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TEST PLAN 213

SENTRY – Model 867 Source Changer Type (B) Transport Package Drop Tests

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Engineering Review	[illegible]	Date: 5 May 15

APPROVALS		
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Quality Assurance	[illegible]	Date: 6 MAY 15

TEST PLAN 213

SENTRY - Model 867 Source Changer Type (B) Transport Package Drop Tests

Rev0

April 27, 2015

Contents

Test Plan No. 213

Section 1 Introduction

This plan tests the changes made to the dust cover assembly (drawing 86725 revisions G and H) to ensure the package remains compliant with 10 CFR Part 71, revised as of March 31, 1999 and the IAEA Regulations for the Safe Transport of Radioactive Material, No. TS-R-1 (2009 Edition). These changes relate to the addition of a tungsten port shield in the assembly.

The contents of this plan describes the test package, testing equipment, testing scenario, justifies the package orientation, and provides test worksheets to record key steps in the testing sequence.

Roles and Responsibilities

The responsibilities of the groups identified in this plan are:

- **Engineering** executes the tests according to the test plan and summarizes the test results. Engineering also provides technical input to assist Regulatory Affairs and Quality Assurance as needed.

- **Regulatory Affairs** monitors the tests and reviews test reports for compliance with regulatory requirements.

- **Quality Assurance** oversees test execution and test report generation to assure compliance with the QSA Global Quality Assurance Program.

- **Engineering, Regulatory Affairs** and **Quality Assurance** are jointly responsible for assessing test and specimen conditions relative to 10 CFR 71 and IAEA TS-R-1.

Section 2 Transport Package Description

The Model 867 is the SENTRY source changer/transport package described on drawing R86000 Revision L. Additional package description can be found in the original transport test plan 180. Figure 2.1 gives an overview of the Model 867 transport package without the optional handling ribs. The package shown in Figure 2.1 is the actual test specimen configuration for this plan.

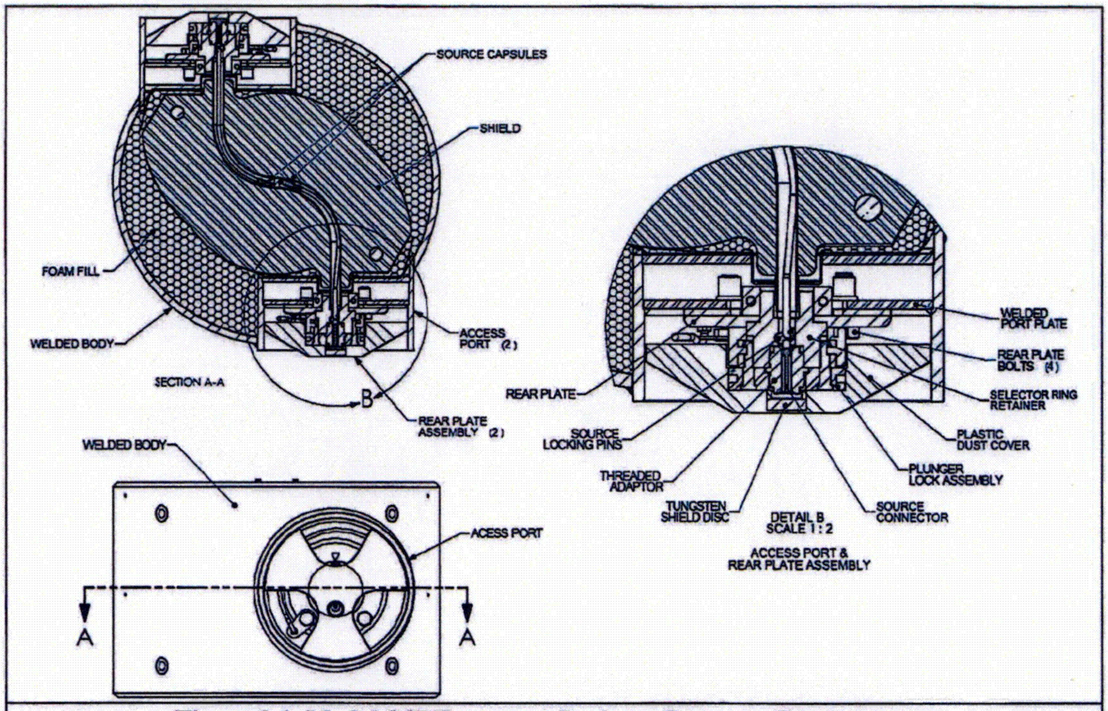

Figure 2.1. Model 867 Transport Package Common Components – Note: Optional Handling Ribs Not Shown

The package tested in test plan 180 has been modified to include a tungsten shield disc in the plastic dust cover at both rear plate assemblies located in the access ports.

