INL/RPT-22-69148-Revision-0

DOESC Closure Leak Test Assembly

September 2022

Changing the World's Energy Future

Devin D Imholte, Daniel Albert Thomas, Nathan Levine Hofmeister, Samuel Jackson Trost

Idaho National Laboratory

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CONTENTS

FIGURES

TABLES

1. BACKGROUND

The Department of Energy (DOE) Spent Nuclear Fuel (SNF) Packaging Demonstration ("Packaging Demonstration") will demonstrate loading of spent nuclear fuel (SNF) into DOE Standard Canisters (DOESCs) for interim storage at the Idaho Nuclear Technology and Engineering Center (INTEC). The Packaging Demonstration is a collaborative effort between the Idaho Cleanup Project (ICP), Idaho National Laboratory (INL) and DOE. The Packaging Demonstration will ultimately develop and demonstrate the designs, technology, processes, and regulatory framework for packaging DOE SNF for road-ready dry storage (RRDS); and establish the processes that will be used in a future storage facility.

2. OBJECTIVES AND SCOPE

The DOESC is a hermetically sealed canister intended for interim storage, transportation and disposal of DOE-managed SNF.[1,2] The DOESC has two possible diameters (Ø 18" [~460 mm] or Ø 24" [~600 mm]) and two possible lengths (10 ft [~3.0 m] or 15 ft [~4.6 m]). The Packaging Demonstration is using the Ø 18" and 15 ft. long (i.e., "18 × 15") version.[3] There are two closure welds that are performed after SNF is loaded into each DOESC. All DOESC welds provide containment for the SNF stored within. This containment is critical for DOE-managed SNF that is failed and/or damaged, which requires an additional level of containment for interim storage. In accordance with the Code of Record for the DOESC, these closure welds will be leak tested to verify containment after SNF loading.[4] The DOESC is shown in Figure 1. These closure welds are shown in Figure 2.

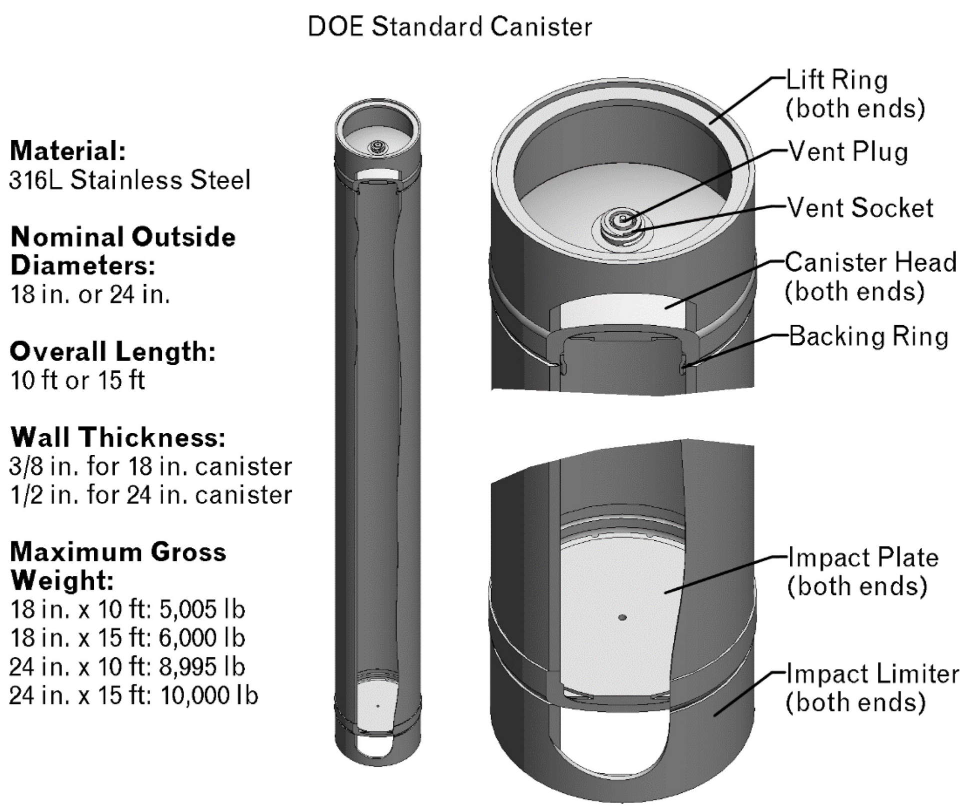

Figure 1: Department of Energy Standard Canister (DOESC)

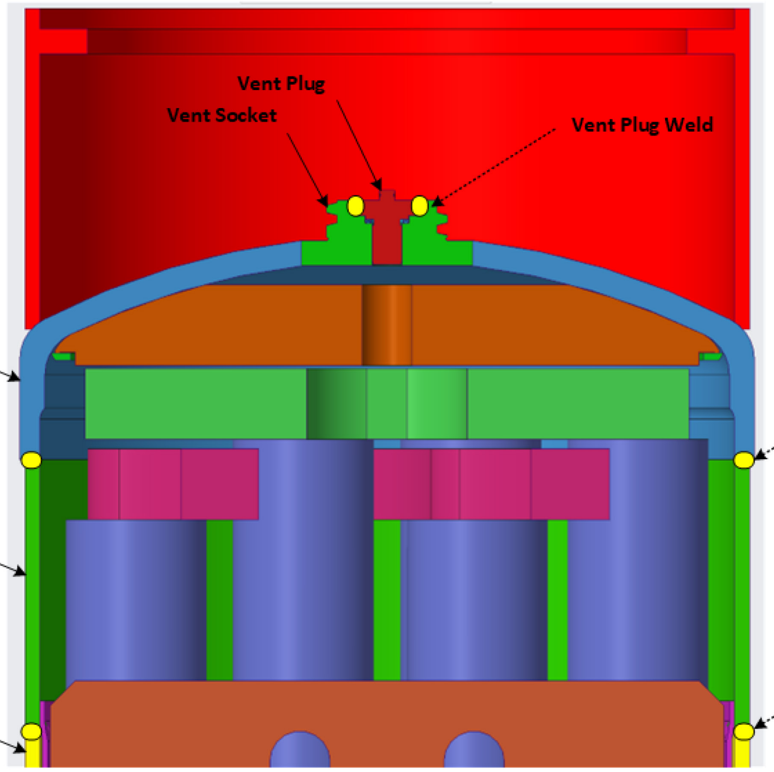

Figure 2: DOESC Closure Welds and Components (diameter mismatch between Top Head and Body Extension is prior to machining)

This Conceptual Design Report (CDR) presents the design for the DOESC Closure Leak Test Assembly that will support the leak test of the closure welds. The primary objectives of this CDR are to (i) demonstrate how the design meets program requirements[5] and (ii) summarize further engineering work associated with its development and demonstration. This CDR is part of a Preliminary Design Report package deliverable required for FY22 Packaging Demonstration activities.

