CROFT

Safkeg-LS 3979A: Package Activity Limits Based on Shielding

Title	Safkeg-LS 3979A: Package Activity Limits Based on Shielding	**Number** **Issue** **File Reference**	CTR 2009/22 Issue B CTR2009-22-B-d2-SAFKEG LS 3979A-Package Activity Limits-Shielding.docx
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Contents

1. Introduction

The Safkeg-LS 3979A package is a general purpose container for the transport of non-fissile and fissile excepted nuclides under non exclusive use, in solid, liquid and gaseous form, via all modes of transport (road, rail, sea and air).

The Safkeg-LS 3979A package consists of an outer stainless steel double-skinned insulated keg (3979) which is 483 mm long and 424 mm in diameter. Carried within the keg is an insulating cork liner into which a single resealable containment vessel 3980 (made of lead clad in stainless steel) is located. The maximum weight of the package is 62.1 kg (137 lbs) excluding the contents. The maximum contents weight is 5.9 kg (13 lbs), therefore the gross weight of the package is 68 kg (150 lbs).

Section views of the package and the containment vessel are shown in Figure 1, 2 and 3 and the dimensions employed in the shielding models are shown in Figures 7 and 8. These figures also give the nomenclature used throughout this report.

The package is designed as a general purpose package for radioactive material that requires some shielding, however, the design includes additional optional shielding inserts, for radioactive material that requires additional shielding.

The package is designed for radioactive material that emits alpha, beta or gamma radiation. The specified contents do not include materials that emit a significant amount of neutrons.

The contents may be in solid, liquid or gaseous form and carried in various inserts: Design No's 3983, 3984 and 3986, as depicted in Figures 4, 5 and 6.

This report assesses the shielding performance of the Safkeg-LS 3979A package in complying with the non-exclusive use provisions of the 10 CFR71 transport regulations [1] (specifically, the dose limits detailed in10 CFR71.47), when transporting the nuclides detailed in Tables 3 to 6.

The package performance when carrying 1000 Ci of ^{192}Ir was assessed independently in order to establish the worst case orientation of the package in terms of shield performance, as reported in reference 2. The shielding calculations and activity for the

additional radionuclides to be carried were performed using Grove Software's code "MicroShield" [3], employing a 1 Ci point source of each nuclide.

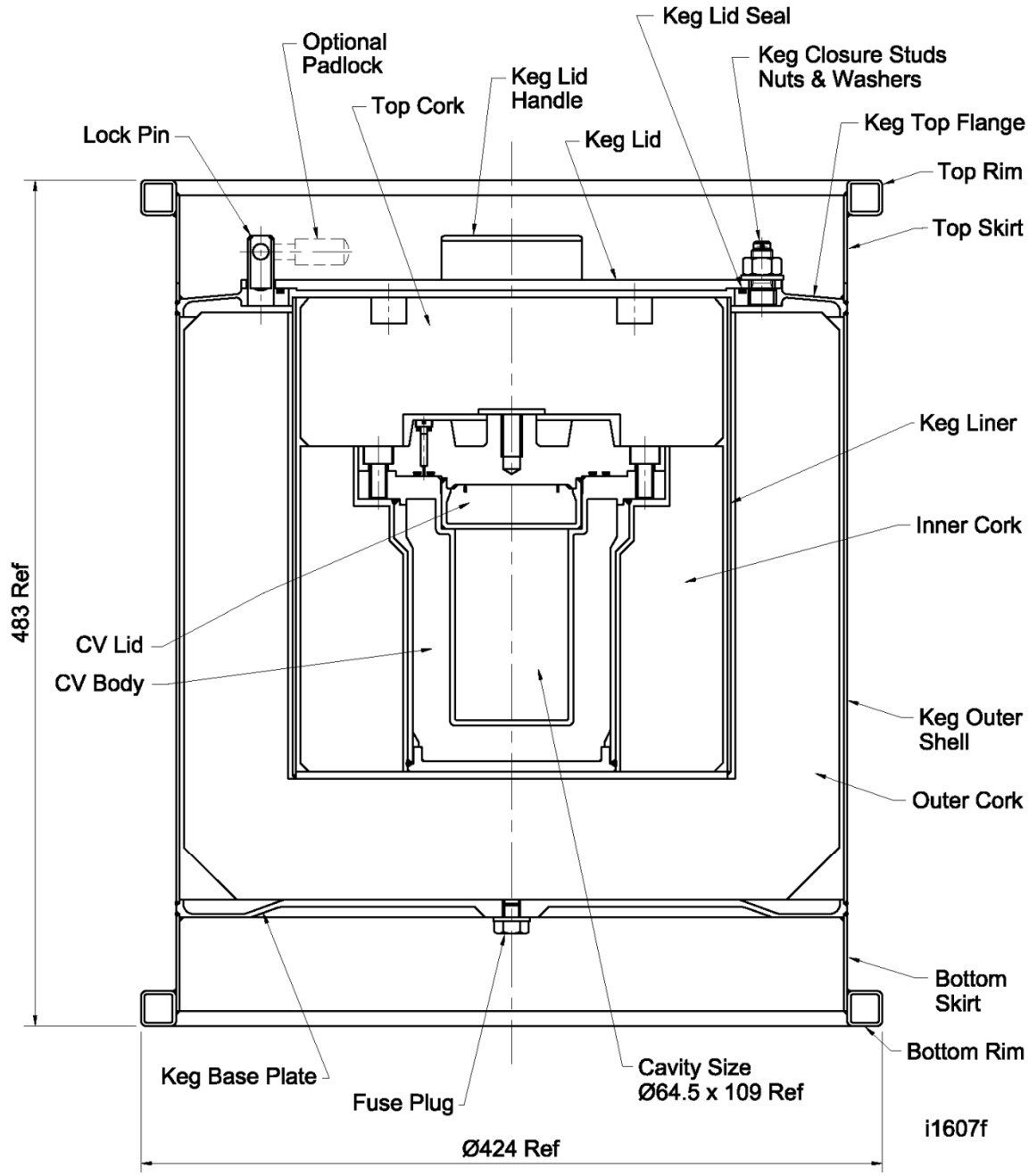
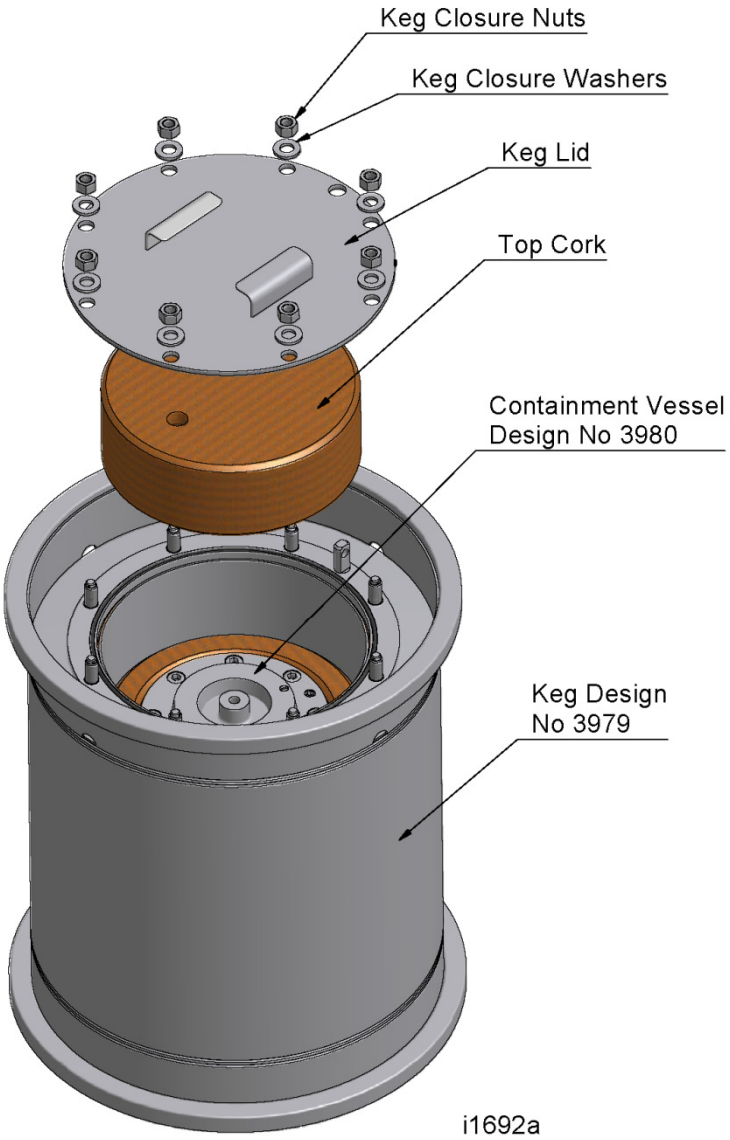


