLAMMABILITY CLASSIFICATION
   RED LABEL -- Flammable, Flash below 100 F (38 C)
EXTINGUISHING MEDIA
   Carbon Dioxide, Dry Chemical, Foam

UNUSUAL FIRE AND EXPLOSION HAZARDS

Closed containers may explode when exposed to extreme heat.

Application to hot surfaces requires special precautions.

During emergency conditions overexposure to decomposition products may cause a health hazard. Symptoms may not be immediately apparent. Obtain medical attention.

SPECIAL FIRE FIGHTING PROCEDURES

Full protective equipment including self-contained breathing apparatus should be used.

Water spray may be ineffective. If water is used, fog nozzles are preferable. Water may be used to cool closed containers to prevent pressure build-up and possible autoignition or explosion when exposed to extreme heat.

Section 6 -- ACCIDENTAL RELEASE MEASURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED

Remove all sources of ignition. Ventilate the area.

Remove with inert absorbent.

Section 7 -- HANDLING AND STORAGE

STORAGE CATEGORY

DOL Storage Class IC

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE

Contents are FLAMMABLE. Keep away from heat, sparks, and open flame.

During use and until all vapors are gone: Keep area ventilated - Do not smoke - Extinguish all flames, pilot lights, and heaters - Turn off stoves, electric tools and appliances, and any other sources of ignition.

Consult NFPA Code. Use approved Bonding and Grounding procedures.

Keep container closed when not in use. Transfer only to approved containers with complete and appropriate labeling. Do not take internally. Keep out of the reach of children.

Section 8 -- EXPOSURE CONTROLS/PERSONAL PROTECTION

PRECAUTIONS TO BE TAKEN IN USE

Use only with adequate ventilation.

Avoid contact with skin and eyes. Avoid breathing vapor and spray mist.

Wash hands after using.

This coating may contain materials classified as nuisance particulates (listed "as Dust" in Section 2) which may be present at hazardous levels only during sanding or abrading of the dried film. If no specific dusts are listed in Section 2, the applicable limits for nuisance dusts are ACGIH TLV 10 mg/m3 (total dust), 3 mg/m3 (respirable fraction), OSHA PEL 15 mg/m3 (total dust), 5 mg/m3 (respirable fraction).

VENTILATION

Local exhaust preferable. General exhaust acceptable if the exposure to materials in Section 2 is maintained below applicable exposure limits. Refer to OSHA Standards 1910.94, 1910.107, 1910.108.

RESPIRATORY PROTECTION

If personal exposure cannot be controlled below applicable limits by ventilation, wear a properly fitted organic vapor/particulate respirator approved by NIOSH/MSHA for protection against materials in Section 2.

When sanding or abrading the dried film, wear a dust/mist respirator approved by NIOSH/MSHA for dust which may be generated from this product, underlying paint, or the abrasive.

PROTECTIVE GLOVES

Wear gloves which are recommended by glove supplier for protection against materials in Section 2.

EYE PROTECTION

Wear safety spectacles with unperforated sideshields.

OTHER PROTECTIVE EQUIPMENT

Use of barrier cream on exposed skin is recommended.

OTHER PRECAUTIONS

This product must be mixed with other components before use. Before opening the packages, READ AND FOLLOW WARNING LABELS ON ALL COMPONENTS.

Intentional misuse by deliberately concentrating and inhaling the contents can be harmful or fatal.

Section 9 -- PHYSICAL AND CHEMICAL PROPERTIES

PRODUCT WEIGHT	12.53 lb/gal	1500 g/l
SPECIFIC GRAVITY	1.51	
BOILING POINT	243 - 360 F	117 - 182 C
MELTING POINT	Not Available	
VOLATILE VOLUME	43 %	
EVAPORATION RATE	Slower than ether	
VAPOR DENSITY	Heavier than air	
SOLUBILITY IN WATER	N.A.	
VOLATILE ORGANIC COMPOUNDS	(VOC Theoretical - As Packaged)	
3.14 lb/gal 377 g/l	Less Water and Federally Exempt Solvents	
3.14 lb/gal 377 g/l	Emitted VOC	

Section 10 -- STABILITY AND REACTIVITY

STABILITY -- Stable

CONDITIONS TO AVOID

None known.

INCOMPATIBILITY

None known.

HAZARDOUS DECOMPOSITION PRODUCTS

By fire: Carbon Dioxide, Carbon Monoxide

HAZARDOUS POLYMERIZATION

Will not occur

Section 11 -- TOXICOLOGICAL INFORMATION

CHRONIC HEALTH HAZARDS

Reports have associated repeated and prolonged overexposure to solvents with permanent brain and nervous system damage.

Ethylbenzene is classified by IARC as possibly carcinogenic to humans (2B) based on inadequate evidence in humans and sufficient evidence in laboratory animals. Lifetime inhalation exposure of rats and mice to high ethylbenzene concentrations resulted in increases in certain types of cancer, including kidney tumors in rats and lung and liver tumors in mice. These effects were not observed in animals exposed to lower concentrations. There is no evidence that ethylbenzene causes cancer in humans.

IARC's Monograph No. 93 reports there is sufficient evidence of carcinogenicity in experimental rats exposed to titanium dioxide but inadequate evidence for carcinogenicity in humans and has assigned a Group 2B rating. In addition, the IARC summary concludes, "No significant exposure to titanium dioxide is thought to occur during the use of products in which titanium is bound to other materials, such as paint."

TOXICOLOGY DATA

CAS No.	Ingredient Name					
100-41-4	Ethylbenzene					
		LC50	RAT	4HR	Not Available	
		LD50	RAT		3500	mg/kg
1330-20-7	Xylene					
		LC50	RAT	4HR	5000	ppm
		LD50	RAT		4300	mg/kg
64742-95-6	Light Aromatic Hydrocarbons					
		LC50	RAT	4HR	Not Available	
		LD50	RAT		Not Available	
108-67-8	1,3,5-Trimethylbenzene					
		LC50	RAT	4HR	Not Available	
		LD50	RAT		Not Available	
95-63-6	1,2,4-Trimethylbenzene					
		LC50	RAT	4HR	Not Available	
		LD50	RAT		Not Available	
71-36-3	1-Butanol					
		LC50	RAT	4HR	8000	ppm
		LD50	RAT		790	mg/kg
111-76-2	2-Butoxyethanol					
		LC50	RAT	4HR	Not Available	
		LD50	RAT		470	mg/kg
Proprietary	Polyamide					
		LC50	RAT	4HR	Not Available	
		LD50	RAT		Not Available	
13463-67-7	Titanium Dioxide					
		LC50	RAT	4HR	Not Available	
		LD50	RAT		Not Available	

Section 12 -- ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL INFORMATION

No data available.

Section 13 -- DISPOSAL CONSIDERATIONS

WASTE DISPOSAL METHOD

Waste from this product may be hazardous as defined under the Resource Conservation and Recovery Act (RCRA) 40 CFR 261.

Waste must be tested for ignitability to determine the applicable EPA hazardous waste numbers.

Incinerate in approved facility. Do not incinerate closed container. Dispose of in accordance with Federal, State/Provincial, and Local regulations regarding pollution.

Section 14 -- TRANSPORT INFORMATION

US Ground (DOT)
1 Gallon and Less may be Classed as CONSUMER COMMODITY, ORM-D
Larger Containers are Regulated as:
UN1263, PAINT, 3, PG III, (ERG#128)

DOT (Dept of Transportation) Hazardous Substances & Reportable Quantities
Ethyl benzene 1000 lb RQ
Xylenes (isomers and mixture) 100 lb RQ

Bulk Containers may be Shipped as (check reportable quantities):
RQ, UN1263, PAINT, 3, PG III, (XYLENES (ISOMERS AND MIXTURE)), (ERG#128)

Canada (TDG)
UN1263, PAINT, CLASS 3, PG III, LIMITED QUANTITY, (ERG#128)

IMO
UN1263, PAINT, CLASS 3, PG III, (29 C c.c.), EmS F-E, S-E

Section 15 -- REGULATORY INFORMATION

SARA 313 (40 CFR 372.65C) SUPPLIER NOTIFICATION

CAS No.	CHEMICAL/COMPOUND	% by WT	% Element
100-41-4	Ethylbenzene	2	
1330-20-7	Xylene	13	
95-63-6	1,2,4-Trimethylbenzene	3	
71-36-3	1-Butanol	1	
	Glycol Ethers	2	

CALIFORNIA PROPOSITION 65

WARNING: This product contains chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.

TSCA CERTIFICATION

All chemicals in this product are listed, or are exempt from listing, on the TSCA Inventory.

Section 16 -- OTHER INFORMATION

This product has been classified in accordance with the hazard criteria of the Canadian Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

Appendix D: Water Chemistry Results

These data are from samples taken April – December 2008, plus an additional set of samples of Fort Bragg tap water collected in June 2009.

