Mitsubishi Nuclear Fuel Co., Ltd.

May 2020

Doc No.: FED-20-256

Summary of Change in Revision 6 of the Safety Analysis Report for the Model MST-30 Package

The safety analysis report for the model MST-30 package (abbreviated as“SAR”) has been revised from Rev.5 to Rev.6.

The principal items revised in Rev.6 are as follows;

1. “Ring Plate” has been added as a new component of MST-30 packaging.
2. The type of cylinder plug has been limited to “Socket Head Plug” only. (Hex Head Plug is not allowed to use for 30B cylinder loaded into MST-30 overpack.)
3. The design maximum weight of the 30B cylinder has been changed from 665kg to 655kg. (The total weight of MST-30 package has not been changed. (4170kg))
4. The criterion for the wall thickness of the 30B cylinder (minimum thickness) which is measured in 5-year inspection has been changed from 10mm to 11.3mm.
5. The evaluation for the valve/plug contact by LS-DYNA code has been added in the structural analysis.
6. The criticality analysis has been totally revised.
7. Other minor revisions include update of information, corrections of phrase, etc.

Detail of the changes is summarized in the attached Revision Comparison Tables.

Attachment

Revision Comparison Table for MST-30 SAR

Revision Comparison Table for MST-30 SAR (1 / 42)

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
cover page	SAFETY ANALYSIS REPORT FOR THE MODEL MST-30 PROTECTIVE SHIPPING PACKAGE FOR 30-INCH UF_6 CYLINDERS (Revision 5, December 2014)	SAFETY ANALYSIS REPORT FOR THE MODEL MST-30 PROTECTIVE SHIPPING PACKAGE FOR 30-INCH UF_6 CYLINDERS (Revision 6, March 2020)	SAR for MST-30 is revised from revision 5 to revision 6.
i	TABLE OF CONTENTS **1.0 GENERAL INFORMATION** 1.1 Introduction .... 1-1 1.2 Package Description .... 1-2 1.2.1 Packaging .... 1-2 1.2.1.1 Gross Weights .... 1-2 1.2.1.2 Materials and Construction .... 1-2 1.2.1.3 Outer and Inner Protrusions .... 1-2 1.2.1.4 Lifting and Tie Down Devices .... 1-3 1.2.1.4.1 Lifting Devices .... 1-3 1.2.1.4.2 Tie-down Devices .... 1-3 1.2.1.5 Shielding .... 1-3 1.2.1.6 Pressure Relief System .... 1-3 1.2.1.7 Closures .... 1-3 1.2.1.8 Containment .... 1-3a 1.2.2 Operational Features .... 1-4 1.2.3 Contents of Packaging .... 1-4 1.3 Appendices .... 1-5 1.3.1 Copies of the Japanese Authority Certificate for the MST-30 1.3.2 Drawing of Model MST-30 Protective Shipping Package 1.3.3 Drawing of 30B Cylinder 1.3.4 Phenolic and Polyurethane Foam	TABLE OF CONTENTS **1.0 GENERAL INFORMATION** 1.1 Introduction .... 1-1 1.2 Package Description .... 1-2 1.2.1 Packaging .... 1-2 1.2.1.1 Gross Weights .... 1-2 1.2.1.2 Materials and Construction .... 1-2 1.2.1.3 Outer and Inner Protrusions .... 1-3 1.2.1.4 Lifting and Tie Down Devices .... 1-3 1.2.1.4.1 Lifting Devices .... 1-3 1.2.1.4.2 Tie-down Devices .... 1-4 1.2.1.5 Shielding .... 1-4 1.2.1.6 Pressure Relief System .... 1-4 1.2.1.7 Closures .... 1-4 1.2.1.8 Containment .... 1-4 1.2.2 Operational Features .... 1-5 1.2.3 Contents of Packaging .... 1-5 1.3 Appendices .... 1-6 1.3.1 Copies of the Japanese Authority Certificate for the MST-30 1.3.2 Drawing of Model MST-30 Protective Shipping Package 1.3.3 Drawing of 30B Cylinder 1.3.4 Phenolic and Polyurethane Foam	Page number is changed.

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
	2.0 STRUCTURAL EVALUATION	**2.0 STRUCTURAL EVALUATION**	
	…	…	
	2.7 Hypothetical Accident Conditions 2-10	2.7 Hypothetical Accident Conditions 2-10	
	2.7.1 Free Drop 2-10	2.7.1 Free Drop 2-10	
	2.7.1.1 End Drop 2-10	2.7.1.1 End Drop 2-11	Page number is changed.
	2.7.1.2 Side Drop 2-11	2.7.1.2 Side Drop 2-11	
	2.7.1.3 Corner Drop 2-11	2.7.1.3 Corner Drop 2-11	
	2.7.1.4 Oblique Drop 2-11	2.7.1.4 Oblique Drop 2-11	
	2.7.1.5 Polyurethane Foam Strength Tolerance Effect on Package Performance 2-12	2.7.1.5 Polyurethane Foam Strength Tolerance Effect on Package Performance 2-12	
		2.7.1.6 Evaluation by LS-DYNA 2-12	Addition of subsection
	2.7.1.6 Summary of Results 2-12	2.7.1.7 Summary of Results 2-12	
	2.7.2 Puncture 2-12	2.7.2 Puncture 2-12	
	2.7.3 Thermal 2-12	2.7.3 Thermal 2-13	Page number is changed.
	2.7.3.1 Summary of Pressures and Temperatures 2-13	2.7.3.1 Summary of Pressures and Temperatures 2-13	
	2.7.3.2 Differential Thermal Expansion 2-13	2.7.3.2 Differential Thermal Expansion 2-14	
	2.7.3.3 Stress Calculations 2-14	2.7.3.3 Stress Calculations 2-15	
ii iii	2.7.3.4 Comparison with Allowable Stresses 2-14	2.7.3.4 Comparison with Allowable Stresses 2-15	
	2.7.4 Immersion – Fissile Material 2-14	2.7.4 Immersion – Fissile Material 2-15	
	2.7.5 Immersion – All Packages 2-15	2.7.5 Immersion – All Packages 2-16	
	2.7.6 Summary of Damage 2-16	2.7.6 Summary of Damage 2-17	
	2.8 Special Form 2-17	2.8 Special Form 2-17a	
	2.9 Fuel Rods 2-17	2.9 Fuel Rods 2-17a	
	2.10 Appendices 2-17	2.10 Appendices 2-17a	
	2.10.1 Compliance Test Report for the MST-30 Protective Shipping Package	2.10.1 Compliance Test Report for the MST-30 Protective Shipping Package	
	2.10.2 Summary of Preliminary Drop Testing	2.10.2 Summary of Preliminary Drop Testing	
	2.10.3 Effect of Fabrication Deviation of Polyurethane Foam	2.10.3 Effect of Fabrication Deviation of Polyurethane Foam	
	2.10.4 Charts for Determining Shell Thickness under External Pressure	2.10.4 Charts for Determining Shell Thickness under External Pressure	
	2.10.5 Detailed Description of Helium Leak Tests	2.10.5 Detailed Description of Helium Leak Tests	
		2.10.6 Evaluation using LS-DYNA code	Addition of appendices
		2.10.7 Summary of analysis code "LS-DYNA"	
		2.10.8 Explanation of derivation methods for material properties used in LS-DYNA	
	2.11 References 2-17	2.11 References 2-17a	

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
1-i	**SECTION 1 GENERAL INFORMATION** TABLE OF CONTENTS 1.1 Introduction .... 1-1 1.2 Package Description .... 1-2 1.2.1 Packaging .... 1-2 1.2.1.1 Gross Weights .... 1-2 1.2.1.2 Materials and Construction .... 1-2 1.2.1.3 Outer and Inner Protrusions .... 1-2 1.2.1.4 Lifting and Tie Down Devices .... 1-3 1.2.1.4.1 Lifting Devices .... 1-3 1.2.1.4.2 Tie-down Devices .... 1-3 1.2.1.5 Shielding .... 1-3 1.2.1.6 Pressure Relief System .... 1-3 1.2.1.7 Closures .... 1-3 1.2.1.8 Containment .... 1-3a 1.2.2 Operational Features .... 1-4 1.2.3 Contents of Packaging .... 1-4 1.3 Appendices .... 1-5 1.3.1 Copies of the Japanese Authority Certificate for the MST-30 1.3.2 Drawing of Model MST-30 Protective Shipping Package 1.3.3 Drawing of 30B Cylinder 1.3.4 Phenolic and Polyurethane Foam LIST OF TABLES Table 1-1 MST-30 Maximum Weights .... 1-6 LIST OF FIGURES Figure 1-1 Illustration of MST-30 Overpack and 30B Cylinder 1-7	**SECTION 1 GENERAL INFORMATION** TABLE OF CONTENTS 1.1 Introduction .... 1-1 1.2 Package Description .... 1-2 1.2.1 Packaging .... 1-2 1.2.1.1 Gross Weights .... 1-2 1.2.1.2 Materials and Construction .... 1-2 1.2.1.3 Outer and Inner Protrusions .... 1-3 1.2.1.4 Lifting and Tie Down Devices .... 1-3 1.2.1.4.1 Lifting Devices .... 1-3 1.2.1.4.2 Tie-down Devices .... 1-4 1.2.1.5 Shielding .... 1-4 1.2.1.6 Pressure Relief System .... 1-4 1.2.1.7 Closures .... 1-4 1.2.1.8 Containment .... 1-4 1.2.2 Operational Features .... 1-5 1.2.3 Contents of Packaging .... 1-5 1.3 Appendices .... 1-6 1.3.1 Copies of the Japanese Authority Certificate for the MST-30 1.3.2 Drawing of Model MST-30 Protective Shipping Package 1.3.3 Drawing of 30B Cylinder 1.3.4 Phenolic and Polyurethane Foam LIST OF TABLES Table 1-1 MST-30 Maximum Weights .... 1-7 LIST OF FIGURES Figure 1-1 Illustration of MST-30 Overpack and 30B Cylinder 1-8	Page number is changed.

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
1-1	1.0 GENERAL INFORMATION 1.1 Introduction The MST-30 Protective Shipping Package (MST-30) is a Type A, Fissile Material and Uranium Hexafluoride(UF_6) Package used for the shipment of 30-inch cylinders containing solid Uranium Hexafluoride (UF_6) enriched up to 5wt% ^{235}U. The package is designed to conform to the technical and regulatory requirements as specified in the Japanese Safe Transport Regulations pursuant to the IAEA Regulations for Safe Transport of Radioactive Materials, 2009 Edition (TS-R-1). The package is intended to be used for transport from, to, or through foreign countries, including the USA. The MST-30 package was approved by the Japanese Authority (Nuclear Regulation Authority: hereinafter referred to as "NRA") and certified as a Type A Fissile UF_6 Package on September 26, 2014 (NRA Certificate number J/159/AF-96(Rev.2)). A copy of the NRA certificate in English dated on October 31, 2014 is provided in Appendix 1.3.1. The maximum transport index (TI) expected from the calculation reported in this safety analysis report (SAR) is 0.5 (Para. 521 of TS-R-1). The criticality safety index (CSI) is 0 (zero), since an unlimited number of packages is subcritical (Para. 683 of TS-R-1). The MST-30 has been rigorously tested according to the regulatory requirements to assure water leak-tightness of the UF_6 cylinder. UF_6 is not only a radioactive material, but is also a corrosive material, classified into Class 8 of the United Nations (UN) Recommendations for Transport of Dangerous Goods (Para.110 of TS-R-1). Additionally, inleakage of water may compromise criticality control; thus, the ability of the MST-30 package to exclude water under all conditions of transport is an indispensable and the most essential design feature. Therefore, the primary goal for the design of the MST-30 was to assure water leak-tightness of package under the severest of conditions. The exacting and comprehensive test program completely confirms that the design of the MST-30 maintains water leak-tightness of the cylinder under all regulatory conditions.	1.0 GENERAL INFORMATION 1.1 Introduction The MST-30 Protective Shipping Package (MST-30) is a Type A, Fissile Material and Uranium Hexafluoride(UF_6) Package used for the shipment of 30-inch cylinders containing solid Uranium Hexafluoride (UF_6) enriched up to 5wt% ^{235}U. The package is designed to conform to the technical and regulatory requirements as specified in the Japanese Safe Transport Regulations pursuant to the IAEA Regulations for Safe Transport of Radioactive Materials, 2012 Edition (SSR-6). The package is intended to be used for transport from, to, or through foreign countries, including the USA. The MST-30 package was approved by the Japanese Authority (Nuclear Regulation Authority: hereinafter referred to as "NRA") and certified as a Type A Fissile UF_6 Package on March 5, 2020 (NRA Certificate number J/159/AF-96(Rev.3)). A copy of the NRA certificate in English dated on March 24, 2020 is provided in Appendix 1.3.1. The maximum transport index (TI) expected from the calculation reported in this safety analysis report (SAR) is 0.5 (Para. 523 of SSR-6). The criticality safety index (CSI) is 0 (zero), since an unlimited number of packages is subcritical (Para. 686 of SSR-6). The MST-30 has been rigorously tested according to the regulatory requirements to assure water leak-tightness of the UF_6 cylinder. UF_6 is not only a radioactive material, but is also a toxic and corrosive material, classified into Class 6/Division 6.1 and Class 8 of the United Nations (UN) Recommendations on the Transport of Dangerous Goods (Para.110 of SSR-6). Additionally, inleakage of water may compromise criticality control; thus, the ability of the MST-30 package to exclude water under all conditions of transport is an indispensable and the most essential design feature. Therefore, the primary goal for the design of the MST-30 was to assure water leak-tightness of package under the severest of conditions. The exacting and comprehensive test program completely confirms that the design of the MST-30 maintains water leak-tightness of the cylinder under all regulatory conditions.	Update of the IAEA Regulations for the Safe Transport of Radioactive Material (SSR-6 (2012) corresponds to the current Japanese Regulation) Update of the Japanese certificate for MST-30 Update of the IAEA regulations Class 6/Division 6.1 was added according to the update of UN Recommendations on the Transport of Dangerous Goods, and update of the IAEA regulations.

Revision Comparison Table for MST-30 SAR (6 / 42)

<table>
<tr><th>page</th><th>SAR Revision 5 (December 2014)</th><th>SAR Revision 6 (March 2020)</th><th>Note</th></tr>
<tr><td>(2014 Ver.)
1-2

(2020 Ver.)
1-2
1-3</td><td>1.2 Package Description

1.2.1 Packaging

Drawings of the MST-30 overpack are provided in Appendix 1.3.2. A drawing of the 30B UF_6 cylinder is provided in Appendix 1.3.3. The MST-30 is an overpack used to protect a 30-inch cylinder containing enriched uranium hexafluoride during transport. The packaging is approximately 1.2m (approx. 47inch) in diameter by 2.4m (approx. 95inch) long.

The annulus between outer shell and inner shell is filled with polyurethane and phenolic foam. Three layers of polyurethane foam plates are used at the ends of the overpack for shock-absorption and fire-resistance. Phenolic foam is used in the annular areas of overpack for fire-resistance. Figure 1-1 provides an illustration of the overpack construction.

1.2.1.1 Gross Weights

The maximum weights of the MST-30 are provided in Table 1-1.

