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Recertification Of The Model 9977 Radioactive Material Packaging

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ABSTRACT

The Model 9977 Packaging was initially issued a Certificate of Compliance (CoC) by the Department of Energy's Office of Environmental Management (DOE-EM) for the transportation of radioactive material (RAM) in the Fall of 2007. This first CoC was for a single radioactive material and two packing configurations. In the five years since that time, seven Addendums have been written to the Safety Analysis Report for Packaging (SARP) and five Letter Amendments have been written that have authorized either new RAM contents or packing configurations, or both. This paper will discuss the process of updating the 9977 SARP to include all the contents and configurations, including the addition of a new content, and its submittal for recertification.

Background

Savannah River National Laboratory (SRNL) developed the Model 9977 Radioactive Material (RAM) Packaging for the Department of Energy (DOE) National Nuclear Security Administration (NNSA) as a replacement for the Specification 6M packaging for which the authorization was withdrawn by the U.S. Department of Transportation (DOT) in 2006. The 9977 RAM shipping package Safety Analysis Report for Packaging (SARP) (S-SARP-G-00001) Revision 2 [Ref 1] was authorized by the DOE Environmental Management (EM) Packaging Certification Program (PCP) Certificate of Compliance (CoC) Revision 0 [Ref 2] on October 9, 2007 with an expiration date of October 31, 2012, per the requirements of DOE Order 460.1C [Ref 3]. The SARP and CoC authorized the shipment of a single Content, 100 grams of plutonium and/or uranium "Heat Source" material in either of two (2) container configurations. The initial SARP established the design of the packaging, its compliance with the requirements of Title 10 of the Code of Federal Regulations (CFR) Part 71 [Ref 4], its design pressures, temperatures, shielding and criticality features, its minimum essential operating procedures, its acceptance and maintenance requirements, and its Quality Assurance program. The SARP follows the content and format requirements specified in Regulatory Guide 7.9 [Ref 5]. The

9977 was authorized with a maximum content weight of 100 pounds and radioactive decay heat rate of 19 watts and has a Containment Vessel maximum design pressure of 800 psi at 300°F.

The utility of the 9977 has been expanded in the years since it was initially certified by the inclusion of additional RAM Contents and packing configurations that support numerous DOE and NNSA sites, programs, and functions. A total of fifteen (15) unique content envelopes, four (4) generic container configurations, and eight (8) specific container configurations (which includes three (3) configurations for Shielded Containers), were authorized. Additional contents and/or configurations were added to the Packaging safety basis through an Addendum or a Letter Amendment Request, which were reviewed by the DOE Certifying Official and authorized through a new revision of the CoC. Table 1 lists the Contents authorized for shipment in the 9977 and the various organizations shipping materials of each envelope. There were a total of seven (7) Addenda and five (5) Letter Amendments issued. The final authorization for the 9977 is Revision 12 of the CoC. Table 2 is an alignment between the Content additions and the CoCs.

SRNL was funded by the NNSA in FY12 to issue a revision of the SARP for recertification of the 9977 Packaging, with an extension of the CoC expiration date for an additional 5 years. SRNL was informed by NNSA in May 2012 that the NNSA Office of Packaging and Transportation (OPT) would be assuming the certification authority for the 9977 and that the SARP Revision 3 originally intended for the DOE-EM PCP should instead be submitted to OPT. Besides the consolidation of Revision 2 with the Addenda and Letter Amendments, SRNL was directed that Revision 3 would revise the Structural analysis evaluating the package stressed using TRESCA criteria instead of the Von Mises criteria used in the baseline analyses.

Per the requirements of 10CFR71.38, “Renewal of a certificate of compliance or quality assurance program approval”, subsection (c):

> In applying for renewal of an existing Certificate of Compliance or Quality Assurance Program Approval, an applicant may be required to submit a consolidated application that incorporates all changes to its program that, are incorporated by reference in the existing approval or certificate, into as few referenceable documents as reasonably achievable.

Discussion

The scope of Revision 3 of the 9977 Packaging SARP was to use the SARP Revision 2 as the basis for the inclusion of the seven (7) Addenda and the five (5) Letter Amendment Requests into a consolidated safety basis document. Since all the additional contents and configurations requested in the Addenda and Letter Amendments were needed for ongoing shipping missions they were all included into the consolidated SARP. Again, per the requirements of 10CFR71.38(b), the SARP Revision 3 was scheduled for submittal no later than the end of September, 2012, 30 days prior to the CoC expiration.

