


SAFKEG-HS 3977A

SARP Update Matrix for Thorium Target

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1 Notes on methodology and content

This Update Matrix document (CTR 2018/01) details the changes in the SAFKEG-HS 3977A SARP (CTR 2008-11) in updating from Rev 13 to Rev 14, and Rev 14 to Rev 15.

This SARP update is to allow Thorium targets to be carried in the package as new Contents Type 6 (CT-6).

This Update Matrix document will be updated during the NRC review process to include responses to questions from the NRC, thereby fully documenting all changes made during the entire SARP update.

Minor editorial changes in the SARP to clarify and correct errors are also detailed in this Update Matrix document.

This Update Matrix document (CTR 2018/01) provides the following in updating from Rev 13 for the addition of Thorium targets.

- Details of SARP supporting document changes proposed with reason for the change - Table 1
- Question and Response Matrix - Table 2 (this includes all the updates made to the SARP to answer all the questions posed by the NRC)
- List of new or edited supporting documents provided in the SARP – Table 3, Appendix A
- Explanation of the approach taken for new contents type CT-6 (radioactive thorium target) - Appendix B.

2 Reason for the changes in the SARP in updating from Rev 13 to Rev 14

Ac-225 is being developed for medical purposes and LANL have developed a methodology of producing Ac-225 by irradiating a thorium target in a proton beam. The SAFKEG-HS 3977A has been identified by LANL as appropriate package for shipping irradiated thorium targets and Croft have been contracted to have irradiated thorium targets added to the SARP.

3 Reason for the changes in the SARP in updating from Rev 14 to Rev 15

The SARP has been updated in response to the NRC RAIs provided on 30 Oct 2018. The major change is a complete revision of the shielding calculations for CT-6 Thorium target using an energy bin approach to determine which radionuclides contribute significantly to the package external radiation levels and to determine the actual maximum radiation levels. Additionally, the SARP has been updated to cover only the BNL thorium target and remove reference to the LANL thorium target which is no longer proposed to be shipped the SAFKEG-HS 3977A package.

The explanation of the contents limit for CT-6 Thorium target based on a revised calculation of the activities of 498 radionuclides produced by the irradiation target and shielding calculations for 498 radionuclides is given in Appendix B of this report (CTR 2018/01) which has been completely revised for the new “energy bin” approach.

On fabrication of a dummy CV and plug with the piston seal (as specified for CT-6 Thorium target in the SARP at Rev 14), it was found to be very difficult to fit the plug into the CV. Consequently, the CV plug having a piston seal is no longer specified in the SARP and instead the contents are to be carried in an insert (Design No. 4109, see Fig 1-5C, in Section 1 of the SARP). The SARP has been revised to take out all reference to the CV plug having a piston seal that was added to the SARP at Rev 14 and the new insert Design No. 4109 added where appropriate. The changes are identified in Table 2B of this document.

4 SARP Changes

These tables contain notes on all the SARP Page Changes and supporting Document Changes.

Table 1A Summary of SARP Changes and Supporting Document Changes for Rev 14

Summary of SARP Page Changes and Supporting Document Changes for Rev 14			
SARP Page or Doc	Location	Change	Reason for Change
Sections 0 to 8	Throughout the SARP	The Rev status has been updated to Rev 14 for all SARP pages and not just pages with changes.	<p>This change has been made to simplify management of the SARP for which master documents are electronic Word documents. This change reduces the potential for editorial errors and also facilitates the production of pdf copies produced for reviewers (simplified as each Section will be complete and not just be separate pages</p> <p>All changes to the SARP from the previous revision are shown in the "Compare" documents provided for each Section.</p>
	Throughout the SARP These are shown in the "Compare" documents provided for each Section.	Editorial changes have been made to correct errors, standardise terminology, etc.	To correct errors, standardise terminology, etc.
All pages	Header throughout the SARP Footer throughout the SARP	Page Rev status amended to Rev 14 for all pages.	Changes required solely to change from page control to document control to facilitate future update.

Summary of SARP Page Changes and Supporting Document Changes for Rev 14			
SARP Page or Doc	Location	Change	Reason for Change
		Filename updated and date removed	Date not needed as it is the same for all pages as shown in Section 0.
Section 0 - Contents			
Page 0-2	Table	Updated for Rev 14	Editorial
	Section 0.2	Page status changed throughout	Update to of Rev
	Documents in Section 1.3.3	Headings have been added for the drawings for each version of the CV. The drawings for the Sealed Split Lid Version of the CV have been added.	This change is required to accommodate a thorium target.
	Documents in Section 3.5.2, Appendix	The document references, status and titles have been edited (for those docs having an External Report Number (ETR #) added).	The ETR #s and eFilenames have been added to facilitate finding electronic copies of these documents (they did not have Ref #s).
	Documents in Section 4.5.2, Appendix	Details for CS2018/01 added	
Section 1 - General Information			
Pages - various	Throughout Section	Editorial changes made as necessary for addition of the sealed split CV lid.	Editorial and clarification
Page 1-3	Section 1.2.1.3	Edited to add the CV seal plug having an O-ring seal.	

Summary of SARP Page Changes and Supporting Document Changes for Rev 14			
SARP Page or Doc	Location	Change	Reason for Change
Page 1-3	Section 1.2.1.3, 5 th para	Details of the sealed split CV lid added	For new Contents Type CT-6
Page 1-4	Section 1.2.1.4	New Figures referenced	
Page 1-4	Section 1.2.1.5	New Figures referenced	
Page 1-8		Figure 1-1c added	Depicting split CV lid
Page 1-8		Details of the package with sealed split CV lid added	For new Contents Type CT-6
Page 1-12		Figure 1-2c added	Shows new sealed split CV lid
Page 1-16		Figure 1-3c added	Shows new sealed split CV lid
Page 1-19		Figure 1-4c added	Shows new sealed split CV lid
Page 1-21	Table 1.1	Contents mass limit for sealed split CV lid added	For new Contents Type CT-6
Page 1-24	Table 1.2	CTs renumbered CT-3 Gas reinstated [as Rev 11 of the SARP] CT-6 added	Editorial adjustment Deleted from the SARP at Rev 13 in error. For new Contents Type CT-6 – Thorium target
Page 1-27	Table 1.3.3	CT-3 Gas reinstated [as Rev 11 of the SARP]	Deleted from the SARP at Rev 13 in error.
Page 1-30	Table 1.3.6	CT-6 added	For new Contents Type CT-6 – Thorium target
Page 1-35	Table 1.4.3	CT-3 Gas reinstated [as Rev 11 of the SARP]	Deleted from the SARP at Rev 13 in error.