This CDR will not solely perform engineering verification of the DOESC Closure Leak Test Assembly. Engineering verification will be performed per LWP-10106[6], LWP-10000 (KB0015843)[7], or approved equivalent procedures.

The DOESC Closure Leak Test Assembly detailed herein is limited to the hardware that directly interfaces with the DOESC. As a result, this CDR will not address design(s) associated with the DOESC or any of the downstream components (e.g., plumbing connections, vacuum pumps, leak detection systems, etc.) that will make up the entire DOESC Closure Leak Test System. However, it will discuss the function of these components, and how they relate to certain features of the DOESC Closure Leak Test Assembly. These downstream components are covered under INTEC Engineering scope per the Packaging Demonstration Interface Agreement.[8]

3. BASIS OF DESIGN

3.1 Key Performance Parameters

There are several requirements and performance parameters associated with the DOESC Closure Leak Test Assembly.[5] But the primary function of the Assembly is to remotely isolate the DOESC closure welds for leak testing against the acceptance criteria and in accordance with established procedures.

3.2 Functional and Operational Requirements

See FOR-760 for a comprehensive list of functional and operational requirements (F&ORs) associated with the DOESC Closure Leak Test Assembly.

3.3 Considerations and Alternatives

3.3.1 Considered Assembly Locations

There are several process considerations/options still under consideration by INL and ICP associated with the Packaging Demonstration that will significantly affect operation of the DOESC Closure Leak Test Assembly. These considerations are not discussed herein because they are subject to ongoing discussions between INL, ICP and DOE. The final engineering deliverables developed for the DOESC Closure Leak Test Assembly will reflect the final chosen considerations/options. Regardless, the considerations/options primarily affect the DOESC Closure Leak Test Assembly by where the leak test occurs.

The SNF that will be loaded into the DOESC will include Peach Bottom Unit 1 Core 2 (PB2) and/or Fort Saint Vrain (FSV).[3] Both of these are stored within the Irradiated Fuel Storage Facility (IFSF, CPP-603). Constructed in the 1970s, IFSF was originally intended for receipt and dry storage of graphite fuel elements from FSV, but has been used for receipt and storage for a wide variety of SNF. The DOESC will therefore be loaded, sealed and tested within CPP-603 prior to further loading operations (e.g., over-canister and storage overpack loading). Currently, there are two proposed locations for performance of the leak test: the CPP-603 Fuel Handling Cave (FHC) and the CPP-603 Permanent Containment Structure (PCS). These locations, and their impact on DOESC Closure Leak Test Assembly function, are briefly summarized below.

3.3.1.1 Fuel Handling Cave

The FHC is a contamination and radiological area. SNF is routinely handled in the FHC without shielding, particularly in the region adjacent to the telemanipulators. This is the area where the leak test could occur in the FHC (Figure 3). Manned entries into the FHC are possible, but infrequent. Due to the radiological environment, remote operation of the DOESC Closure Leak Test Assembly is preferred. While there are two separate cranes (CRN-GSF-101 [15-ton] and CRN-GSF-401 [2-ton]) in the FHC for hoisting and rigging, there are two methods for finer remote operation in the FHC: the telemanipulators and the PaR Systems © arm (connected to CRN-GSF-401). In the FHC, it is therefore important that the DOESC Closure Leak Test Assembly design enables remote handling, installation and operation.

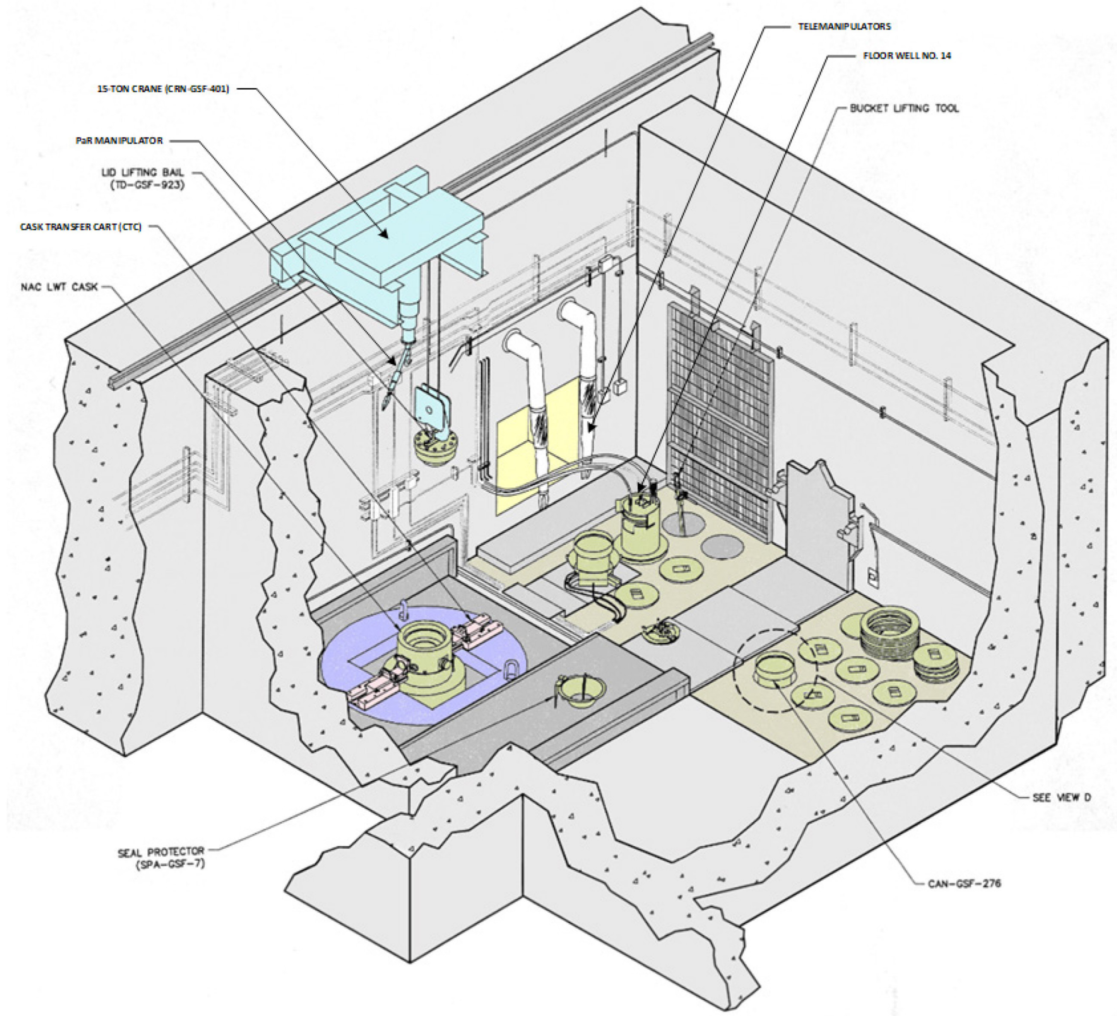

Figure 3: Fuel Handling Cave (FHC)

