APPENDIX D

TEST PHOTOGRAPHS

Test Specimen (B)

Figure 1: Four Foot Drop of Specimen (B)

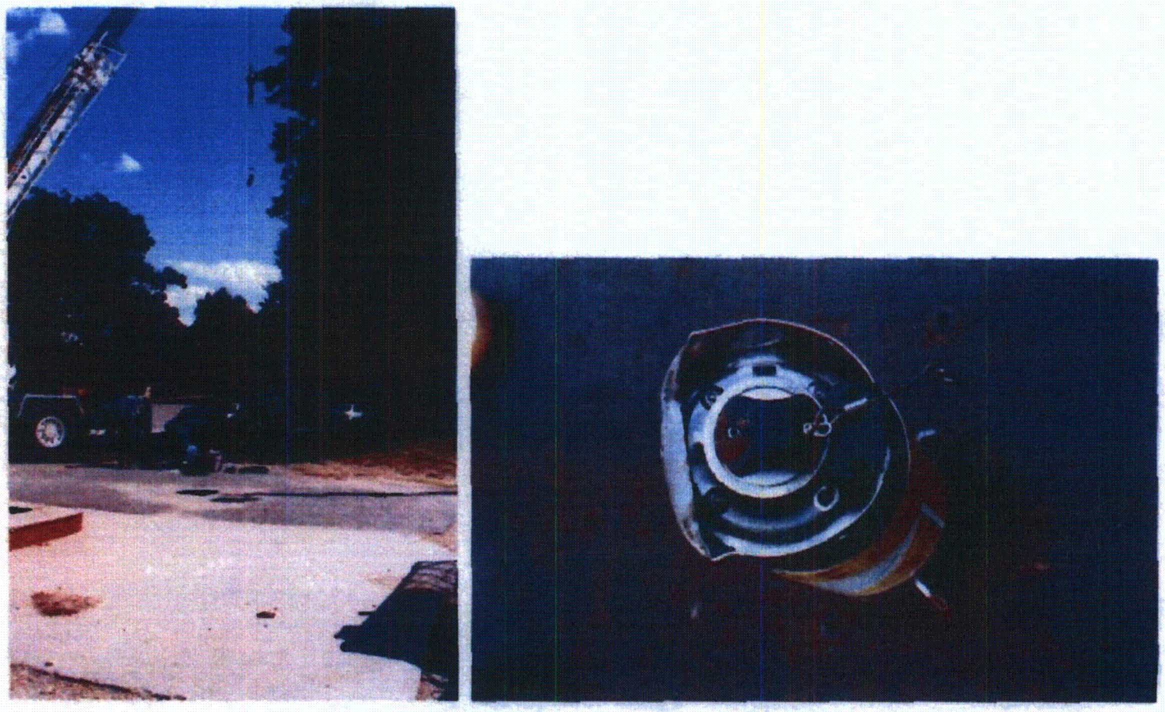


Figure 2: Thirty Foot Drop of Specimen (B)

Figure 3: Puncture Test of Specimen (B)

Test Specimen (C)

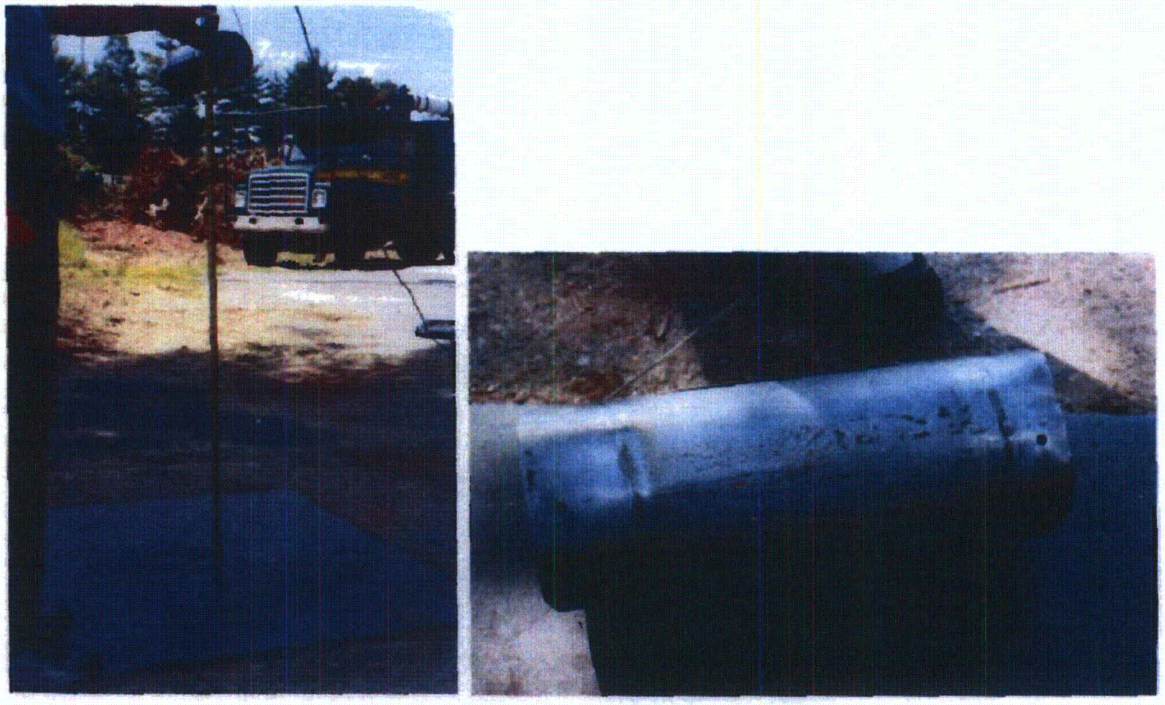


Figure 1: Four Foot Drop of Specimen (C)

Figure 2: Thirty Foot Drop of Specimen (C)

Figure 3: Puncture Test of Specimen (C)

Test Specimen (D)

Figure 1: Four Foot Drop of Specimen (D)

Figure 2: Thirty Foot Drop of Specimen (D)

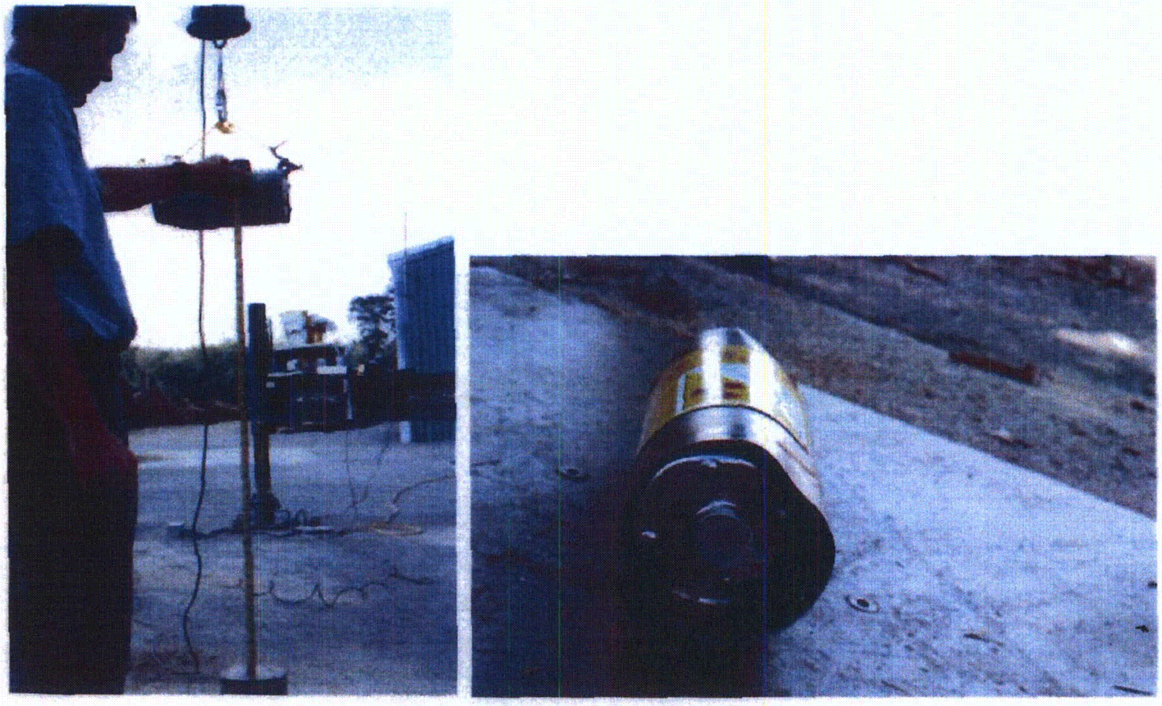


Figure 3: Puncture Test of Specimen (D)

Test Specimen (G)

Figure 1: Four Foot Drop of Specimen (G)

Figure 2: Thirty Foot Drop of Specimen (G)

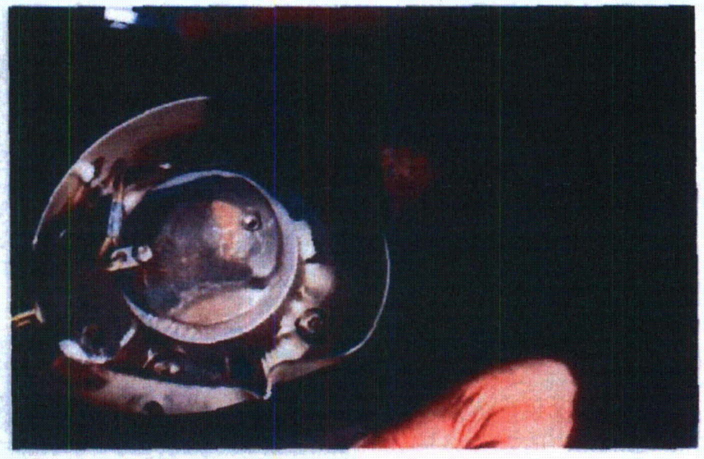


Figure 3: Puncture Test of Specimen (G)

2.12.4 Test Plan 115 (Feb 2001)

TEST PLAN 115

MODEL 880 RADIOGRAPHY PROJECTOR

ISO 3999-1:2000(E) PERFORMANCE TESTS

Table of Contents

Test Plan No. 115

Section 1 Introduction

This test plan is intended to qualify the Model 880 Radiographic Projector to the performance requirements of ISO 3999-1:2000(E), "Radiographic protection – Apparatus for industrial gamma radiography – Part 1: Specifications for performance, design, and tests".

The ISO 3999-1:2000(E) tests covered under this plan are the following with their respective ISO 3999-1:2000(E) sections listed in parenthesis:

- Projection Test (6.2)
- Tensile Test for Source Assemblies (6.5)
- Shield Efficiency Test (6.4.1)
- Endurance Test (6.2)
- Horizontal Shock Test (6.4.6.1)
- Vertical Shock Test (6.4.6.2)
- Tensile Test for Guide Tubes (6.7.4)
- Tensile Test for Drive Cable Assembly (6.6.3)
- Kinking Test for Guide Tubes (6.7.3)
- Kinking Test for Drive Cable Assembly (6.6.2)
- Crushing and Bending Tests (6.6.1 & 6.7.2)
- Lock Breaking Test (6.4.2)
- Wrench Test (6.4.3)

This plan outlines the test procedure, describes the test specimen construction, identifies the test equipment, and provides worksheets for test data recording.

The vibration resistance test was evaluated and deemed unnecessary. The only parts that could come loose from vibration are the tamper-proof screws. However, tamper-proof screws have been used on similar devices over the past 25 years and field use of the screws has shown that the screws have never loosened as a result of vibration.

The accidental drop test was previously accomplished under Test Plan 104 in which the device was dropped from a height of 30 feet. After this drop, the dummy source remained secured in its fully shielded position within the source tube, attached to the source wire and was undamaged.

The design of the Model 880 Radiography Projector ensures that the device will operate continually under normal conditions. The Model 880 was designed ruggedly with non-corrosive materials, such as stainless steel, to prevent any harmful rusting or corrosion.

Only the Model 880-150 Ci device will be used to demonstrate compliance with ISO 3999-1:2000(E) performance tests. The Model 880-50 Ci device, by default, will perform the same or better than the Model 880-150 Ci device due to its lower weight and identical structural construction.

The test sequence to be used for the testing is listed in Section 6.

Section 2 Gamma Radiography Projector Description

The Model 880 projector, shown in Figure 2.1, is a portable (Class P), externally projecting source (Category II) device. The device consists of four major assemblies; the body assembly, the rear plate assembly, the front plate assembly, and the jacket assembly. A source assembly is also used and stored with the device.

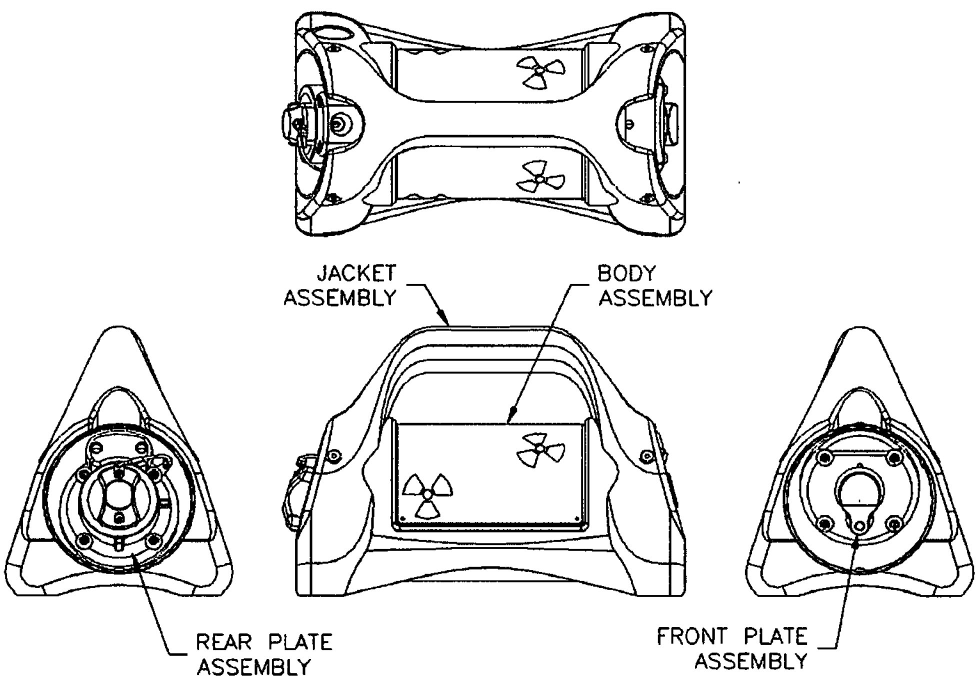


FIGURE 2.1: MODEL 880 PROJECTOR.

Section 3 Discussion on System Failure Modes of Interest

The tests in this test plan subject the test specimen to conditions likely to occur during use. The exposure device and integral safety features shall remain operational after the test and shall experience no loss of shielding efficiency.

A projection test is to be performed to determine the resistance to projection before and after the sequence of operational tests. The maximum force applied to the control handle must not increase by 25% after performing the operational tests. The projection test will be performed before and after the entire sequence of tests instead of each single test. Conducting the test in this manner will give a more conservative test result rather than smaller incremental increases in force from each single test. The test will be set up per Figure 6 in the ISO 3999-1:2000 standards. However, because of limited space, the cable paths used will have added difficulty and will actually be a more tortuous path than the one shown in the figure. The adjustment of this setup will only make the test more difficult and so will not make the test easier to pass. The operational tests include the endurance test, the shielding efficiency test, the horizontal and vertical shock tests, the tensile tests, the kinking tests, and the crushing and bending tests. A failure of the projection test would show an increase of over 125% of the force required to move the source assembly before the test to the force required after the test. A failure would indicate that a part of the exposure device, drive cable, drive cable housing, guide tube, or source assembly was damaged and is restricting movement of the source assembly or drive cable. This could result in an active source getting hung up in an unsecured location.

The source assembly tensile test is also to be performed before and after the sequence of operational tests. The purpose of the test is to ensure that the operational tests do not have any negative effects on the source wire assembly. The same dummy source assembly will be used with all of the operational tests requiring a source assembly except for the shielding efficiency test which requires an active source assembly. If there is enough wear on the swaged features of the assembly, the connections could fail when pulled.

The shielding efficiency test measures the performance of the shield when loaded with a maximum rated activity of 150 curies of Iridium-192. The shield efficiency test was completed on the test device after manufacture on November 10, 2000 and will not be completed again for this test. The results from this test will be included in the final test report at the conclusion of the tests in this test plan. The completion of the shielding efficiency test before the initial projection test and initial tensile test for source assemblies as shown in the test procedure in Section 6 of this test plan will not effect the testing in a negative manner. Performance of the shielding efficiency test does not have any effect on restricting the movement of a source assembly that is measured in the projection test. Also, the dummy source that is to be tested in the tensile test for source assemblies is not the same source assembly that would be used with the shield efficiency test because the shield efficiency test requires an active source. The source used with this test may not be the maximum rated source (150 Ci of Ir-192) that the device can handle but a correction factor will be used to determine the actual maximum dose rates if this is the case. The possible failure mode for this test would be high radiation levels over the

exposure limits for a class P exposure device. Radiation levels over the limits may be the result of a number of factors. The following are possible factors:

1. Wrong source position within the shield tube.
2. Poor shield design or translation of the design to the manufacturing process.
3. Changes in distance of the container's exterior surface relative to the source position.

The endurance test demonstrates that the radiographic system will remain operational after 50,000 cycles. This test will use the same setup as the Projection Test. A failure could cause the source tube to wear resulting in depleted uranium contamination. Also, wear on the front and rear plate mechanisms may prevent the source wire assembly from becoming completely secure in the fully shielded position.

The horizontal shock test demonstrates the ability of the test specimen to withstand swing type impacts occurring during normal use. Three areas of the device that could cause the greatest effect on radiological safety if impacted were chosen for this. The areas include the front cover, the lock, and the rear cover test (see figures 11.1, 11.2, and 11.3). Possible failure would involve the inability to operate the front or rear plate mechanisms. Hitting the small protruding features on each end could cause deformation to the assembly mounting plates or shell endplates that may produce binding in the rotating parts of the mechanisms.

