



Corrosion of type 6061-T6 aluminum in mercury and mercury vapor

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Abstract

To examine potential corrosion of aluminum maintenance equipment in environments periodically containing mercury vapor and droplets of liquid mercury, c-rings of 6061-T6 aluminum have been exposed to a series of screening tests. The tests included vapor phase exposures as well as immersion of stressed and unstressed c-rings in the as-received condition and with chemical treatments to modify the passive film. Test conditions included the temperature range 0–160 °C, times of 3–30 days and, in addition to liquid Hg, various Hg vapor environments including residual air, residual helium and condensing conditions. The results indicate 6061-T6 is quite susceptible to pitting and cracking when immersed in Hg for even a brief time, but at least one chemical treatment was shown to improve corrosion resistance under immersion conditions. Type 6061-T6 was found to be essentially immune to vapor phase corrosion for the conditions examined, with only very minor development of pits or pit precursors.

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1. Introduction

The Spallation Neutron Source (SNS) will generate neutrons via interaction of a pulsed 1.0 GeV proton beam with a liquid mercury target. Substantial research has been undertaken to evaluate potential compatibility issues for type 316L/316LN stainless steel – the target containment material – with Hg under a variety of flow/temperature conditions. This research, which has included thermal convection loops to evaluate dissolution and temperature gradient mass-transfer [1–5] as well as mechanical tests to evaluate liquid metal embrittlement and fatigue [6–8], has shown that 316L/316LN generally resists wetting and corrosion by Hg in laboratory tests and thus appears suitably compatible for target containment.

Although relatively little research has been required for balance-of-plant material issues, one practical concern is for the manipulator arms and tools that will be

used in the target hot cell facility where maintenance and material handling for the Hg target will occur. Materials for these items need to be relatively high strength and low weight to function effectively as remotely operated equipment, so aluminum alloys are prime candidates for these applications. (Moderator assemblies and neutron beam windows will also be aluminum.) At issue is the fact that aluminum alloys are generally considered incompatible with Hg [9–14] due to high dissolution rates, pitting and cracking, yet service in the hot cell and related facilities may periodically expose the aluminum materials to dilute vapors of Hg or perhaps small droplets of Hg during brief periods. While avoiding and prohibiting the direct contact of Hg and aluminum to the greatest extent possible is the goal for operation, screening tests to examine the potential severity of brief/periodic exposure of aluminum alloy 6061-T6 to liquid Hg and Hg vapor have been performed.

2. Experimental

Seamless 6061-T6 aluminum tubing, with 19.1 mm outside diameter (OD) and 1.6 mm wall thickness, was

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used to fabricate the standard c-rings (ASTM G-38) used for most of the screening tests. Type 316L stainless steel bolting materials and non-metallic shoulder washers were used to facilitate testing of highly stressed c-rings. Using an equation in the Appendix of ASTM G-38 to calculate the required diameter decrease, the stressed c-rings were loaded to approximately 205 MPa, or about 85% of the minimum yield strength associated with 6061-T6 aluminum. However, in some cases, c-rings without bolting materials were used to examine the relatively ‘unstressed’ (only residual fabrication stresses) condition. Tubing certified to meet the composition specification given in Table 1 was used to make the c-rings. A standard c-ring assembly appears in Fig 1. The surface area of each c-ring was approximately 20 cm².

In a typical screening test, specimens were stacked in glassware such that three c-rings were immersed in liquid Hg and three identical specimens were exposed in the enclosed vapor space above the Hg. A schematic diagram of the test apparatus is shown in Fig. 2. For the c-rings without bolting hardware attached, the glassware had a circular cross-section with a slightly larger inside diameter (ID) – approximately 21 mm – than the OD of the test specimens; for c-rings with bolting hardware, the

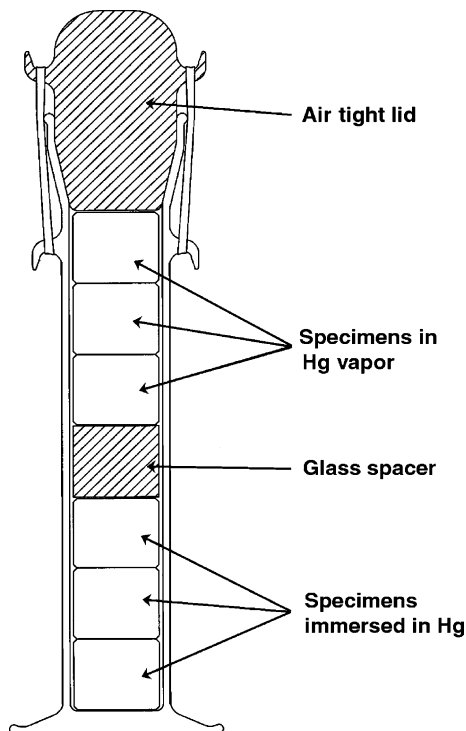


Fig. 2. Schematic diagram of test vessel.