3.3.1.2 Permanent Containment Structure

The PCS provides contamination control during cask preparation activities, such as venting, decontamination, and preparation for unloading or shipping (Figure 4). It is located adjacent to the FHC, and physically connected to the FHC by the Cask Transfer Pit. Manned entries into the PCS are more common given the often lower radiological and contamination hazards. At least two cranes are available for overhead hoisting and rigging (CRN-SF-003 and CRN-SF-004). Both CRN-SF-003 and CRN-SF-004 have a 75-ton capacity.[9] Although it is proposed that telemanipulators may be installed to support the Packaging Demonstration, there are no telemanipulators currently installed to support PCS operations.

Figure 4: Permanent Containment Structure (PCS) - Hot cell window facing the FHC

Given the possibility of leak testing occurring in the FHC and/or PCS, the DOESC Closure Leak Test Assembly design will accommodate remote and manual operation and installation.

3.3.1 Acceptance Criteria (Leak Rate)

The acceptable leak rate has a significant impact on the considered leak test technique (Section 3.3.2). In addition, different regulations (e.g., 10 CFR 71, 10 CFR 72, 10 CFR 63) drive what this acceptance leak rate should be. ANSI N14.5 is the recognized standard for leak testing packages containing SNF and high level waste.[10,11,12] This standard establishes procedures for determining the maximum allowable leak rate based on the radioactive contents, which is required for NRC-licensed packages, unless it can be demonstrated that a package will remain "leaktight" under all normal, off-normal and accident conditions.

In commercial practice, ANSI N14.5 is typically applied to leak testing the over-canisters that directly contain the reactor fuel assemblies. However, the DOESC provides a confinement barrier particularly for damaged DOE SNF per 10 CFR 72.122. Given the large variety of DOE SNF, it is advantageous to set the acceptance criteria, or maximum allowable leak rate, at this "leaktight" threshold, as defined in ANSI N14.5 and FOR-760.[5,10] This would prevent repetitive analysis for the variety of SNF packaging configurations, while maintaining regulatory compliance.

3.3.2 Considered Leak Test Techniques

The technique for measuring the leak rate determines how the leak pathways (i.e., welds) are isolated. TPR-13438[13], INL's official leak testing procedure, lists different leak testing techniques and associated procedures. These techniques, and their suitability for meeting the F&ORs are described below:

3.3.2.1 Bubble Leak Test (Direct-Pressure & Vacuum)

Bubble leak tests require the use of a liquid test media for visual observation of bubbles flowing from, or into, the test volume. This technique is generally limited to leak rates ≥1E-05 std-cc/sec.[10,14] Furthermore, use of a liquid test media in a moderator exclusion environment, such as CPP-603's FHC where the test could take place, is not viable. Given the acceptance criteria defined by FOR-760 (i.e., 1E-07 std-cc/sec), this technique is ultimately unsuitable for the DOE Closure Leak Test Assembly.

3.3.2.2 Halogen Diode Technique

The halogen diode detector probe method requires use of a halogen tracer gas for measuring leaks ≥1E-06 std-cc/sec.[13] Helium is the tracer gas for the DOESC to comply with the DOESC Code of Record[4], inhibit SNF and internal support structure corrosion, and facilitate heat transfer from the SNF to the surrounding containment vessels (i.e., over-canister and overpack). Similar to the bubble leak test method, the halogen diode method's sensitivity is ultimately unsuitable for the DOESC Closure Leak Test Assembly.

3.3.2.3 Detector Probe Technique

The detector probe technique has a relatively high test sensitivity for measuring tracer gas flow through leak pathways. Although INL procedures have helium leak test procedures qualified up to 1E-06 std-cc/sec[13], this technique is capable of measuring tracer gas leak rates ≥1E-08 std-cc/sec.[10,15] However, this technique's sensitivity is dependent on the system setup, which includes the length of tubing connecting the mass spectrometer to the probe. For hot cell assembly, such as in the FHC, relatively long tubing (>20 ft.) would be required, along with remote handling of the probe around the DOESC closure welds. The primary disadvantage presented by this is that the long tubing, combined with no containment of the leaking helium, could underestimate (i.e., false negative) the leak rate. The only way to reduce this tubing length is to collocate the helium mass spectrometer with the DOESC, which is not feasible due to the sensitive nature of the electronics to gamma radiation, contamination, and overall detector performance. It is also worth noting that current INL detector probe procedures are qualified for tubing up to 20 ft. in length, meaning a new procedure would need to be written and qualified for the longer tubing required by the FHC. If the DOESC Closure Leak Test Assembly were to use this technique, it would require significant operational effort and facility modifications to meet the test requirements, but would still present significant risk.

3.3.2.4 Tracer Probe Technique

The tracer probe technique supplies the tracer gas from the high pressure side of the test volume adjacent to the potential leak pathway.[13] The evacuated test volume is connected to a mass spectrometer, which measures leakage of the tracer gas. This technique requires plumbing into the test volume. The DOESC will be a sealed volume during testing without any plumbing penetrations. Therefore, this technique is not feasible for consideration for the DOESC Closure Leak Test Assembly.

