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IN-SITU EPOXY COATING FOR METALLIC PIPE

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FACILITIES ENGINEERING
UTILITIES

IN-SITU EPOXY COATING FOR METALLIC PIPE

1. Purpose. The purpose of this Public Works Technical Bulletin (PWTB) is to transmit current information on coating technology for the interior of existing metallic piping to enhance corrosion protection for implementation at Army installations.

2. Applicability. This PWTB applies to all U.S. Army Public Works activities concerning the maintenance of metallic pipelines.

3. References.

a. AR 420-49-02, Facilities Engineering Utility Services, 28 May 1997.

b. Public Law (PL) 93-523, Safe Drinking Water Act (SDWA), 16 December 1974.

c. Pubic Works Technical Bulletin 420-46-7, Chemical Treatment of Domestic Water to Inhibit Dissolution of Lead in Building Plumbing, 1 November 1996.

d. National Sanitation Foundation ANSI/NSF 61, Drinking Water System Components-Health Effects, Standard Certification.

e. ANSI/AWWA C210-97, Liquid-Epoxy Coating systems for the Interior and Exterior of Special Sections, Connections, and Fittings for Steel Water Pipes.

4. Discussion. This PWTB provides material and performance specification guidance for in situ epoxy coating of metallic pipelines. In-situ coating has been proven to be an effective means of controlling metallic corrosion and soluble metal release in piping systems. This provides the Army with a viable alternative to chemical treatment for drinking water systems. The attached document provides detailed information on the application of in-situ coatings.

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IN SITU EPOXY COATING IN METALLIC PIPE

GUIDANCE

IN SITU EPOXY COATING FOR METALLIC PIPE GUIDANCE

1. Introduction

This Document provides material and performance specification guidance for in-situ epoxy coating of metallic pipelines. In situ coating has been proven to be an effective means of controlling metallic corrosion and soluble metal release in piping systems. This provides the Army with a viable alternative to chemical treatment for drinking water systems.

2. References

Public Law (PL) 93-523, Safe Drinking Water Act (SDWA), 16 December 1974.

Pubic Works Technical Bulletin 420-46-7, Chemical Treatment of Domestic Water to Inhibit Dissolution of Lead in Building Plumbing, 1 November 1996.

USACERL Technical Report 99/39, Laboratory Evaluation of an In Situ Coating Process for Mitigation of Lead and Copper in Drinking Water, Hock V. F., et. al., April 1999.

USACERL Memorandum, Corrosion and Water Treatment Analysis, Composite Medical Facility, Elmendorf AFB, SAB.

National Sanitation Foundation ANSI/NSF 61, Drinking Water System Components-Health Effects, Standard Certification

ANSI/AWWA C210-97, Liquid-Epoxy Coating systems for the Interior and Exterior of Special Sections, Connections, and Fittings for Steel Water Pipes.

3. Background

United States Environmental Protection Agency (USEPA) regulations that were signed into law on 6 June 91 established an action level (AL) of 0.015 milligrams/liter (mg/L) of lead in drinking water. An Action Level (AL) differs from a Maximum Contaminant Level in that it is not a required limit, but if it is exceeded there are certain actions that must be initiated on the part of the water supply. Specifically, a failure to comply with the AL requires the preparation of a treatment plan approved by the appropriate state regulatory agency, optimization of water treatment, and the initiation of a public education program. This regulation is detailed in reference (a). The USEPA estimates that the nationwide cost of compliance will involve a capitol investment of $2.9 billion to $7.6 billion and an annual maintenance cost of $240 million. The Army Environmental Hygiene Agency has stated that forty percent (40%) of all medium

sized water distribution systems are expected to exceed the 0.015 mg/L limit for lead. One of the primary sources of lead in drinking water systems is tin-lead solder that was used to join copper tubes in plumbing systems for many years. The other major historical sources of lead in drinking water systems include leaded brasses used in valves and faucets. Certain water chemistries can result in the release of soluble lead from the soldered joints or brass into the drinking water. Similarly, corrosion of copper piping materials can result in excessive copper concentrations. In addition to these "hot spots", large facilities are dealing with base-wide problems with lead or copper concentrations that exceed the AL, and must be brought into compliance. The army maintains 166,000 occupied family housing units utilizing water chemistries that are aggressive to leaded solder or copper. Many of the plumbing systems are experiencing corrosion problems due to unlined and welded black steel and copper plumbing. This corrosion is causing severe red water problems throughout the facility. In addition to discoloration, the corrosion is elevating soluble copper, iron, and lead levels to unacceptable concentrations. Chemical treatment can, in most cases, be used to control these corrosion problems. This was detailed in previous PWTB, reference (b). An in situ epoxy coating developed by the Construction Engineering Research Laboratory (CERL), the Naval Research Laboratory, and the private sector is suitable for application to the interior of building plumbing systems. Reference (c) is an earlier USACERL publication that provides documentation of the suitability and effectiveness of the in situ coating for preventing lead and copper corrosion with different combinations of water quality and flow parameters. These coatings eliminate the leaching of lead from the soldered joints, and the corrosion of copper and steel pipe, by preventing the water from contacting the metal surface. In addition, the coating will eliminate galvanic corrosion cells that result from joining dissimilar metals and cover over workmanship defects that contribute to premature failure of copper pipe.