The vertical shock test demonstrates the ability of the test specimen to withstand many short drops expected during normal use. There are two normal carrying positions for this device; one with the jacket and the other without the jacket. Although the jacket would add a small amount of weight to the device, the jacket would also absorb some of the impact. This test will be performed without the jacket to prevent any impact absorption and give a more conservative test assessment. Possible failure could occur at the shield support structure, specifically at the pinned connection. If the connection were to fail, misalignment of the source tube could prevent the source wire from moving. Also, damage to the jacket could result in not being able to use the handle to carry the device.

The purpose of the tensile tests on the controls and guide tubes is to demonstrate that the they are able to withstand tensile stresses that may occur during normal use. The connections could fail if there is enough wear on the swaged features. Also, a failure could indicate that the design or manufacture of the controls or guide tubes is faulty.

The kinking tests on the control cable assembly and guide tubes are done to show that the sheaths are able to withstand the conditions they may likely encounter during use. After performing the kinking tests, the control cable assembly and guide tubes should remain operable without any loss of integrity. Also, a failure could indicate that the design or manufacture of the controls or guide tubes is faulty.

The crushing and bending tests are performed to demonstrate that the control cable assembly and guide tubes remain operational after being stepped on by the heel of a shoe. A mechanical device is used to simulate the crushing effect on the tubes from a shoe. After performing the crushing and bending test, the control cable assembly and guide tubes should remain operational without any loss to integrity.

The lock breaking test is performed to check the durability of the lock on the exposure device. A force of 400 N (90 lbs) is gradually applied to the lock and held for several

seconds before being released. The force will be applied to where the key is inserted because this is the most exposed part of the lock and could become jammed or damaged by a force. The force is applied and released in this way eleven consecutive times at each position. A failure would occur if the exposure container could be opened without unlocking the device. A failure of the lock could develop into having an active source exposed without the operator's knowledge.

The wrench test is used to demonstrate that the handle of the exposure device is able to withstand forces that may be encountered during use. A static load of 25 times the weight of the device is placed at the most fragile part of the handle. A failure would be indicated by the handle becoming unattached from the device or becoming unstable. A failure could result in not being able to use the handle to carry the device or possibly an accidental drop.

Section 4 Construction and Condition of Test Specimens

All radiography system components listed in the table below and used in this test plan are manufactured in accordance with the AEA Technology QSA, Inc. Quality Assurance Program.

The Model 880, 150-Curie assembly, part number B88000 will be the device used in all tests requiring the use of a test projection device.

A Model 424-9 dummy source assembly will be loaded into the test specimen for all tests except the shield efficiency test and accidental drop test. An active Model 424-9 source assembly, part number A42409, with at least 75% of the maximum rated capacity (minimum of 112.5 curies of Iridium-192) shall be loaded into the test specimen for the shield efficiency test.

The radiography system consisting of the components in the table below will be used for the endurance test. The same Model 424-9 dummy source assembly used in the endurance test will be used in the tensile test.

Table of Model 880 Radiography System Components		
Part number	**Part Name**	**Quantity**
B88000 Rev.A	MODEL 880 150 Ci MAX ASSEMBLY	1
A42409XL Rev.A	MODEL 424-9 DUMMY SOURCE ASSEMBLY	1*
A42409 Rev.E	MODEL 424-9 SOURCE ASSEMBLY	1*
BTAN69250	PISTOL GRIP CONTROL SYSTEM, 50 FOOT	1
B48930-7 Rev.A	SOURCE GUIDE TUBE ASSEMBLY, 7 FOOT	1
B48907-7 Rev.T	SOURCE GUIDE TUBE ASSEMBLY, 7 FOOT	4
B48906-7 Rev.Q	SOURCE GUIDE TUBE ASSEMBLY, 7 FOOT	1

* Note: Either one of the Model 424-9 source assemblies, Dummy (XL) or Active may be used in the system, but not simultaneously.

Section 5 Material and Equipment List

The worksheets in section 24 identify the equipment and procedure required for the tests. Additional materials and equipment used to facilitate the tests will be listed as needed.

Section 6 Test Procedures

The testing shall follow the sequence below.

Device 1: Model 880, 150 Ci Assembly

1. Initial Projection Test
2. Initial Tensile Test for Source Assemblies
3. Shield Efficiency Test (See Section 3)
4. Endurance Test
5. Horizontal Shock Test
6. Vertical Shock Test
7. Tensile Test for Guide Tubes
8. Tensile Test for Control Cable Assembly
9. Kinking Test for Guide Tubes
10. Kinking Test for Control Cable Assembly
11. Crushing and Bending Tests for Control Cable Assembly and Guide Tubes
12. Final Tensile Test for Source Assemblies
13. Final Projection Test (See Section 3)
14. Lock Breaking Test
15. Wrench Test

Section 7 Testing Safety and Waste Disposal

Testing Safety

The shield efficiency test uses active radioactive material and the test specimen contains depleted uranium (low level radioactive material). Handling radioactive material shall be done with caution and only by qualified personnel.

The weight of the test specimen is approximately 50 pounds. Proper lifting techniques shall be used to prevent injury.

Some tests of this plan may result in heavy falling objects and flying debris. Safety glasses and a safe distance must be used.

The possibility of depleted uranium contamination could be present during and after the tests. Qualified personnel shall ensure all applicable surfaces are free of contamination.

Waste Disposal

The test specimen shall be stored in the low-level waste room until authorization by the regulatory department is given to properly dispose.

Section 8 Initial Projection Test

Requirements

The Projection Test demonstrates that the torque required at the controls to move the source assembly from the secured position to the working position and back to the secured position after certain tests remains within 125% of the torque before the tests. The minimum movement rate for projecting and retracting the source assembly shall be a constant 0.75 m/s (2.5 ft/s) of linear movement until the source stops after each cycle.

Equipment

1. The test projection device equipped with the largest diameter and greatest length dummy source assembly recommended for the device.
2. The largest recommended guide tube and controls (42 ft. guide tube and 50 ft. control cable) connected to the projection device set up in accordance with Figure 6 of the ISO 3999-1:2000 standards (see Section 3).
3. Motor and Controller with torque readout.
4. Cycle counter.
5. Pneumatic actuator for lock slide actuation.

Section 9 Initial Tensile Test for Source Assemblies

Requirements

The tensile tests demonstrate that the source assembly maintains its integrity after experiencing tensile loads that may be encountered during normal use. The Tensile Test for Source Assemblies is performed before and after the sequence of operational tests. The source assembly should remain operable and maintain its integrity.

Equipment

1. Dummy source assembly. (See Section 3)
2. Force gage for measuring the forces required from Section 6.5 of the ISO 3999-1:2000 standard.

Section 10 Endurance Test

Requirements

The Endurance Test demonstrates the gamma radiography system remains operational after 50,000 cycles of the source assembly moving from secure to working positions and back. This test is done to check the resistance due to fatigue and wear of the different components and accessories of the device during normal operation. The automatic securing mechanism and the lock should remain operational and effective.

Equipment

The equipment used for this test is equivalent to the equipment used in the initial projection test (see Section 8).

Section 11 Horizontal Shock Test

Requirements

The horizontal shock test demonstrates that the exposure device will withstand the horizontal impacts the device may encounter (see Section 3).

The exposure device and integral safety features shall remain operational after the test and the device shall experience no loss of shielding efficiency.

Equipment

1. The test projection device equipped with a dummy source assembly secured and locked in its most shielded position with all covers.
2. A target consisting of a steel bar with a flat vertical face 50 mm (1.97 in.) diameter by 300 mm (11.81 in.) long. The bar shall lie horizontally and be fixed or welded to a rigid mass at least 10 times the mass of the exposure device (500 lbs).
3. Suspension equipment for the test projection device that does not cause undesirable rotation around a vertical axis when suspended before being exposed to the shock.

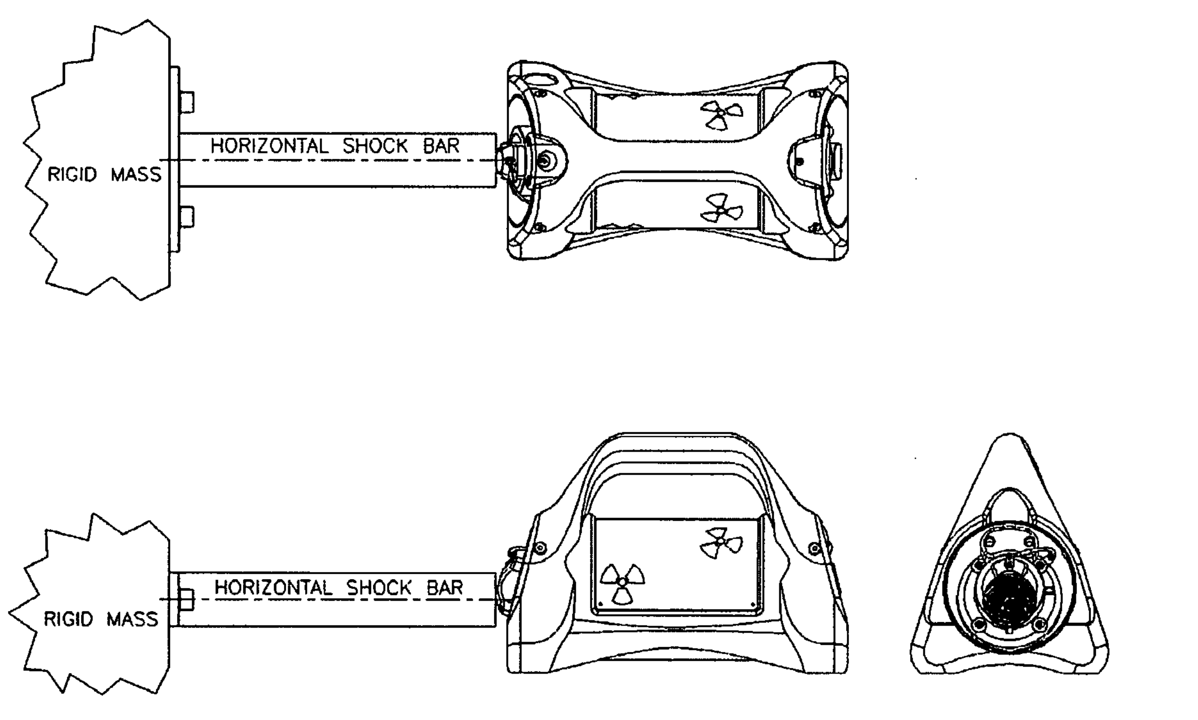


Figure 11.1 Setup for lock cover area.

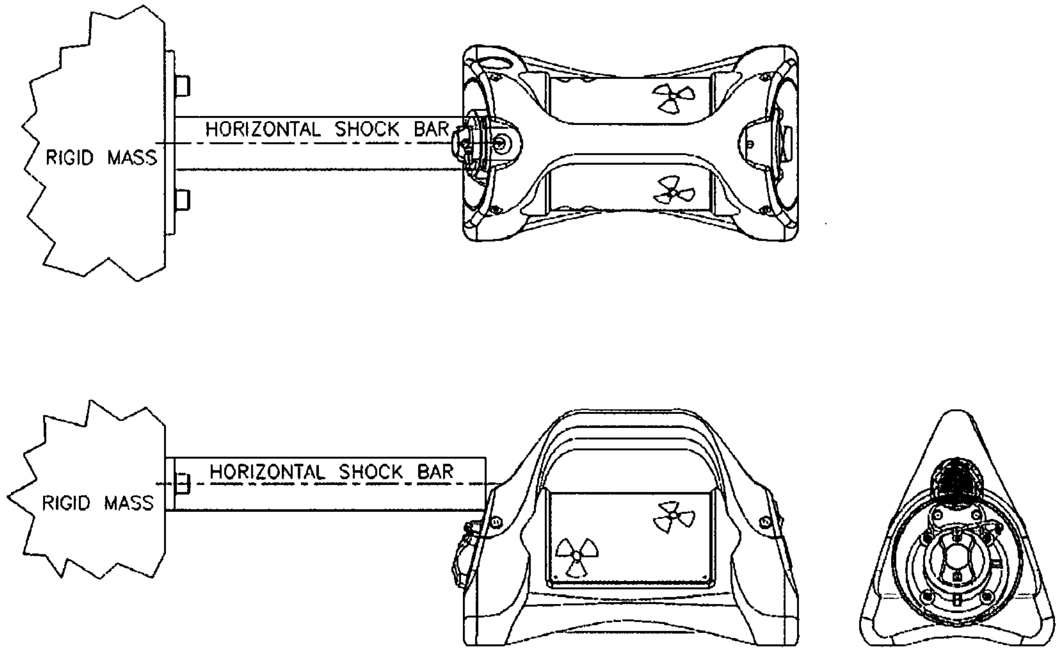


Figure 11.2 Setup for lock mount area.

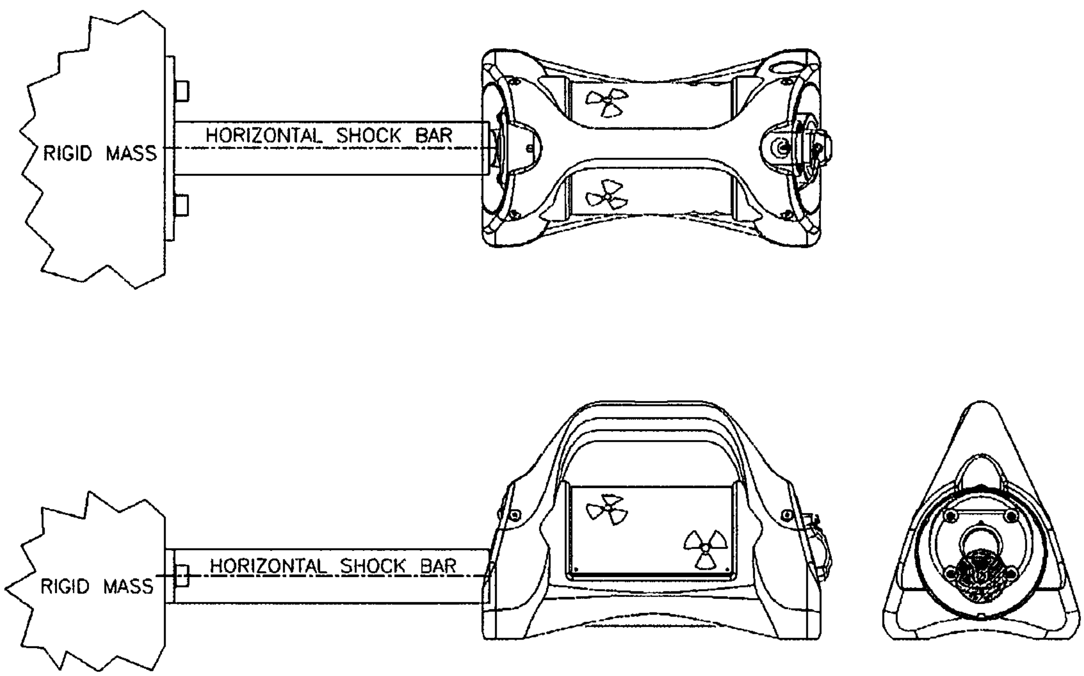


Figure 11.3 Setup for front knob area.

Section 12 Vertical Shock Test

Requirement

The vertical shock test demonstrates that the exposure device will withstand the vertical impacts the device may encounter. This test will be performed without the jacket as shown in Figure 12.1 (see Section 3).

The exposure device and integral safety features shall remain operational after the test and shall experience no loss of shielding efficiency.

Equipment

1. The test projection device equipped with a dummy source assembly secured and locked in its most shielded position with all covers but without the jacket.
2. A rigid target consisting of a flat horizontal surface of steel, concrete or solid timber having a mass at least 10 times the test specimen (500 lbs.). The surface shall be covered with a sheet of 7 or 9 ply (25mm thick) fir plywood or equivalent.

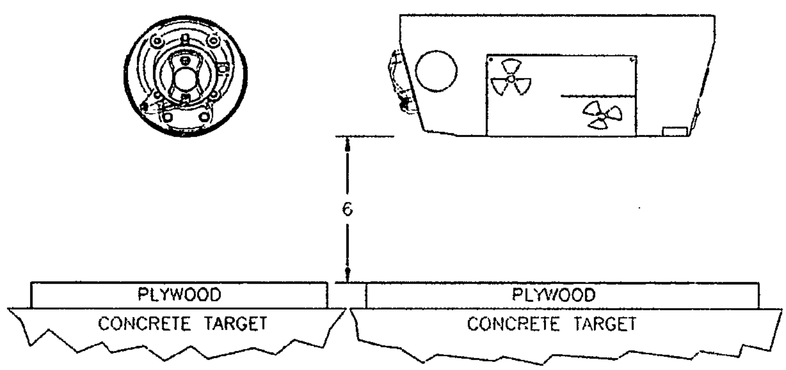


Figure 12.1

Section 13 Tensile Test for Guide Tubes

Requirements

The Tensile Tests demonstrate that the guide tube housing maintains its integrity after experiencing tensile loads that may be encountered during use as shown in Section 6.74 of the ISO 3999-1:2000 standard. The guide tube should remain completely operable without any damage that may restrict travel of the source assembly.

Equipment

1. The test projection device equipped with the dummy source assembly.
2. Test apparatus T10281 used to secure the guide tube.
3. A force or pressure gage for measuring the required loads.

Section 14 Tensile Test for Control Cable Assembly

Requirements

The Tensile Tests demonstrate that the control cable assembly maintains its integrity after experiencing tensile loads that may be encountered during use as shown in Section 6.74 of the ISO 3999-1:2000 standard. The control cable assembly will remain operational after the tests.

Equipment

1. The test projection device equipped with the dummy source assembly.
2. The test control cable assembly.
3. A force or pressure gage for measuring the required loads.

Section 15 Kinking Test for Guide Tube

Requirements

The kinking test demonstrates that the guide tube will withstand conditions that may be encountered during use as shown in Section 6.73 of the ISO 3999-1:2000 standard. The guide tube shall remain operational after the test without any damage that may restrict the travel of the source assembly.

Equipment

1. The test guide tube.
2. A flat test surface equipped with horizontal guides separated by less than or equal to 5 times the diameter of the guide tube.
3. A dynamometer.
4. A tape measure.

