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7. Abstract This report documents the determination that the activities associated with the 100 K West fuel canister gas and liquid sampling are classified as Hazard Category Other (consequences are below criteria for Category 3).		
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HAZARD CATEGORIZATION OF 100 K WEST FUEL CANISTER GAS AND LIQUID SAMPLING

1.0 PURPOSE AND SCOPE

The purpose of this report is to provide a hazard categorization of the gas and liquid sampling activities associated with the fuel characterization program at the 100 K West (KW) fuel storage basin.

The scope of this hazard categorization is limited to the gas and liquid sampling of fuel canisters in the 100 KW fuel storage basin and to the placement and securing of sample containers in an approved shipping container. Shipment of the samples is not addressed in this document.

The methodology of DOE Standard DOE-STD-10227-92 (Reference 6.1) is used for this hazard categorization.

2.0 SUMMARY

Review of the activities and potential accident consequences associated with the gas and liquid sampling of 100 KW fuel canisters indicates that the activities are Hazard Category Other (consequences are below criteria for Category 3).

3.0 DESCRIPTION OF SIGNIFICANT ACTIVITIES

The significant activities that will occur at the 100 KW basin during fuel canister gas and liquid sampling as delineated in the Functional Design Criteria (Reference 6.2) are as follows:

3.1 Canister transport from the main storage basin to the weasel pit

Note: The current plan is for gas and liquid sampling operations to take place in the 105 KW weasel pit. Since other characterization activities will be conducted in the 105 KW south loadout pit transfer channel, a decision could be made to move sampling operations to the same location. Conducting operations in the transfer channel would not invalidate the conclusion of this hazard categorization report. Process Standard C-303 allows up to three canisters in transit in each bay.

Canisters that have been chosen for gas and/or liquid sampling will be transported from their main storage basin rack locations

to the weasel pit using the current monorail system, canister hoists and canister-handling tools.

3.2 Canister gas sampling

The sampling tool will be placed on top of the canister lid so that the outer lid valve is covered and sealed. A 15 cubic centimeter (cm^3) sample container, enclosed in individual stainless steel sleeves to minimize the potential for glass breakage, will be inserted into the tube holder and lowered to the bottom of the sampling tool. The sampling tool will loosen the outer lid valve and a needle in the sampling tool will pierce the sample container rubber stopper to allow gas to flow into the sample container. Approximately 30 seconds later, the canister lid valve will be closed and the sample container will be raised out of the water to the basin operating floor elevation. The sample container will be placed in an appropriate shielded container for shipment. Each shielded shipping container may contain up to four (4) individual 15 cm^3 sample containers.

3.3 Canister liquid sampling

The sampling tool will be placed on top of the canister lid so that the center lid valve is covered and sealed. A 15 cm^3 sample container, enclosed in individual stainless steel sleeves to minimize the potential for glass breakage, will be inserted into the tube holder and lowered to the bottom of the sampling tool. The sampling tool will loosen the center lid valve, a needle will pierce the sample container rubber stopper to allow liquid to flow into the sample container. Approximately 30 seconds later, the canister lid valve will be closed and the sample container will be raised out of the water to the basin operating floor elevation. The sample container will be placed in an appropriate shielded container for shipment. Each shielded shipping container may contain up to four (4) individual 15 cm^3 sample containers.

3.4 Canister transport from the weasel pit to the main storage basin

After sampling of a specific canister has been completed, that canister will be transported from the weasel pit back to its main storage basin rack location using the current monorail system, canister hoists, and canister-handling tools.

3.5 Sample handling and shipment

The 15 cm^3 sample containers will individually be brought above the surface of the water, removed from the sampling equipment with tongs, rinsed and surveyed, and placed into appropriate shielded shipping containers for shipment by truck to a laboratory for

analysis. Up to four (4) individual 15 cm³ samples container may be placed in a shielded shipping container. Only one sample container will be handled at a time.

3.6 Re-encapsulation of sampled canisters that cannot be properly sealed (if required)

In the event that a canister lid valve cannot be completely re-closed, gas remaining in the top of the canister may vent from the canister. Water will then enter the canister through the gas trap attached to the side of the canister barrels due to the hydraulic head of the water above the canister. Gas venting would be expected to continue until all gas in the top of the canister has been displaced by water.

If proper canister valve sealing cannot be obtained following sampling, the canister shall be re-encapsulated prior to storage in the main basin. The canister will be transported from the weasel pit to the south loadout pit transfer channel where the canister lid will be replaced if required, nitrogen purge gas will be introduced through the lid purge valve, and corrosion inhibitor will be added to the water in the canister. The encapsulated canister will then be returned to its main basin storage rack location.