An Addendum establishes that a new content/configuration is either bounded by the established safety basis, that is, it is within the limiting weights, temperatures and pressures, and is within the dose rate limits and is sub-critical. Or it shows that for the new content/configuration is within the limits established by the package design. An Addendum also includes the calculations and analyses needed to establish the new safety basis. The standard Addendum format excludes those sections of the SARP chapters which are not changed by safety analysis for the new content/configuration. Table 3 shows the new Shielding and Criticality analyses performed for the Addendum contents. The Addendum does include SARP text, figures, and tables that are revised, added, or deleted in establishing the safety basis for the new content/configuration. A Letter Amendment Request is an even simpler document with, typically, only one or two minor changes to the existing safety basis.

Development of SARP Revision 3 involved the combination of each individual Addendum and Letter Amendment into the SARP Chapters and the inclusion of Addenda calculations and analysis either by reference or as Appendices. On the face of it, combining a single Addendum or a Letter Amendment into a SARP is a straight forward effort. Combining twelve (12) Addenda/Letter Amendments becomes a bit more difficult.

The first issue to be resolved was in the designation of the Contents. Addenda identify new Contents with a designation and a "name". These designations were not systematically developed but were unique to materials and programs that the Addendum was supporting. An example is "AC.1", which is an acronym for "Addendum Content number 1" in the first 9977 Addendum, S-SARA-G-00003. This Content was named the "Neptunium Sphere" as it is a specific sphere of neptunium. For the consolidation into Revision 3 a new Content designation convention was needed and a method of tying the original Content designations as used in calculations and analyses to the new needed to be provided. This standardization becomes even more important when it was recognized that SRNL has multiple packagings currently certified and that contents and analyses are often shared between multiple packagings. The new convention uses the last two digits of the packaging number (in this case "77"), a "C" for "content", and then a sequential number for the order of the content within the package. The original content and the added contents became Content Envelopes 77C.1 through 77C.18. It is important to note that the Content name is simply a designator, and does not define the content nor place any restrictions on its use. A material may be shipped under the authorization for the 77C.15 "PNNL Training Sources" Content definition that does not have to be from the Pacific Northwest National Laboratory, be used for training purposes, or be qualified as a "source".

Table 1 shows the alignment between the original content designations and the corresponding contents in SARP Revision 3. Two (2) new Content Envelopes, 77C.16 and 77C.17, were added as variations on the previously authorized Content Envelope 77C.6 (previously AC.4). The materials to be shipped under Content Envelope AC.4 are authorized based on isotopic percentages of the total material mass. While this works for most materials, as most

radioisotopes are permitted up to the total content mass, some contents with small but unique isotopes have had issues with not having sufficient "dunnage" isotopes. Content Envelopes 77C.16 and 77C.17 are "gram" based variants of the "percentage" contents where each isotope in the enveloped is authorized based on its individual characteristics.

Because of the time needed to complete the new structural analyses, SARP Revision 3 could not be completed prior to the expiration of the DOE-EM CoC. NNSA OPT requested DOE-EM extend the CoC until OPT could review and approve SARP Revision 3. On September 26th, the Savannah River Operations (SRO) of DOE-EM directed and funded a S-SARP-G-00001, Revision 3 for submittal to PCP by the end of September in support of an "Under Timely Renewal" status for the DOE-EM CoC. An alternate S-SARP-G-00001 Revision 3 based on the NNSA scope but excluding the revised structural analysis was submitted on September 28th and the 9977 CoC was placed "Under Timely Renewal", where it still is to date.

On October 19, 2012 NNSA issued Revision 0 of an Offsite Transportation Certificate (OTC) (as a CoC) with an expiration date of September 30, 2017. The NNSA OTC was based on S-SARP-G-00001 Revision 2 and all the Addenda and Letter Amendments except for the extended maintenance authorization. NNSA next issued a Memorandum to the Manager of the DOE-EM-33 Packaging Certification Program on October 24, 2012 stating "the NNSA's decision to assume certification authority for the 9977 package." On the same day DOE-SRO NNSA directed SRNS to add additional scope to the SARP revision, the "Dual Food-Pack Can" Pu-metal content and configuration, as long as it did not impact the scheduled submittal date. The NNSA also requested that copies of the Shielding and Criticality analyses, with the Input and Output files, done for the Addenda be provided to their SARP Technical Review Team so the Review Team could begin their confirmatory analysis.