Table 1

Composition of the 6061-T6 aluminum test pieces (wt%)

	Minimum	Maximum
Cu	0.15	0.40
Cr	0.04	0.35
Mg	0.80	1.20
Si	0.40	0.80
Fe		0.70
Mn		0.15
Zn		0.25
Others (each)		0.05
Others (total)		0.15
Al		Balance

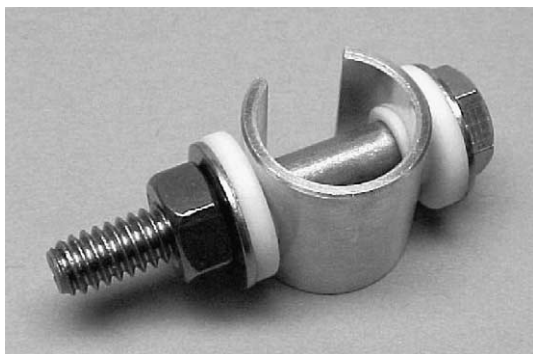


Fig. 1. Aluminum c-ring configuration.

cross-section of the glassware was rectangular with a similar clearance. For some exposures, the entire test vessel was maintained at the test temperature by wrapping with heat tape or by placement in a constant temperature water bath. In other cases, only the bottom of the vessel to the level of the Hg was heated, with the portion of the vessel above the Hg level exposed to a stream of ambient compressed air to encourage condensation in the vapor space.

For each exposure, c-rings were labeled, cleaned ultrasonically in acetone, air dried and weighed prior to attaching/setting the bolting hardware (if required) and loading into the test vessel. The appropriate amount of Hg was placed in the glassware and then the specimens were loaded into the vessel. The lid on each vessel fit in a way that forced the specimens to be positioned as shown in Fig. 2 – that is, three submerged completely in Hg and three in the vapor space separated by a glass spacer – without permitting the entire stack to float. The test temperature was then set and, if required, the external air flow established. In most cases, residual ambient air was inside the test vessel at the beginning of the test and it remained in the sealed vessel with Hg vapor throughout the test. In a few cases, a stopcock and valve arrangement on the lid of the vessel (not shown in Fig. 2) was used to evacuate the air and replace it with high-purity helium prior to heating the vessel to test temperature.

In most cases, the c-ring specimens (with or without stress added via the bolting arrangement) were exposed in the as-received condition, i.e., machined tubing with an average surface roughness of about 0.7 μm rms on all exposed surfaces. For some exposures, the c-ring specimens received an additional surface treatment intended to stabilize the protective film on the specimen. Two different treatments were used:

- (1) The 'HFIR' surface treatment, so named for the standard surface treatment historically given to aluminum fuel cladding at the High Flux Isotope Reactor at the Oak Ridge National Laboratory, was used. This treatment includes immersion in a room temperature solution of (by volume) 15% reagent grade nitric acid, 1% reagent grade hydrofluoric acid and 84% demineralized water for 3 min, rinsing in ambient water and then sealing in demineralized water at 70 °C for 2 min. This treatment develops a uniform boehmite oxide film about 2 μm in thickness with a dull matte (gray) finish compared to the shiny starting material.
- (2) A phosphate conversion treatment was also used. This treatment duplicated the procedure found in [15] and included acid cleaning in a concentrated nitric/hydrofluoric acid solution, rinsing, conversion bath soaking (included ammonium phosphate, potassium dichromate and ammonium bifluoride in water), followed by rinsing and sealing. This treatment generated a faint/pale green coloration on portions of the specimen surface and left a dull finish compared to the shiny starting material.

Mercury from the same batch as that used for the other target material compatibility tests [1–8] was used for these experiments. Standard chemical analyses of representative samples indicated the Hg was quite pure, containing only about 85 ppb Ag and 100 ppb Si above detection limits. Immediately prior to use, the Hg was 'filtered' through cheesecloth to remove the small amount of residual debris (oxides) floating on the surface.

Following each exposure, typically six days in length with a few as long as 30 days, specimens were cleaned (brief ultrasonic treatment in acetone, air dried),

weighed and photographed where appropriate. Metallography of selected test specimens was also performed. Following the initial few exposures, subsequent test conditions were selected to further examine specific results.

3. Results and discussion

3.1. Exposure #1 – effect of temperature

In this experiment, three as-received, unstressed c-rings (no bolting hardware) were immersed in Hg for six days and three identical specimens were exposed to the atmosphere above the liquid (air + Hg vapor) at 0 °C (ice bath), 22 °C (room temperature) and 45 °C (heated water bath). In each case, the entire glass vessel containing the Hg and specimens was at the test temperature.