3.3.2.5 Hood Technique ("Bell Jar" Technique)

The hood technique uses an enclosure (i.e., "bell jar") that contains the test volume and its potential leak pathways. The hood is typically filled with the tracer gas, while the test volume is evacuated and plumbed to a mass spectrometer.[10,16] The bell jar usually contains the entire test volume, but this is not necessarily required if the potential leak pathways can be adequately isolated from the atmosphere's background concentrations of tracer gas. With this technique, total tracer gas flow is measured from all potential leak pathways within the bell jar. A variation of this technique has tracer gas within the sealed test volume, while the bell jar is evacuated and plumbed to a mass spectrometer (i.e., "evacuated envelope" or "inside-out mode"), as shown in Figure 5. [10,17] Other than placing the bell jar onto the test volume (i.e., DOESC) and making plumbing connections to the bell jar, no remote handling is required. No probe is required, and operation of the mass spectrometer, pumps and other system hardware can be performed upstream by hand. The test sensitivity for both techniques is very high at up to 1E-08 std-cc/sec. Due to total containment and measurement of all tracer gas within the enclosure, this method is less affected by the long tubing than the Detector Probe technique (Section 3.3.2.3).

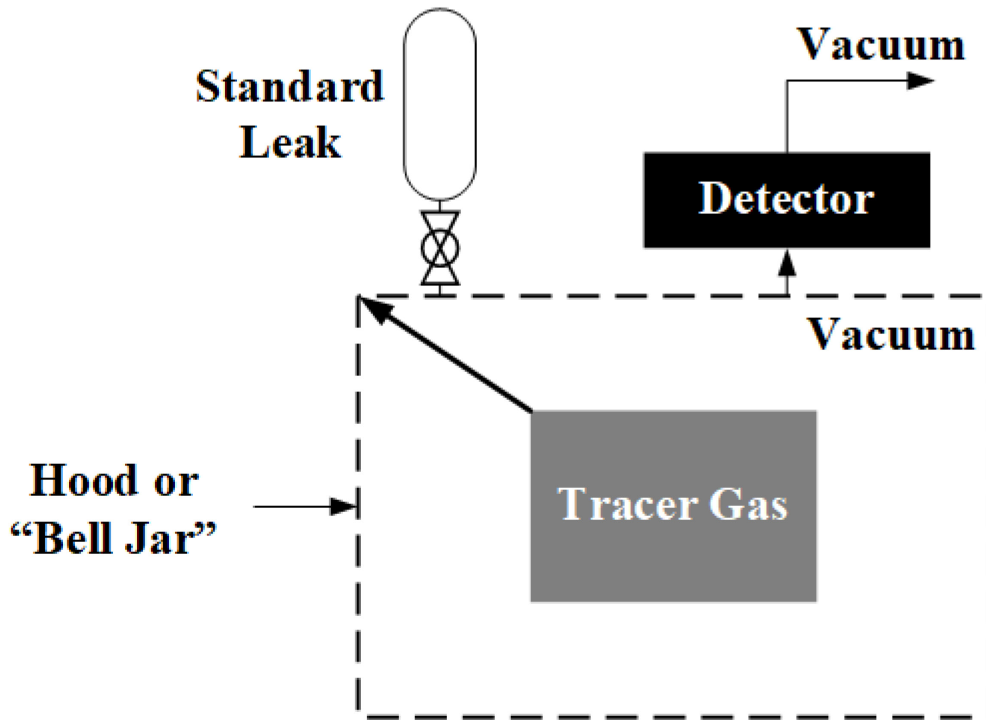

Figure 5: Inside-Out/Evacuated Envelope Leak Testing Technique (adapted from ANSI N14.5[10])

3.3.2.6 Bombing Technique

The bombing technique requires placing the test volume within a pressurized enclosure (i.e., "bombing chamber") to force tracer gas into the test volume through potential leak pathways.[10,13] Then, the test volume is transferred to a vacuum chamber, which is plumbed to a mass spectrometer to detect any helium within the test volume. Due to the presence of tracer gas (i.e., helium) within the DOESC after closure, this test is not necessary for a helium leak test of the DOESC Closure Leak Test Assembly. Even if an alternative tracer gas (e.g., nitrogen, argon) and mass spectrometer were used, this would require fabrication of a large bombing chamber that would at least have to contain the DOESC closure welds. This approach would also require a separate large vacuum chamber for leak detection. Although capable of test sensitivities of 1E-09 std-cc/sec, this approach would require significant engineering, operational and facility effort if used with an alternative tracer gas.

3.3.2.1 Pressure Change/Decay Technique

The pressure change technique does not involve the use of mass spectrometers. It relies on the high resolution measurement of pressure drop of the test volume over time.[10,18] By definition, it requires a plumbing penetration into the test volume. As already mentioned above with the Tracer Probe Technique

(Section 3.3.2.4), this is not feasible for the DOESC. Therefore, this technique is not feasible for the DOESC Closure Leak Test Assembly.

3.4 Environmental Considerations

As detailed in FOR-760, Environmental Checklist ICP-20-018, "INL-DOE SNF Packaging Demonstration Project" covers engineering activities associated with the Packaging demonstration, including the DOESC Closure Leak Test Assembly.[5]

3.5 Safety Considerations

As detailed in FOR-760, the DOESC Closure Leak Test Assembly will be operated in accordance with SAR-100.[5,19]

3.6 Quality Considerations

As detailed in FOR-760, the DOESC Closure Leak Test Assembly shall comply with the INL and ICP quality assurance programs (QAPs).[5]

3.6.1 Quality Level

Both INL and ICP QAPs require assignment of quality levels to structures, systems and components (SSCs) per LWP-13014 and MCP-540, respectively.[20,21] While both INL and ICP currently use four separate quality levels (i.e., QL-1, QL-2, QL-3 and QL-4), their definitions slightly differ. The quality level determinations for the DOESC Closure Leak Test Assembly have not been documented, but the reconciliation of the INL and ICP differences and rationale for quality level selection will be briefly discussed.

The DOESC Closure Leak Test Assembly is not credited as a safety-significant SSC within the safety bases for any of the nuclear facilities where it is intended for use: CPP-603 or CPP-2707.[22,23] It is also not designated as "important to safety" by the U.S. Nuclear Regulatory Commission (NRC), which is relevant for shipment requirements within the scope of the Packaging Demonstration.[24] Therefore, by definition, the DOESC Closure Leak Test Assembly is precluded from classification as a QL-1 (i.e., "Nuclear Use") item.

As has been the case historically, the DOESC could be considered the waste form at a SNF mined geological repository, which is handled and packaged separately from its over-canister.[25] The requirement of inert gas backfill and leak testing has been previously required of SNF canisters, including the DOESC.[26] The DOESC Closure Leak Test Assembly is therefore an SSC that may affect SNF canisterization through acceptance at a geological repository. This meets the definition of an item performing a waste-acceptance-impacting function.[27] MCP-540 (ICP) defines QL-2 items as those performing such a function.[21] However, LWP-13014 (INL) only utilizes QL-2 for items ultimately performing a nuclear safety function. The only applicable LWP-13014 quality level for the DOESC Closure Leak Test Assembly is QL-3 (i.e., "Commercial Use"). To reconcile the differences between these two quality level hierarchies, two separate QLDs will be documented for the DOESC Closure Leak Test Assembly: QL-2 per MCP-540 and QL-3 per LWP-13014.

