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18. AV Reed <i>AV Reed</i> Signature of EDT Originator		19. <i>JR Frederickson</i> JR Frederickson Authorized Representative for Receiving Organization		20. <i>JR Frederickson</i> JR Frederickson Design Authority/ Cognizant Manager		21. DOE APPROVAL (if required) Ctrl. No. ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments	
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Evaluation of Canister Storage Building Cask Receipt Pressure

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Abstract: The basis is described that establishes a pressure criterion for casks received at the canister storage building.

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Evaluation of Canister Storage Building Cask Receipt Pressure

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Evaluation of Canister Storage Building Cask Receipt Pressure

1.0 Purpose and Objective

The purpose for this report is to establish a receipt pressure as an indicator for handling casks upon receipt at the Canister Storage Building (CSB).

2.0 Summary of Final Results and Conclusions

Measurements of the cask receipt pressure are not considered a good indicator of the presence of hydrogen or contamination in the cask cavity. It appears that analyses must be relied upon as the basis for managing the potential for flammable gas in a cask at receipt. Alternate factors, such as climate related temperature increases, can also cause an increase in pressure. However, if the observed cask pressure exceeds 3 psig, a special procedure should be used during cask lid removal (sample gas and controlled venting).

3.0 Assumptions

In determining increased pressure due to hydrogen gas leakage, the assumptions were made that there was no temperature change, that there was only hydrogen gas in the leak, and that the gases followed the ideal gas law.

In determining the pressure capable of lifting the cask lid, the assumptions were made that all gases follow the ideal gas law and the temperature at the time of cask closure in the Cold Vacuum Drying Facility (CVDF) was 25°C.

4.0 Software Applications

No Software Applications

5.0 Computer Model

No Computer Model

6.0 Input Data

The following lists the input data required to calculate the cask receipt pressure.

$n_2/n_1 = 1.04$ (ratio of number of hydrogen moles from cask case 2 to cask case 1 at 4% hydrogen) (Coward and Jones, 1998)

$P_1 = 14.7$ psia (starting pressure) (Pajunen, 1998)

$D = 25.5$ inches (cask lid internal diameter) (Smith, 1999)

$W = 1890$ lb (cask lid weight) (Smith, 1999)

$T_1 = 298\text{K}$ (initial cask wall temperature at time of closure in CVD) (Pajunen, 1998)

R = gas constant (cancels out of equation)

V = cask void volume (cancels out of equation)

$A = 510.45 \text{ in}^2$ (cask lid area)

$$\left(\frac{g}{g_c} \right) = \left(\frac{32.2 \frac{ft}{sec^2}}{32.2 \frac{lb_m \cdot ft}{lb_f \cdot sec^2}} \right) \text{ (acceleration of gravity over gravity constant)}$$

7.0 Calculations

The Multi-Canister Overpack (MCO) seals are leak checked at the CVDF prior to shipping to the CSB. Therefore, actions have been taken to ensure the MCO integrity at the time it leaves the CVDF. Based on the sealed MCO configuration, the following hazards (neglecting physical hazards associated with cask handling) were considered.

- Leakage from the MCO to the cask cavity (Figure 1)
 - Hydrogen exceeds flammability limit, causing flammable gas hazard during cask lid removal.
 - Contamination migration causes radiological hazard during cask lid removal.
- Pressure in cask cavity lifts lid during bolt removal, causing a physical hazard to operating personnel. (Figure 2)

Figure 1: Cask Pressure Diagram

Case 1: Cask leaving CVD

Case 2: Cask receipt at CSB

Equation 1: Pressure Calculation Based on Number of Moles

$$\frac{P_1}{P_2} = \frac{\frac{n_1 RT}{V}}{\frac{n_2 RT}{V}} = \frac{n_1}{n_2} \text{ or } P_2 = \left(\frac{n_2}{n_1} \right) P_1$$

Equation 2: Pressure Calculations Based on Wall Temperature

$$\frac{P_1}{P_2} = \frac{\frac{nRT_1}{V}}{\frac{nRT_2}{V}} \text{ or } P_2 = \left(\frac{T_2}{T_1} \right) P_1$$

Figure 2: Cask Lid Pressure Indication

Equation 3: Cask Lid Allowable Pressure Limit

$$\frac{W}{A} \left(\frac{g}{g_c} \right) = \frac{F}{A}$$

$$\frac{1890lb}{\pi(25.5)^2/4 \text{ in}^2} \left(\frac{g}{g_c} \right) = 3.7 \text{ psi}$$

8.0 Results

A cask pressure measurement is performed upon receipt at the CSB. This is intended to form the basis for performing receipt activities using alternate procedures. The pressure measurement is not capable of determining if particulate contamination has migrated from the MCO to the cask cavity. A pressure change would result if hydrogen were to leak from the MCO to the cask cavity. (See Figure 1) Assuming no temperature change, the cask pressure to reach 4% hydrogen can be estimated assuming a pure hydrogen leak from the MCO to the cask cavity. Based on the ideal gas law. (See equation 1)

For a pure hydrogen leak, $n_2/n_1 = 1.04$ when the hydrogen concentration is at 4%. Based on these assumptions, a starting pressure of 14.7 psia that increases to 15.3 psia (0.6 psig) would indicate the potential for a flammable gas mixture in the cask upon receipt at the CSB. However, the MCO begins with an initial overpressure of helium such that leaks are not pure hydrogen and the cask temperature varies with shipping weather conditions. Therefore, the pressure measurement is not considered an indicator for leakage of a sealed MCO to the cask cavity.