Figure 1: Safkeg-LS 3979A package - Sectional View and Nomenclature



Safkeg LS Design No 3979A

Figure 2: Safkeg-LS 3979A package - Isometric View with Nomenclature

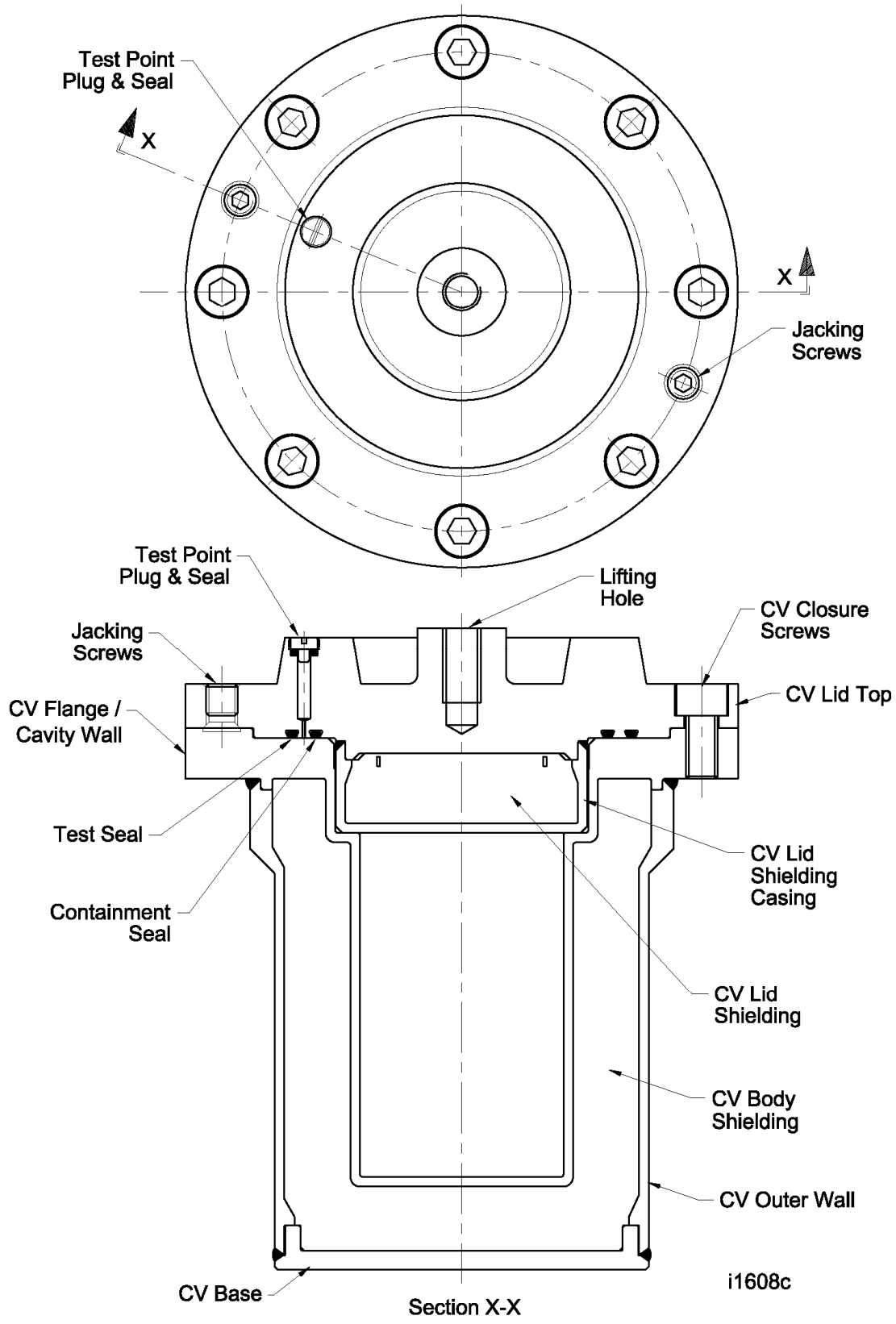


Figure 3: 3980 Containment Vessel - Top and Sectional View with Nomenclature

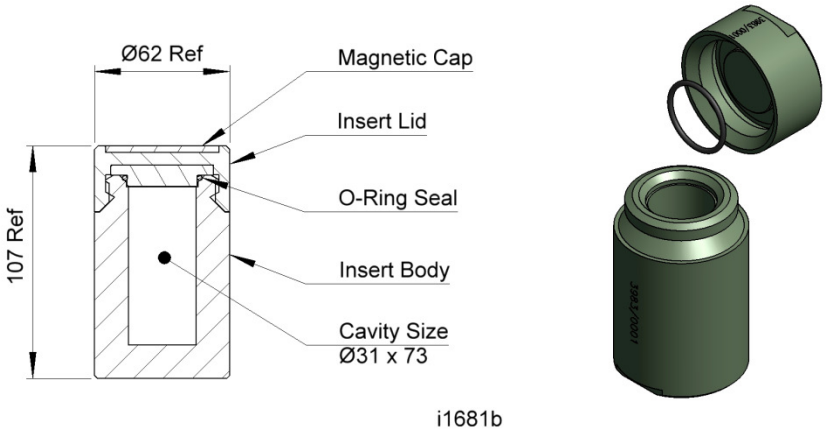


Figure 4: Shielding Insert LS-31x73-Tu, Design No 3983

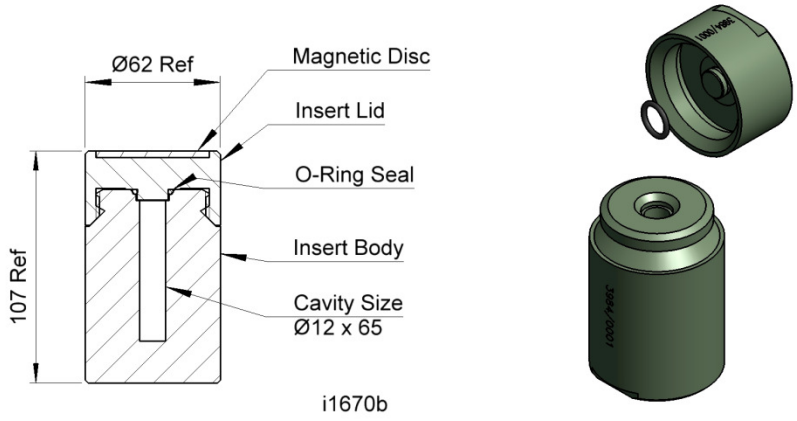


Figure 5: Shielding Insert LS-12x65-Tu, Design No 3984

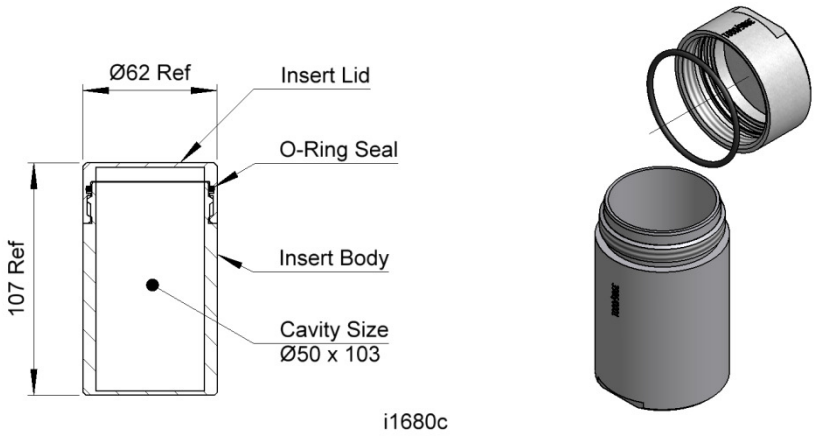


Figure 6: Shielding Insert LS-50x103-SS, Design No 3986

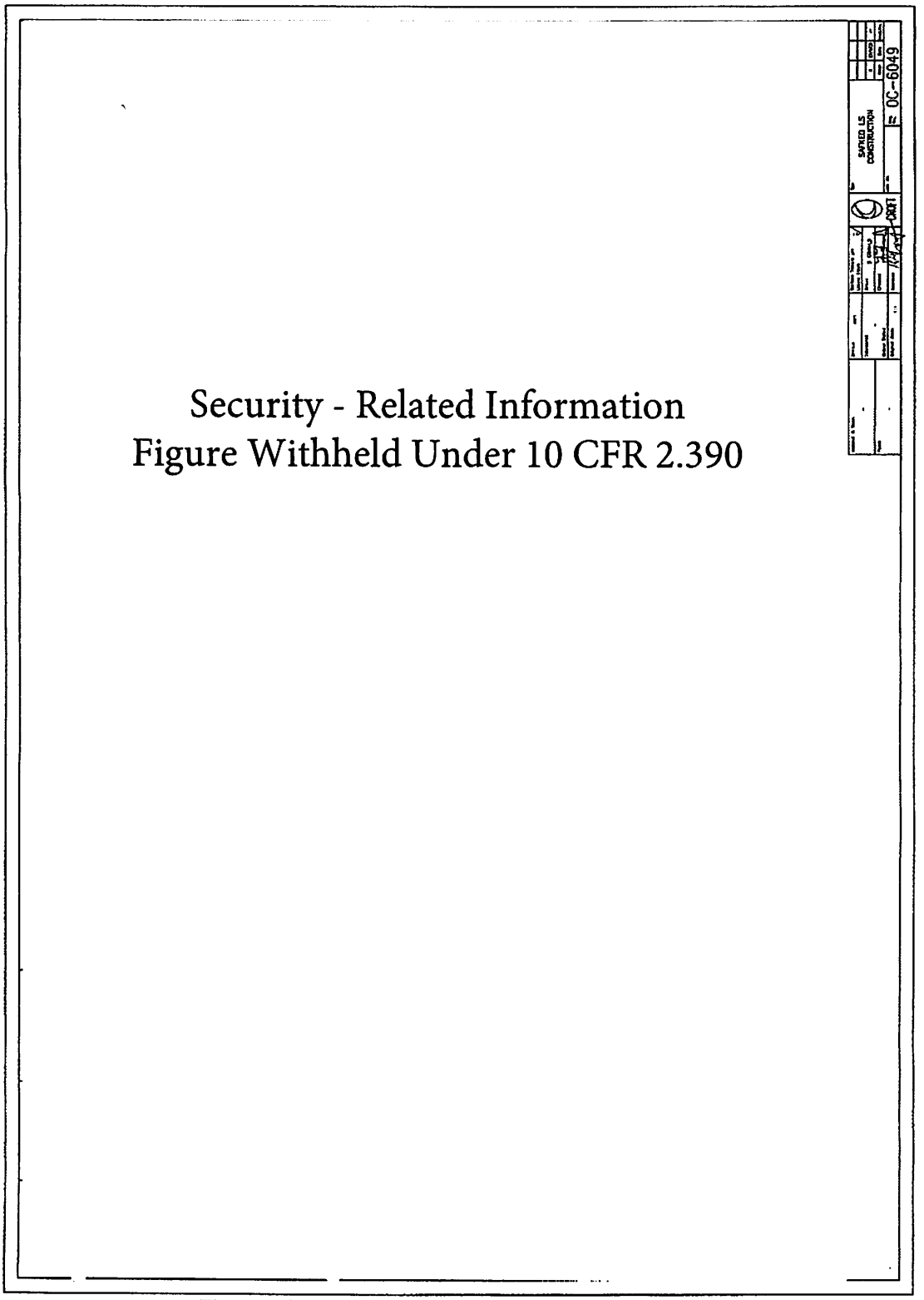


Figure 7: SAFKEG-LS 3979A PACKAGE, Design No 3979

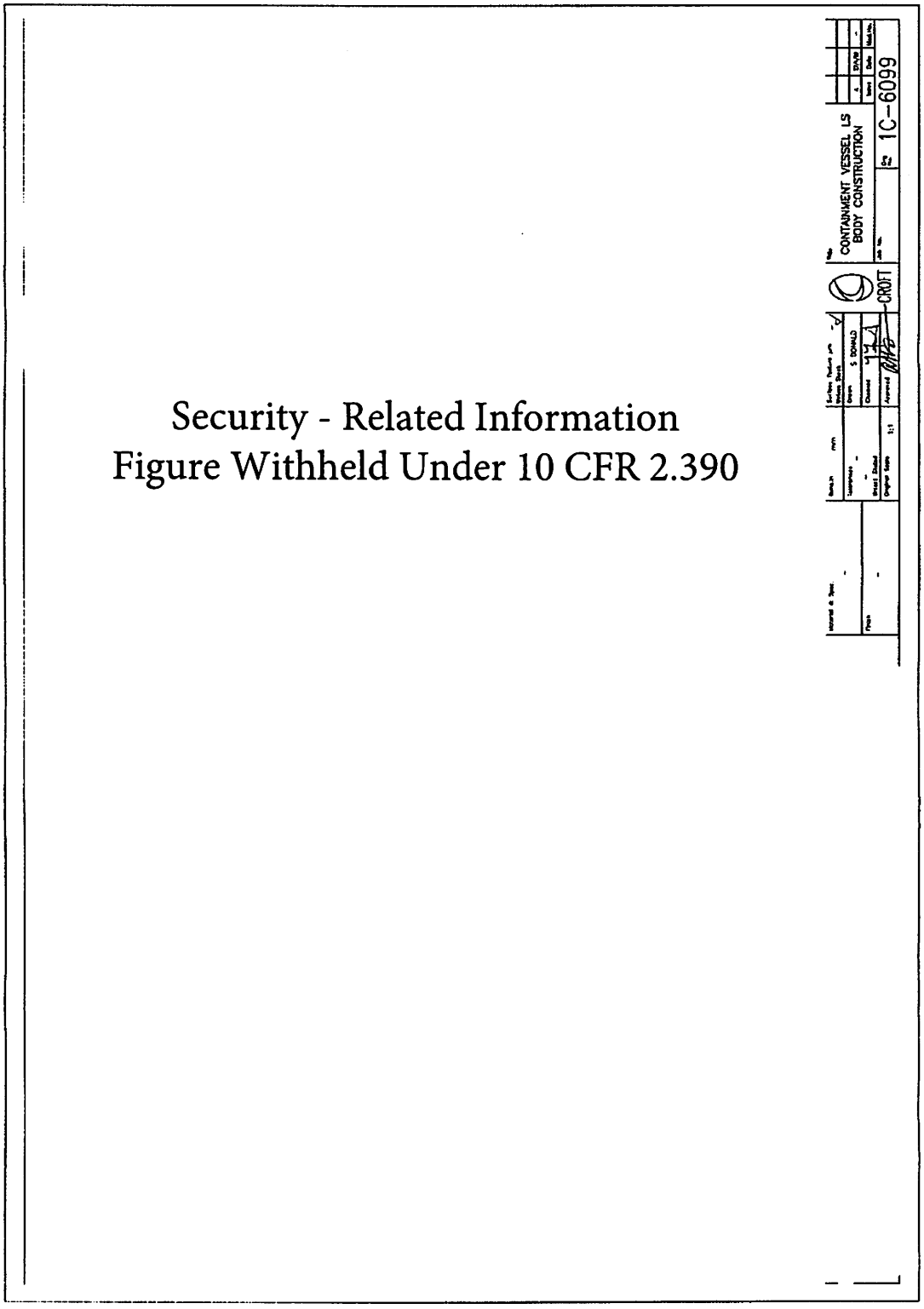


Figure 8: SAFKEG-LS 3979A PACKAGE, Containment Vessel Design No 3980

2. Shielding Assessment

2.1. Comparison with Monte Carlo Based Calculations on ^{192}Ir

The modelling performed in this assessment was validated against Monte Carlo calculations performed by Serco Assurance, using the code MCBEND. The Serco work, which is reported in reference 2, demonstrated that the worst case dose rates occur with a point source at the centre of the package base with the source at the centre of the base of CV or insert; therefore this assessment only addresses dose rates from a point source through the base of the package.

The MicroShield [3] model was initially compared with the work done by Serco in order to check the model, using a 1000 Ci point source of ^{192}Ir, with a tungsten insert (Design No 3984) located in the package cavity (as used in the Serco work [2]). The dose rates calculated by MicroShield [3] are in accordance with those calculated by Serco [2], as shown below in Table 1.