Summary of SARP Page Changes and Supporting Document Changes for Rev 14			
SARP Page or Doc	Location	Change	Reason for Change
Page 1-38	Table 1.4.6	CT-6 added	For new Contents Type CT-6 – Thorium target See also Appendix B
Page 1-46	Section 1.3.3.3 added	Drawings for the package having the new sealed split CV lid added	For new Contents Type CT-6 – Thorium target
Section 2 - Structural Evaluation			
Pages – 2-54, 2-55, 2-58,		Table numbering corrected.	Editorial
Section 3 - Thermal Evaluation			
Page 3-4a	Section 3.1.3, 4 th para	Comment on temperatures for CT-6 added.	For new Contents Type CT-6 – Thorium target
Page 3-23	Section 3.5.2	Document references “ETR” added for MURR reports and Mallinckrodt report.	The ETR #s have been added to facilitate finding electronic copies of these documents (they did not have Ref #s).
Section 4 - Containment Evaluation			
Page 4-1 and elsewhere	Section 4.1, 1 st para and elsewhere	Edited to accommodate new sealed split CV lid	For the new package assembly for CT-6.
Page 4-3	Figure 4-3	Figure 4-3 added.	For the new sealed split CV lid for CT-6.
Page 4-4	Table 4-1, note (2) and last para.	Note re dose rate for CT-4 added.	For the new package assembly for CT-6.
Page 4-5	Section 4.2.2, 2 nd and 3 rd paras.	Edited for reinstatement of CT-3 (gas) and CT-6 (thorium).	Editorial for reinstatement of CT-3 and new CT-6.

Summary of SARP Page Changes and Supporting Document Changes for Rev 14			
SARP Page or Doc	Location	Change	Reason for Change
Page 4-6	Section 4.2.4, 4 th to 7 th paras.	Edited for reinstatement of CT-3 (gas) and CT-6 (thorium).	Editorial for reinstatement of CT-3 and new CT-6.
Page 4-7	Section 4.3.2, 2 nd to 4 th paras.	Edited for reinstatement of CT-3 (gas) and CT-6 (thorium).	Editorial for reinstatement of CT-3 and new CT-6.
Page 4-8, 4-9	Section 4.3.4.2, 3 rd and 4 th paras.	Edited for reinstatement of CT-3 (gas).	Editorial for reinstatement of CT-3.
Page 4-9	Section 4.4.1, 3 rd para.	Requirements for testing the plug/body seal of the split lid sealed plug added.	For the new sealed split CV lid for CT-6.
Page 4-9	Section 4.4.2, 3 rd para.	Requirements for testing the plug/body seal of the split lid sealed plug added.	For the new sealed split CV lid for CT-6.
Page 4-9	Section 4.4.3, 3 rd para.	Requirements for testing the plug/body seal of the split lid sealed plug added.	For the new sealed split CV lid for CT-6.
Page 4-10	Section 4.4.4, 3 rd to 5 th paras.	Edited for renumbering the CTs and comments on not require a leak test for new CT-6.	For the new sealed split CV lid for CT-6.
Page 4-11	Section 4.5.2	Reference for new calculation sheet CS 2018/01 added.	For the gas contents of new CT-6.
CS 2018/01	Append to Section 4	New calculation sheet CS 2018/01 added.	For the gas contents of new CT-6.
Section 5 - Shielding Evaluation			
Page 5-1 and elsewhere	Section 5.1.1, 1 st and 3 rd paras.	Editorial re references, figure and table numbering.	Add references and figures for the new sealed split CV lid for CT-6.

Summary of SARP Page Changes and Supporting Document Changes for Rev 14			
SARP Page or Doc	Location	Change	Reason for Change
Page 5-3	Figure 5-2	Figure 5-2 edited to not show the Insert.	The figure shows the shielding but not the insert which does not provide significant shielding.
Page 5-43	Figure 5-3	Figure 5-5 added	Shows new sealed split CV lid
Page 5-10	Section 5.3.1, three paras following Table 5-3.	Information re MNCP calculations for CT-6 added.	For new CT-6
Page 5-10	Section 5.3.2	Data for neutron sources removed.	None of the radionuclides specified in the contests emit neutrons.
Page 5-11	Section 5.4.1	Editorial changes	Clarification
Page 5-11	Section 5.4.1, 5 th para	Information re MNCP calculations for CT-6 added.	For new CT-6
Page 5-12	Table 5-4 Last row of table	Editorial [spelling] Information re MNCP calculations added.	Correction For new CT-6
Page 5-19	Figure 5-14	Figure 5-14 added to show Thorium target locations for MCNP Model	For new CT-6
Page 5-22	Section 5.4.2, after Table 5-6	Ref to materials properties for CT-6 added.	For new CT-6
Page 5-23	Section 5.5.1	Ref to calculation method for CT-6 added.	For new CT-6

Summary of SARP Page Changes and Supporting Document Changes for Rev 14			
SARP Page or Doc	Location	Change	Reason for Change
Page 5-23	Section 5.5.2	Ref to calculations for CT-6 added.	For new CT-6
Page 5-23	Section 5.5.3	Ref to dose rate conversion for CT-6 added.	For new CT-6
Page 5-28	Section 5.5.4.3	Details of 5.5.4.3 MCNP calculations for thorium target added.	For new CT-6
Page 5-32	Section 5.5.6	Ref for new calculation report for CT-6 /01 added.	For new CT-6
Atkins 5163778-HS-REP-001-001	Append to Section 5	New calculation report for CT-6 added.	For new CT-6
Section 6 - Criticality Evaluation			
Page 6-1, 6-2	Section 6	All details removed.	Consistency and clarification. The contents of this package are non-fissile and therefore no evaluation for the safety of fissile contents is required.
Section 7 - Operating Procedure			
Page 7-1	Section 7, 5 th para	Editorial	Clarification
Page 7-2	Section 7.1.1 – title & para 8)	Editorial	Clarification
Page 7-3	Section 7.1.1 – para 11)	Drawing info added	For new sealed split lid CV
Page 7-4	Section 7.1.2 – para 7)	Editorial	Clarification
Page 7-5	Section 7.1.3 – Note	Editorial	Clarification

Summary of SARP Page Changes and Supporting Document Changes for Rev 14			
SARP Page or Doc	Location	Change	Reason for Change
Page 7-6	Section 7.1.4 – all paras	Loading requirements added for sealed split lid CV	For new CT-6
Page 7-7	Section 7.1.5 – title & para 4)	Editorial	Clarification
Page 7-7	Section 7.1.5, 1)	Editorial	To be consistent with ANSI N14.5 Section 7.6.4 acceptance criterion
Page 7-8	Section 7.2 1 st para	Section references added	Clarification & for new CT-6
Page 7-9	Section 7.2.2 – paras 1) & 6)	Editorial “for contamination” added	Clarification
Page 7-10	Section 7.2.3 – paras 1) & 6)	Editorial “for contamination” added	Clarification
Page 7-11	Section 7.2.4 – all paras	Unloading requirements added for sealed split lid CV	For new CT-6
Page 7-14	Section 7.3,2 para 12)	Requirement added to ovoid damage	Consistency
Page 7-14	Section 7.1.4 – all paras	Loading requirements added for sealed split lid CV	For new CT-6
Page 7-14 & 71-15	Section 7.3.3 – all paras	Requirements added for shipment of empty package having a sealed split lid CV	For new CT-6
Section 8 - Acceptance Tests & Maintenance Program			
Page 8-1	Section 8, 4 th para	Para added	Consistency with Section 7
Page 8-2	Section 8.1.2	Drawing info added	For new sealed split lid CV and clarification
Page 8-2	Section 8.1.3 - 2 nd para	“as specified” added	Clarity