The tungsten shield disc is located in the dust cover directly over the locked source connector. The plastic dust cover thickness increased slightly between the plunger lock assembly and the outer surface to locate and contain the shield disc. The overall size of the cover is unchanged, but the offset thickness causes the plastic dust cover to now protrude by about 0.31 inches beyond the welded access ports. The plastic cover originally protruded about 0.10 inches beyond the port.

Figure 2.2 below shows the original dust cover design. In this design, the cover protrudes by only 0.10 inches from the access port tube with 0.42 inches of plastic between the outside dust cover surface and the plunger lock assembly.

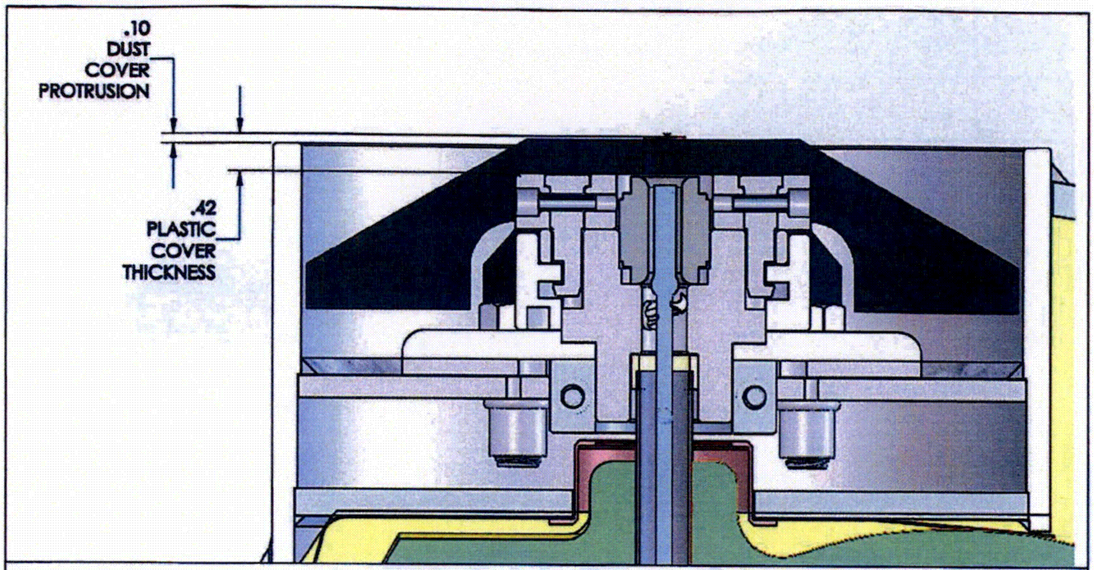

Figure 2.2. Original Dust Cover Design

Figure 2.3 below shows the new dust cover design. The cover now protrudes 0.31 inches from the access port tube with 0.63 inches of plastic between the outside cover surface and the lock housing. The extra plastic thickness is needed to accommodate the new tungsten disc.