4. Material and Performance Specifications.

There are a number of issues that need careful consideration when applying an in situ epoxy coating to existing steel or copper piping materials. Figure 1 outlines a flow chart that details the essential considerations for a successful job. Coatings applied to piping in drinking water systems must meet the guidelines in references (d) and (e). Detailed specifications for pre and post-bid inspection, application, and performance must be developed as outlined in reference (f). Water quality and flow rates in the system should be determined before initiating treatment.

a. Pipe Cleaning and Surface Preparation: In order to achieve proper bonding and adhesion to the surface of the piping material, it is of critical importance to clean and abrasively blast the interior of the piping systems before the epoxy coating is applied. The piping should be thoroughly flushed and drained, followed by forced air drying to remove all moisture. Critical or sensitive equipment, valves, and expansion joints need to be removed or isolated from the system before abrasively cleaning the pipe material. Selected grit sizes shall be blasted through the pipe systems to remove rust and corrosion buildup. An air pressure manifold shall regulate and monitor (in psig) the flow of air through distribution hoses and system piping during the cleaning and application process. The type of blasting material used will be selected based upon the materials to be cleaned and coated. Idaho Almandite Garnet Sand or equivalent (size #16, 18/20, 30/40, 36, 60) shall be used to clean steel pipe and to provide an anchor tooth of 50 to 75 micrometers (2-3 mils) during final surface preparation of the pipe. A surface profile of 2 to 3

mils is recommended to maximize bond strength between the epoxy coating and the interior of the pipe. The surface profile will be measured using a surface roughness gauge. The sand shall be dry and contain less than 5 percent fines, leaving minimal residue in the pipe. The sand shall not contain any feldspar, iron, aluminum or other materials which could be embedded in the surface or create galvanic interaction with the pipe. The abrading agent shall not be re-used. The blasting will conform to SSPC-SP 10 specifications for a near white blast when cleaning steel pipe. Air-surging will be used on clean pipes to remove dust and other minute debris. Collection and filtering equipment approved by the manufacturer shall collect all of the spent abrading agent and filter dust from the air stream. Pipe will be inspected after cleaning to verify that the interior surfaces of the piping systems have been properly prepared to guarantee optimal conditions for epoxy coating adhesion.

b. Coating Application. As soon as the piping surfaces have been cleaned and surface preparation is complete the coating process can be initiated. Final inspection of piping materials before application may be desirable. The contractor should be required to coat test panels prior to coating the entire piping systems. Subsequent to facility approval of the test panel performance, the coating application can proceed. The air and piping may need to be heated to achieve the optimal coating environment and insure proper adhesion to the piping surface. In order for effective coating curing and adhesion, the pipe temperature shall be maintained above the dew point to avoid moisture contamination of the epoxy coating. The temperature range necessary to achieve the ideal coating environment (insuring proper viscosity and curing time) is a minimum of 60°F to a maximum of 100°F. Distribution of the epoxy coating throughout pipe shall be accomplished using heated, compressed air. The maximum pressure applied inside the water distribution pipe system shall not exceed 80 psi during any phase of the application process. In situ epoxy coating shall not be applied on pipe systems or fittings that have less than 40% of their original wall thickness. The epoxy coating must be National Sanitation Foundation Standard 61 certified for potable water distribution piping systems. All work shall be performed in accordance with ANSI/AWWA C210-97 and the product manufacturer's instructions. Coating thickness shall be measured using profile tape, a depth micrometer or a surface profile comparator. The thickness of the coating will be measured as soon as the epoxy has set to the touch. The thickness required shall be determined by the contractor and facility based upon the materials and pipe sizes involved. This thickness shall be achieved through the application of no more than three coats of epoxy. The piping system may require air-drying subsequent to completion of the coating application. The epoxy manufacturer shall be consulted to ascertain the proper curing time of the coating prior to performing the cure testing. The minimum allowable air drying temperature shall be 60°F.

c. Coating Material Specification. The epoxy product used to coat the water distribution system will be a two component 100% solids epoxy system meeting ANSI/NSF 14 and ANSI/NSF 61 standards. The two epoxy components shall both be products of one manufacturer. The epoxy product shall meet the specifications listed in Figure 2. These specifications are for the product described in US Patent No. 5,707,702. The epoxy coating shall be able to withstand exposure to 180°F continuous immersion. The epoxy coating shall not leach any organic compounds into the potable water system. The in situ epoxy coating shall be under full warranty for a period of not less than 10 years.

d. Post-Application Inspection Procedures. The epoxy coating must be cured and pass all tests prior to being subjected to the pressure test and subsequent leak test. After replacing the original valves, expansion joints, and fittings, the pipe shall be subjected for 1 hour to a hydrostatic pressure test. Each valve shall be opened and closed several times during the test. Accessible piping, joints, fittings, and valves shall be carefully examined during the pressure test. All joints showing visible leakage shall be replaced or remade as necessary. Cracked or defective pipe, joints, fittings, and valves discovered in consequence of this pressure test shall be removed and replaced with new material, meeting the original material specifications, and the test shall be repeated until the test results are satisfactory. A leakage test shall be conducted after the pressure tests have been satisfactorily completed. The duration of the leak test shall be at least 2 hours. The piping will be tested at a pressure appropriate for the system, and above the expected operating pressure. No leakage shall be allowed. Defective joints shall be located and repaired until the leakage is stopped, without additional cost to the Government. The pressure test and leak test may be conducted concurrently. Hydrostatic tests and system disinfection may also be conducted concurrently. If water is lost during, or subsequent to the disinfection process, if air is admitted to the piping being tested, or if any repair procedure results in possible contamination of the unit, disinfection shall be repeated. Before returning the system to service for drinking water operation, each section of the completed waterline shall be disinfected as prescribed by AWWA C651. Personnel from the Contractor or an accredited laboratory shall collect water samples from different points in an approved manner, as sanctioned by the Contracting Officer, in state approved, sterilized containers and perform a bacterial examination in accordance with U.S. Environmental Protection Agency approved methods. The laboratory performing the analysis shall be accredited by state authorities for the examination of potable water. Disinfection shall be repeated until tests indicate the absence of bacteria for at least 2 full days. The project will not be accepted until satisfactory bacteriological results have been obtained. Water samples should be obtained for analysis of Total Organic Carbon (TOC, Standard Methods 53.10 or ASTM D2579-93) and Volatile Organic Carbon (VOC). TOC and VOC concentrations for samples collected before the water enters the coated piping and after it exits the coated piping should be within 5%, or less than the method standard deviation. All aspects of the surface preparation and coating operation shall be inspected and documented by a certified coatings inspector. The person shall be certified as either as NACE Level III or as an SSPC Protective Coatings Specialist and have experience in the application and evaluation of epoxy coating on the internal surfaces of pipes. The inspector shall document and submit records of all inspections and operations performed.