Ft.Bragg	Tower #1	Tower #2	Tower #3	Tower #4	Tower #5
Date Collected	4/28/2008	4/28/2008	4/28/2008	4/28/2008	4/28/2008
Hardness (as $CaCO_3$)	NA	21	13	71	60
Iron (as Fe)	NA	0.04	0.03	0.03	1.02
Copper (as Cu)	NA	0.08	0.02	0.01	0.02
Zinc (as Zn)	NA	0.35	0.15	0.09	0.38
Aluminum (as Al)	NA	0.05	0.09	0.07	0.17
Organic Phosphate (as PO_4)	NA	0.30	1.00	2.50	2.40
Orthophosphate (as PO_4)	NA	2.44	3.29	16.76	8.23
pH	NA	7.06	6.56	8.37	10.37
Conductivity uS/cm	NA	124	124	859	829
Date Collected	6/4/2008	6/4/2008	6/4/2008	6/4/2008	6/4/2008
Hardness (as $CaCO_3$)	NA	66	43	55	51
Iron (as Fe)	NA	0.09	0.12	0.02	0.93
Copper (as Cu)	NA	0.12	0.01	0.01	0.02
Zinc (as Zn)	NA	0.33	0.16	0.11	0.27
Aluminum (as Al)	NA	0.21	0.16	0.29	0.15
Organic Phosphate (as PO_4)	NA	0.34	2.10	2.60	2.00
Orthophosphate (as PO_4)	NA	14.57	16.60	16.95	6.73
pH	NA	7.36	8.19	9.12	6.66
Conductivity uS/cm	NA	1011	401	921	691
Date Collected	6/25/2008	6/25/2008	6/25/2008	6/25/2008	6/25/2008
Hardness (as $CaCO_3$)	NA	57	51	55	31
Iron (as Fe)	NA	0.03	0.06	0.11	0.03
Copper (as Cu)	NA	0.10	0.01	0.01	0.01
Zinc (as Zn)	NA	0.25	0.15	0.23	0.06
Aluminum (as Al)	NA	0.26	0.32	0.17	0.00
Organic Phosphate (as PO_4)	NA	3.10	3.10	2.20	2.10
Orthophosphate (as PO_4)	NA	14.11	17.43	15.16	9.87
pH	NA	7.62	8.22	9.14	10.40
Conductivity uS/cm	NA	914	848	860	861
Date Collected	7/23/2008	7/23/2008	7/23/2008	7/23/2008	7/23/2008
Hardness (as $CaCO_3$)	31	52	57	49	58
Iron (as Fe)	0.09	0.05	0.07	0.02	0.10
Copper (as Cu)	0.03	0.08	0.02	0.01	0.01
Zinc (as Zn)	0.29	0.42	0.26	0.14	0.17
Aluminum (as Al)	0.08	0.42	0.29	0.42	0.22
Organic Phosphate (as PO_4)	0.90	4.00	3.50	4.30	2.30
Orthophosphate (as PO_4)	4.69	14.87	17.12	15.30	11.21
pH	9.88	7.30	7.21	7.41	9.61
Conductivity uS/cm	548	839	876	883	867

Ft.Bragg	Tower #1	Tower #2	Tower #3	Tower #4	Tower #5
Date Collected	**8/21/2008**	**8/21/2008**	**8/21/2008**	**8/21/2008**	**8/21/2008**
Hardness (as $CaCO_3$)	21	55	63	56	46
Iron (as Fe)	0.07	0.18	0.09	0.09	0.51
Copper (as Cu)	0.02	0.06	0.02	0.02	0.01
Zinc (as Zn)	0.30	0.59	0.21	0.28	0.23
Aluminum (as Al)	0.06	0.69	0.33	0.37	0.16
Organic Phosphate (as PO_4)	0.50	3.30	3.00	3.40	1.40
Orthophosphate (as PO_4)	2.53	14.75	16.14	16.05	6.72
pH	10.29	7.76	7.59	7.13	10.12
Conductivity uS/cm	347	943	898	911	690
Date Collected	**9/30/2008**	**9/30/2008**	**9/30/2008**	**9/30/2008**	**9/30/2008**
Hardness (as $CaCO_3$)	13	198	143	135	38
Iron (as Fe)	0.00	0.38	0.33	0.33	0.62
Copper (as Cu)	0.01	0.11	0.03	0.01	0.02
Zinc (as Zn)	0.09	1.79	0.99	0.76	0.22
Aluminum (as Al)	0.00	2.02	1.99	1.83	0.14
Organic Phosphate (as PO_4)	0.20	3.10	3.30	2.00	1.30
Orthophosphate (as PO_4)	0.83	6.88	7.91	6.41	6.21
pH	9.25	7.28	7.27	8.99	9.90
Conductivity uS/cm	109	983	813	857	508
Date Collected	**10/22/2008**	**10/22/2008**	**10/22/2008**	**10/22/2008**	**10/22/2008**
Hardness (as $CaCO_3$)	16	195	201	179	34
Iron (as Fe)	0.00	0.12	0.21	0.01	0.95
Copper (as Cu)	0.01	0.07	0.04	0.01	0.02
Zinc (as Zn)	0.09	1.04	0.69	0.17	0.22
Aluminum (as Al)	0.00	0.44	0.87	0.13	0.10
Organic Phosphate (as PO_4)	0.20	2.10	2.80	2.10	1.20
Orthophosphate (as PO_4)	0.98	7.26	7.44	6.88	5.04
pH	9.39	6.92	6.87	6.95	9.93
Conductivity uS/cm	118	827	924	898	490
Date Collected	**11/24/2008**	**11/24/2008**	**11/24/2008**	**11/24/2008**	**11/24/2008**
Hardness (as $CaCO_3$)	31	31	159	122	67
Iron (as Fe)	0.01	0.05	0.21	0.32	0.80
Copper (as Cu)	0.02	0.01	0.03	0.02	0.02
Zinc (as Zn)	1.22	0.20	0.63	0.50	0.51
Aluminum (as Al)	0.07	0.26	0.63	0.04	0.06
Organic Phosphate (as PO_4)	0.30	0.30	2.00	1.10	1.00
Orthophosphate (as PO_4)	1.32	0.45	6.93	5.56	4.57
pH	6.63	6.50	6.79	6.94	7.08
Conductivity uS/cm	168	103	714	680	522

Ft.Bragg	Tower #1	Tower #2	Tower #3	Tower #4	Tower #5
Date Collected	12/30/2008	12/30/2008	12/30/2008	12/30/2008	12/30/2008
Hardness (as $CaCO_3$)	25	32	118	86	79
Iron (as Fe)	0.00	0.01	0.23	0.64	0.82
Copper (as Cu)	0.01	0.01	0.02	0.02	0.02
Zinc (as Zn)	1.26	0.21	0.57	0.52	0.53
Aluminum (as Al)	0.05	0.12	0.44	0.05	0.05
Organic Phosphate (as PO_4)	0.10	0.20	1.60	0.80	0.80
Orthophosphate (as PO_4)	1.00	0.28	5.64	4.18	3.68
pH	6.73	6.49	6.87	6.98	6.94
Conductivity uS/cm	130	112	533	528	507

Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: 820627

Maintaining Scale Facilities since 1949

Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cold Distribution*	***Attention:***	*Mr. Vince Hock*
Location:	*Ft. Bragg Cooling Tap H2*	***Additional Information:***	
Date Collected:	*06/12/09*		

Parameter	*Value*		*Units*
M Alkalinity (as CaCO3)	13		mg/L
Hardness (as CaCO3)	31		mg/L
Calcium (Ca)	11.4		mg/L
Magnesium (Mg)	0.72		mg/L
Sulfate (SO4)	17		mg/L
Chloride (Cl)	11		mg/L
Iron (Fe)	0.04		mg/L
Copper (Cu)	0		mg/L
Zinc (Zn)	0.08		mg/L
Aluminum (Al)	0.20		mg/L
Sodium (Na)	4.1		mg/L
Potassium (K)	1.2		mg/L
Lead (Pb)	<0.10		mg/L
Manganese (Mn)	0.01		mg/L
Polyphosphate (PO4)	0.1		mg/L
Orthophosphate (PO4)	0.55		mg/L
Total Dissolved Solids	60	Calculated	mg/L
pH	7.55	lab	pH units
pH Temperature	23.5	lab	deg. C
Silica (SiO2)	3.5		mg/L
Conductivity	104		uS/cm

Comments

Langelier Calcium Carbonate Saturation Index: -1.55 @ 23.5 degrees C., -1.21 @ 60 degrees C,(140 F.)
The negative numbers indicates that the water has a strong tendency to dissolve calcium scale.
Ryznar Index: 10.78 which indicates that mild steel is expected to experience intolerable corrosion.
Aggressive Index: 10.12 indicates that the water was highly aggressive to asbestos/cement material.
Larson Index: 2.56 which indicates that chlorides and sulfates contribute to extremely high mild steel corrosion.

This is some of the most corrosive water I have seen.

Charles D. Curtiss, Assistant Chemist Charles D. Curtiss ***Phone: 217/244-7391***

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: 820628

IWTP Maintaining State Facilities Since 1939

Analyst:	JLO	**Facility:**	CERL
Sample Type:	Cold Distribution	**Attention:**	Mr. Vince Hock
Location:	Ft. Bragg, DPW Tap H2O	**Additional Information:**	
Date Collected:	06/12/09		

Parameter	Value		Units
M Alkalinity (as CaCO3)	14		mg/L
Hardness (as CaCO3)	32		mg/L
Calcium (Ca)	11.00		mg/L
Magnesium (Mg)	0.96		mg/L
Sulfate (SO4)	17		mg/L
Chloride (Cl)	11		mg/L
Iron (Fe)	0.16		mg/L
Copper (Cu)	0.01		mg/L
Zinc (Zn)	0.35		mg/L
Aluminum (Al)	0.21		mg/L
Sodium (Na)	3.4		mg/L
Potassium (K)	1.1		mg/L
Lead (Pb)	<0.10		mg/L
Manganese (Mn)	0.05		mg/L
Polyphosphate (PO4)	0.1		mg/L
Orthophosphate (PO4)	0.46		mg/L
Total Dissolved Solids	60	Calculated	mg/L
pH	7.17	lab	pH units
pH Temperature	23.6	lab	deg. C
Silica (SiO2)	3.5		mg/L
Conductivity	101		uS/cm

Comments

Langelier Calcium Carbonate Saturation Index: -1.91 @ 23.6 degrees C., -1.52 @ 60 degrees C,(140 F.) The negative numbers indicates that the water has a strong tendency to dissolve calcium scale.
Ryznar Index: 11.07 which indicates that mild steel is expected to experience intolerable corrosion.
Aggressive Index: 9.76 indicates that the water was highly aggressive to asbestos/cement material.
Larson Index: 2.37 which indicates that chlorides and sulfates contribute to extremely high mild steel corrosion.

This is some of the most corrosive water I have seen.