The cask pressure of concern that lifts the lid is estimated from the cask lid diameter and mass. (See Figure 2) The cask lid internal diameter is 25.5 inches, and the cask lid weight is 1890 lb. Therefore, the internal pressure to lift the lid can be approximated. (See equation 3)

This indicates that a hazard would exist during cask lid removal if the cask internal pressure approaches 3.7 psig.

Temperature increases during a hot day transfer are expected to increase the cask receipt pressure independent of gas leakage from the MCO to the cask cavity. (See Figure 1) Based on the analysis of a hot day transfer in Smith, 1999 (Figure B8-10), the cask pressure can be estimated from the increase in cask wall temperature. (See Equation 2) The cask pressure increase is shown below (Table 1) based on the ideal gas law and an initial temperature of 25°C at time of cask closure in the CVD.

Table 1: Change in cask pressure during transfers				
Time after cask closure, hr	0	10	33	∞
Average cask temperature, K	298	313	323	347
Cask internal pressure, psig	0	0.7	1.2	2.4

Larger pressure increases would occur if the temperature at time of closure were reduced. In addition, higher gas pressures would be predicted if the effective gas temperature is taken as an average of the cask wall and MCO wall temperatures. Therefore, cask pressure changes of 2.4+ psig could be observed without any leakage from the MCO to the cask cavity.

9.0 Conclusions

Based on the previous discussion, it is recommended that the cask pressure be reduced to less than 3 psig before initiating removal of the cask lid. This should probably be simplified to specifying that the cask is vented to atmospheric pressure (0 psig) prior to lid removal. Receipt pressures approaching 3 psig should be an anticipated condition, particularly during warm weather transfers (note that a slight vacuum during cold weather transfers could also be observed). Therefore, measurements of the cask receipt pressure

are not considered a good indicator of the presence of hydrogen or contamination in the cask cavity.

If the observed cask pressure exceeds 3 psig, a special procedure should be used during cask lid removal (sample gas and controlled venting). The basis for performing the special procedure is that a cask pressure above 3 psig is not expected and something has occurred during this particular shipment that was not anticipated by the analysis.

10.0 References

- Coward, H.F., and G.W. Jones, 1952, *Limits of Flammability of Gases and Vapors*, Bureau of Mines Bulletin 503, U.S. Department of the Interior, Washington, D.C.
- Smith, R.J., 1999, *MCO Cask Safety Analysis Report For Packaging*, HNF-SD-TP-SARP-017, Rev 1, Waste Management Federal Services, Richland, Washington.
- Pajunen, A.L., 1998, *Spent Nuclear Fuel Project Product Specification*, HNF-SD-SNF-OCD-001, Rev 3, Cogema Engineering, Corp, Richland, Washington.

REVIEW CHECKLIST

Document Reviewed:

HNF-4509 Evaluation of Canister Storage Building Cask Receipt Pressure

Scope of Review:

Check calculation for numerical/typographical errors.

Yes No NA

☐	☐	☒	* Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
☒	☐	☐	Problem completely defined.
☒	☐	☐	Accident scenarios developed in a clear and logical manner.
☒	☐	☐	Necessary assumptions explicitly stated and supported.
☐	☐	☒	Computer codes and data files documented.
☒	☐	☐	Data used in calculations explicitly stated in document.
☒	☐	☐	Data checked for consistency with original source information as applicable.
☒	☐	☐	Mathematical derivation checked including dimensional consistency of results.
☒	☐	☐	Models appropriate and used within range of validity or use outside range of established validity justified.
☒	☐	☐	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
☐	☐	☒	Software input correct and consistent with document reviewed.
☐	☐	☒	Software output consistent with input and with results reported in document reviewed.
☒	☐	☐	Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
☒	☐	☐	Safety margins consistent with good engineering practices.
☒	☐	☐	Conclusions consistent with analytical results and applicable limits.
☒	☐	☐	Results and conclusions address all points required in the problem statement.
☒	☐	☐	Format consistent with appropriate NRC Regulatory Guide or other standards.
☐	☒	☐	* Review calculations, comments, and/or notes are attached.
☒	☐	☐	Document approved.

Heather Wyman

Reviewer (Printed Name and Signature)

5/18/99

Date

*Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

[illegible]