Since the 9977 SARP Revision 3 had been submitted to DOE-EM in September 2012 and the scope of the Revision to be submitted to NNSA was going to be different (different structural basis, a new content/configuration) SRNL decided to produce a new Revision 4 document for the NNSA submittal. Two parallel efforts were required for Revision 4, the revised structural analysis based on the TRESCA criteria and the inclusion of the Dual Food-Pack Can content/configuration into the safety basis. The Dual Food-Pack Can (FPC) configuration consists of two FPC sets stacked inside a specialty Rack. The FPC Rack provides shielding and criticality control under Normal Conditions of Transport. Each FPC set consists of an inner FPC wrapped in a low-density contamination control bag inside an outer FPC. The FPC sets are used to contain a unique content, the 19th for the 9977. Because the Dual 3013 configuration permits up to 38 watts of content decay heat, the packaging configuration includes the FPC Rack and a Heat Dissipation Sleeve around the Containment Vessel. Table 4 lists the final SARP Revision 4 Contents and a summary of their critical parameters and characteristics. This table also lists a summary of the content packing configurations and controls.

9977 SARP Revision 4 was submitted to the NNSA OPT on March 22, 2013 following the completion of the new structural and Dual FPC Content analysis and inclusion into the SARP chapters. On April 17 a SARP Completeness Checklist [Ref 6] was submitted to OTP. To date, both the SARP Revisions 3 and 4 are under review by their respective Certifying Official Technical Review Teams.

Table 1 – 9977 Package Contents and Users

Content		Organization / Description	DHS	NE	NNSA	OS	EM
Rev 3	Original						
77C.1	C.1	Heat Sources			X		
77C.2	AC.1	Np Sphere	X				
77C.3	AC.1	Np Pieces	X				
77C.4	AC.2	BeRP Ball	X				
77C.5	AC.3	Pu/U	X		X		
77C.6	AC.4	Pu/U Metal in Sleeve	X	P	X	X	
77C.7	AC.4	Pu/U Metal in 6CV	X	P			
77C.8	AC.5	U Metal 100% ^{235}U	X			X	
77C.9	AC.5	U Metal 95% ^{235}U	X			X	
77C.10	Type 1	SGQ - Actinides					
77C.11	Type 2	SGQ - Fissile Nuclides					
77C.12	Type 3	SGQ - Gram Based					
77C.13	Type 4	SGQ - OSRP			X		X
77C.14	Type 5	SGQ - AGR-1		X	X		
77C.15	Training Sources	Training Sources			X	X	
77C.16	AC.4 modified	Gram Based Metal					
77C.17	AC.4 modified	Gram Based Oxide					
77C.18	ARIES Oxide	ARIES Oxide – 2 3013s			P		
77C.19	New	Pu Metal - 2 FPCs			X		X

Content Envelopes 77C.10 through 77C.12 are not yet approved

Content Envelopes 77C.16 and 77C.17 are new gram-based envelopes derived from the percentage-based envelope 77C.6

“P” means the site has expressed plans to ship materials under the Content when their Program or the Content is approved

