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Qualification and Application of Linings for Aboveground Storage Tanks

Jiajun (Jeff) Liang
Enbridge Employee Services Canada Inc.
10175-101 Street
Edmonton, Alberta, T5J 0H3
Canada

Amy Baxter
Enbridge Employee Services Inc.
2101 S. Linwood Ave
Cushing, Oklahoma, 74023
U.S.A.

Amal Al-Borno
Charter Coating Service (2000) Ltd.
#6, 4604-13th Street N.E.
Calgary, Alberta, T2E 6P1

Haralampos Tsapraillis
Enbridge Employee Services Canada Inc.
10175-101 Street
Edmonton, Alberta, T5J 0H3
Canada

ABSTRACT

Lining the floor bottoms and vapor space within an Aboveground Storage Tanks (AST) is a well-proven method to mitigate internal corrosion of the carbon steel substrate. An AST is usually scheduled for out-of-service inspection at least 10 years after its initial in-service date; sometimes the out-of-service schedule could be even longer (e.g., over 20 years) depending on the local regulations and engineering assessments. Therefore, the selection of an appropriate tank lining system and its application are critical for long term performance in maintaining the integrity of the assets.

API Recommended Practice (RP) 652 [1] provides recommendations on the application process of lining materials and a guideline for lining system selection. The same practice lists the general benefits and limitations of thin and thick film linings and provides items that should be considered when selecting a liner; however, API RP 652 does not provide a testing protocol for lining selection and qualification.

This paper presents a qualification test protocol for selecting lining for storage tank bottoms and vapor spaces exposed to hydrocarbon products. The protocol includes, but is not limited to, standard atlas cell, pressurized atlas cell, and autoclave testing. In addition, the paper discusses best practices for application of these systems on large diameter (> 50 m) tanks in crude oil service based on extensive field experiences.

Key words: tank lining selection, aboveground storage tanks, internal corrosion, coating specification, application procedure, hold primer, test panel.

INTRODUCTION

Internal corrosion within an aboveground storage tank (AST) or breakout tank may be attributed to water within the crude oil to contact the carbon steel surface. Hydrocarbon products will contain small fractions of basic sediment and water (BS&W) content within crude oil transmission pipeline. The BS&W of hydrocarbon products from Canada are restricted by tariffs to typically not exceed 0.5 percent by volume, while most U.S. tariffs restrict the content to less than 1.0 percent [2]. This water is primarily present as a stable emulsion, maintaining an oil-wet pipe, protecting the internal surface of the pipeline from corrosion [3].

Within an AST or breakout tank, the product velocity decreases significantly allowing the BS&W to settle to the bottoms. Mixers and bottom draws from drains may reduce the amount of solids and water that settles within the tanks. More importantly, lining the bottom floor within an AST is a well-proven method to mitigate internal corrosion and extend the life of the carbon steel substrate. Lining are also applied to the vapor space within floating roof tanks to prevent corrosion caused by condensation.

API Recommended Practice (RP) 652 provides guidelines for the linings of aboveground petroleum storage tank bottoms [1]. In the United States, internal corrosion of breakout tanks requires an installation of a tank bottom lining in accordance with the 2005 edition of API RP 652 unless corrosion control procedures established that all or certain provisions are not necessary for the safety of the tank.[4]

The latest version of API RP 652 (2016) has been updated and provides more detailed work instructions for end users/operators to ensure quality application and selection of the lining systems. An AST is usually scheduled for out-of-service inspection at least 10 years after its initial in-service date; sometimes the out-of-service schedule could be even longer (e.g., over 20 years) depending on the local regulations and engineering assessments. Therefore, the selection of an appropriate tank lining systems and its application are critical for its long-term performance in maintaining the integrity of the assets.

API RP 652 lists the general benefits and limitations of thin and thick film linings and provides items that should be consider when selecting a liner but it does not provide a testing protocol for lining selection and qualification. The recommend practice does state that the owner/operator's operational experience with a given lining system may be used to qualify existing materials, but that new materials should be verified by test data for the intended service and operating conditions. Currently, NACE TEG 524X "Coating and Lining Technology for Oil and Gas" is drafting a list of verifiable tests for liners.

This paper presents a qualification test protocol used to verify several linings for tank bottoms and vapor spaces for aboveground storage tanks. The qualification program expands upon previous work completed by the industry [5, 6, 7 and 8]. In addition, the API RP 652 recommended application procedure is compared and supplemented by field experience and methodologies that have been proven successful.

EXPERIMENTAL

PRODUCT SELECTION

The qualification program involved tank linings products intended primarily for crude oil service. In order to select the most suitable products, the authors invited the lining manufacturers to suggest up to four coating products that would perform successfully under the conditions in Table 1 (The list had a maximum of 32 unique applicable products). The recommendation from manufacturer reflects what will be anticipated to be the best performing and most appropriate product for each scenario. Besides

product data sheets of these recommended products, the related test results from the previously² stored in a retrieval system, or transmitted, in any form or by any means (electronic, mechanical, photocopying, recording, or otherwise), without the prior written permission of AMPP.

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conducted laboratory programs were also accompany to the author company for review. After review, the manufacturer recommended products with manufacturer's own test results, a total of 29 lining systems have been selected and preceded to further laboratory testing at 30 conditions.