5. Conclusion

In-Situ Epoxy Coating has proved to be an effective tool in controlling corrosion and extending the service life of system piping and components. The information contained in this PWTB should allow end-users to develop their own specifications for an In-Situ Coating application at their facility. We have included a sample draft specification in Appendix 1 for guidance.

FIGURE 1

In Situ Coating Process Sequence Chart

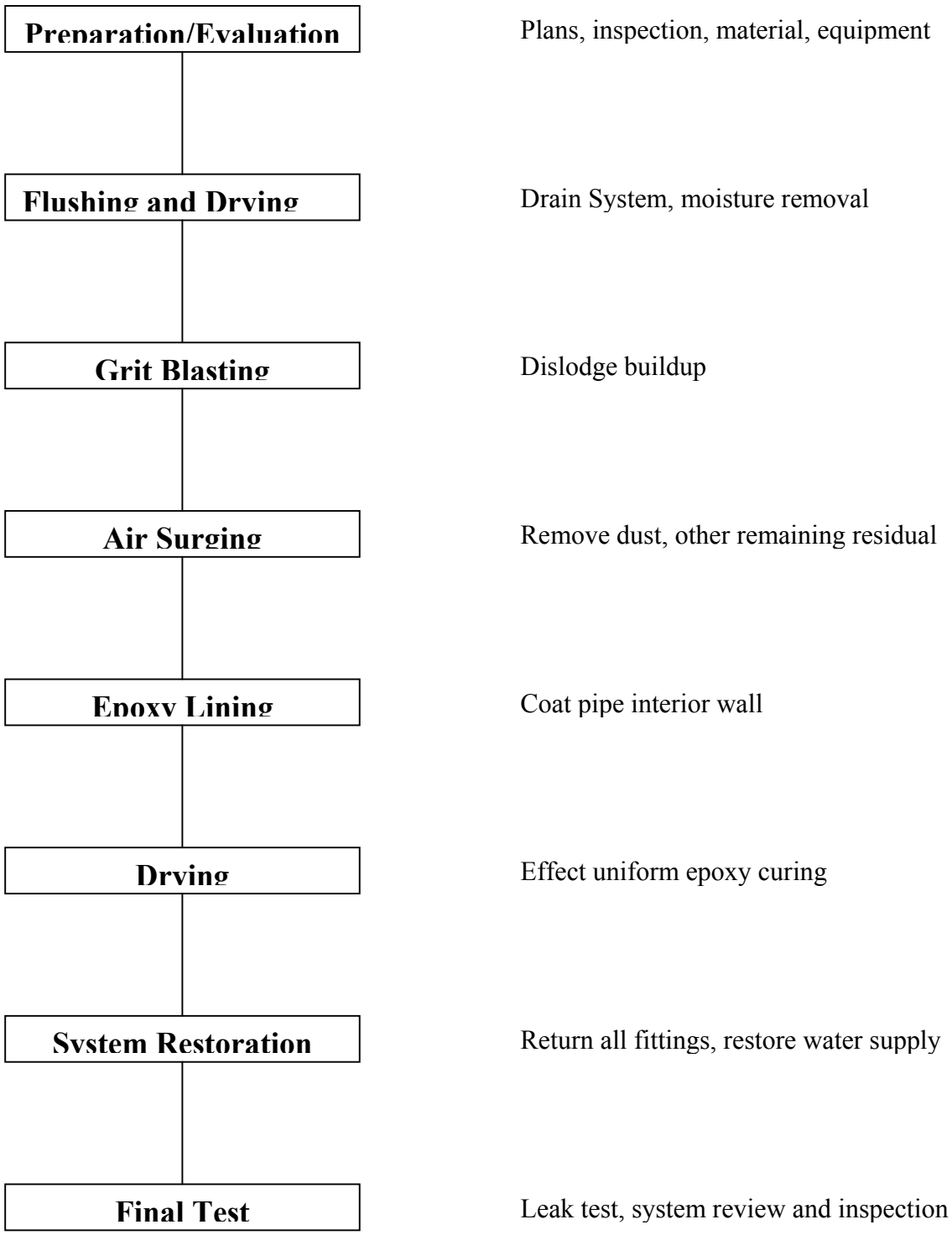

Figure 2
Epoxy Component Specifications

Base component

(1) Vehicle Type	Epoxy
(2) Solids Content	100% by weight; 100% by volume
(3) Coverage (Estimated)	1604 sq. ft / gal at 1mil DFT
(4) Recommended Thickness	7-9 mil per coat
(5) Thinner	Normally not used, #42 thinner
(6) Shelf Life at 75°F	One year guarantee from date of manufacture
(7) Dry Time at 75°F	Set to touch: 2-3 hours Full cure: 7 days
(8) Temperature Limits	Non-immersion 250°F Immersion 180°F
(9) Flash pt. closed cup	Base and catalyst: Above 100°F
(10) Color	Red oxide, others upon request
(11) Coating Finish	High gloss
(12) Pot Life	40-120 min. average, varies depending upon temperature and humidity
(13) Mixing Ratio	2 to 1 by volume (Base: Catalyst)
(14) VOC Content	0
(15) Hazardous components	Liquid epoxy resin 85% by weight Iron oxide 15% by weight
(16) Solubility in water	Not soluble in water
(17) Specific gravity	1.3
(18) Evaporation Rate	Slower than ether