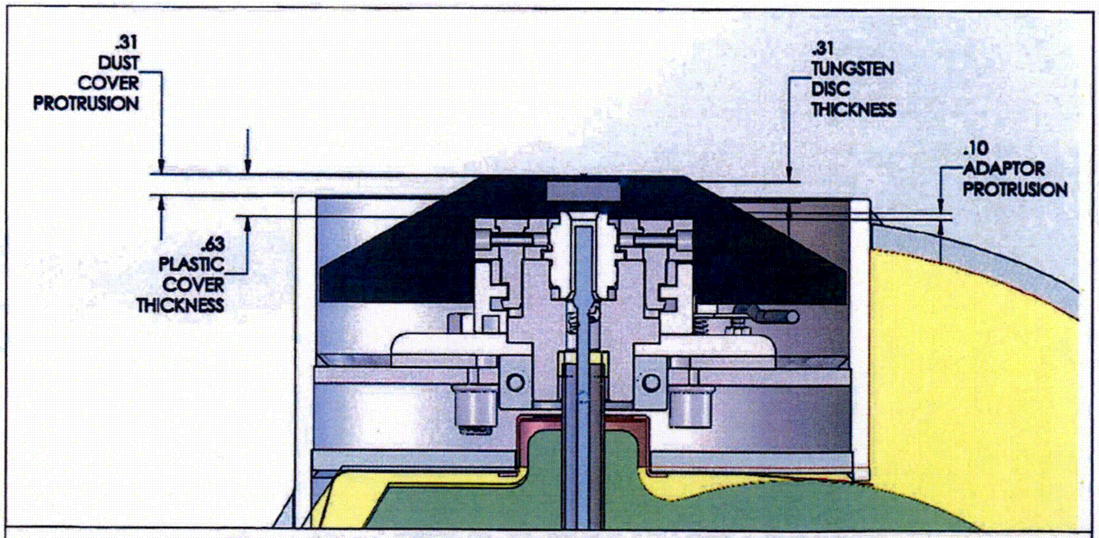

Figure 2.3. New Dust Cover Design – with Tungsten Disc

Section 3 Regulatory Compliance

This test plan evaluates the design change to the Model 867 dust cover assembly against the test Type-B transport requirements of 10 CFR 71 and IAEA TS-R-1 as described below.

The sequence of testing shall follow the order given in section 8.1. The test specimen is first subjected to the required normal conditions of transport tests followed by the hypothetical accident condition tests of 10 CFR Part 71.73. The test sequence in section 8.1 represents the worst case testing sequence for the Model 867 transport package.

3.1 Normal Transport Condition Tests

The **water spray preconditioning** 10 CFR 71.71 (c) (6) will not be performed as the package is constructed of waterproof materials throughout. Water spray would not degrade the structural integrity of the Model 867 transport package.

The **compression test** 10 CFR 71.71 (c) (9) will not be performed since the dust cover design change will not influence the compression test in any way. The results in the test plan 180 report remains acceptable.

The **penetration test** of 10 CFR 71.71 (c) (10) will not be performed since the dust cover design change will not adversely affect the results of the previously performed penetration test. The additional dust cover plastic material provides more protection to the brass plunger lock than the successfully tested design under test plan 180.

The Model 867 package shall be subjected to the **1.2 meter free drop test** per 10 CFR 71.71 (c) (7).

3.2 Hypothetical Accident Condition Tests

The **crush test** (10 CFR 71.73 (c) (2)) will not be performed because the capsules containing the radioactive material and attached to the source wire assemblies are qualified as Special-Form radioactive material.

The Model 867 package shall be subjected to the **9 meter free drop test** (10 CFR 71.73 (c) (1), and then the **puncture test** (10 CFR 71.73 (c) (3).

The **thermal test** (10 CFR 71.73 (c) (4)) will be assessed and not performed. The assessment will be based on the examination of the damage to the test specimen immediately after the puncture test.

The **immersion test** (10 CFR 71.73 (c) (6)) will not be performed. Only the source capsule (containment vessel) is sealed and able to pressurize as a result of 50 feet of water depth. The source capsule is designed and tested to withstand external pressures over 22-lbf/in^2.

3.3 Free Drop Height Adjustment

All free drop test heights specified in 10 CFR Part 71 shall be adjusted higher to allow future Model 867 transport packages built heavier than the test specimen but less than the maximum package weight to comply with 10 CFR Part 71.

The actual adjusted drop heights will be determined once the test specimen is weighed and just before the drop tests. The adjusted heights will provide impact energy equal to or greater than the maximum transport package weight if dropped at the 10 CFR Part 71 specified drop heights (30 feet free drop, 4 feet free drop, and 1 meter puncture).

The actual weight of the Model 867 transport package is directly affected by the following:
1. Minor thickness variations in component materials.
2. Slight polyurethane foam fill density changes as the pre-filled foam ages (shelf life).
3. Extra shield material layers accumulating on the shield casting as the mold cavity wears.

The actual test specimen will weigh less than the maximum transport package weight. The drop height adjustment shall be based on the 780 pound maximum package weight which includes the handling ribs. The test specimen will be tested without the handling ribs, but the rib weight will be accounted for in the drop height adjustment since the ribs provide no impact protection in the port face down orientation.

