A Technical Basis to Relax The Dew Point Specificaion for the Environment in the Vapor Space in DWPF Canisters (U)

by

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**A Technical Basis
to
Relax the Dew Point Specification
for the
Environment in the Vapor Space in DWPF Canisters (U)**

Summary

This memorandum establishes the technical basis to conclude that relaxing, from 0°C to 20°C, the dew point specification for the atmosphere in the vapor space (free volume) of a DWPF canister will not provide an environment that will cause significant amounts of corrosion induced degradation of the canister wall. The conclusion is based on engineering analysis, experience and review of the corrosion literature. The basic assumptions underlying the conclusion are:

- 1) the canister was fabricated from Type 304L stainless steel (1),
- 2) the corrosion behavior of the canister material, including base metal, fusion zones and heat effected zones, is typified by literature data for, and industrial experience with, 300 series austenitic stainless steels, and
- 3) the glass-metal crevices created during the pouring operation will not alter the basic corrosion resistance of the steel although such crevices might serve as sites for the initiation of minor amounts of corrosion on the canister wall (2).

Background

The maximum dew point of the atmosphere in the vapor space of a DWPF canister was specified at 0°C, primarily to assure the absence of water inside a filled and sealed canister. The canister is filled with a borosilicate waste glass. The glass is at a nominal temperature of 1150°C when poured

from the DWPF melter (3). Receipt of this hot glass should thoroughly dry the canister; thus, if the atmosphere inside the canister has a dew point of 0°C, the minimal amount of moisture remaining in the canister will be gaseous at temperatures above 0°C and solid (frost) at temperatures below 0°C. The 0°C dew point specification should therefore assure that corrosion induced degradation processes such as stress corrosion cracking, pitting and crevice corrosion do not initiate on the inner surface of the canister wall. (This specification is based on the assumption that liquid water is required to cause the initiation and propagation of corrosion processes from the interior of the canister wall.)

Recent studies, including tests of four canisters produced from pilot scale testing (3), have shown that the dew point of the environment inside a sealed canister may be above 0°C. If the dew point were above 0°C and a partially filled canister were sealed, then exposed to temperatures above 0°C but below the dew point of the internal canister environment, moisture could condense on the interior of the canister wall. This possibility led to the question, "could such condensation cause stress corrosion cracking, pitting and/or crevice corrosion of the canister wall?". This memorandum summarizes the engineering judgment, experience and review of the corrosion literature used to demonstrate that such condensation will not cause significant corrosion induced degradation of the canister wall if the dew point of the internal environment is at or below 20°C. "

Potential Degradation Mechanisms

Corrosion induced degradation of metals and alloys is frequently categorized into various forms. The techniques for such categorization may be based on the visual appearance, the mechanism of degradation, the area of attack, and/or the nature of the corrosion causing environment. The ASM International Metals Handbook (4) lists eight forms of corrosion for austenitic stainless steel:

- 1) general or uniform corrosion,
- 2) galvanic corrosion,
- 3) pitting,
- 4) crevice corrosion,
- 5) stress-corrosion cracking,

- 6) intergranular corrosion,
- 7) erosion-corrosion, and
- 8) oxidation.

Additionally, corrosion reactions such as, $xM + yH_2O \rightarrow M_xO_y + 2yH$, could generate a hydrogen fugacity at the metal surface or a hydrogen pressure in the canister interior. The potential for hydrogen induced degradation of the canister is considered nil, however, because Type 304 stainless steel pressure vessels have been successfully used to contain high pressure hydrogen gasses for decades.

The next eight sections of this memorandum evaluate the anticipated affect of relaxing the dew point specification on each of the corrosion induced degradation categories summarized above.

Oxidation

Oxidation of 18% Cr-8% Ni austenitic stainless steel requires elevated temperatures and this alloy was developed primarily for its oxidation resistance. On exposure to air, the steel forms a protective oxide film which is approximately 10 Å thick. The glass pouring process may cause a very limited amount of film growth or heat tint (oxidation) but, the maximum canister wall temperature during glass pouring is approximately 500 to 600°C. Oxidation induced degradation of Type 304 stainless steel requires temperatures above 800°C (5). Thus, oxidation of the internal canister wall should be negligible. This conclusion is supported through broad based industrial experience which demonstrates that Type 304 stainless steel is suitable for either intermittent or continuous service in air at temperatures up to 870° C (6). This temperature is significantly above the anticipated temperatures during canister handling and storage. Additionally, if the canister were hot enough to cause oxidation, the limited increase in water vapor pressure which would result from relaxing the dew point specification would not effect the oxidation rate. Thus, the potential for corrosion induced degradation by oxidation will not be altered by relaxing the dew point specification for the DWPF canisters.

