OBU-GSE-2004-00159

November 3, 2004

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CLASSIFICATION OF TRITIUM EXTRACTION FACILITY (TEF) WASTE STREAM AS DOE LOW-LEVEL WASTE (LLW) FOR DISPOSAL (OBU-GSE-2004-00139)

Attached is the DOE approved document that demonstrates the classification of the TEF radioactive waste stream as DOE LLW for disposal.

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Classification of the Tritium Extraction Facility (TEF) Waste Stream

As DOE Low-Level Waste for Disposal

Document OBU-GSE-2004-00139
Revision 0

October 18, 2004

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Purpose

This document provides evidence demonstrating that radioactive waste from the Tritium Extraction Facility (TEF) Project is generated from a DOE activity and shall be managed as radioactive waste in accordance with the requirements contained in DOE Order 435.1. This document will further demonstrate that the radioactive waste generated from the TEF is expected to be properly categorized as low-level waste (LLW) and will be safely managed consistent with DOE Order 435.1 requirements and guidance that are protective of the worker, public and environment. The TEF waste stream consists of: tritium-producing burnable absorber rods (TPBARs) and operations' waste consisting of process job control waste and spent process equipment waste.

Description of Waste Streams

Radioactive waste in the TEF is generated from processing commercial light water reactor (CLWR) irradiated TPBARs to extract tritium for DOE missions. The TPBAR targets were sent to the commercial reactor as DOE-owned material and returned to the DOE-owned TEF where processing occurs that results in the generation of spent TPBAR and other job and process associated waste forms. The post-extraction TPBARs constitute the primary, unavoidable waste stream. The irradiated extracted TPBARs are highly radioactive because they contain several short-lived, high-energy-gamma emitting radionuclides in addition to the tritium. Extraction gases containing tritium undergo further purification to produce the tritium product of the desired purity. Post-extraction tritium processing generates waste streams that should only be contaminated with the radionuclide tritium.

Wastes are generated as part of the production process, decontamination process, analytical activities, and operation of supporting facilities. They are also generated incidentally through failed equipment, routine maintenance and due to off-normal events. Sources of radioactive contaminates include the irradiated TPBARs, reactor corrosion products that adhere to the TPBARs commonly referred to as "crud," and the tritium product. Each is discussed below:

Irradiated TPBARs

TPBARs after undergoing extraction to remove tritium are the primary remote-handled waste stream. It is proposed to dispose of the extracted TPBARs in the Intermediate Level Vaults (ILV) of the Savannah River Site (SRS) E- Area Low-Level Waste Facility (ELLWF). This waste form does not meet the current ELLWF waste acceptance criteria (WAC). A special waste assessment for the ILV must be completed prior to acceptance of the waste for disposal. Characterization data will be

needed for both the Lead Test Assembly (LTA) and the TPBAR Production Assemblies. Pacific Northwest National Laboratory (PNNL) has primary responsibility for this issue and is working to obtain both analytical data from bench-scale extractions and modeling or calculation results. The modeling methodology and calculation results are being validated or benchmarked against analytical characterization data. Table 1, attached, gives the calculated radionuclide distribution in one irradiated but not extracted TPBAR at several time intervals after reactor scram (termination of nuclear reaction). These calculations were done by PNNL using the ORIGEN2 code. The upper bound tritium content of an extracted TPBAR is 133 Ci. Current plans are to dispose of four baskets of up to 300 TPBARs each (1,200 total) in a special disposal container.

Reactor Corrosion Products "Crud"

Irradiated TPBARs received at the TEF are expected to be contaminated with reactor corrosion products, which deposit on TPBAR surfaces. This surface coating of reactor pool corrosion products is commonly referred to as "crud". Crud in spent fuel has been observed in both pools and shipping casks. Although crud does not easily become airborne, it is a potential source of contamination that impacts storage, handling, and shipping operations, as well as TPBAR preparation for extraction.

Preliminary data on potential crud formation on CLWR-irradiated TPBARs is based on surface swipe samples from the LTAs. Analytical results indicate that there is no significant crud formation on TPBARs. Smearable surface contamination results from the LTA are 1.6 μCi/100 cm^2 total gamma, 1.5 μCi/100 cm^2 gross beta and, 7.4E-5 μCi/100 cm^2 alpha. Surface activity levels should not impact characterization or classification of the TPBAR waste stream (i.e. < 1% curie content of the waste stream) or present a significant transferable contamination hazard.

