

Paper No.
16742



Mitigation of Flange Face Corrosion during Plant Construction

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ABSTRACT

In a recent modular construction project, severe corrosion of the gasket contact surfaces of flange faces was found to have occurred after the flanges had been tightened.¹ Root-cause analysis indicated that there is a greater chance of water ingress in tightened flanges in modular construction than in stick-built construction and that the longer construction period in the former can result in the severe corrosion of flange faces observed. Therefore, in order to mitigate or prevent such corrosion in modular construction, countermeasures should be taken. In this paper, two means of mitigating or preventing flange face corrosion in tightened flanges (i.e., a rust preventive coating and a special spiral wound gasket) were tested, and these tests confirmed their effectiveness.

Key words: flange face, contact surface, corrosion mitigation, corrosion prevention, gasket, plant, construction

INTRODUCTION

It has generally been thought that as long as flanges are properly tightened, no particular corrosion of the flange faces would occur during plant construction. However, in a recent plant construction project in which modular construction methods were used, severe corrosion of gasket contact surfaces in tightened flanges was found at the plant construction site.

The plant was partially constructed in module fabrication yards, far from the plant site, and the modules were transported to the plant site by sea. Despite the flanges having been tightened at the module fabrication yards, severe corrosion of the flange faces, including the gasket contact surfaces, was found at the plant site (Figure 1).

Root-cause analysis indicated that there is a greater chance of water ingress in tightened flanges in modular construction than in stick-built construction. Also, the period from flange tightening in the module yard to start-up of the plant is much longer than in stick-built construction. They, combined with the fact that both, the module fabrication yards and the plant site, were in tropical regions, resulted in the severe corrosion observed.

In order to mitigate or prevent corrosion of flange faces in such projects, countermeasures should be taken, and considering the huge number of flanges, those measures should be simple and practical to apply. In this study, two such measures were tested on tightened flanges: one was a rust preventive coating applied by an aerosol spray and the other was a special spiral-wound gasket (SWG).²

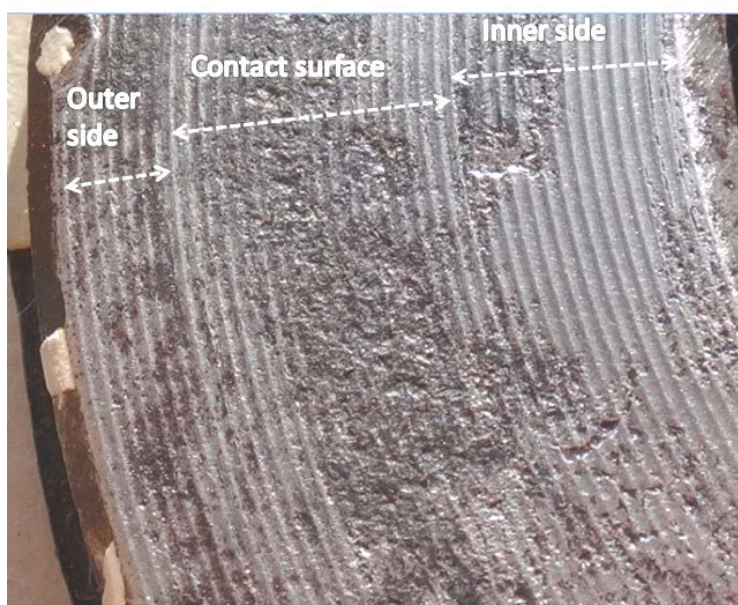


Figure 1: Photo of Flange Face Corrosion

EXPERIMENTAL PROCEDURE

Test Specimen

The corrosion test was conducted using a flange (Class: 150; nominal pipe size: 1 inch; Slip-On Pipe Flange; ASTM⁽¹⁾ A105⁽³⁾) compliant with ASME⁽²⁾ B16.5.⁴

The following three cases were tested (Table 1), and for each case, three tightened flanges were tested.

Case 1: Control (i.e., no corrosion mitigation)

The flange faces were cleaned with ethanol and, then, wetted with saltwater (3 wt% NaCl solution), which was applied using a brush. The gasket used was a normal SWG (316L SS inner ring, carbon steel outer ring, 316L SS hoop, and expanded graphite filler), which was also wetted by immersion in the same saltwater. After the flange faces and the gasket had been wetted, the flange bolting was immediately tightened to a torque of 50 Nm (Figure 2a).

Case 2: Rust Preventive Coating

The flange was prepared in the same manner as in the control case, except that a rust preventive coating (waxy film) was applied by aerosol spray to the flange faces (Figure 2b) to a wet film thickness (WFT) of approximately 200 μm , corresponding to a dry film thickness (DFT) of 100 μm . The coated flange faces were wetted with saltwater 10 minutes after applying the coating, even though the coating had not yet completely dried, since during construction, the flanges would be tightened before the coating had dried.

Note that the coating supplier's catalogue indicated a dry-to-touch time of 0.5–3 h, a dry film time of 12–24 h, and a time of 900–1500 h to ensure protection in a salt spray test in accordance with ASTM B-117.⁵

Case 3: Special Spiral Wound Gasket

The flange was prepared in the same manner as in the control case, except a special SWG was used (Figure 2c). The gasket filler material was a special blend of thermally and chemically exfoliated vermiculite and polymers, but the materials of other parts were the same as in the normal SWG used in case 1.

Table 1
Procedure and Test Conditions of Flanges

Procedure	<u>Case-1</u> Control	<u>Case-2</u> Rust Prevention Coating	<u>Case-3</u> Special Spiral Wound Gasket
(1) Cleaning Up	Cleaning up the flange face by ethanol		
(2) Rust Prevention Coating	Not applied	Applied	Not applied
(3) Wetting Flange Face	Wetting by salty water		
(4) Gasket and Wetting	Usual SWG and Wetting	Usual SWG and Wetting	Special SWG and Wetting
(5) Tightening Flange	Tightening with torque control		

Corrosion Test Conditions

In all three test cases, the specimens were placed in cabinet for the cyclic corrosion test (CCT) in a horizontal direction (i.e., the flange face was in a vertical direction), as shown in Figure 2d, and exposed to a saltwater mist (5 wt% NaCl solution), dry air (60° C; <30% relative humidity) and wet air (50° C; >95% relative humidity) cyclically in accordance with ISO⁽³⁾ 14993.⁶ The test condition was

considered severe corrosion environment, and both outside and inside of specimens (flanges) were exposed to the environment due to the slip-on pipe flange. The test duration was 30 days.

Observations

After the CCT, the tightened flanges were washed with water and dried with hot air, after which, the flange bolts were loosened and removed. Direct visual and microscopic observations were made on both flange faces in each of the three test cases to determine the presence and extent of corrosion of the flange faces. In each of the three test cases, the findings on both flange faces were the same.



Figure 2a: Appearance of Tightened Flange



Figure 2b: Appearance of Flange Face with Rust Preventive Coating