Erosion Corrosion

Erosion corrosion is the acceleration of corrosion by the abrasive removal of a protective oxide film. This removal is frequently caused by fluid flow across the corroding surface. The fluid itself and/or particles entrained in the fluid wear and eventually remove the protective film, exposing the underlying metal to the environment. A filled, sealed and stored DWPF canister will not experience erosion corrosion because of the static storage conditions for the canister. Additionally, the handling procedures necessary to transfer the canister to storage will not be violent enough to cause significant relative motion between the stored glass and the canister wall. Relaxing the dew point specification therefore will have no impact on the potential for erosion corrosion.

Intergranular Corrosion

Intergranular corrosion is preferential attack along grain boundaries in polycrystalline materials. Type 304 stainless steel is particularly susceptible to this phenomenon whenever a thermal cycle has caused grain boundary precipitation of chromium carbides or other chromium rich phases. The formation of the chromium-rich phase causes the chromium content in the grain boundary region adjacent to the phase to be depleted in chromium. This chromium-depleted region is anodic to the remainder of the metal lattice and is therefore the site of local corrosion. The chromium-rich phase is not corroded. Any thermal cycle that leads to this susceptibility is said to have sensitized the material. Sensitization itself will not cause intergranular corrosion unless the environment is capable of attacking the susceptible region and a given thermal cycle will not cause sensitization unless the chromium-rich phase precipitates.

The tendency for the precipitation of grain boundary carbides and thus the susceptibility to sensitization in the 300 series austenitic steels is minimized by controlling the maximum carbon content. Steels less than 0.03% C are designated as L grade alloys. Type 304L stainless steel and Type 308L weld filler metal were used for DWPF canister fabrication to preclude sensitization. The laboratory work to ascertain the lack of sensitization in canisters that have experienced actual glass pouring and welding cycles has not been completed; however, because of the material selection process, through-wall sensitization and thus canister breaching by intergranular corrosion processes are considered very unlikely, even if moisture condensation and subsequent radiolysis created an aggressive (nitric acid) environment inside the canister. Therefore, relaxing the dew

point specification of the gaseous environment inside the canister should not establish conditions which could compromise the integrity of the canister by intergranular corrosion processes.

Stress Corrosion Cracking

Austenitic stainless steels are generally considered to be immune to stress corrosion cracking at temperatures below 50°C (7-9). Industrial experience and laboratory studies tend to confirm this immunity. However, laboratory testing of samples exposed to acid-chloride solutions (for example 5 N H₂SO₄ + 0.5 N NaCl) has shown that stress corrosion cracks may develop at temperatures as low as 25°C (8,10,11). The samples for these studies were either heavily sensitized (8,10) or contained welds with interconnecting austenite-ferrite interfaces (11). Crack growth was by stress assisted, active path corrosion along sensitized grain boundaries (10) or delta ferrite (11).

Transgranular stress corrosion cracking has also been induced by slow strain rate testing of fully annealed Type 304 stainless steel rods (3.5 mm in diameter) in HCl + NaCl solutions at 25°C (12). The transgranular cracks developed by preferential dissolution of strain-induced martensite. Impedance measurements of the effects of time and strain on the protective character of surface oxide films demonstrated that:

- a) the surface film is protective and hinders the process of anodic dissolution, until,
- b) the tensile strains rupture the film by slip step emergence (12), then,
- c) cracks initiate and grow by anodic dissolution along the active path (strain induced martensite in this case). This dissolution processes continues until,
- d) the protective film is reformed (repassivation) over the active or anodic path.

The film rupture process also explains intergranular stress corrosion cracking of sensitized Type 304 stainless steel in 0.01 M Na₂SO₄ at 75, 100 and 125°C (13). The temperature dependence of this stress corrosion cracking process is apparent from the observation that Type 304 steel is not susceptible to cracking in 0.01 M Na₂SO₄ at 50°C (13). The measured

susceptibility of Type 304 stainless steel to intergranular stress corrosion cracking in 0.01 M Na_2SO_4 solutions was similar in constant load and slow strain rate tests. These results demonstrate that chlorides are not necessary for stress corrosion cracking of Type 304 stainless steel. The susceptibility of sensitized Type 304 stainless steel to intergranular stress corrosion in chloride-free water is also demonstrated by the large number of stress corrosion cracking problems with sensitized Type 304 stainless steel in light water reactors, principally the boiling water reactors (14). Oxygen and/or peroxide are among the species that promote stress corrosion cracking in the reactor materials (14).