3.7 Intentional flooding of canisters (if required)

If a liquid sample cannot be obtained from the center valve, the decision may be made to intentionally flood the canister with water to obtain a liquid sample. In this event, the outer valve (or possibly both valves) would be opened until gas stops venting. Valves that had been opened would then be closed and the canister would be kept in the weasel pit for a period of time (presently planned to be approximately 24 hours) to allow water mixing within the canister. The sampling tool would then be placed over the center valve and a liquid sample would be obtained. Any canister that is intentionally flooded shall be transported to the south loadout pit transfer channel for re-encapsulation prior to storage in the main basin.

4.0 HAZARD IDENTIFICATION AND MANAGEMENT

4.1 Identification of potential hazards

The major activities associated with the gas and liquid sampling have been evaluated with respect to the following potential hazards:

4.1.1 Industrial Safety (Electrical)

4.1.2 Fire Protection

4.1.3 Industrial Safety (Crane Operations)

4.1.4 Industrial Safety (Hygiene) - activities which result in worker stress because the equipment or tools do not fit the worker well

4.1.5 Industrial Safety (Other) - other considerations based on operator experience and knowledge of the plant

4.1.6 Industrial Hygiene - potential toxic material exposure or release

4.1.7 Radiation Exposure - potential As Low As Reasonably Achievable (ALARA) considerations and unshielded high radiation fields, inadvertent criticality or inadvertent removal of the fuel from the water

4.1.8 Airborne Material Exposure - airborne radionuclides from increased radionuclides in suspension or solution in the basin water, airborne radionuclides from work in surface contamination zones, direct release of radioactive gases

4.1.9 Nuclear Safety - possibility that the activity exceeds the conditions bounded by the existing Safety Analysis Report

There are no new industrial safety or industrial hygiene issues created from the planned gas and liquid sampling program. The only electrical equipment that will be used will support the sampling tool mechanism that raises and lowers the sampling containers. Air pressure will be used to operate some components on the sampling tool. The sampling equipment will be tested in the 300 Area prior to use at 100 KW. Operations personnel will receive required equipment-specific training using approved and validated operating procedures prior to start of the sampling program.

4.2 Hazards from Fuel Handling

There are no new hazards introduced as a result of normal fuel handling operations. Radiation exposure directly from the transported fuel within the basin will be less than 1 mRem per hour because of the greater than 2.4 meters (8 feet) of water over the fuel canister (Reference 6.3, section 5.2.3). K Basins Process Standard C-303 (Reference 6.5), section D.2.a, requires the use of hoists for the transport of fuel that mechanically prevent raising fuel to within 10 feet of the basin water surface.

The probability of seeing an increase in fission products in the basin water as a result of fuel canister sample is slight since canisters will not be opened in the weasel pit. The seals on the sampling equipment are designed to prevent radioactive gas and liquid removed from the canisters from leaking into the basin water. Periodic center-of-basin water samples will provide an indication of changes in radionuclide level in the basin water.

A stuck-valve scenario would result in the potential for venting of all of the gas in a canister barrel to above the surface of the water. The curie release for seven elements in a canister barrel is documented in Table II of Reference 6.4 with the only gas of concern being ^{85}Kr . The worst case release of ^{85}Kr would be based on the assumptions that the entire ^{85}Kr inventory in the fuel would be released and that the water would not contribute to decontamination. This would result in a ^{85}Kr release of 5.45 curies based on $4.81\text{E}+02$ curies per 1000 kilograms of fuel times 11.3 kilograms of fuel per barrel. The DOE standard for hazard categorization (Reference 6.1) does not include ^{85}Kr on the list of isotopes to be considered.

Being heavier than air, a ^{85}Kr gas bubble breaking the surface of water would tend to diffuse in a layer just above the surface of the water and act as a slab source at a distance of more than four feet below the floor grating. Over a longer time period, the gas would be expected to be affected by air currents in the basin and diffuse throughout the free air volume of the basin structure. The free air volume of the basin structure (including the air space under the grating, above the grating, and in the high bay) is estimated to be approximately $1.18\text{E}+10 \text{ cm}^3$. The resultant ^{85}Kr concentration would be $4.62\text{E}-04 \mu\text{Ci}/\text{cm}^3$ provided that all of the krypton gas remains in the building.