Coating catalyst component

(1) Ingredients	Triethylenetetramine <10% Dimer/Tofa, Reaction products with teta > 90%
(2) Physical form	Mobile liquid
(3)Color	Amber
(4) Odor	Ammoniacal irritating
(5) pH	Alkaline
(6) Vapor pressure (mm Hg at 70°F)	< 1 at 77°F
(7) Vapor density (Air = 1)	No data
(8) Boiling point	No data
(9) Melting point	No data
(10) Solubility in water	Slight
(11) Specific gravity	0.97 at 77°F
(12) Viscosity	11000 at 77°F
(13) Molecular weight	Mixture

APPENDIX 1

EPOXY LINING OF STEEL PIPE IN PLACE
SAMPLE SPECIFICATIOS

GENERAL

The objective of this work is to install an epoxy coating system on the interior wall of the unlined, welded, steel pipes composing the water distribution pipe system. The water distribution pipe system is composed of the pipelines listed below. The pipe lines are located in a concrete utilidor that has walk through capability. The relevant plumbing diagrams will be supplied by the Corps of Engineers. Contractor shall verify the pipe lengths by reference to the plumbing diagrams and at the site visit.

Potable water distribution pipe system (ASTM A 53 Type E, Grade B)

Approximately 2000 ft 8" black steel pipe
Approximately 900 ft 6" black steel pipe

Cooling water distribution pipe system (ASTM A 53 Type E, Grade B)

Approximately 1200 ft 8" black steel pipe
Approximately 700 ft 6" black steel pipe
Approximately 1600 ft 4" black steel pipe

SITE VISITS AND TRAVEL

The Contractor shall visit the site and inspect all existing domestic and cooling water distribution pipe systems prior to bidding in order to determine actual configurations, extent of steel piping, locations of drain points, and locations and types of all connected equipment. Additional site visits may be performed upon request. The Contractor shall notify the Contracting Officers Representative (COR) 3 days prior to the scheduled site visit.

Travel will be required for two visits to site. The first visit will require contractor representatives to complete initial inspection of systems. The second visit will require an entire contractor work crew for a length of stay determined by the contractor subject to approval by the Contracting Officer. During the second visit, the epoxy coating will be installed.

TEMPORARY SERVICE CONNECTIONS

Identify and provide the water systems that need temporary service. Phase work so that not all zones are down at the same time. There are many electrical and small communications equipment rooms that are served by small fan coil units (FCU) with cooling coils. The need to keep these small cooling units operating will largely depend on the duration of the project. If the cooling water flow is to be shut down for only 4-5 days the contractor may not need to provide temporary water to these small units. There are several other units that cool critical rooms and these should be kept in operation at all times. Critical units include fan coil units 1 and 2 at room LC105, FCU 3 at room LC104, FCU 4 at room LC104, FCU 7 at room LC119, FCU-8 at room LE104, FCU 14 and 15 at room LG118, FCU 16, 17 and 18 at room LF119/120, FCU 21 at room LH108, FCU 22 at room LJ104, computer room cooling unit at room 1E106 and the computer room cooling unit at room 2E158. Contractor shall maintain supply to toilet facilities to the maximum extent possible. Contractor shall provide two days notice prior to shutting water supply to toilet facilities.

DESCRIPTION OF WORK

Air Cleaning

Provide for air-sand grit cleaning of water supply piping that will receive the epoxy coating.

Epoxy

Provide for epoxy lining of cleaned pipe runs as per manufacturer's recommendations.

DESCRIPTION OF PROCESS

In-place pipe restoration for piping systems is accomplished by the systematic drying of the pipe interior surface and the subsequent introduction of an air borne stream of abrading agent to clear the pipe interior surface. This step shall also serve to establish a suitable anchor tooth profile within the pipe wall to maximize epoxy coating adhesion.

Following inspection of the pipe to ensure that all grit and surface contaminants have been removed, a two-component, self priming, 100% solids epoxy coating is distributed throughout the pipe, adhering and setting to required thickness. Unless circumstances permit otherwise, each designated pipe section is processed separately at any given time by a single work crew.

Pipe rehabilitation work can be undertaken during both daytime and evening hours. Work time schedules shall be in accordance with local labor regulations and may be adjusted depending upon specific project circumstances.

The process involves the use of compressed air and an approved grit blasting sand for pipe cleaning and coating purposes. The process technology is based upon a patented design offering the flexibility to restore building piping systems of varying lengths, diameters, and bend configurations in a single pipe run. The process does not use, nor is in any way or form designed to accommodate the use and introduction of other mechanical devices into the pipe stream.

GENERAL SAFETY

Personnel Safety

All personnel shall be properly trained in the pipe lining technique, and comply with the Safety and Health Requirements Manual (EM 385-1).

Pre-Grit blast Safety

Abrading Agent

The abrading agent shall be totally contained in the pipe, hoses, and collection equipment

Grounding

All equipment and pipe shall be grounded to dissipate any static charges.

Personal Protection

MSDS

Observe all safety precautions listed in the Material Safety Data Sheets for material being used.

Hearing protection

Hearing protectors safety glasses, gloves, respirators (as necessary), ear plugs and other related safety apparatus shall be used in the vicinity of air generation, grit blast equipment, and/or epoxy application.

Communication

Two-way radio communication shall be maintained between operators whenever air is being transported in the pipe, hoses or equipment.