The impact energy is equal to the total potential energy just before the package is dropped. The potential energy (PE) is simply equal to the weight (W) of the package multiplied by the height (H) of the drop.

$$PE = W \times H$$

In the potential energy equation, the weight (W) is directly proportional to the height (H). A lighter test specimen can be dropped from a higher drop height in order to produce equivalent impact (potential) energy for a heavier test specimen dropped at a lower height.

The following example calculates the adjusted 30-foot free drop height for the Model 867 Changer – Standard configuration.

Drop #1: Maximum package weight = 780 Lbs. and free drop height requirement = 30 feet.

$$PE\ (1) = 780 \times 30 = 23{,}400 \text{ Lbs-Ft}$$

Drop #2: Actual test specimen weight = 680 Lbs. and adjusted free drop height = Unknown feet.

$$PE\ (2) = PE\ (1) = 23{,}400 \text{ Lbs-Ft} = 680 \text{ Lbs} \times H \text{ feet}$$

$$H = 34.4 \text{ feet} = 34 \text{ feet } 5 \text{ inches}$$

Section 4 Discussion on System Failure Modes of Interest

The testing in this plan will attempt to cause damage, failure or malfunction to the source securing features of the rear plate assembly on the Model 867 transport package. The primary failure mode is the relative location of the fully shielded source capsule to the outer surface of the package after testing. A dramatic change in the source location could alter the radiation measurements to unacceptable levels.

The design changes made to the dust cover could affect the source securing features of the rear plate assembly when the package is drop in an orientation where the outward facing surface of the protruding dust cover hits the drop pad first. See figure 4.1 below.

The protruding plastic cover may absorb more impact energy than the previous drops tests of test plan 180, but the protrusion will also transfer an instantaneous shock wave into other important rear plate components before the cover deforms enough to recruit the outer rim of the welded stainless steel port tube enough to protect the bulk of the rear plate assembly.

Since the plastic cover is expected to deform considerably upon impact, the shield disc will be pushed into the package pressing into the threaded adaptor transferring the impact load into the selector ring retainer and possibly compromising the source locking pins. If the locking pins no longer capture the source assembly wire and a retaining cap is no longer present after the fire test, then the source could move out of the fully shielded position in the package. The source could only move out of the shielded position if the package is found with one of the access ports facing towards the ground after the puncture drop test.

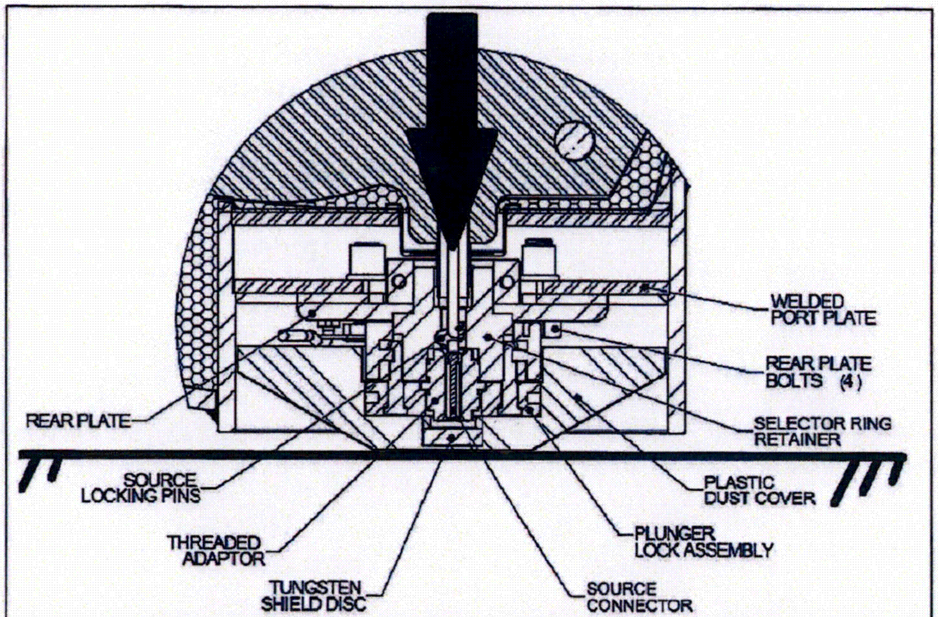

Figure 4.1. Safety components affected by the drop tests

Section 5 Assessment of Package Conformance

5.1 *Normal Conditions of Transport (71.43 (f))*

There should be no loss or dispersal of radioactive contents, no significant increase in external surface radiation levels and no substantial reduction in the effectiveness of the packaging.