Stress corrosion cracks may propagate in heavily sensitized Type 304 exposed to water containing only 200 ppb O_2 (air saturated water contains 8,800 ppb O_2 and has a conductivity of 0.5 $\mu\text{S}/\text{cm}$) or as little as 0.3 μM of sulfuric acid at 25 $^\circ\text{C}$ (15). These low-temperature crack growth rates were between 0.5 and 2 μm per hour. The rates were measured using precracked, compact tension samples loaded to a stress intensity of 33 $\text{MPa}(\text{m})^{1/2}$ with an unloading cycle of $R = 0.5$, 0.01 Hz every 1000 seconds. This unloading cycle is similar to a low R (R is the ratio of minimum load to maximum load) and low Hz ripple load. Ripple loads have been shown to significantly increase stress corrosion crack growth rates (16). The combination of a relatively high applied stress intensity and a ripple load should have maximized the stress corrosion crack growth rates in these test samples and provide very conservative estimates of the behavior of structures fabricated from heavily sensitized, Type 304 stainless steel. The conservative nature of the estimate is apparent in the lack of any crack growth in similar samples exposed under constant load conditions at 50 $^\circ\text{C}$ (13).

Stress corrosion cracking is an initiation and growth process. Consequently, the cracking process may be mitigated by stopping crack initiation or by slowing-down crack propagation (17). Precracked specimens are used to by-pass the initiation step and many estimates of stress corrosion cracking damage are based on crack growth models which assume that most in-service systems will contain structural defects and discontinuities which will serve as initiation sites. Constant extension rate tensile test measurements of the susceptibility of Type 304 stainless steel to stress corrosion cracking in 3N NaCl solutions demonstrated that cracking became initiation limited as "the severity of the environment (impurities, temperature) or material (degree of sensitization, surface conditions) decreases" (18).

Industrial experience, as well as the stress corrosion cracking literature, indicate a general absence of stress corrosion cracking in Type 304 or Type 304L stainless steel structures at temperatures below approximately 50°C. This experience includes paper manufacturing where most of the wetted paper machine surfaces are constructed from Type 304L or 316L stainless steels which are regularly exposed to high chloride solutions. Stress corrosion cracking is not a problem in this system because the temperatures are below 60°C (19). However, experience with corrosion under insulation demonstrates that stress corrosion cracking "of 300 series is likely over the range of 60°C (140°F) to 149°C (300°F) and is most severe at about 93°C (200°F)" (20). Corrosion under insulation is perhaps the industrial experience most relevant to the potential for stress corrosion cracking in the canister because the cracking process includes (21):

- a) trapping of water between the insulation and the pipe (moisture sealed within the canister during closure),
- b) condensation or wetting of the metal surface (temperatures below the dew point of the contained air),
- c) vaporization, if the metal surface is too hot (temperatures above the dew point of the contained air),
- d) penetration of the insulation system by the water vapor (diffusion of the air-moisture environment throughout the canister), and
- e) recondensing of the water vapor on the pipe surface (internal condensation on the cold portions of the canister wall).

Stress corrosion cracks can nucleate and propagate only while water is present on the metal surface (21). This requirement provides the technical basis for the upper temperature limit for stress corrosion cracking under insulation. Additionally, this experience, coupled with the necessity of an electrolyte to most corrosion processes, provides the basis to conclude that a potential for stress corrosion cracking at the canister interior will only exist when water is present (condensed) on the canister wall. Therefore, industrial experience provides the basis to conclude that, if free water is excluded from the canister and the dew point of the air sealed within the canister is below 50°C, stress corrosion cracking will neither initiate on, nor propagate from, the interior canister wall. However, laboratory studies have shown that some potential for cracking may exist.

The laboratory studies of low temperature stress corrosion cracking of Type 304 stainless steel (8, 10-15) demonstrate that such cracking is very difficult to obtain and requires a heavily sensitized microstructure. The DWPF canisters should not be sensitized because they are fabricated from Type 304L stainless steel and welded using Type 308L weld filler material. Additionally, stress corrosion cracking of, even heavily sensitized, laboratory samples of Type 304 stainless steel at temperatures below 50°C generally requires either

- a) load cycling, or
- b) continual strain.