Section 16 Kinking Test for Drive Cable Assembly

Requirements

The kinking test demonstrates that the drive cable housing will withstand conditions that may be encountered during use as shown in Section 6.62 of the ISO 3999-1:2000 standard. The drive cable housing shall remain operational without any loss to structural integrity after the test.

Equipment

1. The test drive cable assembly.
2. A stop watch.
3. A tape measure.
4. A flat test surface.

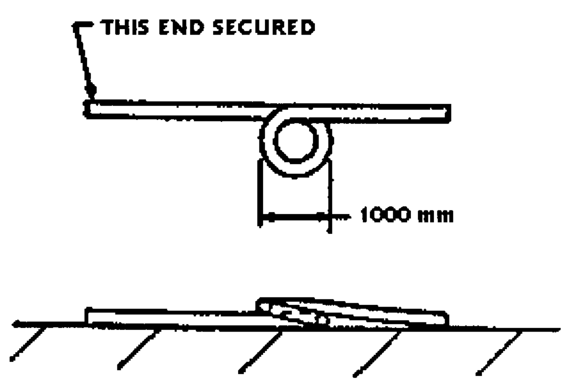


Figure 16.1

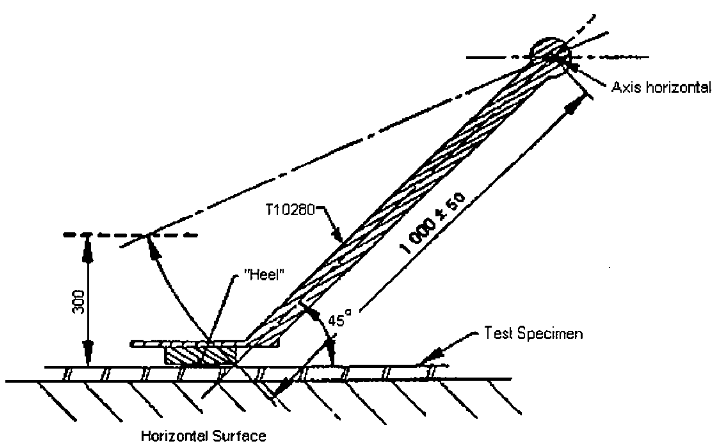
Section 17 Crushing and Bending Test

Requirements

The Crushing and Bending Test demonstrates that the drive cable and the guide tubes remain operational after being impacted by the heel of a shoe. The control cable assembly should remain operable without any loss to structural integrity.

Equipment

1. Test guide tube and control cable.
2. Test surface having a minimum mass of 150 kg (330 lb) and must be hard enough to not deform from the application of a steel punch without the presence of the drive cable housing or guide tube.
3. Steel guides to laterally hold housings with length greater than two heel lengths and a height between .5 and .75 times the sheath height for juxtaposed sheaths or single guide tube and between 1.5 and 1.75 times the sheath height for superimposed sheaths.
4. Steel punch tool T10280 as shown in figure 17.1.
5. Tape measure.



17.1 Crushing Test

Section 18 Final Tensile Test for Source Assemblies

Requirements

The tensile tests demonstrate that the source assembly maintains its integrity after experiencing tensile loads that may be encountered during normal use. The Tensile Test for Source Assemblies is performed before and after the sequence of operational tests. The source assembly should remain operable and maintain its integrity.

Equipment

1. Dummy source assembly. (See Section 3)
2. Force gage for measuring the forces required from Section 6.5 of the ISO 3999-1:2000 standard.

Section 19 Final Projection Test

Requirements

The Projection Test demonstrates that the torque required at the controls to move the source assembly from the secured position to the working position and back to the secured position after certain tests remains within 125% of the torque before the tests. The minimum movement rate for projecting and retracting the source assembly shall be a constant 0.75 m/s (2.5 ft/s) of linear movement until the source stops after each cycle.

Equipment

The equipment used for this test is equivalent to the equipment used in the initial projection test (see Section 8).

Section 20 Lock Breaking Test

Requirements

The Lock Breaking Test demonstrates that the locking mechanism can withstand a breaking force while in the locked position with the key removed. The lock must remain effective and operable after the test.

Equipment

1. The test projection device equipped with a dummy source assembly secured and locked in its most shielded position with all covers.
2. The lock breaking tool, Tool number T10345.
3. A stopwatch.
4. At least 90 lbs. of weights to be added gradually to lock breaking tool during test.

Section 21 Wrench Test

Requirements

The Wrench Test demonstrates that the exposure container handle is able to withstand a static force equal to 25 times the weight of the device (1250 lbs). The force is to be supplied to the most vulnerable part of the handle. The most vulnerable part of the handle is considered to be the middle of the handle the most bending stresses will occur.

Equipment

1. The test projection device equipped with a dummy source assembly secured and locked in its most shielded position with all covers.
2. A test plate with weights that, when strapped to the device, weighs at least 1250 lbs.
3. A scale to verify the weight of the test equipment.
4. Crane

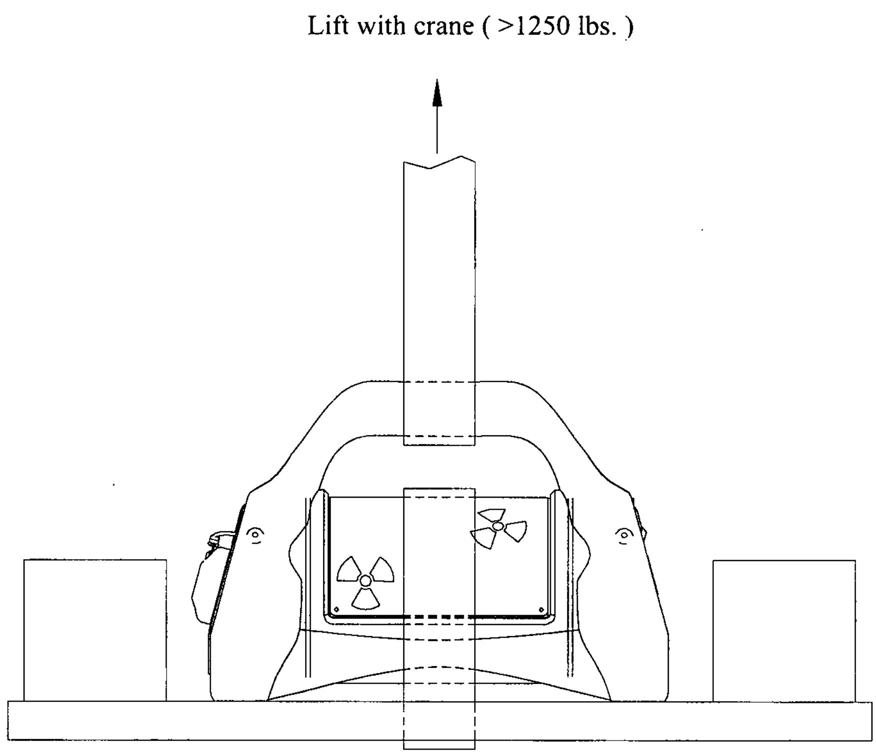


Fig. 21.1

Section 22 Final Test Assessment

After all the tests have been completed, evaluate the condition of the test specimen and assess its performance relative to the test requirements of standard ISO 3999-1:2000(E).

Section 23 Test Worksheets

Test Plan 115 Initial Projection Test

Material and Equipment:

Test device (Model 880) serial number: ___________________
Dummy source assembly serial number: ___________________
Drive control assembly and guide tubes.
Automatic cycling apparatus including motor, controller, pneumatic actuator, and counter.

Test Procedure:

1. Assemble system using Figure 6 of ISO 3999-1:2000 as a guide.
2. Assemble and connect the test specimen to the system.
3. Complete 10 full cycles.
4. Record the rotational speed (P177 rpm): ____________
5. Record the highest operational torque for each cycle. 1:_____ 2:_____ 3:_____ 4:_____ 5:_____

   6:_____ 7:_____ 8:_____ 9:_____ 10:_____

6. Record the average operational torque: _____

Damage and/or operational malfunctions:

____
____
____
____

Test Assessment:

____
____
____

Recorded by: ____________________________ Date: ___________

Witnessed by: ____________________________ Date: ___________

Test Plan 115 Initial Tensile Test for Source Assemblies

Material and Equipment:

Dummy source assembly serial number: ______________________

Force gage serial number: __________________________________

Test Procedure:

1. Record stop ball to connector measurement: _______________
2. Attach control cable to the dummy source assembly.
3. Restrain end of source assembly opposite control cable connection.
4. Gradually apply 1000 N +44/-0 (225 lb +10/-0) force over 10 seconds, hold for 5 seconds, then release.
5. Complete test a total of 10 times.
6. Unrestrain source assembly.
7. Restrain source assembly at largest diameter and repeat steps 3-5.
8. Record stop ball to connector measurement: _______________.
9. Perform a complete functional operation of the device using the dummy source assembly.

Damage and/or operational malfunctions:

____
____
____
____

Test Assessment:

____
____
____

Recorded by: ____________________________________ Date: ______________

Witnessed by: ____________________________________ Date: ______________

Test Plan 115 Endurance Test

Material and Equipment:

Test device (Model 880) serial number: ____________________
Dummy source assembly serial number: ____________________
Drive control assembly and guide tubes.
Automatic cycling apparatus including motor, controller, pneumatic actuator, and counter.

Test Procedure:

1. Prepare test specimen by securing a dummy source into its fully shielded position, attaching all covers, and locking the device.
2. Assemble system using Figure 6 of ISO 3999-1:2000.
3. Set the cycle counter to zero.
4. Cycle the test specimen a minimum of 50,000 times.
5. Record the rotational speed (>2.5 ft/s): ____________________
6. Record the highest operational torque: ____________________
7. Record the total number of cycles (>50,000): ____________________
8. Clean the dummy source assembly.
9. Perform a complete functional operation of the device using the dummy source assembly used in the test.

Damage, maintenance, and/or operational malfunctions:

____
____
____
____

Test Assessment:

____
____
____

Recorded by: ______________________________ Date: ____________

Witnessed by: ______________________________ Date: ____________

Reviewed by:

Engineering: ______________________________ Date: ____________

Regulatory Affairs: ______________________________ Date: ____________

Quality Assurance: ______________________________ Date: ____________

Test Plan 115 Horizontal Shock Test

Material and Equipment:

Test device (Model 880) serial number: ____________________

Target horizontal test bar: Tool Number T10333, serial number: __________

Target mass weight: ______________________ Weight scale used: ______________________

Test Procedure:

1. Prepare test specimen by securing a dummy source into its fully shielded position, attaching all covers, and locking the device.
2. Suspend the test specimen to the test apparatus.
3. Contact the area of impact to the target per figure 11.1.
4. Swing and raise the test specimen "center of gravity" up to at least 4 inches above the target center.
5. Release the test specimen.
6. Perform steps 4 & 5 for a total of twenty (20) times.
7. Perform a complete functional operation of the device using a dummy source assembly.

Damage and/or operational malfunctions:

____
____
____
____

Test Assessment:

____
____
____

Recorded by: ______________________ Date: __________

Witnessed by: ______________________ Date: __________

Test Plan 115 Horizontal Shock Test

Material and Equipment:

Test device (Model 880) serial number: ____________

Target horizontal test bar: Tool Number T10333, serial number: ________

Target mass weight: ______________ Weight scale used: ______________

Test Procedure:

1. Prepare test specimen by securing a dummy source into its fully shielded position, attaching all covers, and locking the device.
2. Suspend the test specimen to the test apparatus.
3. Contact the area of impact to the target per figure 11.2.
4. Swing and raise the test specimen "center of gravity" up to at least 4 inches above the target center.
5. Release the test specimen.
6. Perform steps 4 & 5 for a total of twenty (20) times.
7. Perform a complete functional operation of the device using a dummy source assembly.

Damage and/or operational malfunctions:

____
____
____
____

Test Assessment:

____
____
____

Recorded by: ______________________ Date: ____________

Witnessed by: ______________________ Date: ____________

Test Plan 115 Horizontal Shock Test

Material and Equipment:

Test device (Model 880) serial number: ______________

Target horizontal test bar: Tool Number T10333, serial number: ________

Target mass weight: ______________ Weight scale used: ______________

Test Procedure:

1. Prepare test specimen by securing a dummy source into its fully shielded position, attaching all covers, and locking the device.
2. Suspend the test specimen to the test apparatus.
3. Contact the area of impact to the target per figure 11.3.
4. Swing and raise the test specimen "center of gravity" up to at least 4 inches above the target center.
5. Release the test specimen.
6. Perform steps 4 & 5 for a total of twenty (20) times.
7. Perform a complete functional operation of the device using a dummy source assembly.

Damage and/or operational malfunctions:

Test Assessment:

Recorded by: ______________________ Date: __________

Witnessed by: ______________________ Date: __________

Test Plan 115 Vertical Shock Test

Material and Equipment:

Test device (Model 880) serial number: ______________

Target Used: ______________

Test Procedure:

1. Prepare test specimen by securing a dummy source into its fully shielded position, attaching all covers, and locking the device.
2. Suspend the test specimen at least 6 inches over the test target upside-down with the jacket removed.
3. Drop the test specimen onto target.
4. Perform steps 2 & 3 a total of one hundred (100) times.
5. Perform a complete functional operation of the device using a dummy source assembly.

Damage and/or operational malfunctions:

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Test Assessment:

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Recorded by: ______________________ Date: __________

Witnessed by: ______________________ Date: __________

Test Plan 115 Tensile Test for Guide Tubes

Material and Equipment:

Test device (Model 880) serial number: ______________

Test apparatus T10281.

Force gage serial number: ______________________

Test Procedure:

1. Prepare test specimen by securing a dummy source into its fully shielded position, attaching all covers, and locking the device.
2. Secure exposure device to prevent movement during test.
3. Attach one end of test specimen to apparatus, T10281.
4. Apply a tensile load of 500 N +44/-0 (112 lb +10/-0) for 30 seconds to the end of test specimen. The 112 lbf. tensile load will register as a minimum of 78.4 psi (84.3 psi with gauge tolerance allowance) on the pressure gauge.
5. Release the pressure.
6. Perform steps 4 & 5 a total of 10 times.

Damage and/or operational malfunctions:

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Test Assessment:

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Recorded by: ________________________________ Date: ____________

Witnessed by: ________________________________ Date: ____________

Test Plan 115 Tensile Test for Control Cable Assembly

Material and Equipment:

Test device (Model 880) serial number: ____________________

Force gage serial number: ______________________________

Control Cable Assembly

Test Procedure:

1. Secure test device (Model 880) so that it cannot move during test.
2. Attach the controls to the test device.
3. Apply a tensile load of 500 N +44/-0 (112 lb +10/-0) for 30 seconds to the end of test specimen. The 112 lbf. tensile load will register as a minimum of 78.4 psi (84.3 psi with gauge tolerance allowance) on the pressure gauge.
4. Release the pressure.
5. Perform steps 3 & 4 a total of 10 times.
6. Secure the controls so they will not move during test.
7. Apply a force of 1000 N +44/-0 (225 lb +10/-0) tensile force to the free end of the source assembly for 10 seconds.
8. Perform step 7 a total of 10 times.

Damage and/or operational malfunctions:

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Test Assessment:

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Recorded by: ______________________ Date: __________

Witnessed by: ______________________ Date: __________

Test Plan 115 Kinking Test for Guide Tubes

Material and Equipment:

Guide Tube.

Dynamometer Ser. No. ___________

Tape measure.

Test Procedure:

1. Secure test specimen without connection on a horizontal surface between two parallel plates.
2. Make a flat closed loop with guide tube.
3. Pull the free end of the loop with a force of 200 N +22/-0 (45 lb +5/-0) over 5 seconds and maintain for 10 seconds.
4. Repeat steps 2 through 4 for a total of 10 times using the same point of the guide tube.
5. Redo complete test 10 times with a connection in the loop opposite the crossing point.
6. Remove the test specimen from the clamp.
7. Verify that guide tube is operational.

Damage and/or operational malfunctions:

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Test Assessment:

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Recorded by: ______________________ Date: __________

Witnessed by: ______________________ Date: __________

Test Plan 115 Kinking Test for Control Cable Assembly

Material and Equipment:

Control Cable Assembly.

Tape Measure.

Stop Watch.

Test Procedure:

1. Secure the control housing rectilinearly on a horizontal surface and clamp one end of the housing to the tabletop.
2. Make a 1000mm (39.37 in) loop with the housing on the horizontal surface (see figure 17.1). Verify the diameter of the loop using a tape measure.
3. Pull the free end of the housing without allowing it to rotate along its original axis at a minimum speed of 2.0 m/s (6.6 ft/sec).
4. Repeat test for a total of 10 times at each of 10 equidistant points along the length of the control housing.
5. Remove control housing from the clamp.
6. Verify that control assembly is operational.

Damage and/or operational malfunctions:

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Test Assessment:

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Recorded by: ______________________ Date: ____________

Witnessed by: ______________________ Date: ____________

Test Plan 115 Crushing and Bending Test

Material and Equipment:

Steel Punch, Tool Number T10280.

Tape Measure.

Guide Tube and Control Cable Assembly.

Test Procedure:

1. Place the guide tube test specimen on a rigid horizontal test surface with a minimum mass of 150 kg between the lateral guides. The surface must be hard enough that it will not be deformed by a steel punch (heel) without the presence of the object to be tested.
2. Place the steel punch (T10280) at a point on the test specimen as shown in Figure 17.1
3. Lift the edge of the steel punch heel a minimum of 300mm (11-13/16 in).
4. Drop the steel punch onto the test specimen.
5. Perform steps 3 & 4 a total of ten (10) times on randomly selected points on the test specimen. One of these points shall be on a joint.
6. Verify that the guide tube is operational.
7. Place the control cable test specimen in the juxtaposed position on the same surface used with the guide tube and laterally support with guides 0.5 to 0.75 times the control cable housing height.
8. Repeat steps 2 through 4 on five randomly selected points on the housing making sure the punch heel hits both juxtaposed housings simultaneously.
9. Rotate the control cable test specimen on the surface to the superimposed position between lateral guides 1.5 to 1.75 times the height of a tube.
10. Repeat steps 2 through 4 on five randomly selected points making sure that the heel drops on the top tube.
11. Verify that the control cable assembly is operational.