Tritium

Tritium is a radioactive isotope of hydrogen with a half-life of 12.3 years and a specific activity of about 9,600 Ci/g. It is a pure beta emitter with a maximum energy of 18.6 keV and an average energy of 5.6 keV. Tritium produces a decay heat of about 0.324 watts/g. It decays by emitting an electron to form He-3.

Tritium will permeate or diffuse into almost all surfaces with which it comes in contact and will readily exchange with hydrogen-containing materials such as moisture, corrosion oxide products, oils and polymeric materials. Thus all systems that contact primary tritium confinement systems (pipe, tank, etc.) will eventually become contaminated with tritium.

Tritium contamination may be in the form of "fixed" or "removable" contamination. Fixed contamination (not removable by wiping) is in the form of a physical matrix

into which tritium has diffused or dissolved, such as in a tank, piping or metal hydride bed. This means that tritium has actually diffused into the matrix of the container or metal components (metal films, piping, pump housings, etc.). Elemental tritium diffused into any material will diffuse back out when the original tritium source is removed. Fixed contamination such as metal tritide is very stable and can only be removed or desorbed by heating (for example, to about 650°C for titanium tritide) or isotopic exchange with protium or moisture. Removable or smearable contamination is generally in the form of an oxide, or tritiated water (HTO), or tritiated organic (oil, grease, etc.). Tritium oxide in tritium-processing equipment is unavoidable and will form any time tritium is exposed to air or moisture. It is formed by oxidation, or, more commonly, by isotopic exchange with elemental hydrogen in moisture.

In the TEF, extracted TPBARs will contain residual fixed tritium contamination that was not extracted in the furnace. Some tritium will diffuse out of the TPBARs with time, with most tritium expected to be lost to decay. Most job control waste in the tritium processing and purification operations will contain removable tritium contamination. Failed tritium process equipment and maintenance parts will contain both removable and fixed contamination.

DOE Waste Classification

DOE Order 435.1 Guidance, Section IV. A. Definition of LLW states that LLW is radioactive waste that is not high-level radioactive waste, spent nuclear fuel, TRU waste, byproduct material, or naturally occurring radioactive material.

DOE Order 435.1 Guidance Section III-A also requires that classification of waste be determined at "the time of waste certification, that is, each time the waste is transferred to another person or facility." The waste stream as packaged must be certified after it is prepared to be transferred from the TEF to the E-area LLW Facility. In this case, the waste stream consists of the TPBAR waste form and job and process associated waste forms with each packaged to meet SRS shipping and disposal requirements.

As seen above and in the Guidance for DOE Order 435.1 Section IV.A., LLW is defined by what it is not. The TEF waste is not spent nuclear fuel because it is not fuel that has been withdrawn from a nuclear reactor following irradiation. In fact, the TEF waste results from the processing of targets placed in a reactor for the purpose of producing a product (tritium) and the targets are not providing fuel for the reactor. The TEF waste is not HLW since it is not the result of reprocessing of spent fuel since the targets are not reactor fuel. The TEF waste expected characterization is less than 100 nCi/g transuranics with half lives greater than 20 years and, thus, is not expected to be TRU waste. TRU waste is excluded from the definition of LLW, therefore, if the TEF waste as characterized was determined to meet the definition of TRU waste it would be managed

according to the requirements of DOE Order 435.1 Chapter III. The TEF waste is not byproduct material as defined in Section 11e (2) of the Atomic Energy Act of 1954 because it is not tailings or waste produced by the extraction or concentration of uranium or thorium. And, of course, the TEF waste is not naturally occurring radioactive material.

Although the TPBARs are irradiated in a commercial reactor, the TEF and all the material associated with the processing and waste generation is owned by DOE. The TEF waste is produced from national defense activities, not commercial activities. The requirements for the management of DOE radioactive waste are contained in DOE Order 435.1 and its Manual and Guidance. DOE Order 435.1 provides requirements for the management of LLW, TRU and HLW and the requirements are performance based. In the case of LLW disposal, the Order sets out performance objectives that must be demonstrated. Chapter IV.P says that LLW disposal facilities shall be sited designed, operated, maintained, and closed so that a reasonable expectation exists that the following performance objectives will be met for waste disposed of after September 26, 1988:

- Dose to representative members of the public shall not exceed 25 mrem in a year total effective dose equivalent from all exposure pathways, excluding the dose from radon and its progeny in air.