Table 2 – 9977 Package Contents verses Certificates of Compliance

CoC Rev	Change Document		Authorized Change	Chapters									Drawings	Date
				1	2	3	4	5	6	7	8	9		
0	9977 SARP	S-SARP-G-00001 R2	Baseline	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	-	10/9/2007
1	Addendum 2	S-SARA-G-00005 R1	Metals (AC.1 thru AC.5)	**X**	**X**	**X**	-	**X**	**X**	**X**	**A**	**X**	**X**	1/8/2009
2	Letter Amendment		ICE	**X**	-	-	-	-	-	-	-	-	-	3/11/2009
3	Addendum 3	S-SARA-G-00006 R2	SGQ Type 5 (AGR-1)	**X**	**X**	**X**	-	**X**	**X**	**X**	**A**	**X**	**X**	2/25/2010
4	Addendum 4	S-SARA-G-00010 R0	RFID Tags	**X**	-	-	-	-	-	**X**	-	-	-	2/26/2010
5	Addendum 3	S-SARA-G-00006 R4	SGQ Type 4 (OSRP)	**X**	**X**	**X**	-	**X**	**X**	**X**	-	**X**	**X**	6/2/2010
6	Addendum 5	S-SARA-G-00009 R2	Training Sources	**X**	-	**X**	-	**X**	**X**	**X**	-	**X**	**X**	7/16/2010
7	Letter Amendment		Sleeve & Plug Revision 1	**X**	-	-	-	-	-	-	-	-	**X**	10/29/2010
8	Letter Amendment		Alternate RTG Assembly	**X**	-	-	-	-	-	-	-	-	-	1/20/2011
9	Letter Amendment		Training Sources w 10g U^{234}	**X**	-	-	-	-	-	-	-	-	-	2/4/2011
10	Letter Amendment		Pressure Rise or Drop Test	-	-	-	-	-	-	-	**X**	-	-	5/12/2011
11	Addendum 4	S-SARA-G-00010 R5	Extended Maintenance	**X**	-	-	-	-	-	**X**	**X**	**A**	-	5/9/2012
12	Addendum 7	S-SARA-G-00012 R3	Dual 3013 Contents	**X**	**X**	**X**	-	**X**	**X**	**X**	**A**	**A**	**X**	7/30/2012

"X" ≡ a change was made for this addition

"-" ≡ no change for this addition

"A" ≡ an Appendix changed in this addition

Table 3 – Alignment of Content Envelopes between Original Safety Document and Analysis Calculation and SARP Revision 3

CoC Rev	Change Document		Authorized Change	Content Envelopes	Shielding (N-CLC-G-XXXXX)	Criticality (N-NCS-A-YYYYY)
0	9977 SARP	S-SARP-G-00001 R2	Baseline	Heat Sources	00119	00014 Content Mass Subcritical
1	Addendum 2	S-SARA-G-00005 R1	Metals (AC.1 thru AC.5)	Neptunium Sphere Neptunium Pieces BeRP Ball Pu/U Metal Pu/U Metal in Plug & Sleeve Pu/U Metal in 6CV U Metal 100% ^{235}U U Metal 95% ^{235}U	00131	00017
3	Addendum 3	S-SARA-G-00006 R2	SGQ Type 5	AGR-1	00136	No analysis Content Mass Subcritical
5	Addendum 3	S-SARA-G-00006 R4	SGQ Type 4	OSRP	00138	No analysis Content Mass Subcritical
6	Addendum 5	S-SARA-G-00009 R2	Training Sources	Training Sources	00137	No analysis Content Mass Subcritical
9	Letter Amendment		Training Sources w 10g U^{234}	Training Sources w 10g U^{234}	No analysis Discussion only	No analysis Increased non-fissile RAM
12	Addendum 7	S-SARA-G-00012 R3	Dual 3013 Contents	ARIES Pu/U Oxide	00145	00023
	SARP Rev 3		Gram Based Contents	Pu/U Metal in Plug & Sleeve	00139	00134

Note: Input/Output files are available for all Shielding and Criticality calculations.