Charles D. Curtiss, Assistant Chemist Charles D. Curtiss **Phone: 217/244-7391**

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: *820642*

[redacted]

Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cooling Tower*	***Attention:***	*Mr. Vince Hock*
Location:	*0495801 Ft. Bragg*	***Additional Information:***	
Date Collected:	*07/23/08*		

Parameter	***Value***	***Units***
P Alkalinity (as CaCO3)	26	mg/L
M Alkalinity (as CaCO3)	52	mg/L
Hardness (as CaCO3)	31	mg/L
Calcium (Ca)	9.95	mg/L
Magnesium (Mg)	1.32	mg/L
Sulfate (SO4)	88	mg/L
Chloride (Cl)	74	mg/L
Iron (Fe)	0.09	mg/L
Copper (Cu)	0.03	mg/L
Zinc (Zn)	0.29	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.08	mg/L
Sodium (Na)	96.6	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	0.9	mg/L
Orthophosphate (PO4)	4.69	mg/L
Total Dissolved Solids	370	mg/L
pH	9.88 lab	pH units
pH Temperature	23.2 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	15.00	mg/L
Terpolymer	7.6	mg/L
Conductivity	548	uS/cm

Comments

Hardness: Extremely Low.
Iron and Copper: Low, good.
Zinc and Aluminum: Acceptable.
Organic Phosphate (Phosphonate), the scale inhibitor: Extremely Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Somewhat Low, below the expected 10-25 ppm.
pH: Satisfactory.
Conductivity: The tower was operating at 5.3 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

Charles D. Curtiss, Assistant Chemist Charles D Curtiss ***Phone: 217/244-7391***

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS
Lab Number: *820643*

[redacted]

Analyst: *JLO*
Sample Type: *Cooling Tower*
Location: *0495801 Ft. Bragg*
Date Collected: *08/21/08*

Facility: *CERL*
Attention: *Mr. Vince Hock*
Additional Information:

Parameter	*Value*	*Units*
P Alkalinity (as CaCO3)	16	mg/L
M Alkalinity (as CaCO3)	36	mg/L
Hardness (as CaCO3)	21	mg/L
Calcium (Ca)	6.98	mg/L
Magnesium (Mg)	0.81	mg/L
Sulfate (SO4)	51	mg/L
Chloride (Cl)	42	mg/L
Iron (Fe)	0.07	mg/L
Copper (Cu)	0.02	mg/L
Zinc (Zn)	0.30	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.06	mg/L
Sodium (Na)	53.9	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	0.5	mg/L
Orthophosphate (PO4)	2.53	mg/L
Total Dissolved Solids	212	mg/L
pH	10.29 lab	pH units
pH Temperature	23.2 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	6.1	mg/L
Terpolymer	2.6	mg/L
Conductivity	347	uS/cm

Comments

Hardness: Extremely Low.
Iron and Copper: Low, good.
Zinc and Aluminum: Acceptable.
Organic Phosphate (Phosphonate), the scale inhibitor: Extremely Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Low.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Very Low, below the expected 10-25 ppm.
pH: Satisfactory.
Conductivity: The tower was operating at 3.3 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

Charles D. Curtiss, Assistant Chemist Charles D Curtiss ***Phone: 217/244-7391***
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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: *820644*

[redacted]

Analyst:	*JLO*	***Facility:*** *CERL*	
Sample Type:	*Cooling Tower*	***Attention:*** *Mr. Vince Hock*	
Location:	*0495801 Ft. Bragg*	***Additional Information:***	
Date Collected:	*09/30/08*		

Parameter	***Value***		***Units***
P Alkalinity (as CaCO3)	2		mg/L
M Alkalinity (as CaCO3)	20		mg/L
Hardness (as CaCO3)	13		mg/L
Calcium (Ca)	4.05		mg/L
Magnesium (Mg)	0.44		mg/L
Sulfate (SO4)	14		mg/L
Chloride (Cl)	13		mg/L
Iron (Fe)	0		mg/L
Copper (Cu)	0.01		mg/L
Zinc (Zn)	0.09		mg/L
Molybdenum (Mo)	0		mg/L
Aluminum (Al)	0		mg/L
Sodium (Na)	14.7		mg/L
Manganese (Mn)	0		mg/L
Organic Phosphate (PO4)	0.2		mg/L
Orthophosphate (PO4)	0.83		mg/L
Total Dissolved Solids	62		mg/L
pH	9.25	lab	pH units
pH Temperature	24.00	lab	deg. C
Triazole	0.00		mg/L
Silica (SiO2)	1.3		mg/L
Terpolymer	0.2		mg/L
Conductivity	109		uS/cm

Comments

Hardness: Extremely Low.
Iron, Copper and Aluminum: Low, good.
Zinc: Satisfactory.
Organic Phosphate (Phosphonate), the scale inhibitor: Extremely Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Extremely Low.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Extremely Low, below the expected 10-25 ppm.
pH: Satisfactory.
Conductivity: The tower was operating at 1.0 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

Charles D. Curtiss, Assistant Chemist Charles D Curtiss ***Phone: 217/244-7391***

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: *820645*

Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cooling Tower*	***Attention:***	*Mr. Vince Hock*
Location:	*0495801 Ft. Bragg*	***Additional Information:***	
Date Collected:	*10/22/08*		

Parameter	***Value***	***Units***
P Alkalinity (as CaCO3)	8	mg/L
M Alkalinity (as CaCO3)	23	mg/L
Hardness (as CaCO3)	16	mg/L
Calcium (Ca)	5.19	mg/L
Magnesium (Mg)	0.55	mg/L
Sulfate (SO4)	15	mg/L
Chloride (Cl)	14	mg/L
Iron (Fe)	0	mg/L
Copper (Cu)	0.01	mg/L
Zinc (Zn)	0.09	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0	mg/L
Sodium (Na)	14.7	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	0.2	mg/L
Orthophosphate (PO4)	0.98	mg/L
Total Dissolved Solids	72	mg/L
pH	9.39 lab	pH units
pH Temperature	23.2 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	4.3	mg/L
Terpolymer	0.2	mg/L
Conductivity	118	uS/cm

Comments

Hardness: Extremely Low.
Iron, Copper and Aluminum: Low, good.
Zinc: Satisfactory.
Organic Phosphate (Phosphonate), the scale inhibitor: Extremely Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Extremely Low.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Extremely Low, below the expected 10-25 ppm.
pH: Satisfactory.
Conductivity: The tower was operating at 1.1 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

Charles D. Curtiss, Assistant Chemist Charles D Curtiss ***Phone:*** *217/244-7391*

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS
Lab Number: 820646

[redacted]

Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cooling Tower*	***Attention:***	*Mr. Vince Hock*
Location:	*0495801 Ft. Bragg*	***Additional Information:***	
Date Collected:	*11/24/08*		

Parameter	***Value***	***Units***
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	22	mg/L
Hardness (as CaCO3)	31	mg/L
Calcium (Ca)	10.2	mg/L
Magnesium (Mg)	0.94	mg/L
Sulfate (SO4)	24	mg/L
Chloride (Cl)	21	mg/L
Iron (Fe)	0.01	mg/L
Copper (Cu)	0.02	mg/L
Zinc (Zn)	1.22	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.07	mg/L
Sodium (Na)	17.1	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	0.3	mg/L
Orthophosphate (PO4)	1.32	mg/L
Total Dissolved Solids	114	mg/L
pH	6.63 lab	pH units
pH Temperature	22.9 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	6.8	mg/L
Terpolymer	0.6	mg/L
Conductivity	168	uS/cm

Comments

Hardness: Extremely Low.
Iron and Copper: Low, good.
Zinc: Extremely High.
Aluminum: Acceptable.
Organic Phosphate (Phosphonate), the scale inhibitor: Extremely Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Very Low.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant:Extremely Low, below the expected 10-25 ppm.
pH: Very Low.
Conductivity: The tower was operating at 1.6 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

Charles D. Curtiss, Assistant Chemist ______________ ***Phone: 217/244-7391***
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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: 820647

[redacted]

Analyst:	JLO	**Facility:**	CERL
Sample Type:	Cooling Tower	**Attention:**	Mr. Vince Hock
Location:	0495801 Ft. Bragg	**Additional Information:**	
Date Collected:	12/30/08		

Parameter	Value	Units
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	20	mg/L
Hardness (as CaCO3)	25	mg/L
Calcium (Ca)	8.29	mg/L
Magnesium (Mg)	0.78	mg/L
Sulfate (SO4)	18	mg/L
Chloride (Cl)	15	mg/L
Iron (Fe)	0	mg/L
Copper (Cu)	0.01	mg/L
Zinc (Zn)	1.26	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.05	mg/L
Sodium (Na)	12.7	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	0.1	mg/L
Orthophosphate (PO4)	1.00	mg/L
Total Dissolved Solids	84	mg/L
pH	6.73 lab	pH units
pH Temperature	23.00 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	5.1	mg/L
Terpolymer	0.2	mg/L
Conductivity	130	uS/cm

Comments

Hardness: Extremely Low.
Iron and Copper: Low, good.
Zinc: Extremely High.
Aluminum: Satisfactory.
Organic Phosphate (Phosphonate), the scale inhibitor: Extremely Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Very Low.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Extremely Low, below the expected 10-25 ppm.
pH: Very Low.
Conductivity: The tower was operating at 1.3 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

Charles D. Curtiss, Assistant Chemist Charles D. Curtiss **Phone: 217/244-7391**

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS
Lab Number: *820648*

Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cooling Tower*	***Attention:***	*Mr. Vince Hock*
Location:	*0495802 Ft. Bragg*	***Additional Information:***	
Date Collected:	*04/28/08*		

Parameter	***Value***	***Units***
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	19	mg/L
Hardness (as CaCO3)	21	mg/L
Calcium (Ca)	7.60	mg/L
Magnesium (Mg)	0.63	mg/L
Sulfate (SO4)	20	mg/L
Chloride (Cl)	12	mg/L
Iron (Fe)	0.04	mg/L
Copper (Cu)	0.08	mg/L
Zinc (Zn)	0.35	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.05	mg/L
Sodium (Na)	14.5	mg/L
Manganese (Mn)	0.01	mg/L
Organic Phosphate (PO4)	0.3	mg/L
Orthophosphate (PO4)	2.44	mg/L
Total Dissolved Solids	78	mg/L
pH	7.06 lab	pH units
pH Temperature	23.7 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	5.5	mg/L
Terpolymer	0.5	mg/L
Conductivity	124	uS/cm

Comments

Hardness: Extremely Low.
Iron: Low, good.
Copper and Manganese:Satisfactory.
Zinc and Aluminum: Acceptable.
Organic Phosphate (Phosphonate), the scale inhibitor: Extremely Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Low.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant:Extremely Low, below the expected 10-25 ppm.
pH: Low.
Conductivity: The tower was operating at 1.2 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: *820649*

Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cooling Tower*	***Attention:***	*Mr. Vince Hock*
Location:	*0495802 Ft. Bragg*	***Additional Information:***	
Date Collected:	*06/04/08*		