- Dose to representative members of the public via the air pathway shall not exceed 10 mrem in a year total effective dose equivalent, excluding the dose from radon and its progeny.

- Release of radon shall be less than an average flux of 20 $pCi/m^2/s$ at the surface of the facility.

A performance assessment (PA) and composite analysis (CA) is conducted on a DOE disposal facility to provide a reasonable expectation that the performance objectives will be met by establishing parameters, limits, and controls on the siting, design, operations, maintenance, and closure of the facility in order for there to continue to be an expectation that the criteria delineated in the objectives are met. Disposal of DOE LLW is authorized by DOE-HQ based on the PA and CA demonstration of performance of the waste form in the disposal facility including the properties and radionuclide content.

The DOE Order 435.1 requirements and system for LLW disposal does not use the waste classification system provided by the Nuclear Regulatory Commission (NRC) for waste generated by commercial activities. The NRC waste classification system for waste generated by commercial activities uses waste concentration limits that designate a waste as Class A, B, C, or greater-than-Class C (GTCC) in accordance with 10 CFR 61.55. The TEF waste as discussed above is not a waste generated from a commercial activity and, thus, the NRC waste classification system does not apply to TEF waste.

Conclusion

Spent targets (Tritium Producing Burnable Absorber Rods, TPBARs) and other wastes as described above from the TEF at the Savannah River Site (SRS) will be generated as radioactive waste and packaged in Consolidation Containers for loading into larger PACTEC Containers for shipment to the E-Area LLW Facility for storage and disposal. The TPBARs and other waste from TEF is DOE waste generated from a DOE processing operation. The requirements for storage and disposal of DOE radioactive waste from DOE Order 435.1 must be adhered to when managing this DOE waste stream. This waste is not generated by a commercial activity and is not, therefore, managed under the NRC waste classification system found in 10 CFR 61.55. It would be counter to the requirements of DOE Order 435.1 to classify this waste as GTCC or any of the other NRC waste classifications since this is not waste from a commercial activity.

Table 1. Radionuclide Characteristics of CLWR TPBAR (Ci/TPBAR)

