Fact Sheet from the Navy Pollution Prevention Conference on the Restoration of Drinking Water Piping with Nontoxic Epoxy Linings

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Introduction

Corrosion of water mains introduces impurities into drinking water. When these impurities are heavy metals such as lead, the quality of the water may fail to comply with the requirements of the Safe Drinking Water Act and other regulations. The usual remedies for this situation are to replace the piping or to bring in bottled drinking water; several Naval facilities have actually been taken out of service when their drinking water did not measure up to federal standards. This talk will describe another solution-- lining the interior of the pipe with a nontoxic coating which keeps impurities out of drinking water.

A chemically-resistant nontoxic epoxy lining for water pipes has been developed at the Naval Research Laboratory. This lining is applied to the interior of pipes by compressed air. The operation causes minimum disruption to tenants or their activities and may be used on systems with varying diameters of pipe. Piping may be lined without removal or disassembly and returned to service within 24 hours. The Navy intends to use this technology for fast, economical rehabilitation of drinking water systems aboard ship and at shore facilities around the world.

Background

This lining was originally developed to solve corrosion problems aboard aircraft carriers. These ships experience severe erosion and corrosion of piping in their Collection, Holding, and Transfer (CHT) systems. The Naval Sea Systems Command Detachment responsible for planning and engineering for repairs and alterations of carriers (PERA-CV, Bremerton, Washington), proposed that these piping systems be lined with bisphenol epoxy coatings as part of their Carrier Life Enhancing Repair Program. As a test, a 20-foot section of CHT piping on the USS MIDWAY (CV 41) was lined in Japan in October, 1983, and was found to be in excellent condition in mid-1986.

Following this favorable test, PERA-CV tasked NRL to test commercial bisphenol epoxy coatings for properties which are significant for linings in CHT piping systems. The tests were selected jointly by PERA-CV and NRL. None of the commercial coatings was found to be suitable for aircraft carrier CHT systems.

PERA-CV then tasked NRL to develop a suitable Navy reference formulation for lining 90/10 and 70/30 copper--nickel (CuNi) pipes in both CHT and potable water systems. These coatings have several unique requirements. They must be at least as good as the 1987 standard, a commercially-available Devoe 143 Variation I coating, (the hardening time of which was too fast for convenient use), and they must be formulated from materials approved for use with drinking water so that the same material can be used in both potable water and CHT systems. They must also be usable in commercial pipe lining application techniques which rely only on a pressurized gas to propel the paint through the inside of the pipe being coated.

NRL developed a fast-hardening and chemically impervious epoxy lining known as NRL 4A. This two-part lining contained in the first component a liquid bisphenol-A epoxy resin, an iron oxide coloring pigment, and a thickening agent of amorphous silica which reduces paint flow before cure; the second component contains a curing agent based on methylene dianiline. The lining was tested in non- ship piping systems and approved for use aboard ships. Initial applications of this epoxy pipe lining sometimes produced films which entrapped air bubbles. Such voids provide routes for oxygen, sulfides, and other reactive species to reach the coppernickel pipe and corrode it, and could no be tolerated. Additives to avoid entrapment of air were studied and three materials were identified which decreased air environment. However, changes in the lining application process were implemented which successfully eliminated bubbles in the coating, making unnecessary any change to the formulation of the NRL 4A lining.

The program was temporarily delayed when new federal legislation [Federal Register 57 (154), 35630-35696 (August 10, 1992)] governing the manufacture of the curing agent used in the coating caused the sole producer to stop selling this curing agent. The regulations did not bar production or use of the curing agent, but required all who used it to maintain medical records for 30 years, a requirement deemed to be unreasonably costly. Thus it was necessary to reformulate and retest the lining for drinking water applications. Replacement curing agents were identified and tested, using procedures identical to those used in the development of the original lining. All chemical resistance properties and physical characteristics of the original coating were retained in the reformulated coating. Coatings found acceptable in the laboratory were tested in the field using the same application equipment and procedures. A replacement lining, known as "NRL-4B," was quickly developed and proven. NRL has applied for a patent on this coating, and inquires regarding licensing have been received from commercial applicators.

The process used to line shipboard sanitary piping systems was worked out in detail by the American Pipelining Corporation (San Diego, CA), PERA-CV, and NRL. In the past 7 years, sanitary piping systems aboard 12 aircraft carriers have been lined. Figure 1 shows an elbow of 6'-diameter copper-nickel piping from the USS AMERICA (CV 66) which was lined in November 1988 and removed after two years of service. Note that the coating is thicker at the bottom than at other places in the pipe; this is not a disadvantage since almost all corrosion occurs there and the added protection of a thick coating is valuable.