4. DESIGN DESCRIPTION

4.1 Facility

The DOESC Closure Leak Test Assembly is designed for use in the CPP-603 FHC or PCS, as discussed above (Section 3.3.1). A detailed description of the CPP-603 and CPP-2707 facilities can be found elsewhere. [22,23]

4.2 Mechanical Design

Based on the potential for fewer facility modifications, minimal procedural complexity and reliability associated with the "Bell Jar"/Evacuated Envelope technique described in Section 3.3.2.5, the DOESC Closure Leak Test Assembly design will accommodate this procedure. Herein, the DOESC Closure Leak Test Assembly will be referred to as the "Bell Jar". The Bell Jar design will likewise comply with the requirements defined in FOR-760, including assembly location(s) and acceptance criteria.[5]

4.2.1 General Characteristics

Table 1: General Design Characteristics of DOESC Closure Leak Test Assembly (Bell Jar)

Attribute	Value
Weight	382 lb. (173 kg)
Outside Diameter (excluding duct clamp)	21.1 in. (53.6 cm)
Inside Diameter (excluding gaskets)	19 in. (48.3 cm)
Height (Bell Jar Enclosure only)	23 in. (58.4 cm)
Total Height (including lifting bale)	36 in. (91.4 cm)

4.2.2 Bell Jar Enclosure

The Bell Jar Enclosure is composed of a ~20 in. section of Schedule 40 Ø20" 316SST pipe. 316SST pipe is chosen for ease of availability, corrosion resistance, and weldability. Lighter alloys (e.g., 6061) were considered, but these did not reduce the weight to a level that made personnel lifting and handling feasible.[28] Given the preference for remote assembly where crane access would be provided, assembly weight was not optimized.

The Bell Jar pipe section is closed off with a welded flat head at the top, which is also made of 316 SST (Figure 6). The underside of the flat head has a series of chamfered boss features for alignment with the Lifting Ring (INL Dwg. 1004062, Item 6). Table 2 presents relevant drawings to the overall design of the DOESC Closure Leak Test Assembly. The underside of the flat head rests on the Lifting Ring, which is chosen as the mating surface instead of the Impact Limiter (INL Dwg. 1004061, Item 5) because it will be more protected from damage up to the point of closure. The flat head has grooves cut into its mating surface with the Lifting Ring to allow uninhibited tracer gas flow from the annulus between the DOESC and the inside surface of the Bell Jar Enclosure to the mass spectrometer leak detector.

Table 2: Relevant Drawings

Drawing No. (Owner)	Description	Revision
1004060 (INL)	18 INCH OD LONG SNF CANISTER ASSEMBLY	000A
1004063 (INL)	18 INCH OD LONG SNG CANISTER HEAD DETAIL	000A
448561 (ICP)	FUEL CONDITIONING STATION P&ID	14
447999 (ICP)	FUEL CANNING STATION MECHANICAL INSTALLATION	008
449004 (ICP)	FUEL CANNING STATION VACUUM LID ASSEMBLY	00B

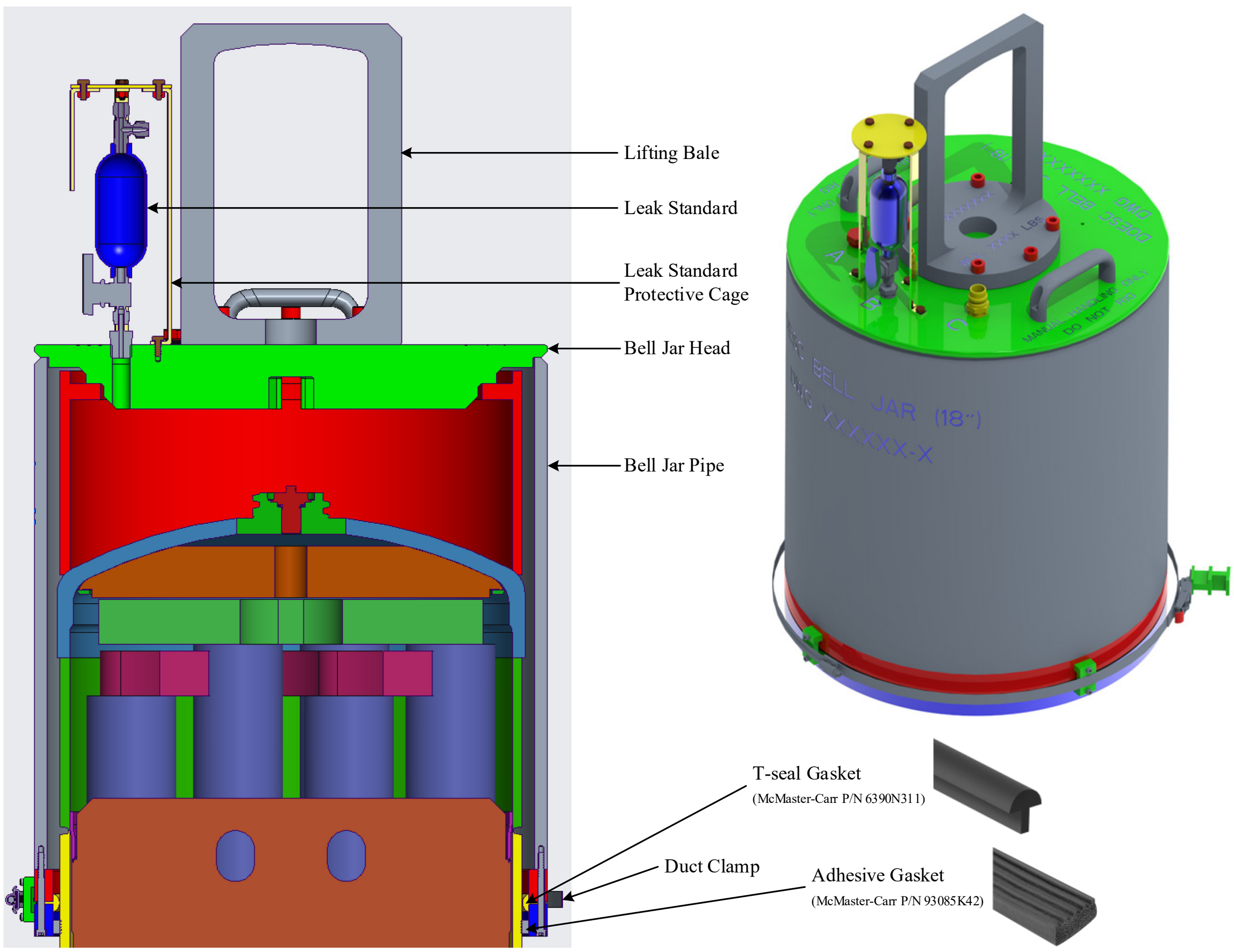

Figure 6: DOESC Closure Leak Test Assembly (Bell Jar).