Nuclide	7 Days	30 Days	90 Days	180 Days	1 Year	5 Year	10 Year
H 3*	1.16E+04	1.15E+04	1.14E+04	1.13E+04	1.10E+04	8.76E+03	6.61E+03
C 14	1.42E-03	1.42E-03	1.42E-03	1.42E-03	1.42E-03	1.42E-03	1.42E-03
NA 24	1.98E-02	1.65E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P 32	1.03E+00	3.38E-01	1.84E-02	2.35E-04	3.02E-08	5.78E-10	5.75E-10
S 35	1.37E-02	1.15E-02	7.15E-03	3.52E-03	8.18E-04	8.22E-09	4.65E-15
AR 37	3.79E-01	2.40E-01	7.32E-02	1.23E-02	3.15E-04	8.74E-17	1.76E-32
AR 39	9.49E-03	9.49E-03	9.48E-03	9.48E-03	9.46E-03	9.37E-03	9.25E-03
K 42	2.18E-04	8.34E-12	8.31E-12	8.27E-12	8.18E-12	7.52E-12	6.77E-12
CA 41	7.51E-05	7.51E-05	7.51E-05	7.51E-05	7.51E-05	7.51E-05	7.51E-05
CA 45	3.13E-01	2.84E-01	2.20E-01	1.50E-01	6.82E-02	1.37E-04	5.78E-08
CA 47	1.57E-04	4.66E-06	4.86E-10	5.17E-16	2.62E-28	0.00E+00	0.00E+00
SC 46	8.20E-03	6.78E-03	4.13E-03	1.96E-03	4.24E-04	2.39E-09	6.57E-16
SC 47	5.68E-04	1.76E-05	1.86E-09	1.98E-15	1.00E-27	0.00E+00	0.00E+00
CR 51	9.67E+02	5.44E+02	1.21E+02	1.28E+01	1.24E-01	1.66E-17	2.38E-37
MN 54	4.19E+01	3.98E+01	3.48E+01	2.85E+01	1.89E+01	7.41E-01	1.29E-02
FE 55	2.15E+02	2.12E+02	2.03E+02	1.90E+02	1.66E+02	5.71E+01	1.51E+01
FE 59	1.98E+01	1.39E+01	5.52E+00	1.38E+00	7.96E-02	1.34E-11	8.14E-24
CO 58	2.69E+02	2.15E+02	1.19E+02	4.95E+01	8.06E+00	4.92E-06	8.41E-14
CO 60	3.60E+01	3.57E+01	3.49E+01	3.38E+01	3.16E+01	1.87E+01	9.68E+00
NI 59	1.68E-01	1.68E-01	1.68E-01	1.68E-01	1.68E-01	1.68E-01	1.68E-01
NI 63	2.29E+01	2.29E+01	2.28E+01	2.28E+01	2.27E+01	2.20E+01	2.12E+01
NI 66	1.52E-04	1.38E-07	1.59E-15	1.97E-27	0.00E+00	0.00E+00	0.00E+00
CU 64	1.27E-03	1.04E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CU 66	1.52E-04	1.38E-07	1.59E-15	1.97E-27	0.00E+00	0.00E+00	0.00E+00
ZN 65	4.13E-03	3.87E-03	3.26E-03	2.53E-03	1.49E-03	2.34E-05	1.31E-07
AS 76	8.74E-01	4.25E-07	1.44E-23	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE 75	8.88E-01	7.77E-01	5.49E-01	3.26E-01	1.12E-01	2.38E-05	6.13E-10
BR 82	1.14E-03	2.25E-08	1.18E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SR 89	7.51E-02	5.48E-02	2.40E-02	6.99E-03	5.49E-04	1.07E-12	1.39E-23
Y 89M	5.48E-04	4.18E-06	1.24E-11	6.39E-20	0.00E+00	0.00E+00	0.00E+00
Y 90	5.14E-01	1.30E-03	1.38E-06	1.37E-06	1.36E-06	1.23E-06	1.09E-06
Y 91	1.92E-01	1.46E-01	7.19E-02	2.47E-02	2.76E-03	8.38E-11	3.36E-20
ZR 89	5.49E-04	4.18E-06	1.25E-11	6.40E-20	5.60E-37	0.00E+00	0.00E+00
ZR 93	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04
ZR 95	6.57E+01	5.12E+01	2.67E+01	1.01E+01	1.36E+00	1.81E-07	4.63E-16
ZR 97	1.12E-01	1.65E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NB 92	3.04E-01	6.34E-02	1.06E-03	2.28E-06	7.41E-12	0.00E+00	0.00E+00
NB 93M	3.68E-06	4.02E-06	4.87E-06	6.15E-06	8.73E-06	2.69E-05	4.49E-05
NB 94	4.76E-04	4.76E-04	4.76E-04	4.76E-04	4.76E-04	4.76E-04	4.76E-04
NB 95	6.93E+01	6.50E+01	4.45E+01	1.99E+01	2.94E+00	4.02E-07	1.03E-15
NB 95M	4.80E-01	3.80E-01	1.98E-01	7.48E-02	1.01E-02	1.34E-09	3.44E-18
NB 96	1.20E-03	9.19E-11	2.51E-29	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Nuclide	7 Days	30 Days	90 Days	180 Days	1 Year	5 Year	10 Year
NB 97	1.13E-01	1.78E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NB 97M	1.06E-01	1.57E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MO 93	1.04E-03	1.04E-03	1.04E-03	1.04E-03	1.04E-03	1.04E-03	1.04E-03