Summary of SARP Page Changes and Supporting Document Changes for Rev 14			
SARP Page or Doc	Location	Change	Reason for Change
Page 8-2	Section 8.1.4 - 1 st para	Editorial	For new CT-6
Page 8-3	Section 8.1.4 penultimate para	Leak testing requirements added for new sealed split lid CV	For new CT-6
Page 8-3	Section 8.1.5.2 – 3 rd para	Editorial	For new CT-6
Page 8-4	Section 8.1.5.5 and 8.1.5.6	Drawing info added	For new sealed split lid CV and clarification
Page 8-6	Section 8.2 – 4 th para	“as specified” added	Clarity
Page 8-7	Section 8.2.2.3 – all paras	Loading requirements added for sealed split lid CV	For new CT-6
Page 8-8	Section 8.2.3.1 – 2 nd paras	Drawing info added	For new sealed split lid CV and clarification
Page 8-8	Section 8.2.3.2 – para 3)	“as specified” added	Clarity
Page 8-9	Section 8.2.3.2 – para 8)	“as specified” added	Clarity
Page 8-9	Section 8.2.3.3 – title	Editorial	Clarification
Page 8-9	Section 8.2.3.3 – para 6)	Drawing info added	For new sealed split lid CV and clarification
Page 8-10	Section 8.2.3.3 – para 7)	Reference added to the section giving the leak test requirements rather than repeating them	Consistency
Page 8-10	Section 8.2.3.3 – para 8)	“as specified” added	Clarity
Page 8-10	Section 8.2.3.4 – para 2)	“as specified” added	Clarity
Page 8-11	Section 8.2.3.5 – para 6)	“as specified” added	Clarity
Page 8-11	Section 8.2.3.6 – para 2)	“as specified” added	Clarity

Summary of SARP Page Changes and Supporting Document Changes for Rev 14			
SARP Page or Doc	Location	Change	Reason for Change
Page 8-11	Section 8.2.3.7 – title para 2)	Editorial “as specified” added	Clarity
Page 8-12	Section 8.2.5.3	“as specified” added	Clarity
Page 8-13	Table 8-1	Insert O-ring added Split lid sealed plug O-ring	Completeness For new sealed split lid CV

Table 2B Summary of SARP Changes and Supporting Document Changes for Rev 15

Summary of SARP Page Changes and Supporting Document Changes for Rev 15			
Note: All changes to the SARP from the previous revision are shown in the "Compare" documents provided for each Section.			
SARP Page or Doc	Location	Change	Reason for Change
Sections 0 to 8	Throughout the SARP	The Rev status has been updated to Rev 15 for all SARP pages and not just pages with changes.	SARP update
	Throughout the SARP	Editorial changes have been made to correct errors, standardise terminology, etc.	To correct errors, standardise terminology, etc.
Section 0 - Contents			
Page 0-3	Section 0.1	Table updated	
Page 0-6	Section 0.2	Plug design changed to remove the piston seal: 1C-7947	Trials showed that the piston seal made it difficult to fit the plug to the CV body. A new insert Design No. 4109 is to be used to provide confinement.
Page 0-7	Section 0.2	PCS 038 now issue J	New shielding limits
Page 0-8	Section 0.2	CS 2019-02 added	New pressure due to radiolysis calculation
Page 0-9	Section 0.2: Documents in Section 5.5.2, Appendix	New Atkins report 5183326 replaces existing report 5163778.	Updated shielding calculations.
Section 1 - General Information			
Page 1-3	Section 1.2.1.3, 1 st para 8 th para	Fig ref for sealed split lid deleted. Details for sealed split lid deleted.	Update

Summary of SARP Page Changes and Supporting Document Changes for Rev 15			
Note: All changes to the SARP from the previous revision are shown in the “Compare” documents provided for each Section.			
SARP Page or Doc	Location	Change	Reason for Change
Page 1-4	Section 1.2.1.4	Fig ref for sealed split lid deleted.	Update
Page 1-4	Section 1.2.1.6, 1 st para	Fig ref for sealed split lid deleted.	Update
Page 1-8	Section 1.2.1.8	Fig 1-1c for sealed split lid deleted, subsequent Figures re-numbered.	Update
Page 1-12	Section 1.2.1.8	Fig 1-2c for sealed split lid deleted, subsequent Figures re-	Update
Page 1-16	Section 1.2.1.8	Fig 1-3c for sealed split lid deleted	Update
Page 1-19	Section 1.2.1.8	Fig 1-4c replaced (was for sealed split lid)	Update
Page 1-20	Section 1.2.2.1, 4 th para	Text edited	Clarification re pyrophoricity.
Page 1-20	Section 1.2.2.1, 9 th para	Text edited for removal of sealed split lid	Update
Page 1-21	Section 1.2.2.2, 2 nd para Table 1-1	Fig ref for sealed split lid deleted. Details for inset 4109 added	Update
Page 1-23	Section 1.2.2.2,	Fig 1-5e insert 4109 added	Update
Page 1-24	Section 1.2.2.2,	Fig 1-7 revised	Update
Page 1-25	Section 1.2.2.3, Table 1-2	Details of insert for CT-6 added	Update

Summary of SARP Page Changes and Supporting Document Changes for Rev 15			
Note: All changes to the SARP from the previous revision are shown in the “Compare” documents provided for each Section.			
SARP Page or Doc	Location	Change	Reason for Change
	PCS 038 Section 2.3 Table 3	References under CT-4 and CT-5 “exchanged”	To correct typographical error.
Page 1-31	Table 1-3-6	Revised contents specification especially with respect to use of insert 4109 and packing for the thorium target. Jar for the target pieces specified as plastic or metal.	Amended to remove Inconel housing no longer to be shipped. Other changes are clarification. To give flexibility to the user.
Page 1-38	Tables 1-4-6	The listed nuclides have been changed to those that contribute significantly to the package surface dose rate.	This is explained in Appendix B to this document (CTR 2018, Issue B).
Page 1-46	Section 1.3.3.3	Drawing details revised for use of insert 4109.	Update
PCS 038 ref in SARP Section 1.3.4	PCS 038 Section 1.1	Table 1, Insert added for CT-6	Update
	PCS 038 Section 2.2	Table 2, Insert added for CT-6 and weights amended	Update
	PCS 038 Section 2.3	Table 3 has been edited: CT-4 -s for I-131 CT-5 is for Mo-99	Correction
	PCS 038 Section 2.3	Table 4-has been revised to just include the 17 radionuclides that that contribute significantly to the	The radionuclide list has been determined by the shielding calculations in new Atkins report

Summary of SARP Page Changes and Supporting Document Changes for Rev 15			
Note: All changes to the SARP from the previous revision are shown in the "Compare" documents provided for each Section.			
SARP Page or Doc	Location	Change	Reason for Change
		package surface dose rate + Ac-225.	5183326-HS-REP-001 (ref in SARP Section 5.6.2).
Section 2 - Structural Evaluation			
Page 2-3	Section 2.1.1, 1st para	Details revised for use of insert 4109.	Update
Page 2-4	Section 2.1.1, last para	Details revised for use of insert 4109.	Update
Page 2-18	Table 2-10	4109 insert referenced (55x113-SS)	Update
Page 2-20	Section 2.2.3, new 3 rd para to 7 th para added	Data added re radiation levels for O-ring seals for CT-6.	RAI Q2.2 New calcs in report Atkins 5183326-HS-REP-001 (in Section 5.6.2).
Section 3 - Thermal Evaluation			
Page 3-15	Section 3.3.2, new 7 th para	New para added with ref to CS 2019/02 to address pressure rise from radiolysis.	RAI Q2.2 Pressure rise due to radiolysis added.
Page 3-23: CS 2019-02-A-v2-Safkeg-HS - Gas generated by radiolysis of moisture in the air	Section 3.5.2, Appendix	New document info added.	RAI Q2.2
Section 4 - Containment Evaluation			
Page 4-3	Section 4.1 Fig 4-3	Fig for sealed split lid deleted	Update