4.2.3 Mechanical Sealing and Interface with the DOESC

The Bell Jar Enclosure to isolates the two closure welds from the surrounding atmosphere. It is sized to perform leak tests with and without the Canister Body Extension (INL Dwg. 1004062, Item 4), which is only used for specific SNF loading fuel loading configurations being considered for the Packaging Demonstration (Figure 2).[29] Per INL Dwgs. 1004060 and 1004063, no more than two closure welds will be performed, and subsequently leak tested.

The Bell Jar seals against the outside diameter of the DOESC with an EPDM rubber t-seal gasket (Figure 6). Additional space is provided above and below the t-seal to apply other adhesive type gaskets. There is nominally a slight radial gap between the t-seal and the outside diameter of the DOESC. A quick-release duct clamp is fitted to the outside diameter of the Bell Jar to tighten the outside diameter to help squeeze the gasket around the outside diameter of the DOESC. The duct clamp is modified by (i) permanently affixing the latch to the opposite end of the clamp to prevent unwinding of the duct clamp during operation and (ii) placement of a telemanipulator handle for easier remote actuation in the FHC or PCS (Figure 7).

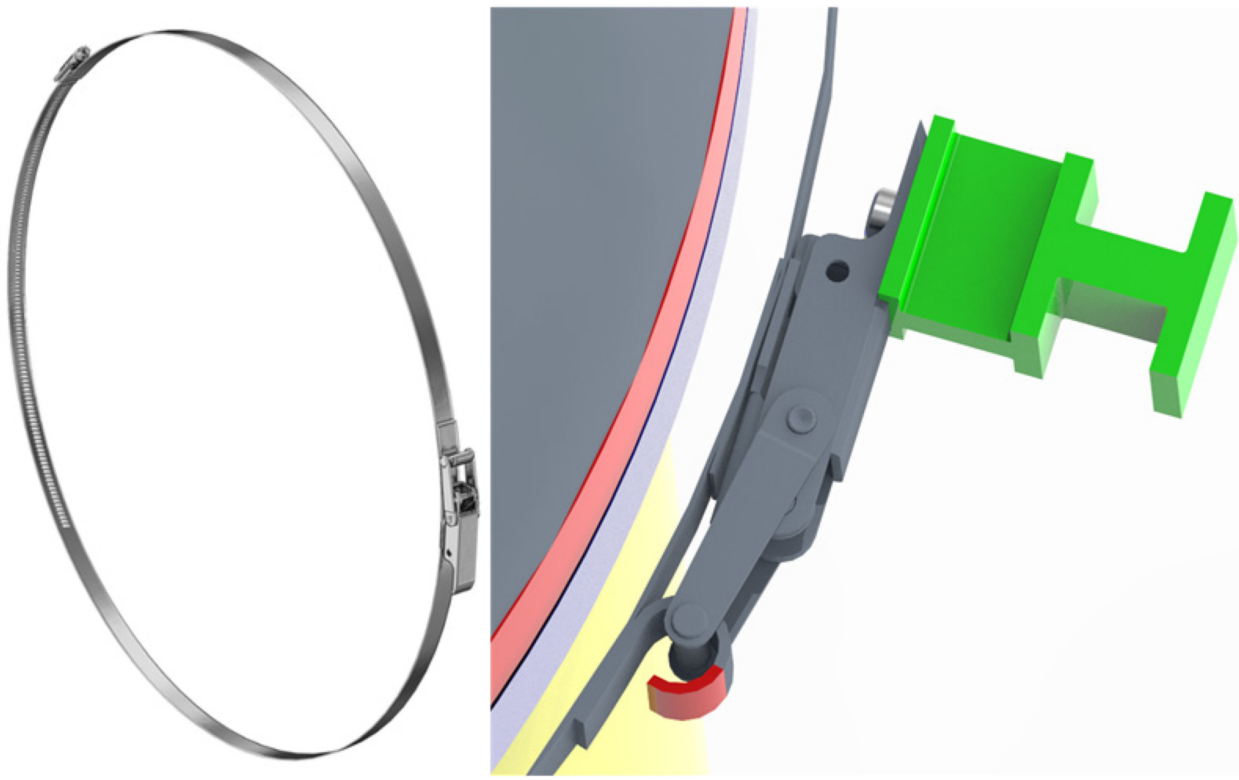

Figure 7: Duct Clamp - Left: unmodified duct clamp (McMaster-Carr P/N 5215K33); Right: Modified latch and telemanipulator handle

4.2.3.1 Bench Test for Vacuum and Leak Response Characterization

A bench test is planned in support of the DOESC Closure Leak Test Assembly to (i) demonstrate the vacuum within the Bell Jar meets the pressure differential requirements and (ii) characterize the response time within the Bell Jar using a simulated helium leak device (Figure 8). The test will include a 1:3 scale version of the Bell Jar with INL-qualified leak testing personnel.