Table 1: Code Comparisons

Insert	Nuclide	Activity (Ci)	Microshield Exposure Rate mR/h	Effective Dose Equivalent (ICRP 51) mSv/h	Serco Report (Table 6 [2]) mSv/h
3984(1)	Ir-192	1000	**8.38E+03**	7.71E+01	7.72E+01
3983(1)	Ir-192	1000	**1.87E+04**	1.72E+02	1.67E+02
3986(1)	Ir-192	1000	**3.81E+05**	3.52E+03	N/A
No Insert (2)	Ir-192	1000	**4.37E+05**	4.04E+03	4.30E+03
Note					
1	Microshield model adjusted to match Serco results for Insert				
	Design No 3984 - W density reduced from 18 to 17.9				
2	Microshield model - no adjustments, default material properties used.				

2.2. Source and Shield Model

The Safkeg-LS 3979A package geometry employed in the shielding models together with the regional shield materials, the position of the measured dose rates (the detector position) and their properties are summarized in Table 2. To predict the maximum dose rates at the detector positions, a point source is assumed, positioned at the base of the cavity in contact with the inner surface of the cavity or insert. The use of a point source provides the greatest pessimism in the calculated dose rates as in reality, the sources used will consist of primary capsules or containers, with the source distributed within the container: additionally, using a point source takes no account of any self shielding from the distributed source or its container.

The source data employed in the calculations are incorporated within the libraries built into the MicroShield code[3], the gamma energy lines, probabilities and shield

build up factors are detailed within the MicroShield calculations for each nuclide: these calculations are provided in Appendix C.

Table 2: Shield regions and detector positions through base of package (input data)

Shield	Nomenclature	Without Insert (cm)	3983 (cm)	3984 (cm)	Material/ Regional Density (g/cm^3)	3986 (cm)	Material/ Regional Density (g/cm^3)	Comment	Drawing Reference
Source		Point						Positioned at the centerline on the base	
1	Insert	0	1.52	1.92	W/17.9	0.18	Fe/7.86		2C-5889, 2C-6180 and 2C-6160
2	CV Cavity Liner	0.3	0.3	0.3	Fe/7.86	0.3	Fe/7.86		1C-6099
3	CV Shield	2.02	2.02	2.02	Pb-Sb/ 11.04	2.02	Pb-Sb/ 11.04		1C-6099
4	CV Outer Skin	0.6	0.6	0.6	Fe/7.86	0.6	Fe/7.86		1C-6099
5	3979 Cavity Liner	0.4	0.4	0.4	Fe/7.86	0.4	Fe/7.86		0C-6049
6	Cork Base	6.75	6.75	6.75	0.25	6.75	0.25		0C-6049
7	3979 Outer Skin (base)	0.4	0.4	0.4	Fe/7.86	0.4	Fe/7.86		0C-6049
	Detector #1	**10.47**	**11.99**	**12.39**		**10.65**		At packaging surface	
	Detector #2	110.47	111.99	112.39		110.65		1 meter from packaging surface	

2.3. Dose Rates from Gamma, Neutron and Bremsstrahlung Radiation

Calculations of the radiation levels at the exterior of the as built Safkeg-LS 3979A package due to gamma radiation have been carried out using the MicroShield code [3]. The results of the calculations performed and their cumulative effect, are detailed in Tables 3 to 6: a typical output from the MicroShield code is shown in Figure 9. The MicroShield calculations are listed in Appendix C.

The dose rate at the exterior surface of the package resulting from neutron radiation is estimated based upon the neutron energy, its intensity and published dose conversion factors from IAEA SS37 [4] and Cember's Health Physics text [5]: the methodology and results of these calculations are detailed in Appendix A.

The calculations show that the dose rate from spontaneous fission from ^{238}Pu and ^{240}Pu, dominate over the gamma rates given in Tables 3 to 6. The total dose rates from these nuclides, gamma plus neutron are shown in Table 7.

A few of the nuclides carried are either pure beta emitters or emit bremsstrahlung radiation. The MicroShield code does not assess beta or x-ray radiation directly. However, Cember's Health Physics text [5] provides equations for estimating the photon flux from bremsstrahlung radiation and this can be imported into MicroShield, together with the beta energy line, to predict a worst case dose rate. The approach used and the results of the MicroShield calculations are detailed in Appendix B. These results are not used for Bi-210 as shielding measurements carried out on the Bi210/Po-210 target demonstrated that these calculations were a factor of 1000 greater than measurements taken [6]. Therefore the results from these calculations have been reduced by a factor of 1000 for the surface dose limit of Bi-210 given in table 5.

MicroShield 7.02
Croft (7.02-0000)

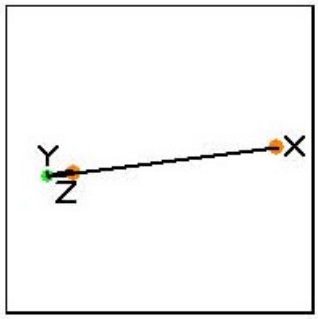
Date	By	Checked

Filename	Run Date	Run Time	Duration
LS-3979A-Base with 3983 Insert-As-77.ms7	June 15, 2009	08:50:40	00:00:00

Project Info	
Case Title	LS 3979A
Description	Base Shielding, point source with 3983 Insert
Geometry	1 - Point

Dose Points			
A	X	Y	Z
#1	11.99 cm (4.7 in)	0.0 cm (0.0 in)	0.0 cm (0.0 in)
#2	111.99 cm (3 ft 8.1 in)	0.0 cm (0.0 in)	0.0 cm (0.0 in)

Shields			
Shield N	Dimension	Material	Density
Shield 1	1.52 cm	Tungsten	17.9
Shield 2	.3 cm	Iron	7.86
Shield 3	2.02 cm	Lead	11.04
Shield 4	.6 cm	Iron	7.86
Shield 5	.4 cm	Iron	7.86
Shield 6	6.75 cm	Cork	0.25
Shield 7	.4 cm	Iron	7.86
Air Gap		Air	0.00122



Source Input: Grouping Method - Actual Photon Energies		
Nuclide	Ci	Bq
As-77	1.0000e+000	3.7000e+010

Buildup: The material reference is Shield 3
Integration Parameters

Results - Dose Point # 1 - (11.99,0,0) cm					
Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0879	7.552e+07	3.303e-86	4.279e-23	5.096e-89	6.602e-26
0.1619	4.705e+07	3.310e-28	6.191e-23	5.557e-31	1.039e-25
0.239	5.809e+08	1.859e-08	2.722e-08	3.403e-11	4.981e-11
0.2455	3.521e+07	5.868e-09	8.611e-09	1.079e-11	1.584e-11
0.2498	1.568e+08	7.121e-08	1.047e-07	1.314e-10	1.932e-10
0.5207	2.266e+08	2.599e+01	5.182e+01	5.101e-02	1.017e-01
Totals	**1.122e+09**	**2.599e+01**	**5.182e+01**	**5.101e-02**	**1.017e-01**

Results - Dose Point # 2 - (111.99,0,0) cm					
Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0879	7.552e+07	3.714e-88	4.905e-25	5.730e-91	7.568e-28
0.1619	4.705e+07	3.734e-30	7.097e-25	6.269e-33	1.191e-27
0.239	5.809e+08	2.101e-10	3.077e-10	3.846e-13	5.630e-13
0.2455	3.521e+07	6.634e-11	9.734e-11	1.220e-13	1.790e-13

Figure 9: MicroShield Output (Example)

Table 3: Insert Design No 3983 – Surface and 1m Dose Rates from gamma and bremsstrahlung

Nuclide	Microshield File Ref.	Original Activity, Bq	Dose Pt: 1.Surface	Exposure Rate, mR/hr + Buildup	Effective Dose Equivalent Rate, mSv/h	Dose Pt: 2. 1m from Surface	Exposure Rate, mR/hr + Buildup
Insert:	3983						
Ac-225	LS-3979A-Base with 3983 Insert-Ac-225.ms7	3.70E+10	1	9.94E+01	8.86E-01	2	1.13E+00
Ac-227	LS-3979A-Base with 3983 Insert-Ac-227.ms7	3.70E+10	1	1.74E+01	1.58E-01	2	1.98E-01
Ac-228	LS-3979A-Base with 3983 Insert-Ac-228.ms7	3.70E+10	1	1.20E+03	1.07E+01	2	1.37E+01
Am-241	LS-3979A-Base with 3983 Insert-Am-241.ms7	3.70E+10	1	4.14E-07	3.94E-09	2	4.69E-09
As-77	LS-3979A-Base with 3983 Insert-As-77.ms7	3.70E+10	1	1.02E-01	9.44E-04	2	1.15E-03
Au-198	LS-3979A-Base with 3983 Insert-Au-198.ms7	3.70E+10	1	6.21E+00	5.62E-02	2	7.06E-02
Ba-131	LS-3979A-Base with 3983 Insert-Ba-131.ms7	3.70E+10	1	3.19E+01	2.89E-01	2	3.63E-01
C-14	LS-3979A-Base with 3983 Insert-C-14 - Brem.ms7	3.7E+13	1	1.55E-21	1.74E-23	2	1.78E-23
Co-60	LS-3979A-Base with 3983 Insert-Co-60.ms7	3.70E+10	1	5.44E+03	4.85E+01	2	6.19E+01
Cs-131	LS-3979A-Base with 3983 Insert-Cs-131.ms7	3.70E+10	1	8.83E-23	1.63E-25	2	1.01E-24
Cs-134	LS-3979A-Base with 3983 Insert-Cs-134.ms7	3.70E+10	1	6.34E+02	5.73E+00	2	7.21E+00
Cs-137	LS-3979A-Base with 3983 Insert-Cs-137.ms7	3.70E+10	1	1.14E+02	1.04E+00	2	1.30E+00
Cu-67	LS-3979A-Base with 3983 Insert-Cu-67.ms7	3.70E+10	1	6.39E-04	6.12E-06	2	7.24E-06
Hg-203	LS-3979A-Base with 3983 Insert-Hg-203.ms7	3.70E+10	1	8.99E-06	8.96E-08	2	1.02E-07
Ho-166	LS-3979A-Base with 3983 Insert-Ho-166.ms7	3.70E+10	1	5.00E+01	4.45E-01	2	5.70E-01
I-125	LS-3979A-Base with 3983 Insert-I-125.ms7	3.70E+10	1	1.74E-22	3.03E-25	2	2.00E-24
I-129	LS-3979A-Base with 3983 Insert-I-129 - Brem.ms7	3.70E+10	1	1.65E-20	1.73E-25	2	1.89E-22
I-131	LS-3979A-Base with 3983 Insert-I-131.ms7	3.70E+10	1	1.21E+01	1.10E-01	2	1.37E-01
In-111	LS-3979A-Base with 3983 Insert-In-111.ms7	3.70E+10	1	1.52E-08	1.54E-10	2	1.72E-10
Ir-192	LS-3979A-Ir192-t0-Base with 3983 Insert.ms7	3.7E+13	1	1.87E+04	1.72E+02	2	2.12E+02
Ir-194	LS-3979A-Base with 3983 Insert-Ir-194.ms7	3.70E+10	1	4.98E+01	4.46E-01	2	5.67E-01
Kr-79	LS-3979A-Base with 3983 Insert-Kr-79.ms7	3.70E+10	1	4.10E+01	3.70E-01	2	4.67E-01
Lu-177	LS-3979A-Base with 3983 Insert-Lu-177.ms7	3.70E+10	1	4.36E-06	4.27E-08	2	4.94E-08
Mo-99	LS-3979A-Base with 3983 Insert-Mo-99.ms7	3.70E+10	1	5.34E+01	4.85E-01	2	6.07E-01
Na-24	LS-3979A-Base with 3983 Insert-Na-24.ms7	3.70E+10	1	1.46E+04	1.31E+02	2	1.66E+02
Np-237	LS-3979A-Base with 3983 Insert-Np-237.ms7	3.70E+10	1	9.00E-07	1.14E-08	2	1.03E-08
P-32	LS-3979A-Base with 3983 Insert-P-32 - Brem.ms7	3.7E+13	1	6.18E+05	5.50E+03	2	7.05E+03
P-33	LS-3979A-Base with 3983 Insert-P-33 - Brem.ms7	3.7E+13	1	7.97E-07	8.07E-09	2	9.02E-09
Pb-203	LS-3979A-Base with 3983 Insert-Pb-203.ms7	3.70E+10	1	1.10E+00	1.01E-02	2	1.25E-02
Pb-210	LS-3979A-Base with 3983 Insert-Pb-210.ms7	3.70E+10	1	4.38E-03	3.97E-05	2	4.98E-05
Pd-109	LS-3979A-Base with 3983 Insert-Pd-109.ms7	3.70E+10	1	1.74E-02	1.62E-04	2	1.97E-04
Pu-238	LS-3979A-Base with 3983 Insert-Pu-238.ms7	3.70E+10	1	4.94E-06	4.41E-08	2	5.64E-08
Pu-239	LS-3979A-Base with 3983 Insert-Pu-239.ms7	3.70E+10	1	1.56E-09	1.59E-11	2	1.77E-11
Pu-240	LS-3979A-Base with 3983 Insert-Pu-240.ms7	3.70E+10	1	3.41E-11	3.07E-13	2	3.89E-13
Pu-241	LS-3979A-Base with 3983 Insert-Pu-241.ms7	3.70E+10	1	1.06E-08	1.01E-10	2	1.20E-10
Ra-223	LS-3979A-Base with 3983 Insert-Ra-223.ms7	3.70E+10	1	1.72E+01	1.56E-01	2	1.96E-01
Ra-224	LS-3979A-Base with 3983 Insert-Ra-224.ms7	3.70E+10	1	3.36E+03	3.03E+01	2	3.84E+01
Ra-226	LS-3979A-Base with 3983 Insert-Ra-226.ms7	3.70E+10	1	3.27E+03	2.92E+01	2	3.73E+01
Re-186	LS-3979A-Base with 3983 Insert-Re-186.ms7	3.70E+10	1	1.13E-01	1.03E-03	2	1.28E-03
Re-188	LS-3979A-Base with 3983 Insert-Re-188.ms7	3.70E+10	1	2.32E+01	2.09E-01	2	2.64E-01
Rh-105	LS-3979A-Base with 3983 Insert-Rh-105.ms7	3.70E+10	1	3.24E-04	3.17E-06	2	3.67E-06
Se-75	LS-3979A-Base with 3983 Insert-Se-75.ms7	3.70E+10	1	4.58E-02	4.36E-04	2	5.19E-04
Sm-153	LS-3979A-Base with 3983 Insert-Sm-153.ms7	3.70E+10	1	2.84E-03	2.68E-05	2	3.22E-05
Sr-89	LS-3979A-Base with 3983 Insert-Sr-89.ms7	3.70E+10	1	1.24E-01	1.12E-03	2	1.41E-03
Sr-90	LS-3979A-Base with 3983 Insert-Sr-90 - Brem.ms7	3.7E+13	1	1.16E+03	1.07E+01	2	1.32E+01
Tb-161	LS-3979A-Base with 3983 Insert-Tb-161.ms7	3.70E+10	1	2.69E-02	2.47E-04	2	3.05E-04
Th-227	LS-3979A-Base with 3983 Insert-Th-227.ms7	3.70E+10	1	8.12E+00	7.36E-02	2	9.24E-02
Th-228	LS-3979A-Base with 3983 Insert-Th-228.ms7	3.70E+10	1	4.41E+03	3.98E+01	2	5.04E+01
Tl-201	LS-3979A-Base with 3983 Insert-Tl-201.ms7	3.70E+10	1	6.12E-18	7.13E-20	2	7.01E-20
U-235	LS-3979A-Base with 3983 Insert-U-235.ms7	3.70E+10	1	2.60E-02	2.36E-04	2	2.96E-04
W-187	LS-3979A-Base with 3983 Insert-W-187.ms7	3.70E+10	1	8.01E+01	7.30E-01	2	9.10E-01
W-188	LS-3979A-Base with 3983 Insert-W-188.ms7	3.70E+10	1	2.21E+01	1.99E-01	2	2.52E-01
Xe-133	LS-3979A-Base with 3983 Insert-Xe-133.ms7	3.70E+10	1	6.96E-23	2.58E-25	2	7.98E-25
Y-90	LS-3979A-Base with 3983 Insert-Y-90 - Brem.ms7	3.7E+13	1	1.29E+06	1.16E+04	2	1.47E+04
Yb-169	LS-3979A-Base with 3983 Insert-Yb-169.ms7	3.70E+10	1	7.93E-05	7.78E-07	2	8.98E-07
Yb-175	LS-3979A-Base with 3983 Insert-Yb-175.ms7	3.70E+10	1	2.13E-02	2.03E-04	2	2.41E-04