These two processes are required to rupture the passive film on the metal surface and neither process should occur during storage of the DWPF canisters. This conclusion is supported by the observation that at least 2% strain is required to cause stress corrosion crack nucleation in constant extension rate tests on heavily sensitized smooth bar specimens (18). Additionally, available crack growth data suggest that even if cracks were nucleated (both a heavily sensitized microstructure and significant plastic deformation are required for nucleation) over 500 hours (20 days) of continuous exposure at temperatures below dew point would be required for the crack to penetrate the canister wall.

Stress corrosion cracking of austenitic stainless steel does not require the presence of chloride ions. However, chlorides do promote stress corrosion cracking and large quantities of chlorides may be absorbed if water condenses on the interior of the canister walls. This chloride rich water might promote transgranular stress corrosion cracking at elevated temperatures but there is little or no data to indicate that transgranular cracking will develop at temperatures below 40°C. This observation provides additional support for the conclusion that stress corrosion cracking will not develop inside a DWPF canisters if free water is excluded from the canister and the dew point of the air sealed within the canister is below approximately 40°C.

The 40°C dew point limit will not provide a significant margin for error against moisture condensation; thus, to assure a margin against any potential for stress corrosion cracking, a maximum dew point of 20°C is recommended. Maintaining the dew point of the air inside the canister at or below 20°C will minimize the amount of moisture present, restrict the temperature range for the presence of condensed water and should assure

that even the very unlikely sequence of events that produced a strain in a heavily sensitized microstructure while water was present on the sensitized surface would not cause stress corrosion crack initiation. Additionally, no data were found to support a case for stress corrosion cracking in Type 304 stainless steel components at temperatures below 20°C. These observations demonstrate that relaxing the dew point specification for the vapor inside a DWPF canister to 20°C should not provide conditions conducive to stress corrosion crack initiation and/or propagation from the canister interior.

Crevice Corrosion

Crevice corrosion is highly localized corrosion which is generally caused by the development of an aggressive environment inside a crevice. The crevice environment develops through a sequence of events (22) which cause:

- 1) oxygen depletion in the crevice environment,
- 2) a decrease in pH and increase in the concentration of aggressive ions (chlorides for example) inside the crevice,
- 3) breakdown of the passive (oxide) film when the pH reaches a certain level,
- 4) crevice corrosion of the crevice walls, and
- 5) repassivation.

Each step in the sequence requires time. Moisture condensation alone will not cause crevice corrosion to initiate inside the canister. The moisture must condense and absorb aggressive ions from the canister wall or the waste glass. The moisture pool must be sufficiently large to cover the crevice and "spill" onto the canister surface to create both a crevice and a bulk environment. The environment must then remain "over" the crevice for sufficient time for oxygen depletion and other changes in the in-crevice environment to lead to corrosion. The rate of change of the in-crevice environment and the response of the canister wall to those changes are temperature dependent.

The 9th Edition of the Metals Handbook (4) concludes that there is a minimum or critical temperature below which crevice corrosion does not

initiate. For any given material, this critical temperature is somewhat dependent on the geometry of the crevice and the nature of the environment. However, by assuming a very tight crevice and a chloride containing bulk environment, an "absolute" minimum for 18% Cr stainless steels can be calculated using the equation (23):

$$\text{Critical Crevice Temperature} = (-45 \pm 5) ^\circ\text{C} + 11(\%\text{Mo})$$

There is no minimum molybdenum content specified for the steel for the DWPF canisters; thus, the above equation predicts that moisture induced crevice corrosion of the canister wall could initiate at any temperature above 0°C. Furthermore, a predictive engineering guide to materials selection for resistance to crevice corrosion concluded that crevice corrosion is likely in pH 6-7 water containing approximately 300 ppm chloride and 300 ppm sulfate at 25 °C; thus, "one would not select the S30400 (Type 304 or Type 304L stainless steel) for a critical application" (24).

This evaluation of the literature thus suggests a real potential for crevice corrosion if moisture condenses on the canister walls. The condensed moisture could absorb chlorides, sulfates and other salts which had deposited on the canister walls during the glass pouring process and, over time, absorb similar chemical species from the glass. The resulting solution could lead to crevice corrosion if the temperature were above freezing and if the solution remained on the surface for an extended period of time. This scenario requires that:

- a) the temperature of some portion of the canister wall be below the dew point of the container environment,
- b) the region of moisture condensation contain a crevice,
- c) the condensed moisture dissolve sufficient chloride, sulfate, and/or other chemical species to cause crevice corrosion (the required amount will increase from 10's to 100's of ppm as the temperature decreases from 25 to 5 °C (24)),
- d) an oxygen depletion cell must form inside the crevice (22), and
- e) the pH inside the crevice decrease sufficiently to destroy the passive film on the canister surface (for a chloride-sulfate solution at 5° C the

pH must reduce to 1.5 while at 25°C a crevice pH of 1.65 will cause corrosion (24)).