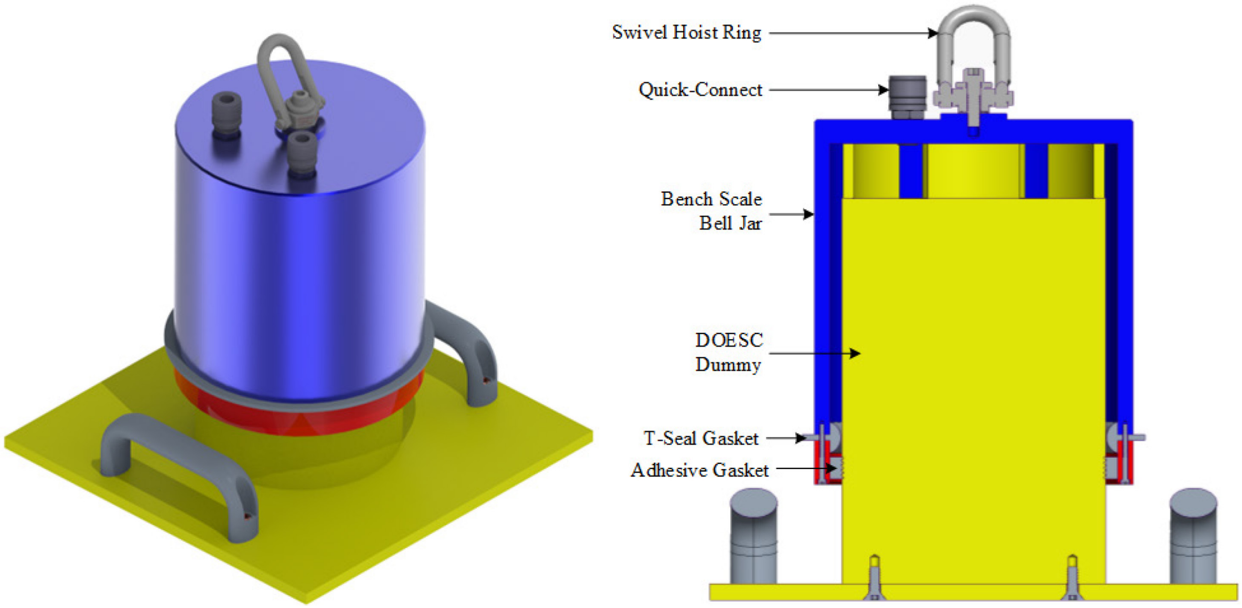

Figure 8: Bell Jar Bench Test Assembly (1:3 scale)

4.2.3.2 Alternative Inflatable Seal Concept

Pending the outcome of the Bell Jar Bench Test (Section 4.2.3.1), an inflatable seal may be a more reliable method for sealing onto the DOESC instead of standard rubber gaskets. Inflatable seals are customizable for inward radial expansion, which are ideal for this application and would require minimal modification to the current Bell Jar design to accommodate (Figure 9). EPDM rubber is a standard material for such inflatable seals, which has superior gamma radiation resistance (>10^9 rad).[30,31] Furthermore, attachment of standard plumbing connections is possible with these inflatable seals. However, this concept would require additional operational steps for pressurizing the seal, including the non-trivial step of venting suspect gas from the inflatable seal. Therefore, it will remain an alternative to the baseline concept with the t-seal and adhesive gaskets.

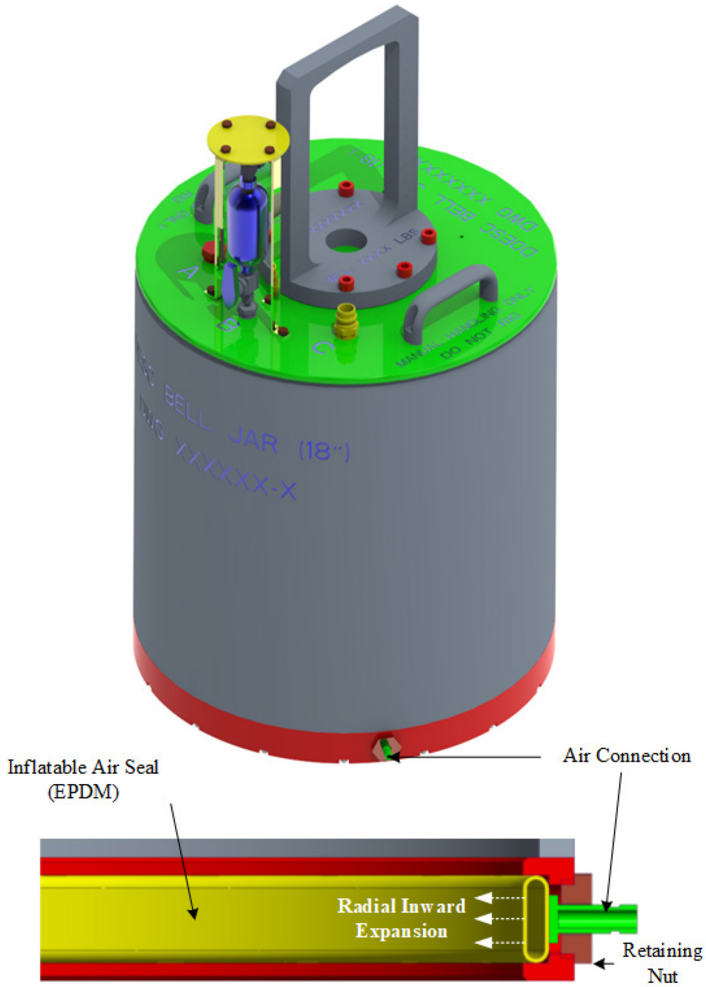

Figure 9: Bell Jar Conceptual Design with Inflatable Seal

4.2.4 Plumbing Connections

As discussed in Section 3.3.2.5, the Bell Jar/Evacuated Envelope technique requires the mass spectrometer leak detector to be connected to the evacuated Bell Jar Enclosure surrounding the DOESC closure welds. The flat head on top of the Bell Jar Enclosure has three penetrations for this purpose (Shown as “A”, “B” and “C” in Figure 6). Two of these holes are 3/4-14 FNPT and one is 1/2-14 FNPT.

The two larger penetrations are meant for a specific type of full-flow, quick-connect Swagelok ® stem fitting that is also used by the Fuel Canning Station (ICP Dwg. 449004). This fitting will allow for air to pass through it will lowering it onto the DOESC lid. Furthermore, this will permit use of the same pneumatic line and fitting that are currently used for operating the Fuel Canning Station (HA-NN-155944, ICP Dwg. 448561 and Dwg. 447999), although additional verification is needed to ensure viability of this approach (Section 4.3). Only one of these two penetrations are needed for normal operation. The unused one is plugged (Connector “A” in Figure 6).

The smaller 1/2-14 FNPT penetration is sized for common calibrated leak standards used by INL leak testing personnel. The calibrated leak standard is required to calibrate the mass spectrometer to the background concentration of helium gas along with the response time. A quarter-turn ball valve is placed between the calibrated leak standard and the Bell Jar Enclosure to isolate the standard when the mass spectrometer is measuring the leak rate from the closure welds. A standard handle can be swapped out for a custom and telemanipulator-compatible solution.

4.2.5 Notable Features

4.2.5.1 Lifting Bale

For compatibility with the cranes in the FHC and PCS areas, a lifting bale is fastened to the top head of the Bell Jar Enclosure (Figure 10). This lifting bale matches the lifting bale used by the Remote Closure System Platforms, which perform the welding, inspection and repair of the DOESC closure welds.