Table 4: Insert Design No 3984 – Surface and 1m Dose Rates from gamma and bremsstrahlung

Nuclide	Microshield File Ref.	Original Activity, Bq	Dose Pt: 1.Surface	Exposure Rate, mR/hr + Buildup	Effective Dose Equivalent Rate, mSv/h	Dose Pt: 2. 1m from Surface	Exposure Rate, mR/hr + Buildup
Insert:	3984						
Ac-225	LS-3979A-Base with 3984 Insert-Ac-225.ms7	3.70E+10	1	6.82E+01	6.08E-01	2	8.25E-01
Ac-227	LS-3979A-Base with 3984 Insert-Ac-227.ms7	3.70E+10	1	9.74E+00	8.83E-02	2	1.18E-01
Ac-228	LS-3979A-Base with 3984 Insert-Ac-228.ms7	3.70E+10	1	7.73E+02	6.92E+00	2	9.33E+00
Am-241	LS-3979A-Base with 3984 Insert-Am-241.ms7	3.70E+10	1	1.10E-07	1.05E-09	2	1.32E-09
As-77	LS-3979A-Base with 3984 Insert-As-77.ms7	3.70E+10	1	4.08E-02	3.79E-04	2	4.91E-04
Au-198	LS-3979A-Base with 3984 Insert-Au-198.ms7	3.70E+10	1	3.52E+00	3.18E-02	2	4.25E-02
Ba-131	LS-3979A-Base with 3984 Insert-Ba-131.ms7	3.70E+10	1	1.81E+01	1.64E-01	2	2.19E-01
C-14	LS-3979A-Base with 3984 Insert-C-14 - Brem.ms7	3.7E+13	1	1.45E-21	1.63E-23	2	1.76E-23
Co-60	LS-3979A-Base with 3984 Insert-Co-60.ms7	3.70E+10	1	3.63E+03	3.24E+01	2	4.39E+01
Cs-131	LS-3979A-Base with 3984 Insert-Cs-131.ms7	3.70E+10	1	8.27E-23	1.53E-25	2	1.01E-24
Cs-134	LS-3979A-Base with 3984 Insert-Cs-134.ms7	3.70E+10	1	3.65E+02	3.30E+00	2	4.41E+00
Cs-137	LS-3979A-Base with 3984 Insert-Cs-137.ms7	3.70E+10	1	5.72E+01	5.22E-01	2	6.89E-01
Cu-67	LS-3979A-Base with 3984 Insert-Cu-67.ms7	3.70E+10	1	1.69E-04	1.63E-06	2	2.03E-06
Hg-203	LS-3979A-Base with 3984 Insert-Hg-203.ms7	3.70E+10	1	6.98E-07	6.95E-09	2	8.37E-09
Ho-166	LS-3979A-Base with 3984 Insert-Ho-166.ms7	3.70E+10	1	3.44E+01	3.06E-01	2	4.16E-01
I-125	LS-3979A-Base with 3984 Insert-I-125.ms7	3.70E+10	1	1.63E-22	2.84E-25	2	1.98E-24
I-129	LS-3979A-Base with 3984 Insert-I-129 - Brem.ms7	3.70E+10	1	1.54E-20	1.62E-25	2	1.87E-22
I-131	LS-3979A-Base with 3984 Insert-I-131.ms7	3.70E+10	1	6.04E+00	5.52E-02	2	7.28E-02
In-111	LS-3979A-Base with 3984 Insert-In-111.ms7	3.70E+10	1	5.30E-10	5.38E-12	2	6.36E-12
Ir-192	LS-3979A-Ir192-t0-Base with 3984 Insert.ms7	3.7E+13	1	8.38E+03	7.71E+01	2	1.01E+02
Ir-194	LS-3979A-Base with 3984 Insert-Ir-194.ms7	3.70E+10	1	3.21E+01	2.87E-01	2	3.87E-01
Kr-79	LS-3979A-Base with 3984 Insert-Kr-79.ms7	3.70E+10	1	2.46E+01	2.22E-01	2	2.97E-01
Lu-177	LS-3979A-Base with 3984 Insert-Lu-177.ms7	3.70E+10	1	6.25E-07	6.11E-09	2	7.50E-09
Mo-99	LS-3979A-Base with 3984 Insert-Mo-99.ms7	3.70E+10	1	2.90E+01	2.64E-01	2	3.50E-01
Na-24	LS-3979A-Base with 3984 Insert-Na-24.ms7	3.70E+10	1	1.06E+04	9.48E+01	2	1.28E+02
Np-237	LS-3979A-Base with 3984 Insert-Np-237.ms7	3.70E+10	1	8.42E-07	1.07E-08	2	1.02E-08
P-32	LS-3979A-Base with 3984 Insert-P-32 - Brem.ms7	3.7E+13	1	4.39E+05	3.90E+03	2	5.31E+03
P-33	LS-3979A-Base with 3984 Insert-P-33 - Brem.ms7	3.7E+13	1	3.09E-08	3.13E-10	2	3.70E-10
Pb-203	LS-3979A-Base with 3984 Insert-Pb-203.ms7	3.70E+10	1	5.60E-01	5.11E-03	2	6.75E-03
Pb-210	LS-3979A-Base with 3984 Insert-Pb-210.ms7	3.70E+10	1	2.47E-03	2.24E-05	2	2.98E-05
Pd-109	LS-3979A-Base with 3984 Insert-Pd-109.ms7	3.70E+10	1	6.79E-03	6.32E-05	2	8.17E-05
Pu-238	LS-3979A-Base with 3984 Insert-Pu-238.ms7	3.70E+10	1	3.46E-06	3.09E-08	2	4.18E-08
Pu-239	LS-3979A-Base with 3984 Insert-Pu-239.ms7	3.70E+10	1	1.07E-09	1.14E-11	2	1.30E-11
Pu-240	LS-3979A-Base with 3984 Insert-Pu-240.ms7	3.70E+10	1	2.44E-11	2.19E-13	2	2.95E-13
Pu-241	LS-3979A-Base with 3984 Insert-Pu-241.ms7	3.70E+10	1	2.80E-09	2.67E-11	2	3.37E-11
Ra-223	LS-3979A-Base with 3984 Insert-Ra-223.ms7	3.70E+10	1	9.65E+00	8.75E-02	2	1.16E-01
Ra-224	LS-3979A-Base with 3984 Insert-Ra-224.ms7	3.70E+10	1	2.47E+03	2.22E+01	2	2.99E+01
Ra-226	LS-3979A-Base with 3984 Insert-Ra-226.ms7	3.70E+10	1	2.29E+03	2.04E+01	2	2.77E+01
Re-186	LS-3979A-Base with 3984 Insert-Re-186.ms7	3.70E+10	1	5.87E-02	5.35E-04	2	7.07E-04
Re-188	LS-3979A-Base with 3984 Insert-Re-188.ms7	3.70E+10	1	1.44E+01	1.29E-01	2	1.73E-01
Rh-105	LS-3979A-Base with 3984 Insert-Rh-105.ms7	3.70E+10	1	4.47E-05	4.38E-07	2	5.37E-07
Se-75	LS-3979A-Base with 3984 Insert-Se-75.ms7	3.70E+10	1	1.22E-02	1.16E-04	2	1.46E-04
Sm-153	LS-3979A-Base with 3984 Insert-Sm-153.ms7	3.70E+10	1	8.38E-04	7.93E-06	2	1.01E-05
Sr-89	LS-3979A-Base with 3984 Insert-Sr-89.ms7	3.70E+10	1	7.39E-02	6.66E-04	2	8.91E-04
Sr-90	LS-3979A-Base with 3984 Insert-Sr-90 - Brem.ms7	3.7E+13	1	4.95E+02	4.58E+00	2	5.95E+00
Tb-161	LS-3979A-Base with 3984 Insert-Tb-161.ms7	3.70E+10	1	1.23E-02	1.13E-04	2	1.48E-04
Th-227	LS-3979A-Base with 3984 Insert-Th-227.ms7	3.70E+10	1	4.55E+00	4.13E-02	2	5.49E-02
Th-228	LS-3979A-Base with 3984 Insert-Th-228.ms7	3.70E+10	1	3.24E+03	2.92E+01	2	3.92E+01
Tl-201	LS-3979A-Base with 3984 Insert-Tl-201.ms7	3.70E+10	1	5.73E-18	6.68E-20	2	6.96E-20
U-235	LS-3979A-Base with 3984 Insert-U-235.ms7	3.70E+10	1	1.46E-02	1.32E-04	2	1.76E-04
W-187	LS-3979A-Base with 3984 Insert-W-187.ms7	3.70E+10	1	4.14E+01	3.77E-01	2	4.98E-01
W-188	LS-3979A-Base with 3984 Insert-W-188.ms7	3.70E+10	1	1.37E+01	1.23E-01	2	1.65E-01
Xe-133	LS-3979A-Base with 3984 Insert-Xe-133.ms7	3.70E+10	1	6.43E-23	2.32E-25	2	7.81E-25
Y-90	LS-3979A-Base with 3984 Insert-Y-90 - Brem.ms7	3.7E+13	1	9.45E+05	8.45E+03	2	1.14E+04
Yb-169	LS-3979A-Base with 3984 Insert-Yb-169.ms7	3.70E+10	1	1.16E-05	1.15E-07	2	1.39E-07
Yb-175	LS-3979A-Base with 3984 Insert-Yb-175.ms7	3.70E+10	1	5.52E-03	5.26E-05	2	6.63E-05