Table 4 – Summary of Critical Parameters and Conditions by Content Envelope

Content	Metal or Oxide	RAM Mass (grams)	Decay (watts)	CSI	Max Dose (mrem/hr)	TI	MNOP (psig)	Required Configuration	Additional/Unique Requirements
77C.1 / Heat Sources	O	100	19	0	141.2	2.6	41.2	SS/FPC/EC/3013/RTGs	-
77C.2 / Neptunium Sphere	M	6,070	[0.38] [a]	1	193	5.2	41.2	SS/FPC/EC	Sleeve & Plug
77C.3 / Neptunium Pieces	M	188	[0.012] [a]	1	6	0.2	41.2	SS/FPC/EC	Sleeve & Plug
77C.4 / BeRP Ball	M	4,484	[11.92] [a]	1	43.9	0.9	42.9 [b]	SS/FPC/EC	-
77C.5 / Pu/U	M	4,400	19	1	188.5	5.4	42.9	SS/FPC/EC/3013	Sleeve & Plug
77C.6 / Pu/U in Sleeve & Plug	M	2,000	19	1	181.9	3.0	42.9	SS/FPC/EC/3013	Sleeve & Plug
77C.7 / Pu/U in 6CV	M	450	[15] [a]	1	40.92	0.7	42.9	SS/FPC/EC	
77C.8 / U as 100% ^{235}U	M	16,000	[2.9] [a]	1	68.11	1.4	42.9	SS/FPC/EC/3013	Sleeve & Plug
77C.9 / U as 95% ^{235}U	M	18,000	[3.25] [a]	1	76.62	1.5	42.9	SS/FPC/EC/3013	Sleeve & Plug
77C.10 / SGQ Special Actinides	M/O	5	[9.5] [a, c]	0	d	d	102.6 [e]	SS/FPC/EC/3013/SCs/EC1	-
77C.11 / SGQ Fissile Nuclides	M/O	100	19 [c]	0	d	d	102.6 [e]	SS/FPC/EC/3013/SCs/EC1	-
77C.12 / SGQ Metals	M	100	19 [c]	0	d	d	102.6 [e]	SS/FPC/EC/3013/SCs/EC1	-
77C.13 / OSRP	M/O [f]	69.5	19 [c]	0	d	d	102.6 [e]	SCs/EC1	-
77C.14 / INL AGR-1 Fuel	g	1	19	0	110	3.6	102.6 [e]	SC3	-
77C.15 / PNNL Training Sources	M/O	12,780	3.5	1	198.6	4.3	397	SS/FPC/EC	-
77C.16 / Gram Based Metal	M	4,400	19	1	199	4.6	41.2	SS/FPC/EC/3013	Sleeve & Plug
77C.17 / Gram Based Oxide	O	4,400	19	1	199.5	6.1	41.2	SS/FPC/EC/3013/ICE	Sleeve & Plug/Inerting
77C.18 / Dual 3013 Configuration	O	8,800 [h]	38 [h]	1	72.5	3.4	422	3013	3013 Spacer/HDS/Inerting
77C.19 / Dual FPC Configuration	M	6,000 [i]	25.2 [i]	0	196.1	7.54	25.5	FPC [j]	FPC Rack/HDS
Package Design Limit		100 (lbs) total	38		200	10	800		

Table Notes

a	For these contents the Decay-Heat Rate Limit is 19 watts/package, but the values listed in [ ] are their calculated maximum values.
b	This MNOP is the bounding (highest T, lowest V) established for contents 77C.4, 77C.5, 77C.6, 77C.7, 77C.8 & 77C.9.
c	The Decay-Heat limit is reduced to 6 watts and 3 watts when the Content is shopped in the SGQ-SC1 and SGQ-SC2, respectively.
d	Dose rate measured at surface and at 1-m at the time of shipment, in the EC1 the limits are reduced to 180 and 9 mrem/hr, respectively.
e	Bounding MNOP based on the SGQ-SC2 configuration.
f	May contain carbonaceous matrix materials, halides, hydroxides, hydrides, oxycarbides, titanates, silicates, sulfates, or aluminosilicates.
g	Pellets (~ 1-inch long by ½-inch diameter) consisting of coated fuel particles in a thermoset graphite matrix.
h	Content/Configuration is for two (2) 3013 and each is limited to no greater than half the values listed.
i	Content/Configuration is for two (2) Food-Pack Cans and each is limited to no greater than half the values listed.
j	The Outer FPC shall be a 504×500 or smaller and the Inner FPC shall be a 414×304 or smaller

References

1 *Safety Analysis Report for Packaging Model 9977 Type B(M)F-96*, S-SARP-G-00001, Revision 2, Savannah River National Laboratory, Savannah River Site (August 2007).
2 *DOE Certificate of Compliance No. 9977 for the 9977*, 9977, Revision 0, U.S. Department of Energy (October 2007).
3 DOE O 460.1C, *Packaging and Transportation Safety*, U.S. Department Of Energy Office of Environmental Management, (May 2010)
4 *Packaging and Transportation of Radioactive Material*, Code of Federal Regulations, Title 10, Part 71, Washington, DC (December 2012).
5 Regulatory Guide 7.9, Standard Format and Content of Part 71 Applications for Approval Of Packages For Radioactive Material, Revision 2 (March 2005)
6 *Safety Guide, SARP Completeness Review Checklist for NNSA Packages*, SG 200 Revision 3, National Nuclear Security Administration Service Center, (May 2006)