Figure 1. A pipe elbow lined with the nontoxic epoxy lining.

Note increased thickness on bottom. [refer to source document]

Linings for Drinking Water Pipes

The technology used aboard aircraft carriers is directly transferrable to piping systems at shore establishments. It comprises the same nontoxic lining and the same process to install it. The chemically-resistant nontoxic epoxy lining for water pipes, known as "NRL-4B", contains no solvents, dries in 20 minutes, and resists mechanical abuse. The lining has been submitted for testing to the National Sanitation Foundation of Ann Arbor, MI for compliance to NSF Standard 61, "Drinking Water System Components - Health Effects." NSF Inc., a not-for-profit organization, is the only firm authorized by the US Environmental Protection Administration to test and approve materials which contact with drinking water.

This technology has been shown to be a proven inexpensive alternative to replacement of pipe and the Navy now intends to extend this technology to fast, economical rehabilitation of drinking water systems aboard ships and at shore facilities around the world. Pipes 2 lined without removal or disassembly. Trailersize air compressors are placed outside the building and air hoses lead inside where they are connected to the piping system. A hose on the end of the pipe leads outside to a dust collector. Hot dry air is blown through the pipe, and some grit is added to remove rust or other contaminants and give the inside of the pipe a rough surface. Paint is then blown through the pipe, where it hardens in about 20 minutes. The stream of hot air is maintained for about an hour to dry the paint thoroughly. Then water is flushed through the pipe and tested to make sure no undesired substances are present. The pipe is returned to service within 24 hours. The operation is fast and causes minimum disruption to buildings or their occupants. It is suitable for pipe inside buildings and underground, and economical compared with the cost of replacing pipe. It may be used on pipes as long as 1000 feet, even if they have numerous bends and varying diameters.

The application method is known as the "Air-Sand" method. A turbulent stream of air is passed through the pipe to be lined; the pipe is cleaned by sand added to the air stream, and then lined by paint added to the air stream. If necessary, a second coat of paint is applied in the reverse direction before the first coat has cured completely. Warm air is passed through the pipe until the paint is completely cured. Pipes are flushed with water to remove any contaminants before the pipe is reassembled and the water system is placed back in service.

Plans are being made to demonstrate this technology by lining the drinking water systems in Navy buildings in the Washington, DC area during the summer of 1995. Technical and procurement guidance is available to Defence activities which desire to use this technology to clean and line their drinking water distribution systems. Specifications and quality control parameters are available for the lining, and installation and inspection standards are available for the installation process. All future installations of pipe linings in Defense facilities will be carried out according to these standard procedures.

At the conclusion of laboratory work, this technology will be transferred to the Naval Facilities Engineering Command (NAVFAC), the Air Force, the Army Corps of Engineers, and to their field activities. A Guide Specification for Drinking Water Pipe Linings will be prepared by NRL. NAVFAC routinely uses guide specifications for construction and repair activities of all kinds. This document will be indexed, reproduced, and distributed to engineering field activities in the same manner as current guide specifications. NRL will provide on-site assistance during the first installation of the coating in each NAVFAC geographical Division, and will incorporate lessons learned into the Guide Specification. NRL will be available for consultation and advice after the document is issued and, if funding is available, will update the document as circumstances require.

The Guide Specification will contain at least the following information: Applicable federal health and safety laws and regulations; Indications where use of the coating, or replacement of pipe, is recommended or not recommended; the formulation and quality control limits for the coating; safety precautions to be followed during installation; procedures for pipe cleaning, surface preparation and application; and procedures for testing and inspecting installed coatings.

Conclusions

It is now possible to rehabilitate deteriorated drinking water systems by installing a nontoxic lining which prevents corrosion and leaching of lead and other heavy metals into drinking water. This method is

1. rapid (less than 24 hours),
2. suitable for use inside buildings and underground,
3. effective in bent pipes and pipes of different diameters,
4. economical compared with the cost of replacing pipe,
5. practical for pipe diameters between 1/8" and 24",

6. useful in pipe runs of 1000', and
7. minimally disruptive of tenants and their activities.

It is recommended for fast, economical, in-place rehabilitation of drinking water systems at Defense facilities around the world.

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