Table 5: Insert Design No 3986 – Surface and 1m Dose Rates from gamma and bremsstrahlung

Nuclide	Microshield File Ref.	Original Activity, Bq	Dose Pt: 1.Surface	Exposure Rate, mR/hr + Buildup	Effective Dose Equivalent Rate, mSv/h	Dose Pt: 2. 1m from Surface	Exposure Rate, mR/hr + Buildup
Insert:	3986						
Ac-225	LS-3979A-Base with 3986 Insert-Ac-225.ms7	3.70E+10	1	3.98E+02	3.56E+00	2	3.67E+00
Ac-227	LS-3979A-Base with 3986 Insert-Ac-227.ms7	3.70E+10	1	1.51E+02	1.37E+00	2	1.38E+00
Ac-228	LS-3979A-Base with 3986 Insert-Ac-228.ms7	3.70E+10	1	5.85E+03	5.25E+01	2	5.39E+01
Am-241	LS-3979A-Base with 3986 Insert-Am-241.ms7	3.70E+10	1	6.54E-05	6.26E-07	2	5.99E-07
As-77	LS-3979A-Base with 3986 Insert-As-77.ms7	3.70E+10	1	2.79E+00	2.59E-02	2	2.56E-02
Au-198	LS-3979A-Base with 3986 Insert-Au-198.ms7	3.70E+10	1	1.04E+02	9.72E-01	2	9.57E-01
Ba-131	LS-3979A-Base with 3986 Insert-Ba-131.ms7	3.70E+10	1	3.49E+02	3.20E+00	2	3.20E+00
Bi-210	LS-3979A-Base with 3986 Insert-Bi-210.msd	3.70E+10	1	3.02E+03	2.70E+00	2	2.78E+03
C-14	LS-3979A-Base with 3986 Insert-C-14 - Brem.ms7	3.7E+13	1	4.49E-14	5.03E-16	2	4.10E-16
Co-60	LS-3979A-Base with 3986 Insert-Co-60.ms7	3.70E+10	1	2.25E+04	2.01E+02	2	2.08E+02
Cs-131	LS-3979A-Base with 3986 Insert-Cs-131.ms7	3.70E+10	1	1.12E-22	2.06E-25	2	1.04E-24
Cs-134	LS-3979A-Base with 3986 Insert-Cs-134.ms7	3.70E+10	1	5.05E+03	4.58E+01	2	4.64E+01
Cs-137	LS-3979A-Base with 3986 Insert-Cs-137.ms7	3.70E+10	1	1.38E+03	1.26E+01	2	1.27E+01
Cu-67	LS-3979A-Base with 3986 Insert-Cu-67.ms7	3.70E+10	1	1.01E-01	9.65E-04	2	9.25E-04
Hg-203	LS-3979A-Base with 3986 Insert-Hg-203.ms7	3.70E+10	1	1.23E-01	1.23E-03	2	1.13E-03
Ho-166	LS-3979A-Base with 3986 Insert-Ho-166.ms7	3.70E+10	1	1.86E+02	1.66E+00	2	1.72E+00
I-125	LS-3979A-Base with 3986 Insert-I-125.ms7	3.70E+10	1	2.21E-22	3.84E-25	2	2.04E-24
I-129	LS-3979A-Base with 3986 Insert-I-129 - Brem.ms7	3.70E+10	1	3.11E-15	2.19E-25	2	2.84E-17
I-131	LS-3979A-Base with 3986 Insert-I-131.ms7	3.70E+10	1	1.60E+02	1.47E+00	2	1.47E+00
In-111	LS-3979A-Base with 3986 Insert-In-111.ms7	3.70E+10	1	4.29E-03	4.35E-05	2	3.92E-05
Ir-192	LS-3979A-Ir192-t0-Base with 3986 Insert.ms7	3.7E+13	1	3.81E+05	3.52E+03	2	3.49E+03
Ir-194	LS-3979A-Base with 3986 Insert-Ir-194.ms7	3.70E+10	1	2.46E+02	2.21E+00	2	2.27E+00
Kr-79	LS-3979A-Base with 3986 Insert-Kr-79.ms7	3.70E+10	1	3.27E+02	2.98E+00	2	3.00E+00
Lu-177	LS-3979A-Base with 3986 Insert-Lu-177.ms7	3.70E+10	1	5.88E-03	5.75E-05	2	5.38E-05
Mo-99	LS-3979A-Base with 3986 Insert-Mo-99.ms7	3.70E+10	1	4.78E+02	4.34E+00	2	4.39E+00
Na-24	LS-3979A-Base with 3986 Insert-Na-24.ms7	3.70E+10	1	4.61E+04	4.13E+02	2	4.25E+02
Np-237	LS-3979A-Base with 3986 Insert-Np-237.ms7	3.70E+10	1	1.17E-06	1.48E-08	2	1.08E-08
P-32	LS-3979A-Base with 3986 Insert-P-32 - Brem.ms7	3.7E+13	1	3.76E+05	3.36E+03	2	3.46E+03
P-33	LS-3979A-Base with 3986 Insert-P-33 - Brem.ms7	3.7E+13	1	5.33E-02	5.39E-04	2	4.87E-04
Pb-203	LS-3979A-Base with 3986 Insert-Pb-203.ms7	3.70E+10	1	1.42E+01	1.30E-01	2	1.30E-01
Pb-210	LS-3979A-Base with 3986 Insert-Pb-210.ms7	3.70E+10	1	3.42E-02	3.10E-04	2	3.14E-04
Pd-109	LS-3979A-Base with 3986 Insert-Pd-109.ms7	3.70E+10	1	5.30E-01	4.93E-03	2	4.86E-03
Po-210	LS-3979A-Base with 3986 Insert-Po-210.msd	3.70E+10	1	4.14E-02	3.76E-04	2	3.81E-04
Pu-239	LS-3979A-Base with 3986 Insert-Pu-239.ms7	3.70E+10	1	9.58E-09	8.96E-11	2	8.81E-11
Pu-240	LS-3979A-Base with 3986 Insert-Pu-240.ms7	3.70E+10	1	1.19E-10	1.08E-12	2	1.10E-12
Pu-241	LS-3979A-Base with 3986 Insert-Pu-241.ms7	3.70E+10	1	1.78E-06	1.71E-08	2	1.63E-08
Ra-223	LS-3979A-Base with 3986 Insert-Ra-223.ms7	3.70E+10	1	1.49E+02	1.36E+00	2	1.37E+00
Ra-224	LS-3979A-Base with 3986 Insert-Ra-224.ms7	3.70E+10	1	1.05E+04	9.45E+01	2	9.67E+01
Ra-226	LS-3979A-Base with 3986 Insert-Ra-226.ms7	3.70E+10	1	1.22E+04	1.09E+02	2	1.12E+02
Re-186	LS-3979A-Base with 3986 Insert-Re-186.ms7	3.70E+10	1	1.17E+00	1.07E-02	2	1.08E-02
Re-188	LS-3979A-Base with 3986 Insert-Re-188.ms7	3.70E+10	1	1.36E+02	1.23E+00	2	1.25E+00
Rh-105	LS-3979A-Base with 3986 Insert-Rh-105.ms7	3.70E+10	1	5.10E-01	4.99E-03	2	4.67E-03
Se-75	LS-3979A-Base with 3986 Insert-Se-75.ms7	3.70E+10	1	6.06E+00	5.77E-02	2	5.55E-02
Sm-153	LS-3979A-Base with 3986 Insert-Sm-153.ms7	3.70E+10	1	2.48E-01	2.35E-03	2	2.27E-03
Sr-89	LS-3979A-Base with 3986 Insert-Sr-89.ms7	3.70E+10	1	7.76E-01	6.99E-03	2	7.14E-03
Sr-90	LS-3979A-Base with 3986 Insert-Sr-90 - Brem.ms7	3.7E+13	1	8.95E+03	8.28E+01	2	8.22E+01
Tb-161	LS-3979A-Base with 3986 Insert-Tb-161.ms7	3.70E+10	1	4.74E-01	4.37E-03	2	4.35E-03
Th-227	LS-3979A-Base with 3986 Insert-Th-227.ms7	3.70E+10	1	7.04E+01	6.41E-01	2	6.47E-01
Th-228	LS-3979A-Base with 3986 Insert-Th-228.ms7	3.70E+10	1	1.38E+04	1.24E+02	2	1.27E+02
Tl-201	LS-3979A-Base with 3986 Insert-Tl-201.ms7	3.70E+10	1	5.82E-13	6.39E-15	2	5.31E-15
U-235	LS-3979A-Base with 3986 Insert-U-235.ms7	3.70E+10	1	2.26E-01	2.06E-03	2	2.08E-03
W-187	LS-3979A-Base with 3986 Insert-W-187.ms7	3.70E+10	1	9.12E+02	8.34E+00	2	8.38E+00
W-188	LS-3979A-Base with 3986 Insert-W-188.ms7	3.70E+10	1	1.30E+02	1.17E+00	2	1.20E+00
Xe-133	LS-3979A-Base with 3986 Insert-Xe-133.ms7	3.70E+10	1	4.25E-13	4.60E-15	2	3.88E-15
Y-90	LS-3979A-Base with 3986 Insert-Y-90 - Brem.ms7	3.7E+13	1	1.37E+06	1.23E+04	2	1.27E+04
Yb-169	LS-3979A-Base with 3986 Insert-Yb-169.ms7	3.70E+10	1	1.49E-01	1.46E-03	2	1.36E-03
Yb-175	LS-3979A-Base with 3986 Insert-Yb-175.ms7	3.70E+10	1	3.03E+00	2.89E-02	2	2.78E-02

Table 6: Without Inserts – Surface and 1m Dose Rates from gamma and bremsstrahlung