Table 2 summarizes the results of the initial test. The immersed specimens exhibited readily detectable but variable weight loss as a result of the exposure, with the general trend of increasing weight loss with increasing exposure temperature. Specimens immersed in Hg also revealed readily visible pits on each specimen, with a pit density (pits per unit area) that increased with exposure temperature.

Following immersion at 45 °C, typical pits were approximately 0.5 mm (20 mils) in diameter but generally only about 0.15 mm (5–6 mils) deep. In addition, a dark stain was associated with nearly every pit, and frequently the stained area was significantly larger than the actual pit and roughly centered in the stained area. Fig. 3 shows a representative photograph of a post-test c-ring (immersed at 45°) compared to its unexposed counterpart and a cross-section of the exposed specimen to confirm the typical pit depth. The OD surface of the exposed c-ring exhibited far less pitting than the ID surface, which was found to be a general trend for all cases in which significant pitting was observed. Since the c-rings were fabricated from standard seamless tubing, it seems unlikely that a composition or microstructure gradient in the specimen material is responsible for this observation. Rather, the ID surface of the specimens

Table 2
Results of six day exposures for 6061-T6 aluminum specimens in Hg environments

Environment	Weight change (mg)	Specimen appearance
Immersed at 45 °C	–2.2, –4.4, –39.0	Etched, scattered pits and cracks
Immersed at 22 °C	–2.7, –2.6, –12.6	Etched, scattered pits, pit precursors
Immersed at 0 °C	–0.1, –0.1, –0.1	Pit precursors
Vapor at 45 °C	No change	Pit precursors
Vapor at 22 °C	No change	Few pit precursors
Vapor at 0 °C	No change	Few pit precursors

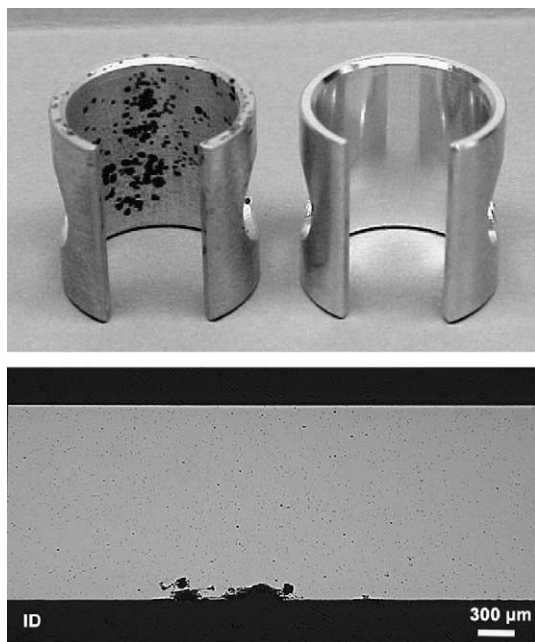


Fig. 3. Top: c-ring immersed in Hg at 45 °C for six days (left) beside unexposed specimen. Bottom: as-polished cross-section (longitudinal orientation) of exposed specimen showing representative depth of attack in pitted area.

tends to exhibit slightly greater surface roughness than the OD in localized areas, perhaps due to more difficult machining on the inside surface and it is possible that the greater roughness corresponds to apparently greater pitting susceptibility.

One specimen immersed at 45 °C exhibited significant pitting but also cracked as a result of exposure (Fig. 4). The crack appears to have initiated from a pit at/near the bolt hole on the specimen ID. In addition to the crack that penetrated the specimen cross-section in only six days, there appears to be significant subsurface corrosion and crack propagation.

Specimens immersed at 22 °C generally exhibited fewer pits than specimens exposed at 45 °C and had less staining associated with the pits. Typically, specimens immersed at 22 °C developed many approximately circular areas which were etched or roughened due to corrosion activity, but the depth of penetration associated with the rough areas was minor. Fig. 5 is representative of c-rings immersed at 22 °C, which reveals only one large pit among the many roughened areas. At the highest magnification shown in Fig. 5, the depth of penetration associated with the roughened areas is approximately 10–20 μm.

C-rings immersed at 0 °C showed only minor weight loss with no readily detectable pits. However, a few pit ‘precursors’ were observed scattered over the exposed

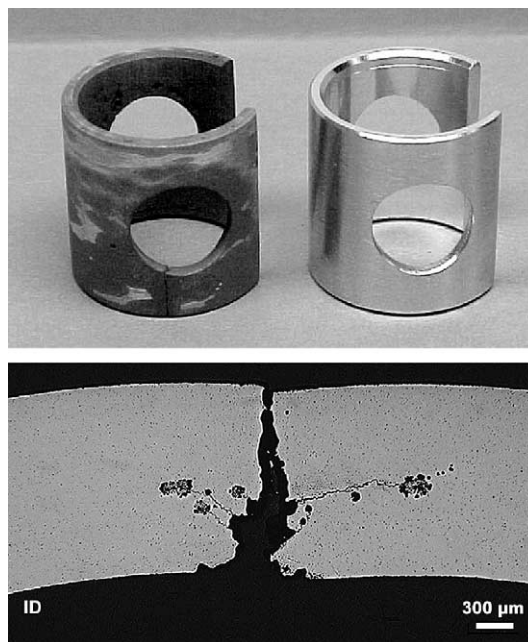


Fig. 4. Top: c-ring immersed in Hg at 45 °C for six days (left) beside unexposed specimen; the exposed c-ring exhibits a crack just below the bolt hole. Bottom: as-polished cross-section of the cracked specimen.