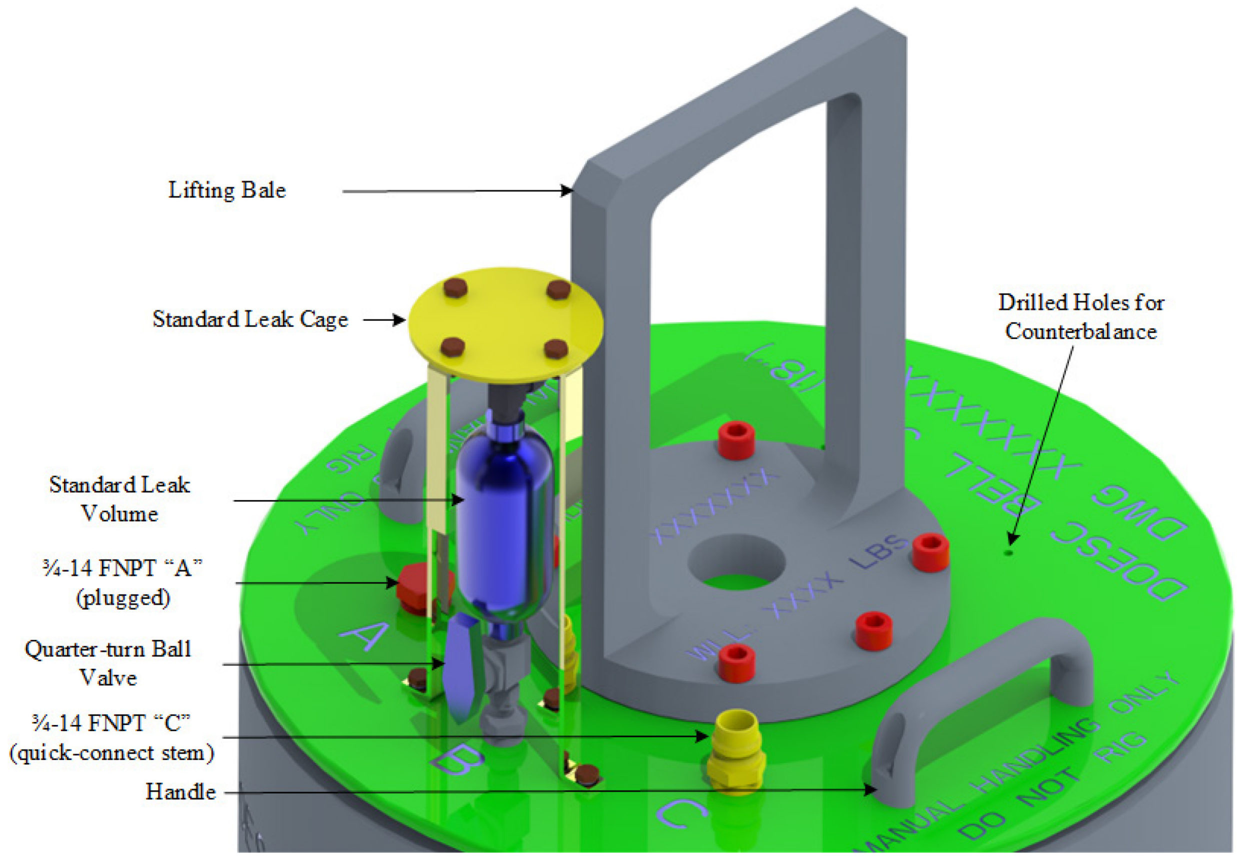

Figure 10: Features of Bell Jar Enclosure Top Head

4.2.5.2 Handles

There are two handles fastened for fine adjustment by personnel or telemanipulators during installation or removal of the Bell Jar Enclosure (Figure 10). If not required or desired for PCS or FHC operation, these may be removed and the holes plugged to minimize traps for contamination. These are not for rigging, and are labeled as such directly on the top head.

4.2.5.3 Standard Leak Cage

To protect the Standard Leak from damage during hoist and rigging and remote operation of the ball valve, a protective cage is fastened to the top head that surrounds most of the Standard Leak. The region surrounding the ball valve handle is open for access during performance of the leak test. This design closely resembles that of the Fuel Canning Station operated in the FHC, which has protective cage that protects its pressure transducer (ICP Dwg. 449004).

4.3 Key Technical Risks

4.3.1 Mechanical Seal

The Bell Jar's ability to isolate the welds from the surrounding atmosphere is a critical function. The t-seal, adhesive gaskets and duct clamp are currently the items that perform this function. Bench tests and scale tests need to be performed to qualify this design for reliable use. These tests may determine that the existing EPDM gasket is inadequate for performing this seal. If so, changing to a different gasket profile or narrowing the radial gap may be required. If the tests determine that this seal is fundamentally inadequate, then other techniques, namely the inflatable seal concept, will be pursued (Section 4.2.3.2).

4.3.2 FHC Plumbing

Although the quick-connect fittings are designed for compatibility and minimal modification to FHC facility features, the existing pipe configuration needs to be characterized in detail. Currently, the preferred location for leak test equipment is the Cask Receiving Area (CRA), adjacent to the PCS. The only existing plumbing from this area to the FHC is Ø1/2" tubing (HA-NN-155944, ICP Dwg. 448561) with a series of actuators, pressure sensors, regulators, isolation valves and other components downstream from the tube's opening (IEC Dwg. 448561). This tube opening is presumably where the mass spectrometer leak detector would connect. All of the components downstream from the tube opening, including the in-line filter (F-GSF-5, ICP Dwg. 448561), need to be assessed for vacuum service because this line was originally designed for pressurized argon.

If it is determined that this existing plumbing line cannot be used as-is for whatever reason, a T-fitting could be installed along the length of HA-NN-155944 with isolation valves, as required. If the HA-NN-155944 cannot be used or modified for whatever reason, there are two alternative Ø1/2" tubing connections from the into the FHC and are adjacent to HA-NN-155944. In addition to filters, regulators and other devices that would be needed in the CRA, flexible tubing would be required inside the FHC To go from the Ø1/2" tubing to the Bell Jar quick-connect.

If neither of these Ø1/2" tubing can be used for whatever reason, then the Ø1" vacuum line for the Fuel Conditioning Station (HA-AR-155945, ICP Dwg. 448561) could be assessed for its suitability with the Bell Jar/Evacuated Enclosure leak technique. This vacuum line is significantly longer than the Ø1/2" tubing mentioned above (> 100 ft). The long length of tubing, while not currently a concern, could introduce other issues and would require more rigorous qualification of the procedure.

5. REFERENCES

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