1.2.1.2 Materials and Construction

…
The annulus between the MST's inner shell and outer shell is filled with two (2) kinds of shock-absorbing and/or fire-resistant materials: closed-cell polyurethane foam, and phenolic foam. The polyurethane foam is used in the ends of the package for extra impact resistance and has densities of 0.37 g/cm^3 (approximately 23 lb/ft.^{3}) and 0.48 g/cm^3 (approximately 30 lb/ft.^{3}). The phenolic foam is used in the MST's annular area. The phenolic foam used has a very low free chloride content. The specifications for the Phenolic and Polyurethane foams used to fabricate the MST are provided in Appendix 1.3.4.

The 30B cylinder and valve are constructed in accordance with ANSI N14.1 or ISO 7195. They are defined to be the containment boundary of the packaging.</td><td>1.2 Package Description

1.2.1 Packaging

Drawings of the MST-30 overpack including the ring plate are provided in Appendix 1.3.2. A drawing of the 30B UF_6 cylinder is provided in Appendix 1.3.3. The MST-30 is an overpack used to protect a 30-inch cylinder containing enriched uranium hexafluoride during transport. The packaging is approximately 1.2m (approx. 47inch) in diameter by 2.4m (approx. 95inch) long.

The annulus between outer shell and inner shell of the overpack is filled with polyurethane and phenolic foam. Three layers of polyurethane foam plates are used at the ends of the overpack for shock-absorption and fire-resistance. Phenolic foam is used in the annular areas of overpack for fire-resistance. Figure 1-1 provides an illustration of the overpack construction.

The ring plate is a stainless steel plate in a circular ring form. It is inserted in the gap on the plug side between the overpack and the cylinder when the cylinder is loaded in the overpack in order to prevent excessive deformation of the inner shell of the overpack.

1.2.1.1 Gross Weights

The maximum weights of the MST-30 are provided in Table 1-1.

1.2.1.2 Materials and Construction

…
The annulus between the MST's inner shell and outer shell is filled with two (2) kinds of shock-absorbing and/or fire-resistant materials: closed-cell polyurethane foam, and phenolic foam. The polyurethane foam is used in the ends of the package for extra impact resistance and has densities of 0.37 g/cm^3 (approximately 23 lb/ft.^{3}) and 0.48 g/cm^3 (approximately 30 lb/ft.^{3}). The phenolic foam is used in the MST's annular area. The phenolic foam used has a very low free chloride content. The specifications for the Phenolic and Polyurethane foams used to fabricate the MST are provided in Appendix 1.3.4.

The ring plate is a circular ring form with an outer diameter of 770 mm (30.3in), an inner diameter of 624 mm (24.6in) and a thickness of 6 mm (0.24in). This plate is made of JIS SUS-304.

The 30B cylinder, valve and plug are constructed in accordance with ANSI N14.1 or ISO 7195. They are defined to be the containment boundary of the packaging. In the case of the MST-30 package, the type of plug allowed is a socket head plug only. A hex head plug is not available. A 30B cylinder which does not have any plug and plug-coupling may be used.</td><td>Addition of the Ring Plate (New component)

Addition of a description of the Ring Plate

Addition of a description of the Ring Plate

Addition of explanations on the type of cylinder plug and the cylinder without plug and plug-coupling</td></tr>
</table>

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
(2014 Ver.) 1-2 (2020 Ver.) 1-3	1.2.1.3 Outer and Inner Protrusions There are no inner protrusions on MST-30 overpack. Outer protrusions on the MST-30 overpack consist of lifting and tie-down point and fastening devices.	1.2.1.3 Outer and Inner Protrusions There are no inner protrusions on MST-30 overpack. Outer protrusions on the MST-30 overpack consist of lifting and tie-down point and fastening devices. And there is no protrusion on the ring plate.	Addition of a description of the Ring Plate
(2014 Ver.) 1-3a (2020 Ver.) 1-4	1.2.1.8 Containment The containment boundary is defined as the Model 30B UF_6 cylinder and valve. The cylinder is constructed and maintained in accordance with USEC-651 and ANSI N14.1 or ISO 7195.	1.2.1.8 Containment The containment boundary is defined as the Model 30B UF_6 cylinder, valve and plug. The cylinder is constructed and maintained in accordance with USEC-651 and ANSI N14.1 or ISO 7195.	Revised to be precise.
(2014 Ver.) 1-4 (2020 Ver.) 1-5	1.2.2 Operational Features The principal design features of MST-30 overpack are as follows: ▪ Valve Pocket - sufficient space is provided around the valve to prevent direct contact of the valve with any other component of the packaging for Normal and Hypothetical Accident Conditions (HAC) without the need for a valve protection device (VPD); … ▪ Impact Limiters – Closed-cell, high-density polyurethane foam is used in both end walls of the overpack to maintain appropriate energy absorption and impact resistance to protect the valve or plug from damage.	1.2.2 Operational Features The principal design features of MST-30 overpack and ring plate are as follows: ▪ Valve Pocket - sufficient space is provided around the valve to prevent direct contact of the valve with any other component of the packaging for Normal and Hypothetical Accident Conditions (HAC) without the need for a valve protection device (VPD); … ▪ Impact Limiters – Closed-cell, high-density polyurethane foam is used in both end walls of the overpack to maintain appropriate energy absorption and impact resistance to protect the valve or plug from damage. ▪ Ring Plate – A ring plate is inserted in the gap on the plug side between the overpack and the 30B cylinder. The ring plate is used to prevent the internal end plate on plug side of the overpack from excessively deforming in the HAC. In the case of a 30B cylinder with no plug, use of a ring plate is optional.	Addition of a description of the Ring Plate

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
(2014 Ver.) 1-5 (2020 Ver.) 1-6	see Row 1, Revision 5 below	see Row 1, Revision 6 below	Update of the IAEA regulations
(2014 Ver.) 1-6 (2020 Ver.) 1-7	see Row 2, Revision 5 below	see Row 2, Revision 6 below	The maximum design weight of the cylinder was changed. (-10kg) The maximum design weight of the Ring Plate (10kg) was added. (note) The total weight of the package is not changed.
Appendix 1.3.1 all pages	see Row 3, Revision 5 below	see Row 3, Revision 6 below	The Japanese authority certificate has been replaced with new one. (See the SAR for details.)

Row 1 — SAR Revision 5 (December 2014)

1.2.3 Contents of Packaging

…

The specification of the maximum quantity of radionuclides for the UF_6 is as follows;

^{232}U	0.0001 μg/gU
^{234}U	11.0×10^3 μg/g^{235}U
^{235}U	5.0 wt%
^{236}U	5000 μg/g^{235}U
^{238}U	balance of total uranium content
^{99}Tc	0.01 μg/gU

(Note) Above listed values of ^{232}U, ^{234}U and ^{99}Tc are quoted from the radionuclides specification for Enriched Commercial Grade Uranium Hexafluoride (ECGU) in ASTM C996 (2010). Value of ^{236}U is complied with the definition of unirradiated uranium in TS-R-1.

Row 1 — SAR Revision 6 (March 2020)

1.2.3 Contents of Packaging

…

The specification of the maximum quantity of radionuclides for the UF_6 is as follows;

^{232}U	0.0001 μg/gU
^{234}U	11.0×10^3 μg/g^{235}U
^{235}U	5.0 wt%
^{236}U	5000 μg/g^{235}U
^{238}U	balance of total uranium content
^{99}Tc	0.01 μg/gU

(Note) Above listed values of ^{232}U, ^{234}U and ^{99}Tc are quoted from the radionuclides specification for Enriched Commercial Grade Uranium Hexafluoride (ECGU) in ASTM C996 (2010). Value of ^{236}U is complied with the definition of unirradiated uranium in SSR-6.

Row 2 — SAR Revision 5 (December 2014)

Table 1-1 MST-30 Maximum Weights

Component	Weight (kg)	Weight (lb)
MST-30 Overpack	1,228	2,707
30B Cylinder	665	1,466
UF_6 Maximum load	2,277	5,020
Gross Weight of Loaded Package	4,170	9,193

Row 2 — SAR Revision 6 (March 2020)

Table 1-1 MST-30 Maximum Weights

Component	Weight (kg)	Weight (lb)
MST-30 Overpack	1,228	2,707
30B Cylinder	655	1,444
UF_6 Maximum load	2,277	5,020
Ring Plate	10	22
Gross Weight of Loaded Package	4,170	9,193

Row 3 — SAR Revision 5 (December 2014)

Appendix 1.3.1

Copies of the Japanese Authority Certificate for the MST-30

(note) In this Appendix, previous Japanese certificate of MST-30 package design (J/159/AF-96(Rev.2), issued on October 31, 2014) was attached.

Row 3 — SAR Revision 6 (March 2020)

