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Performance evaluation of some fusion-bonded epoxy coatings under water transmission line conditions

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ABSTRACT

The work presented in this paper deals with the performance evaluation of some fusion-bonded epoxy (FBE) coatings under water transmission line conditions. The work is aimed to evaluate corrosion–erosion behavior of selected FBE coatings in different product waters under simulated water transmission line conditions to find applications in sections of water transmission lines which are subjected to high flow, water hammer or turbulence. Three different FBE coatings, namely, Scotchkote 206 N, NAP-GARD 7–2500, and RESICOAT R4 Blue were considered for the studies. The studies were carried out in treated SWRO (seawater reverse osmosis) permeate and treated and untreated MSF (multistage flash) product water. To generate data about the erosion–corrosion resistance of the coatings under pipelines operating conditions, coated steel panels of fixed dimension were subjected to jet impingement test (JIT). ac impedance tests were carried out on the coated steel samples obtained after subjecting to JIT. The tests were carried out to evaluate qualitatively water uptake by the coatings. Adhesion test was carried out to assess the adhesive strength of the coatings. The monitoring of total organic carbon (TOC) in the test media, before and after subjecting of JIT, was also carried out. The extent of formation of TOC in the test media is indicative of the possible degradation/leaching of coatings under severe JIT conditions.

All the three coatings subjected to JIT did not show any impingement damage, loss of adhesion, blistering damage or color changes, thus reflecting their excellent corrosion–erosion property. The effect of residual chlorine concentration on the corrosion–erosion property of the coatings appears to be insignificant. The results of ac impedance showed very high initial impedance for all the three coatings giving them excellent ratings. However, the performances of Scotchkote 206 N and NAP-GARD 7–2500 in treated SWRO permeate was found to be affected after 10 months immersion. The results of TOC monitoring indicated the presence of some organic compounds in the test media possibly due to the degradation/leaching of coatings under severe JIT conditions. The residual chlorine concentration in the test media appears to influence the formation of TOC. Therefore, further studies are needed to establish the safety of the coating from health point of view.

1. Introduction

Cement mortar lining (CML) and fusion-bonded epoxy (FBE) are the two internal linings usually used for potable water transmission piping. Compared to CML which has been used worldwide for several decades, FBE is relatively new lining for the potable water lines. Currently, FBE is one of the best high performance corrosion resistance coatings available in the coating industry. FBE-coated pipelines have a number of advantages over CML especially in terms of pipeline construction and water transportation cost and uninterrupted service. In addition, FBE forms strong adhesion with the metal substrate and provides excellent resistance to cathodic disbondment and minimize cathodic protection expenses. FBE has equally good resistance to water permeation. The track record of FBE coating in Saudi Arabia is quite satisfactory. The Saudi Armco has been using FBE coatings in their pipelines for the last 30 years. The surveys on 30 years old pipelines has shown that the steel substrate protected by FBE is still in excellent condition as if new without any problem and coating is still adhering well to the metal substrate. FBE coatings are also being successfully used in UK, USA and many other western countries as internal coatings for their drinking water pipelines [1,2]. A recent study on the corrosion and mechanical behavior of fusion-bonded epoxy in aqueous media has indicated that FBE is promising material for internal coating on steel in water transmission systems [3].

The effect of chlorinated water on the performance of FBE is a matter of concern and investigation for the users of the coating for treated product water transportation systems. The study on the effect of residual chlorine concentrations on the performance

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of FBE under simulated water transmission line conditions will help in establishing the safety of coatings from health point of view. During disinfection of drinking water, the naturally occurring organic substances present in the water react with the disinfectants and form halogenated organic compounds. These compounds are commonly referred to as disinfection by-products (DBPs). The nature and extent of formation of DBPs depends upon several factors such as precursor concentration, pH, temperature, contact time and nature and concentration of disinfectant. The amount of total organic carbon (TOC) in the water is a direct measure of DBPs precursor. The DBPs include trihalomethanes, haloacetic acids, haloacetonitriles, haloketones and chloropicrin. Potential health hazards from the exposure of some of the halogenated organic compounds have been identified and reported in many epidemiological and toxicological studies. The reputed organizations like WHO (World Health Organization), USEPA (US Environmental Protection Agency) and SASO (Saudi Arabian Standard Organization) have regulated the maximum possible limits of DBPs in the drinking water due to their carcinogenic and mutagenic nature or possible teratogenic effect [4–6].

The present paper describes the evaluation results of three FBE coatings in treated and untreated product waters under simulated water transmission line conditions. The aim of investigation is to evaluate the mechanical and barrier properties of the coatings in order to find application in sections of water transmission lines which are subjected to high flow, water hammer or turbulence and to establish the safety of the coatings from health point of view. Since the TOC is considered as the major DBPs precursor the monitoring of TOC in the different product waters during the severe JIT condition will establish the suitability of coatings from health point of view.