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C210-97	(1997) Liquid Epoxy Coating systems for Interior and Exterior of Steel Water Pipelines
AWWA B300	(1992) Hypochlorites
AWWA B301	(1992) Liquid Chlorine
AWWA C651	(1992) Disinfecting Water Mains

AMERICAN NATIONAL STANDARDS INSTITUTE/NATIONAL SANITATION FOUNDATION

ANSI/NSF 14	(1998) Plastic Piping Systems Components and Related Materials
ANSI/NSF 61	(1998) Drinking Water System Components-Health Effects

AMERICAN SOCIETY FOR TESTING AND MATERIALS

ASTM 3359	(1995) Measuring Adhesion by Tape Test
ASTM A 53	(1997) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless

CORPS OF ENGINEERS (COE) PUBLICATIONS

EM 385-1-1	(Sept 1996) Safety and Health Requirements Manual.

STEEL STRUCTURES PAINTING COUNCIL (SSPC)

SSPC SP5	(1985) Surface Preparation Specification No. 5. White Metal Blast Cleaning
SSPC SP 1	(1982) Solvent Cleaning

SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-01 Data

Work Plan; FIO.

Contractor shall submit a detailed work plan that will describe all work items of work required for completion of the work required by this specification, including a Safety Plan to meet the requirements of this contract.

SD-06 Instructions

Installation; FIO

The manufacturer's recommendations for each material or procedure to be utilized.

MSDS; FIO

Provide a copy of the MSDS for all materials used on the project.

SD-07 Schedules

Schedule: FIO.

Schedule will show all work items, with duration, required. This will include Mobilization, pre-cleaning TV inspection, pipe cleaning, post-cleaning TV inspection, flushing, disinfection, and all other work items required to accomplish the contract.

SD-08 Statements

Waste Water Disposal Method; FIO.

The method proposed for disposal of waste water from flushing, hydrostatic tests and disinfection, prior to performing hydrostatic tests. Submit a copy of all required permits.

Epoxy Lining; GA.

The Epoxy report showing the epoxy lining material meets the specifications and performance requirements. A small section of lined steel pipe from a previous project, if available.

Qualifications: GA.

Provide the qualifications of the Independent Quality Control Representative and the epoxy lining applicator with all required certifications.

Laboratory: FIO.

Provide certification that the laboratory meets the specifications.

SD-09 Reports

Bacterial Disinfection; FIO.

Test results from commercial laboratory verifying disinfection.

TV Inspection videos; FIO.

Provide a copy of all TV inspection video tapes and written logs showing location and description of defects found during the TV inspections.

Hydrostatic Testing; FIO.

Leaching test; FIO.

Provide a copy of the water quality test for leaching.

Post Application Tests; FIO.

Epoxy lining thickness test; FIO

Visual Examination; FIO

Bond Tests; FIO

Knife Peel tests; FIO

SD-13 Certificates

Certification for Epoxy Material; FIO.

Epoxy lining warranty; FIO.

PRODUCTS

Air Generation System

Air compressor(s) and peripheral equipment shall provide air volume and stream velocity to effectively clean, establish a pipe interior anchor tooth, and line the pipe.

Filters

Water/oil filters shall be used in the air generation system and shall be periodically inspected as required and serviced to ensure continuous delivery of uncontaminated dry air. The maximum airborne particle size shall be 0.3 microns for oil and water.

Air Distribution Manifold

An air pressure manifold shall regulate and monitor (in psig) the flow of air through distribution hoses and system piping.

Abrading Agent Injector

A mechanical device approved by the manufacturer shall inject the abrading agent into the air stream at a controlled and measured rate.

Dust Collector

Collection and filtering equipment approved by the manufacturer shall collect all the spent abrading agent and filter dust in the air stream.

Abrading Agent

Idaho Almandite Garnet Sand or equivalent (size #16, 18/20, 30/40, 36, 60) shall be used to clean the pipe and to provide an anchor tooth of 50 to 75 micrometers (2-3 mils) during final surface preparation of the pipe. The sand shall be dry and contain less than 5 percent fines, leaving minimal residue in the pipe. The sand shall not contain any feldspar, iron, aluminum or other materials which could be embedded in the surface or create galvanic interaction with the pipe. The abrading agent shall not be re-used.

Epoxy Coating

The epoxy product used to coat the water distribution system will be a two component 100% solids epoxy system meeting ANSI/NSF 14 and ANSI/NSF 61 standards. The epoxy shall be products of one manufacturer. The epoxy shall meet the following specifications. These specifications are for the product described in US Patent No. 5,707,702.

a. Description of coating base component

(1) Vehicle Type	Epoxy
(2) Solids Content	100% by weight; 100% by volume
(3) Coverage (Estimated)	1604 sq. ft / gal at 1mil DFT
(4) Recommended Thicknesses	7-9 mil per coat
(5) Thinner	Normally not used, #42 thinner
(6) Shelf Life at 75°F	One year guarantee from date of manufacture
(7) Dry Time at 75°F	Set to touch: 2-3 hours Full cure: 7 days
(8) Temperature Limits	Non-immersion 250°F Immersion 180°F
(9) Flash pt. closed cup	Base and catalyst: Above 100°F
(10) Color	Red oxide, others upon request
(11) Coating Finish	High gloss
(12) Pot Life	40-120 min. average, varies depending upon temperature and humidity
(13) Mixing Ratio	2 to 1 by volume (Base: Catalyst)
(14) VOC Content	0
(15) Hazardous components	Liquid epoxy resin 85% by weight Iron oxide 15% by weight
(16) Solubility in water	Not soluble in water
(17) Specific gravity	1.3
(18) Evaporation Rate	Slower than ether

b. Description of coating catalyst component

(1) Ingredients	Triethylenetetramine <10% Dimer/Tofa, Reaction products with teta > 90%
(2) Physical form	Mobile liquid
(3)Color	Amber
(4) Odor	Ammoniacal irritating
(5) pH	Alkaline
(6) Vapor pressure (mm Hg at 70°F)	< 1 at 77°F
(7) Vapor density (Air = 1)	No data
(8) Boiling point	No data
(9) Melting point	No data
(10) Solubility in water	Slight
(11) Specific gravity	0.97 at 77°F
(12) Viscosity	11000 at 77°F
(13) Molecular weight	Mixture

Performance

The epoxy coating used in the water distribution pipe system will comply with following guidelines.