Parameter	***Value***	***Units***
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	66	mg/L
Hardness (as CaCO3)	66	mg/L
Calcium (Ca)	20.3	mg/L
Magnesium (Mg)	3.52	mg/L
Sulfate (SO4)	186	mg/L
Chloride (Cl)	144	mg/L
Iron (Fe)	0.09	mg/L
Copper (Cu)	0.12	mg/L
Zinc (Zn)	0.33	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.21	mg/L
Sodium (Na)	182	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	3.4	mg/L
Orthophosphate (PO4)	14.57	mg/L
Total Dissolved Solids	702	mg/L
pH	7.36 lab	pH units
pH Temperature	23.9 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	29.9	mg/L
Terpolymer	14.8	mg/L
Conductivity	1011	uS/cm

Comments

Hardness: Low.
Iron: Low, good.
Copper and Zinc: Acceptable.
Aluminum: High.
Organic Phosphate (Phosphonate), the scale inhibitor: Satisfactory, within the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Probably High.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant:Satisfactory, within the expected 10-25 ppm.
pH: Somewhat Low.
Conductivity: The tower was operating at 9.7 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: 820650

[redacted]

Analyst:	*JLO*	***Facility:*** *CERL*	
Sample Type:	*Cooling Tower*	***Attention:*** *Mr. Vince Hock*	
Location:	*0495802 Ft. Bragg*	***Additional Information:***	
Date Collected:	*06/25/08*		

Parameter	***Value***		***Units***
P Alkalinity (as CaCO3)	0		mg/L
M Alkalinity (as CaCO3)	74		mg/L
Hardness (as CaCO3)	57		mg/L
Calcium (Ca)	17.1		mg/L
Magnesium (Mg)	3.31		mg/L
Sulfate (SO4)	159		mg/L
Chloride (Cl)	125		mg/L
Iron (Fe)	0.03		mg/L
Copper (Cu)	0.10		mg/L
Zinc (Zn)	0.25		mg/L
Molybdenum (Mo)	0		mg/L
Aluminum (Al)	0.26		mg/L
Sodium (Na)	168		mg/L
Manganese (Mn)	0		mg/L
Organic Phosphate (PO4)	3.1		mg/L
Orthophosphate (PO4)	14.11		mg/L
Total Dissolved Solids	636		mg/L
pH	7.62	lab	pH units
pH Temperature	23.8	lab	deg. C
Triazole	0		mg/L
Silica (SiO2)	31.8		mg/L
Terpolymer	19.00		mg/L
Conductivity	914		uS/cm

Comments

Hardness: Low.
Iron: Low, good.
Copper and Zinc: Acceptable.
Aluminum: High.
Organic Phosphate (Phosphonate), the scale inhibitor: Satisfactory, within the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Probably High.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant:Satisfactory, within the expected 10-25 ppm.
pH: Somewhat Low.
Conductivity: The tower was operating at 8.8 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: *820651*

[redacted]

Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cooling Tower*	***Attention:***	*Mr. Vince Hock*
Location:	*0495802 Ft. Bragg*	***Additional Information:***	
Date Collected:	*07/23/08*		

Parameter	*Value*	*Units*
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	68	mg/L
Hardness (as CaCO3)	52	mg/L
Calcium (Ca)	15.8	mg/L
Magnesium (Mg)	3.13	mg/L
Sulfate (SO4)	147	mg/L
Chloride (Cl)	115	mg/L
Iron (Fe)	0.05	mg/L
Copper (Cu)	0.08	mg/L
Zinc (Zn)	0.42	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.42	mg/L
Sodium (Na)	155	mg/L
Manganese (Mn)	0.01	mg/L
Organic Phosphate (PO4)	4.00	mg/L
Orthophosphate (PO4)	14.87	mg/L
Total Dissolved Solids	598	mg/L
pH	7.30 lab	pH units
pH Temperature	23.6 lab	deg. C
Triazole	1.00	mg/L
Silica (SiO2)	32.7	mg/L
Terpolymer	19.4	mg/L
Conductivity	839	uS/cm

Comments

Hardness: Low.
Iron: Low, good.
Copper and Manganese: Satisfactory.
Zinc: Acceptable.
Aluminum: High.
Organic Phosphate (Phosphonate), the scale inhibitor: Satisfactory, within the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Probably High.
Triazole, the copper corrosion inhibitor:Low, below the recommended 2-5 ppm.
Terpolymer, the dispersant:Extremely Low, below the expected 10-25 ppm.
pH: Low.
Conductivity: The tower was operating at 8.0 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: *820652*

Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cooling Tower*	***Attention:***	*Mr. Vince Hock*
Location:	*0495802 Ft. Bragg*	***Additional Information:***	
Date Collected:	*08/21/08*		

Parameter	***Value***	***Units***
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	74	mg/L
Hardness (as CaCO3)	55	mg/L
Calcium (Ca)	16.9	mg/L
Magnesium (Mg)	2.88	mg/L
Sulfate (SO4)	166	mg/L
Chloride (Cl)	142	mg/L
Iron (Fe)	0.18	mg/L
Copper (Cu)	0.06	mg/L
Zinc (Zn)	0.59	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.69	mg/L
Sodium (Na)	175	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	3.3	mg/L
Orthophosphate (PO4)	14.75	mg/L
Total Dissolved Solids	694	mg/L
pH	7.76 lab	pH units
pH Temperature	23.7 lab	deg. C
Triazole	0.00	mg/L
Silica (SiO2)	36.4	mg/L
Terpolymer	20.7	mg/L
Conductivity	943	uS/cm

Comments

Hardness: Low.
Iron and Copper: Satisfactory.
Zinc: High.
Aluminum: Extremely High.
Organic Phosphate (Phosphonate), the scale inhibitor: Satisfactory, within the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Probably High.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant:Satisfactory, within the expected 10-25 ppm.
pH: Somewhat Low.
Conductivity: The tower was operating at 9.1 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: 820653

Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cooling Tower*	***Attention:***	*Mr. Vince Hock*
Location:	*0495802 Ft. Bragg*	***Additional Information:***	
Date Collected:	*09/30/08*		

Parameter	Value	Units
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	64	mg/L
Hardness (as CaCO3)	198	mg/L
Calcium (Ca)	70.9	mg/L
Magnesium (Mg)	5.32	mg/L
Sulfate (SO4)	193	mg/L
Chloride (Cl)	138	mg/L
Iron (Fe)	0.38	mg/L
Copper (Cu)	0.11	mg/L
Zinc (Zn)	1.79	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	2.02	mg/L
Sodium (Na)	118	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	3.1	mg/L
Orthophosphate (PO4)	6.88	mg/L
Total Dissolved Solids	750	mg/L
pH	7.28 lab	pH units
pH Temperature	24.00 lab	deg. C
Triazole	0.00	mg/L
Silica (SiO2)	43.9	mg/L
Terpolymer	18.9	mg/L
Conductivity	983	uS/cm

Comments

Hardness: Satisfactory.
Iron: Satisfactory.
Copper: Acceptable.
Zinc and Aluminum: Extremely High.
Organic Phosphate (Phosphonate), the scale inhibitor: Satisfactory, within the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Probably High.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant:Satisfactory, within the expected 10-25 ppm.
pH: Somewhat Low.
Conductivity: The tower was operating at 9.5 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: *820654*

Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cooling Tower*	***Attention:***	*Mr. Vince Hock*
Location:	*0495802 Ft. Bragg*	***Additional Information:***	
Date Collected:	*10/22/08*		

Parameter	***Value***	***Units***
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	42	mg/L
Hardness (as CaCO3)	195	mg/L
Calcium (Ca)	70.3	mg/L
Magnesium (Mg)	4.80	mg/L
Sulfate (SO4)	158	mg/L
Chloride (Cl)	119	mg/L
Iron (Fe)	0.12	mg/L
Copper (Cu)	0.07	mg/L
Zinc (Zn)	1.04	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.44	mg/L
Sodium (Na)	85.2	mg/L
Manganese (Mn)	0.02	mg/L
Organic Phosphate (PO4)	2.1	mg/L
Orthophosphate (PO4)	7.26	mg/L
Total Dissolved Solids	678	mg/L
pH	6.92 lab	pH units
pH Temperature	23.7 lab	deg. C
Triazole	0.00	mg/L
Silica (SiO2)	39.3	mg/L
Terpolymer	21.1	mg/L
Conductivity	827	uS/cm

Comments

Hardness: Satisfactory.
Iron, Copper and Manganese: Satisfactory.
Zinc: Extremely High.
Aluminum: High.
Organic Phosphate (Phosphonate), the scale inhibitor: Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant:Extremely Low, below the expected 10-25 ppm.
pH: Low.
Conductivity: The tower was operating at 8.0 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

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WATER SAMPLE ANALYSIS
Lab Number: 820655

Analyst:	JLO	**Facility:**	CERL
Sample Type:	Cooling Tower	**Attention:**	Mr. Vince Hock
Location:	0495802 Ft. Bragg	**Additional Information:**	
Date Collected:	11/24/08		

Parameter	Value	Units
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	12	mg/L
Hardness (as CaCO3)	31	mg/L
Calcium (Ca)	11.00	mg/L
Magnesium (Mg)	0.72	mg/L
Sulfate (SO4)	15	mg/L
Chloride (Cl)	11	mg/L
Iron (Fe)	0.05	mg/L
Copper (Cu)	0.01	mg/L
Zinc (Zn)	0.20	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.26	mg/L
Sodium (Na)	4.5	mg/L
Manganese (Mn)	0.01	mg/L
Organic Phosphate (PO4)	0.3	mg/L
Orthophosphate (PO4)	0.45	mg/L
Total Dissolved Solids	82	mg/L
pH	6.50 lab	pH units
pH Temperature	23.7 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	6.00	mg/L
Terpolymer	0.2	mg/L
Conductivity	103	uS/cm

Comments

Hardness: Extremely Low.
Iron and Copper: Low, good.
Zinc: Acceptable.
Aluminum: High.
Manganese:Satisfactory.
Organic Phosphate (Phosphonate), the scale inhibitor: Extremely Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Extremely Low.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant:Extremely Low, below the expected 10-25 ppm.
pH: Very low.
Conductivity: The tower was operating at 1.0 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

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Illinois State
WATER
Survey (1895)

WATER SAMPLE ANALYSIS
Lab Number: *820656*

Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cooling Tower*	***Attention:***	*Mr. Vince Hock*
Location:	*0495802 Ft. Bragg*	***Additional Information:***	
Date Collected:	*12/30/08*		