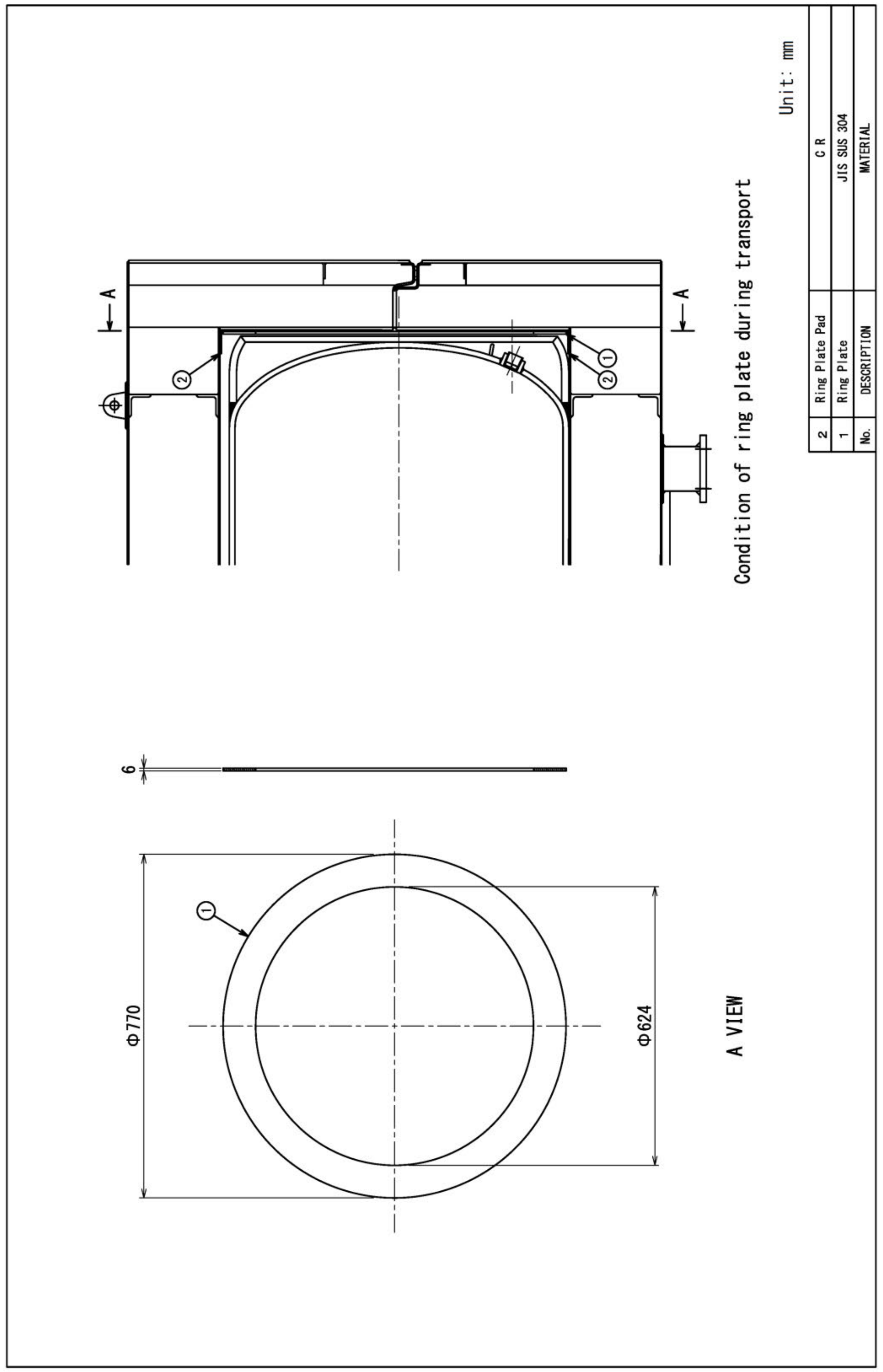
Appendix 1.3.1

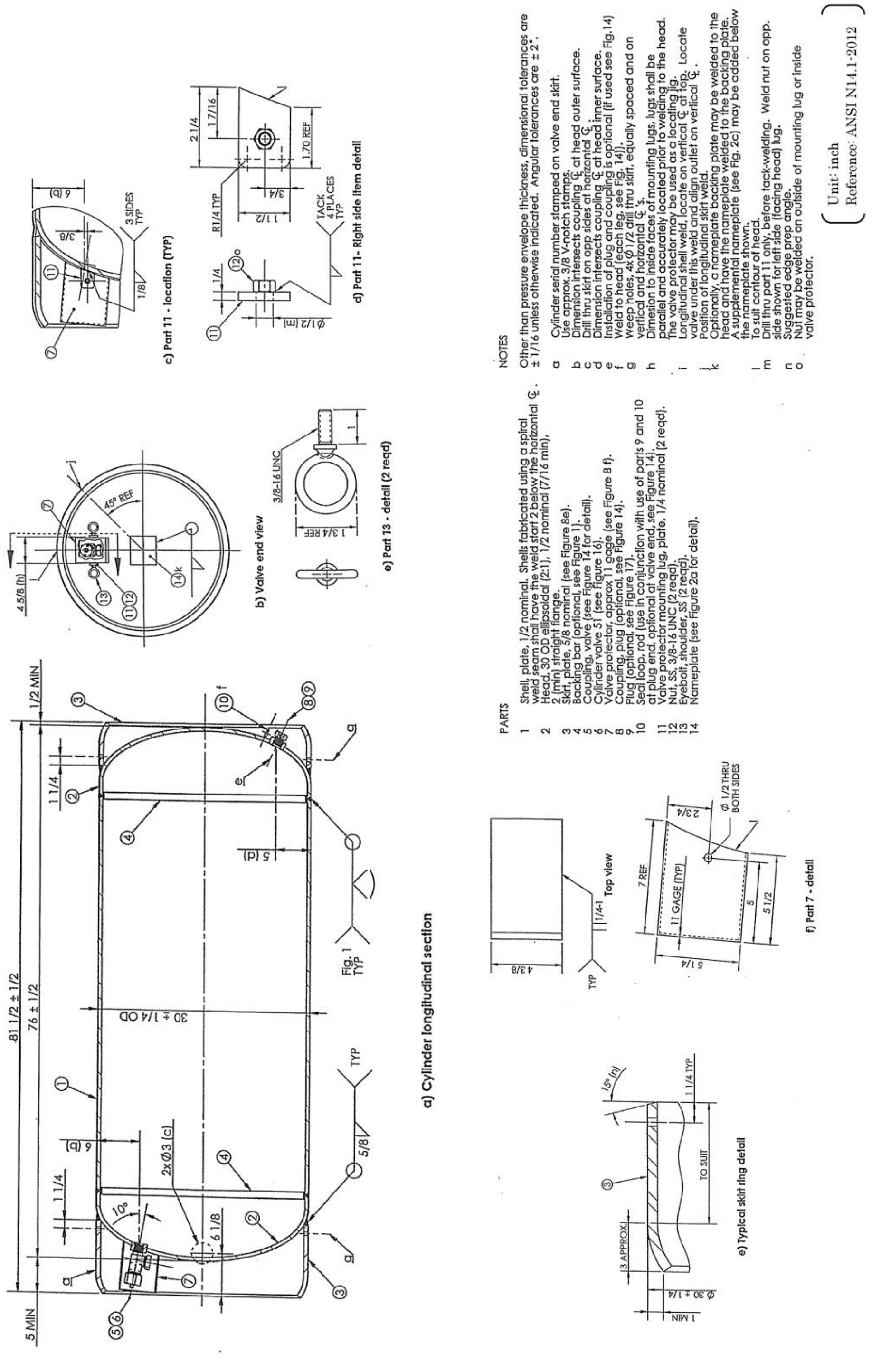
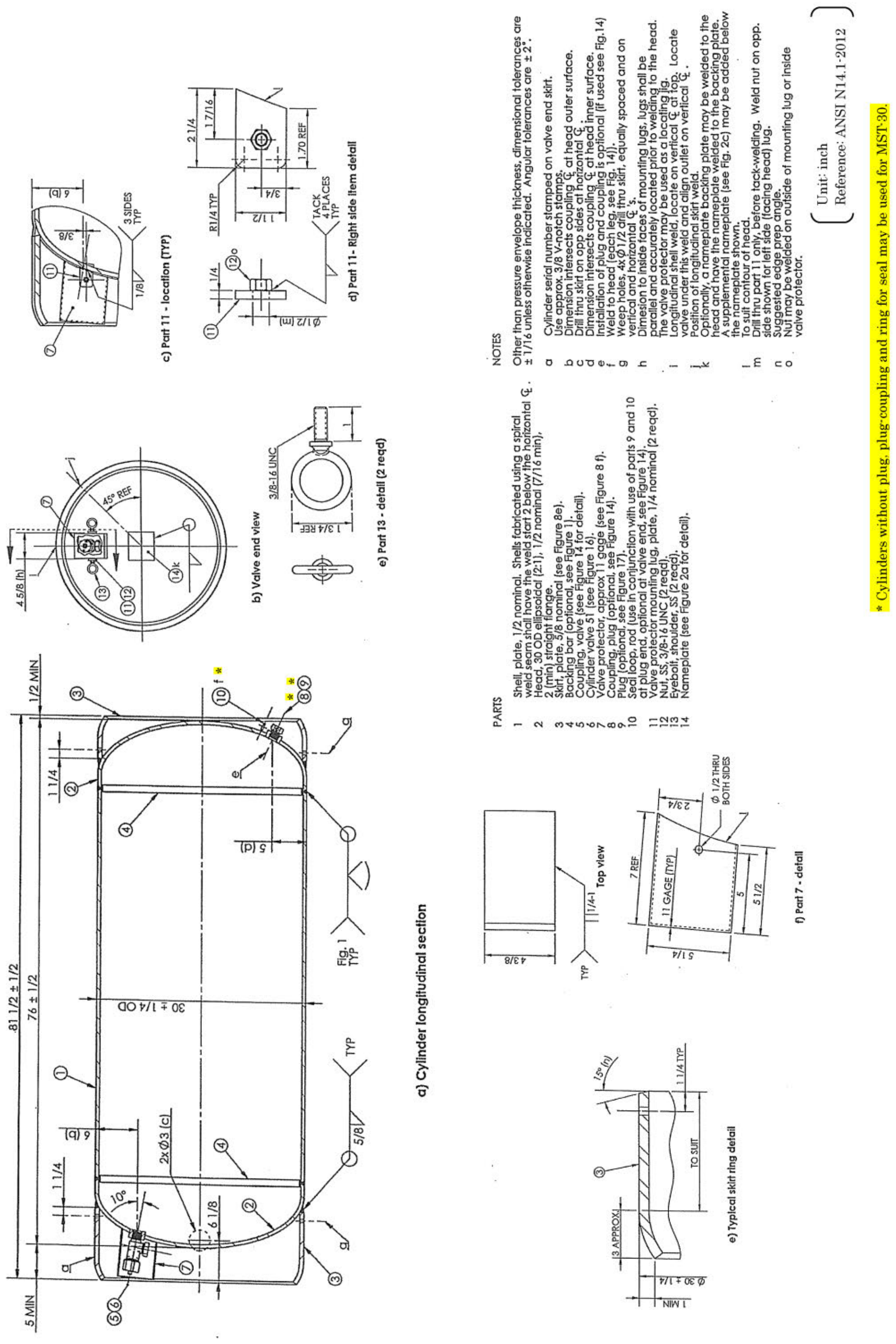
Copies of the Japanese Authority Certificate for the MST-30

(note) In this Appendix, new Japanese certificate of MST-30 package design (J/159/AF-96(Rev.3), issued on March 24, 2020) is attached.

Revision Comparison Table for MST-30 SAR (9 / 42)

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
Appendix 1.3.2-2	[redacted]	[redacted]	Appendix 1.3.2 Drawing of Model MST-30 Protective Shipping Package Addition of the Ring Plate Pad (No.13) (The pads are pasted on the inner shell of the top and bottom halves of the overpack.)

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
Appendix 1.3.2-3	(none)		Appendix 1.3.2 Drawing of Model MST-30 Protective Shipping Package Addition of a figure of the Ring Plate

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
Appendix 1.3.3-1			Appendix 1.3.3 Drawing of 30B Cylinder Addition of footnotes for a cylinder which has no plug and plug-coupling (No.8, 9 and 10)

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
2-i	SECTION 2 STRUCTURAL EVALUATION TABLE OF CONTENTS 2.1 Structural Design ....2-1 … 2.7 Hypothetical Accident Conditions ....2-10 2.7.1 Free Drop ....2-10 2.7.1.1 End Drop ....2-10 … 2.7.1.5 Polyurethane Foam Strength Tolerance Effect on Package Performance ...2-12 2.7.1.6 Summary of Results 2-12	SECTION 2 STRUCTURAL EVALUATION TABLE OF CONTENTS 2.1 Structural Design ....2-1 … 2.7 Hypothetical Accident Conditions ....2-10 2.7.1 Free Drop ....2-10 2.7.1.1 End Drop ....2-11 … 2.7.1.5 Polyurethane Foam Strength Tolerance Effect on Package Performance ...2-12 2.7.1.6 Evaluation by LS-DYNA 2-12	Page number is changed. Addition of subsection
2-ii	TABLE OF CONTENTS (continued) 2.7.2 Puncture ....2-12 2.7.3 Thermal....2-12 2.7.3.1 Summary of Pressures and Temperatures ....2-13 2.7.3.2 Differential Thermal Expansion ....2-13 2.7.3.3 Stress Calculations ....2-14 2.7.3.4 Comparison with Allowable Stresses ....2-14 2.7.4 Immersion – Fissile Material ....2-14 2.7.5 Immersion – All Packages ....2-15 2.7.6 Summary of Damage ....2-16 2.8 Special Form ....2-17 2.9 Fuel Rods ....2-17 2.10 Appendices ....2-17 2.10.1 Compliance Test Report for the MST-30 Protective Shipping Package … 2.10.5 Detailed Description of Helium Leak Tests 2.11 References ....2-17 …	TABLE OF CONTENTS (continued) 2.7.1.7 Summary of Results....2-12 2.7.2 Puncture ....2-12 2.7.3 Thermal ....2-13 2.7.3.1 Summary of Pressures and Temperatures ....2-13 2.7.3.2 Differential Thermal Expansion ....2-14 2.7.3.3 Stress Calculations ....2-15 2.7.3.4 Comparison with Allowable Stresses ....2-15 2.7.4 Immersion – Fissile Material ....2-15 2.7.5 Immersion – All Packages ....2-16 2.7.6 Summary of Damage ....2-17 2.8 Special Form ....2-17a 2.9 Fuel Rods ....2-17a 2.10 Appendices ....2-17a 2.10.1 Compliance Test Report for the MST-30 Protective Shipping Package … 2.10.5 Detailed Description of Helium Leak Tests 2.10.6 Evaluation using LS-DYNA code 2.10.7 Summary of analysis code "LS-DYNA" 2.10.8 Explanation of derivation methods for material properties used in LS-DYNA 2.11 References ....2-17a …	Page number is changed. Addition of appendices

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
2-1	2.0 STRUCTURAL EVALUATION 2.1 Structural Design 2.1.1 Discussion The MST-30 Protective Shipping Package (MST-30) is a Type A Fissile package used for the shipment of 30-inch cylinders containing Uranium Hexafluoride (UF_6) enriched up to 5wt% U-235. Drawings of the MST-30 overpack are provided in Appendix 1.3.2. A drawing of the 30B UF_6 cylinder is provided in Appendix 1.3.3. The MST-30 is approximately 1.2m (approx. 47 inches) in diameter by 2.4m (approx. 95 inches) long. It consists of steel inner and outer shells filled with polyurethane and phenolic foam. The overpack is split axially with a stepped joint, creating upper and lower sections to allow loading of the UF_6 cylinder. Three layers of polyurethane foam plates are provided in the ends of the overpack for shock-absorption and fire-resistance. Phenolic foam is used in the annular areas of overpack for fire-resistance. The MST-30 has been rigorously tested according to the regulatory requirements to assure water leak-tightness of the UF_6 cylinder, since it is absolutely required that water be excluded from the cylinder for moderation control of enriched UF_6.	2.0 STRUCTURAL EVALUATION 2.1 Structural Design 2.1.1 Discussion The MST-30 Protective Shipping Package (MST-30) is a Type A Fissile package used for the shipment of 30-inch cylinders containing Uranium Hexafluoride (UF_6) enriched up to 5wt% U-235. Drawings of the MST-30 overpack including the ring plate are provided in Appendix 1.3.2. A drawing of the 30B UF_6 cylinder is provided in Appendix 1.3.3. The MST-30 is approximately 1.2m (approx. 47 inches) in diameter by 2.4m (approx. 95 inches) long. The MST-30 package consists of the overpack, the ring plate and the 30B cylinder. The overpack consists of steel inner and outer shells filled with polyurethane and phenolic foam. The overpack is split axially with a stepped joint, creating upper and lower sections to allow loading of the UF_6 cylinder. Three layers of polyurethane foam plates are provided in the ends of the overpack for shock-absorption and fire-resistance. Phenolic foam is used in the annular areas of overpack for fire-resistance. The ring plate is inserted in the gap on the plug side between the overpack and the 30B cylinder. The MST-30 has been rigorously tested according to the regulatory requirements to assure water leak-tightness of the UF_6 cylinder, since it is absolutely required that water be excluded from the cylinder for moderation control of enriched UF_6.	Addition of the Ring Plate
	2.1.2 Design Criteria The MST-30 is designed to conform to the technical and regulatory requirements of a Type A, Fissile UF_6 Package as specified in the Japanese Safe Transport Regulations pursuant to TS-R-1. The package is intended to be used for transport from, to, or through foreign countries, including the USA. The MST-30 package is also designed in compliance with the current 10CFR Part 71 and 49CFR Part 173 Subpart I.	2.1.2 Design Criteria The MST-30 is designed to conform to the technical and regulatory requirements of a Type A, Fissile UF_6 Package as specified in the Japanese Safe Transport Regulations pursuant to SSR-6. The package is intended to be used for transport from, to, or through foreign countries, including the USA. The MST-30 package is also designed in compliance with the current 10CFR Part 71 and 49CFR Part 173 Subpart I.	Update of the IAEA regulations (SSR-6 (2012) corresponds to the current Japanese Regulation.)

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
2-2	2.4 General Standards for All Packages 2.4.1 Minimum Package Size The MST-30 packaging meets the minimum size requirement specified in Para. 634 of TS-R-1 and 10CFR § 71.43(a). 2.4.2 Tamper Proof Feature Each UF_6 cylinder must be secured for shipment with a numbered tamper-indicating device (TID). The TID is attached to each cylinder-valve in the manner shown in USEC-651, Rev.9. Furthermore, four (4) stainless steel semi-circular rings are welded at the overpack closure joint to provide a tamper-indicating device for the overpack. Thus, the package is in compliance with Para. 635 of TS-R-1 and 10 CFR § 71.43(b). 2.4.3 Positive Closure The top and bottom halves of overpack are securely closed with ten (10) fastening devices in accordance with Paras. 612 and 639 of TS-R-1 and 10 CFR § 71.43 (c). The fastening devices utilize a swing-lever system that assures positive capture of the fasteners. Each device is equipped with a M20 size JIS SUS-316 (equivalent to ASTM SS-316) stainless steel bolt to assure that the halves of the overpack are not inadvertently opened by vibration or shock during transport of the packages. 2.4.4 Chemical and Galvanic Reactions The MST-30 materials of construction, stainless steel, carbon steel, Monel, aluminum bronze, polyurethane foam, phenolic foam, neoprene, silicone rubber, are such that no significant chemical or galvanic reactions occur between the package components and/or the package contents in accordance with Para. 613 of TS-R-1 and 10 CFR § 71.43 (d).	2.4 General Standards for All Packages 2.4.1 Minimum Package Size The MST-30 packaging meets the minimum size requirement specified in Para. 636 of SSR-6 and 10CFR § 71.43(a). 2.4.2 Tamper Proof Feature Each UF_6 cylinder must be secured for shipment with a numbered tamper-indicating device (TID). The TID is attached to each cylinder-valve in the manner shown in USEC-651, Rev.10. Furthermore, four (4) stainless steel semi-circular rings are welded at the overpack closure joint to provide a tamper-indicating device for the overpack. Thus, the package is in compliance with Para. 637 of SSR-6 and 10 CFR § 71.43(b). 2.4.3 Positive Closure The top and bottom halves of overpack are securely closed with ten (10) fastening devices in accordance with Paras. 613 and 641 of SSR-6 and 10 CFR § 71.43 (c). The fastening devices utilize a swing-lever system that assures positive capture of the fasteners. Each device is equipped with a M20 size JIS SUS-316 (equivalent to ASTM SS-316) stainless steel bolt to assure that the halves of the overpack are not inadvertently opened by vibration or shock during transport of the packages. 2.4.4 Chemical and Galvanic Reactions The MST-30 materials of construction, stainless steel, carbon steel, Monel, aluminum bronze, polyurethane foam, phenolic foam, neoprene, silicone rubber, are such that no significant chemical or galvanic reactions occur between the package components and/or the package contents in accordance with Para. 614 of SSR-6 and 10 CFR § 71.43 (d).	Update of the IAEA regulations Update of USEC-651 Update of the IAEA regulations