While this value is higher than the Derived Air Concentration (DAC) limit of $1.0\text{E}-04 \mu\text{Ci}/\text{cm}^3$ stated in Appendix C of Reference 6.6, the DAC limit is based on worker immersion in a radioactive cloud for 2,000 hours over a year period (40 hours per week for 50 weeks per work year). The maximum credible worker exposure time during sampling would be assumed to be an eight-hour shift. Worker exposure for eight hours at $4.62\text{E}-04 \mu\text{Ci}/\text{cm}^3$ will be approximately 1.8 percent of the exposure for a worker in a $1.0\text{E}-04 \mu\text{Ci}/\text{cm}^3$ radioactive cloud environment for 2000 hours. Assuming that all of the ^{85}Kr gas generated would be available for release from the canister barrel is very conservative since not all of it would be expected to escape through the uranium metal. The analysis does not take credit for dilution of the gas during the exposure time as a result of operation of the 105 KW basin exhaust fans. The design combined flowrate of the exhaust fans in the 105 KW basin is in excess of $1.0\text{E}+09 \text{ cm}^3$ per minute.

The spilling of the contents of three canisters of fuel (42 assemblies) onto the fuel storage basin floor during canister transport to or from the weasel pit will result in a k_{eff} below the 0.98 limit (Reference 6.3, section 8.1.3). Up to three canisters per bay may be in transit at a time. Imposing the same fuel assembly limit as for the transfer channel and loadout pit (Reference 6.5 sections D.3.b and D.3.c), no more than four canisters will be allowed in the weasel pit at one time.

Decapping and re-encapsulation of a fuel canister will be required prior to storage in the main basin if the canister lid valves cannot be properly resealed after opening or if the seal between the lid and the canister were to be lost. Re-encapsulation of a canister will also be required if a canister is intentionally flooded. There are no new safety hazards identified as a result of possible canister decapping or encapsulation at 100 KW. Since the operation would be performed in the south loadout pit transfer channel subject to the controls and limits of K Basins Process Standard C-303, section D.3, no new criticality issues are introduced.

4.3 Hazards from Sample Handling

The primary source of personnel radiation exposure during the sampling program will be from transferring the liquid samples from the sampling mechanism to the shipping container. Exposure from the water samples (due primarily to ^{137}Cs) is expected to be less than 16 milliRem per hour at 0.3 meters (1 foot) based on calculations performed by the K Basins Radiological Controls group. Personnel exposure from gas samples will be less than from liquid samples. No significant airborne exposure is expected unless a sample container breaks. Sample containers will be placed in stainless steel sleeves to minimize the potential for glass breakage. The sample container will be rinsed upon removal from the water and will be surveyed prior to placement in the shielded shipping container. The job-specific Radiation Work Permit (RWP) will specify all necessary radiological controls.

The broken-sample-container accident provides the maximum amount of radionuclide material available for airborne release. This is the bounding accident since underwater fuel handling activities for fuel transport would be limited to a three canister per bay limit and decapping/re-encapsulation would involve only one canister at a time. Any underwater release would have a decontamination factor of 10,000 (Reference 6.4, section 4.2.1) associated with the release. The maximum amount of fuel contained in a three canisters is 42 assemblies. Applying a decontamination factor of 10,000 to the contents of one canister would result in 0.0042 assemblies for release. This is below the Category 3 threshold of 0.029 assemblies shown on Table 1.

Only one sample container will be handled at a time during the activities involving the sample containers (removal of sample container from the sampling equipment, rinsing and surveying of the sample container, and placement of the sample container into a shielded shipping container). The upper limit on the amount of fuel that would be available for release would be the mass of uranium (assumed to be in the form of UO_2 contained in a 60 cm^3 volume (four 15 cm^3 sample containers). At a uranium dioxide density of 10.96 grams per cubic centimeter, the maximum weight of irradiated uranium metal fuel in four sample containers would be 579.7 grams ($60 \text{ grams} * 10.96 \text{ grams per cm}^3 \text{ UO}_2 * 238/270 \text{ grams U per grams of UO}_2$). The worst-case assumption of a 60 cm^3 volume of UO_2 is justified for the following reasons:

- 4.3.1 The most likely form of particulate in the canister is uranium oxide, not uranium metal.
- 4.3.2 By using only the vacuum in the sample container and the hydraulic head of the basin water as a driving force for the transfer of material into the sample container, it would not be considered credible that the container would completely fill with a solid.
- 4.3.3 Water entering the sample container would decrease the volume available for solids.

The Hazard Category 3 threshold (shown on Table 1) is 0.029 assemblies or 657.7 grams of irradiated uranium metal fuel based on an assumed weight of 22,679.6 grams (50 pounds) per assembly. The maximum amount of irradiated uranium fuel in four sample containers in a shipping container is less than the Hazard Category 3 threshold.

