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**Shielding Analysis Report for F-522 Mo-99 Impurities**

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**Approvals**

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Shielding Analysis Report for F-522 Mo-99 Impurities

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Document Change Details

Rev #	What Items Changed (list specifics)	Rationale
1	N/A	New document.

## Shielding Analysis Report for F-522 Mo-99 Impurities

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### 1. PURPOSE

This report characterizes the impurities that may be present when shipping Mo-99 in the F-522 transport container and defines activity limits to satisfy shielding requirements. A Microshield analysis has been performed for three separate activity profiles, which are all shown to be below the regulatory dose rate of 2mSv/hr. Characterization testing will be performed prior to the first shipment to ensure that the contents are below the limits detailed in this report.

The Mo-99 impurities were previously described in terms of I-132 equivalence such that the maximum activity limit was 1850 GBq, this dose limit is used as a baseline for the impurity profiles in this report. The shielding calculations have been performed using Microshield version 10.0.

### 2. MICROSHIELD PARAMETERS

The following assumptions and parameters were used with the Microshield software:

- 1) The ANSI/ANS 6.1.1-1977 fluence to dose conversion factors were used per US NRC guidance instead of the default ICRP 51 factors.
- 2) The ICRP-107 nuclide library was used for the isotope energies
- 3) The minimum tolerance dimensions were used for the F-522 transport container and UK-201 shielding vessel. Tolerances were applied for the steel and depleted uranium thicknesses as well as the overall outer dimensional tolerances.
- 4) The shielding materials, thicknesses and dose points are tabulated below. Please note that the surface dose point is based off of the minimum tolerance for the outer surface of the F-522 and that the F-522 foam material is conservatively modeled as air.

**Table 1: Microshield parameters**

Shield Material	Distance
Iron (7.86 g/cc)	2.018 cm
Depleted Uranium (18.7 g/cc)	7.61 cm
Dose Point	Distance
#1 - Surface Dose	22.31 cm
#2 - TI dose	122.31 cm

### 3. SHIELDING ACTIVITY LIMITS

Due to the uncertainties to the quantities of Mo-99 impurities, three separate activity profiles were assessed to meet the shielding requirements of the F-522. The 1850 GBq I-132 equivalent dose limit was used as the baseline and is calculated as [REDACTED]. Each of the three impurity activity profiles are shown to be below this [REDACTED] limit.

The maximum dose contribution from Mo-99 is calculated to be [REDACTED] as shown in Table 3 below. When it is added to the I-132 equivalent dose, the maximum dose is [REDACTED].

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The Mo-99 impurities as well as their Microshield calculated individual dose values are tabulated below.

Table 2: Dose per activity for impurity isotopes

Isotope	Surface Dose per Activity		TI per Activity	
	mR/hr per Ci	mSv/hr per TBq	TI/Ci	TI/TBq
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

[REDACTED]

Each isotope in Table 2 is used in the three individual cases (below). The main varying isotopes for the different cases are those with the highest energies such as [REDACTED] as they have the largest impact to the shielding case.

Additional fission isotopes may also be present that have no impact to the shielding case. These impurities have an upper bound limit of 0.8 MeV and maximum emission rate of  $9.25 \times 10^{12}$  photons/s.