Nuclide	Microshield File Ref.	Original Activity, Bq	Dose Pt: 1.Surface	Exposure Rate, mR/hr + Buildup	Effective Dose Equivalent Rate, mSv/h	Dose Pt: 2. 1m from Surface	Exposure Rate, mR/hr + Buildup
Insert:	No Insert						
Ac-225	LS-3979A-Base withou Insert-Ac-227.ms7	3.70E+10	1	1.79E+02	3.92E+00	2	1.60E+00
Ac-227	LS-3979A-Base without Insert-Ac-225.ms7	3.70E+10	1	4.38E+02	1.63E+00	2	3.92E+00
Ac-228	LS-3979A-Base without Insert-Ac-228.ms7	3.70E+10	1	6.49E+03	7.38E-07	2	5.79E+01
Am-241	LS-3979A-Base without Insert-Am-241.ms7	3.70E+10	1	7.70E-05	5.32E-05	2	6.84E-07
As-77	LS-3979A-Base without Insert-As-77.ms7	3.70E+10	1	3.22E+00	5.82E+01	2	2.86E-02
Au-198	LS-3979A-Base without Insert-Au-198.ms7	3.70E+10	1	1.20E+02	2.99E-02	2	1.07E+00
Ba-131	LS-3979A-Base without Insert-Ba-131.ms7	3.70E+10	1	3.97E+02	1.12E+00	2	3.54E+00
C-14	LS-3979A-Base without Insert-C-14 - Brem.ms7	3.7E+13	1	5.94E-14	6.65E-16	2	5.25E-16
Co-60	LS-3979A-Base without Insert-Co-60.ms7	3.70E+10	1	2.48E+04	3.65E+00	2	2.21E+02
Cs-131	LS-3979A-Base without Insert-Cs-131.ms7	3.70E+10	1	1.16E-22	2.21E+02	2	1.04E-24
Cs-134	LS-3979A-Base without Insert-Cs-134.ms7	3.70E+10	1	5.68E+03	2.14E-25	2	5.07E+01
Cs-137	LS-3979A-Base without Insert-Cs-137.ms7	3.70E+10	1	1.57E+03	5.16E+01	2	1.40E+01
Cu-67	LS-3979A-Base without Insert-Cu-67.ms7	3.70E+10	1	1.19E-01	1.44E+01	2	1.06E-03
Hg-203	LS-3979A-Base without Insert-Hg-203.ms7	3.70E+10	1	1.49E-01	1.14E-03	2	1.32E-03
Ho-166	LS-3979A-Base without Insert-Ho-166.ms7	3.70E+10	1	2.04E+02	1.48E-03	2	1.82E+00
I-125	LS-3979A-Base without Insert-I-125.ms7	3.70E+10	1	2.28E-22	1.82E+00	2	2.05E-24
I-129	LS-3979A-Base without Insert-I-129 - Brem.ms7	3.70E+10	1	4.09E-15	3.98E-25	2	3.62E-17
I-131	LS-3979A-Base without Insert-I-131.ms7	3.70E+10	1	1.83E+02	2.27E-25	2	1.63E+00
In-111	LS-3979A-Base without Insert-In-111.ms7	3.70E+10	1	5.25E-03	1.68E+00	2	4.65E-05
Ir-192	LS-3979A-Ir192-t0-Base without Insert.ms7	3.7E+13	1	4.37E+05	4.04E+03	2	3.89E+03
Ir-194	LS-3979A-Base without Insert-Ir-194.ms7	3.70E+10	1	2.73E+02	2.45E+00	2	2.44E+00
Kr-79	LS-3979A-Base without Insert-Kr-79.ms7	3.70E+10	1	3.69E+02	3.36E+00	2	3.29E+00
Lu-177	LS-3979A-Base without Insert-Lu-177.ms7	3.70E+10	1	7.02E-03	6.86E-05	2	6.22E-05
Mo-99	LS-3979A-Base without Insert-Mo-99.ms7	3.70E+10	1	5.40E+02	4.90E+00	2	4.81E+00
Na-24	LS-3979A-Base without Insert-Na-24.ms7	3.70E+10	1	4.99E+04	4.48E+02	2	4.47E+02
Np-237	LS-3979A-Base without Insert-Np-237.ms7	3.70E+10	1	1.22E-06	1.53E-08	2	1.09E-08
P-32	LS-3979A-Base without Insert-P-32 - Brem.ms7	3.7E+13	1	7.91E+05	7.04E+03	2	7.07E+03
P-33	LS-3979A-Base without Insert-P-33 - Brem.ms7	3.7E+13	1	6.51E-02	6.59E-04	2	5.77E-04
Pb-203	LS-3979A-Base without Insert-Pb-203.ms7	3.70E+10	1	1.61E+01	1.48E-01	2	1.44E-01
Pb-210	LS-3979A-Base without Insert-Pb-210.ms7	3.70E+10	1	3.84E-02	3.48E-04	2	3.42E-04
Pd-109	LS-3979A-Base without Insert-Pd-109.ms7	3.70E+10	1	6.12E-01	5.69E-03	2	5.44E-03
Pu-238	LS-3979A-Base without Insert-Pu-238.ms7	3.70E+10	1	2.01E-05	1.80E-07	2	1.80E-07
Pu-239	LS-3979A-Base without Insert-Pu-239.ms7	3.70E+10	1	1.08E-08	1.00E-10	2	9.59E-11
Pu-240	LS-3979A-Base without Insert-Pu-240.ms7	3.70E+10	1	1.30E-10	1.17E-12	2	1.16E-12
Pu-241	LS-3979A-Base without Insert-Pu-241.ms7	3.70E+10	1	2.10E-06	2.02E-08	2	1.87E-08
Ra-223	LS-3979A-Base without Insert-Ra-223.ms7	3.70E+10	1	1.68E+02	1.53E+00	2	1.50E+00
Ra-224	LS-3979A-Base without Insert-Ra-224.ms7	3.70E+10	1	1.13E+04	1.02E+02	2	1.01E+02
Ra-226	LS-3979A-Base without Insert-Ra-226.ms7	3.70E+10	1	1.33E+04	1.19E+02	2	1.19E+02
Re-186	LS-3979A-Base without Insert-Re-186.ms7	3.70E+10	1	1.33E+00	1.21E-02	2	1.18E-02
Re-188	LS-3979A-Base without Insert-Re-188.ms7	3.70E+10	1	1.52E+02	1.37E+00	2	1.36E+00
Rh-105	LS-3979A-Base without Insert-Rh-105.ms7	3.70E+10	1	6.09E-01	5.97E-03	2	5.40E-03
Se-75	LS-3979A-Base without Insert-Se-75.ms7	3.70E+10	1	7.11E+00	6.77E-02	2	6.32E-02
Sm-153	LS-3979A-Base without Insert-Sm-153.ms7	3.70E+10	1	2.90E-01	2.74E-03	2	2.58E-03
Sr-89	LS-3979A-Base without Insert-Sr-89.ms7	3.70E+10	1	8.66E-01	7.81E-03	2	7.73E-03
Sr-90	LS-3979A-Base without Insert-Sr-90 - Brem.ms7	3.7E+13	1	1.03E+04	9.52E+01	2	9.16E+01
Tb-161	LS-3979A-Base without Insert-Tb-161.ms7	3.70E+10	1	5.44E-01	5.01E-03	2	4.84E-03
Th-227	LS-3979A-Base without Insert-Th-227.ms7	3.70E+10	1	7.95E+01	7.24E-01	2	7.08E-01
Th-228	LS-3979A-Base without Insert-Th-228.ms7	3.70E+10	1	1.49E+04	1.34E+02	2	1.33E+02
Tl-201	LS-3979A-Base without Insert-Tl-201.ms7	3.70E+10	1	7.58E-13	8.32E-15	2	6.70E-15
U-235	LS-3979A-Base without Insert-U-235.ms7	3.70E+10	1	2.55E-01	2.32E-03	2	2.27E-03
W-187	LS-3979A-Base without Insert-W-187.ms7	3.70E+10	1	1.04E+03	9.47E+00	2	9.23E+00
W-188	LS-3979A-Base without Insert-W-188.ms7	3.70E+10	1	1.45E+02	1.31E+00	2	1.29E+00
Xe-133	LS-3979A-Base without Insert-Xe-133.ms7	3.70E+10	1	5.46E-13	5.90E-15	2	4.83E-15
Y-90	LS-3979A-Base without Insert-Y-90 - Brem.ms7	3.7E+13	1	1.49E+06	1.33E+04	2	1.33E+04
Yb-169	LS-3979A-Base without Insert-Yb-169.ms7	3.70E+10	1	1.78E-01	1.75E-03	2	1.58E-03
Yb-175	LS-3979A-Base without Insert-Yb-175.ms7	3.70E+10	1	3.56E+00	3.40E-02	2	3.17E-02

Table 7: Summation of Gamma and Neutron Dose Rates

Nuclide	Original Activity, Bq, gamma	Effective Dose Equivalent Rate, mSv/h, gamma	Dose rate at neutron Activity	Neutron Activity, Bq	Neutron Dose Rate, surface, mSv/h	Neutron+ gamma	Package Limit, Bq
Pu-238	3.70E+10	4.41E-08	3.57E-04	2.99E+14	2	2.00E+00	2.99E+14
Pu-240	3.70E+10	3.07E-13	9.54E-11	1.15E+13	2	2.00E+00	1.15E+13

3. References

1. Title 10, Code of Federal Regulations, Part 71, Office of the Federal Register, Washington, DC, 2009
2. Serco Assurance, SERCO/TAS/003191/001 Issue 1, *Monte Carlo Modelling of Safkeg LS*
3. Grove Software Inc, MicroShield v7.02, *Radiation Shielding Software Container*, June 2009
4. Advisory Material for the IAEA *Regulations for the Safe Transport of Radioactive Material* (1985 Edition, as Amended 1990), IAEA Safety Series No. 37
5. *Introduction to Health Physics*, Herman Cember, Third Edition, McGraw-Hill
6. Bismuth-Polonium Activities and Measurements, MU Research Reactor, 26 March 2015

Appendix A Neutron Dose Calculations

Appendix A Table 1: Package without an Insert

No Insert

3979 radius, r =	10.47	cm	- distance from source centre to measurement position
Surface area =	1377.536856	cm2	- assuming a spherical source, to determine the neutron flux after a NCT damage at radius, r (cm)

A	B	C	D	E	F	G	H	I	J	K	L	
Nuclide	Element	Package Limits (Surface Transport)		Neutron emission/ transformation, SF-n (ICRP 38, 1983 [1])	MeV	Total Netrons per sec, n/s (C x E)	Neutron Flux, n/s/cm2 (G/Surface area)	SS37 [2] Conversion factor from Table A-I (cm-2.s-1 per uSv/h)	Cember [3], Table 9.5,Fluence rate producing 1mSv in 40h	Dose Rate based on I, mSv/h (H x I/1000)	Dose Rate based on J, mSv/h (H/(J*40))	Dose Rate at 1m (Based on distance squared ratio), mSv/h
		(Bq)	(g)									
		Note - adjust this limit to get surface dose of 2mSv/h										
Pu-238	Plutonium	2.89E+14	455.3	4.20E-09	1.927	1.21E+06	8.81E+02	8.08E-01	1.10E+01	7.12E-01	2.00E+00	1.80E-02
Pu-240		1.11E+13	1.31E+03	1.09E-07	1.915	1.21E+06	8.78E+02	8.08E-01	1.10E+01	7.09E-01	2.00E+00	1.79E-02

[1] ICRP 38, Radionuclide Transformations - Energy and Intensity of Emissions
[2] IAEA SS37, Third Edition, as Amended 1990.
[3] Herman Cember, Introduction to Health Physics, Third Edition.

Appendix A Table 2: Package with LS-31x73-Tu Design No 3983

3983 Insert

3979 radius, r =	11.99	cm	- distance from source centre to measurement position
Surface area =	1806.542696	cm2	- assuming a spherical source, to determine the neutron flux after a NCT damage at radius, r (cm)

A	B	C	D	E	F	G	H	I	J	K	L	
Nuclide	Element	Package Limits (Surface Transport)		Neutron emission/ transformation, SF-n (ICRP 38, 1983 [1])	MeV	Total Netrons per sec, n/s (C x E)	Neutron Flux, n/s/cm2 (G/Surface area)	SS37 [2] Conversion factor from Table A-I (cm-2.s-1 per uSv/h)	Cember [3], Table 9.5,Fluence rate producing 1mSv in 40h	Dose Rate based on I, mSv/h (H x I/1000)	Dose Rate based on J, mSv/h (H/(J*40))	Dose Rate at 1m (Based on distance squared ratio), mSv/h
		(Bq)	(g)									
		Note - adjust this limit to get surface dose of 2mSv/h										
Pu-238	Plutonium	3.79E+14	597.1	4.20E-09	1.927	1.59E+06	8.81E+02	8.08E-01	1.10E+01	7.12E-01	2.00E+00	2.30E-02
Pu-240		1.46E+13	1.73E+03	1.09E-07	1.915	1.59E+06	8.81E+02	8.08E-01	1.10E+01	7.11E-01	2.00E+00	2.29E-02

[1] ICRP 38, Radionuclide Transformations - Energy and Intensity of Emissions
[2] IAEA SS37, Third Edition, as Amended 1990.
[3] Herman Cember, Introduction to Health Physics, Third Edition.

Appendix A Table 3: Package with insert LS-12x65-Tu Design No 3984

3984 Insert

3979 radius, r =	12.39	cm	- distance from source centre to measurement position
Surface area =	1929.089942	cm2	- assuming a spherical source, to determine the neutron flux after a NCT damage at radius, r (cm)

A	B	C	D	E	F	G	H	I	J	K	L	
Nuclide	Element	Package Limits (Surface Transport)		Neutron emission/ transformation, SF-n (ICRP 38, 1983 [1])	MeV	Total Netrons per sec, n/s (C x E)	Neutron Flux, n/s/cm2 (G/Surface area)	SS37 [2] Conversion factor from Table A-I (cm-2.s-1 per uSv/h)	Cember [3], Table 9.5,Fluence rate producing 1mSv in 40h	Dose Rate based on I, mSv/h (H x I/1000)	Dose Rate based on J, mSv/h (H/(J*40))	Dose Rate at 1m (Based on distance squared ratio), mSv/h
		(Bq)	(g)									
		Note - adjust this limit to get surface dose of 2mSv/h										
Pu-238	Plutonium	4.04E+14	636.5	4.20E-09	1.927	1.70E+06	8.80E+02	8.08E-01	1.10E+01	7.10E-01	2.00E+00	2.43E-02
Pu-240		1.56E+13	1.85E+03	1.09E-07	1.915	1.70E+06	8.81E+02	8.08E-01	1.10E+01	7.12E-01	2.00E+00	2.43E-02

[1] ICRP 38, Radionuclide Transformations - Energy and Intensity of Emissions
[2] IAEA SS37, Third Edition, as Amended 1990.
[3] Herman Cember, Introduction to Health Physics, Third Edition.