Page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
2-3a	$\sigma_0 = \frac{P}{2(b-a)h} = \frac{1.181\times 10^4\ N}{2\times(37\ mm - 16\ mm)\times 25\ mm}$ = 11.25 N/mm^2 (1,631 psi). Therefore, the margin of safety for shackle support fixture can be obtained as: M.S. = (205 N/mm^2 / 24.98 N/mm^2) –1 = 7.2. Thus, the lifting shackles and shackle support fixtures exceed the minimum safety factor of three against yielding required by regulation when the package is lifted in the intended manner. Para. 607 of TS-R-1 requires that each lifting device that is a structural part of the package be designed so that failure of the device under excessive loading would not impair the ability of the package to meet other requirements in the regulation. If the MST-30 is lifted improperly, the lifting shackles could fail under excessive loads. The worst-case result of lifting shackle failure is a drop of the package. Free drop tests under normal and hypothetical accident conditions as prescribed in the regulations were performed using full-scale prototypes of the MST-30 package, and the test results demonstrate that the package integrity is maintained (See Sections 2.6.7 and 2.7.1, and Appendix 2.10.1). Therefore, in the event of shackle failure due to improper lifting and excessive loading, the ability of the package to meet the other requirements of IAEA regulations or Subpart E of 10CFR Part 71 would not be impaired.	$\sigma_0 = \frac{P}{2(b-a)h} = \frac{1.181\times 10^4\ N}{2\times(37\ mm - 16\ mm)\times 25\ mm}$ = 11.25 N/mm^2 (1,631 psi). Therefore, the margin of safety for shackle support fixture can be obtained as: M.S. = (205 N/mm^2 / 24.98 N/mm^2) –1 = 7.2. Thus, the lifting shackles and shackle support fixtures exceed the minimum safety factor of three against yielding required by regulation when the package is lifted in the intended manner. Para. 608 of SSR-6 requires that each lifting device that is a structural part of the package be designed so that failure of the device under excessive loading would not impair the ability of the package to meet other requirements in the regulation. If the MST-30 is lifted improperly, the lifting shackles could fail under excessive loads. The worst-case result of lifting shackle failure is a drop of the package. Free drop tests under normal and hypothetical accident conditions as prescribed in the regulations were performed using full-scale prototypes of the MST-30 package, and the test results demonstrate that the package integrity is maintained (See Sections 2.6.7 and 2.7.1, and Appendix 2.10.1). Therefore, in the event of shackle failure due to improper lifting and excessive loading, the ability of the package to meet the other requirements of IAEA regulations or Subpart E of 10CFR Part 71 would not be impaired.	2.5 Lifting and Tie-down Devices for All Packages 2.5.1 Lifting Devices Update of the IAEA regulations

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
2-6	2.6.3 Reduced External Pressure Assuming that the cylinder's internal pressure is at the minimum (0 psia), the net pressure on cylinder resulting from a reduced ambient pressure of 60kPa (8.7psia) (Para. 643 of TS-R-1) is 60kPaG (8.7psig), applied as an external pressure. The 30B cylinder is designed for an external pressure of 172kPa (25 psig) as specified in ANSI N14.1 and ISO 7195; therefore, the net external pressure of 60kPaG is well within the capabilities of the cylinder. …	2.6.3 Reduced External Pressure Assuming that the cylinder's internal pressure is at the minimum (0 psia), the net pressure on cylinder resulting from a reduced ambient pressure of 60kPa (8.7psia) (Para. 645 of SSR-6) is 60kPaG (8.7psig), applied as an external pressure. The 30B cylinder is designed for an external pressure of 172kPa (25 psig) as specified in ANSI N14.1 and ISO 7195; therefore, the net external pressure of 60kPaG is well within the capabilities of the cylinder. …	2.6 Normal Conditions of Transport Update of the IAEA regulations
2-8	2.6.7 Free Drop In accordance with the relevant regulations (Para. 722 of TS-R-1), the packaging must be drop tested in the position for which the most damage is expected through a distance of 1.2 m (4 ft). …	2.6.7 Free Drop In accordance with the relevant regulations (Para. 722 of SSR-6), the packaging must be drop tested in the position for which the most damage is expected through a distance of 1.2 m (4 ft). …	2.6 Normal Conditions of Transport Update of the IAEA regulations
2-9	2.6.10 Penetration Dropping a 6 kg (13 lb) rod onto the MST-30 as described in Para. 724 of TS-R-1 has a negligible effect on the 3mm (0.12 in) stainless steel shell. 2.6.11 Summary of Normal Conditions of Transport Following the1.2m (4ft) Free drop tests, the prototypes remained closed, with no gaps that would admit a 10-cm cube. The gross package dimensions were maintained, and the gross volume of the packaging was reduced by approximately 0.2% in maximum. Therefore, MST-30 is in accordance with Para. 675 of TS-R-1 and 10 CFR § 71.55 (d)(4).	2.6.10 Penetration Dropping a 6 kg (13 lb) rod onto the MST-30 as described in Para. 724 of SSR-6 has a negligible effect on the 3mm (0.12 in) stainless steel shell. 2.6.11 Summary of Normal Conditions of Transport Following the1.2m (4ft) Free drop tests, the prototypes remained closed, with no gaps that would admit a 10-cm cube. The gross package dimensions were maintained, and the gross volume of the packaging was reduced by approximately 0.2% in maximum. Therefore, MST-30 is in accordance with Para. 678 of SSR-6 and 10 CFR § 71.55 (d)(4).	2.6 Normal Conditions of Transport Update of the IAEA regulations

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
(2014 Ver.) 2-10 (2020 Ver.) 2-10,11	2.7 Hypothetical Accident Conditions (HAC) … Each test article consisted of a MST-30 prototype overpack, loaded with a 30B cylinder containing a simulated payload. The prototypes were fabricated to the drawings provided in Appendix 2.10.1 (Figure 2.10.1-2). Prototype A is used for Vertical Drops (End Drops) throughout the testing (including the Normal condition). Prototype B is used for the Corner Drops throughout the testing (including the Normal condition). Prototype C is used for the Horizontal Drops (Side Drops) throughout the testing (including the Normal condition). In order to indicate valve contact with the overpack wall during impact, an aluminum honeycomb was inserted in the valve pocket of Prototype A and B prior to all test series (i.e. prior to Normal Condition drop). The target for the free drop tests and puncture tests of MST-30 package was constructed to satisfy the guidance specified in the Advisory Material for 1985 IAEA regulations, i.e. IAEA Safety Series No.37. Following the series of tests, it was confirmed that no water leaks (ingress) into 30B cylinder occurred, and that the overpack remained closed at all times. 2.7.1 Free Drop The same MST-30 prototype that was subjected to the Normal Condition drop tests was used for the HAC sequence. The package was not opened or repaired prior to the HAC sequence. The package was dropped through a distance of 9m (30 ft) onto an unyielding surface. Three tests were performed on the prototypes: Vertical Drop(End Drop), Horizontal Drop(Side Drop), and Corner Drop. Details of the tests are provided in Appendix 2.10.1 and a summary of the test results is provided in Table 2-4. 2.7.1.1 End Drop …	2.7 Hypothetical Accident Conditions (HAC) … Each test article consisted of a MST-30 prototype overpack, loaded with a 30B cylinder containing a simulated payload. The prototypes were fabricated to the drawings provided in Appendix 2.10.1 (Figure 2.10.1-2). Prototype A is used for Vertical Drops (End Drops) throughout the testing (including the Normal condition). Prototype B is used for the Corner Drops throughout the testing (including the Normal condition). Prototype C is used for the Horizontal Drops (Side Drops) throughout the testing (including the Normal condition). In order to indicate valve contact with the overpack wall during impact, an aluminum honeycomb was inserted in the valve pocket of Prototype A and B prior to all test series (i.e. prior to Normal Condition drop). These prototype drop tests were conducted without ring plate. The target for the free drop tests and puncture tests of MST-30 package was constructed to satisfy the guidance specified in the Advisory Material for 1985 IAEA regulations, i.e. IAEA Safety Series No.37. Following the series of tests, it was confirmed that no water leaks (ingress) into 30B cylinder occurred, and that the overpack remained closed at all times. In addition to the above-mentioned prototype drop tests, analyses using a LS-DYNA code were conducted for the Vertical Drop (End Drop) and Corner Drop configurations in order to confirm that the cylinder valve and plug do not make contact with the overpack in the HAC. As the results, it was confirmed that the valve and plug have no contact with the overpack. The detail of the evaluation using LS-DYNA is provided in Appendix 2.10.6. 2.7.1 Free Drop The same MST-30 prototype that was subjected to the Normal Condition drop tests was used for the HAC sequence. The package was not opened or repaired prior to the HAC sequence. The package was dropped through a distance of 9m (30 ft) onto an unyielding surface. Three tests were performed on the prototypes: Vertical Drop(End Drop), Horizontal Drop(Side Drop), and Corner Drop. The outlines of the tests are presented in 2.7.1.1 to 2.7.1.5. Details of the tests are provided in Appendix 2.10.1 and a summary of the test results is provided in Table 2-4. Furthermore, evaluation by LS-DYNA is carried out for the orientations of Vertical Drops and Corner Drops on the valve and plug ends. The outline is presented in 2.7.1.6. 2.7.1.1 End Drop …	Explanation about the Ring Plate Addition of the evaluation using a finite element analysis code (LS-DYNA)

<table>
<tr><th>page</th><th>SAR Revision 5 (December 2014)</th><th>SAR Revision 6 (March 2020)</th><th>Note</th></tr>
<tr><td>(2014 Ver.)
2-12

(2020 Ver.)
2-12,13</td><td>2.7.1.5 Polyurethane Foam Strength Tolerance Effect on Package Performance
…

2.7.1.6 Summary of Results
Following the Normal Condition Drops, the three prototypes were subjected to 9m (30ft) free drops. Some of the fastening devices (closures) were slightly damaged due to the drop impact, but all of the devices remained in place and fastened following the drops. The resulting deformation of the prototypes is summarized in Table 2-4.

2.7.2 Puncture
…
The honeycomb was inspected after the test series was completed (TEST-A after puncture drop and TEST-B after thermal test). No marks were found on the material, indicating that the cylinder valves did not contact the honeycomb during either TEST-A or TEST-B. Therefore, a margin equivalent to at least the thickness of the aluminum honeycomb (40mm) exists for contact between the valve and any other components for HAC.</td><td>2.7.1.5 Polyurethane Foam Strength Tolerance Effect on Package Performance
…

2.7.1.6 Evaluation by LS-DYNA
Analyses by LS-DYNA are conducted in the conditions of drops from 10.2m height taking into account the cumulative effect of the normal conditions of transport. The drop orientations are Vertical Drops and Corner Drops on the valve and plug ends. The calculation results show that the valve and plug have no contact with the overpack. The detail is provided in Appendix 2.10.6.

2.7.1.7 Summary of Results
Following the Normal Condition Drops, the three prototypes were subjected to 9m (30ft) free drops. Some of the fastening devices (closures) were slightly damaged due to the drop impact, but all of the devices remained in place and fastened following the drops. The resulting deformation of the prototypes is summarized in Table 2-4.
Furthermore, evaluation by LS-DYNA was conducted. The results show that the cylinder valve and plug have no contact with the overpack.

2.7.2 Puncture
…
The honeycomb was inspected after the test series was completed (TEST-A after puncture drop and TEST-B after thermal test). No marks were found on the material, indicating that the cylinder valves did not contact the honeycomb during either TEST-A or TEST-B. Therefore, a margin equivalent to at least the thickness of the aluminum honeycomb (40mm) exists for contact between the valve and any other components for HAC.
With regard to the evaluation by LS-DYNA, it was calculated taking into account the cumulative effect of the free drop. The drop orientations are Vertical and Corner Drops on to the valve and plug positions. The calculation results show that valve and plug have no contact with the overpack. The detail is provided in Appendix 2.10.6.</td><td>2.7 Hypothetical Accident Conditions
2.7.1 Free Drop

Addition of the evaluation using a finite element analysis code (LS-DYNA)

The result of the finite element analysis (LS-DYNA) is added.</td></tr>
</table>

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
(2014 Ver.) 2-13 (2020 Ver.) 2-14	2.7.3.2 Differential Thermal Expansion During the thermal test, extreme temperature differentials occurred through the package. A qualitative analysis of the thermal expansion of the parts is provided in Table 2-7. In order to avoid unacceptable stresses due to thermal expansion, it is necessary to assure that there is no restraint between the inner shell of overpack and the cylinder. There is no possibility that the cylinder is restrained in the radial direction, since the gap between the inner shell and the cylinder in the radius direction is relatively large. The possibility of restraint in the longitudinal direction is evaluated allowing for manufacturing tolerances. Conservatively assuming that the initial temperature of 30B cylinder is -40°C (-40°F) and the final temperature is the maximum calculated for the thermal event (119°C, 246°F), the elongation of the cylinder in the longitudinal direction due to thermal expansion is: $\delta_c = \alpha \cdot L \cdot \Delta t = 12.24 \times 10^{-6} \times 2083 \times 159 = 4.1mm$ (0.16 in) where: δ_c is the elongation of cylinder (mm) α is the thermal expansion coefficient of cylinder at 121°C (250°F), 12.24×10^{-6} mm/mm-°C L is the longitudinal length of cylinder with the allowable errors in construction, 2083 mm (81-1/2 in + 1/2 in) Δt is the differential temperature, 159 °C	2.7.3.2 Differential Thermal Expansion During the thermal test, extreme temperature differentials occurred through the package. A qualitative analysis of the thermal expansion of the parts is provided in Table 2-7. In order to avoid unacceptable stresses due to thermal expansion, it is necessary to assure that there is no restraint between the inner shell of overpack and the cylinder. There is no possibility that the cylinder is restrained in the radial direction, since the gap between the inner shell and the cylinder in the radius direction is relatively large. The possibility of restraint in the longitudinal direction is evaluated allowing for manufacturing tolerances. The ring plate is also taken into account since in some cases a ring plate may be inserted on the plug side of the cylinder in the overpack. Conservatively assuming that the initial temperature of 30B cylinder is -40°C (-40°F) and the final temperature is the maximum calculated for the thermal event (119°C, 246°F), the elongation of the cylinder in the longitudinal direction due to thermal expansion is: $\delta_c = \alpha_c \cdot L_{c0} \cdot \Delta t = 12.24 \times 10^{-6} \times 2083 \times 159 = 4.1mm$ (0.16 in) where, δ_c is the elongation of cylinder (mm) α_c is the thermal expansion coefficient of cylinder at 121°C (250°F), 12.24×10^{-6} mm/mm/°C L_{c0} is the longitudinal length of cylinder with the allowable errors in construction, 2083 mm (81-1/2 in + 1/2 in) Δt is the differential temperature, 119 - (-40) = 159 °C	2.7 Hypothetical Accident Conditions 2.7.3 Thermal Change related to the Ring Plate (The evaluation was reviewed taking the ring plate into account.)

