EVALUATION OF SCC SUSCEPTIBILITY OF ALLOY 800 UNDER CANDU SG SECONDARY–SIDE CONDITIONS

Sue Liu, Yucheng Lu,
Atomic Energy of Canada Ltd.

Abstract

As part of a coordinated program, AECL is developing a set of tools to aid with the prediction and management of steam generator (SG) performance. Although stress corrosion cracking (SCC) of Alloy 800 has not been detected in any operating SG, it is necessary to develop mechanistic models to predict the conditions under which SCC is plausible. Therefore, constant extension rate tests (CERT) were carried out for Alloy 800 under various SG crevice chemistry conditions at applied potentials. These tests were to evaluate the SCC susceptibility of Alloy 800 under CANDU® steam generator operating conditions. Based on the experimental results, the recommended electrochemical corrosion potential (ECP)/pH zone determined for Alloy 800 by electrochemical polarization measurements was verified with the respect of SCC susceptibility. The effects of lead contamination on the SCC susceptibility of Alloy 800 tubing were also evaluated.

The experimental results from CERT tests obtained under applied potentials suggest that Alloy 800 has good performance inside much of a previously recommended ECP/pH zone determined by electrochemical analysis. Alloy 800 is not susceptible to SCC under normal CANDU SG operating conditions. However, Alloy 800 may be susceptible to SCC under near-neutral crevice chemistry conditions in the presence of oxidants. In addition, SCC susceptibility is increased by lead contamination. This observation suggests that the upper previously defined ECP limit under near-neutral crevice conditions could be modified to minimize SCC of Alloy 800. The test results from this work also suggest that the pH dependency of the SCC susceptibility of Alloy 800 in the secondary side steam generator crevice solutions is different from that observed in sodium hydroxide solutions. This information can be used by utilities to assess the SCC of Alloy 800 steam generator tubing materials and to make decisions for steam generator water chemistry management.

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1. INTRODUCTION

Alloy 800 has demonstrated excellent operating performance as steam generator (SG) tube material in pressurized (light) water reactors (PWRs). Alloy 800 has been used by Siemens/KWU (now Framatome ANP GmbH) for more than 30 years. There has been no in-service cracking of Alloy 800 tubing observed among more than 234,000 tubes installed in these SGs, and only one defect at the tube-tubesheet joint associated with mechanical damage has been found [1, 2, 3]. Alloy 800 was selected to be the replacement tubing material for the DOEL 3 SGs in 1993, based on a material assessment of both Alloy 690 and Alloy 800 [4].

In CANDU® reactors, nuclear grade Alloy 800 has been the preferred SG tube material and its performance has been very good, with only a few cases of localized corrosion in some stations [5]. However, stress corrosion cracking (SCC) has been a significant degradation mode in Alloy 600 steam generator (SG) tubing, and the SCC is enhanced by lead contamination [6]. Both Alloy 690 and Alloy 800 have also been found to be susceptible to lead-induced stress corrosion cracking (PbSCC) in laboratory tests [7, 8]. Whilst relatively fewer data have been published on PbSCC of Alloy 800, most of the data were obtained in water and sodium hydroxide solutions containing lead, as reviewed by Staehle [9]. These test environments are not representative of those experienced in the field in PWR or CANDU reactors.

In our previous work, the electrochemical behaviour of Alloy 800 tube material was studied under some plausible CANDU SG crevice chemistry conditions [10, 11, 12]. A recommended electrochemical corrosion potential (ECP)/pH zone [12] for Alloy 800 was established in which corrosion degradation is minimized, based on the results from electrochemical analysis combined with data from accelerated crevice corrosion tests. SCC is a complicated degradation mode determined by the interactions between many factors, including the susceptible material, environmental factors and the stress/strain. It is generally accepted that the passivity breakdown of Alloy 800 may be the precursor of SCC. However, SCC susceptibility cannot be determined merely by the electrochemical behaviour of the alloy material. Therefore, it is required that the recommended ECP/pH zone of Alloy 800 defined in terms of its corrosion and SCC susceptibility determined by electrochemical screening methods be verified by accelerated corrosion tests and SCC tests.

SCC tests were previously conducted by capsule tests with C-ring samples in plausible SG crevice chemistries [13, 14]. Alloy 800 was found to be susceptible to intergranular SCC (IGSCC) in simulated SG crevice environments with and without lead contamination. The limitation of the C-ring capsule tests was that they were only performed under free-corrosion potential and the chemistry conditions could not be well controlled due to the small volume of the test solution relative to the sample surface area.

Therefore, constant extension rate tensile (CERT) tests were conducted in this test program to further evaluate the SCC susceptibility of Alloy 800. As a complementary method to the capsule tests at free-corrosion potential, CERT tests were performed in an autoclave at various applied potentials. Subsequently, the recommended ECP/pH zone for Alloy 800 determined by electrochemical polarization measurements was verified with respect to SCC susceptibility. Lead has been found as a contamination in SG secondary side chemistries of CANDU units [13] and

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typical PWRs [9], and has been identified as an element that can cause or accelerate SCC of SG tubing materials [9, 15]. Thus, the effects of lead contamination on the stress corrosion cracking susceptibility of Alloy 800 tubing were also evaluated in this work.

It should be noted that, due to the accelerated nature of the CERT technique [16], the results are not intended to represent service performance, but rather to provide a basis for screening the interactions of a material with environmental variables. In many cases, the CERT method has been found to be a conservative test for SCC. Therefore, it may produce failures in the laboratory under conditions that do not necessarily cause SCC under service conditions. Additionally, in some limited cases, SCC indications are not found in CERT tests even when service failures have been observed. This effect usually occurs when there is a delay in the initiation of localized corrosion processes.

2. EXPERIMENTAL CONDITIONS

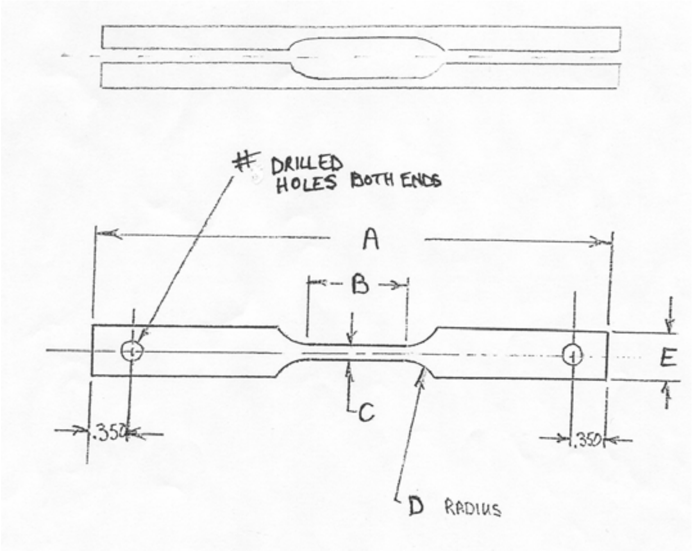
2.1 Material and Specimen Preparation

CERT test specimens were machined from Alloy 800 tubing supplied by Huntington Alloys; the final heat treatment was a bright annealing at 980 ± 10°C. The chemical composition of Alloy 800 tubing, as per mill certificate, is given in Table 1. The material meets the requirements of the ASTM B163 standard (Table 1) as far as the chemical composition is concerned.