surface area. The pit ‘precursors’ appear to be embryonic pits exhibiting little or no roughening and penetration; they can be distinguished on the post-test surface only as a result of slight discoloration in a small circular area associated with each precursor. A 10× magnification is generally required to observe these indications.

In contrast, c-rings exposed to vapor above the Hg did not exhibit any weight change (measured to 0.00 mg) and revealed only a few pit precursors on the surface following exposure at each temperature. Like the pit precursors on specimens immersed at 0 °C, these indications were small round discolorations exhibiting little or no roughness and penetration. Fig. 6 is representative of this observation; in particular notice that typical penetration associated with the ‘pit precursors’ is only 1–2 μm if it can be detected at all.

These results are qualitatively very similar to corrosion data for type 5083-O aluminum exposed to liquid Hg and in vapor above Hg [9], in which severe embrittlement and cracking was observed on slow strain rate specimens exposed directly to liquid Hg, but there was no effect for specimens exposed in various Hg vapor compositions. Further, various surface treatments for 5083-O aluminum were found to improve resistance to embrittlement and cracking in Hg, as will be demonstrated below for 6061-T6.

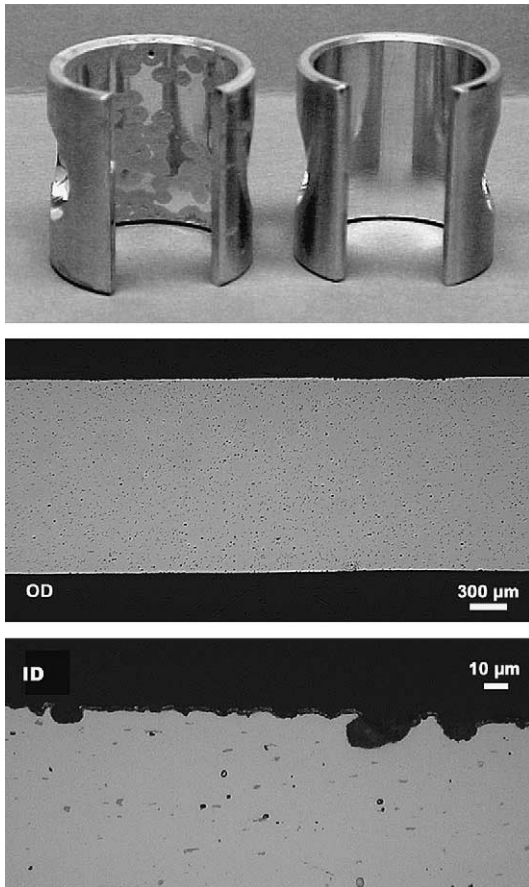


Fig. 5. Top: c-ring immersed in Hg at 22 °C for six days (left) beside unexposed specimen. Center: as-polished cross-section (longitudinal orientation) of exposed specimen, showing only slight surface roughening in the discolored areas. Bottom: Higher magnification of the cross-section of the exposed specimen.

3.2. Exposure #2 – effect of surface treatment and stress

In this experiment, the surface of unstressed c-rings was modified with a chemical treatment to examine potential improvements in performance. In one vessel, three specimens immersed in Hg and three specimens exposed to the vapor phase above the Hg all received the ‘HFIR’ surface treatment. An identical experiment was performed with specimens receiving a phosphate conversion treatment.

In addition, for comparison with the results of Exposure #1, standard as-received c-rings were stressed to about 85% of the minimum yield stress for the material and three each exposed immersed in Hg and in the vapor phase above the Hg. All experiments in Exposure #2 were at ambient (22 °C) for six days, with no external heating or cooling applied.