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
(2014 Ver.) 2-13,14 (2020 Ver.) 2-14,15	The longitudinal elongation of the inner shell of the overpack is conservatively neglected. The bottom half of the overpack has a smaller nominal clearance; thus, the dimensions of the bottom half are used in the evaluation. The minimum distance from the inner wall end of overpack to the tip of cylinder-skirt (l) for the maximum thermal expansion is: $l = L_i - L_c = 2091 - 2087.1 = 3.9mm$ (0.15 in) where, l the distance from the inner shell to the tip of cylinder-skirt (mm) L_i the minimum internal cavity length for the bottom half of the overpack, 2096 - 5 = 2091 mm L_c the longitudinal length of cylinder at the maximum temperature, 2083+ 4.1 = 2087.1 mm Thus, the minimum clearance between the cylinder ends and the overpack interior is 3.9 mm. Therefore, there is no constraint between the inner shell of the overpack and the cylinder.	The time of the maximum temperature of the inner cylindrical shell part of the overpack differs from that of the cylinder body. Then, assuming conservatively the temperature of the inner cylindrical shell part to be 60˚C (140°F), which is the initial temperature before the thermal test, the elongation between both endplates of the inner shell is given by the following equation. The bottom half of the overpack has a smaller nominal clearance; thus, the dimensions of the bottom half are used in the evaluation. $\delta_i = \alpha_i \cdot L_{i0} \cdot \Delta t = 15.56 \times 10^{-6} \times 2091 \times 100 = 3.2mm$ (0.12 in) where, δ_i is the elongation between both endplates of the inner shell (mm) α_i is the thermal expansion coefficient of the inner shell at 60°C (140°F), 15.56×10^{-6} mm/mm/˚C L_{i0} is the internal cavity length for the bottom half of the overpack with the manufacturing tolerance, 2096 - 5 = 2091 mm Δt is the differential temperature, 60 - (-40) = 100 ˚C Based on the above, the minimum distance from the inner wall end of overpack to the tip of cylinder-skirt (l) for the maximum thermal expansion is: $l = L_i - L_c = 2094.2 - 2087.1 = 7.1mm$ (0.27 in) where, l is the distance from the inner shell to the tip of cylinder-skirt (mm) L_i is the internal cavity length for the bottom half of the overpack at the evaluation temperature, 2091 + 3.2 = 2094.2 mm L_c is the longitudinal length of cylinder at the maximum temperature, 2083+ 4.1 = 2087.1 mm Thus, the minimum clearance between the cylinder ends and the overpack interior is 7.1 mm. Therefore, there is no constraint between the inner shell of the overpack and the cylinder even if a ring plate (6 mm thick) is inserted between them.	2.7 Hypothetical Accident Conditions 2.7.3 Thermal 2.7.3.2 Differential Thermal Expansion Change related to the Ring Plate (The evaluation was reviewed taking the ring plate into account.)

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
(2014 Ver.) 2-17 (2020 Ver.) 2-17a	2.10 Appendices … 2.10.5 Detailed Description of Helium Leak Tests 2.11 References …	2.10 Appendices … 2.10.5 Detailed Description of Helium Leak Tests 2.10.6 Evaluation using LS-DYNA code 2.10.7 Summary of analysis code "LS-DYNA" 2.10.8 Explanation of derivation methods for material properties used in LS-DYNA 2.11 References …	Addition of appendices related to LS-DYNA

<table>
<tr><th>page</th><th>SAR Revision 5 (December 2014)</th><th>SAR Revision 6 (March 2020)</th><th>Note</th></tr>
<tr><td>2-18</td><td>

Table 2-1 Maximum Weight of MST-30 Package

<table>
<tr><th>Component</th><th colspan="2">Maximum Weight</th></tr>
<tr><td>Overpack</td><td>1,228 kg</td><td>(2,707 lb)</td></tr>
<tr><td>30 B Cylinder</td><td>665 kg</td><td>(1,466 lb)</td></tr>
<tr><td>Maximum UF_6 Load (Content)</td><td>2,277 kg</td><td>(5,020 lb)</td></tr>
<tr><td>Maximum Package Weight</td><td>4,170 kg</td><td>(9,193 lb)</td></tr>
</table>

</td><td>

Table 2-1 Maximum Weight of MST-30 Package

<table>
<tr><th>Component</th><th colspan="2">Maximum Weight</th></tr>
<tr><td>Overpack</td><td>1,228 kg</td><td>(2,707 lb)</td></tr>
<tr><td>30 B Cylinder</td><td>655 kg</td><td>(1,444 lb)</td></tr>
<tr><td>Maximum UF_6 Load (Content)</td><td>2,277 kg</td><td>(5,020 lb)</td></tr>
<tr><td>Ring Plate</td><td>10 kg</td><td>(22 lb)</td></tr>
<tr><td>Maximum Package Weight</td><td>4,170 kg</td><td>(9,193 lb)</td></tr>
</table>

</td><td>The maximum design weight of the cylinder was changed. (-10kg)

The maximum design weight of the Ring Plate (10kg) was added.

(note) The total weight of the package is not changed.</td></tr>
<tr><td>Appendix 2.10.6 all pages</td><td>(none)</td><td>Appendix 2.10.6
Evaluation using LS-DYNA code</td><td>Added new.
(See the SAR for details.)</td></tr>
<tr><td>Appendix 2.10.7 all pages</td><td>(none)</td><td>Appendix 2.10.7
Summary of analysis code “LS-DYNA”</td><td>Added new.
(See the SAR for details.)</td></tr>
<tr><td>Appendix 2.10.8 all pages</td><td>(none)</td><td>Appendix 2.10.8
Explanation of derivation methods for material properties used in LS-DYNA</td><td>Added new.
(See the SAR for details.)</td></tr>
</table>

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
3-1	3.0 THERMAL EVALUATION The MST-30 Protective Shipping Package (MST-30) is a Type A, Fissile UF_6 Package used for the shipment of 30-inch cylinders containing Uranium Hexafluoride (UF_6) enriched up to 5wt% ^{235}U. The MST-30 is designed to conform to the technical and regulatory requirements of a Type A, Fissile UF_6 Package as specified in the Japanese Safe Transport Regulations pursuant to TS-R-1. The package is intended to be used for transport from, to, or through foreign countries, including the USA. The MST-30 package is also designed in compliance with the current 10CFR Part 71 and 49CFR Part 173 Subpart I.	3.0 THERMAL EVALUATION The MST-30 Protective Shipping Package (MST-30) is a Type A, Fissile UF_6 Package used for the shipment of 30-inch cylinders containing Uranium Hexafluoride (UF_6) enriched up to 5wt% ^{235}U. The MST-30 is designed to conform to the technical and regulatory requirements of a Type A, Fissile UF_6 Package as specified in the Japanese Safe Transport Regulations pursuant to SSR-6. The package is intended to be used for transport from, to, or through foreign countries, including the USA. The MST-30 package is also designed in compliance with the current 10CFR Part 71 and 49CFR Part 173 Subpart I.	Update of IAEA Regulations (SSR-6 (2012) corresponds to the current Japanese Regulation.)
3-6	3.5.1 Thermal Model 3.5.1.1 Analytical Model and Evaluation The ABAQUS model described for the normal condition evaluation was used to calculate the package temperature distribution for HAC. In order to calculate the maximum temperature of the package components due to the HAC thermal event, three calculation steps are required: Step1 Analysis of the initial component temperatures. The temperature of the package is calculated for an ambient temperature of 38°C (100°F) with solar insolation in accordance with Paras 630(c) and 728 in TS-R-1. The results of Step 1 are reported in Section 3.4.2.	3.5.1 Thermal Model 3.5.1.1 Analytical Model and Evaluation The ABAQUS model described for the normal condition evaluation was used to calculate the package temperature distribution for HAC. In order to calculate the maximum temperature of the package components due to the HAC thermal event, three calculation steps are required: Step1 Analysis of the initial component temperatures. The temperature of the package is calculated for an ambient temperature of 38°C (100°F) with solar insolation specified in Table 12 in accordance with Para.728 in SSR-6. The results of Step 1 are reported in Section 3.4.2.	Correction and update of the IAEA regulations

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
3-14	Table 3-3 (see below)	Table 3-3 (see below)	Typo was corrected.

SAR Revision 5 (December 2014)

Table 3-3 Thermal Properties of Materials of Components used in Thermal Evaluation

Component	Material	Density (kg/m^3)	Specific Heat (J/kg·K)		Thermal Conductivity (W/m·K)		Remarks
Outer Shell And Inner Shell	Stainless Steel Plates	7640	449	27°C	16.0	27°C	Reference 3.7.4
			511	127°C	16.5	127°C	
			556	327°C	19.0	327°C	
			620	527° C	22.5	527° C	
			644	727° C	25.7	727° C	
Cylinder	Mild Steel	7710	473	27°C	51.6	27°C	Reference 3.7.4
			529	227°C	47.8	227°C	
			690	527°C	38.2	527°C	
Shock Absorber and Thermal Insulator for Overpack	Polyurethane Foam-1 & Polyurethane Foam-3	340	1350	Overall temperature range	0.122	Overall temperature range	See Section 3.4.1.3
	Polyurethane Foam-2	450	1350	Overall temperature range	0.136	Overall temperature range	
	Phenolic Foam	100	1047	60°C	0.09	20°C	
			1130	100°C	0.18	550°C	
			1256	150°C			
			1298	200°C	0.35	>600°C	
			702	802°C			

SAR Revision 6 (March 2020)

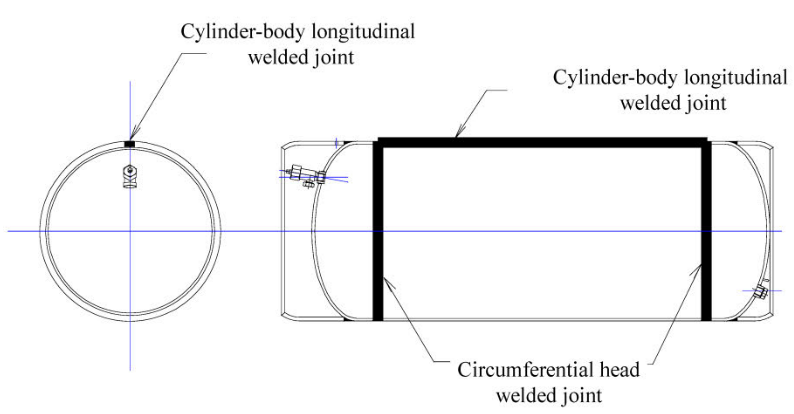
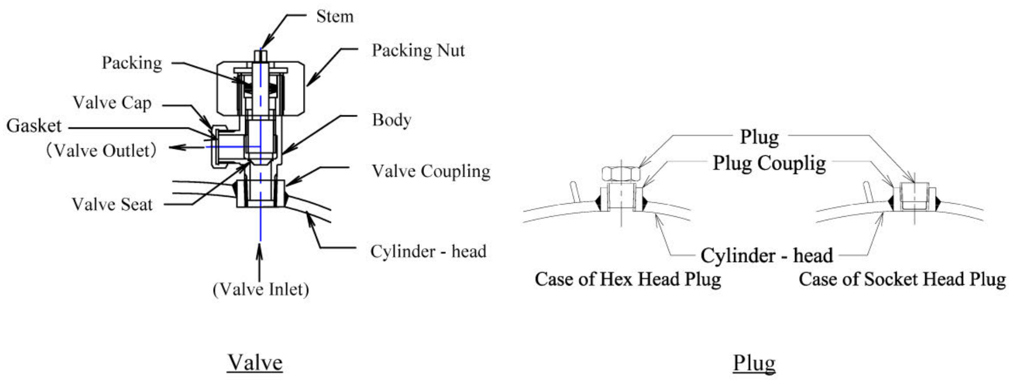
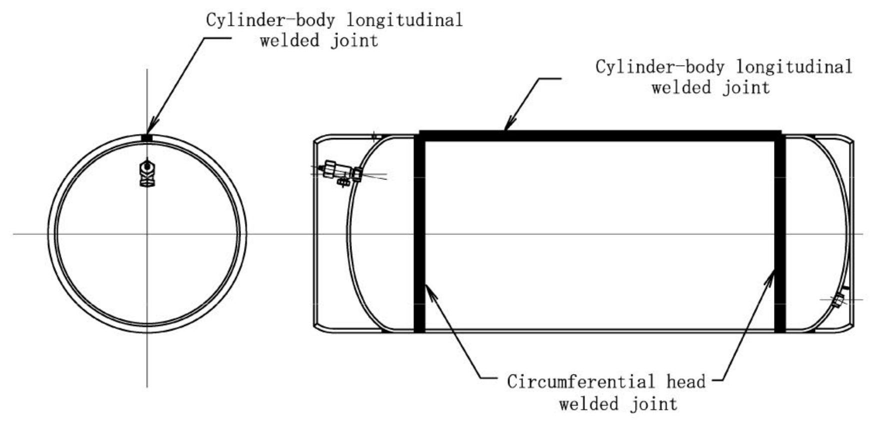
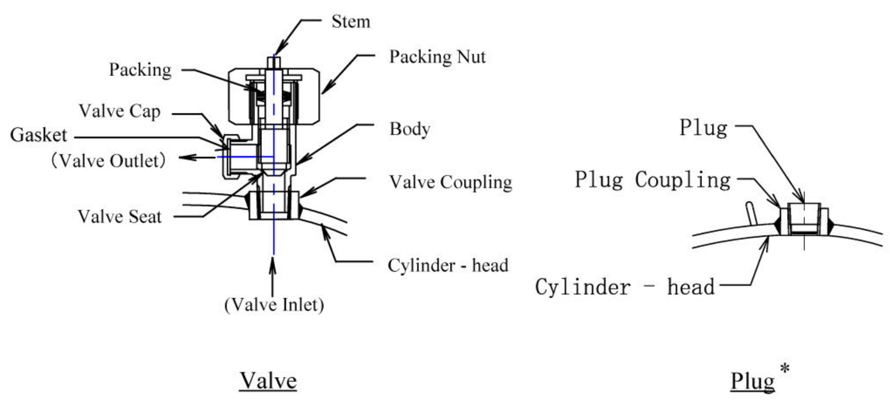
Table 3-3 Thermal Properties of Materials of Components used in Thermal Evaluation

Component	Material	Density (kg/m^3)	Specific Heat (J/kg·K)		Thermal Conductivity (W/m·K)		Remarks
Outer Shell And Inner Shell	Stainless Steel Plates	7640	499	27°C	16.0	27°C	Reference 3.7.4
			511	127°C	16.5	127°C	
			556	327°C	19.0	327°C	
			620	527° C	22.5	527° C	
			644	727° C	25.7	727° C	
Cylinder	Mild Steel	7710	473	27°C	51.6	27°C	Reference 3.7.4
			529	227°C	47.8	227°C	
			690	527°C	38.2	527°C	
Shock Absorber and Thermal Insulator for Overpack	Polyurethane Foam-1 & Polyurethane Foam-3	340	1350	Overall temperature range	0.122	Overall temperature range	See Section 3.4.1.3
	Polyurethane Foam-2	450	1350	Overall temperature range	0.136	Overall temperature range	
	Phenolic Foam	100	1047	60°C	0.09	20°C	
			1130	100°C	0.18	550°C	
			1256	150°C			
			1298	200°C	0.35	>600°C	
			702	802°C			