**Table 1 Detailed information of the Alloy 800 tube material.
(Based on mill test certificate)**

Heat No	**Size**	**Composition wt %**													
		C	**Si**	**Mn**	**P**	**S**	**Cr**	**Ni**	**Co**	**Ti**	**Cu**	**Al**	**Mo**	**N**	**Fe**
HH9043A	0.625 x 0.044” Wall (15.88 x 1.12 mm)	0.015	0.10	0.80	0.009	0.002	21.70	34.11	0.012	0.42	0.03	0.41	-	0.028	42.41
ASTM B163 Requirements		0.10 max	1.0 max	1.5 max	..	0.015 max	19.0 – 23.0	30.0-35.0	...	0.15 – 0.60	0.75 max	0.15-0.60	...	...	39.5 min

The tube was cut in half axially and then machined into CERT specimens. The dimensions of the specimens are shown in Figure 1. The full thickness of the tube wall was adopted for the specimens and the inside and outside surfaces of the tube were used as received; there was no further polishing applied prior to testing. However, specimens were cleaned first with acetone, then with ethanol and dried with air before the tests.



A Specimen Length = 5” (127 mm)
B Gauge Length = 1.000” (25.40 mm)
C Gauge Length Width
=0.150 ± 0.001” (3.81 ± 0.0254 mm)
D Radius = 0.375” (9.53 mm)
E Nominal Tube Diameter
=0.625” (15.9 mm)

Figure 1 Schematic diagram showing the CERT specimen dimensions.

2.2 Test Environments

CERT tests for Alloy 800 tubing were performed under simulated CANDU steam generator crevice chemistry conditions as defined in Tables 2a and 2b at 300°C. All test solutions were prepared with deionised water and analytical grade reagents. The solution was purged with ultra-high purity argon to a very low dissolved oxygen content (estimated <5 µg/kg) before each CERT test. The control test was performed in Argon gas, which is considered to be an inert environment, at 300°C.

Table 2a Simulated CANDU SG crevice chemistries without lead contamination.

Crevice Environment Simulated	Test Solution Composition
"Near-neutral" crevice environment $pH_{300^\circ C} = 6.10$; $pH_{neutral} = 5.16$	0.15M Na_2SO_4 0.3M NaCl 0.05M KCl 0.15M $CaCl_2$ (reference solution #1)
Alkaline crevice environment. Deviation from “near-neutral” electrolyte $pH_{300^\circ C} = 9.26$; $pH_{neutral} = 5.14$	Add 0.4 M NaOH to “reference solution #1”
Acidic crevice environment. Deviation from “near-neutral” electrolyte $pH_{300^\circ C} = 3.22$; $pH_{neutral} = 5.16$	Add 0.05M $NaHSO_4$ to “reference solution #1”

Table 2b Simulated CANDU SG crevice chemistries with lead contamination.

Crevice Environment Simulated	Test Solution Composition
"Near-neutral" crevice environment $pH_{300^\circ C} = 6.88$; $pH_{neutral} = 5.16$	Add : ~500 mg/kg PbO* to “reference solution #1”
Alkaline crevice environment. Deviation from “near-neutral” electrolyte $pH_{300^\circ C} = 9.26$; $pH_{neutral} = 5.15$	Add 0.4 M NaOH to “reference solution #1” plus: ~500 mg/kg PbO*
Acidic crevice environment. Deviation from “near-neutral” electrolyte $pH_{300^\circ C} = 3.31$; $pH_{neutral} = 5.16$	Add 0.05M $NaHSO_4$ to “reference solution #1” plus: ~500 mg/kg PbO*

* This is the mass of PbO added to the solution. The actual speciation and concentration of the dissolved lead species in solution are not known due to the lack of high-temperature solubility information for lead compounds.

The at-temperature pH of the solution was estimated using a computer code ("ChemSolv"). The pH of the solutions containing lead was estimated using MULTEQ. The addition of lead oxide was found to have little, if any, effect on pH under alkaline conditions, but increased the pH under near-neutral conditions by about 0.8 pH unit and under acidic conditions by about 0.1 pH unit.

2.3 CERT Tests

CERT tests were carried out in a static autoclave (1.3 L capacity) made of Hastelloy C. Two identical CERT systems were used for tests under lead-free (Table 2a) and lead-contaminated (Table 2b) chemistry conditions, respectively. All CERT tests were performed at a strain rate of 0.9×10^{-6}/s. A control test was carried out in argon gas at 300°C. The susceptibility to SCC in the crevice chemistries was assessed as compared with the material behaviour in the inert environment.

CERT tests were conducted under potentiostatic conditions at various applied potentials. An EG&G Model 263A/99 Potentiostat/Galvanostat with a floating/auxiliary input option was used for conducting CERT tests at different applied potentials based on the potentiodyamic polarization curves obtained previously at 300°C under the same simulated SG crevice chemistry conditions [12]. The working electrode was the CERT specimen, and the counter electrode was a platinum foil. Internal Ag/AgCl/0.65 M KCl high-temperature reference electrodes were used to perform the potentiostatic polarization during CERT tests. Because the test solutions contain 0.65 M of chloride, using an Ag/AgCl/0.65 M KCl electrode minimizes the variation in chloride concentration. The typical potential drift of a reference electrode for valid tests was measured to be less than 30 mV. To minimize the solution IR drop, the Luggin capillary of the reference electrode was placed close to the specimen surface ($\leq$1 mm). For this work, all potentials quoted were converted to the standard hydrogen electrode scale (SHE) using methods quoted in previous publications [17, 18].

The specimen was isolated from all autoclave parts including the loading pins, frames and grips using Teflon sheathing or sheet materials. After the test solution was transferred into the autoclave, the autoclave was deaerated by purging with ultra-high purity argon gas for two hours, and then the autoclave was heated to 300°C. After a steady free corrosion potential was reached, a desired potential was applied to the CERT specimen. The specimen was then preloaded to 90 N and followed by dynamic tensile straining at the specified constant strain rate.

The percentage of elongation and time to failure were recorded after each test. The full gauge length of each specimen was first checked by 30× stereo optical microscopy for indications of secondary cracks. At the same time, any sign of corrosion other than SCC was also recorded. One half of a specimen from a test was sectioned along the gauge length. Metallographic examinations were performed on this cross section surface to observe the morphology of localized corrosion and secondary cracks. The fracture surface and gauge length of the other half of the specimen, specifically with cracking indications, were examined by scanning electron microscopy (SEM). The cracking mode, i.e., transgranular, intergranular, or a mixture of both types of cracking, was determined based on these post-test examinations.