A scenario of four water-filled 15 cm^3 sample containers was also reviewed since this scenario is more likely than the oxide-filled sample container scenario. The two water-soluble isotopes of concern are ^{90}Sr and ^{137}Cs . The maximum amount of ^{90}Sr and ^{137}Cs that would be contained in 60 cm^3 of water obtained from a canister barrel has been calculated to be approximately 5.14 Curies and 0.65 Curies, respectively. This is based on a canister barrel water volume of $10,754 \text{ cm}^3$ and complete deposition of the ^{90}Sr and ^{137}Cs contained in seven fuel assemblies into the canister barrel water. Both values are below the individual isotopic Curie thresholds for Category 3 shown on Table 1. Since the only two isotopes considered are both below their Category 3 thresholds, the water-filled sample container scenario results in Curie amounts below the Category 3 threshold.

5.0 CONCLUSIONS

Based on analysis of the in-basin activities associated with the fuel characterization program canister gas and liquid sampling, the appropriate hazard classification per Reference 6.1 is Hazard Category Other (consequences are below criteria for Category 3). Handling of sample containers during the period between obtaining a gas or liquid sample and placing the sample containers into an approved shipping cask shall not create a credible accident that could cause damage to more than four sample canisters at one time.

6.0 REFERENCES

- 6.1 DOE-STD-10227-92, DOE Standard - Hazard Categorization and Accident Analysis Techniques for Compliance With DOE Order 5480.23, Nuclear Safety Analysis Reports
- 6.2 WHC-SD-SNF-FDC-001, Revision 1, Gas and Liquid Sampling for Closed Canisters in K-West Basins - Functional Design Criteria
- 6.3 WHC-SD-WM-SAR-062, Revision 1, Safety Analysis Irradiated N Reactor Fuel
- 6.4 WHC-SD-SNF-SARR-001, Revision 0, Review of Consequences of Uranium Hydride Formation in N-Reactor Fuel Elements Stored in the K-Basin
- 6.5 K Basins Process Standard C-303, Fissile Material Control - KE and KW Storage
- 6.6 Code of Federal Regulations, Title 10, Chapter III, Part 835, Occupational Radiation Protection

7.0 TABLES

Table 1 Hazard Category 2 and 3 Thresholds

Isotope	Ci/MTU	Ci/Assembly	Cat 3 Threshold Ci	Cat 2 Threshold Ci	Cat 2 Ratio	Cat 3 Ratio
Pu-236	2.20E-04	4.99E-06		5.50E+01	9.07E-08	
Pu-238	4.80E+01	1.09E+00	6.20E-01	6.20E+01	1.76E-02	1.76E+00
Pu-239	1.10E+02	2.49E+00	5.20E-01	5.60E+01	4.45E-02	4.80E+00
Pu-240	5.80E+01	1.32E+00		5.50E+01	2.39E-02	
Pu-241	4.40E+03	9.98E+01	3.20E+01	2.90E+03	3.44E-02	3.12E+00
Pu-242	2.10E+02	4.76E+00	5.20E-01	5.50E+01	8.66E-02	9.16E+00
Am-241	9.30E+01	2.11E+00	5.20E-01	5.50E+01	3.83E-02	4.06E+00
Cm-244	4.60E+00	1.04E-01		5.50E+01	1.90E-03	
Eu-154	8.80E+01	2.00E+00		1.10E+05	1.81E-05	
Cs-134	1.30E+02	2.95E+00	4.20E+01	6.00E+04	4.91E-05	7.02E-02
Cs-137	7.30E+03	1.66E+02	6.00E+01	8.90E+04	1.86E-03	2.76E+00
Ce-144	2.80E+01	6.35E-01	1.00E+02	8.20E+04	7.74E-06	6.35E-03
Pr-144	2.80E+01	6.35E-01		4.30E+05	1.48E-06	
Pr-144M	3.30E-01	7.48E-03		4.30E+05	1.74E-08	
Pm-147	2.00E+03	4.54E+01	1.00E+03	8.40E+05	5.40E-05	4.54E-02
Sb-125	1.20E+02	2.72E+00		4.30E+05	6.33E-06	
Te-125M	3.00E+01	6.80E-01		4.30E+05	1.58E-06	
Ru-106	5.20E+01	1.18E+00	1.00E+02	6.50E+06	1.81E-07	1.18E-02
Sr-90	5.80E+03	1.32E+02	1.60E+01	2.20E+04	5.98E-03	8.22E+00
Y-90	5.80E+03	1.32E+02		4.30E+05	3.06E-04	
Total					2.56E-01	3.40E+01
Number of assemblies to exceed Hazard Category 2 Threshold -- DF=1					3.913	
Number of assemblies to exceed Hazard Category 3 Threshold -- DF=1						0.029
Cat 2 Threshold from DOE-STD-1027-92						
Cat 2 or 3 ratio is Ci/assembly divided by Threshold Ci						
Uranium isotopes are not shown because they are negligible						
Fuel weight is assumed to be 22,679.6 grams (50 pounds) per assembly						