Summary of SARP Page Changes and Supporting Document Changes for Rev 15			
Note: All changes to the SARP from the previous revision are shown in the "Compare" documents provided for each Section.			
SARP Page or Doc	Location	Change	Reason for Change
Page 4-3	Section 4.1, final paras	Data added re radiation levels for O-ring seals for CT-6.	New calcs in report Atkins 5183326-HS-REP-001 (in Section 5.6.2).
Section 5 - Shielding Evaluation			
Page 5-1	Section 5.1.1, 3 rd para	Ref to insert 4109 added	Update
Page 5-4	Section 5.1.1,	Fig 5-4 revised to not show seal in the lid plug	Update
Page 5-7	Section 5.2.1	Fig 5-8 insert 4109 added, subsequent pages re-numbered	Update
Page 5-8 (was 5-7)	Section 5.2.1, 5 th para	Requirement to use a pallet added.	Necessary to aid compliance with SARP requirements.
Page 5-9	Section 5.2.1, para above Table 5-1	Last sentence added re CT-6 Thorium Target	Clarification
Page 5-9	Section 5.2.1, Table 5-1	New data added for CT-6 Thorium Target	New data in document 5183326
Page 5-10	Section 5.3.1, 3 rd para	Reference at end changed to 5.6.2.	Correction
Page 5-11	Section 5.3.1, para after Table 5-3	Edited for information in new document 5183326.	To reference new calculations in document 5183326 and provide information from that report.
Page 5-12	Section 5.3.1, final para	Reference to Inconel housing removed.	Inconel housing not to be included in the contents.
Page 5-12	Section 5.4.1, 4 th para	Edited for information in new document 5183326 and reference to Inconel housing removed.	To reference new calculations in document 5183326

Summary of SARP Page Changes and Supporting Document Changes for Rev 15			
Note: All changes to the SARP from the previous revision are shown in the “Compare” documents provided for each Section.			
SARP Page or Doc	Location	Change	Reason for Change
Page 5-13	Table 5-4	Additional row added for thorium target. Footnote 4 updated to reference 5183326 shielding report.	Update
Page 5-20	Fig 5-14	Replaced with new shielding model target positions	To reference the revised thorium MCNP model in document 5183326
Page 5-23	Section 5.4.2, Table 5-7	Reference changed to new document 5183326 and reference to Inconel housing removed.	New document provided.
Page 5-24	Section 5.5.2, 2 nd para	Reference changed to new document 5183326. Report number corrected to CTR 2013/09 and Reference at end corrected to 5.6.2.	New document provided.
Page 5-29	Section 5.5.4.3, 1 st para 2 nd para and Table 5-15	Beam current edited. Reference changed to new document 5183326. Table title amended.	As specified in BNL report C-A/BLIP/001 (ref SARP Section 5.6.2). For new document provided.
Page 5-29	Section 5.5.4.3	Reference to Inconel housing removed. Beam current edited.	Inconel housing not to be included in the contents.

Summary of SARP Page Changes and Supporting Document Changes for Rev 15			
Note: All changes to the SARP from the previous revision are shown in the “Compare” documents provided for each Section.			
SARP Page or Doc	Location	Change	Reason for Change
	After Table 5-15	<p>References added.</p> <p>Information regarding dominant radionuclides (in terms of contribution to dose rates) added with Figure 5-16.</p> <p>Para added re dose rate calculations and use of insert 4109.</p> <p>Second para (now third) amended to reference Atkins and BNL reports.</p> <p>Last para and Figure 5-16 added.</p>	<p>As specified in BNL report C-A/BLIP/001 (ref SARP Section 5.6.2).</p> <p>To show rapid reduction of activity and dose rates due to radioactive decay.</p> <p>Update.</p> <p>Update.</p> <p>Clarification and explanation of dose rate nuclide contributions.</p>
Page 5-31	Section 5.5.4.4, 2 nd para	Reference changed to 5.6.2.	Correction
Page 5-33	Section 5.6.2	Reference changed to Atkins report 5183326.	New report replaces existing report.
Section 6 - Criticality Evaluation			
		No Changes	
Section 7 - Operating Procedure			
Page 7-3	Sections 7.1.1, 11)	Insert 4109 added and sealed split lid ref deleted.	Update
Page 7-4	Sections 7.1.2, 4)	Note added to require that for insert Design No. 3987 and insert	Clarification added – this requirement is in the certificate in para 7. (a).

Summary of SARP Page Changes and Supporting Document Changes for Rev 15			
Note: All changes to the SARP from the previous revision are shown in the “Compare” documents provided for each Section.			
SARP Page or Doc	Location	Change	Reason for Change
		Design No. 4081, new seals shall be fitted prior to each use.	
Page 7-4	Sections 7.1.2, 7)	Clarification that only the outer seal should be leak tested in insert Design No. 3987. Para 8 split to have loading in new para 9).	Clarification Clarification
Page 7-5	Sections 7.1.3	Title clarified	Clarification
Page 7-6	Sections 7.1.4	Revised for use of insert 4109. Packing requirements for the thorium target amended.	RAI Q7.2 Clarification and consistency.
Page 7-10	Sections 7.2.3, Title & paras 7).	Title clarified Use of jacking screws clarified in para 5).	Correction.
Page 7-11	Sections 7.2.4	Handling requirements for the spaces and jar for the thorium target amended.	RAI Q7.2 Clarification
Page 7-13	Sections 7.3.2, 3)	Edited to cover insert 4109 which does not use a tungsten liner.	Update
Page 7-14	Sections 7.3.3	Deleted as seal split lid no longer specified in the SARP.	Update

Summary of SARP Page Changes and Supporting Document Changes for Rev 15			
Note: All changes to the SARP from the previous revision are shown in the “Compare” documents provided for each Section.			
SARP Page or Doc	Location	Change	Reason for Change
Page 7-14	Section 7.4	Requirements for pallets added.	Necessary to aid compliance with SARP requirements.
Section 8 - Acceptance Tests & Maintenance Program			
Page 8-2	Section 8.1.2	Edited for use of new insert 4109.	Update
Page 8-7	Sections 8.2.2.2 – new 1 st para	Requirement added for new seals to be fitted to the inserts at maintenance.	Clarification added – this requirement is in the certificate in para 7. (a).
Page 8-7	Sections 8.2.2.2 – 2 nd para	Clarification that only the outer seal should be leak tested in insert Design No. 3987.	Clarification
Page 8-7	Sections 8.2.2.3	Deleted as seal split lid no longer specified in the SARP.	Update
Page 8-9	Sections 8.2.3.3, 6)	Edited for use of new insert 4109.	Update
Page 8-13	Table 8-1	Ref to split lid sealed plug O-rig deleted.	Update

NRC Questions and Croft Responses

This section is provided to document all NRC Questions and Croft Responses.