3. TEST RESULTS

Tests were performed under both lead-free and lead-contaminated crevice chemistry conditions (Tables 2a and 2b) at various applied potentials. The results are graphically illustrated in Figure 2.

In summary, SCC was only observed under near-neutral crevice chemistry conditions (with and without lead contamination) at elevated ECPs. No SCC was observed under the acidic and alkaline crevice chemistry conditions tested.

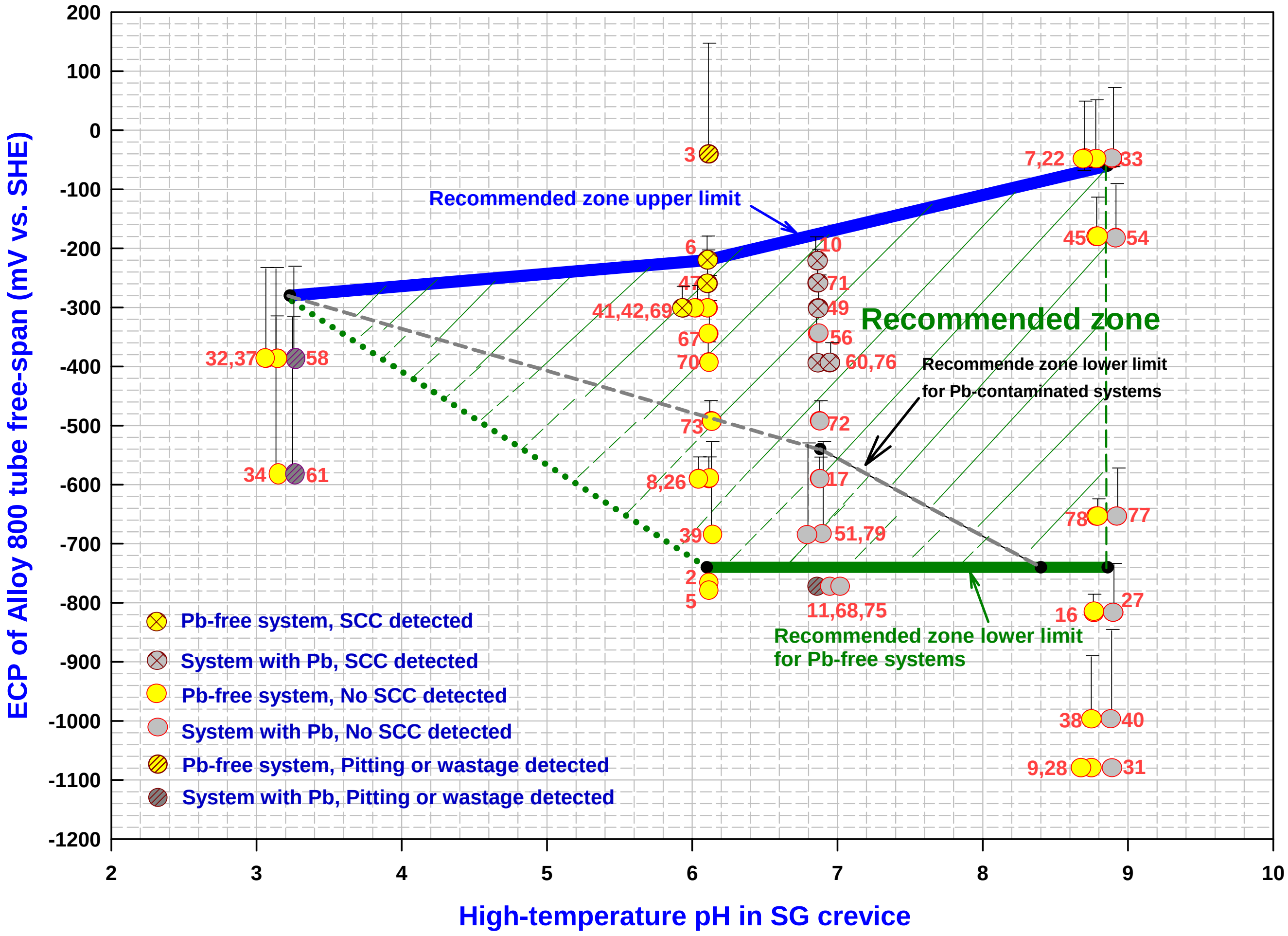


Figure 2 **A summary of the CERT test results superimposed on the ECP/pH zone for Alloy 800, which is published in reference [12].**

3.1 Control Test in Argon

The specimen from the control test showed a typical mechanical failure, i.e., ductile fracture with dimples. Although the specimen failed mechanically with a large deformation near the fracture, shallow cracks were still observed on the gauge length. The relatively deep cracks near the fracture were induced by localized plastic deformation, which was a result of planar slip arising from the low stacking fault energy of the austenitic alloy. The crack tips were blunt. This feature distinguishes these cracks from SCC cracks, which typically have sharp crack tips. The existence of shallow cracks on the gauge length from the control test in argon makes the assessment of the SCC susceptibility of Alloy 800 more complicated. In this work, the criteria for the occurrence of SCC were that the secondary cracks became deeper than those observed on the control specimen and the percentage of elongation was significantly reduced for a test carried out in the test solutions, as compared to the control test in argon.

3.2 Near-neutral pH Conditions

Under lead-free near-neutral crevice chemistry conditions, the test at –240 mV (Test 6) resulted in many secondary cracks on the surface of the gauge length (Figure 3). The crack morphology on the sectioned surface by metallographic examination is shown in Figure 4. The fracture surface, crack tip and side surfaces are all covered with an oxide film. Figure 4b shows the typical transgranular mode of cracks. The cracks are often branched, as observed in Test 47 at –270 mV (see Figure 5). As shown in Figure 5c, the cracks became broad and blunt after etching.