Warranty

The contractor shall warranty the epoxy lining for 10 years. The Contractor is liable for materials and any damage resulting from a failure of the epoxy lining during the warranty period.

Temperature

The epoxy coating shall be able to withstand exposure to 180°F continuous immersion.

Leaching

The epoxy coating shall not leach any organic compounds into the potable water system.

NSF Approval

NSF approval for potable water systems.

EXECUTION TEST SECTION

Contractor shall select a section of pipe with a minimum length of 400 feet and apply the epoxy lining with the methods and materials stated in this specification. The lining shall be inspected and tested as stated in this specification for all lining testing procedures. Satisfactory demonstration of the lining technique on the test section and written approval from the Contracting Officer is required before work begins on the remainder of the piping.

Pipe System Preparation (Pre-rehabilitation)

Prior to commencing with rehabilitation, the existing pipe environment shall be reviewed at accessible locations, normally at pipe end sections at the main(s) or mechanical room(s). Pre-rehabilitation preparatory measures will include the following:

Disassembly

Disassembly and removal of existing valves, fittings, instrumentation, cooling coils and other related fixtures.

Retrofitting

Retrofitting of existing lines using approved temporary assemblies to accommodate the cleaning and lining process.

Bypass

Installation of temporary water (bypass) provisions as required.

TV Inspection

The interior condition of the steel pipe shall be inspected by means of a closed circuit television prior to the beginning of the cleaning process. 100 percent of the steel piping to be lined shall be TV inspected.
The television cameras used for the inspection shall be one specifically designed and constructed for such inspection. Lighting for the camera shall be suitable to allow a clear

picture of the entire periphery of the pipe. The camera shall be operable in 100% humidity conditions. The camera, television monitor, and other components of the video system shall be capable of producing picture quality to the satisfaction of the CO.

Procedure

The camera shall be moved through the line in either direction at a rate which allows clear viewing of the internal pipe surface, stopping when necessary to permit proper documentation of the water lines condition. In no case will the television camera be pulled at a speed greater the 30 feet per minute. Manual winches, power winches, TV cable, and powered rewinds or other devices that do not obstruct the camera view or interfere with proper documentation of the water lines condition shall be used to move the camera through the water line.

Communication

When manually operated winches are used to pull the television camera through the pipe, telephone lines or other suitable means of communication shall be set up on each end of the pipe being inspected to insure good communications between the crew members.

Distance recording

Accurate distance measurements are required to locate defects in the pipe. Measurements shall be made using an automatic footage meter. Distances shall be visually recorded on the video tape recording of the inspection.

Documentation

Documentation of the TV inspection shall be written and videotaped. The videotape recordings shall be in VHS format and shall supply a visual and audio record of the location and description of the problem areas of the lines that may be replayed. Videotapes recording playback shall be at the same speed that it was recorded. The tapes shall become the property of the CO. Video recordings shall be cross referenced to written logs with an identifying system that clearly identifies all sections of piping. The intent is to facilitate retrieval and review of information.

Pipe Interior Surface Preparation

The pipe section(s) to be cleaned shall initially be drained of its contents and dried for a minimum of 2 hours using compressed air. The minimum allowable air drying temperature

shall be 60°F. Prior to abrasive blast cleaning, surfaces shall be inspected and, if required, cleaned according to SSPC SP 1 to remove oil, grease, or other foreign matter. Only approved solvents that do not leave a residue shall be used. The pipe interior surface shall subsequently be prepared by sequentially passing an airborne abrading agent through the pipe to clean and dry the substrate, and provide the acceptable anchor tooth profile. When appropriate, a scraping mechanism shall be passed through the pipe section, followed by the grit blasting procedure. The prepared surface shall have a near-white metal blast appearance (conforming to SSPC SP5 Blast Cleaning Standards) and anchor tooth profile of 50 to 75 micrometers (2-3 mils), measured at the pipe inlet and discharge point(s) using profile tape, a depth micrometer or or a surface profile comparator. The prep-surface shall be free of oil, dust. mill scale. oxides and other foreign material. Blast cleaned pipe surfaces shall be protected from conditions of high humidity or surface moisture. Pipe shall not be allowed to flash rust before coating.

TV Inspection

The interior of all cleaned steel pipe shall be visually inspected and documented by means of closed-circuit television following the cleaning of the pipe in accordance with the procedures outlined in section Pipe System Preparation (Pre-rehabilitation). 100 percent of the piping cleaned shall be TV inspected.

Epoxy Coating

Effective coating shall require the pipe temperature to be maintained above the dew point to avoid moisture contamination of the epoxy coating. Heat the air in the pipe, and the pipe itself to achieve optimal coating environment within the pipe. The temperature range necessary to obtain optimal coating environment (viscosity, curing time) is minimum 60°F to maximum of 100°F. Distribute the epoxy coating throughout pipe lengths using heated compressed air. The epoxy coating must be able to be used in potable water systems with out the trace of the epoxy or volatiles in the water. The maximum temperature applied on the epoxy coating shall not exceed 100°F during any phase of the application process. The minimum temperature applied on the epoxy coating shall not fall below 60°F during any phase of the application process. The maximum pressure applied inside the water distribution pipe system shall not exceed 80 psi during any phase of the application process. The epoxy coating will be used in water distribution pipe systems with couplings, fittings, angles, and horizontal and vertical branches having pipe diameters from 4 inch to 8 inch. The epoxy coating must be National Sanitation Foundation Standard 61 certified for potable water distribution pipe systems. All work shall be performed in accordance with ANSI/AWWA C210-97 and manufacturer's instructions. The final epoxy thickness shall be 14 mil min.. This thickness shall be achieved in two coats min. and no more than three coats. The second coat shall be applied within the time limits, surface conditions, and temperature recommended by the manufacturer. If the period between coats is exceeded, then a repair procedure shall be obtained from the coating manufacturer and its recommendation followed. The epoxy coating shall be evenly distributed throughout the length of the pipe utilizing compressed air as the transport medium. The air stream and epoxy

flow will be inspected at the exhaust end of the pipe via a clear hose section. Visually examine the coating's exit as coverage is completed.