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
4-1	4.0 CONTAINMENT 4.1 Containment Boundary The containment system of this package is composed of the 30B cylinder-body, the valve and the plug. The design and specifications of the containment system are specified by ANSI N14.1 or ISO 7195.	4.0 CONTAINMENT 4.1 Containment Boundary The containment system of this package is composed of the 30B cylinder-body, the valve and the plug. The design and specifications of the containment system are specified by ANSI N14.1 or ISO 7195. In the case of the MST-30 package, the type of plug allowed is a socket head plug only. A hex head plug is not available. A cylinder which does not have any plug and plug-coupling may be used.	Addition of explanations on the type of cylinder plug and the cylinder without plug and plug-coupling
4-2	4.1.3 Seals and Welds The cylinder valve is sealed using Teflon packing (5 required) attached to the valve-stem and a Teflon gasket attached to the valve cap as shown in Figure 4-2. The service-temperature of Teflon is within the range between -100°C and 260°C (-148°F and 500°F). The cylinder valve is tinned with the specified lead-tin solder material having a solidus temperature of 183 °C (361°F), effectively sealing the valve/coupling threads on the cylinder-head. Further, ANSI N14.1 and ISO 7195 requires that 7-12 threads be engaged on the valve, using 271-542 N·m (200-400 ft.-lb) of torque. The lead-tin solder is also used to tin the threads of the plug/coupling on the other head of the cylinder. Similarly, 5-8 threads must be engaged on the plug, using between 203-813 N·m (150-600 ft.-lb) of torque.	4.1.3 Seals and Welds The cylinder valve is sealed using Teflon packing (5 required) attached to the valve-stem and a Teflon gasket attached to the valve cap as shown in Figure 4-2. The service-temperature of Teflon is within the range between -100°C and 260°C (-148°F and 500°F). The cylinder valve is tinned with the specified lead-tin solder material having a solidus temperature of 183 °C (361°F), effectively sealing the valve/coupling threads on the cylinder-head. Further, ANSI N14.1 and ISO 7195 requires that 7-12 threads be engaged on the valve, using 271-542 N·m (200-400 ft.-lbf) of torque. The lead-tin solder is also used to tin the threads of the plug/coupling on the other head of the cylinder. The socket head plug shall be installed with a maximum of three threads (6.63 mm (0.261 in.)) above flush with the outer face of the cylinder coupling to a maximum of two threads (4.42 mm (0.174 in.)) beyond flush with the outer face of the cylinder coupling, using between 203-881 N·m (150-650 ft.-lbf) of torque for 1 in. plug and between 271-1803 N·m (200-1330 ft.-lbf) of torque for 1-1/2 in. plug.	Change of a description of plug installation (Socket head plug (1” and 1-1/2”))

Revision Comparison Table for MST-30 SAR (26 / 42)

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
4-3	4.2 Requirements for Normal Conditions of Transport 4.2.1 Containment of Radioactive Material The Japanese Safe Transport Regulations pursuant to TS-R-1 require that any package containing 0.1 kg or more of Uranium Hexafluoride (UF_6) be designed such that there is no loss or dispersal of radioactive material and no damage of its containment system, including the valve, under Normal Conditions of Transport (NOC) as specified in Para. 630(b) of TS-R-1. Additionally, Para. 646(a) states that a Type A package must be designed such that there is no loss or dispersal of radioactive material under normal conditions of transport. Sections 2 and 3 demonstrate that the integrity of the containment system is maintained under both normal and hypothetical accident conditions of transport.	4.2 Requirements for Normal Conditions of Transport 4.2.1 Containment of Radioactive Material The Japanese Safe Transport Regulations pursuant to SSR-6 require that any package containing 0.1 kg or more of Uranium Hexafluoride (UF_6) be designed such that there is no loss or dispersal of radioactive material and no damage of its containment system, including the valve, under Normal Conditions of Transport (NOC) as specified in Para. 632(b) of SSR-6. Additionally, Para. 648(a) states that a Type A package must be designed such that there is no loss or dispersal of radioactive material under normal conditions of transport. Sections 2 and 3 demonstrate that the integrity of the containment system is maintained under both normal and hypothetical accident conditions of transport.	Update of the IAEA regulations (SSR-6 (2012) corresponds to the current Japanese Regulation.)
4-3 4-4	4.3 Containment Requirements for Hypothetical Accident Conditions 4.3.1 Fission Gas Products There are no fission gas products contained within the MST-30 package. 4.3.2 Containment of Radioactive Materials The Japanese Safe Transport Regulations pursuant to TS-R-1 require that any package containing 0.1 kg or more of UF_6 shall be designed to withstand the thermal test without rupture of the containment system as specified in Para.630(c) of TS-R-1. The current Japanese Regulations also require that any packaging containing Fissile Uranium Hexafluoride (UF_6) enriched up to 5wt% ^{235}U shall be designed such that there is no physical contact between the cylinder valve and any other component of the packaging after the mechanical tests and, in addition, the valve remain leak-tight after the thermal test and water immersion test, as specified in Para.677 (b) (i) of TS-R-1. Sections 2 and 3 demonstrate that the integrity of the containment system is maintained throughout and following the mechanical and thermal tests specified by regulation for Normal and Hypothetical Accident conditions.	4.3 Containment Requirements for Hypothetical Accident Conditions 4.3.1 Fission Gas Products There are no fission gas products contained within the MST-30 package. 4.3.2 Containment of Radioactive Materials The Japanese Safe Transport Regulations pursuant to SSR-6 require that any package containing 0.1 kg or more of UF_6 shall be designed to withstand the thermal test without rupture of the containment system as specified in Para.632(c) of SSR-6. The current Japanese Regulations also require that any packaging containing Fissile Uranium Hexafluoride (UF_6) enriched up to 5wt% ^{235}U shall be designed such that there is no physical contact between the cylinder valve and any other component of the packaging after the mechanical tests and, in addition, the valve remain leak-tight after the thermal test and water immersion test, as specified in Para.680 (b) (i) of SSR-6. Sections 2 and 3 demonstrate that the integrity of the containment system is maintained throughout and following the mechanical and thermal tests specified by regulation for Normal and Hypothetical Accident conditions.	Update of the IAEA regulations

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
4-5	 **Figure 4- 1 Welded Portions of Cylinder-Body**  **Figure 4- 2 Installation of Valve and Plug into Cylinder-head**	 **Figure 4- 1 Welded Portions of Cylinder-Body**  * In some cases, a cylinder without plug and plug-coupling may be used. **Figure 4- 2 Installation of Valve and Plug into Cylinder-head**	Change of the plug type (From Hex Head Plug to Socket Head Plug.) The hex head plug was removed from the figure. (The type of plug was changed into only the Socket Head Plug.) Addition of a footnote to the cylinder which has no plug and plug-coupling
Appendix 4.4.1-1	3 Discussion The criticality analysis in Section 6 [Reference 4.5.2] includes 7.6800×10^{-4} (atms•barn•cm) x 10^{24} (cm^2/barn) x 736000 (minimum cylinder volume, cc) = 5.6525×10^{26} atoms of hydrogen in the 30B cylinder, …	3 Discussion The criticality analysis in Reference 4.5.2 includes 7.6800×10^{-4} (atms/barn•cm) x 10^{24} (barn/cm^2) x 736000 (minimum cylinder volume, cc) = 5.6525×10^{26} atoms of hydrogen in the 30B cylinder, …	Appendix 4.4.1 Effect of Moist Air Ingress Change related to revision of Section 6 “Criticality evaluation” (New Section 6 does not refer to Reference 4.5.2), and correction of typo

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
5-1	5.0 SHIELDING EVALUATION The MST-30 Protective Shipping Package (MST-30) is a Type A, Fissile Material and Uranium Hexafluoride(UF_6) Package used for the shipment of 30-inch cylinders containing Uranium Hexafluoride (UF_6) enriched up to 5 wt% ^{235}U. The package is designed to conform to the technical and regulatory requirements as specified in the Japanese Safe Transport Regulations pursuant to TS-R-1. The package is intended to be used for transport from, to, or through foreign countries, including the USA. The MST-30 package is also designed in compliance with the current 10CFR Part 71 and 49CFR Part 173 Subpart I. The MST-30 package was approved by the Japanese Authority and certified as a Type A Fissile UF_6 Package on September 26, 2014 (NRA Certificate number J/159/AF-96(rev.2)). A copy of the NRA Certificate in English dated on October 31, 2014 is provided in Appendix 1.3.1. Drawings of the package are available in Appendix 1.3.2 and 1.3.3.	5.0 SHIELDING EVALUATION The MST-30 Protective Shipping Package (MST-30) is a Type A, Fissile Material and Uranium Hexafluoride(UF_6) Package used for the shipment of 30-inch cylinders containing Uranium Hexafluoride (UF_6) enriched up to 5 wt% ^{235}U. The package is designed to conform to the technical and regulatory requirements as specified in the Japanese Safe Transport Regulations pursuant to SSR-6. The package is intended to be used for transport from, to, or through foreign countries, including the USA. The MST-30 package is also designed in compliance with the current 10CFR Part 71 and 49CFR Part 173 Subpart I. The MST-30 package was approved by the Japanese Authority and certified as a Type A Fissile UF_6 Package. A copy of the NRA Certificate in English is provided in Appendix 1.3.1. Drawings of the package are available in Appendix 1.3.2 and 1.3.3.	Update of the IAEA Regulations (SSR-6 (2012) corresponds to the current Japanese Regulation.) The issue date and certificate number of the Japanese authority certificate were removed from the sentence.
5-2 5-3	5.3 Model Specification 5.3.1 Routine Transport The radiation source is assumed to be a right circular cylinder having the internal dimensions of the 30B cylinder (74.5 cm(29.33in) OD x 191.9 cm(75.55in) long):the diameter is to be the value subtracting the thickness of the cylinder wall (1.2cm(4.47in)) from the allowable maximum diameter of the cylinder(76.9cm(30.25in)) and the length is to be subtracting the thickness of both cylinder-heads from the allowable maximum length of the cylinder-body(194.3cm(76.5in)). The source is assumed to be distributed homogeneously throughout the volume, with a density of 2.72 g/cm^3(169.8lb.ft^3). The shielding effectiveness of the overpack is conservatively neglected. The spaces from the external surface of the cylinder to the external surface of outer shell of the overpack are 16.8(6.61in) cm on the end wall side and 20.8cm(8.19in) on the cylindrical side. So, the spaces of the model are assumed to be 16cm(6.3in) and 20cm(7.9in),respectively. A schematic of the model is shown in Figure 5-1.	5.3 Model Specification 5.3.1 Routine Transport The radiation source is assumed to be a right circular cylinder having the internal dimensions of the 30B cylinder (74.5 cm (29.33 in) ID x 191.9 cm (75.55 in) long) : the diameter is to be the value subtracting the thickness of the cylinder wall (1.2 cm (4.47 in)) from the allowable maximum diameter of the cylinder (76.9 cm (30.25 in)) and the length is to be subtracting the thickness of both cylinder-heads from the allowable maximum length of the cylinder- body (194.3 cm (76.5 in)). The source is assumed to be distributed homogeneously throughout the volume, with a density of 2.72 g/cm^3 (169.8 lb ft^3). The shielding effectiveness of the overpack and a ring plate is conservatively neglected. The spaces from the external surface of the cylinder to the external surface of outer shell of the overpack are 16.8 cm (6.61 in) on the end wall side and 20.8cm (8.19 in) on the cylindrical side. So, the spaces of the model are assumed to be 16 cm (6.3 in) and 20 cm (7.9 in), respectively. A schematic of the model is shown in Figure 5-1.	Explanation of the Ring Plate in the shielding model (ignored) Besides, some correction

Revision Comparison Table for MST-30 SAR (29 / 42)

Page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
	SECTION 6 CRITICALITY EVALUATION	**SECTION 6 CRITICALITY EVALUATION**	In SAR revision 6, the criticality analysis is totally revised.
	TABLE OF CONTENTS	TABLE OF CONTENTS	
	6.1 Discussion and Results 6-1	6.1 Discussion and Result 6-2	
	6.2 Package Fuel Loading 6-2	6.2 Object for Analysis 6-3	
		6.2.1 Contents of Package 6-3	
		6.2.2 Packaging 6-3	
		6.2.3 Neutron Absorber 6-3	
	6.3 Model Specification 6-3	6.3 Model Specification 6-4	
		6.3.1 Analysis Model 6-4	
		6.3.2 Atomic Number Density of Each Region for Analysis Model 6-7	
	6.4 Criticality Calculation 6-3	6.4 Criticality Calculation 6-8	
		6.4.1 Calculation Conditions 6-8	
		6.4.2 Water Leakage into Packages 6-8	
		6.4.3 Calculation Procedures 6-9	
(2014 Ver.)		6.4.4 Results of Criticality Calculation 6-12	
6-i	6.5 Criticality Benchmark Experiments 6-3	6.5 Benchmark Tests 6-13	
		6.6 Summary of Analysis Results and the Evaluation 6-15	
(2020 Ver.)		6.7 Appendices 6-16	
6-i		6.7.1 Sensitivity analysis on the modeling conditions of criticality evaluation	
6-ii		6.7.2 Summary of analysis code "SCALE"	
	6.6 References 6-4	6.8 References 6-16	
	LIST OF TABLES	LIST OF TABLES	
	Table 6-1 Summary of Criticality Evaluation 6-5	Table 6-1 Atomic Number Densities of Each Region 6-7	
		Table 6-2 Calculation Results of Effective Neutron Multiplication Factor 6-12	
		Table 6-3 Calculation Conditions 6-14	
		Table 6-4 Benchmark Results 6-14	
		LIST OF FIGURES	
		Figure 6-1(a) Criticality Analysis Model (axial direction) 6-6	
		Figure 6-1(b) Criticality Analysis Model (A-A cross section in radial direction) 6-6	
		Figure 6-2 Flow of Criticality Calculation for the Packages 6-11	
		Figure 6-3 Calculation geometry of HEU-SOL-THERM-039 Benchmark 6-13	