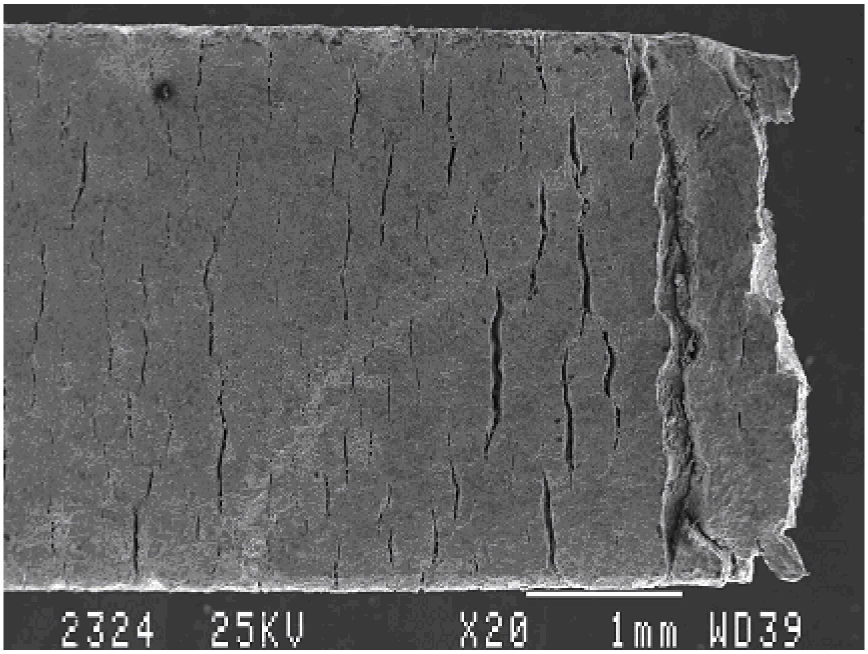
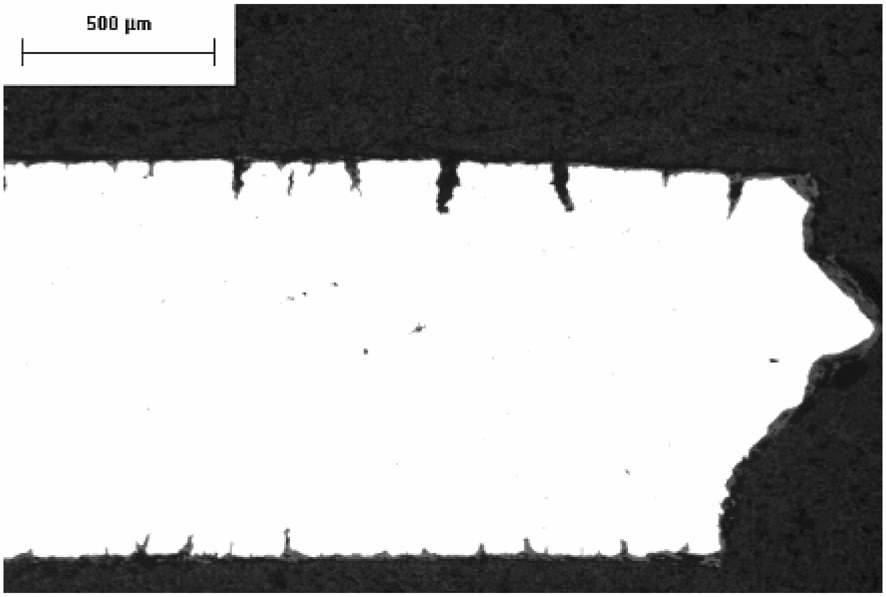
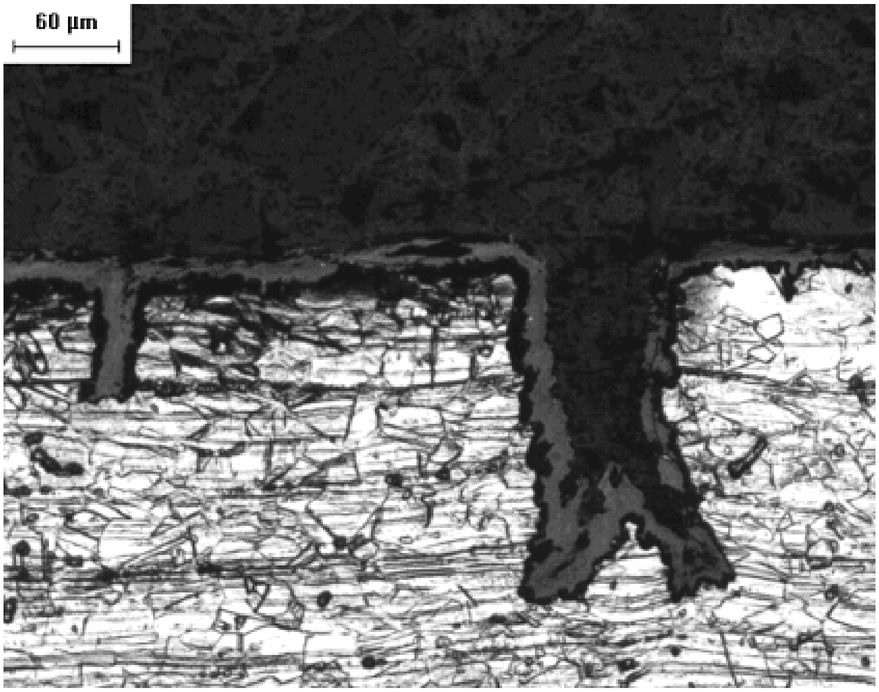


Figure 3 **SEM image of the gauge length of an Alloy 800 specimen tested under lead-free near-neutral crevice chemistry conditions at –240 mV, showing the extensive secondary cracks (Test 6).**

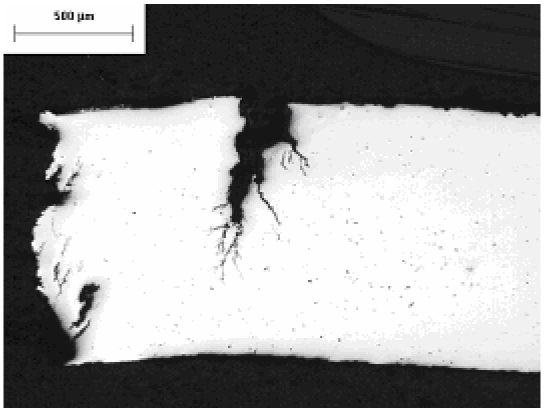


(a) Low magnification image showing the secondary cracks

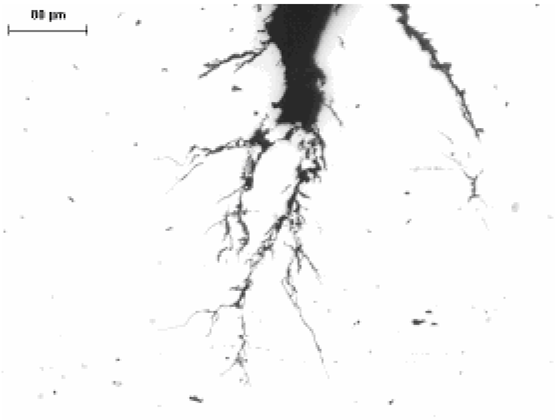


(b) High magnification image after etching showing the transgranular crack mode

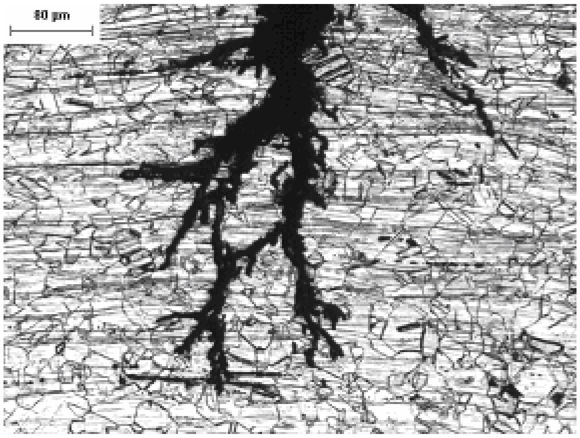
Figure 4 The appearance of the secondary cracks on the metallographic section of the gauge length of the same Alloy 800 specimen shown in Figure 7 (Test 6).