2. Experimental

2.1. Coatings

Three types of FBE coatings namely, Scotchkote 206 N XTRALG, NAP-GARD 7–2500 and RESICOAT PI-HJH01R (RT-9000 R4) were employed for the studies. Scotchkote 206 N XTRALG FBE from 3M, USA is a one-part, heat curable thermosetting, powdered epoxy coating designed for coating the interior of the line pipe. The coating is tested and certified to ANSI/NSF standard 61 to meet the requirements of drinking water services. NAP-GARD product number 7–2500 FBE from DuPont Powder Coatings, USA is a thermosetting epoxy powder designed as a coating for underground pipeline service. The product has been certified to meet the requirements of CSA Z245.20–98 and NSF 61 for potable water services. RESICOAT R4 Blue FBE from AKZO NOBEL powder coating, Germany is an epoxy based powder coating designed as internal pipe coating. The coating is a WRAS-UK (BS 6920) approved product and is suitable for use in contact with potable water. The coated steel coupons of size 80 mm × 40 mm were used for the studies. The photograph of the coated specimens in as received condition is shown in Fig. 1.

2.2. Equipment

The experimental work was done using the following equipment:

(i) Jet impingement test apparatus (JITA) from Cortest, UK.
(ii) AC Impedance Unit, Solartron 1250 B Frequency response analyzer with blank front panel and 1287 electrochemical interface unit.
(iii) Total organic carbon (TOC) analyzer, Shimadzu TOC 500.
(iv) Pneumatic adhesion tester, Elcometer 110 PATTI from Electomer Instruments, England.

2.3. Test media

The performance evaluation of the coatings was done in three types of product water. The typical composition of each type of product water is given below:

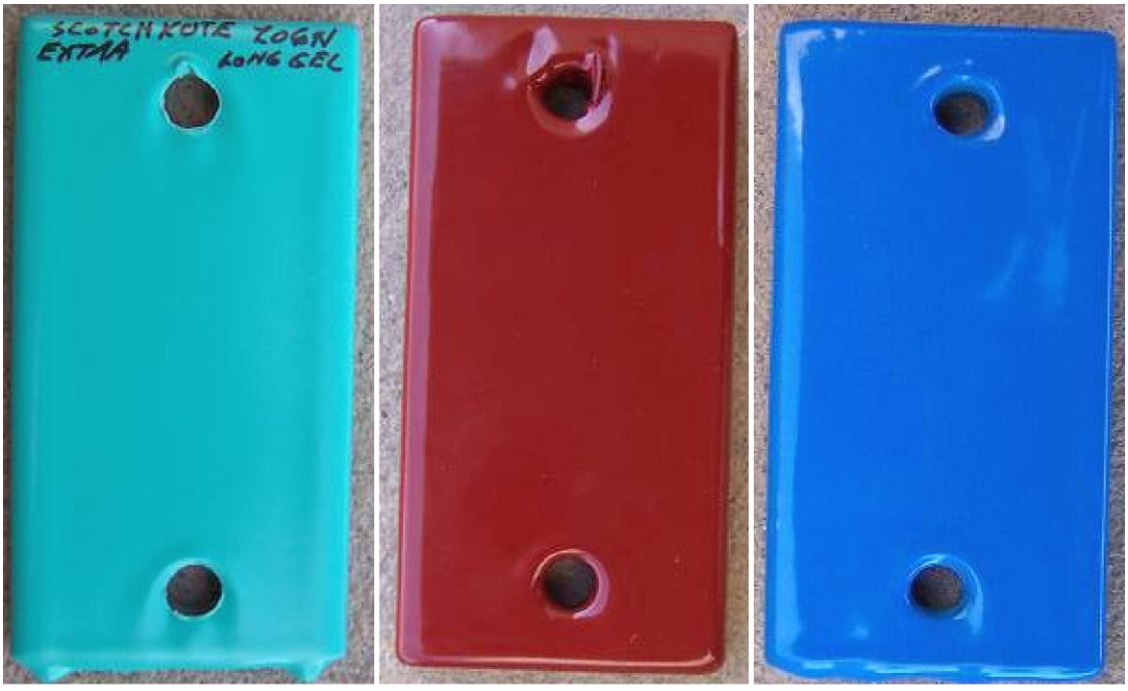

Fig. 1. Photograph of: (a) Scotchkote 206 N, (b) NAP-GARD 7–2500 and (c) RESICOAT in as received condition.