Damage and/or operational malfunctions:

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Test Assessment:

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Recorded by: ______________________ Date: __________

Witnessed by: ______________________ Date: __________

Test Plan 115 Final Tensile Test for Source Assemblies

Material and Equipment:

Dummy source assembly serial number: ____________________

Force gage serial number: ______________________________

Test Procedure:

1. Record stop ball to connector measurement: ____________
2. Attach control cable to the dummy source assembly.
3. Restrain end of source assembly opposite control cable connection.
4. Gradually apply 1000 N +44/-0 (225 lb +10/-0) force over 10 seconds, hold for 5 seconds, then release.
5. Complete test a total of 10 times.
6. Unrestrain source assembly.
7. Restrain source assembly at largest diameter and repeat steps 3-5.
8. Record stop ball to connector measurement: ____________
9. Perform a complete functional operation check of the device using the dummy source assembly.

Damage and/or operational malfunctions:

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Test Assessment:

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Recorded by: ________________________________ Date: ____________

Witnessed by: ________________________________ Date: ____________

Test Plan 115 Final Projection Test

Material and Equipment:

Test device (Model 880) serial number: __________________
Dummy source assembly serial number: __________________
Drive control assembly and guide tubes.
Automatic cycling apparatus including motor, controller, pneumatic actuator, and counter.

Test Procedure:

1. Assemble system using Figure 6 of ISO 3999-1:2000 as a guide.
2. Assemble and connect the test specimen to the system.
3. Complete 10 full cycles.
4. Record the rotational speed (P 177 rpm): ___________
5. Record the highest operational torque for each cycle. 1:____ 2:____ 3:____ 4:____ 5:____

   6:____ 7:____ 8:____ 9:____ 10:____
6. Record the average operational torque: _____

Damage and/or operational malfunctions:

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Test Assessment:

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Recorded by: ______________________________ Date: ___________

Witnessed by: ______________________________ Date: ___________

Test Plan 115 Lock Breaking Test

Material and Equipment:

Test device (Model 880) serial number: ____________________

Lock Breaking Tool, Tool Number T10345

Stopwatch.

Weights.

Test Procedure:

1. Prepare test specimen by securing a dummy source into its fully shielded position, attaching all covers, and locking the device.
2. Secure test specimen to prevent movement during test.
3. Set up Lock Breaking Tool with rod end resting on lock.
4. Gradually apply a load of 400 N +44/-0 (90 lbs +10/-0) force to lock over 10 seconds by adding weights to the top of the Lock Breaking Tool. Max Force: _______
5. Maintain the force for 5 seconds.
6. Gradually remove weights over 10 seconds.
7. Repeat test 10 times.
8. Perform a complete functional operation of the device using the dummy source assembly.

Damage and/or operational malfunctions:

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Test Assessment:

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Recorded by: ______________________________ Date: ______________

Witnessed by: ______________________________ Date: ______________

Test Plan 115 Wrench Test

Material and Equipment:

Test device (Model 880) serial number: __________________

Weight of test device (Model 880): __________________

Total weight of test equipment: ________________

Scale: ________________

Test Procedure:

1. Prepare test specimen by securing a dummy source into its fully shielded position, attaching all covers, and locking the device.
2. Secure device to plate and add weight to 25 times weight of test specimen as shown in Fig. 22.1.
3. Lift test specimen and weight from middle of handle with crane.
4. Perform a complete functional operation of the device using the dummy source assembly.

Damage and/or operational malfunctions:

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Test Assessment:

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Recorded by: ____________________________________ Date: ______________

Witnessed by: ____________________________________ Date: ______________

Section 25 Appendix: ISO 3999-1:2000

2.12.5 Test Plan Report 115 Minus Appendices (March 2001)

TEST REPORT 115

MODEL 880
RADIOGRAPHY PROJECTOR

ISO 3999-1:2000
PERFORMANCE TESTS

Table of Contents

Test Report No. 115

Section 1 Introduction

This report documents the performance of the Model 880 Radiographic Projector to the test requirements of ISO 3999-1:2000, Radiological Safety for the Design and Construction of Apparatus for Gamma Radiography.

The ISO 3999-1:2000 tests were done in the following order:

- Initial Projection Test
- Initial Tensile Test for Source Assemblies
- Endurance Test
- Horizontal Shock Test
- Vertical Shock Test
- Tensile Test for Guide Tubes
- Tensile Test for Control Cable Assembly
- Kinking Test for Guide Tubes
- Kinking Test for Control Cable Assembly
- Crushing and Bending Tests
- Final Tensile Test for Source Assemblies
- Final Projection Test
- Lock Breaking Test
- Wrench Test

A test data worksheet was produced for each test detailing the material and equipment used for the test, the test procedure, a list of any damage or operational malfunctions as a result of the test, and the test assessment. Each test data worksheet is located in Appendix A. Copies of the route cards used in the production of the test device and dummy source assembly are located in Appendix B. In addition, a shield efficiency profile was completed before and after all of the above tests. Copies of the shield profile inspection forms are contained within Appendix C.

Section 2 Test Specimen Construction and Acceptance

All radiography system components listed in the table below and used in this test plan were manufactured and accepted in accordance with the AEA Technology QSA, Inc. Quality Assurance Program.

Except for the tensile test, the test specimen was the Model 880, 150-Curie projector. The projector was manufactured to drawing B88000 Rev. A and is serialized D1000.

A Model 424-9 dummy source assembly was loaded into the test specimen for all tests.

The radiography system consisting of the components in the table below was used for the endurance test. The same Model 424-9 dummy source assembly used in the endurance test was used in the tensile test for the source assembly.

Table of Model 880 Radiography System Components

Part number	Part Name	Quantity
B88000 Rev. A	MODEL 880 150 Ci MAX ASSEMBLY	1
A42409XL Rev. A	MODEL 424-9 DUMMY SOURCE ASSEMBLY	1
BTAN69250 Rev. C	PISTOL GRIP CONTROL SYSTEM, 50 FOOT	1
B48930-7 Rev. A	SOURCE GUIDE TUBE ASSEMBLY, 7 FOOT	1
B48907-7 Rev. T	SOURCE GUIDE TUBE ASSEMBLY, 7 FOOT	4
B48906-7 Rev. Q	SOURCE GUIDE TUBE ASSEMBLY, 7 FOOT	1

Section 3 Test Objectives and Results

Initial Projection Test

The initial projection test is used to determine crank torque amounts before any other testing. A final projection test is done following all of the operational tests. ISO-3999:1-2000 standards state that the torque values cannot increase by more than 25% from the initial projection test to the final projection test. The setup for the test is the same as the setup for the endurance test.

The test resulted in an average torque of 41% of full motor torque (or 51 in-lbs).

Initial Tensile Test for Source Assembly

The tensile test demonstrates the source assembly maintains its integrity after experiencing tensile loads likely to occur during use.

The tensile tests resulted in an increase in the stop ball to connector measurement from 1.227 in. to 1.249 in. Inspection of the source assembly under a microscope revealed that the source wire stretched and unraveled slightly nearest the stop ball connector explains the increased measurement. However, a complete functional test with the test Model 880 projector showed that the source assembly was still completely functional. Therefore, the source assembly passed this test.

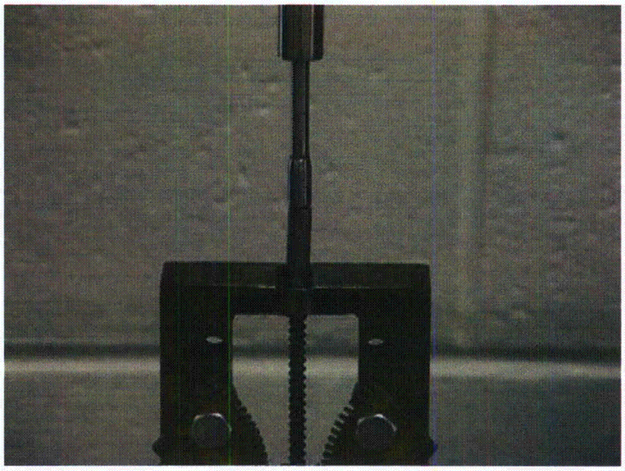


Figure 3.1 Source Assembly Tensile Test Connector and Ball Setup

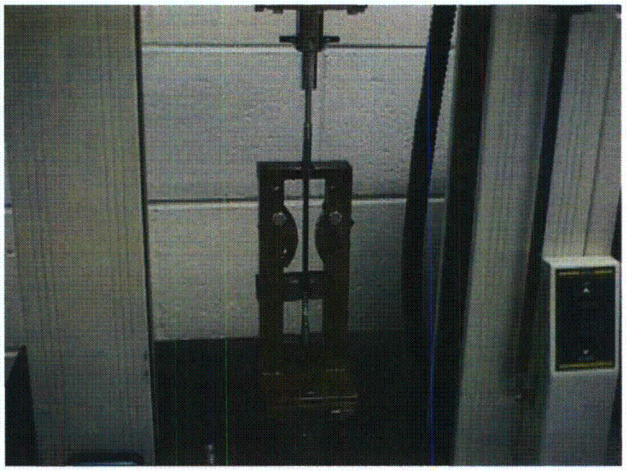


Figure 3.2 Source Assembly Tensile Test Connector and Capsule Setup

Endurance Test

The endurance test demonstrates that the gamma radiation system remains operational after 50,000 cycles of the source assembly moving from secure to working position and back while using the longest recommended guide tubes and controls. The exposure device and integral safety features shall remain operational after experiencing this test.

The device was put through 51,026 cycles at a speed of 3.28 ft/s. The highest operational torque observed was 41.4 % full load torque (or 51 in-lbs). There was no visible damage and there was only negligible wear to the device, drive cable, and guide tubes. One of the crank bearings was broken but the crank still turned freely. There were no functional or operational problems resulting from this test. Therefore, the device passed this endurance test.

Figure 3.3 Endurance Test Setup

Horizontal Shock Test

The horizontal shock test demonstrates the exposure device will withstand the horizontal impacts likely to occur during use. The exposure device and integral safety features shall remain operational after the test and the device shall experience no loss to shielding integrity.

The test was performed on three areas of the device: the lock cover area (Fig. 3.4), the lock mount area, and the front knob area (Fig. 3.5). The test was initially performed by measuring the 4 inch pendulum lift from the foot of the impact side of the device. This resulted in the center of gravity being lifted 4.5 inches which is more than the 4 inch lift required by ISO 3999-1:2000. The lock cover and lock mount areas became dented after the 4.5 inch center of gravity lift. However, the two areas did not lose any functionality.

The front knob area was tested twice using the 4.5 inch center of gravity lift. The impacts resulted in the front knob tightening enough to not be able to be pulled and turned by hand. Also, the front plate buckled inward slightly which prevented the fitting entering and turning the slider.

A new front plate assembly was installed and tested by lifting the center of gravity of the device only the required 4 inches. This test resulted only in minor dents to the front knob and very slight buckling of the front plate. The knob could be pulled and turned by hand and the fitting could enter and turn the slider proving that the device passes the minimum requirements of this test.

A further test was performed on the front knob by lifting the center of gravity of the device the 4 inches and allowing it to drop on the impact cylinder at an angle. This test was done to prove that the device could withstand an angled shock to the most fragile area of the device. The test produced only minor dents on the impact side of the front knob. The knob could be pulled and turned by hand and the fitting could enter and turn the slider.

After the tests, the device was put through a complete functional test that resulted in normal operation. Therefore, the device passed the horizontal shock test.

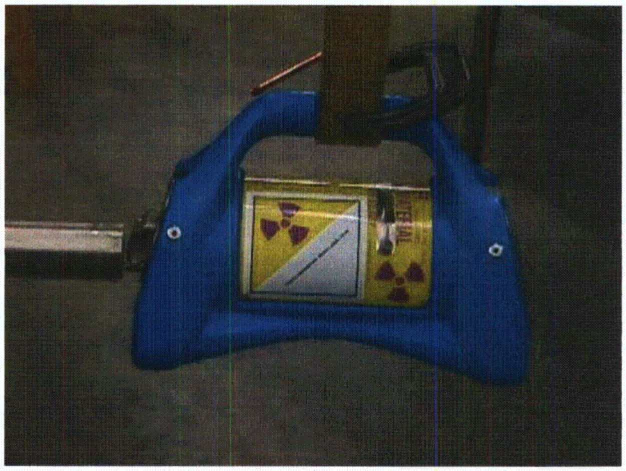


Figure 3.4 Horizontal Shock on Lock Cover

Figure 3.5 Horizontal Shock on Front Knob

Vertical Shock Test

The vertical shock test demonstrates the exposure device will withstand the vertical impacts likely to occur during use. The exposure device and integral safety features shall remain operational after the test and shall experience no loss of shielding integrity.

The test was performed on the device without the jacket in the normal carrying position. The device showed no visible damage after being dropped one hundred times from a height of 6 inches. The device functioned properly after having undergone a complete functional test. The device passed the vertical shock test.

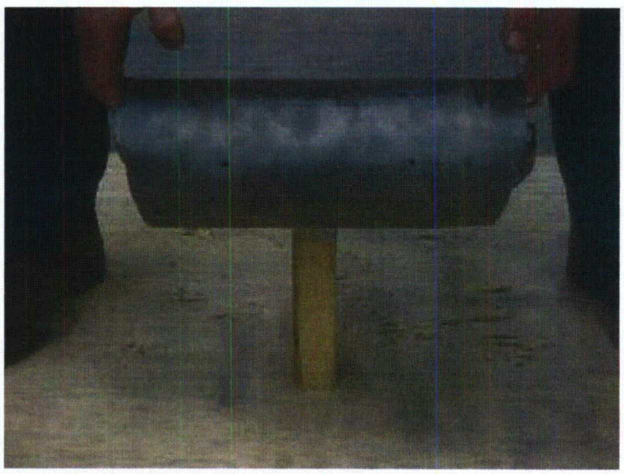


Figure 3.6 Vertical Shock Test

Tensile Test for Guide Tubes

The tensile test for guide tubes demonstrates that the guide tube housing maintains its integrity after experiencing tensile loads that may be encountered during regular use. The guide tube should remain operable after this test.

This test resulted in no apparent damage to the guide tube. The test dummy source assembly was not restricted while being passed through the guide tube during a functional test. Therefore, the guide tubes pass this test.

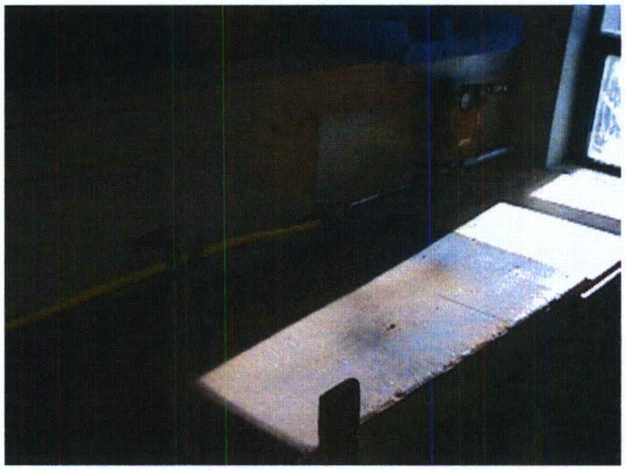


Figure 3.7 Tensile Test for Guide Tubes

Tensile Test for Control Cable Assembly

The tensile test for control cable assembly demonstrates that the control cable assembly maintains its integrity after experiencing tensile loads that may be encountered during regular use. The control cable assembly should remain operable after this test.

The test was conducted in two parts. The first part (Fig. 3.8 & 3.9) placed a tensile load on the control cable housing while connected to the device. The second part of the test (Fig. 3.10) placed a tensile load on the control cable itself while inside the control cable housing. This test resulted in no visible damage to the control cable assembly. The control cable was not restricted while being cranked through the control cable housing during a functional test. Therefore, the control cable assembly passes this test.

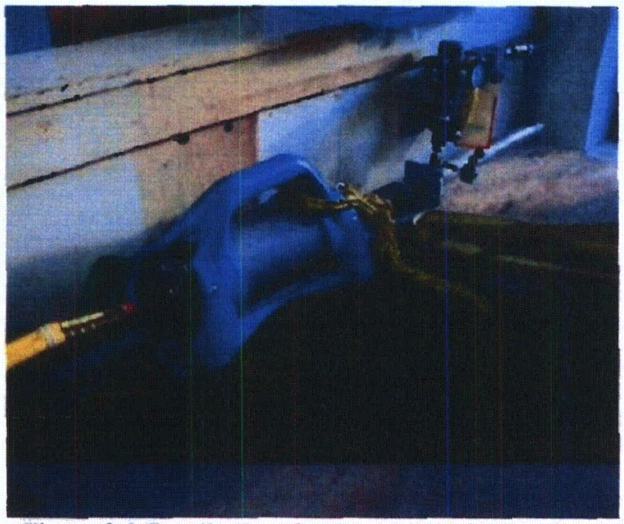


Figure 3.9 Tensile Test for Control Cable Housing

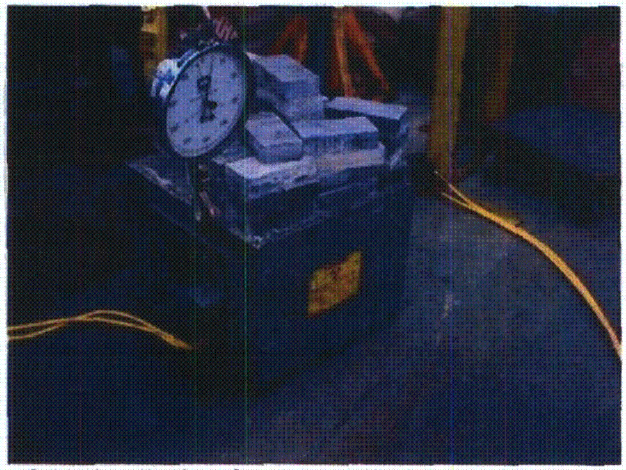


Figure 3.10 Tensile Test for Control Cable with Source Assembly

Kinking Test for Guide Tubes

The kinking test for the guide tube demonstrates that the guide tube withstands conditions that may be encountered during regular use. The guide tube should remain operational after experiencing this test.