Epoxy Curing

Following lining, a controlled flow of air shall be introduced into the pipe to facilitate curing of the epoxy coating. The epoxy manufacturer shall be consulted to ascertain the proper cure time of the coating prior to performing the cure testing. When circumstances necessitate, a pneumatically controlled spinning-head spray mechanism shall be used to line the pipe segment, and the lining subsequently cured using the mentioned controlled air flow curing procedure.

TV Inspection of Epoxy

The interior of all epoxy lined pipes shall be inspected by means of closed circuit television after the epoxy application. TV inspection shall be in accordance with the procedures outlined in section Pipe System Preparation (Pre-rehabilitation). 100 percent of the lined pipe shall be TV inspected.

Evaluation of Pipe Lining

Each section of pipe lined in one procedure shall have a final evaluation of the coated pipe system. The contractor will certify that the preparation of the pipe, application of the epoxy coating, curing, and inspection/testing were satisfactory. Evaluation includes, but is not limited to the following tasks.

Thickness

The thickness of the coating will be measured as soon as the epoxy has set to touch. Wet gauge measurement shall be sufficient for 100% solid epoxy coatings.

Coating Repair

If, after inspection of the epoxy coating , it is determined that the epoxy coating is in need of repair (coating cracking, low coating thickness, etc.), then the contractor will make the specified repairs to the epoxy coating. Repair techniques and procedures shall be performed in accordance with this specification. The contractor shall request approval from the COR prior to proceeding with any repairs.

HYDROSTATIC TESTING

Pressure Test

After returning the original valves, expansion joints, and fittings, but before connection to the copper system, the steel pipe shall be subjected for 1 hour to a hydrostatic pressure test of 200 psi. Each valve shall be opened and closed several times during the test. Exposed pipe, joints, fittings, and valves shall be carefully examined during the pressure test. Joints showing visible leakage shall be replaced or remade as necessary. Cracked or defective pipe, joints, fittings, and valves discovered in consequence of this pressure test shall be removed and replaced with new material, meeting the original material specifications, and the test shall be repeated until the test results are satisfactory.

Leakage Test

Leakage test shall be conducted after the pressure tests have been satisfactorily completed. The duration of each leakage test shall be at least 2 hours, and during the test the water line shall be subjected to not less than 200 psi pressure. No Leakage will be allowed. Defective joints shall be located and repaired until the leakage is stopped., without additional cost to the Government.

Time for Making Test

The epoxy coating must have cured and passed all tests prior to being subjected to the pressure test and subsequent leakage test.

Concurrent Hydrostatic Tests

The Contractor may elect to conduct the hydrostatic tests using either or both of the following procedures. Regardless of the sequence of tests employed, the results of pressure tests, leakage tests, and disinfection shall be as specified. Replacement, repair or retesting required shall be accomplished by the Contractor at no additional cost to the Government.

a. Pressure test and leakage test may be conducted concurrently.

b. Hydrostatic tests and disinfection may be conducted concurrently, using the water treated for disinfection to accomplish the hydrostatic tests. If water is lost when treated for disinfection and air is admitted to the unit being tested, or if any repair procedure results in contamination of the unit, disinfection shall be reaccomplished.

DISINFECTION

Bacteriological Disinfection

Before acceptance of potable water operation, each section of completed waterline shall be disinfected as prescribed by AWWA C651. From several points in the section, personnel from the Contractor's commercial laboratory shall take at least 3 water samples from different points, approved by the Contracting Officer, in proper sterilized containers and perform a bacterial examination in accordance with state approved methods. The commercial laboratory shall be certified by the state's approving authority for examination of potable water. The disinfection shall be repeated until tests indicate the absence of bacteria for at least 2 full days. The section will not be accepted until satisfactory bacteriological results have been obtained.

LEACHING TEST

The water flow in the chilled water system and the domestic water system will be tested using EPA Method 8260B to insure that the epoxy coating is not leaching any volatile organic compounds(VOC's) into the water. The test will occur after all epoxy testing, hydrostatic testing, and disinfection. Testing will by a State and Corps of Engineers certified laboratory. One test shall be done prior to the beginning of any work. This will be the base line test to compare to the post epoxy lining tests.

RESTORATION OF SYSTEM

Reconnect the copper branch lines and equipment to the steel piping systems. Restoring the permanent domestic and cooling supply connections to the system and conducting a final leak test.

QUALITY CONTROL

Qualification of Epoxy Lining Applicator

Pipe restoration and epoxy lining shall be performed by a manufacturer-approved and experienced epoxy lining Applicator able to provide credible references, and having clearly

demonstrated skill and expertise in the use of the air sand grit cleaning technology and epoxy lining procedure as described herein.

a. A minimum of five years experience installing epoxy coatings in potable water pipe systems in government facilities, county and municipal facilities, schools and/or universities facilities or under similar performance requirements other than in a residential environment.

b. The ability to coat unlined, welded, steel pipes with diameters of 4 inch, 6 inch, and 8 inches.

c. The ability to coat pipe runs of 400 ft.

d. The ability to coat 180° pipe bends of 1 ft radii without removal of the pipe bend.

e. Manufacturer Certification for installing the epoxy coating.