Table 3 - Question and Response Matrix Table

Q#	Review Question	Croft Response	Changed Item
	RAIs Provided by email dated 30/10/2018		
1.1	<p>Revise the free volume description in safety analysis report (SAR) Table 1-3-6.</p> <p>In SAR Table 1-3-6, the applicant states that "...the product container and spacers shall be so designed as to leave a free volume of 225 cc within the [containment vessel] cavity." This statement neither identifies the free volume if the thorium target were shipped without a product container, as Table 1-3-6 allows, nor is consistent with the free volume description in proprietary calculation CS2018/01.</p> <p>This information is necessary to satisfy the requirements in Title 10 of the Code of Federal Regulations (10 CFR) 71.33(a).</p>	<p>The volume of the cavity of the containment vessel - as specified in drawing 1C-7940 and identified in Figure 1-1c – is 450 cc. The volume of the jar, spaces and packing has been calculated as nominally 68 cc. Therefore, the free volume of the CV carrying the thorium target in the jar and packed with spacers is nominally 382 cc.</p> <p>The free volume used in calculation CS 2018/01 has been conservatively specified as 225cc.</p> <p>The text in the SARP in Table 1-3-6 has been edited to clarify the free volume.</p>	SARP Table 1-3-6

2.1	<p>Correct and revise, if necessary, the pyrophoric description of the proposed contents in SAR Table 1-3-6.</p> <p>SAR Table 1-3-6 states "The are not pyrophoric." (ADAMS Accession No. ML18136A487) The applicant confirmed that the statement should read "The contents are not pyrophoric." (ADAMS Accession No. ML18226A238) However, the U.S. Department of Energy Handbook, Primer on Spontaneous Heating and Pyrophoricity, FSC-6910, identifies that thorium can be pyrophoric under certain conditions (e.g., a critical surface area in the presence of water). Therefore, the applicant needs to provide information which demonstrates that the proposed contents will not spontaneously combust.</p> <p>This information is necessary to satisfy the requirements in 10 CFR 71.43(d).</p>	<p>The text in the SARP in Table 1-3-6 has been edited to say: "The thorium disc is are not pyrophoric."</p> <p>The thorium is in the form of a metal disk and the only moisture present is from the humidity in the air. Also, the materials are not in fine powder form and there is no source of ignition within the CV. LANL also reports that they have not observed any evidence of combustion in their handling of many thorium targets</p> <p>We conclude that contents in the CV are not capable of spontaneous combustion.</p> <p>Section 1.2.2.1 4th para states "Pyrophoric materials are permitted under the conditions specified." This para has been edited to provide justification.</p> <p>It is noted that it has been previously accepted for Contents Types CT-1 and CT-2 that the contents of the CV may be pyrophoric.</p>	<p>SARP Section 1.2.2.1 4th para</p>
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2.2	<p>Analyze the changes caused by radiation from the irradiated thorium target in the package containment vessel (CV).</p> <p>SAR Section 2.2.3 only discusses the effects of radiation on package materials associated with the containment vessel. It does not discuss the impact of radiation on package components which are inside the containment boundary (e.g., the CV plug seal and the plastic product container) which are closer to the radiation source. In addition, since the applicant does not inert the CV cavity during loading operations, radiation from the thorium target may produce a combustible combination of gases due to the presence of water vapor. The applicant needs to provide a bounding assessment of (i) the radiation effects on components which are inside the containment boundary, and (ii) the amount of gas production due to radiolysis of moisture in the CV.</p> <p>This information is necessary to satisfy the requirements in 10 CFR 71.43(d).</p>	<p>The responses to the questions are as follows.</p> <p>Q(i) radiation effects</p> <p>Details of the packing within the CV for the thorium target have been added to SARP section 1.2.2.2.</p> <p>The dose rate at the CV containment seal and the CV plug seal at time of packing (24 hr from EOB) have been calculated as 5.4E-7 Mrad/hr (0.0054 Gy/h) and 2.9E-4 Mrad/hr (2.9 Gy/h) respectively (see document 5183326, SARP Section 5.6.2). The absorbed dose in a period of 1 year at the dose rate at 1 day from EOB at the CV containment seal and the 4109 insert seal would be 0.0047 Mrad (47 Gy) and 2.5 Mrad (2.5E4 Gy) respectively.</p> <p>The Viton containment seal would not be damaged by 0.0047 Mrad – see Parker catalogue which indicates concern for doses of 10 Mrad.</p> <p>The Viton CV plug seal would not be significantly damaged by 2.5 – see Parker catalogue which indicates concern for doses of 10 Mrad.</p> <p>The plastic jar (if used instead of a metal tin) carrying the thorium target would have similar dose rates to the CV plug seal. The plastic would not be expected to be damaged by the calculated max dose of 2.5 Mrad.</p> <p>In practice the absorbed doses would be much less calculated due to the decay of the radioactive contents which reduces to ~12% after 4 days. (from 1 day after EOB).</p>	SARP section 2.2.3
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		<p>SARP Section 2.2.3 has been edited to address the above issues (new 7th para) and 4.1 (at the end of this section).</p> <p>Q(ii) gas production due to radiolysis</p> <p>The maximum pressure that could arise from gas production due to radiolysis of moisture in the CV has been added to SARP section 3.3.2 [MNOP] with reference to new calculation CS 2019/02 (ref Section 3.5.2) which shows that the pressure increase if the moisture was fully dissociated would be 0.02 bar. In practice full dissociation would not occur and there the pressure increase is regarded as negligible.</p> <p>Calculation CS 2019/02 also shows that the maximum hydrogen produced would be ~ 0.2% which is below the level of concern for detonation/deflagration.</p>	<p>SARP Sections 3.3.2</p> <p>CS 2019/02</p>
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2.3	<p>Demonstrate that the thorium target transportation configurations will not significantly increase external surface radiation levels.</p> <p>The applicant states in SAR Table 1-3-6 that the thorium target may be shipped in a product container. However, a proprietary drawing submitted by the applicant shows a configuration in which the thorium target is encased in Inconel and shipped outside of a product container. It is understood that Inconel may be susceptible to embrittlement by proton irradiation. For example Carsughi et al. (1999) investigated Inconel 718 irradiated with 800 MeV protons, and found that the mechanical properties of Inconel 718 degraded after approximately 20 hours of irradiation at dose rates of 0.57 – 0.78 Sv/hour. If Inconel embrittlement occurs due to proton bombardment, normal conditions of transport (NCT) could damage the Inconel housing allowing either pieces of Inconel or pieces of thorium to relocate and produce increased radiation levels.</p> <p>This information is necessary to satisfy the requirements in 10 CFR 71.43(f).</p>	<p>The text in the SARP in Table 1-3-6 and SARP Section 7.1.4 has been edited to clarify the packing for the thorium target in cut pieces in a jar as below.</p> <p>The jar is robust and located by spacers – see Fig 1-7 added to SARP Section 1.2.2.2. This configuration prevents significant variation in the external radiation levels due to movement of the thorium.</p> <p>Options for the jar are specified in SARP in Table 1-3-6 as commercial items may become unavailable. The jar may be plastic or metal.</p> <p>Note that it is no longer proposed to ship a thorium target in an Inconel housing.</p>	<p>SARP in Table 1-3-6 and SARP Section 7.1.4</p>
