

# CORROSION OF A193 GRADE B7 BOLT MATERIAL IN BWR SODIUM PENTABORATE SOLUTIONS



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**CORROSION OF  
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BWR SODIUM  
PENTABORATE SOLUTIONS**

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## FOREWORD

The effect of corrosion of typical Boiler Water Reactor (BWR) borated water system bolting used in stainless steel valve flanges installed in BWR sodium pentaborate systems has been recently questioned. A better understanding of BWR borated water system bolt corrosion will help determine whether BWR borated water is not as corrosive as PWR borated water. This report was undertaken to assess the use of A193 Grade B7 bolts in stainless steel flanges installed in a BWR sodium pentaborate systems. The research was conducted by NWT Corporation at the request of Electric Power Research Institute (EPRI).

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## 1 INTRODUCTION

To better determine the impacts of using A193 Grade B7 bolts in stainless steel flanges installed in a Boiler Water Reactor (BWR) sodium pentaborate (NaPB) systems, quantification of the corrosion rates of this material in NaPB solutions was investigated. Two types of tests were performed. First, coupons of 4140 (the base material for A193 Grade B7), C4340 low alloy steel, C1010 carbon steel and 410 stainless steel were immersed in a 12% NaPB solution at ~95°F and a 12 to 20% solution at ~185°F. An A193 Grade B7 bolt was also immersed in a 12% NaPB solution and in demineralized water at 95°F. Coupons and bolts were intermittently examined and photographed, and weight change measurements were made to assess corrosion rates after three weeks and two months of exposure.

Second, tests to assess corrosion of A193 Grade B7 bolts when leakage occurs across stainless steel flange seal surfaces were performed. The test flanges had a 4-inch diameter and a bolt circle diameter of ~3 inches. Three flanges were exposed at ~99°F, and one flange was exposed at ~203°F. Leakage of the NaPB solution was simulated by injecting a 12 weight percent NaPB solution through a small diameter Teflon tube onto one of the four bolts in each flange at a rate of ~0.1 ml per minute. One flange was allowed to accumulate borate salts as a result of the leakage. The exterior surface of the other flanges was brushed clean approximately every two weeks. The third 100°F flange was insulated with NUKON<sup>TM</sup> and was not cleaned during the test period. The 203°F flange was not insulated and was allowed to accumulate borate salts over the test period. Flanges were exposed for approximately two months.

After the nearly two month exposures, the flanges were disassembled, and the bolts and flanges were photographed and inspected. The bolts were rinsed of borate salts, weighed, de-scaled, and reweighed to determine metal loss. Local corrosion depths were estimated based on the weight losses.

Test methodology is summarized in Section 2. Coupon test results are summarized in Section 3. Flange bolt testing is summarized in Section 4.

## 2 TEST METHODOLOGY

### 2.1 Coupon Tests

Rectangular coupons of C1010 (carbon steel), C4340 and C4140 low alloy steel and 410 stainless steel were exposed at static conditions to a sodium pentaborate solution with an initial concentration of 12% at temperatures of  $\sim 95^{\circ}\text{F}$  and  $185^{\circ}\text{F}$ . 4140 is the base material for the A193 Grade B7 bolts. The other materials were selected since their corrosion behavior in PWR boric acid solutions had been previously evaluated [1][2]. The coupons were intermittently removed for inspection and weighing to assess corrosion.

Composition of the coupons is shown in Figure 2-2 [3]. Dimensions are shown in Figure 2-1. Total area of each coupon was  $\sim 3\text{ in}^2$  or  $0.194\text{ dm}^2$ . The coupons were finished using a 120 grit belt prior to exposure [3]. The pH and conductivity of the 12% NaPB solution at  $\sim 25^{\circ}\text{C}$  were 7.08 and  $11,600\text{ }\mu\text{S/cm}$ , respectively.

Coupons were cleaned with acetone and weighed before testing. Four coupons of each alloy were suspended by nylon lines in separate 800 ml glass beakers and covered with polycarbonate sheet for testing during the  $95^{\circ}\text{F}$  tests. A similar approach was used for the tests at  $185^{\circ}\text{F}$  except the beakers were polycarbonate. The coupons were completely submerged in the 12% NaPB solution. Solutions were air saturated. Coupons were visually inspected, dried and weighed after approximately 20 days and also after two months of exposure.

The NaPB solution concentration remained at 12% throughout the tests at  $95^{\circ}\text{F}$  since evaporative water losses were minimal. However, water losses during the  $185^{\circ}\text{F}$  tests were significant, and solution losses were initially compensated for by adding a 12% NaPB solution. This led to an increase in the solution NaPB concentration from 12% to  $\sim 18\%$  over the first 10 days of testing. At that time, the solution concentration was adjusted to 12%, and demineralized water was subsequently added to compensate for water losses. The solution concentration remained at 12% for the remainder of the exposures.

Figure 2-1 Coupon Design