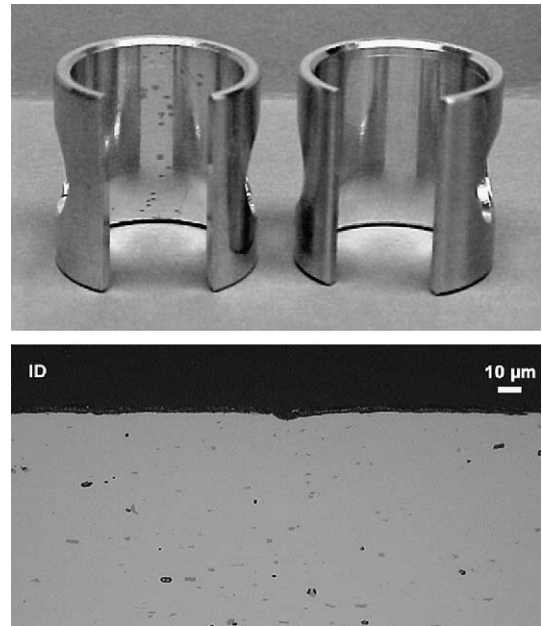


Fig. 6. Top: c-ring exposed in Hg vapor at 22 °C for six days (left) beside unexposed specimen. Bottom: as-polished cross-section of area with ‘pit precursor’ indications.

Examination of the ‘HFIR’ surface treated specimens (immersed and vapor phase) revealed no change in weight or appearance, no pits (or precursors) or cracks and the specimens seemed immune to Hg under these conditions. Similarly, the phosphate-conversion treated specimens also appeared immune to Hg in this exposure. Based on comparative results for immersion at 22 °C, then, the surface treatments result in a considerable increase in resistance to pitting for 6061-T6 aluminum.

The stressed c-rings that received no surface treatment performed very similarly to the unstressed counterparts at room temperature in Exposure #1. The specimens exposed in the vapor phase revealed no change in weight or appearance and exhibited no pits or cracks. The specimens immersed in Hg revealed only a minor weight change (0.1–0.5 mg), but did reveal various degrees of pitting similar in size/distribution to that on unstressed specimens. No distinct pattern of pit depth or density was observed as a function of stress (none vs. 85% of yield) on the c-rings.

One stressed specimen cracked into two pieces in very brittle fashion (Fig. 7). The crack perhaps initiated from pits/corrosion on the OD surface (Fig. 8) and was largely intergranular (Fig. 9). It is interesting that the pits associated with the crack were approximately the same depth (0.15 mm) as those observed on the unstressed specimens, perhaps indicating that a particular depth of material is susceptible to pitting due to a non-uniform microstructure. However, metallographic analysis

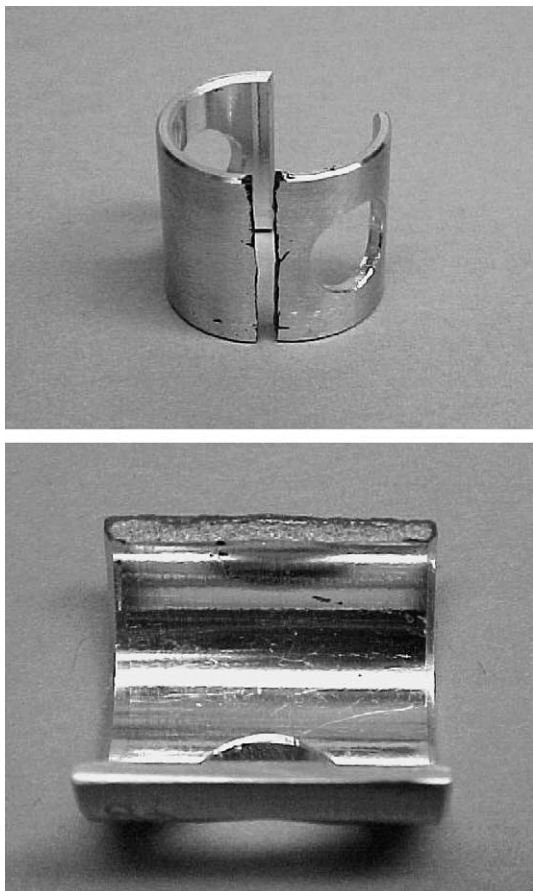


Fig. 7. Views of the fracture of a stressed c-ring immersed in Hg at 22 °C for six days.

revealed a consistent grain size and a sparse, apparently random, distribution of small inclusions across the entire thickness. Alternately, pitting to a depth of 0.15 mm could have caused a local stress in excess of yield. This might cause the aluminum to suffer intergranular fracture due to liquid metal embrittlement (via decohesion of grain boundaries). When the fractured c-ring was removed from the test, it was somewhat surprising that the fresh (oxide-free) fracture surface was not wet by Hg. The residual Hg (and/or oxides of Hg) clinging to the fracture was easily removed by light tapping and a brief ultrasonic treatment in acetone. EDX analysis of the post-test surface after this limited cleaning revealed only a few tiny beads of Hg and no indication of a chemical interaction between Hg and the Al.