Parameter	***Value***	***Units***
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	10	mg/L
Hardness (as CaCO3)	32	mg/L
Calcium (Ca)	11.7	mg/L
Magnesium (Mg)	0.71	mg/L
Sulfate (SO4)	20	mg/L
Chloride (Cl)	11	mg/L
Iron (Fe)	0.01	mg/L
Copper (Cu)	0.01	mg/L
Zinc (Zn)	0.21	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.12	mg/L
Sodium (Na)	5.2	mg/L
Manganese (Mn)	0.01	mg/L
Organic Phosphate (PO4)	0.2	mg/L
Orthophosphate (PO4)	0.28	mg/L
Total Dissolved Solids	78	mg/L
pH	6.49 lab	pH units
pH Temperature	23.6 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	5.9	mg/L
Terpolymer	0.1	mg/L
Conductivity	112	uS/cm

Comments

Hardness: Extremely Low.
Iron and Copper: Low, good.
Zinc: Acceptable.
Aluminum: High.
Manganese: Satisfactory.
Organic Phosphate (Phosphonate), the scale inhibitor: Extremely Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Extremely Low.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant:Extremely Low, below the expected 10-25 ppm.
pH: Very low.
Conductivity: The tower was operating at 1.1 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: 820657

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Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cooling Tower*	***Attention:***	*Mr. Vince Hock*
Location:	*0495803 Ft. Bragg*	***Additional Information:***	
Date Collected:	*04/28/08*		

Parameter	*Value*	*Units*
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	16	mg/L
Hardness (as CaCO3)	13	mg/L
Calcium (Ca)	4.05	mg/L
Magnesium (Mg)	0.75	mg/L
Sulfate (SO4)	20	mg/L
Chloride (Cl)	12	mg/L
Iron (Fe)	0.03	mg/L
Copper (Cu)	0.02	mg/L
Zinc (Zn)	0.15	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.09	mg/L
Sodium (Na)	17.8	mg/L
Manganese (Mn)	0.01	mg/L
Organic Phosphate (PO4)	1.00	mg/L
Orthophosphate (PO4)	3.29	mg/L
Total Dissolved Solids	78	mg/L
pH	6.58 lab	pH units
pH Temperature	24.00 lab	deg. C
Triazole	0.00	mg/L
Silica (SiO2)	3.9	mg/L
Terpolymer	0.8	mg/L
Conductivity	124	uS/cm

Comments

Hardness: Very Low.
Iron and Copper: Low, good.
Zinc and Aluminum: Acceptable.
Manganese Satisfactory.
Organic Phosphate (Phosphonate), the scale inhibitor: Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Very Low, below the expected 10-25 ppm.
pH:Very Low.
Conductivity: The tower was operating at 1.2 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS
Lab Number: 820658

Analyst:	JLO	**Facility:**	CERL
Sample Type:	Cooling Tower	**Attention:**	Mr. Vince Hock
Location:	0495803 Ft. Bragg	**Additional Information:**	
Date Collected:	06/04/08		

Parameter	Value	Units
P Alkalinity (as CaCO3)	4	mg/L
M Alkalinity (as CaCO3)	42	mg/L
Hardness (as CaCO3)	43	mg/L
Calcium (Ca)	13.8	mg/L
Magnesium (Mg)	2.21	mg/L
Sulfate (SO4)	70	mg/L
Chloride (Cl)	46	mg/L
Iron (Fe)	0.12	mg/L
Copper (Cu)	0.01	mg/L
Zinc (Zn)	0.16	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.16	mg/L
Sodium (Na)	63.00	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	2.1	mg/L
Orthophosphate (PO4)	16.60	mg/L
Total Dissolved Solids	282	mg/L
pH	8.19 lab	pH units
pH Temperature	23.7 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	16.8	mg/L
Terpolymer	23.6	mg/L
Conductivity	401	uS/cm

Comments

Hardness: Low.
Iron: Satisfactory.
Copper: Low, good.
Zinc: Acceptable.
Aluminum: High.
Organic Phosphate (Phosphonate), the scale inhibitor: Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory,within the expected 10-25 ppm.
pH: Satisfactory.
Conductivity: The tower was operating at 3.9 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS
Lab Number: 820659

Analyst:	JLO	**Facility:**	CERL
Sample Type:	Cooling Tower	**Attention:**	Mr. Vince Hock
Location:	0495803 Ft. Bragg	**Additional Information:**	
Date Collected:	06/25/08		

Parameter	Value	Units
P Alkalinity (as CaCO3)	6	mg/L
M Alkalinity (as CaCO3)	72	mg/L
Hardness (as CaCO3)	51	mg/L
Calcium (Ca)	15.6	mg/L
Magnesium (Mg)	2.68	mg/L
Sulfate (SO4)	148	mg/L
Chloride (Cl)	120	mg/L
Iron (Fe)	0.06	mg/L
Copper (Cu)	0.01	mg/L
Zinc (Zn)	0.15	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.32	mg/L
Sodium (Na)	157	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	3.1	mg/L
Orthophosphate (PO4)	17.43	mg/L
Total Dissolved Solids	606	mg/L
pH	8.22 lab	pH units
pH Temperature	23.6 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	15.4	mg/L
Terpolymer	24.1	mg/L
Conductivity	848	uS/cm

Comments

Hardness: Low.
Iron and Copper: Low, good.
Zinc: Acceptable.
Aluminum: High.
Organic Phosphate (Phosphonate), the scale inhibitor: Satisfactory, within the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Probably High.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH: Satisfactory.
Conductivity: The tower was operating at 8.2 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS
Lab Number: 820660

Analyst:	JLO	**Facility:**	CERL
Sample Type:	Cooling Tower	**Attention:**	Mr. Vince Hock
Location:	0495803 Ft. Bragg	**Additional Information:**	
Date Collected:	07/23/08		

Parameter	Value	Units
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	58	mg/L
Hardness (as CaCO3)	57	mg/L
Calcium (Ca)	17.5	mg/L
Magnesium (Mg)	3.12	mg/L
Sulfate (SO4)	148	mg/L
Chloride (Cl)	120	mg/L
Iron (Fe)	0.07	mg/L
Copper (Cu)	0.02	mg/L
Zinc (Zn)	0.26	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.29	mg/L
Sodium (Na)	159	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	3.5	mg/L
Orthophosphate (PO4)	17.12	mg/L
Total Dissolved Solids	636	mg/L
pH	7.21 lab	pH units
pH Temperature	23.5 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	30.3	mg/L
Terpolymer	21.9	mg/L
Conductivity	876	uS/cm

Comments

Hardness: Low.
Iron and Copper: Low, good.
Zinc: Acceptable.
Aluminum: High.
Organic Phosphate (Phosphonate), the scale inhibitor: Satisfactory, within the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Probably High.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH: Slightly low.
Conductivity: The tower was operating at 8.4 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

Charles D. Curtiss, Assistant Chemist Charles D. Curtiss **Phone: 217/244-7391**
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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS
Lab Number: 820661

ISWS Maintaining State Facilities Since 1895

Analyst:	JLO	**Facility:**	CERL
Sample Type:	Cooling Tower	**Attention:**	Mr. Vince Hock
Location:	0495803 Ft. Bragg	**Additional Information:**	
Date Collected:	08/21/08		

Parameter	Value	Units
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	56	mg/L
Hardness (as CaCO3)	63	mg/L
Calcium (Ca)	20.00	mg/L
Magnesium (Mg)	3.24	mg/L
Sulfate (SO4)	152	mg/L
Chloride (Cl)	126	mg/L
Iron (Fe)	0.09	mg/L
Copper (Cu)	0.02	mg/L
Zinc (Zn)	0.21	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.33	mg/L
Sodium (Na)	160	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	3.00	mg/L
Orthophosphate (PO4)	16.14	mg/L
Total Dissolved Solids	632	mg/L
pH	7.59 lab	pH units
pH Temperature	23.6 lab	deg. C
Triazole	0.00	mg/L
Silica (SiO2)	10.6	mg/L
Terpolymer	21.1	mg/L
Conductivity	898	uS/cm

Comments

Hardness: Low.
Iron and Copper: Low, good.
Zinc: Acceptable.
Aluminum: High.
Organic Phosphate (Phosphonate), the scale inhibitor: Satisfactory, within the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Probably High.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH: Slightly low.
Conductivity: The tower was operating at 8.6 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

Charles D. Curtiss, Assistant Chemist Charles D Curtiss **Phone: 217/244-7391**
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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: *820662*

Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cooling Tower*	***Attention:***	*Mr. Vince Hock*
Location:	*0495803 Ft. Bragg*	***Additional Information:***	
Date Collected:	*09/30/08*		

Parameter	***Value***	***Units***
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	64	mg/L
Hardness (as CaCO3)	143	mg/L
Calcium (Ca)	48.4	mg/L
Magnesium (Mg)	4.21	mg/L
Sulfate (SO4)	157	mg/L
Chloride (Cl)	117	mg/L
Iron (Fe)	0.33	mg/L
Copper (Cu)	0.03	mg/L
Zinc (Zn)	0.99	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	1.99	mg/L
Sodium (Na)	107	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	3.3	mg/L
Orthophosphate (PO4)	7.91	mg/L
Total Dissolved Solids	610	mg/L
pH	7.27 lab	pH units
pH Temperature	23.9 lab	deg. C
Triazole	0.00	mg/L
Silica (SiO2)	31.2	mg/L
Terpolymer	22.6	mg/L
Conductivity	813	uS/cm

Comments

Hardness: Satisfactory.
Iron: Satisfactory.
Copper: Low, good.
Zinc: High.
Aluminum: Extremely High.
Organic Phosphate (Phosphonate), the scale inhibitor: Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH: Low.
Conductivity: The tower was operating at 7.8 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

Charles D. Curtiss, Assistant Chemist Charles D. Curtiss ***Phone: 217/244-7391***

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: 820663

Analyst:	JLO
Sample Type:	Cooling Tower
Location:	0495803 Ft. Bragg
Date Collected:	10/22/08
Facility:	CERL
Attention:	Mr. Vince Hock
Additional Information:	