Table 1. Tank and Pontoon Vapor Space Lining Testing Conditions

Tank Lining	Crude oil, natural gas liquids, and condensates, $\leq 65^{\circ}\text{C}$, <50 psi Trace water, trace H_2S	New tanks and maintenance	Summer and Winter field application conditions
Tank Lining	Crude oil, natural gas liquids, and condensates, $\leq 120^{\circ}\text{C}$, <50 psi Trace water, trace H_2S	New tanks and maintenance	Summer and Winter field application conditions
Pontoon Vapor Space Coating	Crude oil, natural gas liquids, and condensates, $\leq 65^{\circ}\text{C}$, <50 psi Trace water, trace H_2S	New tanks and maintenance	Summer and Winter field application conditions
Pontoon Vapor Space Coating	Crude oil, natural gas liquids, and condensates, $\leq 120^{\circ}\text{C}$, <50 psi Trace water, trace H_2S	New tanks and maintenance	Summer and Winter field application conditions

The authors sent criteria (table 1) to manufacturers, the manufacturers sent the authors products, and the authors reviewed the product and testing and picked the following (Table 2):

Table 2. Selected Testing Products

Coating Number	Coating Chemistry	Lining Type	Application	Coating Number	Coating Chemistry	Lining Type	Application
1	Epoxy	Thin Film	Vapor Space – Winter	11	Novolac Epoxy	Thick Film, Unreinforced	Tank Lining – Summer
2	Epoxy	Thick Film, Unreinforced	Tank Lining – Summer	12	Novolac Epoxy	Thin Film	Tank Lining – Summer
3	Epoxy Amine	Thick Film, Unreinforced	Tank Lining – Summer	13	Novolac Epoxy	Thin Film	Vapor Space - Summer
4	Epoxy Amine	Thick Film, Unreinforced	Tank Lining – Summer	14	Novolac Epoxy	Thin Film	All application
5	Epoxy Amine	Thick Film, Unreinforced	Tank Lining – Winter	15	Novolac Epoxy	Thin Film	Tank Lining – Summer
6	Epoxy Amine	Thick Film, Unreinforced	Tank Lining – Summer	16	Novolac Epoxy	Thick Film, Unreinforced	Tank Lining – Summer
7	Epoxy Amine	Thick Film, Unreinforced	Tank Lining – Winter	17	Novolac Epoxy	Thin Film	Vapor Space - Summer
8	Epoxy Amine	Thin Film	Vapor Space - Winter	18	Novolac Epoxy	Thick Film, Unreinforced	All application
9	Epoxy Mastic	Think Film	Tank Lining - Summer/Vapor Space - Winter	19	Plasticized Gypsum	Thick Film, Unreinforced	Tank Lining – Summer
10	Fusion Bonded Epoxy	Think Film	Tank Lining - Shop				

APPLICATION OF LININGS

The applications of the lining systems were completed by company approved applicators. Technical support was also provided by each manufacturer on-site during the field application in order to ensure the application would result in manufacturer expected product performance. During the application, every single hold point from manufacturer's Inspection Testing Plan (ITP) was witnessed by company inspectors to verify the application follows manufacturer suggested procedure. These ITP hold points include but were not limited to ambient condition, surface preparation, product temperature, shore D, dry film thickness (DFT) and holiday test. The verification of ITP is a key step for the company to ensure that the same lining product performance could be reproduced in the future once the manufacturer's application procedure is followed.

QUALIFICATION PROGRAM

Before the laboratory testing, the company also provided the third-party labs with typical crude oil samples which are representative of the intended liner service conditions within ASTs intended service for. This crude oil samples then will be used during the actual testing. This is the best method to mimic the operation condition into the laboratory tests, so the results could be more representative.

Table 3: Laboratory Test Summary

Test	Coatings in Test	Condition
Autoclave 65°C or less NACE TM 0185	Tank Linings Pontoon Vapor Space	• Temperature: 65°C/149°F • Pressure: 50 psi • Gas phase: 5% H₂S, 5% CO₂ and 90% CH₄ • Hydrocarbon phase: Crude Oil from Enbridge • Water phase: 5% NaCl in Tap Water • Duration: 14 days • Decompression: cool down to 30°C, then release the pressure in 15 minutes
Autoclave 120°C or less NACE TM 0185	Tank Linings Pontoon Vapor Space	• Temperature: 120°C/248°F • Pressure: 100 psi • Gas phase: 5% H₂S, 5% CO₂ and 90% CH₄ • Hydrocarbon phase: Crude Oil from Enbridge • Water phase: 5% NaCl in Tap Water • Duration: 14 days • Decompression: cool down to 30°C, then release the pressure in 15 minutes
Pressurized Atlas Cell 65°C or less NACE TM 0174	Tank Linings	• Temperature: 65°C/149°F • Pressure: 50 psi • Gas phase: 5% H₂S, 5% CO₂ and 90% CH₄ • Hydrocarbon phase: Crude Oil from Enbridge • Water Phase: 5% NaCl in Tap Water • Duration: 28 days • Decompression: cool down to 30°C, then release the pressure in 15 minutes