3.3. Exposure #3 – effect of accelerated condensation and temperature

This test was very similar to Exposure #2, with the primary difference being that only unstressed specimens

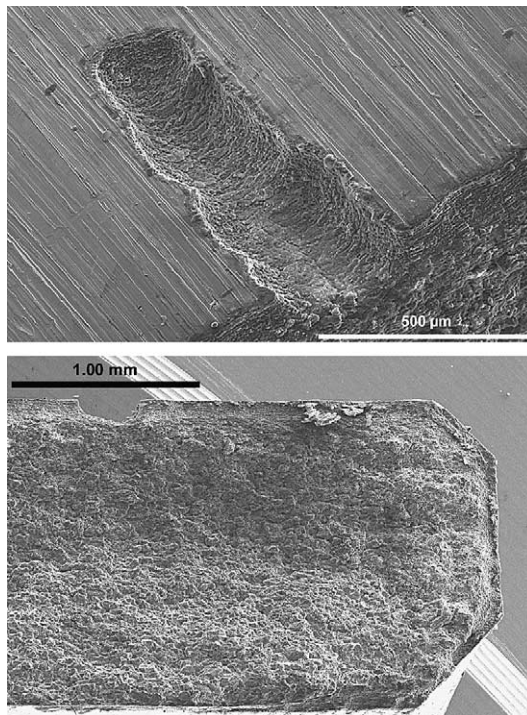


Fig. 8. Scanning electron microscope images (secondary electrons) of the fracture surface depicted in Fig. 7.

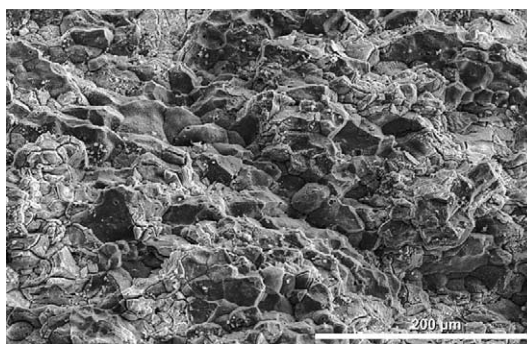


Fig. 9. Scanning electron microscope image (secondary electrons) of the fracture surface shown in Fig. 8. This image, from near the center of the c-ring cross-section, shows mostly intergranular failure.

were examined and the Hg temperature was raised to 45 °C using a water bath. Heat was extracted from the vapor space region by blowing three streams of compressed ambient air across the top portion of the vessel. The purpose of the lower temperature in the vapor space was to encourage condensation of Hg in this region. As in Exposure #2, one vessel contained unstressed specimens with the 'HFIR' surface treatment (three specimens immersed in Hg and three exposed in the vapor

space). Likewise, the other two vessels contained unstressed specimens receiving the phosphate conversion treatment (three immersed and three in vapor), and unstressed c-rings in the as-received condition (three in Hg and three in vapor). The test duration was six days.

Again, the specimens with the ‘HFIR’ surface treatment were essentially immune to Hg for the test conditions, as demonstrated by no change in weight or appearance for immersed or vapor phase coupons. The phosphate conversion specimens did not fare as well – vapor phase c-rings were essentially immune to attack, but various degrees of pitting and discoloration were observed on the immersed specimens. The as-received c-rings were also very resistant to the vapor phase, but significant pitting similar in depth and distribution to that observed in Exposure #1 was observed on each of the immersed specimens.

3.4. Exposures #4 and #5 – effect of increased condensation and stress

The intent of these exposures was to generate a higher concentration of Hg in the vapor space of the test vessel compared to previous tests. This was accomplished by placing a small amount of Hg in the bottom of the heavily insulated glass test vessels which were then warmed with heat tapes to 100 °C for exposure #4 and to 160 °C in Exposure #5. Several glass spacers (small pieces of tubing) were placed on top of the Hg pool and this permitted vapors to pass to the top of the vessel but prohibited direct contact of any of the c-ring specimens with liquid Hg. Above the glass spacers, each vessel was filled with four c-ring specimens – three in the as-received condition and one with the ‘HFIR’ surface treatment. One vessel at each temperature contained all unstressed c-rings and the other contained c-rings stressed to 85% of the minimum yield stress. (Stress was applied to ‘HFIR’ treated specimens after the surface treatment procedure.) The top portion of each vessel, where the c-ring specimens were located, was cooled with three streams of compressed lab air. Again, the test duration for all four vessels – stressed and unstressed c-rings at each of two temperatures – was six days. Specimens were reused from Exposure #4 in Exposure #5.