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
6-1	6.0 CRITICALITY EVALUATION The MST-30 Protective Shipping Package (MST-30) is a Type A, Fissile Material and Uranium Hexafluoride (UF_6) Package used for the shipment of 30-inch cylinders containing Uranium Hexafluoride (UF_6) enriched up to 5 wt% ^{235}U. The package is designed to conform to the technical and regulatory requirements as specified in the Japanese Safe Transport Regulations pursuant to the TS-R-1. The package is intended to be used for transport from, to, or through foreign countries, including the USA. The MST-30 package is also designed in compliance with the current 10CFR Part 71 and 49CFR Part 173 Subpart I. The MST-30 package was approved by the Japanese Authority and certified as a Type A Fissile UF_6 Package on September 26, 2014 (NRA Certificate number J/159/AF-96(Rev.2)). A copy of the NRA Certificate in English dated on October 31, 2014 is provided in Appendix 1.3.1. Drawings of the package are available in Appendix 1.3.2 and 1.3.3. The MST-30 has been rigorously tested according to the regulatory requirements to assure water leak-tightness of the UF_6 cylinder. UF_6 is not only a radioactive material but also a strong corrosive material and is classified into Class 8 of the United Nations (UN) Recommendations for Transport of Dangerous Goods (Para. 110 of TS-R-1). UF_6 rapidly reacts in the presence of water, even the low percentage of water vapor present in the air. When exposed to moisture, UF_6 generates hydrogen fluoride (HF), which has the potential to cause serious damage to people and vegetation (Para. 506 of TS-R-1). Additionally, inleakage of water may compromise criticality control. Therefore, the primary goal for the design of the MST-30 was to assure water leak-tightness of package under the severest of conditions. The exacting and comprehensive test program completely confirms that the design of the MST-30 maintains water leak-tightness of the cylinder under all regulatory conditions.	6.0 CRITICALITY EVALUATION The MST-30 Protective Shipping Package (MST-30) is a Type A, Fissile Material and Uranium Hexafluoride (UF_6) Package used for the shipment of 30-inch cylinders containing Uranium Hexafluoride (UF_6) enriched up to 5 wt% ^{235}U. The package is designed to conform to the technical and regulatory requirements as specified in the Japanese Safe Transport Regulations pursuant to the SSR-6. The package is intended to be used for transport from, to, or through foreign countries, including the USA. The MST-30 package is also designed in compliance with the current 10CFR Part 71 and 49CFR Part 173 Subpart I. The MST-30 package was approved by the Japanese Authority and certified as a Type A Fissile UF_6 Package. A copy of the NRA Certificate in English is provided in Appendix 1.3.1. Drawings of the package are available in Appendix 1.3.2 and 1.3.3. The MST-30 has been rigorously tested according to the regulatory requirements to assure water leak-tightness of the UF_6 cylinder. UF_6 is not only a radioactive material but also a toxic and corrosive material, classified into Class 6 / Division 6.1 and Class 8 of the United Nations (UN) Recommendations on the Transport of Dangerous Goods (Para. 110 of SSR-6). UF_6 rapidly reacts in the presence of water, even the low percentage of water vapor present in the air. When exposed to moisture, UF_6 generates hydrogen fluoride (HF), which has the potential to cause serious damage to people and vegetation (Para. 507 of SSR-6). Additionally, inleakage of water may compromise criticality control. Therefore, the primary goal for the design of the MST-30 was to assure water leak-tightness of package under the severest of conditions. The exacting and comprehensive test program completely confirms that the design of the MST-30 maintains water leak-tightness of the cylinder under all regulatory conditions.	Update of the IAEA regulations (SSR-6 (2012) corresponds to the current Japanese Regulation.) The issue date and certificate number of the Japanese authority certificate were removed from the sentence. Class 6 / Division 6.1 was added according to the update of UN Recommendations on the Transport of Dangerous Goods, and update of the IAEA regulations.

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
(2014 Ver.) 6-1~5 (2020 Ver.) 6-2~16	6.1 Discussion and Results 6.2 Package Fuel Loading 6.3 Model Specification 6.4 Criticality Calculation 6.5 Criticality Benchmark Experiments 6.6 References	6.1 Discussion and Result 6.2 Object for Analysis 6.3 Model Specification 6.4 Criticality Calculation 6.5 Benchmark Tests 6.6 Summary of Analysis Results and the Evaluation 6.7 Appendices 6.7.1 Sensitivity analysis on the modeling conditions of criticality evaluation 6.7.1.1 Parametric evaluation of the wall thickness of the cylinder 6.7.1.2 Parametric evaluation of UF_6 configuration and mass 6.7.1.3 Parametric evaluation of air moisture inleakage into the cylinder 6.7.1.4 Parametric evaluation of the uneven distribution of impurities contained in UF_6 6.7.1.5 Parametric evaluation of the hydrate remaining in the cylinder 6.7.1.6 Combined effect of the uneven distribution of residual hydrates and impurities contained in UF_6 6.7.1.7 Evaluation taking into account the presence of the overpack 6.7.2 Summary of analysis code "SCALE" 6.8 References	The criticality analysis is totally revised. The criticality calculation in section 6.3 and 6.4 is determined based on the parametric study in appendix 6.7.1. (See the SAR for details.)
Appendix 6.7.1 all pages	(none)	Appendix 6.7.1 Sensitivity analysis on the modeling conditions of criticality evaluation	Added new. (See the SAR for details.)
Appendix 6.7.2 all pages	(none)	Appendix 6.7.2 Summary of analysis code "SCALE"	Added new. (See the SAR for details.)

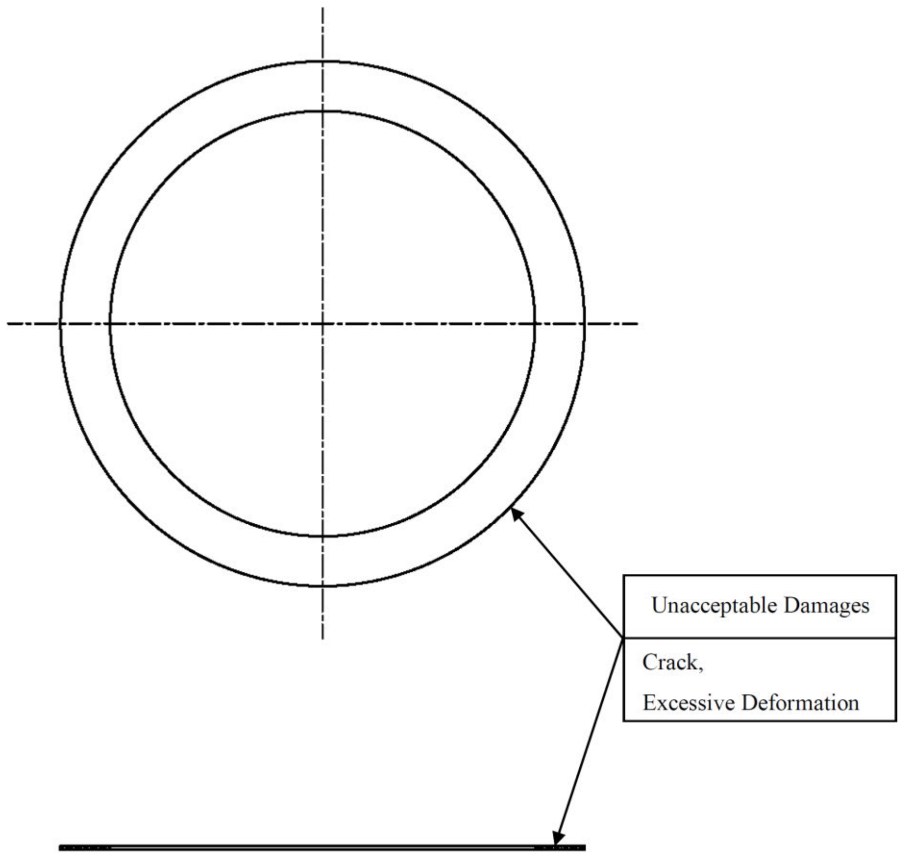
page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
7-i	**SECTION 7 OPERATING PROCEDURES** TABLE OF CONTENTS 7.1 Procedures for Loading the Package .... 7-1 7.1.1 Receipt and Filling of 30B Cylinder .... 7-1 7.1.2 Cylinder Inspection .... 7-1 7.1.3 Overpack Inspection .... 7-1 7.1.4 Procedure for Loading the 30 B Cylinder .... 7-2 7.1.5 Procedure for Loading the MST-30 Overpack .... 7-2 7.2 Procedures for Unloading the Package .... 7-3 7.2.1 Procedure for Unloading the MST-30 Overpack .... 7-3 7.2.2 Procedure for Unloading the 30B Cylinder .... 7-3 7.3 Shipment of Empty Packages .... 7-4 7.3.1 Preparation of an Empty Cylinder for Shipment .... 7-4 LIST OF FIGURE Figure 7-1 Visual Inspection Criteria of MST-30 Overpak 7-5	**SECTION 7 OPERATING PROCEDURES** TABLE OF CONTENTS 7.1 Procedures for Loading the Package .... 7-1 7.1.1 Receipt and Filling of 30B Cylinder .... 7-1 7.1.2 Cylinder Inspection .... 7-1 7.1.3 Overpack Inspection .... 7-1 7.1.4 Procedure for Loading the 30 B Cylinder .... 7-2 7.1.5 Procedure for Loading the MST-30 Overpack .... 7-2a 7.2 Procedures for Unloading the Package .... 7-3 7.2.1 Procedure for Unloading the MST-30 Overpack .... 7-3 7.2.2 Procedure for Unloading the 30B Cylinder .... 7-3 7.3 Shipment of Empty Packages .... 7-4 7.3.1 Preparation of an Empty Cylinder for Shipment .... 7-4 LIST OF FIGURE Figure 7-1 Visual Inspection Criteria of MST-30 Overpack .... 7-5 Figure 7-2 Visual Inspection Criteria of Ring Plate 7-6	Page number is changed. Correction of a typo Addition of a figure

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
7-1 7-2	7.1 Procedure for Loading the Package … 7.1.3 Overpack Inspection The user shall establish and implement written procedures to inspect the MST-30 overpack prior to each use to assure the following (See: Figure 7-1): (a) The overpack legs and supports are sound with no broken welds or components. … (m) The tamper proof feature (security seal apparatus) is undamaged. Following the inspection, an inspection report shall be completed verifying that the overpack is free from damage and is in working order. Any defective condition must be corrected and the overpack must be re-certified prior to use.	7.1 Procedures for Loading the Package … 7.1.3 Overpack Inspection The user shall establish and implement written procedures to inspect the MST-30 overpack and the ring plate prior to each use to assure the following (See: Figure 7-1 and Figure 7-2): (a) The overpack legs and supports are sound with no broken welds or components. … (m) The tamper proof feature (security seal apparatus) is undamaged. (n) The ring plate is intact with no crack and no excessive deformation. Following the inspection, an inspection report shall be completed verifying that the overpack is free from damage and is in working order. Any defective condition must be corrected and the overpack must be re-certified prior to use.	Addition of the Ring Plate Addition of a description of the Ring Plate
7-2	7.1.4 Procedure for Loading the 30B Cylinder The MST-30 overpack is loaded and unloaded and the 30B cylinder is filled, tested, and handled in accordance with standard, in-plant operating procedural requirements at the facility and ANSI Standard N14.1 Leak-tightness of the UF_6 filled cylinder shall have been previously verified using a test having a sensitivity of at least 1 x 10^{-3} ref-cc/sec. … Prior to loading into the MST-30 Overpack, the valve port and valve boss/coupling shall be inspected for solid deposits. Solid deposits around the valve port or valve boss/coupling indicate a leak condition, and the cylinder shall not be loaded into the overpack. Corrective measure shall be taken to remedy the leak as proscribed by the facility's operating procedures. If the valve port and valve boss/coupling are free of solid deposits, the cylinder may be loaded into the MST-30 Overpack.	7.1.4 Procedure for Loading the 30B Cylinder The MST-30 overpack is loaded and unloaded and the 30B cylinder is filled, tested, and handled in accordance with standard, in-plant operating procedural requirements at the facility and ANSI Standard N14.1. The type of plug allowed for the 30B cylinder loaded in the MST-30 overpack is a socket head plug only. The use of a hex head plug is not allowed in the case of MST-30. The cylinder into which UF_6 is loaded shall be a clean and washed out cylinder. Loading of UF_6 into an uncleaned cylinder after withdrawal of UF_6 shall not be conducted. Leak-tightness of the UF_6 filled cylinder shall have been previously verified using a test having a sensitivity of at least 1 x 10^{-3} ref-cc/sec. … Prior to loading into the MST-30 Overpack, the valve port and valve boss/coupling shall be inspected for solid deposits. Solid deposits around the valve port or valve boss/coupling indicate a leak condition, and the cylinder shall not be loaded into the overpack. Corrective measure shall be taken to remedy the leak as prescribed by the facility's operating procedures. If the valve port and valve boss/coupling are free of solid deposits, the cylinder may be loaded into the MST-30 Overpack.	7.1 Procedures for Loading the Package Addition of a description of the type of the cylinder plug allowed Addition of the condition of the cylinders before filling with UF_6 (Uncleaned cylinders are not allowed to be refilled.) Correction of a typo

Page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
7-2a	7.1.5 Procedure for Loading the MST-30 Overpack (a) The inspection required by Section 7.1.2 shall be performed and documented prior to loading a 30B cylinder into the overpack. (b) Carefully lift the 30B cylinder horizontally, directing the cylinder-valve toward the inner shell of the wall end of the bottom half on which step-joint the cylinder positioning device is installed. Then, carefully load the cylinder into the bottom half with the cylinder-valve positioned up at one (1) o'clock position. Then, securely insert the pin of cylinder positioning device into the hole of cylinder-skirt; otherwise the top half (lid) is prevented from proper seating and closure due to contact with the pin of positioning device located on the bottom half. (c) Carefully place the top half on the bottom half of overpack. (d) Tighten all fastening devices alternating first corner-to-corner (4 devices) followed by side-to-side (6 devices). (e) Install tamper-proof seals and record their numbers. (f) Complete radiation survey and assign Transport Index as per applicable regulations. (g) Remove old labels and re-label following the applicable regulations.	7.1.5 Procedure for Loading the MST-30 Overpack (a) The inspection required by Section 7.1.2 shall be performed and documented prior to loading a 30B cylinder into the overpack. (b) Carefully lift the 30B cylinder horizontally, directing the cylinder-valve toward the inner shell of the wall end of the bottom half on which step-joint the cylinder positioning device is installed. Then, carefully load the cylinder into the bottom half with the cylinder-valve positioned up at one (1) o'clock position. Then, securely insert the pin of cylinder positioning device into the hole of cylinder-skirt; otherwise the top half (lid) is prevented from proper seating and closure due to contact with the pin of positioning device located on the bottom half. (c) Insert a ring plate into the gap on the plug side between the overpack and the 30B cylinder. (d) Carefully place the top half on the bottom half of overpack. (e) Tighten all fastening devices alternating first corner-to-corner (4 devices) followed by side-to-side (6 devices). (f) Install tamper-proof seals and record their numbers. (g) Complete radiation survey and assign Transport Index as per applicable regulations. (h) Remove old labels and re-label following the applicable regulations.	7.1 Procedures for Loading the Package Addition of a description of the Ring Plate

Page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
7-3	7.2 Procedures for Unloading the Package 7.2.1 Procedure for Unloading the MST-30 Overpack (See: Figure 7-1) (a) Visually inspect the exterior of overpack as possible for damage using the steps provided in Section 7.1.3 (a), (b), (g), (h), (i), (j), (k), (l) and (m). Document any damage observed. Complete receiving report as required by the facility's operating procedures. (b) Remove and record the overpack tamper-proof seals. (c) Loosen all fastening devices. (d) Remove the upper half of overpack. Then, remove the cylinder positioning device from the hole of cylinder-skirt. (e) Remove the cylinder from the overpack. (f) Clean any loose debris from the interior of overpack. (g) Close the overpack prior to storage.	7.2 Procedures for Unloading the Package 7.2.1 Procedure for Unloading the MST-30 Overpack (See: Figure 7-1) (a) Visually inspect the exterior of overpack as possible for damage using the steps provided in Section 7.1.3 (a), (b), (g), (h), (i), (j), (k), (l) and (m). Document any damage observed. Complete receiving report as required by the facility's operating procedures. (b) Remove and record the overpack tamper-proof seals. (c) Loosen all fastening devices. (d) Remove the upper half of overpack. Then, remove the cylinder positioning device from the hole of cylinder-skirt. (e) Remove the ring plate from the overpack. (f) Remove the cylinder from the overpack. (g) Clean any loose debris from the interior of overpack. (h) Close the overpack prior to storage.	Addition of a description of the Ring Plate