Parameter	Value	Units
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	60	mg/L
Hardness (as CaCO3)	201	mg/L
Calcium (Ca)	69.2	mg/L
Magnesium (Mg)	5.84	mg/L
Sulfate (SO4)	179	mg/L
Chloride (Cl)	139	mg/L
Iron (Fe)	0.21	mg/L
Copper (Cu)	0.04	mg/L
Zinc (Zn)	0.69	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.87	mg/L
Sodium (Na)	105	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	2.8	mg/L
Orthophosphate (PO4)	7.44	mg/L
Total Dissolved Solids	714	mg/L
pH	6.87 lab	pH units
pH Temperature	23.6 lab	deg. C
Triazole	0.00	mg/L
Silica (SiO2)	37.7	mg/L
Terpolymer	20.9	mg/L
Conductivity	924	uS/cm

Comments

Hardness:Satisfactory.
Iron: Satisfactory.
Copper: Low, good.
Zinc and Aluminum: High.
Organic Phosphate (Phosphonate), the scale inhibitor: Slightly low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH: Very low.
Conductivity: The tower was operating at 8.9 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

Charles D. Curtiss, Assistant Chemist Charles D Curtiss **Phone: 217/244-7391**

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS
Lab Number: 820664

HQTPA Maintaining State Facilities Since 1949

Analyst:	JLO	**Facility:**	CERL
Sample Type:	Cooling Tower	**Attention:**	Mr. Vince Hock
Location:	0495803 Ft. Bragg	**Additional Information:**	
Date Collected:	11/24/08		

Parameter	Value	Units
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	46	mg/L
Hardness (as CaCO3)	159	mg/L
Calcium (Ca)	54.2	mg/L
Magnesium (Mg)	4.60	mg/L
Sulfate (SO4)	126	mg/L
Chloride (Cl)	104	mg/L
Iron (Fe)	0.21	mg/L
Copper (Cu)	0.03	mg/L
Zinc (Zn)	0.63	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.63	mg/L
Sodium (Na)	75.4	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	2.00	mg/L
Orthophosphate (PO4)	6.93	mg/L
Total Dissolved Solids	550	mg/L
pH	6.79 lab	pH units
pH Temperature	23.5 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	27.6	mg/L
Terpolymer	16.3	mg/L
Conductivity	714	uS/cm

Comments

Hardness: Satisfactory.
Iron: Satisfactory.
Copper: Low, good.
Zinc: High.
Aluminum: Extremely High.
Organic Phosphate (Phosphonate), the scale inhibitor: Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH:Very Low.
Conductivity: The tower was operating at 6.9 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

Charles D. Curtiss, Assistant Chemist Charles D Curtiss **Phone: 217/244-7391**

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: *820665*

Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cooling Tower*	***Attention:***	*Mr. Vince Hock*
Location:	*0495803 Ft. Bragg*	***Additional Information:***	
Date Collected:	*12/30/08*		

Parameter	***Value***	***Units***
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	38	mg/L
Hardness (as CaCO3)	118	mg/L
Calcium (Ca)	40.6	mg/L
Magnesium (Mg)	3.48	mg/L
Sulfate (SO4)	91	mg/L
Chloride (Cl)	74	mg/L
Iron (Fe)	0.23	mg/L
Copper (Cu)	0.02	mg/L
Zinc (Zn)	0.57	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.44	mg/L
Sodium (Na)	53.9	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	1.6	mg/L
Orthophosphate (PO4)	5.64	mg/L
Total Dissolved Solids	396	mg/L
pH	6.87 lab	pH units
pH Temperature	23.7 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	19.9	mg/L
Terpolymer	11.6	mg/L
Conductivity	533	uS/cm

Comments

Hardness: Satisfactory.
Iron: Satisfactory.
Copper: Low, good.
Zinc and Aluminum: High.
Organic Phosphate (Phosphonate), the scale inhibitor: Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory,within the expected 10-25 ppm.
pH:Very Low.
Conductivity: The tower was operating at 5.1 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

Charles D. Curtiss, Assistant Chemist Charles D. Curtiss ***Phone: 217/244-7391***

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: 820666

Analyst:	JLO	**Facility:**	CERL
Sample Type:	Cooling Tower	**Attention:**	Mr. Vince Hock
Location:	0495804 Ft. Bragg	**Additional Information:**	
Date Collected:	04/28/08	Lead(Pb) = <0.10 mg/L	

Parameter	**Value**	**Units**
P Alkalinity (as CaCO3)	2	mg/L
M Alkalinity (as CaCO3)	66	mg/L
Hardness (as CaCO3)	71	mg/L
Calcium (Ca)	21.7	mg/L
Magnesium (Mg)	3.92	mg/L
Sulfate (SO4)	179	mg/L
Chloride (Cl)	122	mg/L
Iron (Fe)	0.03	mg/L
Copper (Cu)	0.01	mg/L
Zinc (Zn)	0.09	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.07	mg/L
Sodium (Na)	148	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	2.5	mg/L
Orthophosphate (PO4)	16.76	mg/L
Total Dissolved Solids	602	mg/L
pH	8.37 lab	pH units
pH Temperature	22.9 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	26.7	mg/L
Terpolymer	12.2	mg/L
Conductivity	859	uS/cm

Comments

Hardness: Low.
Iron and Copper: Low, good.
Zinc: Satisfactory.
Aluminum: Acceptable.
Organic Phosphate (Phosphonate), the scale inhibitor: Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor: None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH: Satisfactory.
Conductivity: The tower was operating at 8.4 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

Charles D. Curtiss, Assistant Chemist Charles D. Curtiss **Phone: 217/244-7391**

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Illinois State Water Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: *820667*

Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cooling Tower*	***Attention:***	*Mr. Vince Hock*
Location:	*0495804 Ft. Bragg*	***Additional Information:***	
Date Collected:	*06/04/08*	*Lead(Pb) = <0.10 mg/L*	

Parameter	*Value*	*Units*
P Alkalinity (as CaCO3)	12	mg/L
M Alkalinity (as CaCO3)	92	mg/L
Hardness (as CaCO3)	55	mg/L
Calcium (Ca)	16.2	mg/L
Magnesium (Mg)	3.23	mg/L
Sulfate (SO4)	172	mg/L
Chloride (Cl)	137	mg/L
Iron (Fe)	0.02	mg/L
Copper (Cu)	0.01	mg/L
Zinc (Zn)	0.11	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.29	mg/L
Sodium (Na)	166	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	2.6	mg/L
Orthophosphate (PO4)	16.95	mg/L
Total Dissolved Solids	658	mg/L
pH	9.12 lab	pH units
pH Temperature	22.9 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	24.3	mg/L
Terpolymer	20.8	mg/L
Conductivity	921	uS/cm

Comments

Hardness: Low.
Iron and Copper: Low, good.
Zinc: Acceptable.
Aluminun: High.
Organic Phosphate (Phosphonate), the scale inhibitor: Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH: Satisfactory.
Conductivity: The tower was operating at 8.9 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

Charles D. Curtiss, Assistant Chemist Charles D. Curtiss ***Phone: 217/244-7391***

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS
Lab Number: 820668

Analyst:	JLO	**Facility:**	CERL
Sample Type:	Cooling Tower	**Attention:**	Mr. Vince Hock
Location:	0495804 Ft. Bragg	**Additional Information:**	
Date Collected:	06/25/08	Lead(Pb) = <0.10 mg/L	

Parameter	**Value**	**Units**
P Alkalinity (as CaCO3)	10	mg/L
M Alkalinity (as CaCO3)	92	mg/L
Hardness (as CaCO3)	55	mg/L
Calcium (Ca)	16.3	mg/L
Magnesium (Mg)	3.34	mg/L
Sulfate (SO4)	160	mg/L
Chloride (Cl)	127	mg/L
Iron (Fe)	0.11	mg/L
Copper (Cu)	0.01	mg/L
Zinc (Zn)	0.23	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.17	mg/L
Sodium (Na)	157	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	2.2	mg/L
Orthophosphate (PO4)	15.16	mg/L
Total Dissolved Solids	618	mg/L
pH	9.14 lab	pH units
pH Temperature	22.9 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	11.9	mg/L
Terpolymer	27.3	mg/L
Conductivity	860	uS/cm

Comments

Hardness: Low.
Iron: Satisfactory.
Copper: Low, good.
Zinc: Acceptable.
Aluminun: High.
Organic Phosphate (Phosphonate), the scale inhibitor: Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor: None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH: Satisfactory.
Conductivity: The tower was operating at 8.3 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

Charles D. Curtiss, Assistant Chemist Charles D. Curtiss **Phone: 217/244-7391**

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Illinois State **WATER** Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: *820669*

Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cooling Tower*	***Attention:***	*Mr. Vince Hock*
Location:	*0495804 Ft. Bragg*	***Additional Information:***	
Date Collected:	*07/23/08*	*Lead(Pb) = <0.10 mg/L*	

Parameter	***Value***	***Units***
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	84	mg/L
Hardness (as CaCO3)	49	mg/L
Calcium (Ca)	14.9	mg/L
Magnesium (Mg)	2.84	mg/L
Sulfate (SO4)	160	mg/L
Chloride (Cl)	131	mg/L
Iron (Fe)	0.02	mg/L
Copper (Cu)	0.01	mg/L
Zinc (Zn)	0.14	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.42	mg/L
Sodium (Na)	162	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	4.3	mg/L
Orthophosphate (PO4)	15.30	mg/L
Total Dissolved Solids	650	mg/L
pH	7.41 lab	pH units
pH Temperature	22.9 lab	deg. C
Triazole	1.5	mg/L
Silica (SiO2)	31.2	mg/L
Terpolymer	22.3	mg/L
Conductivity	883	uS/cm

Comments

Hardness: Low.
Iron and Copper: Low, good.
Zinc: Acceptable.
Aluminun: High.
Organic Phosphate (Phosphonate), the scale inhibitor: Satisfactory, withinthe recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, High.
Triazole, the copper corrosion inhibitor:Low, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH: Somewhat low.
Conductivity: The tower was operating at 8.5 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

Charles D. Curtiss, Assistant Chemist Charles D. Curtiss ***Phone: 217/244-7391***

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: *820670*

Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cooling Tower*	***Attention:***	*Mr. Vince Hock*
Location:	*0495804 Ft. Bragg*	***Additional Information:***	
Date Collected:	*08/21/08*	*Lead(Pb) = <0.10 mg/L*	