(a) Secondary cracks on the section surface



(b) The enlarged framed area shown in image a) before etching

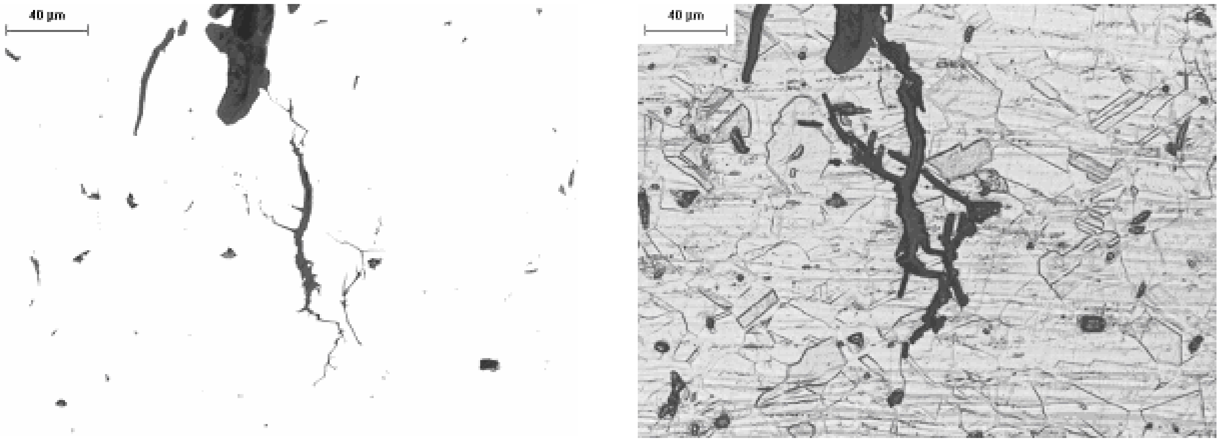


(c) The enlarged framed area shown in image a) after etching

Figure 5 **The appearance of the branched transgranular cracks on the metallographic section of the gauge length of an Alloy 800 specimen tested under lead-free near-neutral crevice chemistry conditions at –270 mV (Test 47).**

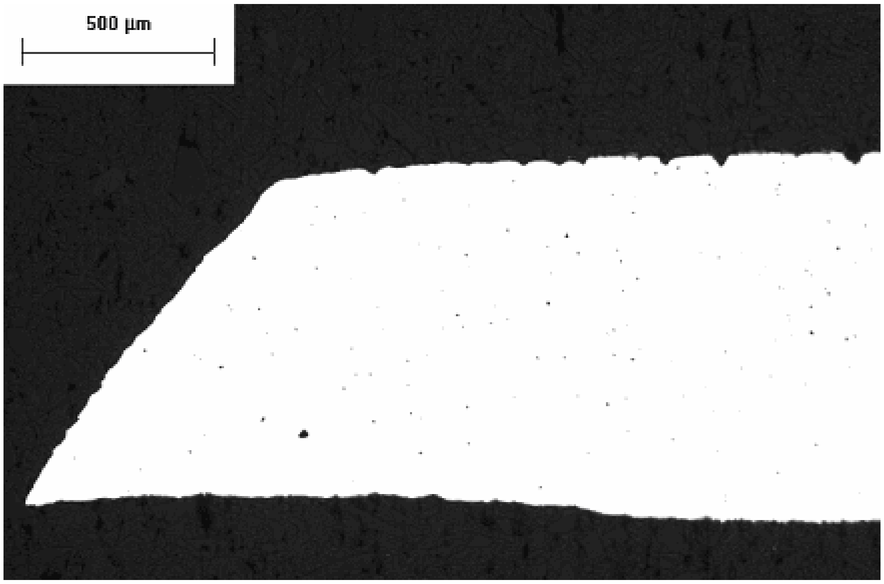
The cracks formed in lead-contaminated near-neutral chemistry are also transgranular. The typical crack morphology from the specimen tested at –270 mV (Test 71) is illustrated in Figure 6. In Test 72, the Alloy 800 specimen was tested under lead-contaminated near-neutral crevice chemistry conditions at –490 mV. The secondary cracks on the gauge length are slightly deeper than those observed in the control test, shown in Figure 7, but no obvious SCC was observed on the fracture surface.

Wastage was seen in one of the three tests performed under the near-neutral crevice chemistry conditions in the presence of lead at –770 mV (Test 11).

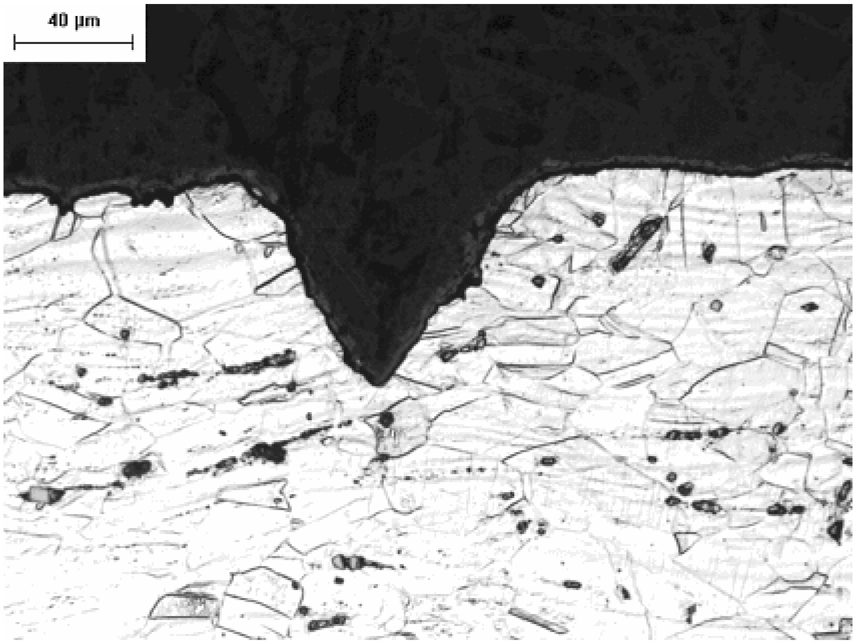


(a) Before etching **(b) After etching**

Figure 6 The appearance of the cracks on the metallographic section of the gauge length of the Alloy 800 specimen from Test 71. The branched transgranular-cracking features are shown before and after etching.