At the end of each test, Hg condensate on specimens from the vapor space was evident to variable degree. For the tests with Hg at 160 °C, the two specimens closest to the glass spacers were essentially covered with tiny beads of Hg (Fig. 10), with a smaller number of beads located on specimens higher in the stack. In all cases, the beads exhibited a very high contact angle (no apparent wetting) and were easily dislodged from the specimen by light tapping. Although this could be related to the location and geometry of the specimens relative to the container walls, the beads of Hg were almost exclusively located on the ID of the c-rings. Again, the locally greater surface

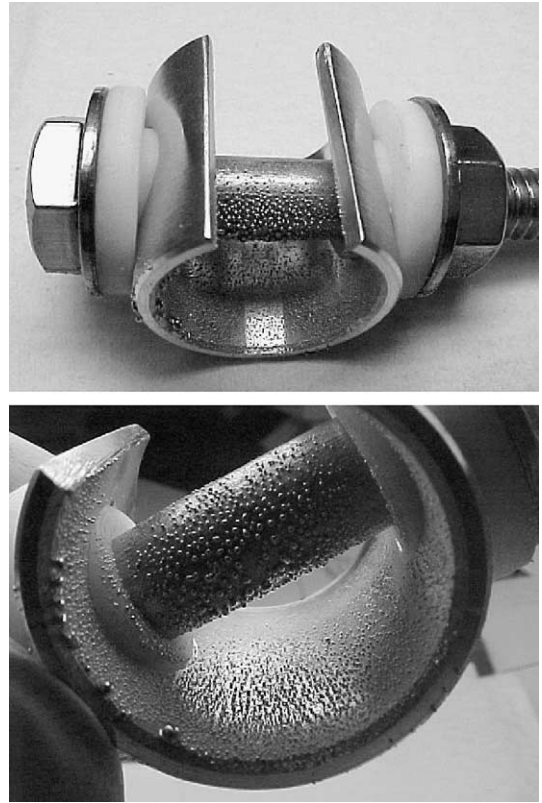


Fig. 10. C-rings following exposure in condensing conditions over Hg at 100 °C for six days. Note the presence of many tiny beads of Hg that do not appear to wet the substrate surface.

roughness of the ID may have encouraged or trapped condensation preferentially. None of the specimens so exposed – in vapor at 100 or 160 °C – exhibited more than 0.1 mg weight change and none of the specimens exhibited any sign of attack (no discoloration, pitting, or cracking). It is not clear why a specimen covered in Hg condensate is not susceptible to pitting similar to specimens immersed in Hg. Based on the contact angle, none of the condensate beads were observed to wet the 6061-T6 surface and without wetting there can be no attack by Hg. As a matter of speculation, it may be that the statistics of pitting for an immersed specimen (having Hg in contact with a location susceptible to pitting) are much more favorable than the statistics associated with apparently random locations for condensate beads to collect.

Because the target containment will be 316L/316LN stainless steel, it is significant to note that the Hg vapor (and beads formed in the condensing section of the glassware) also did not appear to wet/attack the 316L stainless steel bolting material nor the plastic shoulder washers. No discoloration, pitting, or cracking was observed on any of the bolting materials following any of the exposure tests.

3.5. Exposure #6 – increased vapor exposure time

To examine potential effects of longer exposures, stressed c-rings (85% of the minimum yield stress) were exposed to Hg vapor in the as-received condition and the 'HFIR' surface treatment condition for 30 days. Triplicate specimens at each condition were exposed in Hg vapor (with residual air) at room temperature and at 45 °C (vessel wrapped with heat tape). In each case, the entire containment vessel was at the test temperature as opposed to condensing conditions in the vapor space. Similarly, triplicate c-rings in the unstressed condition were also exposed in the as-received condition and following 'HFIR' surface treatment. No immersion tests were performed for the 30-day exposure.

Consistent with the results from similar shorter duration tests (six days), none of the 'HFIR' treated specimens were observed to develop any discoloration or visually detectable pits. Only one of the as-received c-rings developed pitting in the 30-day exposure; in this case, the pits on the specimen exposed at 22 °C were very small and required magnification of about 10× to distinguish them from a surface blemish. Independent of exposure temperature and stress, all of the as-received specimens lost 0.1–0.2 mg as a result of the 30-day exposure.

Overall, the results after exposure to Hg vapor for 30 days are very similar to those for short-term exposures (six days) in that the 'HFIR' surface treatment rendered specimens essentially immune to attack while the as-received specimens exhibited only very modest pitting susceptibility. Further, this result suggests that time – up to 30 days, at least – is not a critical factor in the pitting (or lack thereof) observed on specimens exposed in low temperature vapor over Hg. Even longer duration exposures may result in the development of pitting or cracking.

3.6. Exposure #7 – effect of cover gas

This test was essentially a duplicate of one of the initial tests in which a stack of c-rings was immersed in Hg as well as exposed to vapor over the Hg. In the present case, however, the air was removed from the vapor space of the container by a sequence of vacuum/backfill steps using a roughing pump and helium. The purpose of the test was to determine if the absence of air (oxygen) in the vapor space made a difference in the pitting resistance of 6061-T6 to Hg vapor. (Although He will not be present in the target hot cell facility, He may be present in the target He and was chosen as the inert cover gas for this reason.)