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3.1	<p>Clarify what is the maximum decay heat for content type CT-6, and provide NCT and HAC thermal evaluations for content type CT-6 if applicable.</p> <p>Page 3-4 of the SAR states “The package temperatures for Contents Type CT-6 (thorium target located at mid height of the CV cavity) would be bounded by those calculated for the higher maximum heat output of 30 W, as determined for the Inserts.” This gives the impression that the Contents Type CT-6 have a lower decay heat which is inconsistent with SAR Table 1-3-6 that provides the maximum decay heat of 30 W for the new contents. Also, page 17 of SARP Update Matrix for Thorium Target (CTR 2018/01) states that the heat output is less than 1 W which shows another inconsistency in the application. The staff needs this information to determine that predicted temperatures are below allowable limits for all package components.</p> <p>This information is needed to determine compliance with 10 CFR 71.33(b)(7), 71.71(a), 71.71(c)(1), and 71.73(c)(4).</p>	<p>Revised SARP Table 1-4-6 gives the calculated heat output for the contents as 0.036 W.</p> <p>Table 1-3-6 [Contents Type CT-6 – Thorium Target] has been revised to a bounding limit of <1W which is consistent with the heat output given in Table 1-4-6.</p> <p>The package has been assessed as satisfactory for 30 W and therefor detailed assessment for the thorium target emitting <1W is deemed unnecessary.</p>	<p>Table 1-4-6</p> <p>SARP Table 1-3-6</p>
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5.1	<p>Provide justification for using Ac-225 activity to define the content nuclides for CT-6 (activated thorium) within SAR Table 1-3-6.</p> <p>Although many radionuclides are present, Table 1-3-6 only provides Ac-225 activity limits for the activated thorium content. The applicant explains its intent by the statement in Appendix B of "SARP Update Matrix for Thorium Target." which states: <i>It is proposed that only the activity of Ac-225 (being the principal radionuclide of interest) be reported on the shipping labels and documentation and the there is no need to the shipper to establish that the limit for the radionuclides calculated to be in the thorium target are less than specified limits.</i></p> <p>Section 2 of the shielding assessment (Document 5163778-HS-REP-001) states: <i>"The 3977A Type B SAFKEG-HS package is required to contain a thorium target consisting of a radioactive thorium disc surrounded by a thin Inconel housing. The source contains a host of radionuclides present in both the thorium disc and the Inconel housing. These radionuclides are listed in Table 7-1 and were provided by Reference [1]."</i></p> <p>The applicant needs to demonstrate the nuclide profile and activity used is bounding of any Inconel incased proton activated thorium target that would produce 7.9 GBq (0.2 Ci). Specifically the staff requests the following:</p> <ol style="list-style-type: none"> 1. Provide Reference 1 from Document 5163778-HS-REP-001, 2. Justify that the activation and decay assumptions from SAR Section 5.5.4.3 are bounding for all proton activated thorium contents, 3. Justify how the radionuclide profile was determined and state if daughter products of radionuclides were considered, and 4. Justify the amounts of thorium, inconel and impurities (e.g., cobalt within the Inconel) used to simulate the target are bounding. 	<p>The responses to the questions are as follows.</p> <p>Q1 Document 5163778 is no longer relevant as the shielding assessment has been revised and document 5163778 replaced by document 5183326 (see SARP Section 5.3.1 and Section 5.6.2).</p> <p>Q2 The activation of the thorium target calculated using the FLUKA code is given in BNL report C-A/BLIP/001 (ref SARP Section 5.3.1) which lists all individual radioisotopes (498 isotopes in total) determined by the code at 24 hours decay time following the target irradiation (otherwise known as 24 hours End of Beam (EOB)). The activity (Bq) for each isotope is also provided.</p> <p>Q3 See Q2. Daughter products of radionuclides are included.</p> <p>Q4 The target is thorium only – the Inconel housing is not to be shipped. The target assumed in the BNL FLUKA calculation is 100% Th-232 which is the composition of the actual target.</p>	<p>SARP Sections 5.3.1, and Section 5.6.2</p>
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	This information is needed to verify compliance with 10 CFR 71.33(b)(1), 71.47 and 71.51(a)(2).		
5.2	<p>Justify the use of nominal dimensions for the shielding components.</p> <p>The staff compared the dimensions shown in Tables 7-2 and 7-3 of the shielding assessment (Document 5163778-HS-REP-001) to that of the drawings 0C-7942, 0C-7943 and 1C-7946. The staff finds use of nominal dimensions non-conservative. The staff requests that the applicant provide additional justification demonstrating that using nominal rather than minimum dimensions does not cause the package to exceed regulatory dose rate limits in 10 CFR 71.47 and 10 CFR 71.51(a)(2). Although the applicant addressed this item during initial issuance of the certificate, the staff does not find that the previously submitted uncertainty analyses address this item for the following reasons: (1) the content and analysis method are completely different from that of the initial approval, and (2) the staff's acceptance of the previous uncertainty analysis (ADAMS Accession No. ML14092A086) was based on conservatism and margins to regulatory limits associated with the application for initial issuance of the certificate. The current analysis has removed some of those conservatisms (e.g., the source is no longer a point source and the cork material is now being credited within the analysis). Further, since the staff did not locate the dose rates (see RAI 5-7), the staff cannot determine if there is sufficient margin to the regulatory dose rate limit to compensate for this uncertainty.</p> <p>This information is needed to verify compliance with 10 CFR 71.47 and 71.51(a)(2).</p>	<p>New shielding Assessment 5183326 assesses dose rates at 24 h EOB. All relevant dimensional tolerances (as provided in the CAD drawings) have been carefully considered and the dimensions have been adjusted, within the tolerances, to ensure the modelled geometry gives conservative, bounding dose rates. In practice this means that dimensions are adjusted to reduce distances and shielding between the sources and outside surface of the package.</p> <p>SARP Section 5.3.2 (penultimate paras) and Section 5.5.4.3 have been edited to reference the new shielding Assessment 5183326.</p>	<p>SARP Sections 5.3.1, 5.5.4.3 and 5.6.2</p>