(a) Low magnification image showing the deformation near the fracture and the secondary cracks on the section surface of the gauge length

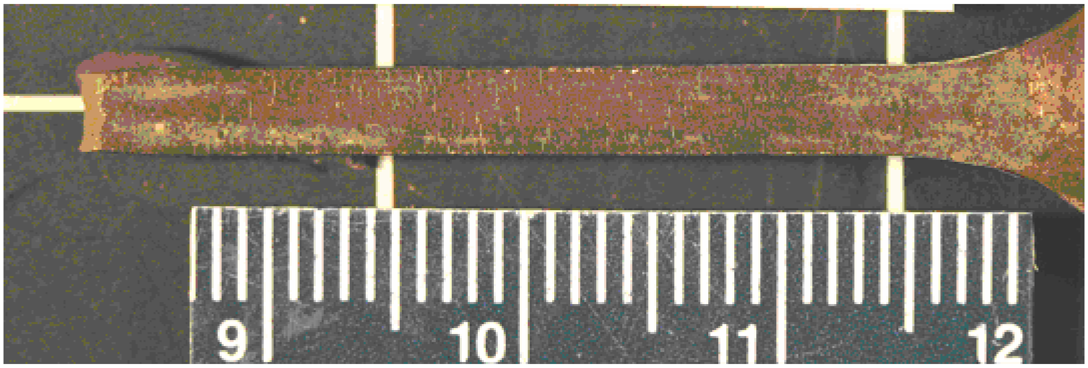


(b)) High magnification image showing the penetration of the secondary cracks

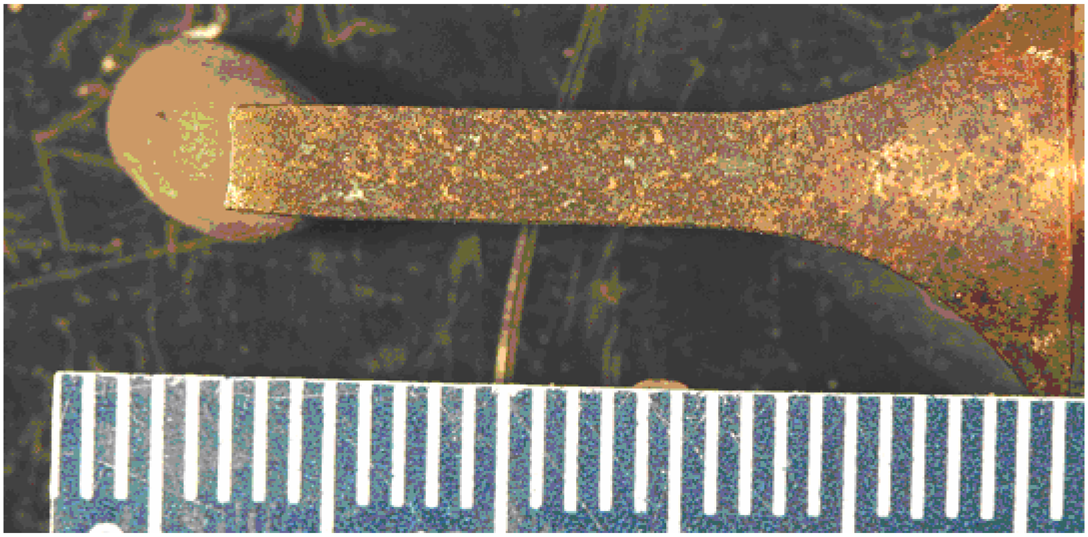
Figure 7 The appearance of the cracks on the metallographic section of the gauge length of an Alloy 800 specimen tested under near-neutral crevice chemistry conditions with lead at –490 mV, showing slightly deeper secondary cracks than those observed in the control test (Test 72).

3.3 Acidic Conditions

Cracking was not observed under acidic crevice chemistry conditions, with or without lead. However, both specimens tested in solutions with lead show pitting corrosion (Figure 8). In contrast, pitting did not occur under lead-free acidic crevice chemistry (Figure 9). Thus, lead was found to enhance pitting corrosion of Alloy 800 under acidic crevice conditions.

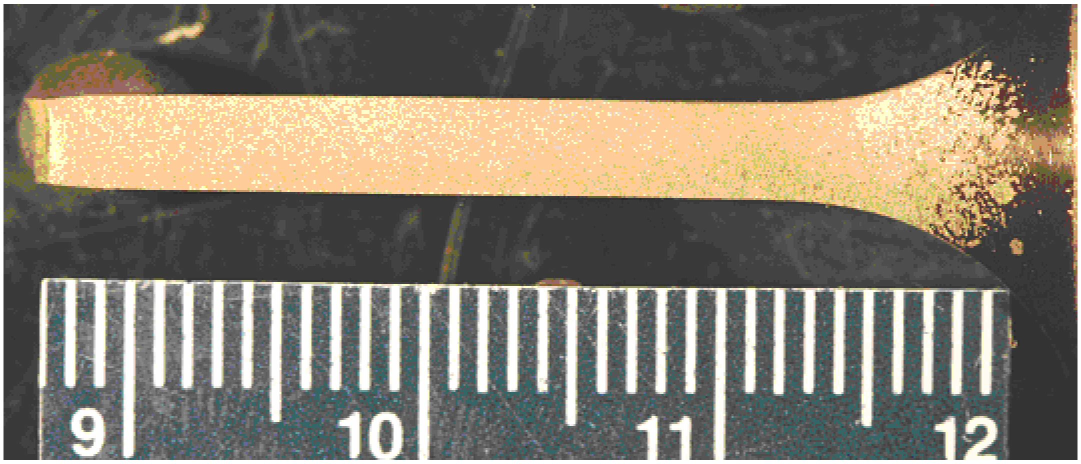


(a) Test at –590 mV (Test 61)

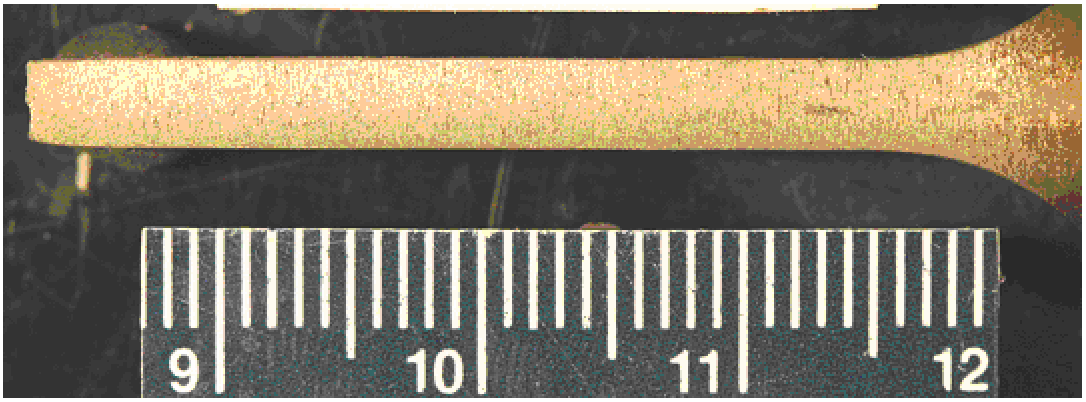


(b) Test at –390 mV (Test 58)