Each of the last three sequential steps requires time for the transport of metallic and non-metallic ions throughout the crevice. This transport time represents an incubation period for the initiation of crevice corrosion. Experience has demonstrated that incubation times are long, requiring six months to a year of exposure for crevice attack to initiate at room temperature (25). The long incubation time should mitigate the potential for crevice corrosion inside the DWPF canister even if the dew point of the environment is as high as 20°C because the residence time of condensed moisture will be insufficient for crevice corrosion initiation.

The effects of repeated condensation-evaporation sequences could not be directly established, although, engineering judgment suggests that crevice corrosion may initiate given sufficient wet cycle time. However, the extent of attack should be minimal for two reasons:

- 1) There is a limited quantity of moisture inside the canister. Deposited salts and the surfaces of the waste glass will compete with any corrosion process for this moisture. As the moisture is used in the formation of hydrated salts, by adsorption on the glass surfaces and/or by conversion to metal oxides or hydroxides by corrosion, the dew point of the environment is decreased and the tendency for any form of corrosion activity will be reduced. It is considered likely that the dew point of the environment will be below 0°C before crevice corrosion has caused any measurable attack on the canister wall.
- 2) The amount of condensed moisture and thus the size of the wetted region is temperature dependent. If the dew point of the environment is 20°C, the area of coverage at 20° C will be zero. As the temperature is reduced, the area of the canister surface covered by moisture will increase but there will be a corresponding decrease in the mobility of the ions in the condensed layer. This decrease in mobility will increase the incubation time for crevice corrosion. If there were sufficient time for crevice attack to initiate during any given wet cycle, the resulting corrosion process would consume moisture and decrease the dew point of the canister environment. This decrease in dew point should decrease the potential for crevice corrosion during the next wet cycle because of the decreased temperature required to obtain a given moisture coverage. This process should become self limiting.

These observations and analyses demonstrate that if the vapor inside a DWPF canister has a 20°C dew point conditions may develop that are conducive to a minimal amount of crevice corrosion. However, the probability for the initiation of crevice corrosion is considered minimal and even if initiation were to occur, the time for (corrosion only occurs when the crevice is wetted), and temperature of, corrosion and the limited moisture supply should assure that the canister integrity is not compromised by crevice corrosion from the canister interior.

Pitting

Pitting of austenitic stainless steels is highly localized corrosive attack which initiates at a discontinuity in the passive film. The discontinuity may be caused by either mechanical or chemical processes (4). Non-metallic inclusions and other metallurgical inhomogenities at the canister wall surfaces will disrupt the passive film and may act as pit initiation sites (26). Numerous inclusions and other metallurgical disruptions will exist in each square centimeter of internal (and external) surface of the DWPF waste glass canisters. However, if pitting were to develop, the anticipated pit density would be approximately 10 pits per square meter of surface area. This approximation was based on the evaluation of engineering studies of pitted structures (26) and demonstrates that local breakdown of passivity is a necessary, but in no way a sufficient, condition for pitting (26). Most pit nucleation sites do not experience significant growth because the underlying metal repassivates almost immediately after the nucleation event. This repassivation mitigates both the corrosion process and pit growth. Pitting induced degradation may therefore be avoided by precluding or at least minimizing the conditions necessary for pit growth.

Austenitic stainless steels, as an alloy class, are the most susceptible group of alloys to pitting (4). However, for any specific grade of stainless steel there is a specific temperature or narrow range of temperatures above which pits may develop and below which pits are not formed (4). This critical pitting temperature is, for 300 series stainless steels, given by the equation (23):

$$\text{Critical Pitting Temperature} = [5 + 7(\% \text{Mo})] \text{ } ^\circ\text{C}.$$

The critical temperature for the DWPF canisters is therefore 5°C.

Relaxing the dew point specification to any temperature above 5°C may provide environmental conditions conducive to pit induced degradation.

