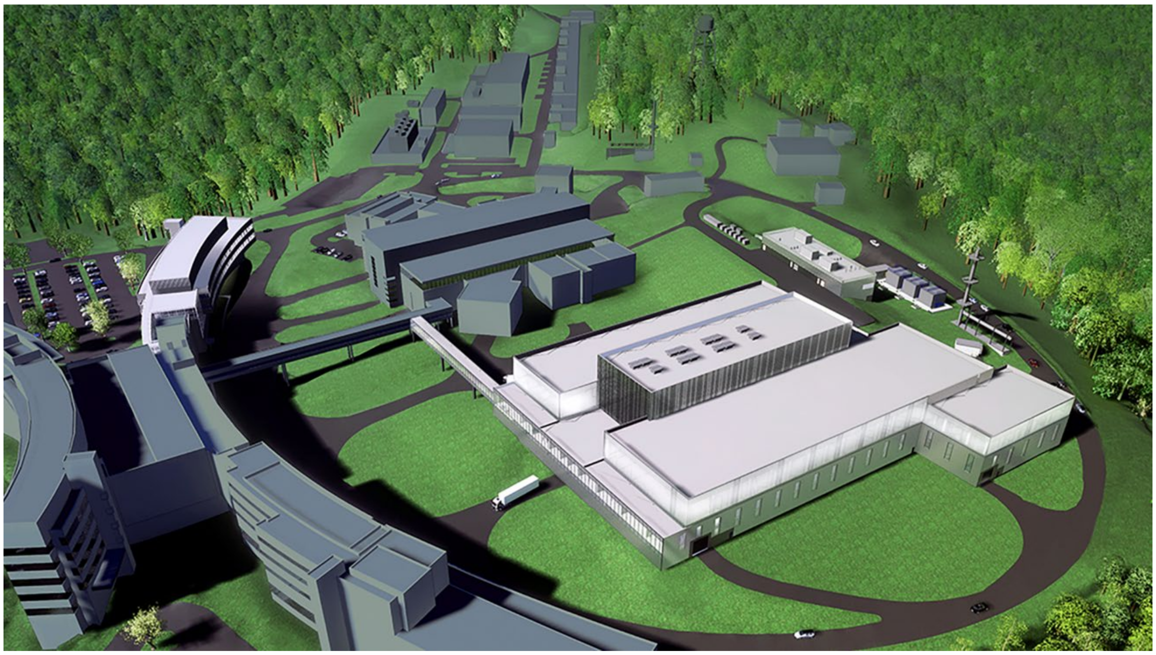
S03040000-ESH10000

Second Target Station Project: Preliminary Radionuclide Characterization of Moderator-Reflector Assembly



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Second Target Station Project

PRELIMINARY RADIONUCLIDE CHARACTERIZATION OF MODERATOR-REFLECTOR ASSEMBLY

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March, 2024

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ABSTRACT

Preliminary characterization of the radionuclide content of the MRA based on Neutronics analysis from February, 2022, applying the requirements in 10CFR61.55 ‘Licensing Requirements for Land Disposal of Radioactive Waste, Subpart D—Technical Requirements for Land Disposal Facilities’. From this analysis, the waste would be Class C based on total >5y alpha and Pu-241 concentrations.

1. Introduction

The moderator-reflector assembly (MRA) at the Second Target Station (STS) consists of four major materials that will need to be disposed of at its end of life. The following is a characterization of the radionuclide content of the MRA and is intended to determine if the item is disposable in current DOE and NRC licensed facilities. While the requirements in 10CFR61.55 ‘Licensing Requirements for Land Disposal of Radioactive Waste, Subpart D—Technical Requirements for Land Disposal Facilities’ do not apply directly to DOE facilities, they are still useful in determining whether waste items are acceptable for land disposal.

1.1 MRA Description

The MRA is shown in Figure 1 below. It consists of aluminum moderator vessels which contain low temperature hydrogen at high pressure and a reflector containing beryllium that is cooled by water. These vessels are supported by a stainless steel backbone.