5.3	<p>Discuss how the effects from NCT and HAC were incorporated into the shielding evaluation.</p> <p>The applicant's shielding evaluation does not discuss effects to the package due to NCT and HAC. However, SAR Section 2.7.8 indicates that there is deformation to the package as a result of the side puncture test and the 10.2 meter drop. In addition, both SAR pages 3-10 and 3-11 state: <i>"Under HAC conditions the cork reaches a maximum temperature of 788oC. Cork ablates under high temperatures and leaves a low density carbonaceous layer which provides insulation equivalent to still CO₂."</i> The applicant needs to discuss how these effects are accounted for within the shielding evaluation. Although the applicant has addressed this item during initial issuance of the certificate, the staff does not find that the previously submitted uncertainty analyses address this item for the following reasons: (1) the content and analysis method are completely different than that of the initial approval, and (2) the staff's acceptance of the previous uncertainty analysis (ADAMS Accession No. ML14092A086) was based on conservatisms and margins to regulatory limits associated with the application for initial issuance of the certificate. The current analysis has removed some of those conservatisms (e.g., the source is no longer a point source and the cork material is now being credited within the analysis). Further, since the staff did not locate the dose rates (see RAI 5-7), the staff cannot determine if there is sufficient margin to the regulatory dose rate limit to compensate for this uncertainty.</p> <p>This information is needed to verify compliance with 10 CFR 71.47 and 71.51(a)(2).</p>	<p>New shielding Assessment 5183326 assesses dose rates at 24 h EOB under the NCT (SARP Section 5.6.2). The relevant damage from the NCT test is an 8.06 mm dent in the package outer keg skin. This results in the surface of the package at the dent location effectively being closer (by 8.06 mm) to the centrally held source, this potentially increases the peak dose rates measured from the surface. In order to assess this in a bounding manner the entire outer steel dimensions of the package have been reduced by 8.06 mm in the shielding model.</p> <p>The effect of the HAC drop tests are reported in the SARP in Section 5.2.2 which gives the effect of HAC as an 11 mm dent to the side of the package. This dent would cause a 5% increase in dose rate on the package which is not a significant increase from the NCT dose rates (a much larger increase is allowed by the regulations).</p>	SARP Section 5.6.2
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5.4	<p>Clarify the minimum dimensions for both the activated thorium source and the Inconel housing and justify the dimensions used in the shielding evaluation.</p> <p>Proprietary drawing No. 1C-7972, "Packing for Thorium Target in Design No. 3978 – Sealed Plug," shows the dimensions of the activated thorium source as 57.15 mm in diameter by 0.37 mm thick. However, SAR Section 5.3.1 states that the source is nominally 60 mm x 5 mm. In addition to clarifying the dimensions of the activated thorium disc, the applicant needs to identify if these dimensions are exact, minimum or nominal and provide the tolerances for the activated thorium disc.</p> <p>The size of the Inconel cladding for the thorium target is not specified in Drawing 1C-7972. Section 3.2.3 of the shielding assessment (Document 5163778-HS-REP-001) states that the source dimensions are a cylindrical disc of thorium with radius 3 cm and height 0.5 cm, surrounded by a 0.1 cm thick Inconel housing. These dimensions are roughly consistent with the source dimensions specified within the SAR; however, they are non-conservative compared to the source as specified in Drawing 1C-7972. Since they are larger and include the Inconel housing, this provides additional self-shielding. Since the Inconel housing is assumed to be present within the shielding evaluation, the applicant needs to justify that the source will retain its analyzed geometry and will not be separated from its Inconel housing under NCT or HAC additionally taking into consideration any Inconel embrittlement from the source radiation. The staff needs this information to determine if the amount of self-shielding assumed within the shielding evaluation is appropriate and conservative.</p> <p>This information is needed to verify compliance with 10 CFR 71.33(b)(3), 71.47 and 71.51(a)(2).</p>	<p>The inclusion of an Inconel housing is no longer specified in the SARP.</p> <p>New shielding Assessment 5183326 models the thorium target as dia 57.15 mm x 0.37 mm which is nominally the same as the dimensions used in the calculations using the FLUKA code as given in BNL report C-A/BLIP/001.</p> <p>SARP Section 5.3.1 has been edited to give the correct dimensions for the thorium target (dia 60 mm x 0.37 +/- 0.025 mm) as specified in BNL report C-A/BLIP/001 (ref SARP Section 5.3.1 and Section 5.6.2).</p>	<p>SARP Section 5.3.1 and Section 5.6.2</p>

5.5	<p>Provide the distances from the package surface used to evaluate regulatory dose rates in 10 CFR 71.47 and 10 CFR 71.51(a)(2).</p> <p>The staff was unable to locate the distances that the applicant used to evaluate the regulatory dose rate limits. The staff requires this information to be able to verify that the locations used for evaluating dose rates under NCT are consistent with the distances prescribed in 10 CFR 71.47(b) for exclusive use and 10 CFR 71.51(a)(2).</p> <p>This information is needed to verify compliance with 10 CFR 71.47 and 71.51(a)(2).</p>	<p>Additional analysis has been provided in SARP section 5.2.1 re dose rates under for exclusive use.</p> <p>SARP Section 5.2.1 and Section 7.4 has been edited to require use of a pallet 750 mm high to space the package from the floor of the conveyance for Contents Type 6 - CT-6 for the Thorium target.</p> <p>Shielding Assessment 5183326 (see SARP Section 5.6.2) assesses dose rates (given in Section 5.2.1) at:</p> <ul style="list-style-type: none"> • Package Surface • Outer Surface of Conveyance • 2 m from Edge of Conveyance • 1 m from Package Surface • 1 m from Edge of Conveyance 	<p>SARP Section 5.2.1</p> <p>Section 7.4</p> <p>SARP Section 5.6.2</p> <p>Section 5.2.1</p>
5.6	<p>Provide a representative Monte Carlo N-Particle (MCNP) input and output file.</p> <p>The applicant did not provide an MCNP input or output file. The staff uses these files to verify if package design information has been properly input into the code, to ensure that proper convergence is achieved and that the calculated dose rates from the output files agree with those reported in the application.</p> <p>This information is needed to verify compliance with 10 CFR 71.47 and 71.51(a)(2).</p>	<p>Representative Monte Carlo N-Particle (MCNP) input and output files have been provided [associated with the calculations in report 5183326 ref SARP Section 5.6.2].</p>	

5.7	<p>Provide calculated dose rate levels.</p> <p>SAR Table 5-15, "Summary Table of package base external dose rates from MCNP calculations for the Nuclide Activities in LANL calculations for a typical target activated to produce 0.2 Ci Ac-225" states: "See Atkins report 5163778-HS-REP-001-001 (Section 5.5.6)." Neither the Atkins report nor the SAR has a Section 5.5.6. Column 12 in SAR Table 1-4-6 reported a maximum surface dose rate; however, this value exceeds the regulatory dose rate limit of 10 mSv/hr in 10 CFR 71.47(b)(1).</p> <p>This information is needed to verify compliance with 10 CFR 71.47 and 71.51(a)(2).</p>	<p>Shielding Assessment 5183326 (ref SARP Section 5.6.2) provides assessed dose rates.</p> <p>Dose rate data has been added to SARP Section 5.2.1, Table 5-1</p> <p>Table 5-15 in SARP Section 5.5.4.3 has been edited to reference the new report 5183326 with ref to location of full reference information given in the References in SARP Section 5.6.2.</p>	<p>SARP Section 5.6.2</p> <p>SARP section 5.5.4.3</p>
7.1	<p>Revise steps 5 and 8 of SAR Section 7.1.4.</p> <p>Steps 5 and 8 of SAR Section 7.1.4 do not direct the user to perform an action. If the information in these steps is important to package operations, the applicant should either revise steps 5 and 8 to direct the user what action to perform or reformat the information (e.g., provide the information as a Note). In addition, the information in step 8 associates 225 cc only with the use of spacers while with the information provided in Table 1-3-6 associates 225 cc with the use of spacers and a product container. If the applicant chooses to retain the information in step 8, the applicant needs to make the information in Table 1-3-6 consistent with the information in step 8.</p> <p>This information is needed to verify compliance with 10 CFR 71.87(f).</p>	<p>SARP section 7.1.4 has been edited to move Steps 5 and 8 (in SARP Rev 14) into the NOTES.</p> <p>The 2nd note re leak testing has been edited for clarity.</p> <p>The 3rd note re contents packing requirements has been edited to refer to details given in SARP Section 1.2.2.2 in Figure 1-7. The requirement for a free volume of 225 cc has been removed as this is ensured by the design of the packing specified in SARP Section 1.2.2.2 in Figure 1-7.</p> <p>Steps 5 and 6 have been edited for clarity.</p>	<p>SARP section 7.1.4</p> <p>SARP Section 1.2.2.2 in Figure 1-7</p>