Figure 8 **The appearance of the gauge length surfaces of Alloy 800 specimens tested under lead-contaminated acidic crevice chemistry, showing pitting corrosion. The units of the scales are cm.**



(a) Test at –590 mV (Test 34)



(b) Test at –390 mV (Test 32)

Figure 9 **The appearance of the gauge length surfaces of Alloy 800 specimens tested under lead-free acidic crevice chemistry conditions, showing no obvious pitting corrosion. The units of the scales are cm.**

3.4 Alkaline Conditions

SCC was not observed under alkaline chemistry conditions, with or without lead. However, the oxide film formed in the solution containing lead was often not as uniform as the one formed in the solution without lead, based on visual inspection. It appeared that there were more deposits on the specimen surfaces exposed to solutions containing lead than in the lead-free solutions.

3.5 Discussion and Revision to the ECP/pH Zone

The results of the CERT tests were positioned in Figure 2 based on the corresponding applied potential and the high temperature pH of the each test. Because of the existence of an IR drop between the tubing free span and the tube area inside the crevice, the ECP of free span tubing is expected to be higher than that of the tube inside the crevice. The higher the corrosion current the larger the ECP shift will be. The maximum shift in ECP is expected at the active peak potential. The possible maximum shift in ECP values between the tube free span and the tube under different crevice chemistry conditions was measured experimentally and was estimated to be 150 mV under near-neutral and alkaline chemistry conditions, and 250 mV under acidic chemistry conditions at 300°C [12]. Therefore the applied potential during the tests is the lower limit of the ECP for free span tubing when determining the SCC susceptibility of Alloy 800 tubing in an ECP/pH zone map. A bar is attached to each test point in Figure 2 to schematically show the possible ECP range of the free span tubing.

CERT tests were performed under acidic, near-neutral, and alkaline crevice conditions; SCC was only observed in near-neutral crevice chemistry, both with and without lead, at elevated potentials. With lead addition, the potential range in which SCC occurred is enlarged. This observation seems to disagree with the published literature, where the consensus is that PbSCC most likely occurs under high pH alkaline conditions [9].

In general, the data from literature show that lead significantly accelerates SCC except in mildly acidic electrolytes. Lead is reported to produce the greatest PbSCC under alkaline conditions. Under acidic conditions, lead accelerates SCC in chloride solutions, but not in sulfate solution because of the low solubility of $PbSO_4$. This behavior is mainly observed for Alloy 600 in 10% NaOH solution [9]. The trend plausibly exists for PbSCC in Alloy 800, but relatively few data have been published for Alloy 800. Vaillant and co-workers [19, 20] reported that Alloys 690 and 800 were not susceptible to SCC in all volatile treatment (AVT) water plus PbO at pH values close to neutrality, but were susceptible to SCC in high pH NaOH solutions. The SCC sensitivity of Alloy 800 increases with NaOH concentrations from 4 to 50% at 320°C. Lead contamination is particularly detrimental for Alloy 800 in NaOH solutions. Similarly, Helie et al. [21, 22] did not observe SCC in Alloys 690 and 800 in deionized water containing 10g/L PbO. They suggested that the presence of caustic might be required to promote SCC of Alloys 690 and 800. Castano-Marin et al. [23] also found that Alloy 800 cracked in caustic solutions with 0.008 % (~80 mg/kg) of PbO.

The reason for the discrepancy between this study and the literature may be that the SCC experiments for Alloy 800 performed by other investigators were carried out either in sodium hydroxide solutions or in water, which are not representative of the secondary side chemistries at the crevice locations where SCC potentially occurs in PWR or CANDU reactors. Some of these tests were performed in sodium hydroxide solutions with very high PbO concentrations (~10g/kg) [22]. However, crevice chemistries in operating steam generators are very complex, and are now thought to be closer to neutral pH rather than to highly alkaline conditions [9]. In addition to lead, these crevices contain many other species, such as calcium, sulphate and chloride, etc. These species may interact with each other and with lead, and inhibit or enhance SCC. Therefore, the data from the above references cannot be used to verify the SCC susceptibility of Alloy 800 under CANDU SG secondary side crevice conditions. In the present study, the results were obtained under more representative SG secondary side crevice chemistries conditions.

Ogundele and co-workers [13, 14] conducted capsule tests using C-ring samples under simulated CANDU crevice chemistry conditions identical to those listed in Tables 2a and 2b, except that their solutions contained silica at 0.5 M. Their results suggest that Alloy 800 is susceptible to SCC when exposed to these environments at 305~315ºC. SCC was observed mainly in alkaline crevice environments with and without lead addition. Alloy 800 C-ring samples cracked under acidic crevice chemistry conditions as well. Silica was found to reduce the detrimental effect of lead in electrochemical tests [11]. Therefore, the SCC observation in alkaline and acidic crevice chemistries could not be attributed to silica addition. As compared to the CERT tests at applied potentials, the C-ring tests were performed at the free-corrosion potential and the pH of the test solutions could be lower than anticipated because of the hydrolysis of dissolved metal cations.

Based on the results obtained from the CERT tests and the discussion above, the recommended ECP/pH zone [12] previously defined by electrochemical tests can be verified and revised, as shown in Figure 10. SCC was observed on CERT specimens tested under lead-free near-neutral crevice chemistry conditions at potentials of –300 mV and above. Three tests were performed at –300 mV and SCC was found in one of the tests. Alloy 800 showed no cracking at –350 mV under lead-free near-neutral crevice chemistry conditions. It is therefore assumed that the boundary between the SCC and the SCC-free zone is located at –325 mV under lead-free near-neutral conditions. SCC was observed in Alloy 800 tube specimens after CERT tests performed in lead contaminated near-neutral crevice solutions at about –400 mV and above. Alloy 800 tested in lead-contaminated near-neutral crevice solutions at –490 mV showed no cracks. The results indicate that the upper ECP limit of the safe zone for Alloy 800 under lead-contaminated crevice chemistry conditions should be moved down to –400 mV. To be conservative, the boundary is set at –450 mV.

The data from the C-ring tests [13, 14] are also schematically shown in Figure 10. The data points of the C-ring tests showing cracking are outside both the original and revised recommended ECP/pH zones. Thus, CERT tests performed in an autoclave at applied potentials and the results from the C-ring tests are considered to be complementary for determining the SCC susceptibility of Alloy 800 under CANDU SG crevice conditions.