Appendix A Table 4: Package with insert LS-50x103-SS Design No 3986

3986 Insert

3979 radius, r =	10.65	cm	- distance from source centre to measurement position
Surface area =	1425.309171	cm2	- assuming a spherical source, to determine the neutron flux after a NCT damage at radius, r (cm)

A	B	C	D	E	F	G	H	I	J	K	L	
Nuclide	Element	Package Limits (Surface Transport)		Neutron emission/ transformation, SF-n (ICRP 38, 1983 [1])	MeV	Total Netrons per sec, n/s (C x E)	Neutron Flux, n/s/cm2 (G/Surface area)	SS37 [2] Conversion factor from Table A-I (cm-2.s-1 per uSv/h)	Cember [3], Table 9.5,Fluence rate producing 1mSv in 40h	Dose Rate based on I, mSv/h (H x I/1000)	Dose Rate based on J, mSv/h (H/(J*40))	Dose Rate at 1m (Based on distance squared ratio), mSv/h
		(Bq)	(g)									
		Note - adjust this limit to get surface dose of 2mSv/h										
Pu-238	Plutonium	2.99E+14	471.1	4.20E-09	1.927	1.26E+06	8.81E+02	8.08E-01	1.10E+01	7.11E-01	2.00E+00	1.86E-02
Pu-240		1.15E+13	1.36E+03	1.09E-07	1.915	1.25E+06	8.79E+02	8.08E-01	1.10E+01	7.10E-01	2.00E+00	1.85E-02

[1] ICRP 38, Radionuclide Transformations - Energy and Intensity of Emissions
[2] IAEA SS37, Third Edition, as Amended 1990.
[3] Herman Cember, Introduction to Health Physics, Third Edition.

Appendix B Bremsstrahlung Dose Rates

3979A Bremsstrahlung Calculations

Introduction to Health Physics, 3rd Edition - Herman Cember
p130, formula 5.11a.

$F_B = 3.5 \times 10^{-4} Z.E_M$

Primary Shield, Steel, Z = 26 (Cavity is Stain.S lined)
E_M = 2.28 MeV

F_B = 2.07E-02

Flux = $F_B.E_B.A/E$ = **1.87E+12** photons/sec A = 3.70E+13 Bq
E = 9.35E-01 Mev

Where:
Z = Atomic Number of the absorber
A = Activity, Bq
E_B = Em = Maximum Beta erergy, MeV (Kaye & Laby, 16th Edition)
E = Average Beta Energy, MeV (ICRP 38, 1983)

Photon Flux

Using the above formula, the total flux for each beta emitter can be calculated, as shown below:

Steel Insert

Nuclide	Z	E_M	F_B	A	E	Flux, photons/s
Bi-210	26	1.16	0.010556	3.70E+13	3.89E-01	1.16E+12
C-14	26	0.156	0.00142	3.70E+13	4.95E-02	1.66E+11
I-129	26	0.15	0.001365	3.70E+13	4.89E-02	1.55E+11
P-32	26	1.71	0.015561	3.70E+13	0.6947	1.42E+12
P-33	26	0.249	0.002266	3.70E+13	7.66E-02	2.73E+11
Sr-90	26	0.55	0.005005	3.70E+13	1.96E-01	5.20E+11
Y-90	26	2.28	0.020748	3.70E+13	9.35E-01	1.87E+12

Tungsten Insert

Nuclide	Z	E_M	F_B	A	E	Flux, photons/s
C-14	74	0.156	0.00404	3.70E+13	4.95E-02	4.72E+11
I-129	74	0.15	0.003885	3.70E+13	4.89E-02	4.41E+11
P-32	74	1.71	0.044289	3.70E+13	0.6947	4.03E+12
P-33	74	0.249	0.006449	3.70E+13	7.66E-02	7.76E+11
Sr-90	74	0.55	0.014245	3.70E+13	1.96E-01	1.48E+12
Y-90	74	2.28	0.059052	3.70E+13	9.35E-01	5.33E+12

From Cember, p131: "For Helth Physics purposes, it is assumed that all bremsstrahlung photons are of the maximum energy".

Dose Rates

Importing the Photon Flux derived above into Microshield, the following dose rates are derived.

No Insert	Exposure Rate mR/h		Effective Dose Equivalent Rate	
Microshield Case No	Surface	1m	Surface, mSv/h	1m, mSv/h
LS-3979A-Base without Insert-C-14 - Brem.ms7	5.94E-14	5.25E-16	6.65E-16	5.88E-18
LS-3979A-Base without Insert-I-129 - Brem.ms7	4.09E-15	3.62E-17	4.64E-17	4.10E-19
LS-3979A-Base without Insert-P-32 - Brem.ms7	7.91E+05	7.07E+03	7.04E+03	6.30E+01
LS-3979A-Base without Insert-P-33 - Brem.ms7	6.51E-02	5.77E-04	6.59E-04	5.84E-06
LS-3979A-Base without Insert-Sr-90 - Brem.ms7	1.03E+04	9.16E+01	9.52E+01	8.47E-01
LS-3979A-Base without Insert-Y-90 - Brem.ms7	1.49E+06	1.33E+04	1.33E+04	1.19E+02

3983 Tungsten Insert	Exposure Rate mR/h		Effective Dose Equivalent Rate	
Microshield Case No	Surface	1m	Surface, mSv/h	1m, mSv/h
LS-3979A-Base with 3983 Insert-C-14 - Brem.ms7	1.55E-21	1.78E-23	1.74E-23	1.99E-25
LS-3979A-Base with 3983 Insert-I-129 - Brem.ms7	1.65E-20	1.89E-22	1.86E-22	2.14E-24
LS-3979A-Base with 3983 Insert-P-32 - Brem.ms7	6.18E+05	7.05E+03	5.50E+03	6.27E+01
LS-3979A-Base with 3983 Insert-P-33 - Brem.ms7	7.97E-07	9.02E-09	8.07E-09	9.12E-11
LS-3979A-Base with 3983 Insert-Sr-90 - Brem.ms7	1.16E+03	1.32E+01	1.07E+01	1.22E-01
LS-3979A-Base with 3983 Insert-Y-90 - Brem.ms7	1.29E+06	1.47E+04	1.16E+04	1.32E+02

3986 Steel Insert	Exposure Rate mR/h		Effective Dose Equivalent Rate	
Microshield Case No	Surface	1m	Surface, mSv/h	1m, mSv/h
LS-3979A-Base with 3986 Insert-Bi-210 - Brem.msd	3.02E+05	2.78E+03	2.70E+03	2.48E+01
LS-3979A-Base with 3986 Insert-C-14 - Brem.ms7	4.49E-14	4.10E-16	5.03E-16	4.59E-18
LS-3979A-Base with 3986 Insert-I-129 - Brem.ms7	3.11E-15	2.84E-17	3.52E-17	3.21E-19
LS-3979A-Base with 3986 Insert-P-32 - Brem.ms7	3.76E+05	3.46E+03	3.36E+03	3.10E+01
LS-3979A-Base with 3986 Insert-P-33 - Brem.ms7	5.33E-02	4.87E-04	5.39E-04	4.93E-06
LS-3979A-Base with 3986 Insert-Sr-90 - Brem.ms7	8.95E+03	8.22E+01	8.28E+01	7.60E-01
LS-3979A-Base with 3986 Insert-Y-90 - Brem.ms7	1.37E+06	1.27E+04	1.23E+04	1.13E+02

3984 Tungsten Insert	Exposure Rate mR/h		Effective Dose Equivalent Rate	
Microshield Case No	Surface	1m	Surface, mSv/h	1m, mSv/h
LS-3979A-Base with 3984 Insert-C-14 - Brem.ms7	1.45E-21	1.76E-23	1.63E-23	1.98E-25
LS-3979A-Base with 3984 Insert-I-129 - Brem.ms7	1.54E-20	1.87E-22	1.75E-22	2.12E-24
LS-3979A-Base with 3984 Insert-P-32 - Brem.ms7	4.39E+05	5.31E+03	3.90E+03	4.72E+01
LS-3979A-Base with 3984 Insert-P-33 - Brem.ms7	3.09E-08	3.70E-10	3.13E-10	3.75E-12
LS-3979A-Base with 3984 Insert-Sr-90 - Brem.ms7	4.95E+02	5.95E+00	4.58E+00	5.51E-02
LS-3979A-Base with 3984 Insert-Y-90 - Brem.ms7	9.45E+05	1.14E+04	8.45E+03	1.02E+02

Appendix C: MicroShield Calculations

Contents

#	Microshield File Ref.
	3983
1	LS-3979A-Base with 3983 Insert-Ac-225.ms7
2	LS-3979A-Base with 3983 Insert-Ac-227.ms7
3	LS-3979A-Base with 3983 Insert-Ac-228.ms7
4	LS-3979A-Base with 3983 Insert-Am-241.ms7
5	LS-3979A-Base with 3983 Insert-As-77.ms7
6	LS-3979A-Base with 3983 Insert-Au-198.ms7
7	LS-3979A-Base with 3983 Insert-Ba-131.ms7
8	LS-3979A-Base with 3983 Insert-C-14 - Brem.ms7
9	LS-3979A-Base with 3983 Insert-Co-60.ms7
10	LS-3979A-Base with 3983 Insert-Cs-131.ms7
11	LS-3979A-Base with 3983 Insert-Cs-134.ms7
12	LS-3979A-Base with 3983 Insert-Cs-137.ms7
13	LS-3979A-Base with 3983 Insert-Cu-67.ms7
14	LS-3979A-Base with 3983 Insert-Hg-203.ms7
15	LS-3979A-Base with 3983 Insert-Ho-166.ms7
16	LS-3979A-Base with 3983 Insert-I-125.ms7
17	LS-3979A-Base with 3983 Insert-I-129 - Brem.ms7
18	LS-3979A-Base with 3983 Insert-I-131.ms7
19	LS-3979A-Base with 3983 Insert-In-111.ms7
20	LS-3979A-Ir192-t0-Base with 3983 Insert.ms7
21	LS-3979A-Base with 3983 Insert-Ir-194.ms7
22	LS-3979A-Base with 3983 Insert-Kr-79.ms7
23	LS-3979A-Base with 3983 Insert-Lu-177.ms7
24	LS-3979A-Base with 3983 Insert-Mo-99.ms7
25	LS-3979A-Base with 3983 Insert-Na-24.ms7
26	LS-3979A-Base with 3983 Insert-Np-237.ms7
27	LS-3979A-Base with 3983 Insert-P-32 - Brem.ms7
28	LS-3979A-Base with 3983 Insert-P-33 - Brem.ms7
29	LS-3979A-Base with 3983 Insert-Pb-203.ms7
30	LS-3979A-Base with 3983 Insert-Pb-210.ms7
31	LS-3979A-Base with 3983 Insert-Pd-109.ms7
32	LS-3979A-Base with 3983 Insert-Pu-238.ms7
33	LS-3979A-Base with 3983 Insert-Pu-239.ms7
34	LS-3979A-Base with 3983 Insert-Pu-240.ms7
35	LS-3979A-Base with 3983 Insert-Pu-241.ms7
36	LS-3979A-Base with 3983 Insert-Ra-223.ms7
37	LS-3979A-Base with 3983 Insert-Ra-224.ms7
38	LS-3979A-Base with 3983 Insert-Ra-226.ms7
39	LS-3979A-Base with 3983 Insert-Re-186.ms7
40	LS-3979A-Base with 3983 Insert-Re-188.ms7
41	LS-3979A-Base with 3983 Insert-Rh-105.ms7
42	LS-3979A-Base with 3983 Insert-Se-75.ms7
43	LS-3979A-Base with 3983 Insert-Sm-153.ms7
44	LS-3979A-Base with 3983 Insert-Sr-89.ms7
45	LS-3979A-Base with 3983 Insert-Sr-90 - Brem.ms7
46	LS-3979A-Base with 3983 Insert-Tb-161.ms7
47	LS-3979A-Base with 3983 Insert-Th-227.ms7
48	LS-3979A-Base with 3983 Insert-Th-228.ms7
49	LS-3979A-Base with 3983 Insert-Tl-201.ms7
50	LS-3979A-Base with 3983 Insert-U-235.ms7
51	LS-3979A-Base with 3983 Insert-W-187.ms7
52	LS-3979A-Base with 3983 Insert-W-188.ms7
53	LS-3979A-Base with 3983 Insert-Xe-133.ms7
54	LS-3979A-Base with 3983 Insert-Y-90 - Brem.ms7
55	LS-3979A-Base with 3983 Insert-Yb-169.ms7
56	LS-3979A-Base with 3983 Insert-Yb-175.ms7