Project Site Evaluation

Assess site environment and plan work sequence, address items including:

(a) Maximum treatable length of pipe *per* segment shall be 400 - 1000 linear feet maximum, depending on configuration, diameter, layout, pipe type, condition and other site factors.
(b) Suitability of existing ambient temperature and related weather conditions at the site.
(c) Appropriate staging areas for equipment, vehicles
(d) Traffic control
(e) Temporary bypass water requirements
(g) Advance notification of work activity to COR and other facilities when minor disruption is inevitable.
(h) Governmental permits
(i) Impact of compressor noise
(j) Accessibility of pipe
(k) Interference with existing hydronic system components
(l) Availability of utilities

Independent Quality Control

The Contractor shall provide a certified coatings inspector to document all aspects of the surface preparation and coating operation. The person shall be certified as either as NACE Level III or as an SSPC Protective Coatings Specialist and have experience in epoxy coating internal surfaces of pipes. The inspector shall document and submit records of inspections and operations performed directly to the COR.

Inspections

Inspections performed, including the location of piping involved and the results of the inspection.

Pre-Application Setup

Mobilization of equipment, materials, personnel, on site to ensure all sensitive procedures are executed properly and temperature dependent materials are handled and stored properly.

Surface Preparation

Surface preparation operations performed, the mode of preparation, the kinds of solvent, abrasive, or power tools employed, cleanness of the pipe wall and whether contract requirements were met.

Thinning

Thinning operations performed, including thinners used, batch numbers, and thinner/paint volume ratios.

Application

Application operations performed, including the makeup of the coating components, the pipe location, mode of application employed, ambient temperature, substrate temperature, dew point, relative humidity, type of paint with batch numbers, elapsed time between surface preparation and application, elapsed time for recoat, condition of underlying coat, number of coats applied, and if specified, measured dry film thickness or spreading rate of each new coating.

Post-Application Procedures

Proper flushing, disinfection, and water quality sampling are performed according to the specifications.

Protection of Coatings

The epoxy coating shall be protected from excessive heat and moisture while curing to achieve optimal surface profiles. Coated pipe may be returned to service after drying for a minimum of **24** hours at approximately 75 degrees (F), and following all post-application verification procedures.

Epoxy Thickness Measurement

A thickness measurement shall be performed using a nondestructive, calibrated wet film thickness gauge per manufacturer recommendation. Unless otherwise specified, a minimum coating thickness of 14 mils shall be maintained at all points around the circumference of the pipe interior. Measurements shall be made by trained technicians immediately following epoxy application.

Visual Examination

The inlet and outlet of each lined pipe section shall be examined visually by a trained technician as soon as practical following coating. The coating shall have a smooth, uniform appearance and shall conform to the contour of the substrata. The coating shall not contain any blisters or loosely adhering particles, nor shall it contain any cracks, pinholes, fish-eyes, or chips, which expose the metal substrate.

Bond Test

The contractor shall perform bond strength testing via ASTM 3359 - Method A (Measuring Adhesion by Tape Test) provides an epoxy lining bond strength having a 5A rating.

Knife-Peel Test

The test consists of making a V-shaped cut through the coating with a sharp knife. The adhesion will be considered satisfactory if the film cannot be peeled by the knife either from the steel or between coats for a maximum distance of 1/8 inch from the intersection of the cut lines forming the "V," Forcible rupture of the coating that leaves portions of the film adhering tightly to the metal shall not be cause for rejection.

REPORTS

The contractor shall submit the following to the Contracting Officer within the specified time after award of the purchase order.

a. Submit material certification that the coating satisfies all current applicable federal, state, and local governmental health and safety requirements with regard to suitability for use in potable water systems. Certification includes, but is not limited to NSF 61 Standard Certification and ANSI/AWWA C210-97 compliance.

b. Submit a preliminary report outlining the suitability of the epoxy coating system for coating the piping system. The report should support suitability claims based on this specification.

c. Submit a preliminary report describing initial inspection results, observations and a proposed schedule for actual epoxy coating work within one week of the first site visit. Schedule shall include estimated date(s) and anticipated duration of any water outages in the CMF.

d. Perform the epoxy coated test section prior to coating entire piping system.

e. Submit written progress reports on a daily basis.

f. Submit one (1) hard copy and one (1) electronic copy of the draft technical report on the installation of the epoxy coating within two weeks of installation. The draft technical report will describe in detail all work associated with this specification.

g. Submit hydrostatic and disinfection test report within two weeks of testing.

h. Submit a summary of findings on system performance after installation of the epoxy coating is complete.

i. Submit one (1) hard copy and one (1) electronic copy of the final technical report. This final draft will also address any comments made by the C.O. on the previous draft report.

ENVIRONMENTAL CONCERNS

Noise

The air compressor and other air generation equipment shall be rated at 70 dB. Neighboring residents and/or other facilities shall be notified in advance of project startup when noise disruption can be anticipated or is inevitable. The contractor shall use reasonable discretion to keep equipment operating times and noise levels compliant with local ordinances.

Air Quality

Before release of the discharged air into the environment, an exhaust collection system shall be utilized. Fines or dust shall be screened out in a final stage dust collector with an efficiency of 99.5% using .5 micron fitters.

Grit Disposal

The spent abrading agent, corrosion residue and any excess epoxy resin shall be disposed of in accordance with all Local, State, and Federal regulations.

Sanitation

The contractor shall arrange for as determined necessary, portable sanitation and garbage disposal provisions for the work crew and site environs.

Post-rehabilitation Site Condition

General work site clean-up and the return of altered facilities to original condition and location.