IAEA TS-R-1 paragraph 646 stipulates the same criteria except that it also requires that the loss of shielding integrity should not result in more than a 20% increase in the radiation level at any external surface of the package.

5.2 *Hypothetical Accident Conditions (71.51 (a)(2))*

There should be no escape of radioactive materials greater than A_2 in one week and no external dose rate greater than 1 R/hr at 1m from the external surface with the maximum radioactive contents which the package is designed to carry.

5.3 *Transport Package Contents*

The Model 867 transport package is designed to carry a special form cobalt-60 source capsule. Containment of the radioactive source is tested at manufacture. The source capsule design has been certified in accordance with the performance requirements for special form as specified in 10 CFR Part 71 and IAEA TS-R-1.

This test plan therefore does not discuss/specify tests associated with the containment of the radioactive source. The purpose of the tests is to demonstrate that the source remains shielded within the limits specified by the regulations.

Since source integrity has been demonstrated through special form testing, a simulated source will be used during testing of the package. The radiation levels after testing will be measured by replacing the simulated source with an active source. The post-test measurements will be compared with pre-test measurements to verify the source has not shifted within the shield.

5.4 *Pass Criteria*

Upon conclusion of any test, the test specimen shall be considered passing the test if the package meets the criteria in section 5.1 and 5.2 above.

Section 6 Construction and Condition of Test Specimens

The Model 867 transport package test specimen shall be constructed in accordance with QSA Global drawing number 86715-330 and Quality Assurance Program. The drawings and quality program accurately represent the intended design along with methods for manufacturing and verifying the finished product. See the Test Report appendices for the general assembly drawing for the test specimen and the test specimen build documents.

6.1 Test Specimen Justification

Test specimen Model 867 serial number 180J shall be the only unit used for this test. This specimen was originally built for test plan 180, but was not tested since the specimen used, the SENTRY 330 projector, was deemed equivalent for testing. Serial number 180J was only used for evaluating radiation profile measurements.

Serial number 180J shall be modified to be tested with the new dust cover assembly and threaded adaptor but without the optional handling ribs. The drop height will be adjusted higher to account for the ribs weight as if they were present. This configuration shall be used as the basis for assessing compliance to the free drop testing requirements of 10 CFR Part 71 and IAEA TS-R-1.

The post-test radiation profile measurements shall be compared against the pre-test measurements when assessing the package test performance and compliance under Normal transport conditions.

6.2 Structural Materials of Test Specimen

The structural components of the rear plate assembly, as well as the access ports of the welded body, are made of type 304 series stainless steel. This material was selected for its corrosion protection properties, but more importantly for its toughness properties when subjected to an energy limited event such as any of the three transport drop tests (1.2-meter, 9-meter, & 1-meter puncture). These components are expected to deform considerably before failing by fracture.

The tungsten and plastic components are not considered structural but could influence the load path in the structural components of these tests.

6.3 Temperature Conditions

The toughness of the Model 867 transport package structural materials will not change significantly within the temperature range of -40°F to +100°F (-40°C to +38°C).

6.4 Pressure Conditions

Except for the source capsule, the transport package is open to the atmosphere and therefore in equilibrium with the outside pressure of the package. The internal operating pressure of the containment system, namely the source capsule, has been successfully tested to withstand the pressure range of 3.6 PSI absolute to 1,015 PSI absolute. This was based on Class 4 pressure test requirements of ANSI N542-1977. The tests will therefore be performed at atmospheric pressure.

6.5 Vibration Conditions

Vibration normally occurring in transport has been addressed under test plan 178, ISO/ANSI performance testing and found to not adversely affect the structural aspects of the transport package. Changes to the dust cover and threaded adaptor are not expected to change the vibration performance of the Model 867 transport package.

Section 7 Material and Equipment List

The equipment list worksheets in Section 9 identify the equipment required, with additional space to list other necessary equipment and measuring instruments needed to perform the tests. Additional materials and equipment used to facilitate the tests will be listed as needed.

Section 8 Test Procedure

The test specimen shall follow the planned sequence presented below. Any change to the planned drop orientations shall require pre-approval by Engineering, Regulatory and Quality Assurance based on a documented justification and description for the new orientation.