The kinking test resulted in no visible damage to the guide tube. A complete functional test verified that the test dummy source assembly passed through the guide tube without any problems. Therefore, the guide tubes passed this test.

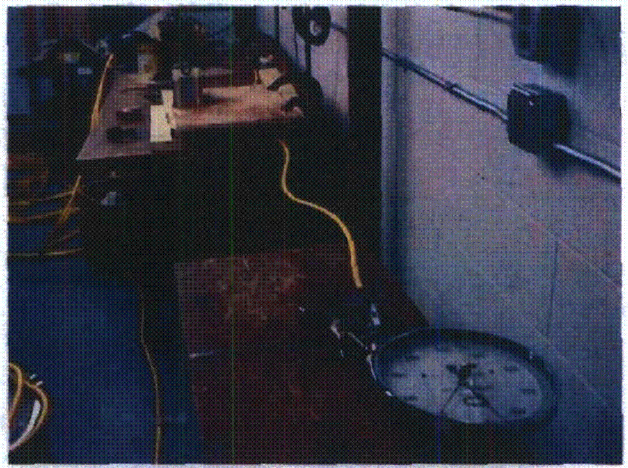


Figure 3.11 Kinking Test for Guide Tube

Kinking Test for Control Cable Assembly

The kinking test for the control cable assembly demonstrates that the control cable assembly can withstand kinking conditions that may occur during normal use. The control cable assembly should remain operational after performing this test.

After experiencing this test, the control cable assembly maintained its integrity without any apparent damage. A complete functional test was performed satisfactorily. The control cable assembly passed this kinking test.

Crushing and Bending Test

The crushing and bending demonstrates that the guide tubes and control cable assemblies can withstand a crushing test from a simulated heel (Fig. 3.12).

The control cable assembly showed some slight deformation from the impact of the simulated heel but the control cable had no problems passing through the control housings.

Three guide tubes were used in the crushing test. All of the guide tubes showed deformation from the heel impacts at each of the crushed points except for the connection point. The crushing test on the guide tube connection point resulted in no apparent damage. One of the ten crush points on each of the first two guide tubes tested resulted in enough deformation that the source assembly had trouble sliding through the area. Adding extra force to the hand crank allowed the source assembly to be forced through these tight areas. The test on the third guide tube did not require as much added force at the hand crank and the source assembly traveled through all ten crush points on the third guide tube much easier.

Although increased torque was required at the hand crank to push the source assembly through some of the crushed areas of the guide tubes, the source assembly was able to pass through all of the test samples during a functional test. Therefore, the guide tubes pass the crushing and bending test.

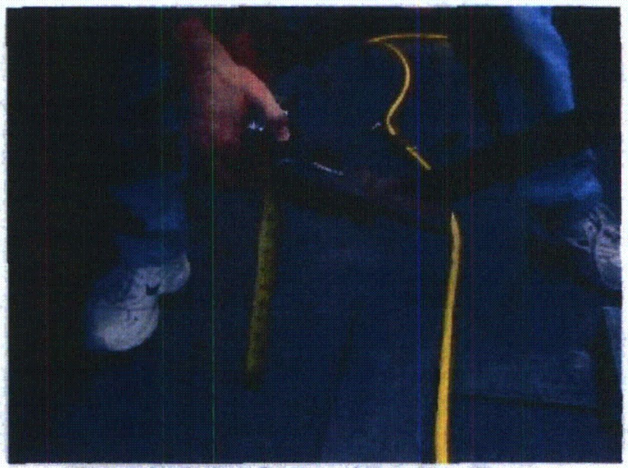


Figure 3.12 Crushing and Bending Test

Final Tensile Test

The final tensile test demonstrates the source assembly maintains its integrity after having undergone all of the other operational tests. The same dummy source assembly (Serial number TP115DEMO) that was used for this test is the same as used in all of the operational tests.

The tensile tests resulted in an increase in the stop ball to connector measurement from 1.240 in. to 1.250 in. A complete functional test with the test Model 880 projector showed that the source assembly was still completely functional. Therefore, the source assembly passed this test.

Final Projection Test

The final projection test demonstrates that the crank torque amount does not increase by more than 25% after the device and equipment have undergone all other operational tests. The setup that was used for this test is the same as the setup used for the initial projection test and the endurance test.

The test resulted in an average torque of 45% (or 56 in-lbs). The increase from the initial projection test was only approximately 10%. Therefore, the device passes the final projection test.

Lock Breaking Test

The lock breaking test demonstrates that the locking mechanism can withstand a breaking force while in the locked position with the key removed. The lock should remain operable after experiencing this test.

The locking mechanism had no visible damage after performance of the lock breaking test. The locking mechanism continued to be completely functional after this test. Therefore, the device passes the lock breaking test.

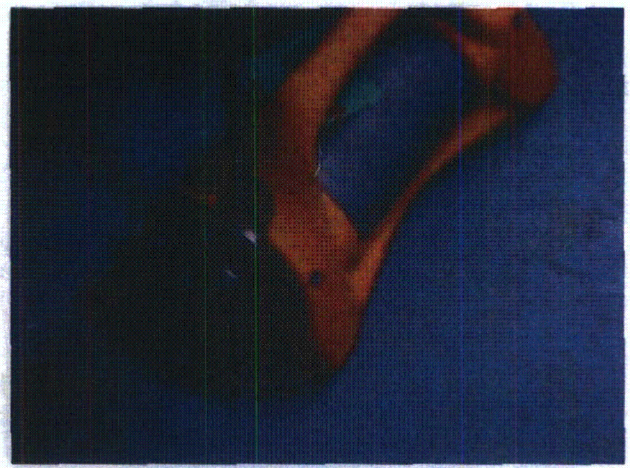


Figure 3.12 Lock Breaking Test

Wrench Test

The wrench test demonstrates that the handle of the exposure device is able to withstand a static force equal to at least 25 times the weight of the device (1250 lbs). This test was conducted on two different jackets with similar results. The first jacket contained metal wire wrapped around the device connected to a steel tube inside the handle for added support. The second device did not contain any added supports. Both handles lifted a load of 1288 lbs. with only slight bowing of the handle during the lift. The devices were inspected after the lift and showed no visible damage. Therefore, both handle options passed the wrench test.

Section 4 Conclusion

The Model 880 system consisting of the projector, control assembly, guide tubes and source assembly, satisfies the projection tests, the tensile tests for source assemblies, the endurance test, the horizontal shock test, the vertical shock test, the tensile and kinking tests for guide tubes and control cable assemblies, the crushing and bending tests, the lock breaking test, and the handle wrench test in accordance with ISO 3999-1:2000.

In addition to the tests performed under this test plan, ISO 3999-1:2000 also calls for a vibration resistance test and an accidental drop test.

A final shield profile was performed after the completion of all tests. There were only minor changes between the shield profile done previous to all the tests and the device remained within acceptable dose ranges. Both shield profile data sheets are located in Appendix C.

The vibration resistance test was evaluated and deemed unnecessary. The only parts that could come loose from vibration are the tamper proof screws. However, the tamper-proof screws are tightened to a prescribed torque to prevent unintentional release after repeated use or vibration. None of the tests performed resulted in a conditions that would increase chance that vibration could cause damage.

The accidental drop test was previously conducted under test plan 108 by dropping a Model 880 Projector from a height of 1.2 m (4 ft) three times to impact three different areas. There was no affect on the simulated source assembly from any of the impacts. Also, a shield profile did not show any increase in dose rate as a result of the impacts.

2.12.6 Test Plan Report 125 Rev B (Mar 2003)

TEST PLAN 125 (Rev. B) Report

MODEL 880
TYPE B CONTAINER
TRANSPORT CONDITIONS
With #88070 Foot Button Assembly
And #88022 Lock Mount Modification

AEA Technology QSA Inc.
40 North Avenue
Burlington
MA 01803

MARCH 2003

CONTENTS

Section 1. Purpose

The purpose of these tests were to assess the Model 880 transport container with the addition of the #88070 (F.C.B.A.) foot control button assembly. With the addition of this assembly and the modification of the #88022 lock mount, they will not adversely affect the packages ability as a "Type B" transport container.

Testing was performed on the 88070 F.C.B.A. to 10CFR71 regulations for 71.73(1) *free drop*, 71.73(3) *puncture*, and 71.71(10) *penetration*. These tests followed a random order except that the 71.73(3) puncture test was to follow the 71.73(1) free drop test if the specimen survived. Also, testing was performed according to ISO 3999-1 regulations for 6.4.6.1 *horizontal shock*. This horizontal shock test was relevant for both the 88070 F.C.B.A. and the 88022 lock mount assembly.

Section 2. Scope of Testing

Section 2.1 Normal Conditions of Transport and Accidental Drop

The tests for accidental drop described in ISO 3999-1, and normal conditions of transport in 10CFR71 are the tests. These tests will include a horizontal shock test, and penetration test.

Horizontal Shock Test

The 880 unit was oriented so the (1) F.C.B.A. and the (2) Lock Mount would impact the end-face of (T10333 SN01) 50 mm (2 in) diameter steel bar. The criteria is 300 mm (12 in) in length lying horizontally, that is fixed or welded to a rigid mass at least ten times the mass of the 880. The 880 was suspended from a fixed point so that, when at rest, the F.C.B.A. and Lock Mount just touches the target. The 880 was moved from its resting position until its center of gravity is 100 mm (4 in) higher than in the resting position and let loose, so that it swung in a pendulum movement against the target. This was carried out for a total of twenty (20) times.

Penetration Test

The 880 unit was oriented so as the foot control button assembly would be facing upward while the jacket will be supported on an unyielding surface. The hemispherical end of a vertical steel cylinder (AEA Technology QSA Drawing #BT10129) of 3.2 cm (1.25 in) diameter and 6 kg (13 lbs.) mass dropped from a height of 1 m (40 in) onto the surface of the F.C.B.A.

Section 2.2 Hypothetical Accident Conditions

The Hypothetical Accident Tests described in 10CFR71 are the 9m (30-foot) drop, the 1m (~3-foot) puncture drop.

9m (30-foot) Free Drop Test

The 880 radiographic unit was oriented so that the F.C.B.A. would be facing downward toward the test pad (T10261 SN01) for the 9m (30 ft.) drop test. This exposed the assembled unit so the F.C.B.A. received an impact similar to a slap down effect. One test was performed. It is described in the following sections.

Puncture Test

According to the Purpose (Section 1.0 paragraph 4) section of the test plan, an evaluation would be made before this test was to be performed. Normally, the 880 unit would be oriented in a similar angled fashion as above for the 1m (40 in.) drop test. The unit would be dropped onto a test billet (T10119 SN01) so as the F.C.B.A. sustains the full initial impact. This test was not performed. Reasons are described in the following sections.

Section 3. Test Unit Descriptions

Section 3.1 Test Unit 1 – Serial Number 01

The construction of this package is in accordance with the following AEA TECHNOLOGY QSA INC. documentation:

Assembly	Bill of Materials	Assembly Drawing
880 Delta Simulator Drawings	88017XLS TP125A Rev 1	B88017XLS Rev A BTP125A Rev 1
Foot Button Assy	BM 88070 Rev C	A88070 Rev B
Foot Control Shaft	N/A	A88070-4 Rev 3
Rear Plate Assy	BM 88020 Rev 5	B88020 Rev 5

The unit started construction to an earlier revision and Test Plan (See Appendix C Manufacturing Support Documentation). Changes to the unit during construction were recorded as mark-ups on the production prints and subsequently transferred to the above revisions.

As indicated above, the test unit was assembled with a modified rear plate assembly that includes changes to the *lock mount assembly.* Also, the *foot control button assembly* was modified with a G-10 shaft (Rev. 3) and installed onto the jacket for the testing. The test unit weighed approximately 49 pounds.

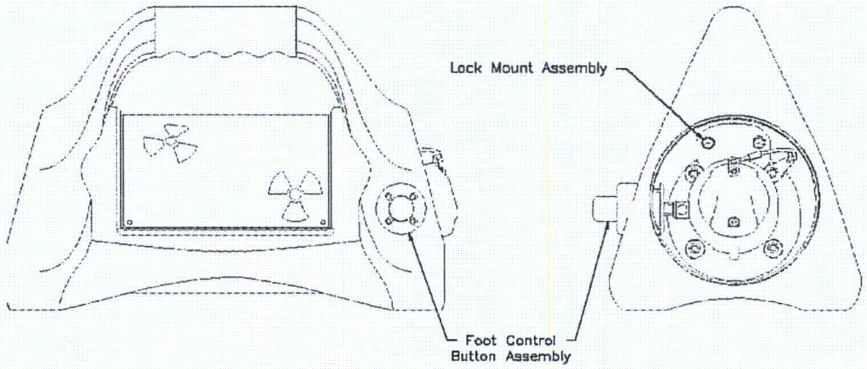


FIGURE 1. MODEL 880 (Test Unit #21) WITH FOOT BUTTON AND LOCK MOUNT ASSEMBLIES

Section 4. Changes to Test Conditions or Orientations

Section 4.1 Normal Conditions of Transport and Accidental Drop

No changes from plan were performed.

Section 4.2 Hypothetical Accident Conditions of Transport

No changes from plan were performed.

Section 5. Test Specimen Results

Section 5.1 Horizontal Shock Test – Foot Button Assembly

The test unit was set up on a portable crane type apparatus. Lead blocks were stacked around the base of the unit to keep it stationary and in position. The test unit was suspended (see figure 1) from the crane by means of its steel cable and a cloth rope around the test unit's handle. The 50mm 2 in diameter bar (T10333 SN01) was bolted to a Model 770 that weighted approx. 950 lbs.

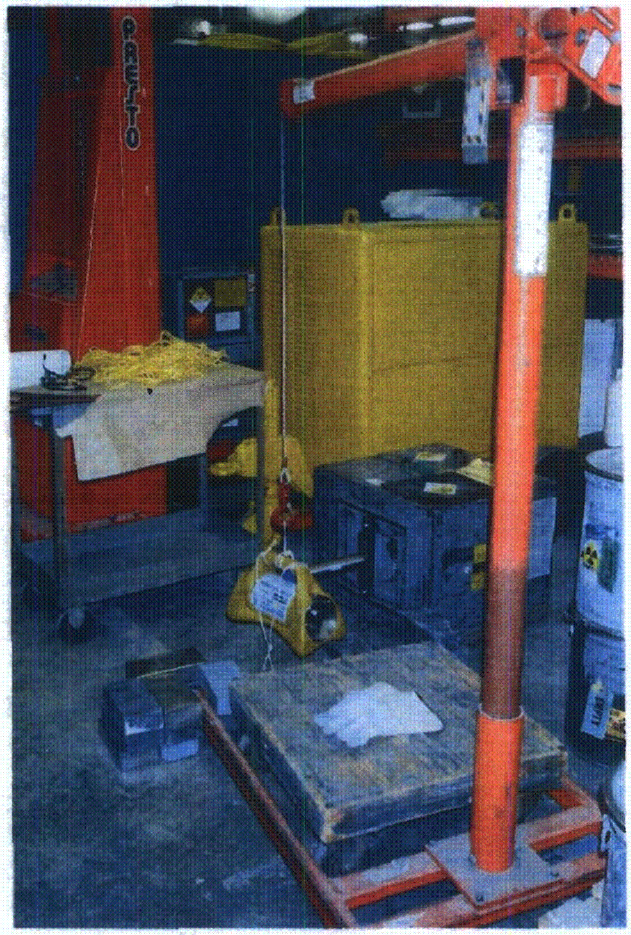


Figure 1

The test was then performed according to ISO 3999-1 regulations for 6.4.6.1 horizontal shock (see figure 2) test.

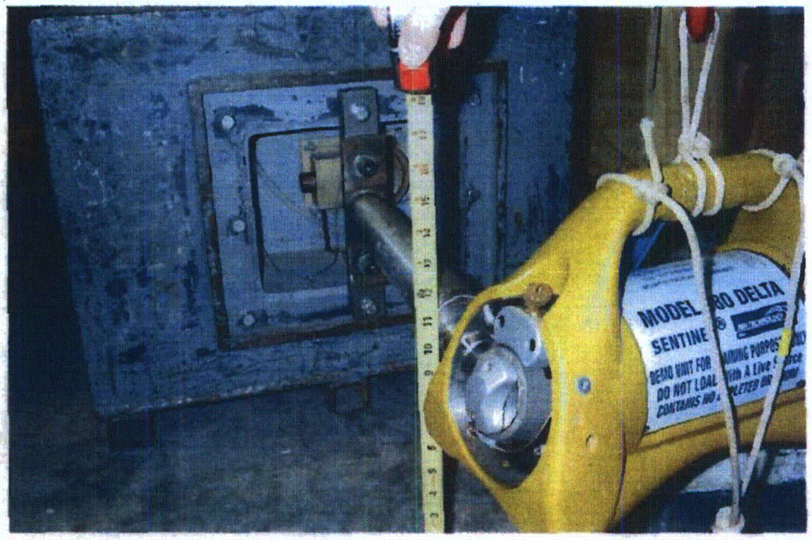


Figure 2

The unit was swung from the apparatus for a total of 20 times. The G-10 Shaft inside the F.C.B.A. broke, this was the piece that was expected to break. (see figure 3) The selector ring was not compromised. The unit passed the test.

Figure 3

Section 5.2 Horizontal Shock Test – Lock Mount Assembly

The test unit was set up on the portable crane type apparatus as on the F.C.B.A. The same testing was performed. See figure 4.