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
7-4	7.3 <u>Shipment of Empty Packages</u> … 7.3.1 <u>Preparation of an Empty Cylinder for Shipment</u> (a) Prior to the shipment of each empty cylinder, the interior of the empty cylinder shall be completely washed out. (b) Load the cylinder into the MST-30 using the procedure provided in Section 7.1.5. (c) Survey radiation level on the external surface of the overpack. The radiation level on any external surface of the overpack may not exceed 5 μSv/hr. If the radiation level exceeds 5μSv/hr, then the empty cylinder once loaded into the overpack shall be unloaded therefrom and may not be used for shipment until the radiation level of the cylinder is reduced sufficiently. (d) Remove old labels and re-label as per applicable regulations. Washed empty cylinders may be shipped as a Type L Package, which is a package category specified in JPN transport regulations and corresponds to Excepted Package specified in TS-R-1, in Japan. In other countries including USA, it may be shipped as an Excepted Package or other package type which is complied with regulations in each country.	7.3 <u>Shipment of Empty Packages</u> … 7.3.1 <u>Preparation of an Empty Cylinder for Shipment</u> (a) Prior to the shipment of each empty cylinder, the interior of the empty cylinder shall be completely washed out. (b) Load the cylinder into the MST-30 using the procedure provided in Section 7.1.5. (c) Insert the ring plate into the overpack using the procedure provided in Section 7.1.5. (d) Survey radiation level on the external surface of the overpack. The radiation level on any external surface of the overpack may not exceed 5 μSv/hr. If the radiation level exceeds 5μSv/hr, then the empty cylinder once loaded into the overpack shall be unloaded therefrom and may not be used for shipment until the radiation level of the cylinder is reduced sufficiently. (e) Remove old labels and re-label as per applicable regulations. Washed empty cylinders may be shipped as a Type L Package, which is a package category specified in JPN transport regulations and corresponds to Excepted Package specified in SSR-6, in Japan. In other countries including USA, it may be shipped as an Excepted Package or other package type which is complied with regulations in each country.	Addition of a description of the Ring Plate Update of the IAEA regulations (SSR-6 (2012) corresponds to the current Japanese Regulation.)

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
(2020 Ver.) 7-6	(none)	 **Figure 7-2 Visual Inspection Criteria of Ring Plate**	Addition of a figure of the visual inspection for the Ring Plate

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
8-i	**SECTION 8 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM** TABLE OF CONTENTS 8.1 Acceptance Tests .... 8-1 8.1.1 Acceptance Tests for the MST-30 Overpack .... 8-1 8.1.2 Acceptance Tests for the Cylinder .... 8-1 8.1.3 Package Inspection Prior to Each Shipment .... 8-2 8.2 Maintenance Program .... 8-3 8.2.1 Maintenance Program for the MST-30 Overpack .... 8-3 8.2.1.1 Annual Inspection .... 8-3 8.2.1.2 Weight Inspection .... 8-4 8.2.1.3 Re-certification of Overpack .... 8-4 8.2.2 Maintenance Program for the 30B Cylinder .... 8-5 8.2.2.1 Annual Inspection .... 8-5 8.2.2.2 Every Five (5) Year Inspection .... 8-5 8.2.2.3 Valve Inspection .... 8-6 8.2.2.4 Re-certification of 30B Cylinder .... 8-6 8.3 Appendix .... 8-6 8.3.1 Procedures for Package Inspection Prior to Each Shipment	**SECTION 8 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM** TABLE OF CONTENTS 8.1 Acceptance Tests .... 8-1 8.1.1 Acceptance Tests for the MST-30 Overpack .... 8-1 8.1.2 Acceptance Tests for the Cylinder .... 8-1 8.1.3 Package Inspection Prior to Each Shipment .... 8-2 8.2 Maintenance Program .... 8-3 8.2.1 Maintenance Program for the MST-30 Overpack .... 8-3 8.2.1.1 Annual Inspection .... 8-3 8.2.1.2 Weight Inspection .... 8-4 8.2.1.3 Re-certification of Overpack .... 8-4 8.2.2 Maintenance Program for the 30B Cylinder .... 8-5 8.2.2.1 Annual Inspection .... 8-5 8.2.2.2 Every Five (5) Year Inspection .... 8-5 8.2.2.3 Valve Inspection .... 8-6 8.2.2.4 Re-certification of 30B Cylinder .... 8-6 8.3 Appendix .... 8-7 8.3.1 Procedures for Package Inspection Prior to Each Shipment 8.4 Reference 8-7	Page number is changed. Addition of the reference

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
8-3 8-4	8.2 <u>Maintenance Program</u> 8.2.1 <u>Maintenance Program</u> … 8.2.1.1 <u>Annual Inspection</u> Once a year, overpack shall be inspected visually to ensure that it is not damaged and is adequate for its use. Furthermore, in case the packaging is used for transport more than 10 times per year, this annual inspection shall be conducted every 10 times use in accordance with JPN transport regulations. As a minimum, the following point shall be checked: (a) Visually inspect the lifting shackles, fastening devices with bolts, and tie-down supports (legs) for unacceptable discontinuities, damage and deterioration. Repair as necessary to the original drawings and specifications. … (i) Check that the outer and inner surfaces of overpack are free from debris or standing water. Remove as necessary any debris or standing water.	8.2 <u>Maintenance Program</u> 8.2.1 <u>Maintenance Program</u> … 8.2.1.1 <u>Annual Inspection</u> Once a year, the overpacks and the ring plates shall be inspected visually to ensure that they are not damaged and are adequate for their use. Furthermore, when the packagings are used for transport more than 10 times per year, this annual inspection shall be conducted every 10 times use in accordance with JPN transport regulations. As a minimum, the following point shall be checked: (a) Visually inspect the lifting shackles, fastening devices with bolts, and tie-down supports (legs) for unacceptable discontinuities, damage and deterioration. Repair as necessary to the original drawings and specifications. … (i) Check that the outer and inner surfaces of overpack are free from debris or standing water. Remove as necessary any debris or standing water. (j) Visually inspect the ring plate for damage and deterioration. Repair as necessary according to the original drawings and specifications.	Addition of a description of the Ring Plate Addition of a description of the Ring Plate

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
8-6	8.2.2.2 Every Five (5) Year Inspection Every five year inspection of each 30B cylinder in service shall be performed in the presence of a qualified inspector in accordance with ANSI N14.1 or ISO 7195. A cylinder which is filled with UF_6 at the time of expiry of the five year period need not be emptied for this test, but shall not be transported until 5 year periodic inspection is conducted after being emptied. The following inspections shall be performed: (a) Hydrostatic Pressure Test of the Cylinder-Body at 400 psig (2.76 MPa G); … (c) Cylinder Shell Thickness Inspection Using Ultrasonic Thickness Gage; The acceptance criterion is such that: The thickness of cylinder-shell is to be maintained more than 10 mm (approx. 3/8 inch).	8.2.2.2 Every Five (5) Year Inspection Every five year inspection of each 30B cylinder in service shall be performed in the presence of a qualified inspector in accordance with ANSI N14.1 or ISO 7195. A cylinder which is filled with UF_6 at the time of expiry of the five year period need not be emptied for this test, but shall not be transported until 5 year periodic inspection is conducted after being emptied. The following inspections shall be performed: (a) Hydrostatic Pressure Test of the Cylinder-Body at 400 psig (2.76 MPa G); … (c) Cylinder Shell Thickness Inspection Using Ultrasonic Thickness Gage; The acceptance criterion is such that: The thickness of cylinder-shell is to be maintained more than 11.3 mm (approx. 0.445 inch). (note) The criterion of 11.3 mm for the cylinder shell thickness is decided by adding a corrosion margin for 5 years to 11 mm to ensure that the thickness is not less than 11 mm. The corrosion margin is assumed to be 0.254 mm (0.0508 mm/year [Reference 8.4.1] × 5 years).	8.2 Maintenance Program 8.2.2 Maintenance Program for the 30B Cylinder Change of the criterion for the cylinder wall thickness
(2020 Ver.) 8-7	(none)	8.4 Reference 8.4.1 POEF-TS-02, "Review of Corrosion in 10- and 14-Ton Mild Steel Depleted UF_6 Storage Cylinders", Michael L. Lykins, August 1995	Addition of a reference

Revision Comparison Table for MST-30 SAR (41 / 42)

page	SAR Revision 5 (December 2014)			SAR Revision 6 (March 2020)			Note
	Procedures for Package Inspection Prior to Each Shipment (1/2)			**Procedures for Package Inspection Prior to Each Shipment (1/2)**			
	Inspection Item	**How to inspect**	**Acceptance Criteria**	**Inspection Item**	**How to inspect**	**Acceptance Criteria**	
Appendix 8.3.1-1	Visual Inspection	Visually inspect the outside of MST-30 overpack and 30Bcylinder in which the specified UF_6 is contained.	No unacceptable discontinuities, cracks, damage or deterioration shall be detected. Both halves of overpack shall be tightly fastened with fastening devices.	Visual Inspection	Visually inspect the outside of MST-30 overpack, ring plate and 30B cylinder.	·No unacceptable discontinuities, cracks, damage or deterioration shall be detected. Both halves of overpack shall be tightly fastened with fastening devices. ·The type of the plug installed on the cylinder shall be the socket head plug. (*1) ·The ring plate shall be inserted on the plug side. (*1)	Addition of inspections for the Ring Plate and the plug type
		Visually inspect portions around the fittings, such as, valve,plug, their couplings, etc.	No solid deposits around the fittings shall be detected.		Visually inspect portions around the fittings of 30B cylinder, such as, valve, plug, their couplings, etc.	· No solid deposits around the fittings shall be detected.	Revised to be precise
	Lifting Inspection	Visually inspect whether the lifting shackles, pins & their supports have any damage or anomaly when the package is lifted up by a crane.	No damage or anomaly shall be detected on the shackles, pins and/or supports.	Lifting Inspection	Visually inspect whether the lifting shackles, pins & their supports have any damage or anomaly when the package is lifted up by a crane.	·No damage or anomaly shall be detected on the shackles, pins and/or supports.	
	Weight Inspection	Weigh the cylinder containing UF_6, and add the standard weight of the over pack.	The gross weight shall not exceed 4,170 kg (approx. 9,193 lbs).	Weight Inspection	Weigh the cylinder containing UF_6 and check the contents (UF_6) weight. Check the package weight (calculated by adding the cylinder gross weight to the maximum design weight of the overpack and the ring plate).	·The contents (UF_6) weight shall not exceed 2,277 kg (approx.5,020 lbs) ·The gross weight of the package shall not exceed 4,170 kg (approx. 9,193 lbs).	The Ring Plate was added, and description was revised to clarify the content.
	External Surface Contamination Survey	Survey the contamination level per unit area at any external surface of the overpack by smear method.	Surface contamination level shall not exceed 0.4 Bq / cm^2 for alpha emitters and 4Bq/cm^2 for non alpha emitters.	External Surface Contamination Survey	Survey the contamination level per unit area at any external surface of the overpack by smear method.	·Surface contamination level shall not exceed 0.4 Bq / cm^2 for alpha emitters and 4Bq/cm^2 for non alpha emitters.	
	Survey of Radiation Dose Rate	Survey γ-ray radiation level of the package in which the specified UF_6 is contained by survey meter.	Not more than 2mSv/hr at any external surface of the overpack. Not more than 0.1mSv/ hr at any point of 1 m from any external surface of the overpack.	Survey of Radiation Dose Rate	Survey γ-ray radiation level of the package in which the specified UF_6 is contained by survey meter.	·Not more than 2mSv/hr at any external surface of the overpack. ·Not more than 0.1mSv/ hr at any point of 1 m from any external surface of the overpack.	
	Sub-criticality Inspection	Visually inspect the cylinder for defects, damage, and/or deterioration of the valve, plug or couplings through which water-ingress may occur	No unacceptable defect, damage and deterioration shall be detected on the valve, plug or couplings.	Sub-criticality Inspection	Visually inspect the cylinder for defects, damage, and/or deterioration of the valve, plug or couplings through which water-ingress may occur	·No unacceptable defect, damage and deterioration shall be detected on the valve, plug or couplings. ·No significant deformation of the cylinder shall be detected.	Revised to be precise
				(*1) In the case of 30B cylinders with no plug, inspection for plugs and ring plates are not required, and use of ring plates is optional.			Addition of a footnote for the cylinder with no plug

page	SAR Revision 5 (December 2014)	SAR Revision 6 (March 2020)	Note
Appendix 8.3.1-2	(see below)	(see below)	The footnote number is changed.

SAR Revision 5 (December 2014)

Procedures for Package Inspection Prior to Each Shipment (2/2)

Inspection Item	How to inspect	Acceptance Criteria
Verification of Data for Contents (the UF_6 contained in the package)	Check the data for specifications of the UF_6 contained, such as, enrichment, each loading quantity of UF_6, U content & ^{235}U content and other nuclides contents(^{232}U, ^{234}U, ^{236}U & ^{99}Tc)	Conformity of the data received with the required specifications shall be verified. · The enrichment of the contents shall not exceed 5 wt.% ^{235}U · The contents of ^{232}U, ^{234}U, ^{236}U and ^{99}Tc shall satisfy the following value, respectively.(*1) $^{232}U \leq 0.0001$ μg/gU $^{234}U \leq 11.0\times10^3$ μg/g^{235}U $^{236}U \leq 5000$ μg/g^{235}U $^{99}Tc \leq 0.01$ μg/gU · The purity of UF_6 shall be more than 99.5%. · The contents weight shall not exceed 2,277kg.

(*1) In case the ^{236}U measurement result is less than 125μg/gU, confirmation of ^{232}U and ^{99}Tc can be omitted in accordance with ASTM C996

SAR Revision 6 (March 2020)

Procedures for Package Inspection Prior to Each Shipment (2/2)

Inspection Item	How to inspect	Acceptance Criteria
Verification of Data for Contents (the UF_6 contained in the package)	Check the data for specifications of the UF_6 contained, such as, enrichment, each loading quantity of UF_6, U content & ^{235}U content and other nuclides contents (^{232}U, ^{234}U, ^{236}U & ^{99}Tc)	Conformity of the data received with the required specifications shall be verified. · The enrichment of the contents shall not exceed 5 wt.% ^{235}U · The contents of ^{232}U, ^{234}U, ^{236}U and ^{99}Tc shall satisfy the following value, respectively.(*2) $^{232}U \leq 0.0001$ μg/gU $^{234}U \leq 11.0\times10^3$ μg/g^{235}U $^{236}U \leq 5000$ μg/g^{235}U $^{99}Tc \leq 0.01$ μg/gU · The purity of UF_6 shall be more than 99.5%. · The contents weight shall not exceed 2,277kg.

(*2) When the ^{236}U measurement result is less than 125μg/gU, confirmation of ^{232}U and ^{99}Tc can be omitted in accordance with ASTM C996.