8.1 Test Sequence

1. Test specimen preparation and inspection.
2. 1.2m (Four-foot) free drop test (10 CFR 71.71(c) (7))
3. Optional test inspection (radiation profile)
4. 9m (30-foot) free drop test (10 CFR 71.73(c) (1))
5. Puncture test (10 CFR 71.73(c) (3))
6. Test inspection.
7. Thermal assessment (10 CFR 71.73(c) (4)).
8. Final test inspection and/or assessment.
9. Test specimen storage.

8.2 Test Specimen Preparation and Inspection

1. Manufacture the SENTRY test specimen per drawing 86715-330 per temporary manufacturing instruction (TMI) 811. The specimen shall use the welded body assembly previously built to route card RC86710-330 for TP180J. Both rear plate assemblies, lock covers, and dust covers shall be built to TMI 797, 799, & 798 respectively before being added to 86715-330.
2. Inspect the test specimens to ensure that:

- All fabrication and inspection records are documented in accordance with the QSA Global Quality Assurance Program.
- The test specimen complies with the requirements of the drawing.

3. Perform and record the radiation profile in accordance with QSA Global Work Instruction WI-Q-1806.
4. Engineering, Regulatory Affairs and Quality Assurance will jointly verify that the test specimen complies with the drawings and the QSA Global Quality Assurance Program.
5. Prepare the test specimens for transport.

8.3 1.2m & 9m Free Drop Tests

The 1.2 meter free drop test is meant to induce normal transport damage to precondition the test specimen for the hypothetical accident sequence.

The 9 meter free drop test is the hypothetical accident conditions test. This test is meant to demonstrate compliance to the hypothetical accident sequence.

Unless determined otherwise, the 9 meter drop orientation will be identical to the 1.2 meter orientation.

The 1.2 meter (4 foot) and 9 meter (30 foot) drop heights are minimum heights. The actual or adjusted free drop heights shall be recorded on the test data sheet.

8.3.1 1.2m & 9m Free Drop Test Set-up

To set up a package for the specified drop test:

1. Place the specimen on the drop surface and position it according to the planned orientation.
2. Measure and record the ambient temperature.
3. Raise the package slightly and photograph the set-up.
4. Start the video recorder.
5. Raise the package so that the impact target is at the weight adjusted specified height above the drop surface. Ensure the center of gravity is over the impact point
6. Drop the package.
7. Stop the video recorder.
8. Record the damage to the package and take a photographic record.

8.3.2 Drop Test Orientation

Figure 8.3.2 shows the drop orientation which attempts to induce failure in the source securing mechanism of the rear plate assembly. The impact surface is the protruding face of the dust cover extending beyond the rim of the rear-plate access port.

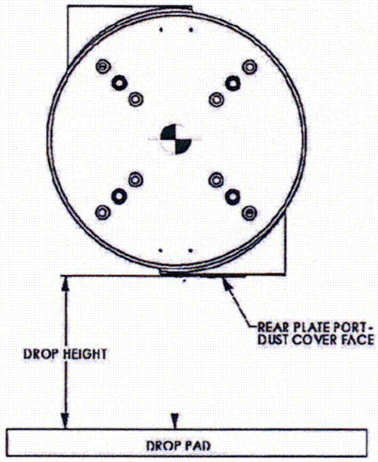

Figure 8.3.2: Drop Test Orientation

8.3.3 1.2m & 9m Free Drop Test Assessment

Upon completion of each test, **Engineering, Regulatory Affairs** and **Quality Assurance** team members will jointly take the following actions:

- Review the test execution to ensure that each test was performed in accordance with 10 CFR 71, IAEA TS-R-1, and this test plan.
- Make a preliminary evaluation of the specimen relative to the requirements of 10 CFR 71 and IAEA TS-R-1.
- Assess the damage to the specimen to decide whether testing of that specimen is to continue.
- Evaluate the condition of the specimen after the 1.2m free drop test to determine
  - what changes, if any, are necessary in package orientation in the 30-foot drop test to achieve maximum damage and
  - Whether post-test radiation profile is necessary to demonstrate compliance to the normal condition dose limits before proceeding to the HAC drop testing.
- Evaluate the condition of the specimen after the 9m free drop test to determine what changes, if any, are necessary in package orientation in the puncture test to achieve maximum damage.