MO 99	1.68E+01	5.11E-02	1.38E-08	1.94E-18	0.00E+00	0.00E+00	0.00E+00
TC 99	4.35E-05	4.36E-05	4.36E-05	4.36E-05	4.36E-05	4.36E-05	4.36E-05
RU103	3.21E-03	2.14E-03	7.41E-04	1.52E-04	5.76E-06	3.67E-17	3.71E-31
CD115	2.91E-04	2.27E-07	1.78E-15	1.23E-27	0.00E+00	0.00E+00	0.00E+00
CD115M	1.84E-04	1.28E-04	5.05E-05	1.25E-05	7.00E-07	9.62E-17	4.52E-29
IN113M	1.31E+00	1.14E+00	7.94E-01	4.62E-01	1.51E-01	2.28E-05	3.83E-10
IN114	1.26E-01	9.13E-02	3.94E-02	1.12E-02	8.36E-04	1.10E-12	8.64E-24
IN114M	1.32E-01	9.54E-02	4.12E-02	1.17E-02	8.73E-04	1.15E-12	9.03E-24
SN113	1.31E+00	1.14E+00	7.93E-01	4.61E-01	1.51E-01	2.28E-05	3.82E-10
SN117M	8.21E+00	2.63E+00	1.35E-01	1.57E-03	1.64E-07	0.00E+00	0.00E+00
SN119M	8.42E+00	7.89E+00	6.66E+00	5.16E+00	3.06E+00	4.90E-02	2.80E-04
SN121	7.39E-02	4.66E-08	3.12E-24	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SN121M	5.54E-04	5.53E-04	5.52E-04	5.50E-04	5.46E-04	5.17E-04	4.82E-04
SN123	4.78E-01	4.22E-01	3.06E-01	1.89E-01	6.99E-02	2.75E-05	1.52E-09
SN125	2.20E+00	4.21E-01	5.63E-03	8.71E-06	1.43E-11	0.00E+00	0.00E+00
SB122	1.10E-01	2.99E-04	6.12E-11	5.66E-21	0.00E+00	0.00E+00	0.00E+00
SB124	1.86E-02	1.43E-02	7.16E-03	2.54E-03	3.01E-04	1.49E-11	1.10E-20
SB125	1.67E+00	1.66E+00	1.60E+00	1.50E+00	1.32E+00	4.87E-01	1.39E-01
SB126	5.64E-02	1.56E-02	5.45E-04	3.55E-06	1.13E-10	0.00E+00	0.00E+00
TE123M	3.02E-03	2.65E-03	1.87E-03	1.11E-03	3.80E-04	8.02E-08	2.05E-12
TE125M	3.26E-01	3.40E-01	3.58E-01	3.56E-01	3.22E-01	1.19E-01	3.40E-02
CS131	5.10E-02	2.34E-02	1.17E-03	7.33E-06	1.50E-10	0.00E+00	0.00E+00
BA131	3.68E-02	9.53E-03	2.81E-04	1.43E-06	2.69E-11	0.00E+00	0.00E+00
BA133	7.43E-04	7.40E-04	7.32E-04	7.20E-04	6.97E-04	5.38E-04	3.90E-04
BA133M	3.65E-05	1.95E-09	1.39E-20	2.26E-37	0.00E+00	0.00E+00	0.00E+00
BA135M	2.77E-04	4.49E-10	3.51E-25	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA140	3.92E-04	1.86E-07	6.07E-09	4.62E-11	2.02E-15	0.00E+00	0.00E+00
LU177	2.13E-03	1.99E-04	1.57E-06	7.79E-07	3.40E-07	4.95E-10	1.40E-13
HF175	3.25E-02	2.59E-02	1.43E-02	5.86E-03	9.37E-04	4.88E-10	6.84E-18
HF181	8.82E-01	6.06E-01	2.27E-01	5.22E-02	2.52E-03	1.07E-13	1.15E-26
TA182	1.07E+01	9.33E+00	6.50E+00	3.78E+00	1.24E+00	1.85E-04	3.84E-09
TA183	2.54E+01	1.12E+00	3.21E-04	1.56E-09	1.82E-20	0.00E+00	0.00E+00
W181	5.88E-03	5.16E-03	3.66E-03	2.19E-03	7.58E-04	1.78E-07	5.17E-12
W185	2.09E-01	1.69E-01	9.69E-02	4.22E-02	7.64E-03	1.06E-08	5.09E-16
W187	2.68E-02	2.99E-09	2.18E-27	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W188	1.65E-02	1.31E-02	7.22E-03	2.94E-03	4.62E-04	2.12E-10	2.54E-18
RE186	3.18E-02	4.66E-04	7.70E-09	5.16E-16	8.85E-31	0.00E+00	0.00E+00
RE188	1.79E-02	1.33E-02	7.29E-03	2.97E-03	4.67E-04	2.15E-10	2.57E-18
OS191	4.87E-05	1.73E-05	1.16E-06	2.03E-08	4.86E-12	0.00E+00	0.00E+00
TOTAL	**1.34E+04**	**1.28E+04**	**1.21E+04**	**1.17E+04**	**1.12E+04**	**8.86E+03**	**6.66E+03**

*The ORIGEN2 values for H-3 are not reported. The values given for H-3 are based on a maximum of 1.2 g of tritium per TPBAR at discharge, as specified in the Functional Requirements document. The upper bound tritium content following tritium extraction is 133 Ci/TPBAR.