#	Microshield File Ref.
	3984
57	LS-3979A-Base with 3984 Insert-Ac-225.ms7
58	LS-3979A-Base with 3984 Insert-Ac-227.ms7
59	LS-3979A-Base with 3984 Insert-Ac-228.ms7
60	LS-3979A-Base with 3984 Insert-Am-241.ms7
61	LS-3979A-Base with 3984 Insert-As-77.ms7
62	LS-3979A-Base with 3984 Insert-Au-198.ms7
63	LS-3979A-Base with 3984 Insert-Ba-131.ms7
64	LS-3979A-Base with 3984 Insert-C-14 - Brem.ms7
65	LS-3979A-Base with 3984 Insert-Co-60.ms7
66	LS-3979A-Base with 3984 Insert-Cs-131.ms7
67	LS-3979A-Base with 3984 Insert-Cs-134.ms7
68	LS-3979A-Base with 3984 Insert-Cs-137.ms7
69	LS-3979A-Base with 3984 Insert-Cu-67.ms7
70	LS-3979A-Base with 3984 Insert-Hg-203.ms7
71	LS-3979A-Base with 3984 Insert-Ho-166.ms7
72	LS-3979A-Base with 3984 Insert-I-125.ms7
73	LS-3979A-Base with 3984 Insert-I-129 - Brem.ms7
74	LS-3979A-Base with 3984 Insert-I-131.ms7
75	LS-3979A-Base with 3984 Insert-In-111.ms7
76	LS-3979A-Ir192-t0-Base with 3984 Insert.ms7
77	LS-3979A-Base with 3984 Insert-Ir-194.ms7
78	LS-3979A-Base with 3984 Insert-Kr-79.ms7
79	LS-3979A-Base with 3984 Insert-Lu-177.ms7
80	LS-3979A-Base with 3984 Insert-Mo-99.ms7
81	LS-3979A-Base with 3984 Insert-Na-24.ms7
82	LS-3979A-Base with 3984 Insert-Np-237.ms7
83	LS-3979A-Base with 3984 Insert-P-32 - Brem.ms7
84	LS-3979A-Base with 3984 Insert-P-33 - Brem.ms7
85	LS-3979A-Base with 3984 Insert-Pb-203.ms7
86	LS-3979A-Base with 3984 Insert-Pb-210.ms7
87	LS-3979A-Base with 3984 Insert-Pd-109.ms7
88	LS-3979A-Base with 3984 Insert-Pu-238.ms7
89	LS-3979A-Base with 3984 Insert-Pu-239.ms7
90	LS-3979A-Base with 3984 Insert-Pu-240.ms7
91	LS-3979A-Base with 3984 Insert-Pu-241.ms7
92	LS-3979A-Base with 3984 Insert-Ra-223.ms7
93	LS-3979A-Base with 3984 Insert-Ra-224.ms7
94	LS-3979A-Base with 3984 Insert-Ra-226.ms7
95	LS-3979A-Base with 3984 Insert-Re-186.ms7
96	LS-3979A-Base with 3984 Insert-Re-188.ms7
97	LS-3979A-Base with 3984 Insert-Rh-105.ms7
98	LS-3979A-Base with 3984 Insert-Se-75.ms7
99	LS-3979A-Base with 3984 Insert-Sm-153.ms7
100	LS-3979A-Base with 3984 Insert-Sr-89.ms7
101	LS-3979A-Base with 3984 Insert-Sr-90 - Brem.ms7
102	LS-3979A-Base with 3984 Insert-Tb-161.ms7
103	LS-3979A-Base with 3984 Insert-Th-227.ms7
104	LS-3979A-Base with 3984 Insert-Th-228.ms7
105	LS-3979A-Base with 3984 Insert-Tl-201.ms7
106	LS-3979A-Base with 3984 Insert-U-235.ms7
107	LS-3979A-Base with 3984 Insert-W-187.ms7
108	LS-3979A-Base with 3984 Insert-W-188.ms7
109	LS-3979A-Base with 3984 Insert-Xe-133.ms7
110	LS-3979A-Base with 3984 Insert-Y-90 - Brem.ms7
111	LS-3979A-Base with 3984 Insert-Yb-169.ms7
112	LS-3979A-Base with 3984 Insert-Yb-175.ms7

#	Microshield File Ref.
	3986
113	LS-3979A-Base with 3986 Insert-Ac-225.ms7
114	LS-3979A-Base with 3986 Insert-Ac-227.ms7
115	LS-3979A-Base with 3986 Insert-Ac-228.ms7
116	LS-3979A-Base with 3986 Insert-Am-241.ms7
117	LS-3979A-Base with 3986 Insert-As-77.ms7
118	LS-3979A-Base with 3986 Insert-Au-198.ms7
119	LS-3979A-Base with 3986 Insert-Ba-131.ms7
119a	LS-3979A-Base with 3986 Insert-Bi-210 - Brem.ms7
120	LS-3979A-Base with 3986 Insert-C-14 - Brem.ms7
121	LS-3979A-Base with 3986 Insert-Co-60.ms7
122	LS-3979A-Base with 3986 Insert-Cs-131.ms7
123	LS-3979A-Base with 3986 Insert-Cs-134.ms7
124	LS-3979A-Base with 3986 Insert-Cs-137.ms7
125	LS-3979A-Base with 3986 Insert-Cu-67.ms7
126	LS-3979A-Base with 3986 Insert-Hg-203.ms7
127	LS-3979A-Base with 3986 Insert-Ho-166.ms7
128	LS-3979A-Base with 3986 Insert-I-125.ms7
129	LS-3979A-Base with 3986 Insert-I-129 - Brem.ms7
130	LS-3979A-Base with 3986 Insert-I-131.ms7
131	LS-3979A-Base with 3986 Insert-In-111.ms7
132	LS-3979A-Ir192-t0-Base with 3986 Insert.ms7
133	LS-3979A-Base with 3986 Insert-Ir-194.ms7
134	LS-3979A-Base with 3986 Insert-Kr-79.ms7
135	LS-3979A-Base with 3986 Insert-Lu-177.ms7
136	LS-3979A-Base with 3986 Insert-Mo-99.ms7
137	LS-3979A-Base with 3986 Insert-Na-24.ms7
138	LS-3979A-Base with 3986 Insert-Np-237.ms7
139	LS-3979A-Base with 3986 Insert-P-32 - Brem.ms7
140	LS-3979A-Base with 3986 Insert-P-33 - Brem.ms7
141	LS-3979A-Base with 3986 Insert-Pb-203.ms7
142	LS-3979A-Base with 3986 Insert-Pb-210.ms7
143	LS-3979A-Base with 3986 Insert-Pd-109.ms7
143a	LS-3979A-Base with 3986 Insert-Po-210.msd
144	LS-3979A-Base with 3986 Insert-Pu-238.ms7
145	LS-3979A-Base with 3986 Insert-Pu-239.ms7
146	LS-3979A-Base with 3986 Insert-Pu-240.ms7
147	LS-3979A-Base with 3986 Insert-Pu-241.ms7
148	LS-3979A-Base with 3986 Insert-Ra-223.ms7
149	LS-3979A-Base with 3986 Insert-Ra-224.ms7
150	LS-3979A-Base with 3986 Insert-Ra-226.ms7
151	LS-3979A-Base with 3986 Insert-Re-186.ms7
152	LS-3979A-Base with 3986 Insert-Re-188.ms7
153	LS-3979A-Base with 3986 Insert-Rh-105.ms7
154	LS-3979A-Base with 3986 Insert-Se-75.ms7
155	LS-3979A-Base with 3986 Insert-Sm-153.ms7
156	LS-3979A-Base with 3986 Insert-Sr-89.ms7
157	LS-3979A-Base with 3986 Insert-Sr-90 - Brem.ms7
158	LS-3979A-Base with 3986 Insert-Tb-161.ms7
159	LS-3979A-Base with 3986 Insert-Th-227.ms7
160	LS-3979A-Base with 3986 Insert-Th-228.ms7
161	LS-3979A-Base with 3986 Insert-Tl-201.ms7
162	LS-3979A-Base with 3986 Insert-U-235.ms7
163	LS-3979A-Base with 3986 Insert-W-187.ms7
164	LS-3979A-Base with 3986 Insert-W-188.ms7
165	LS-3979A-Base with 3986 Insert-Xe-133.ms7
166	LS-3979A-Base with 3986 Insert-Y-90 - Brem.ms7
167	LS-3979A-Base with 3986 Insert-Yb-169.ms7
168	LS-3979A-Base with 3986 Insert-Yb-175.ms7

#	Microshield File Ref.
	No Insert
169	LS-3979A-Base withou Insert-Ac-227.ms7
170	LS-3979A-Base without Insert-Ac-225.ms7
171	LS-3979A-Base without Insert-Ac-228.ms7
172	LS-3979A-Base without Insert-Am-241.ms7
173	LS-3979A-Base without Insert-As-77.ms7
174	LS-3979A-Base without Insert-Au-198.ms7
175	LS-3979A-Base without Insert-Ba-131.ms7
176	LS-3979A-Base without Insert-C-14 - Brem.ms7
177	LS-3979A-Base without Insert-Co-60.ms7
178	LS-3979A-Base without Insert-Cs-131.ms7
179	LS-3979A-Base without Insert-Cs-134.ms7
180	LS-3979A-Base without Insert-Cs-137.ms7
181	LS-3979A-Base without Insert-Cu-67.ms7
182	LS-3979A-Base without Insert-Hg-203.ms7
183	LS-3979A-Base without Insert-Ho-166.ms7
184	LS-3979A-Base without Insert-I-125.ms7
185	LS-3979A-Base without Insert-I-129 - Brem.ms7
186	LS-3979A-Base without Insert-I-131.ms7
187	LS-3979A-Base without Insert-In-111.ms7
188	LS-3979A-Ir192-t0-Base without Insert.ms7
189	LS-3979A-Base without Insert-Ir-194.ms7
190	LS-3979A-Base without Insert-Kr-79.ms7
191	LS-3979A-Base without Insert-Lu-177.ms7
192	LS-3979A-Base without Insert-Mo-99.ms7
193	LS-3979A-Base without Insert-Na-24.ms7
194	LS-3979A-Base without Insert-Np-237.ms7
195	LS-3979A-Base without Insert-P-32 - Brem.ms7
196	LS-3979A-Base without Insert-P-33 - Brem.ms7
197	LS-3979A-Base without Insert-Pb-203.ms7
198	LS-3979A-Base without Insert-Pb-210.ms7
199	LS-3979A-Base without Insert-Pd-109.ms7
200	LS-3979A-Base without Insert-Pu-238.ms7
201	LS-3979A-Base without Insert-Pu-239.ms7
202	LS-3979A-Base without Insert-Pu-240.ms7
203	LS-3979A-Base without Insert-Pu-241.ms7
204	LS-3979A-Base without Insert-Ra-223.ms7
205	LS-3979A-Base without Insert-Ra-224.ms7
206	LS-3979A-Base without Insert-Ra-226.ms7
207	LS-3979A-Base without Insert-Re-186.ms7
208	LS-3979A-Base without Insert-Re-188.ms7
209	LS-3979A-Base without Insert-Rh-105.ms7
210	LS-3979A-Base without Insert-Se-75.ms7
211	LS-3979A-Base without Insert-Sm-153.ms7
212	LS-3979A-Base without Insert-Sr-89.ms7
213	LS-3979A-Base without Insert-Sr-90 - Brem.ms7
214	LS-3979A-Base without Insert-Tb-161.ms7
215	LS-3979A-Base without Insert-Th-227.ms7
216	LS-3979A-Base without Insert-Th-228.ms7
217	LS-3979A-Base without Insert-Tl-201.ms7
218	LS-3979A-Base without Insert-U-235.ms7
219	LS-3979A-Base without Insert-W-187.ms7
220	LS-3979A-Base without Insert-W-188.ms7
221	LS-3979A-Base without Insert-Xe-133.ms7
222	LS-3979A-Base without Insert-Y-90 - Brem.ms7
223	LS-3979A-Base without Insert-Yb-169.ms7
224	LS-3979A-Base without Insert-Yb-175.ms7