8.4 Puncture Test

The package is dropped from a height of <u>at least</u> 1m (40") onto the puncture billet. This test uses the 12" high puncture billet. The billet meets the minimum height (8") required in 10 CFR 71.73(c) (3). The specimen has no projections or overhanging members longer than 12" which could act as impact absorbers, allowing the billet to cause the maximum damage to the specimen. The billet is to be bolted to the drop surface used in the drop tests.

The justification for the puncture orientation is the same as the orientation for the 30-foot drop test. If the orientation needs to be changed, the new orientation must be documented and approved with a justification describing how it would be a worst condition than the planned orientation.

8.4.1 Puncture Test Set-up

To set up a package for the puncture test:

1. Position the test specimen in the orientation shown in figure 8.3.2 or other documented and approved orientation.
2. Measure and record the ambient temperature.
3. Raise the package slightly and photograph the set-up.
4. Start the video recorder.
5. Raise the package so that the impact target is the weight adjusted equivalent to 1m (40") between the impact point on the package and the top of the puncture billet.
6. Drop the package.
7. Stop the video recorder.
8. Do not move the test specimen until a photo is taken.
9. Record the damage to the package.

8.4.2 Puncture Test Assessment

Upon completion of the test, **Engineering, Regulatory Affairs** and **Quality Assurance** team members will jointly take the following actions:

- Review the test execution to ensure that the tests were performed in accordance with 10 CFR 71, IAEA TS-R-1, and this test plan.
- Make a preliminary evaluation of the specimen relative to the requirements of 10 CFR 71 and IAEA TS-R-1.

8.5 Post Test Inspection

Perform the test inspection after the puncture tests.

1. Measure and record the damage to the test specimen.
2. Measure and record the package for signs of any permanent strain.
3. Remove and assess the condition of the simulated source including comparing the source position after testing to its position prior to testing.
4. Reassemble the package using a representative active source, making sure that the source position and the package configuration are the same as they were immediately after the puncture test.
5. Measure and record a radiation profile of the test specimen in accordance with QSA Global Work Instruction WI-Q-1806.
6. Assess the significance of any change in radiation at the surface and at one meter from the package.
7. Determine whether it is necessary to radiograph the test specimens for inspection of hidden component damage or failure.
8. Record any damage or failure found in radiograph of the test specimens, if performed.

8.6 Thermal Test Assessment

The test specimen shall be assessed to determine whether it will pass the thermal test. The assessment will be based on the examination of the damage to the test specimen after the puncture test. Experience from thermal testing the Model 660 & Model 680 transport packages has shown the shield will oxidize and diminish its ability to protect only when the adjacent foam fill is allowed to combust and then fall away from the shield. Charred foam provides enough thermal insulation to prevent the shield from oxidizing as long as the charred foam remains in place. Any damage producing an unintentional opening in the shell or welded body would need to be assessed to determine whether the transport package would pass or fail the thermal test.

Engineering, **Regulatory Affairs**, and **Quality Assurance** team members will make a final assessment of each test specimen and jointly determine whether the specimens meet the requirements of 10 CFR 71 and IAEA TS-R-1.

8.7 Test Specimen Storage

Place the test specimen in an appropriate container and store the container in the "low level" waste room. Written management approval is needed to dispose of any test specimen of this test plan. If the specimens are disposed of, then include a copy of the signed disposal approval in the SENTRY design history file.

Section 9 Worksheets

Use the following worksheets for executing the tests of section 8. Each test shall have three worksheets; an equipment list, a procedure checklist, and a data sheet. Record the information onto copies of these worksheets for each test performed.

Attach a copy of the relevant inspection report or calibration certificate after the range and accuracy of the equipment has been verified.

Test Specimen & Equipment Documentation

Test Specimen

Model #	Drawing Number	Serial Number	Attach IIR	Attach NCR	Attach Route Cards
867	86715-330 Per TMI 811	TP180J	NA	NA	Yes

Tools & Equipment

Tool Description	Enter the Model and Serial Number Mark NA when not used.	Attach Inspection Report or Calibration Certificate
Drop Surface	T10740, S/N 001	Yes
Puncture Billet	T10119, SN01	Yes

Record any additional tools used to facilitate the test and attach the appropriate inspection report or calibration certificates.