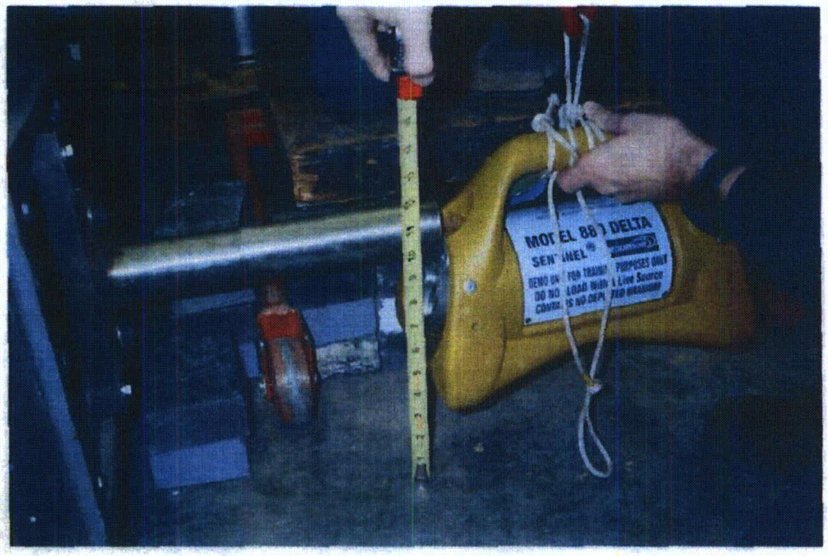


Figure 4

The unit was swung from the apparatus for a total of 20 times. The Lock Mount Assembly sustained minimal damage. Moreover, the corbin lock actuated smoothly and effortlessly. (See figure 5) The unit passed the test.

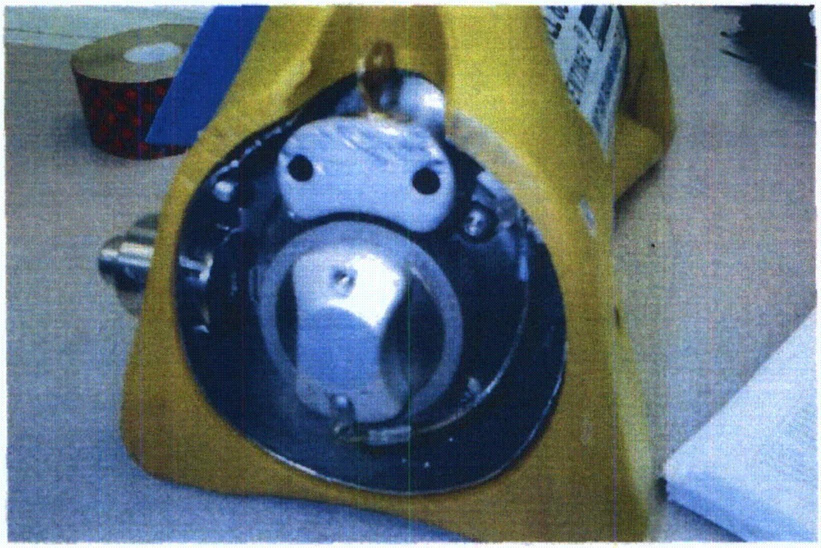


Figure 5

Section 5.3 Penetration Shock Test – Foot Button Assembly

The test unit was set up so the F.C.B.A. was facing upward. An aluminum angle was used to guide the test bar directly to the center of the F.C.B.A. (as shown in Figure 6).

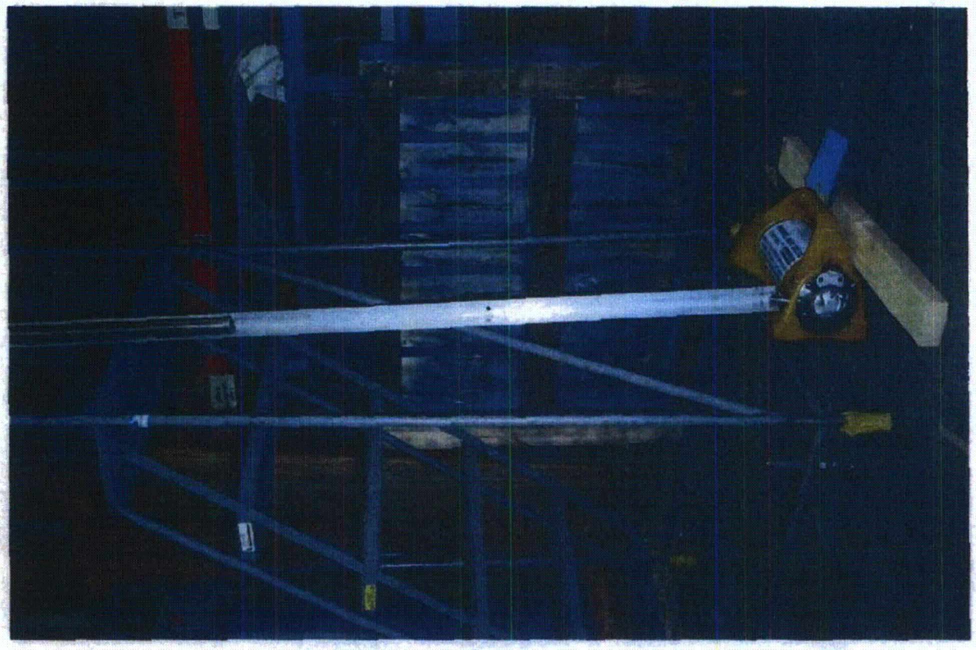


Figure 6 (rotated 90 degrees)

Upon dropping the bar, the G-10 Shaft broke. The button assembly needed to be disassembled to activate the selector ring and lock slide on the test unit. The test unit worked fine and passed the test.

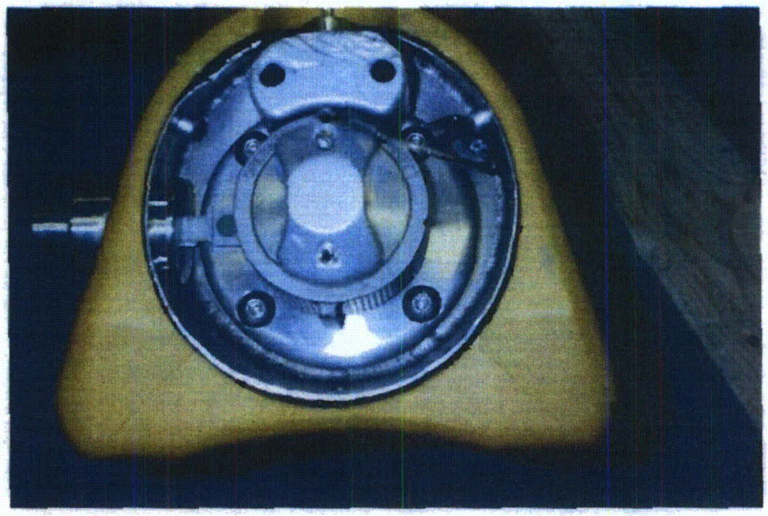


Figure 7

Section 5.4 9.m (30 ft.) Free Drop Test – Foot Button Assembly

The test unit was set up so that the F.C.B.A. was facing downward according to test plan instructions. The unit was dropped to induce the most rapid and damaging deceleration, which in this case had a slap down effect. See Test Plan 125B section 8.0 for setup orientation, and below (figure 8) for more information.

Figure 8

When the test unit was dropped, the unit fell as anticipated in the test plan. The polyurethane jacket and stainless steel canister deflected inward from the impact. The F.C.B.A. dented the side of the #88021 rear plate and the G-10 shaft contained within the button assembly shattered upon impact. Unfortunately due to the severe deflection of the components, the back of the F.C.B.A. hit the lock slide forcing it through the selector ring. The unit failed the test. See figure 9 and 10 for visual results. All testing was stopped at this time. Moreover, the Puncture Test was not performed.

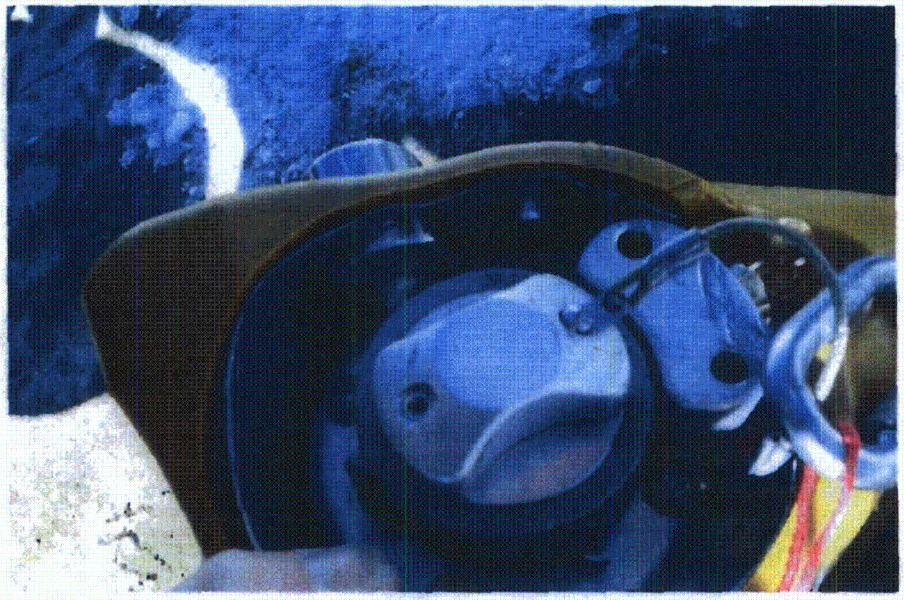


Figure 9

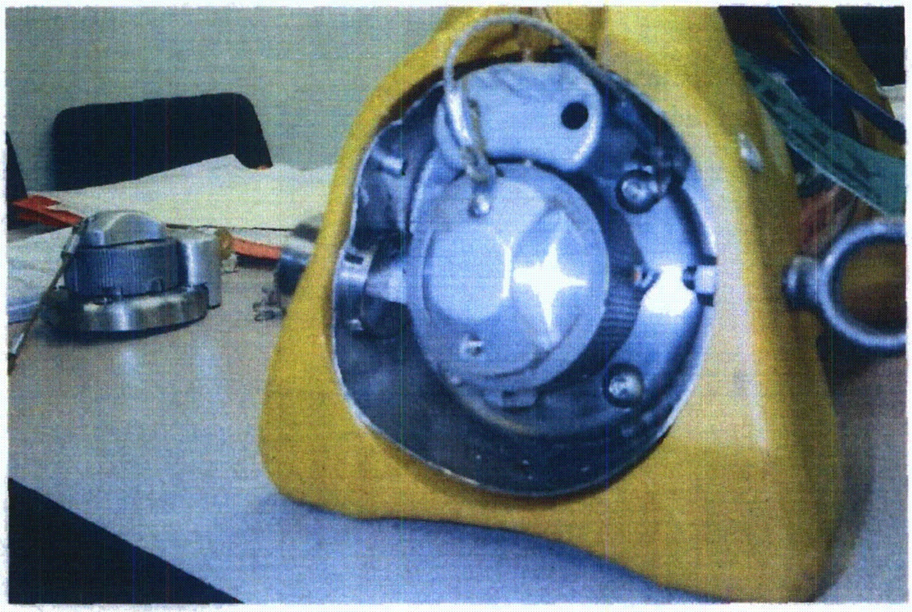


Figure 10

Section 6. Analysis, Summary, and Conclusions

Section 6.1 Analysis of testing not performed

Thermal Analysis
Because of the detailed assessment contained in TP108 a full weight "lead" dummy unit was used for this testing. Also, the melting temperature for all other materials of the internal support structure, rear plate assembly and source assembly is above the thermal test temperature of 800°C.

Moreover, the load condition for the thermal test is for the internal structure to support the static weight of the shield in suspension. The dynamic impact nature of the drop tests can subject the structure to a force over 100 times the static weight of the shield. This means the strength of the materials used in the structure would need to decrease by two orders of magnitude or to about 1% of their strength at room temperature. The 30-minute thermal test is not long enough for significant creep deformation to occur in the structure.

Puncture Test Analysis
This testing was performed on TP108. The testing passed when no damage occurred to the units. Therefore, testing was not performed on the Lock Mount Assembly. Also, the Lock Mount sits below the surface (with or without the jacket) of the radiographic camera and therefore would not be compromised. Moreover, the Lock Cover that is attached to the Rear Plate Assembly aids in the protection of the Lock Mount Assembly.

Vertical Shock Test Analysis
The vertical shock testing that was performed on TP115 for the model 880 unit showed no damage. The device functioned properly after having undergone a complete functional test. Therefore, vertical shock testing was not performed on this test unit.

Section 6.2 Summary and Conclusion

The Lock Mount Assembly with its addition of a stainless steel sleeve performed very well. The Lock Mount was also environmentally tested (see Technical Report #40) and performed superior. The design of the lock mount can be modified easily by enlarging its corbin lock retaining hole to accept the stainless sleeve. Moreover, the sleeve will be secured in place from the back with a 8-32 stainless set screw and a removable thread lock material.

The F.C.B.A. button assembly did pass the Horizontal Shock, and Penetration Test, but failed at the 9m (30ft.) Drop test. The G-10 fiberglass shaft reacted as designed, which shattered upon impact. As stated in the section 5.4, because of the severe force that was distributed through the F.C.B.A. stainless steel housing the lock slide was forced through the side of the selector ring.

From the test data, and the analysis contained within this report, we draw the following conclusions about the Model 880 (as tested):

1. The lock mount and F.C.B.A. can withstand the *Normal Conditions of Transport* and *Accidental Drop Test* situations.
2. The lock mount can withstand the *Hypothetical Conditions of Transport.*

Section 7. APPENDIX A – DRAWINGS

Security-Related Information
Figure Withheld Under 10 CFR 2.390

MATERIALS: SEE PARTS LIST

PROTECTIVE FINISH: NONE

UNLESS OTHERWISE SPECIFIED:
1. DIMENSIONS ARE IN INCHES.
2. MIN SURFACE TEXTURE: 125
3. TOLERANCES APPLY AFTER PLATING.
4. REMOVE BURRS AND SHARP EDGES.
5. DO NOT SCALE DRAWING.
6. TOLERANCES: .X ± 0.1
FRACTIONS ± 1/64 .XX ± 0.01
MACHINED ANGLES ± 1° .XXX ± 0.005

USED ON:

DRAWN	[illegible]	25SEP00
CHECKED	[signature]	11SEP00
APPR.	[signature]	11SEP00

THIRD ANGLE PROJECTION

SAFETY CLASS C

AEA TECHNOLOGY QSA
40 NORTH AVE, BURLINGTON, MA 01803

TITLE: MODEL 880 DELTA SIMULATOR ASSEMBLY

SIZE B | DWG. NO. 88017XLS | REV A

SCALE: NONE | SHEET 1 OF 1

Security-Related Information
Figure Withheld Under 10 CFR 2.390

MATERIALS:	SEE PARTS LIST
PROTECTIVE FINISH:	NONE
USED ON:	
DRAWN	
CHECKED	
APPR.	
SAFETY CLASS	A

UNLESS OTHERWISE SPECIFIED:
1. DIMENSIONS ARE IN INCHES.
2. MIN SURFACE TEXTURE: 125
3. TOLERANCES APPLY AFTER PLATING.
4. REMOVE BURRS AND SHARP EDGES.
5. DO NOT SCALE DRAWING.
6. TOLERANCES: FRACTIONS ± 1/64, MACHINED ANGLES ± 1°, .X ± 0.1, .XX ± 0.01, .XXX ± 0.005

THIRD ANGLE PROJECTION

AEA TECHNOLOGY QSA
40 NORTH AVE, BURLINGTON, MA 01803

TITLE: MODEL 880 DELTA SIMULATOR ASSEMBLY

SIZE	DWG. NO.	REV
B	TP125A	1

SCALE: NONE | SHEET 1 OF 1

Security-Related Information
Figure Withheld Under 10 CFR 2.390

MATERIALS: SEE PARTS LIST

PROTECTIVE FINISH: NONE

UNLESS OTHERWISE SPECIFIED:
1. DIMENSIONS ARE IN INCHES.
2. MIN SURFACE TEXTURE: 125
3. TOLERANCES APPLY AFTER PLATING.
4. REMOVE BURRS AND SHARP EDGES.
5. DO NOT SCALE DRAWING.
6. TOLERANCES: FRACTIONS ± 1/64; MACHINED ANGLES ± 1°; .X ± 0.1; .XX ± 0.01; .XXX ± 0.005

USED ON: 880

DRAWN	S.GRENIER	11SEP00
CHECKED	M.TREMBLAY	11SEP00
APPR.	M.TREMBLAY	11SEP00

THIRD ANGLE PROJECTION

SAFETY CLASS C

AEA TECHNOLOGY QSA
40 NORTH AVE, BURLINGTON, MA 01803

TITLE: BODY WELDMENT DELTA SIMULATOR

SIZE: B | DWG. NO. 88011XLS | REV B

SCALE: 1/2 | SHEET 1 OF 1

Security-Related Information
Figure Withheld Under 10 CFR 2.390

MATERIALS: SEE PARTS LIST

PROTECTIVE FINISH: NONE

UNLESS OTHERWISE SPECIFIED;
1. DIMENSIONS ARE IN INCHES.
2. MIN SURFACE TEXTURE: 63
3. DIMENSIONS APPLY AFTER FINISH.
4. REMOVE BURRS AND SHARP EDGES.
5. DO NOT SCALE DRAWING.
6. TOLERANCES: .X ± 0.1
FRACTIONS ± 1/64 .XX ± 0.01
ANGLES ± 1° .XXX ± 0.005

880

DRAWN	S.GRENIER	20JUL00
CHECKED	M.TREMBLAY	20JUL00
APPR.	M.TREMBLAY	20JUL00

THIRD ANGLE PROJECTION

QUALITY CLASS A

AEA TECHNOLOGY QSA
40 NORTH AVE, BURLINGTON, MA 01803

TITLE: REAR PLATE ASSEMBLY

SIZE B | DWG. NO. 88020 | REV 5

SCALE: 1/2 | SHEET 1 OF 1

Security-Related Information

Figure Withheld Under 10 CFR 2.390

MATERIALS: 300 SERIES STAINLESS STEEL

PROTECTIVE FINISH: NONE

UNLESS OTHERWISE SPECIFIED;
1. DIMENSIONS ARE IN INCHES.
2. MIN SURFACE TEXTURE: 63
3. DIMENSIONS APPLY AFTER FINISH.
4. REMOVE BURRS AND SHARP EDGES.
5. DO NOT SCALE DRAWING.
6. TOLERANCES: .X ± 0.1; .XX ± 0.01; .XXX ± 0.005; FRACTIONS ± 1/64; ANGLES ± 1°

DRAWN		
CHECKED	NA	
APPR.		