Parameter	***Value***	***Units***
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	72	mg/L
Hardness (as CaCO3)	56	mg/L
Calcium (Ca)	17.2	mg/L
Magnesium (Mg)	3.00	mg/L
Sulfate (SO4)	164	mg/L
Chloride (Cl)	137	mg/L
Iron (Fe)	0.09	mg/L
Copper (Cu)	0.02	mg/L
Zinc (Zn)	0.28	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.37	mg/L
Sodium (Na)	161	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	3.4	mg/L
Orthophosphate (PO4)	16.05	mg/L
Total Dissolved Solids	670	mg/L
pH	7.13 lab	pH units
pH Temperature	22.9 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	32.7	mg/L
Terpolymer	24.1	mg/L
Conductivity	911	uS/cm

Comments

Hardness: Low.
Iron and Copper: Low, good.
Zinc: Acceptable.
Aluminun: High.
Organic Phosphate (Phosphonate), the scale inhibitor: Satisfactory, within the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, High..
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH: Low.
Conductivity: The tower was operating at 8.8 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

Charles D. Curtiss, Assistant Chemist Charles D. Curtiss ***Phone: 217/244-7391***

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: 820671

Analyst:	JLO	**Facility:** CERL	
Sample Type:	Cooling Tower	**Attention:** Mr. Vince Hock	
Location:	0495804 Ft. Bragg	**Additional Information:**	
Date Collected:	09/30/08	Lead (Pb) = < 0.10 mg/L	

Parameter	Value	Units
P Alkalinity (as CaCO3)	10	mg/L
M Alkalinity (as CaCO3)	84	mg/L
Hardness (as CaCO3)	135	mg/L
Calcium (Ca)	45.4	mg/L
Magnesium (Mg)	4.33	mg/L
Sulfate (SO4)	179	mg/L
Chloride (Cl)	129	mg/L
Iron (Fe)	0.33	mg/L
Copper (Cu)	0.01	mg/L
Zinc (Zn)	0.76	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	1.83	mg/L
Sodium (Na)	119	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	2.0	mg/L
Orthophosphate (PO4)	6.41	mg/L
Total Dissolved Solids	628	mg/L
pH	8.99 lab	pH units
pH Temperature	22.9 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	3.0	mg/L
Terpolymer	21.5	mg/L
Conductivity	857	uS/cm

Comments

Hardness: Satisfactory.
Iron: Satisfactory.
Copper: Low, good.
Zinc: High.
Aluminum: Extremely High.
Organic Phosphate (Phosphonate), the scale inhibitor: Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor: None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH: Satisfactory.
Conductivity: The tower was operating at 8.2 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

Charles D. Curtiss, Assistant Chemist **Phone: 217/244-7391**

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS
Lab Number: 820672

Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cooling Tower*	***Attention:***	*Mr. Vince Hock*
Location:	*0495814 Ft. Bragg*	***Additional Information:***	
Date Collected:	*10/22/08*	*Lead(Pb) = <0.10 mg/L*	

Parameter	***Value***	***Units***
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	56	mg/L
Hardness (as CaCO3)	179	mg/L
Calcium (Ca)	61.1	mg/L
Magnesium (Mg)	5.02	mg/L
Sulfate (SO4)	176	mg/L
Chloride (Cl)	140	mg/L
Iron (Fe)	0.01	mg/L
Copper (Cu)	0.01	mg/L
Zinc (Zn)	0.17	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.13	mg/L
Sodium (Na)	106	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	2.1	mg/L
Orthophosphate (PO4)	6.88	mg/L
Total Dissolved Solids	702	mg/L
pH	6.95 lab	pH units
pH Temperature	22.9 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	34.3	mg/L
Terpolymer	15.1	mg/L
Conductivity	898	uS/cm

Comments

Hardness: Satisfactory.
Iron and Copper: Low, good.
Zinc: Acceptable.
Aluminun: High.
Organic Phosphate (Phosphonate), the scale inhibitor: Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH: Low.
Conductivity: The tower was operating at 8.6 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: *820672*

Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cooling Tower*	***Attention:***	*Mr. Vince Hock*
Location:	*0495814 Ft. Bragg*	***Additional Information:***	
Date Collected:	*10/22/08*	*Lead(Pb) = <0.10 mg/L*	

Parameter	*Value*	*Units*
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	56	mg/L
Hardness (as CaCO3)	179	mg/L
Calcium (Ca)	61.1	mg/L
Magnesium (Mg)	5.02	mg/L
Sulfate (SO4)	176	mg/L
Chloride (Cl)	140	mg/L
Iron (Fe)	0.01	mg/L
Copper (Cu)	0.01	mg/L
Zinc (Zn)	0.17	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.13	mg/L
Sodium (Na)	106	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	2.1	mg/L
Orthophosphate (PO4)	6.88	mg/L
Total Dissolved Solids	702	mg/L
pH	6.95 lab	pH units
pH Temperature	22.9 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	34.3	mg/L
Terpolymer	15.1	mg/L
Conductivity	898	uS/cm

Comments

Hardness: Satisfactory.
Iron and Copper: Low, good.
Zinc: Acceptable.
Aluminun: High.
Organic Phosphate (Phosphonate), the scale inhibitor: Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor:None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH: Low.
Conductivity: The tower was operating at 8.6 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

Charles D. Curtiss, Assistant Chemist Charles D. Curtiss ***Phone: 217/244-7391***

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS
Lab Number: 820674

IDPH Maintaining State Facilities since 1919

Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cooling Tower*	***Attention:***	*Mr. Vince Hock*
Location:	*0495804 Ft. Bragg*	***Additional Information:***	
Date Collected:	*12/30/08*	*Lead (Pb) = <0.10mg/L*	

Parameter	***Value***	***Units***
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	46	mg/L
Hardness (as CaCO3)	86	mg/L
Calcium (Ca)	28.8	mg/L
Magnesium (Mg)	2.94	mg/L
Sulfate (SO4)	88	mg/L
Chloride (Cl)	77	mg/L
Iron (Fe)	0.64	mg/L
Copper (Cu)	0.02	mg/L
Zinc (Zn)	0.52	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.05	mg/L
Sodium (Na)	66.1	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	0.8	mg/L
Orthophosphate (PO4)	4.18	mg/L
Total Dissolved Solids	372	mg/L
pH	6.98 lab	pH units
pH Temperature	22.9 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	17.6	mg/L
Terpolymer	12.2	mg/L
Conductivity	528	uS/cm

Comments

Hardness: Low.
Iron and Aluminum: Acceptable.
Copper: Low, good.
Zinc: High
Organic Phosphate (Phosphonate), the scale inhibitor: Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor: None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH: Low.
Conductivity: The tower was operating at 5.1 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: *820629*

[illegible]

Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cooling Tower*	***Attention:***	*Mr. Vince Hock*
Location:	*0495805, Ft. Bragg*	***Additional Information:***	
Date Collected:	*04/28/08*		

Parameter	***Value***		***Units***
P Alkalinity (as CaCO3)	26		mg/L
M Alkalinity (as CaCO3)	70		mg/L
Hardness (as CaCO3)	60		mg/L
Calcium (Ca)	20.1		mg/L
Magnesium (Mg)	2.45		mg/L
Chloride (Cl)	124		mg/L
Iron (Fe)	1.02		mg/L
Copper (Cu)	0.02		mg/L
Zinc (Zn)	0.38		mg/L
Molybdenum (Mo)	0		mg/L
Aluminum (Al)	0.17		mg/L
Sodium (Na)	144		mg/L
Lead (Pb)	<0.10		mg/L
Manganese (Mn)	0.01		mg/L
Organic Phosphate (PO4)	2.4		mg/L
Orthophosphate (PO4)	8.23		mg/L
Total Dissolved Solids	580		mg/L
pH	10.37	lab	pH units
pH Temperature	23.4	lab	deg. C
Triazole	0		mg/L
Silica (SiO2)	19.7		mg/L
Terpolymer	21.5		mg/L
Conductivity	829		uS/cm

Comments

Hardness: Low.
Iron and Zinc: Acceptable.
Copper: Low, good.
Aluminum: High
Manganese: Satisfactory.
Organic Phosphate (Phosphonate), the scale inhibitor: Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor: None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH: Satisfactory.
Conductivity: The tower was operating at 8.0 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: *820630*

Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cooling Tower*	***Attention:***	*Mr. Vince Hock*
Location:	*0495805, Ft. Bragg*	***Additional Information:***	
Date Collected:	*06/04/08*		

Parameter	***Value***	***Units***
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	58	mg/L
Hardness (as CaCO3)	51	mg/L
Calcium (Ca)	17.1	mg/L
Magnesium (Mg)	2.12	mg/L
Chloride (Cl)	96	mg/L
Iron (Fe)	0.93	mg/L
Copper (Cu)	0.02	mg/L
Zinc (Zn)	0.27	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.15	mg/L
Sodium (Na)	119	mg/L
Lead (Pb)	<0.10	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	2.00	mg/L
Orthophosphate (PO4)	6.73	mg/L
Total Dissolved Solids	468	mg/L
pH	6.66	pH units
pH Temperature	23.4 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	6.7 lab	mg/L
Terpolymer	19.5	mg/L
Conductivity	691	uS/cm

Comments

Hardness: Low.
Iron and Zinc: Acceptable.
Copper: Low, good.
Aluminum: High
Organic Phosphate (Phosphonate), the scale inhibitor: Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor: None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH: Extremely low.
Conductivity: The tower was operating at 6.6 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: 820631

Analyst:	JLO	**Facility:**	CERL
Sample Type:	Cooling Tower	**Attention:**	Mr. Vince Hock
Location:	0495805, Ft. Bragg	**Additional Information:**	
Date Collected:	06/25/08		

Parameter	**Value**	**Units**
P Alkalinity (as CaCO3)	24	mg/L
M Alkalinity (as CaCO3)	76	mg/L
Hardness (as CaCO3)	31	mg/L
Calcium (Ca)	12.00	mg/L
Magnesium (Mg)	0.38	mg/L
Sulfate (SO4)	161	mg/L
Chloride (Cl)	125	mg/L
Iron (Fe)	0.03	mg/L
Copper (Cu)	0.01	mg/L
Zinc (Zn)	0.06	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0	mg/L
Sodium (Na)	160	mg/L
Lead (Pb)	<0.10	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	2.1	mg/L
Orthophosphate (PO4)	9.87	mg/L
Total Dissolved Solids	610	mg/L
pH	10.40 lab	pH units
pH Temperature	23.3 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	22.7	mg/L
Terpolymer	18.3	mg/L
Conductivity	861	uS/cm