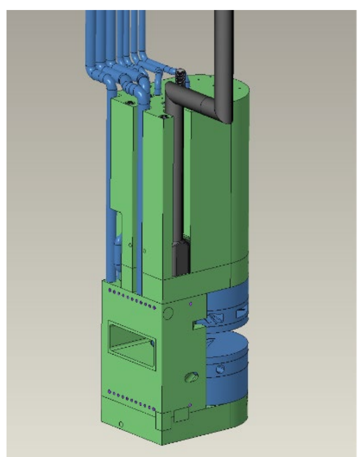

Figure 1

Moderator-Reflector Assembly

2. Characterization

The radionuclide content of the MRA was calculated in reference 1. The applicable 10CFR61.55 limits are shown in Tables 1 and 2 below.

TABLE 1 Characterization by Long Lived Nuclides

Radionuclide	Concentration (Ci/m^3)
C–14	8
C–14 in activated metal	80
Ni–59 in activated metal	220
Nb–94 in activated metal	0.2
Tc–99	3
I–129	0.08
Alpha emitting transuranic	100[1]
Pu–241	3,500[1]
Cm–242	20,000[1]

[1] nano-Ci/g

TABLE 2 Characterization by Short Lived Nuclides

Radionuclide	Class A	Class B	Class C
	Ci/m^3		
Total of all nuclides with less than 5 year half-life	700	(1)	(1)
H–3	40	(1)	(1)
Co–60	700	(1)	(1)
Ni–63	3.5	70	700
Ni–63 in activated metal	35	700	7000
Sr–90	0.04	150	7000
Cs–137	1	44	4600

(1) There are no limits established for these radionuclides in Class B or C wastes. Practical considerations such as the effects of external radiation and internal heat generation on transportation, handling, and disposal will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other nuclides in Table 2 determine the waste to be Class C independent of these nuclides.

In Table 1 above, if the concentration is greater than 0.1 times the value in the table, the waste is class C. If it is greater than the table value, the waste is not suitable for shallow land disposal.

The characterization of the MRA is shown in Tables 3 and 4 below. As shown, based upon the total alpha and Pu-241 concentration, the waste would be Class C. This characterization is based on a waste volume of 0.772 m3, which is the volume a postulated liner which will ship in the TN-RAM cask. This cask is the cask of choice for shipping large waste items at STS. Data used in the calculation of the MRA waste form is shown in Table 5.

The presence of uranium as a naturally occurring impurity in beryllium is the source of the transuranic content of the MRA post-irradiation. The predominately U-238 transmutes into the Pu and other alpha emitting nuclides.

TABLE 3 MRA Characterization by Long Lived Nuclides

Isotope	Activity	Concentration	Waste
	Ci	Ci/m^3	Class
C-14	6.76E-03	8.76E-03	A
Ni-59	2.66E+00	3.44E+00	A
Nb-94	3.03E-03	3.93E-03	A
Tc-99	7.68E-02	9.94E-02	A
I-129	0	0.00E+00	
Total alpha	5.16E-02	2.19E+01[1]	C
Pu-241	2.64E+00	1.12E+03[1]	C
Cm-242	9.29E-01	3.94E+02[1]	A

[1] nano-Ci/g

TABLE 4 MRA Characterization by Short Lived Nuclides

Isotope	Activity	Concentration	Waste
	Ci	Ci/m^3	Class
Total	1.89E+04	2.45E+04	B
H-3	7.77E+03	1.01E+04	B
Co-60	9.71E+03	1.26E+04	B
Ni-63	3.17E+02	4.11E+02	B
Sr-90	4.43E-03	5.73E-03	A
Cs-137	0	0.00E+00	

TABLE 5 MRA Data used in Characterization

Parameter	Value
MRA Weight =	1,361,700 g
MRA Volume =	0.1925 m^3
Liner weight =	998,580 g
Liner material volume =	0.127 m^3
Liner ID =	0.685 m
Liner inside length =	1.75 m
Liner internal volume =	0.645 m^3
Waste form volume =	0.772 m^3
Waste form weight =	2,360,280 g

References

1. Excel Spreadsheet calculation ‘MRA_Waste_Classification_(02-2023).xlsx’.

2. McClanahan, Tucker,   Oak Ridge National Laboratory Second Target Station (STS) Target System Bulk Activation Characterization, S03120100-TRT10005, ORNL/TM-2022/2782, November.