The potential and pH of Alloy 800 tubing under normal CANDU SG operating conditions is also shown in Figure 10. The normal CANDU SG operating condition estimated for the neutral pH range and the ECP for Alloy 800 tubing is around –580 to –600 mV. CERT tests performed under near-neutral crevice chemistry conditions in this ECP range produced no SCC in Alloy 800 tubing specimens. Therefore, as long as CANDU SGs operate under normal operating conditions, it is expected that Alloy 800 is not susceptible to SCC. This prediction is supported by the excellent in-service records of Alloy 800 in CANDU 6 units [5] and in Siemens/KWU units [1, 2, 3]. However, the PbSCC susceptibility of Alloy 800 at ECP values as low as –400 mV indicates that oxidizing excursions should be avoided. Other forms of lead-induced tube degradation such as pitting, wastage and denting resulting from heavy scaling may take place in the potential range below –540 mV to –680mV. These data suggest that lead-induced tube degradation could be a potential issue for SGs using Alloy 800 as well as other SG tube alloys including Alloy 690. Prevention of the release of any immobilized lead inventory from SG deposits through water chemistry management is of vital importance and lead-contamination should be minimized for SG systems.

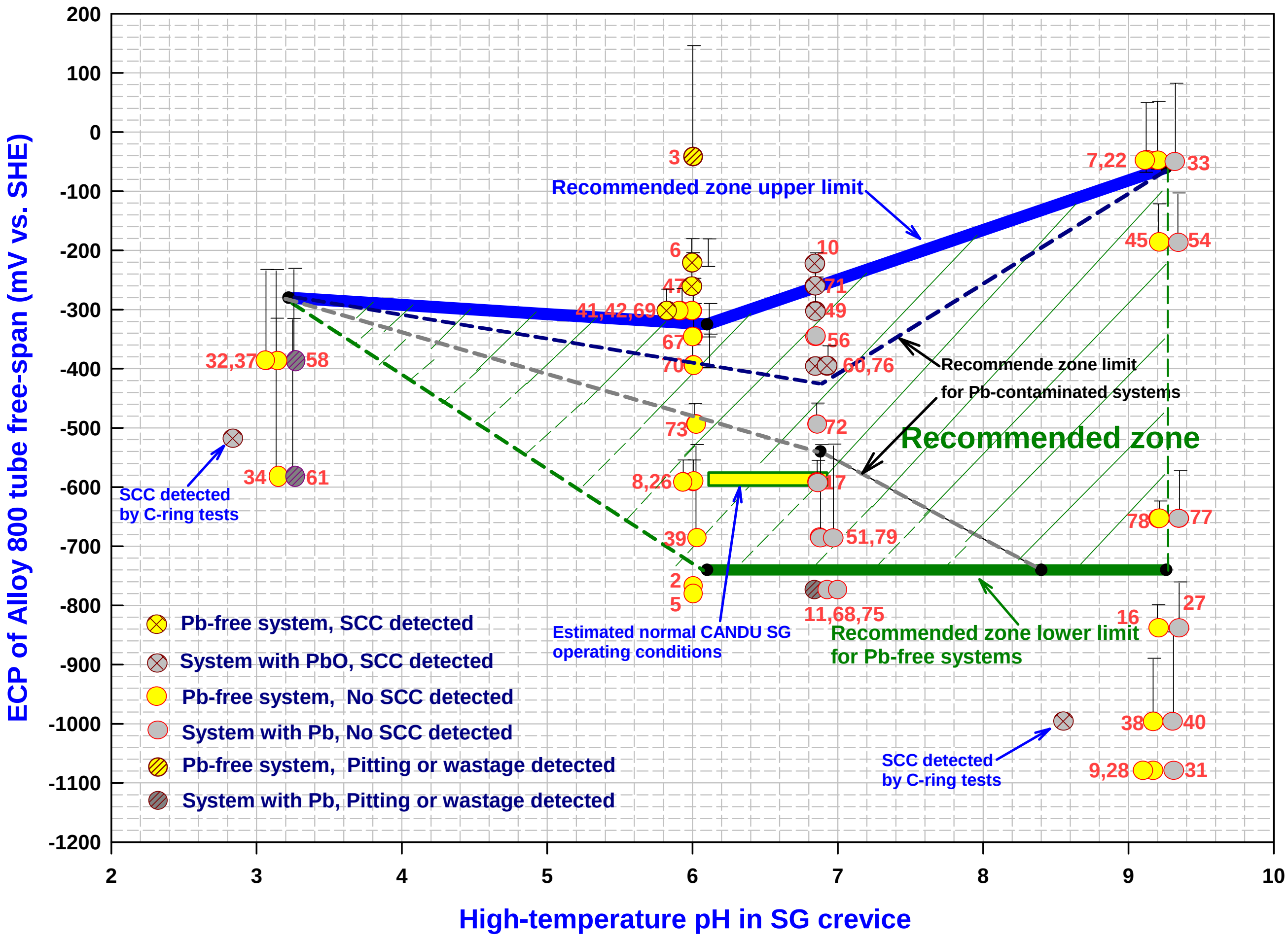


Figure 10 Revised recommended ECP/pH zone to minimize SCC of Alloy 800 tubing.

4. CONCLUSIONS

CERT tests were performed on Alloy 800 tubing material under simulated acidic, near-neutral, and alkaline crevice chemistry conditions applicable to CANDU steam generators, both with and without lead contamination, at various applied potentials and at 300°C. The following conclusions from the experimental results can be made:

- SCC was only observed in near-neutral crevice chemistry, both with and without lead, at elevated potentials. The cracking was transgranular. With lead contamination, the potential range in which SCC occurred is enlarged. No SCC was observed under acidic and alkaline crevice chemistry conditions, both with and without lead contamination.
- Lead contamination increased the SCC susceptibility at high potentials under the near-neutral crevice conditions tested. No lead enhancement of SCC was observed under the acidic and alkaline crevice chemistry conditions tested. The results suggest that the pH dependence of the SCC susceptibility of Alloy 800 in simulated steam generator crevice solutions is different from that observed in sodium hydroxide solutions.
- Lead was found to enhance pitting corrosion of Alloy 800 under acidic crevice conditions.

- The CERT results suggest that Alloy 800 has good performance inside much of the recommended electrochemical corrosion potential/pH zone determined by electrochemical analysis. Only the upper ECP limit under near-neutral crevice conditions needs to be modified with respect to SCC susceptibility, i.e., the ECP upper limit should be lowered for near-neutral pH conditions to –325 mV under lead-free, and to –450 mV under lead-contaminated, crevice chemistry conditions.
- Alloy 800 is not susceptible to SCC under recommended and specified CANDU steam generator operating conditions.
- Oxygen excursions should be avoided and lead contamination should be minimized for SGs because Alloy 800 may be susceptible to SCC under near-neutral crevice chemistry conditions in the presence of oxidants, especially in lead-contaminated systems.

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