Comments

Hardness: Low.
Iron, Copper and Aluminum: Low, good.
Zinc: Satisfactory.
Organic Phosphate (Phosphonate), the scale inhibitor: Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor: None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH: Satisfactory.
Conductivity: The tower was operating at 8.3 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: 820632

Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cooling Tower*	***Attention:***	*Mr. Vince Hock*
Location:	*0495805, Ft. Bragg*	***Additional Information:***	
Date Collected:	*07/23/08*		

Parameter	***Value***	***Units***
P Alkalinity (as CaCO3)	20	mg/L
M Alkalinity (as CaCO3)	68	mg/L
Hardness (as CaCO3)	58	mg/L
Calcium (Ca)	17.5	mg/L
Magnesium (Mg)	3.37	mg/L
Chloride (Cl)	114	mg/L
Iron (Fe)	0.10	mg/L
Copper (Cu)	0.01	mg/L
Zinc (Zn)	0.17	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.22	mg/L
Sodium (Na)	153	mg/L
Lead (Pb)	<0.10	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	2.3	mg/L
Orthophosphate (PO4)	11.21	mg/L
Total Dissolved Solids	594	mg/L
pH	9.61 lab	pH units
pH Temperature	23.3 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	17.4	mg/L
Terpolymer	20.00	mg/L
Conductivity	867	uS/cm

Comments

Hardness: Low.
Iron: Satisfactory.
Copper: Low, good.
Zinc: Acceptable.
Aluminum: High
Organic Phosphate (Phosphonate), the scale inhibitor: Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor: None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH: Satisfactory.
Conductivity: The tower was operating at 8.3 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: 820633

[illegible]

Analyst:	*JLO*	***Facility:***	*CERL*
Sample Type:	*Cooling Tower*	***Attention:***	*Mr. Vince Hock*
Location:	*0495805, Ft. Bragg*	***Additional Information:***	
Date Collected:	*08/21/08*		

Parameter	*Value*	*Units*
P Alkalinity (as CaCO3)	18	mg/L
M Alkalinity (as CaCO3)	62	mg/L
Hardness (as CaCO3)	46	mg/L
Calcium (Ca)	14.1	mg/L
Magnesium (Mg)	2.49	mg/L
Chloride (Cl)	89	mg/L
Iron (Fe)	0.51	mg/L
Copper (Cu)	0.01	mg/L
Zinc (Zn)	0.23	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.16	mg/L
Sodium (Na)	117	mg/L
Lead (Pb)	<0.10	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	1.4	mg/L
Orthophosphate (PO4)	6.72	mg/L
Total Dissolved Solids	450	mg/L
pH	10.12 lab	pH units
pH Temperature	23.3 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	11.9	mg/L
Terpolymer	14.4	mg/L
Conductivity	690	uS/cm

Comments

Hardness: Low.
Iron and Zinc: Acceptable.
Copper: Low, good.
Aluminum: High
Organic Phosphate (Phosphonate), the scale inhibitor: Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor: None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH: Satisfactory.
Conductivity: The tower was operating at 6.6 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS
Lab Number: 820634

Analyst:	JLO	**Facility:**	CERL
Sample Type:	Cooling Tower	**Attention:**	Mr. Vince Hock
Location:	0495805, Ft. Bragg	**Additional Information:**	
Date Collected:	09/30/08		

Parameter	Value	Units
P Alkalinity (as CaCO3)	8	mg/L
M Alkalinity (as CaCO3)	50	mg/L
Hardness (as CaCO3)	38	mg/L
Calcium (Ca)	11.7	mg/L
Magnesium (Mg)	1.87	mg/L
Chloride (Cl)	63	mg/L
Iron (Fe)	0.62	mg/L
Copper (Cu)	0.02	mg/L
Zinc (Zn)	0.22	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.14	mg/L
Sodium (Na)	86.2	mg/L
Lead (Pb)	<0.10	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	1.3	mg/L
Orthophosphate (PO4)	6.21	mg/L
Total Dissolved Solids	328	mg/L
pH	9.90 lab	pH units
pH Temperature	23.4 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	1.4	mg/L
Terpolymer	19.7	mg/L
Conductivity	508	uS/cm

Comments

Hardness: Low.
Iron and Zinc: Acceptable.
Copper: Low, good.
Aluminum: High
Organic Phosphate (Phosphonate), the scale inhibitor: Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor: None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH: Satisfactory.
Conductivity: The tower was operating at 4.9 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS
Lab Number: 820635

ISWS Maintaining State Facilities Since 1949

Analyst:	JLO	**Facility:**	CERL
Sample Type:	Cooling Tower	**Attention:**	Mr. Vince Hock
Location:	0495805 Ft. Bragg	**Additional Information:**	
Date Collected:	10/22/08		

Parameter	Value	Units
P Alkalinity (as CaCO3)	10	mg/L
M Alkalinity (as CaCO3)	54	mg/L
Hardness (as CaCO3)	34	mg/L
Calcium (Ca)	11.6	mg/L
Magnesium (Mg)	1.30	mg/L
Chloride (Cl)	61	mg/L
Iron (Fe)	0.95	mg/L
Copper (Cu)	0.02	mg/L
Zinc (Zn)	0.22	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.10	mg/L
Sodium (Na)	83.9	mg/L
Lead (Pb)	<0.10	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	1.2	mg/L
Orthophosphate (PO4)	5.04	mg/L
Total Dissolved Solids	318	mg/L
pH	9.93 lab	pH units
pH Temperature	23.6 lab	deg. C
Triazole	0.00	mg/L
Silica (SiO2)	0.9	mg/L
Terpolymer	13.9	mg/L
Conductivity	490	uS/cm

Comments

Hardness: Low.
Iron and Zinc: Acceptable.
Copper: Low, good.
Aluminum: High
Organic Phosphate (Phosphonate), the scale inhibitor: Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor: None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH: Satisfactory.
Conductivity: The tower was operating at 4.7 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

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Illinois State
WATER
Survey (1895)

WATER SAMPLE ANALYSIS
Lab Number: 820636

Analyst:	JLO	**Facility:**	CERL
Sample Type:	Cooling Tower	**Attention:**	Mr. Vince Hock
Location:	0495805, Ft. Bragg	**Additional Information:**	
Date Collected:	11/24/08		

Parameter	Value	Units
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	52	mg/L
Hardness (as CaCO3)	67	mg/L
Calcium (Ca)	21.9	mg/L
Magnesium (Mg)	2.60	mg/L
Chloride (Cl)	72	mg/L
Iron (Fe)	0.80	mg/L
Copper (Cu)	0.02	mg/L
Zinc (Zn)	0.51	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.06	mg/L
Sodium (Na)	77.00	mg/L
Lead (Pb)	<0.10	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	1.00	mg/L
Orthophosphate (PO4)	4.57	mg/L
Total Dissolved Solids	364	mg/L
pH	7.08 lab	pH units
pH Temperature	23.6 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	16.7	mg/L
Terpolymer	13.9	mg/L
Conductivity	522	uS/cm

Comments

Hardness: Low.
Iron and Aluminum: Acceptable.
Copper: Low, good.
Zinc: High
Organic Phosphate (Phosphonate), the scale inhibitor: Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor: None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH: Low.
Conductivity: The tower was operating at 5.0 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

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Illinois State WATER Survey (1895)

WATER SAMPLE ANALYSIS

Lab Number: 820637

ISWS Maintaining State Facilities Since 1949

Analyst:	JLO	**Facility:**	CERL
Sample Type:	Cooling Tower	**Attention:**	Mr. Vince Hock
Location:	0495805, Ft. Bragg	**Additional Information:**	
Date Collected:	12/30/08		

Parameter	Value	Units
P Alkalinity (as CaCO3)	0	mg/L
M Alkalinity (as CaCO3)	46	mg/L
Hardness (as CaCO3)	79	mg/L
Calcium (Ca)	26.1	mg/L
Magnesium (Mg)	2.85	mg/L
Chloride (Cl)	73	mg/L
Iron (Fe)	0.82	mg/L
Copper (Cu)	0.02	mg/L
Zinc (Zn)	0.53	mg/L
Molybdenum (Mo)	0	mg/L
Aluminum (Al)	0.05	mg/L
Sodium (Na)	66.2	mg/L
Lead (Pb)	<0.10	mg/L
Manganese (Mn)	0	mg/L
Organic Phosphate (PO4)	0.8	mg/L
Orthophosphate (PO4)	3.68	mg/L
Total Dissolved Solids	360	mg/L
pH	6.94 lab	pH units
pH Temperature	23.8 lab	deg. C
Triazole	0	mg/L
Silica (SiO2)	16.2	mg/L
Terpolymer	11.1	mg/L
Conductivity	507	uS/cm

Comments

Hardness: Low.
Iron and Aluminum: Acceptable.
Copper: Low, good.
Zinc: High.
Organic Phosphate (Phosphonate), the scale inhibitor: Low, below the recommended 3-6 mg/L but over time has probably degraded to Orthophosphate, Satisfactory.
Triazole, the copper corrosion inhibitor: None, below the recommended 2-5 ppm.
Terpolymer, the dispersant: Satisfactory, within the expected 10-25 ppm.
pH:Extremely Low.
Conductivity: The tower was operating at 4.9 cycles of concentration using the conductivity from the June 12, 2009 sample. It is probable that the quality of the cold distribution water changes throughout the year.

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14. ABSTRACT
Two critical infrastructure corrosion issues at Fort Bragg, NC, are the corrosion of steel utility piping union joints in mechanical rooms and the corrosion of steel pump housings in cooling tower systems. Reliable operation of these components is essential to the Fort Bragg mission. Pump corrosion can lead to system failure, causing disruptions in facility operation and incurring considerable expense for emergency repair labor and parts. This projected demonstrated reliable corrosion prevention technologies — including high-performance coatings, materials, insulation, water treatment, and dehumidification — as applied to mechanical room pipes and cooling tower housings. The performance of the technologies was monitored along with the overall corrosivity of the environment from January – December 2008. Then, in mid-2010, coating condition in both the mechanical rooms and on the cooling-tower pumps was inspected and reassessed. This report presents corrosion data spanning approximately 30 months of service and evaluates the performance of each technology in terms of cost effectiveness, system reliability, and safety.

15. SUBJECT TERMS
corrosion prevention program (CPC), demonstration, pump corrosion, infrastructure, corrosion prevention technologies, performance

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