However, the limited supply of moisture and the temperature dependence of the wetted area, as outlined in the discussion on crevice corrosion, should also limit the extent of degradation by pitting. Corrosion, then repassivation, at the numerous incipient pit sites should compete with the adsorbed salts, the dry glass surfaces, and crevices for the available moisture to lower the dew point. Additionally, even if environmental conditions were suitable for pitting, the canister geometry and orientation will minimize the probability of pitting.

Pits usually grow in the direction of gravity. "Most pits develop and grow downward from horizontal surfaces. Lesser numbers start on vertical surfaces and only rarely do pits grow upward from the bottom of horizontal surfaces" (27). This effect of gravity suggests that, other things being equal, the bottom would be the most likely place for a pit to penetrate a DWPF canister. The waste glass, even in a partially filled canister, will be on the canister bottom. The heat load from radioactive decay in this glass will also be at the canister bottom, thus it is highly unlikely that moisture condense in that region. The canister top, which is the most remote portion of the canister relative to the waste glass, should provide the coldest interior canister surface and thus be the preferential site for moisture condensation. Fortunately, this region, in an upright canister, has an orientation where "only rarely do pits grow" (26).

The evaluation of pitting in a DWPF canister demonstrates that relaxing the dew point specification to 20°C may provide an internal environment which is conducive to pitting. However, the limited supply of moisture, competition for that moisture and the canister shape and orientation should minimize the potential for significant pit growth. Additionally, even in the event of a pit, or several pits, penetrating the canister wall, the structural integrity of the canister should not be compromised.

Galvanic Corrosion

Galvanic corrosion may develop when two or more dissimilar metals are connected in a corrosive medium. All wrought portions of the DWPF canister are Type 304 stainless steels and the weld filler metal, Type 308 stainless steel, is matched for both chemical and mechanical compatibility. These alloy pairs have been used for decades, without inducing galvanic corrosion, throughout the chemical process and nuclear industries. Additionally, the galvanic series for commercial metals and alloys in sea water even groups Types 304 and 316 stainless steels into a single unit (28) even though the Mo addition to Type 316 is known to significantly

reduce (relative to Type 304) the susceptibility of the steel to several of the forms of corrosion. The galvanic series does demonstrate that galvanic corrosion may develop in Type 304 stainless steel if an active section of steel is connected to a passive section. Localized breakdown of the passive film on the DWPF canister wall may cause such coupling. In fact, this type of coupling plays a major, controlling role in the processes of intergranular attack, stress corrosion cracking, crevice corrosion and pitting and has been discussed in the preceding sections of this memorandum. However, these phenomena are not termed galvanic corrosion and their existence would not demonstrate the presence of that category of corrosion.

Classical galvanic corrosion will not develop at the interior of a DWPF canister because the material selection process has assured against the coupling of dissimilar alloys. Therefore, relaxing the dew point specification to 20°C will not impact the susceptibility of the canister to this form of corrosion.

Uniform Corrosion

Uniform or general corrosion is characterized by chemical or electrochemical reactions developing relatively uniformly over the exposed surfaces. Although this form of corrosion is common and causes the greatest destruction of metal on a tonnage basis, general corrosion can be prevented by proper materials selection (27). The materials of construction for the DWPF canisters were selected to preclude uniform corrosion in the anticipated exposure environments. The success of this selection has as a foundation the continued use of Type 304 stainless steel piping and vessels to contain and transport fluids. Frequently these fluids are significantly more aggressive than any anticipated storage environment inside (or outside) the canister. Additionally, as stated previously, the limited quantity of moisture available will severely limit the amount of corrosion that could develop. Uniform corrosion of the interior surface of a filled, or partially filled, and sealed canister will not cause significant degradation of the canister regardless of the dew point specification for the vapor inside the canister.

Evaluation and analysis thus demonstrate that relaxing the dew point specification from 0 to 20 °C will have no significant impact the tendency for the interior of the DWPF canister to be degraded by uniform corrosion. Furthermore, uniform corrosion to remove the limited moisture sealed in the canister would actually be beneficial because such corrosion would

reduce the dew point and thereby mitigate the potential for pitting, crevice corrosion and stress corrosion cracking.

Conclusions

The data and analysis presented in this report provide the technical basis to conclude that relaxing the dew point specification for the environment inside a filled, or partially filled, DWPF canister from 0° to 20°C will not provide an internal environment which will cause sufficient corrosion induced degradation to compromise the integrity of the canisters. The potential for limited attack by crevice corrosion, stress corrosion cracking and pitting will exist; however, even if such process developed, the limited quantity of moisture available and other mitigation processes would assure that the structural integrity of the canister was not compromised.

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