Signature	Print Name	Date
Engineering:		
Regulatory:		
Quality Assurance:		

1.2 Meter Free Drop Test Data Sheet				
Step	**Instruction**	**Data**		
1	Record test location.	**QSA Global, Inc. 40 North Ave, Burlington, MA**		
2	Record test specimen serial number.	**TP180J**		
3	Record test date & time			
4	Record the ambient temperature (°C):		Instrument S/N:	
5	Record actual drop height.		Method:	
6	Place the specimen on the drop surface and position it according to the planned drop orientation.			
7	Raise the specimen slightly and photograph the set-up in at least two perpendicular planes.			
8	Begin the video recorder			
9	Release the test specimen.			
10	Stop the video recorder.			
11	Was the point of impact achieved?			
12	Photograph the test specimen.			
13	Record the damage to the test specimen.			
14	Engineering, Regulatory Affairs and Quality Assurance make a preliminary assessment relative to 10 CFR 71.	Was the test performed in accordance with 10 CFR 71, IAEA TS-R-1, and this plan?		
		Were there any changes in the planned drop orientation? If yes, then explain.		
		Should this specimen continue on to the next test?		

Test witnessed by (Signature)	**Print Name**	**Date**
Engineering:		
Regulatory Affairs:		
Quality Assurance:		

9 Meter Free Drop Test Data Sheet				
Step	**Instruction**	**Data**		
1	Record test location.	**QSA Global, Inc. 40 North Ave, Burlington, MA**		
2	Record test specimen serial number.	**TP180J**		
3	Record test date & time			
4	Record the ambient temperature (°C):		Instrument S/N:	
5	Record actual drop height.		Method:	
6	Place the specimen on the drop surface and position it according to the planned drop orientation.			
7	Raise the specimen slightly and photograph the set-up in at least two perpendicular planes.			
8	Begin the video recorder			
9	Release the test specimen.			
10	Stop the video recorder.			
11	Was the point of impact achieved?			
12	Photograph the test specimen.			
13	Record the damage to the test specimen.			
14	Engineering, Regulatory Affairs and Quality Assurance make a preliminary assessment relative to 10 CFR 71.	Was the test performed in accordance with 10 CFR 71, IAEA TS-R-1, and this plan?		
		Were there any changes in the planned drop orientation? If yes, then explain.		
		Should this specimen continue on to the next test?		

Test witnessed by (Signature)	**Print Name**	**Date**
Engineering:		
Regulatory Affairs:		
Quality Assurance:		

Puncture Drop Test Data Sheet				
Step	**Instruction**	**Data**		
1	Record test location.	**QSA Global, Inc. 40 North Ave, Burlington, MA**		
2	Record test specimen serial number.	**TP180J**		
3	Record test date & time			
4	Record the ambient temperature (°C):		Instrument S/N:	
5	Record actual drop height.		Method:	
6	Place the specimen on the drop surface and position it according to the planned drop orientation.			
7	Raise the specimen slightly and photograph the set-up in at least two perpendicular planes.			
8	Begin the video recorder			
9	Release the test specimen.			
10	Stop the video recorder.			
11	Was the point of impact achieved?			
12	Photograph the test specimen immediately after the drop.			
13	Record the damage to the test specimen.			
14	Engineering, Regulatory Affairs and Quality Assurance make a preliminary assessment relative to 10 CFR 71.	Was the test performed in accordance with 10 CFR 71, IAEA TS-R-1, and this plan?		
		Were there any changes in the planned drop orientation? If yes, then explain.		

Test witnessed by (Signature)	**Print Name**	**Date**
Engineering:		
Regulatory Affairs:		
Quality Assurance:		

Post Test Inspection Data Sheet	
Test Specimen Serial No.: **TP180J**	Last Test Performed:
Describe and measure (if appropriate) any damage or broken parts, etc.:	
Describe and measure (if appropriate) any signs of permanent strain or deformation:	
Describe the condition and position of the simulated source wire assembly.	
Reassemble the package using a representative active source, making sure that the source position and the package configuration is the same as they were immediately after the last test. Measure and record a radiation profile of the test specimen in accordance with QSA Global Work Instruction WI-Q-1806.	
Compare the pre-test dose levels with post-test dose levels at the surface of the package and at 1 meter from the surface of the package.	
Is a radiograph required to inspect for hidden component damage or failure? If radiography is performed, describe any damage or failures found.	
Completed by:	Date:

2.12.15 Test Plan 213 Report Rev 0 dated 17 Jun 15