THIRD ANGLE PROJECTION

QUALITY CLASS B

AEA TECHNOLOGY QSA
40 NORTH AVE, BURLINGTON, MA 01803

TITLE: LOCK MOUNT S.S. INSERT

SIZE: B | DWG. NO. 88022-1 | REV 3

SCALE: 1:1 | SHEET 1 OF 1

Security-Related Information

Figure Withheld Under 10 CFR 2.390

MATERIALS: 6061-T6 ALUMINUM

PROTECTIVE FINISH: SEE NOTES

UNLESS OTHERWISE SPECIFIED:
1. DIMENSIONS ARE IN INCHES.
2. MIN SURFACE TEXTURE: 63
3. DIMENSIONS APPLY AFTER FINISH.
4. REMOVE BURRS AND SHARP EDGES.
5. DO NOT SCALE DRAWING.
6. TOLERANCES: .X ± 0.1, .XX ± 0.01, .XXX ± 0.005; FRACTIONS ± 1/64; ANGLES ± 1°

DRAWN	S.GRENIER	15JUN00
CHECKED	M.TREMBLAY	15JUN00
APPR.	M.TREMBLAY	15JUN00

THIRD ANGLE PROJECTION

SAFETY CLASS C

AEA TECHNOLOGY QSA
40 NORTH AVE, BURLINGTON, MA 01803

TITLE: LOCK MOUNT

SIZE B | DWG. NO. 88022 | REV 7

SCALE: 1:1 | SHEET 1 OF 1

REVISIONS				
.V.	ECO/TGR #	DESCRIPTION	APPROVALS	DATE
		PROTOTYPE RELEASE	SEE TITLE	BLOCK

Security-Related Information
Figure Withheld Under 10 CFR 2.390

\TERIALS: SPECIFICATION #3

:OTECTIVE FINISH: NONE

NLESS OTHERWISE SPECIFIED;
DIMENSIONS ARE IN INCHES.
MIN SURFACE TEXTURE: 125
TOLERANCES APPLY AFTER PLATING.
REMOVE BURRS AND SHARP EDGES.
DO NOT SCALE DRAWING.
TOLERANCES: .X ± 0.1
FRACTIONS ± 1/64 .XX ± 0.01

USED ON: 880

DRAWN		
CHECKED		
APPR.		

SAFETY CLASS

AEA TECHNOLOGY
QSA
40 NORTH AVE, BURLINGTON, MA 01803

TITLE: 8-32 X 3/16 LONG DOG PT. SET SCREW

SIZE	DWG. NO.	REV
A	SCR225	1

AEA TECHNOLOGY QSA

FORM E001 rev A

Bill Of Materials

Part No.: 88070

Title: FOOT CONTROL BUTTON ASSY.

Rev: C

Rev	ERF	Date	Ckd.	Appvd.	Rev	ECO	Date	Ckd.	Appvd.	Rev	ECO	Date	Ckd.	Appvd.
A	2871	6APR01	PAB	MT										
B	15	25Jun01	RLM	PAB										
C	27	11JUL01	PAB	[illegible]										

Item	Qty	P/N	Description
1	0	A88070	FOOT CONTROL BUTTON ASSEMBLY
2	1	B88070-1	FOOT CONTROL SLEEVE
3	1	B88070-2	FOOT CONTROL END
4	1	A88070-3	FOOT CONTROL KNOB
5	1	B88070-4	FOOT CONTROL SHAFT
6	1	B88070-5	FOOT CONTROL CORE
7	4	SCR210	#6-32 SOCKET HEAD CAP SCREW 3/8" LONG
8	1	SPR040	SPRING, 3/8" LONG X .48" O.D. (61 lbs./in.)
9	1	SPR041	SPRING, 3/4" LONG X .48" O.D. (19 lbs./in.)
10	1	BAG003	7" x 9" zip lock bag
11	1	INST 02	Instruction Sheet - Foot Control Button
12	1	TOL009	7/64 Hex Key

		REVISIONS		
EV.	ERF #	DESCRIPTION	APPROVALS	DATE
B	27	CHANGED SPRINGS/ ADDED BALLOONS	PAB / [illegible]	11JUL01

Security-Related Information
Figure Withheld Under 10 CFR 2.390

ATERIALS: AISI TYPE 304 STAINLESS STEEL

ROTECTIVE FINISH: NONE

INLESS OTHERWISE SPECIFIED;
DIMENSIONS ARE IN INCHES.
MIN SURFACE TEXTURE: 63
DIMENSIONS APPLY AFTER FINISH.
REMOVE BURRS AND SHARP EDGES.
DO NOT SCALE DRAWING.
TOLERANCES: .X ± 0.1
FRACTIONS ± 1/64 .XX ± 0.01
ANGLES ± 1° .XXX ± 0.005

DRAWN	P.BUTTRICK	10APR01
CHECKED	M.TREMBLAY	10APR01
APPR.	M.TREMBLAY	10APR01

THIRD ANGLE PROJECTION

SAFETY CLASS B

AEA TECHNOLOGY QSA
40 NORTH AVE, BURLINGTON, MA 01803

TITLE: FOOT CONTROL BUTTON ASSEMBLY

SIZE	DWG. NO.	REV
A	88070	B

SCALE: 1:1 SHEET 1 OF 1

Security-Related Information
Figure Withheld Under 10 CFR 2.390

MATERIALS: AISI TYPE 304 STAINLESS STEEL

PROTECTIVE FINISH: PASSIVATE PER MILS-5002C

UNLESS OTHERWISE SPECIFIED:
1. DIMENSIONS ARE IN INCHES.
2. MIN SURFACE TEXTURE: 63
3. DIMENSIONS APPLY AFTER FINISH.
4. REMOVE BURRS AND SHARP EDGES.
5. DO NOT SCALE DRAWING.
6. TOLERANCES: .X ± 0.1, .XX ± 0.01, .XXX ± 0.005, FRACTIONS ± 1/64, ANGLES ± 1°

DRAWN	P.BUTTRICK	10APR01
CHECKED	M.TREMBLAY	10APR01
APPR.	M.TREMBLAY	10APR01

THIRD ANGLE PROJECTION

SAFETY CLASS B

AEA TECHNOLOGY QSA
40 NORTH AVE, BURLINGTON, MA 01803

TITLE: FOOT CONTROL CORE

SIZE B | DWG. NO. 88070-5 | REV C

SCALE: 1:1 | SHEET 1 OF 1

Security-Related Information
Figure Withheld Under 10 CFR 2.390

MATERIALS: AISI TYPE 304 STAINLESS STEEL

PROTECTIVE FINISH: PASSIVATE PER MILS-5002C

AEA TECHNOLOGY QSA
40 NORTH AVE, BURLINGTON, MA 01803

UNLESS OTHERWISE SPECIFIED:
1. DIMENSIONS ARE IN INCHES.
2. MIN SURFACE TEXTURE: 63
3. DIMENSIONS APPLY AFTER FINISH.
4. REMOVE BURRS AND SHARP EDGES.
5. DO NOT SCALE DRAWING.
6. TOLERANCES:
   FRACTIONS ± 1/64 .X ± 0.1
   ANGLES ± 1° .XX ± 0.01
   .XXX ± 0.005

DRAWN	P.BUTTRICK	10APR01
CHECKED	M.TREMBLAY	10APR01
APPR.	M.TREMBLAY	10APR01

THIRD ANGLE PROJECTION

SAFETY CLASS B

TITLE: FOOT CONTROL SHAFT

SIZE	DWG. NO.	REV
B	88070-4	C

SCALE: 1:1 SHEET 1 OF 1

Security-Related Information

Figure Withheld Under 10 CFR 2.390

MATERIALS: AISI TYPE 304 STAINLESS STEEL

PROTECTIVE FINISH: PASSIVATE PER MILS-5002C

UNLESS OTHERWISE SPECIFIED:
1. DIMENSIONS ARE IN INCHES.
2. MIN SURFACE TEXTURE: 63
3. DIMENSIONS APPLY AFTER FINISH.
4. REMOVE BURRS AND SHARP EDGES.
5. DO NOT SCALE DRAWING.
6. TOLERANCES: .X ± 0.1, .XX ± 0.01, .XXX ± 0.005, FRACTIONS ± 1/64, ANGLES ± 1°

DRAWN	P.BUTTRICK	10APR01
CHECKED	M.TREMBLAY	10APR01
APPR.	M.TREMBLAY	10APR01

THIRD ANGLE PROJECTION

SAFETY CLASS B

AEA TECHNOLOGY QSA
40 NORTH AVE, BURLINGTON, MA 01803

TITLE: FOOT CONTROL END

SIZE B | DWG. NO. 88070-2 | REV C

SCALE: 1:1 | SHEET 1 OF 1

Security-Related Information
Figure Withheld Under 10 CFR 2.390

MATERIALS: AISI TYPE 304 STAINLESS STEEL

PROTECTIVE FINISH: PASSIVATE PER MILS-5002C

UNLESS OTHERWISE SPECIFIED:
1. DIMENSIONS ARE IN INCHES.
2. MIN SURFACE TEXTURE: 63
3. DIMENSIONS APPLY AFTER FINISH.
4. REMOVE BURRS AND SHARP EDGES.
5. DO NOT SCALE DRAWING.
6. TOLERANCES: .X ± 0.1
FRACTIONS ± 1/64 .XX ± 0.01
ANGLES ± 1° .XXX ± 0.005

DRAWN	[signature]	10/31/01
CHECKED	[signature]	[illegible]
APPR.	[signature]	[illegible]

THIRD ANGLE PROJECTION

SAFETY CLASS B

AEA TECHNOLOGY QSA
40 NORTH AVE, BURLINGTON, MA 01803

TITLE: FOOT CONTROL SLEEVE

SIZE B | DWG. NO. 88070-1 | REV A

SCALE: 1:1 | SHEET 1 OF 1

REVISIONS				
REV.	ECO/TGR #	DESCRIPTION	APPROVALS	DATE
A	2871	INITIAL RELEASE	SEE TITLE	BLOCK
B	2877	CHG. R.025 TO R.063, ADDED DRILL NOTE	[illegible]	20APR01

Security-Related Information
Figure Withheld Under 10 CFR 2.390

MATERIALS: AISI TYPE 304 STAINLESS STEEL

PROTECTIVE FINISH: PASSIVATE PER MILS-5002C

AEA TECHNOLOGY QSA
40 NORTH AVE, BURLINGTON, MA 01803

UNLESS OTHERWISE SPECIFIED:
1. DIMENSIONS ARE IN INCHES.
2. MIN SURFACE TEXTURE: 63
3. DIMENSIONS APPLY AFTER FINISH.
4. REMOVE BURRS AND SHARP EDGES.
5. DO NOT SCALE DRAWING.
6. TOLERANCES:
   FRACTIONS ± 1/64 | .X ± 0.1 | .XX ± 0.01 | .XXX ± 0.005
   ANGLES ± 1°

DRAWN	P.BUTTRICK	10APR01
CHECKED	M.TREMBLAY	10APR01
APPR.	M.TREMBLAY	10APR01

THIRD ANGLE PROJECTION

SAFETY CLASS B

TITLE: FOOT CONTROL KNOB

SIZE	DWG. NO.	REV
A	88070-3	B

SCALE: 1:1 | SHEET 1 OF 1

Security-Related Information
Figure Withheld Under 10 CFR 2.390

MATERIALS:	G-10 FIBERGLASS
PROTECTIVE FINISH:	N/A

UNLESS OTHERWISE SPECIFIED;
1. DIMENSIONS ARE IN INCHES.
2. MIN SURFACE TEXTURE: 63
3. DIMENSIONS APPLY AFTER FINISH.
4. REMOVE BURRS AND SHARP EDGES.
5. DO NOT SCALE DRAWING.
6. TOLERANCES: .X ± 0.1
FRACTIONS ± 1/64 .XX ± 0.01
ANGLES ± 1° .XXX ± 0.005

DRAWN	P.BUTTRICK	10APR01
CHECKED	M.TREMBLAY	10APR01
APPR.	M.TREMBLAY	10APR01

THIRD ANGLE PROJECTION

SAFETY CLASS B

AEA TECHNOLOGY QSA
40 NORTH AVE, BURLINGTON, MA 01803

TITLE: FOOT CONTROL SHAFT

SIZE	DWG. NO.	REV
B	88070-4	3

SCALE: 1:1 SHEET 1 OF 1

Security-Related Information
Figure Withheld Under 10 CFR 2.390

MATERIALS: G-10 FIBERGLASS

PROTECTIVE FINISH: N/A

UNLESS OTHERWISE SPECIFIED:
1. DIMENSIONS ARE IN INCHES.
2. MIN SURFACE TEXTURE: 63
3. DIMENSIONS APPLY AFTER FINISH.
4. REMOVE BURRS AND SHARP EDGES.
5. DO NOT SCALE DRAWING.
6. TOLERANCES: .X ± 0.1
FRACTIONS ± 1/64 .XX ± 0.01
ANGLES ± 1° .XXX ± 0.005

DRAWN	P.BUTTRICK	10APR01
CHECKED	M.TREMBLAY	10APR01
APPR.	M.TREMBLAY	10APR01

THIRD ANGLE PROJECTION

SAFETY CLASS B

AEA TECHNOLOGY QSA
40 NORTH AVE. BURLINGTON, MA 01803

TITLE: FOOT CONTROL SHAFT

SIZE B | DWG. NO. 88070-4 | REV 3

SCALE: 1:1 | SHEET 1 OF 1

Section 8. APPENDIX B – CALCULATIONS

(1)
F.C.B.A.

Horizontal Shock Test
ISO 3999-1

Test Specimen:

Drawing No. 88017XLS/TP125A Rev. B Serial Number: 12

Test weight 49 LBS Scale Used FWC DWM III
CAL. DATE MAY 28 2003

Test Setup:

Set up per: ISO 3999-1 (6.4.6.1) horizontal shock test procedure.

Pictures: K:\TEST PLAN\TP125A

Notes:

Horizontal Test Bar:

Drawing No. T10333 SN01 Rev. A Location: ENGR TEST CAGE

Test Period:

Date & time: 13FEB03 2:30 PM

Specimen Damage:

G-10 SHAFT BROKE AFTER 4TH HIT. FINISHED TEST OF 20 HITS. F.C.B.A. DID NOT WORK AT COMPLETION. UNIT (880) WAS NOT DAMAGED, WORKED FINE. PASSED TEST.

Post test assessment:

Recorded by: [signature]	Date: 14FEB03
Witnessed by: [signature]	Date: 13FEB03
Regulatory reviewed by: [signature]	Date: 13 Feb 03
Q.A. reviewed by: [signature]	Date: 13 feb 03

(1)

LOCK MOUNT

AEA Technology QSA, Inc.

TEST PLAN 125B
September 2002

Horizontal Shock Test
ISO 3999-1

Test Specimen:

Drawing No. 88017X1S/TP125A Rev. B Serial Number: 12

Test weight 49 LBS. Scale Used FWC DW INT
CAL. DATE MAY 28 2003

Test Setup:

Set up per: ISO 3999-1 (6.4.6.1) horizontal shock test procedure.

Pictures: K:\TEST PLAN\TP125A

Notes:

Horizontal Test Bar:

Drawing No. T10333 SN01 Rev. A Location: ENGR. STOCK CAGE

Test Period:

Date & time: 13FEB03 3PM

Specimen Damage:

ALUMINUM LOCK MOUNT W/S.S. INSERT WAS HIT 20 TIMES. FRONT OF LOCK MOUNT DAMAGEDED BUT FUNCTIONED PROPERLY. KEY ACTUATION WAS SMOOTH. PASSED TEST.

Post test assessment:

Recorded by: [signature]	Date: 13FEB03
Witnessed by: [signature]	Date: 13 Feb 03
Regulatory reviewed by: [signature]	Date: 13 Feb 03
Q.A. reviewed by: [signature]	Date: 13 Feb 04

(2)

Penetration Test **10CRF71**	
Test Specimen: Drawing No. 88017XLS/TP125A Rev. B Serial Number: 12 Test weight 49 LBS. Scale Used FWC DWM IV CAL. DATE 28 MAY 03	
Test Setup: Set up per: 10CR71 (71.71(10)) penetration test procedure. Pictures: K:\TEST PLAN\TP125 Notes:	
Drop surface: Drawing No. T10129 SN01 Rev. A Location: ENG./SHIPPING	
Test Period: Date & time: 17 FEB03 9:30AM	
Specimen Damage: UPON DROPPING BAR ON THE F.C.B.A. THE 6-10 SHAFT BROKE. THE F.C.B.A. NEEDED TO BE DIS-ASSEMBLED TO ACTUATE THE SELECTOR RING AND LOCK SLIDE. UNIT WORKED FINE, PASSED TEST.	
Post test assessment:	
Recorded by: [signature]	Date: 17FEB03
Witnessed by: [signature]	Date: 17FEB03
Regulatory reviewed by: [signature]	Date: 17FEB03
Q.A. reviewed by: [signature]	Date: 17Feb03

3

Free Drop Test
10CRF71

Test Specimen:

Drawing No. 88017 XLS/TP125A Rev. B Serial Number: 12

Test weight 49 LBS. Scale Used FWC DWM III
CAL. DATE 28 MAY03

Test Setup:

Set up per: 10CFR71 (71.73(1)) free drop test procedure.

Pictures: K:\TEST PLAN\TP125B

Notes:
SUSPENDED UNIT BY EYEHOOKS FROM A CRANE UNIT. VIDEO AND DIGITAL CAMERAS WERE USED TO DOCUMENT DROP.

Drop surface:

Drawing No. T10261 SN01 Rev. A Location: GROVELAND, MA.

Test Period:

Date & time: 07 MAR03 9:42 AM

Specimen Damage:

UPON HITTING THE TEST PAD THE F.C.B.A.'S G-10 SHAFT BROKE AS DESIGNED. UNFORTUNATELY THE F.C.B.A.'S S.S. HOUSING ALSO CAME IN CONTACT WITH THE ~~SELECTOR~~ ROCK SLIDE, FORCING IT THROUGH THE SELECTOR RING.

Post test assessment:

IF THE REAR MOST COMPONENT (F.C.B.A.) WAS ALSO MADE OF G-10 MATERIAL, THAN THERE WOULD BE A CHANCE OF THE F.C.B.A. WOULD PASS THE TEST.