7.2	<p>Clarify the instructions associated with inserts in the sealed split lid configuration.</p> <p>SAR Sections 7.1.4, 7.2.4 and 7.3.3 each contain steps associated with inserts. However, the applicant did not provide insert drawings for the sealed split lid package configuration, and other SAR Sections do not discuss the use of an insert with the sealed split lid package configuration. Therefore, the applicant should either remove these steps, or if the applicant wishes to retain the flexibility to use inserts with the split lid configuration, the applicant should modify these instructions to identify under what circumstances they need to be performed.</p> <p>This information is needed to ensure compliance with 10 CFR 71.87(f).</p>	<p>SARP section 7.1.4, 7.2.4 and 7.3.3 have been edited to clarify packing requirements for the thorium target.</p>	
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Appendix A New or edited Supporting Documents provided in the SARP from Rev 13

Supporting Documents provided in the SARP at Rev 14

Table 1a - New or edited supporting documents provided in the SARP

Related SARP Section or Doc	Document Reference		Title
Section 1 - General Information			
Documents in Section 1.3.3, Licensing Drawings			
Addition	1C-7940	A	Cover sheet for Safkeg-HS Design No. 3977A – Sealed plug
Addition	0C-7941	A	Safkeg-HS Design No. 3977A – Sealed plug
Addition	0C-7942	A	Keg Design No. 3977 – Sealed plug
Addition	0C-7943	A	Cork set for Safkeg-HS – Sealed plug
Addition	1C-7944	A	CV Design No. 3978 – Sealed plug
Addition	1C-7945	A	CV lid – Sealed plug
Addition	1C-7946	A	CV body – Sealed plug
Addition	1C-7947	A	Containment vessel plug – Sealed plug
Documents in Section 1.3.4 Supporting Documents			
Updated for Rev 15	PCS 038	J	Package Contents Specification for Safkeg-HS - Package Design No 3977A
Section 5 – Shielding Evaluation			
Documents in Section 5.6.2			
Deleted for Rev 15	Atkins report: 5163778-HS-REP- 001-001	Iss 001	HS Container Shielding Assessment with Thorium Target

Supporting Documents provided in the SARP at Rev 15

Table 1b - New or edited supporting documents provided in the SARP

Related SARP Section or Doc	Document Reference		Title
Section 1 - General Information			
Documents in Section 1.3.3, Licensing Drawings			
Addition	1C-7975	B	Packing for thorium target in Design No 3978
Documents in Section 1.3.4 Supporting Documents			
Update	PCS 038	J	Package Contents Specification for Safkeg-HS - Package Design No 3977A
Section 5 – Shielding Evaluation			
Addition	CS 2018/01	A	SAFKEG-HS 3977A - Gas contents limit for leaktight condition – Thorium target
Documents in Section 5.6.2			
Addition	BNL report C-A/BLIP/001	January 2019	Activation of Th-232 target using FLUKA simulation code
Addition	Atkins report: 5183326-HS-REP- 001	01	Shielding Assessment of the 3977A SAFKEG Transport Package Type B(U) with Thorium Target Source

Appendix B Contents Type CT-6 – Thorium Target

This appendix is provided to explain the approach taken for specifying the contents type CT-6 which is for a radioactive thorium target.

The radioactive content of the thorium target arises from proton irradiation at BNL with proton beam energy range of 191 MeV and the beam current of 165 μ A to produce nominally $7.964\text{E}+09$ Bq (0.215 Ci) Ac-225. The target is allowed to decay for 24 hour after EOB to allow short halflife radionuclides to decay and to reduce the radiation dose from the target – the activity of the Ac-225 will be nominally $7.46\text{E}+09$ Bq (0.2 Ci) Ac-225 at that time. The activation of the thorium target is given in BNL report C-A/BLIP/001 (SARP Section 5.6.2) and the associated spreadsheet which gives details at 24 hour after EOB for the 498 isotopes in total produced by the activation.

Monte Carlo shielding calculations, for all the radionuclides present at EOB in the activated thorium target, are reported in Atkins report 5183326-HS-REP-001 (Section 5.6.2). The calculations determine the external dose rates for the package.

Under NCT and HAC, it is assumed that the contents (thorium target) are located nominally in a fixed position in the CV in and insert, a jar with knit wire packing and the spacers above and below the jar. Containment is provided by the inner seal of the double O-ring seal system provided by the CV. Confinement within the CV cavity is ensured by the seal in the insert.

The Monte Carlo shielding calculations for NCT, as reported in Atkins report 5183326-HS-REP-001 (SARP Section 5.6.2), provide dose rate information on a per photon/s basis for 15 energy groups at various distances from the transport package. This information is used to determine the dose rates from each nuclide from the radioactivity information at 24 hours from EOB. The results of the dose rate calculations are provided in SARP Section 5.1.1.

The dose rate calculations as reported in Atkins document 5183326 were carried out for the contents carried in the CV without an insert. As the packing is similar with the required insert (HS-55x113-SS), the dose rates with the insert would be slightly lower than without the insert.

The shielding calculations show that the dose rate on the external surface of the package will exceed the non-exclusive use regulatory limit of 2 mSv/h but will be within the Exclusive Use limits for a shipment. The calculated maximum package surface dose rate for the activated thorium target is 8.18 mSv/hr at 1 day from EOB: an approximate calculation has shown that this dose rate reduces to about 2 mSv/hr at 2 days from EOB.

The dose rates are not significantly affected by HAC: this is explained in SARP Section 5.1.2.

The BNL FLUKA calculations (BNL report C-A/BLIP/00, SARP Section 5.6.2) showed that 498 nuclides with activity greater than $1\text{E}-09$ of the total activity after 24 hours cooling time are produced by the activation: it is assumed that the contribution to dose rate for nuclides with activity less than $1\text{E}-09$ of the total activity after 24 hours cooling time is negligible. All 498 nuclides are included in the Atkins shielding calculations (Atkins report 5183326-HS-REP-001,

SARP Section 5.6.2), however, on sorting the table of Package Surface Dose Rate Results (Table A-6 in Atkins report) by dose rate for each nuclide only 17 nuclides contribute > 1% to this dose rate: the package surface dose rate for these 17 nuclides is 7.1 mSv/h with the same rate for all 498 nuclides is 8.2 mSv/h. In order to simplify the reporting, only the 17 nuclides that contribute > 1% to the package surface dose rate (+ Ac-225 which has a very low contribution of <1E-4% to the package surface dose rate) are listed in PCS 038 and SARP Section 1, Table 1-4-6. However, the dose rates reported in SARP Section 5.5.1 are for all 498 nuclides.