After the final evacuation, a slight overpressure of helium was introduced to the container and it was then sealed for the duration of the test. The overpressure was still present at the end-of-test, indicating no significant

gas leakage during the exposure. In this test, triplicate c-rings of as-received/unstressed stock were exposed, immersed and in the vapor, for six days at room temperature. An attempt was made to evaluate stressed c-rings as well, but the rectangular cross-section glassware cracked during the vessel evacuation process.

Similar to the exposure in which air was present with the Hg vapor, the immersed specimens lost variable weight (0.1–0.4 mg) and exhibited various degrees of shallow pitting. One of the immersed specimens also developed a crack near the bolt hole (similar to that shown in Fig. 4). The specimens exposed in the vapor space (Hg + He) remained shiny and free of any pitting and exhibited negligible weight changes. Although the data are limited, the performance of the 6061-T6 c-rings appears not to be critically dependent on the residual atmosphere present with Hg vapor.

3.7. Exposures #8 and #9 – effect of fabrication history

All of the previously described tests were performed with c-ring specimens from a specific heat of 6061-T6 tubing. To examine the possibility that the performance observed was specific to this heat of material, brief immersion and vapor phase exposures were performed for 6061-T6 from other heats/forms of material. Exposure to the other forms of 6061-T6 offered the possibility to examine material with a slightly different composition (within the specification for the material) and with a different fabrication history.

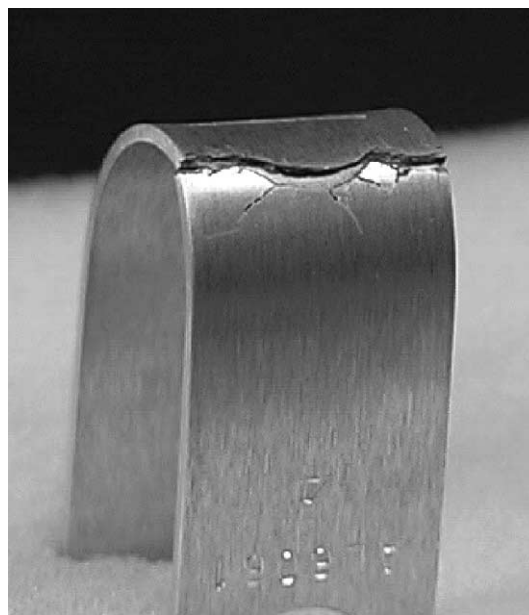


Fig. 11. Type 6061-T6 U-bend immersed in Hg for three days at 22 °C.

In one set of exposures, rectangular coupons prepared from 6061-T6 plate (6 mm thick; composition certification same as that in Table 1) were exposed for six days in the vapor above Hg (with air) up to 60 °C. Specimens in the as-rolled condition (slightly rough surface) as well as polished (1200 grit paper) were included in the testing. Minor weight losses up to 0.5 mg (from 9 cm² of surface area) were observed, but only a few minor pits or pit precursors were observed on these specimens. No plate specimens were exposed in the fully immersed condition.

In another set of exposures, standard U-bends (ASTM G-30) made from 6061-T6 sheet (1.5 mm thick; composition certification same as that in Table 1) were exposed for three days immersed and in vapor above Hg (with air) up to 75 °C. No pitting was observed on any of the U-bends exposed only to vapor, but one of a pair of specimens immersed in ambient Hg cracked in 72 h. Fig. 11 shows the post-test specimen; like the fracture shown in Fig. 7 (from Exposure #2), very little if any wetting of the fracture face by Hg was observed.

4. Conclusions

C-rings of type 6061-T6 aluminum were immersed in Hg and exposed to the vapor above mercury for periods up to 30 days and temperatures up to 160 °C. The results indicate that this material is readily susceptible to pitting and cracking when immersed in liquid Hg, even at ambient temperature. Pits up to about 0.15 mm deep and through-thickness cracks in material up to 1.6 mm thick were observed in as little as 72 h in the immersion exposures. However, the HFIR surface treatment was successful at improving the resistance of 6061-T6 to Hg in six day immersion experiments, demonstrating the importance of a uniform passive film to protect the aluminum.

On the other hand, 6061-T6 aluminum demonstrated good resistance to Hg vapor. Tests up to 30 days in duration included specimens in Hg vapor with residual air or residual He and incorporated condensing and non-condensing conditions up to 160 °C. The results indicate that 6061-T6 is resistant to Hg vapor and typically exhibits, at worst, the development of shallow pit precursors during the range of exposure conditions examined here.

One practical implication for the SNS is that contact of aluminum components with liquid Hg should be avoided to the greatest extent possible. Where even brief exposure to liquid occurs, the aluminum surfaces should be cleaned and inspected to assess damage. Where periodic exposure to liquid Hg simply cannot be avoided, it appears likely that a surface modification such as the

HFIR surface treatment may increase the corrosion resistance of Al to Hg. Periodic exposure to Hg vapor, however, can be tolerated for reasonable periods without concern for pitting or cracking of 6061-T6 material.

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