Recorded by: [signature]	Date: 14 MAR03
Witnessed by: [signature]	Date: 17 MAR03
Regulatory reviewed by: [signature]	Date: 18 Mar03
Q.A. reviewed by: [signature]	Date: 19 March 03

Puncture Test
10CRF71

Test Specimen:

Drawing No. 88017XLS /TP125A Rev. A Serial Number: 12

Test weight 49 LBS. Scale Used FWC DWM IV
CAL. DATE 28 MAY 03

Test Setup:

Set up per: 10CR71 (71.73(3)) puncture test procedure and assessed configuration.

Pictures: N/A

Notes (assessed configuration):

Drop surface:

Drawing No. T10261 SN01 Rev. A Location: GROVELAND, MA.

Test Period:

Date & time: 07 MAR 03 10:00 AM

Specimen Damage:

NOT PERFORMED. UNIT FAILED ON FREE DROP TEST. ALL TESTING STOPPED AT THIS TIME

Post test assessment:

Recorded by: [signature]	Date: 14 MAR 03
Witnessed by: [signature]	Date: 17 MAR 03
Regulatory reviewed by: [signature]	Date: 18 Mar 03
Q.A. reviewed by: [signature]	Date: 19 Mar 03

Final Test Assessment

Test Specimen:

Serial Number(s): 88017XLS/TP125 S/N 21

Foot Control Button evaluation:

Spring (61lb.): IN GOOD WORKING ORDER
Spring (19lb.): IN GOOD WORKING ORDER
Stainless steel components: IN GOOD WORKING ORDER
F.C.B.A. working condition after Horizontal shock. YES *

Foot Control Button Assembly evaluation:

Is the F.C.B.A. in working condition?
THE ASSEMBLIES G-10 SHAFT BROKE ON IMPACT. THE F.C.B.A. HOUSING CAME IN CONTACT W/THE LOCK SLIDE, FORCING IT THROUGH THE SELECTOR RING

Comments:
* THE G-10 SHAFT WAS REPLACED AND THE ASSEMBLY WORKED FINE.

THE F.C.B.A. FAILED THE 9m FREE DROP. THE PUNCTURE TEST WAS NOT PERFORMED.

Engineering Review by: [signature]	Date: 03APR03
SME Review by: [signature]	Date: 03APR03
Regulatory Review by: [signature]	Date: 3Apr03
Q.A. Review by: [signature]	Date: 4April03

Final Test Assessment

Test Specimen:

Serial Number(s): 88017XLS

Lock Mount Assembly evaluation:

Aluminum housing: DENTED AND SCRAPED (OK)
Stainless steel insert: NO DAMAGE
Corbin lock: NO DAMAGE
Lock Mount Assembly working condition after Horizontal shock. YES

Lock Mount evaluation:

Is the lock mount assembly in working condition?

THE LOCK MOUNT ASSY. STILL WORKS VERY SMOOTHLY.

Comments:

REFER TO TECHNICAL REPORT #40 FOR ADDITIONAL TEST OF THE LOCK MOUNT ASSY. WHICH ALSO FAVORS THE S.S. INSERT DESIGN.

Engineering Review by: [signature]	Date: 02APR03
SME Review by: [signature]	Date: 03APR03
Regulatory Review by: [signature]	Date: 3 Apr 03
Q.A. Review by: [signature]	Date: 4 April 03

Section 10. APPENDIX D – MANUFACTURING RECORDS

AEA TECHNOLOGY
QSA

SPS-E-1724-1Rev1

ROUTE CARD

Part No.: 88017XLS		Rev: B		Page 1 of 1	
Desc: 880 DELTA "SIMULATOR" ASSEMBLY					
By: P Buttrick 9 JAN 03		Ckd: R. [illegible] 9 JAN 03			
Safety Class: N/A	WO INDIRECT		Qty: 1		
Serial/Lot Number(s): 21					

OP#	Work Center	Operation	Part#	Rev	Lot or s/n	Reference Document	Tools	By	Date	Comments
010	Assy	Attach jacket	88041-1 88011XLS RIV093	C B A	S/n 21	B88017XLS	T10367 T10324	DA	9 JAN 03	
020	Assy	Attach front plate Torque screws ✓	88030 SCR154	C A		B88017XLS	Torque wrench S/n 182	DA	9 JAN 03	
030	Assy	Attach rear plate Torque screws ✓	88020 SCR154	5 A	S/n 1146	B88017XLS	Torque wrench S/n 182	DA	9 JAN 03	DA 7 FEB 03
040	Assy	Attach F.C.B.A.	88070	2		B88070		DA	9 JAN 03	
050	Assy	Label	88042-5 RIV003			B88017XLS		DA	9 JAN 03	
060	QC	Final inspection			Pass ____ Fail X RE-INSPECT Acceptable DW 7 Feb 03	B88017XLS		DW	7 Feb 03	

AEA TECHNOLOGY QSA

SPS-E-1724-1Rev1

ROUTE CARD

Part No.: 88017XLS	Rev: A	Page 1 of 1	
Desc: 880 DELTA "SIMULATOR" ASSEMBLY			
By: [signature] 17 DEC 01	Ckd: [signature] 17 DEC 01		
Safety Class: ~~N/A~~ 17 JAN	WO INDIRECT	Qty: 1	
Serial/Lot Number(s): 21			

OP#	Work Center	Operation	Part#	Rev	Lot or s/n	Reference Document	Tools	By	Date	Comments
010	Assy	Attach jacket	88041-1 88011XLS RIV093	C A A	S/n 21	B88017XLS	T10367 T10324	DAL	17 DEC 01	
020	Assy	Attach front plate Torque screws ✓	88030 SCR154	B A		B88017XLS	Torque wrench S/n 182	DAL	17 DEC 01	
030	Assy	Attach rear plate Torque screws ✓	88020 SCR154	B A	S/n 1146	B88017XLS	Torque wrench S/n 182	DAL	17 DEC 01	
040	Engr	Attach F.C.B.A.	88070	2		B88070		DAL	17 DEC 01	DAL 14 NOV 02
050	QC	Final inspection			Pass X Fail ___	B88017XLS	[stamp]	[stamp]	20 DEC 01	

AEA TECHNOLOGY QSA

Dw 17 JAN02 125 A PAB 17JAN02

Device for Test Plan ~~119~~

Inspection Instruction And Record		**Originator/Date** Dave [signature] 18DEC01		**Rev** A		**Part No.** 88017XLS		**Supplier**				
		QA Approval/Date [signature] 18DEC01		**CM** C		**PIL** N/A	**Eng. Approval/Date** [signature] 18DEC01					
Item Description: Model 880 Delta Simulator Assembly												
Characteristics	**Tolerance**	**MTE**	**AQL**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
General Visual	N/A	N/A	C / 100%	0 / 1								
Verify all Items Present Per Drawing	N/A	N/A	C / 100%	0 / 1								
Verify Assembled per Drawing	N/A	N/A	C / 100%	0 / 1								
Total Weight 50 Lbs Max.	N/A	Scale	C / 100%	0 / 1								
Funtional Test With Dummy Source	N/A	N/A	C / 100%	0 / 1								
Verify Foot Control Button Assy Pt. # 88070 Installed	N/A	N/A	C / 100%	0 / 1								
Verify Foot Control Button Assy Functions Properly	N/A	N/A	C / 100%	0 / 1								
Less Name Plate & Source ID Tag	N/A	N/A	C / 100%	0 / 1								
Comments		**PO / WO #**		INDIRECT								
		Traveler / QCL #		N / A								
		Lot / Serial #		21								
		Lot Qty.		1								
		Qty. Rej / NCR		0 / NA								
		Qty. Acc.		1								
		Insp / Date		DW / 20 DEC01								

AEA TECHNOLOGY QSA SPS-E-1724-3Rev1	ROUTE CARD	Part No.: 88011XLS	Rev: B ~~A~~	Page 1 of 1
		Desc: Body Weldment "Delta Simulator"		
		By: [signature] 12 DEC 01	Ckd: R. [signature] 12 DEC 01	
		Safety Class: C ~~N/A~~	WO INDIRECT	Qty: 1
		Serial/Lot Number(s): 21		

Op #	Work Center	Operation	Part #	Lot or S/N	Reference Documents/Rev	Tools	by	Date	Comments
010	Assy	Stamp S/N	88010	S/N 21	B88011XLS		DAL	12 DEC 01	
020	Assy	Assemble shields & End plates	88052-1 88010 88003	Lot# 01171-1	B88011XLS		RWR	12 Dec 01	
030	Weld	Tack Weld	88011XLS WEL003	Lot# 01026-2	B88011XLS	T10318 S/N 02	E.P.	12 Dec 01	
040	Weld	Weld	88011XLS WEL003	Lot# 01026-2	B88011XLS		E.P.	12 Dec 01	
050	QC	Inspect weld (VT)		Pass X Fail ___	B88011XLS		DL	14 Dec 01	
060	Assy	Foam	FOM001		B88011XLS WI-P1712 SPS-P1712-1	T10329 S/N N4	DFW	15 DEC 01	
070	~~Assy~~ QC	Inspect			B88011XLS		DL	17 Dec 01	

AEA TECHNOLOGY QSA

Inspection Instruction And Record	Originator/Date [signature] 12 Dec 01	Rev B	Part No. 88011XLS	Supplier
	QA Approval/Date [signature] 17 Dec 01	CM C	PIL 3	Eng. Approval/Date [signature] 18 DEC 01

Item Description: Body Weldment Delta Simulator

Characteristics	Tolerance	MTE	AQL	1	2	3	4	5	6	7	8	9
General Visual	N/A	N/A	MJ / 1.0	0 / 1								
Verify Assembled per Drawings Route Card Verification	N/A	N/A	MJ / 1.0	0 / 1								
1.75	+ .02 - .08	Micro Hite	MJ / 1.0	0 / 1								
8.5	+ / - .1	Micro Hite	MJ / 1.0	0 / 1								
Welded Per Dwg.	N/A	N/A	MJ / 1.0	0 / 1								
Stamp Serial # per Dwg.	N/A	N/A	MJ / 1.0	0 / 1								

Comments		1	2	3	4	5	6	7	8	9
	PO / WO #	INDIRECT								
	Traveler / QCL #	N / A								
	Lot / Serial #	21								
	Lot Qty.	1								
	Qty. Rej / NCR	0 / NA								
	Qty. Acc.	1								
	Insp / Date	DW / 17 DEC 01								

AEA TECHNOLOGY QSA

FIRST ARTICLE REPORT
Form F-Q1807-2

Supplier: MACHINE SHOP	Part No.: 88022-1	P.O. /W.O.
Item Description: LOCK MOUNT INSERT	Qty. 2	Qty./Insp. 2
Drawing No. 88022-1	Rev. 3	CM: B
Inspected by: [signature]	Date: 18 DEC 02	Lot/Ser.#

Drawing Dimension	Actual Dimension	M&TE Used	SN & Cal. Due Date
SLOT .188	.188-.189	Caliper	#305 10-4-03
.562	.565 - .560	↓	" "
.755 ± .003	.756 - .758	Bore Gage	#111 4-5-03
.875 +.000 -.005	.875	Caliper	#305 10-4-03
.165	.164 - .166	MICRO Hite	271 4-2-03
.125 Ø Thru	.125	pin gage	292 4-2-03
.35	.345 / .350	MICRO HITE	#270 4-2-03
.89	.892 / .896	↓	↓
.93	.933	↓	↓
.16	.158 .160	Caliper	#305 10-4-03
.31 Rad	.31 Rad	Pin gage	293 4-2-03
300 Series S.S.	S.S	Visual / magnet	NA

Results:	Accepted ✗	Rejected	

Comments:

QC Forward this inspection report along with the samples to Engineering for review and approval. Retain a copy of the report in the file until approved.

Approved ☒ **Not Approved** ☐

[signature] **Date:** 06 JAN 03

Engineering

Engineering return approved report to QC for records retention.

QCL#
125730

Security-Related Information
Figure Withheld Under 10 CFR 2.390

MATERIALS: 300 SERIES STAINLESS STEEL

PROTECTIVE FINISH: NONE

UNLESS OTHERWISE SPECIFIED;
1. DIMENSIONS ARE IN INCHES.
2. MIN SURFACE TEXTURE: 63
3. DIMENSIONS APPLY AFTER FINISH.
4. REMOVE BURRS AND SHARP EDGES.
5. DO NOT SCALE DRAWING.
6. TOLERANCES: .X ± 0.1
FRACTIONS ± 1/64 .XX ± 0.01
ANGLES ± 1° .XXX ± 0.005

DRAWN		
CHECKED	NA	
APPR.		

THIRD ANGLE PROJECTION

QUALITY CLASS B

AEA TECHNOLOGY QSA
40 NORTH AVE, BURLINGTON, MA 01803

TITLE: LOCK MOUNT S.S. INSERT

SIZE	DWG. NO.	REV
B	88022-1	3

SCALE: 1:1 SHEET 1 OF 1

AEA TECHNOLOGY QSA

FIRST ARTICLE REPORT
Form F-Q1807-2

Supplier: A.E.A MACHINE Shop	Part No.: 88070-4	P.O. /W.O: Indirect
Item Description: Foot Control Shaft	Qty. 10	Qty./Insp. 5
Drawing No.	Rev. 3	CM: B
Inspected by: Norgie Benitez	Date: 01OCT02	Lot/Ser.# N/A

Drawing Dimension	Actual Dimension	M&TE Used	SN & Cal. Due Date
General Visual	Conform	Visual	N/A
1.500	1.500	CALIPER	340 - 8/8/03
R.030	.030	RADIUS GAGE	QC-10 - 4/1/03
Φ.490	.490	Caliper	340 - 8/8/03
.60°	.60°	OPTICAL COMP.	340 - 8/8/03
.437	.437	Caliper	↓
.500	.500	↓	↓
.156	.156	↓	↓
R.180 (2 PLS)	R.187	Radius Gage	QC-10 - 4/1/03
.115	.115	Caliper	340 - 8/8-03
.230	.230	Caliper	340 - 8/8-03
.360	.360	Caliper	340 - 8/8-03
	Results:	Accepted	Rejected X

Comments:

QC Forward this inspection report along with the samples to Engineering for review and approval. Retain a copy of the report in the file until approved.

Approved [X] **Not Approved** [ ]

[signature] Engineering **Date:** 03OCT02

Engineering return approved report to QC for records retention.

Security-Related Information

Figure Withheld Under 10 CFR 2.390

MATERIALS: G-10 FIBERGLASS

PROTECTIVE FINISH: N/A

UNLESS OTHERWISE SPECIFIED;
1. DIMENSIONS ARE IN INCHES.
2. MIN SURFACE TEXTURE: 63
3. DIMENSIONS APPLY AFTER FINISH.
4. REMOVE BURRS AND SHARP EDGES.
5. DO NOT SCALE DRAWING.
6. TOLERANCES: .X ± 0.1, FRACTIONS ± 1/64, .XX ± 0.01, ANGLES ± 1°, .XXX ± 0.005

DRAWN	P.BUTTRICK	10APR01
CHECKED	M.TREMBLAY	10APR01
APPR.	M.TREMBLAY	10APR01

THIRD ANGLE PROJECTION

SAFETY CLASS B

AEA TECHNOLOGY QSA
40 NORTH AVE, BURLINGTON, MA 01803

TITLE: FOOT CONTROL SHAFT

SIZE B | DWG. NO. 88070-4 | REV 3

SCALE: 1:1 | SHEET 1 OF 1

Section 11. APPENDIX E – TECHNICAL REPORTS

AEA TECHNOLOGY QSA, Inc.
Engineering Department
Technical Report

Title: 88022 Lock Mount "Environmental Test" evaluation

Prepared by: [signature] Date: 11JUN02
Checked by: [signature] Date: 11JUN02
Engineering Approval: [signature] Date: 11JUN02

1.0 PURPOSE

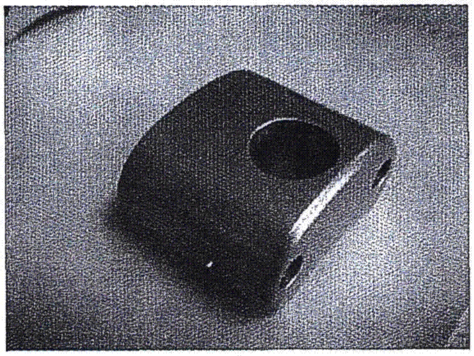
The purpose of the report is to set forth results on testing of the #88022 Lock Mount assembly, then propose and test new designs as to arrive at one that will not experience operating problems in the future.

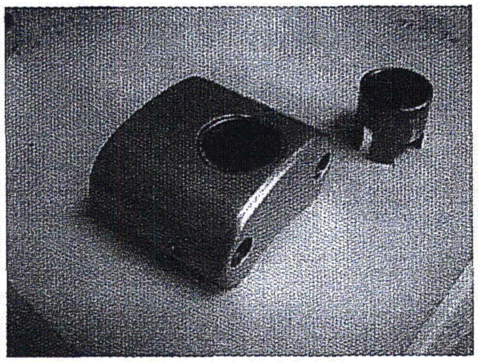
2.0 SCOPE

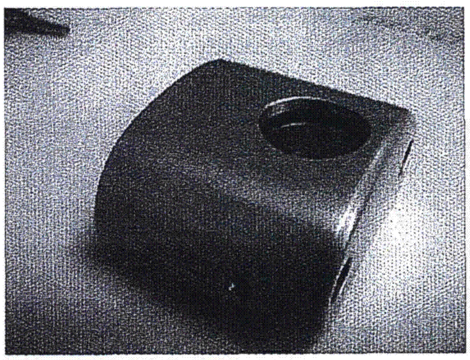
We have received customer concerns (see CR 151, CR177) about the aluminum #88022 lock mount and its brass #66001-11 lock plunger sticking (not unlocking) after being subjected to several days of marine environment and dark room exposure. Other concerns of mud and water submersion to the lock mount assembly during "normal" daily operations have been made in reference to faulty lock operations. Moreover, corrosion between the aluminum lock mount and the brass lock plunger will be evaluated when tested.

3.0 METHODS

The test method employed was performed on three different designs. The first design is the part as currently manufactured. The second design has a stainless steel sleeve inserted into the existing design's enlarged hole. The third, a rubber o-ring design incorporated into the existing design. Two complete assemblies of each of the three different configurations were used in the testing. The test was as follows.





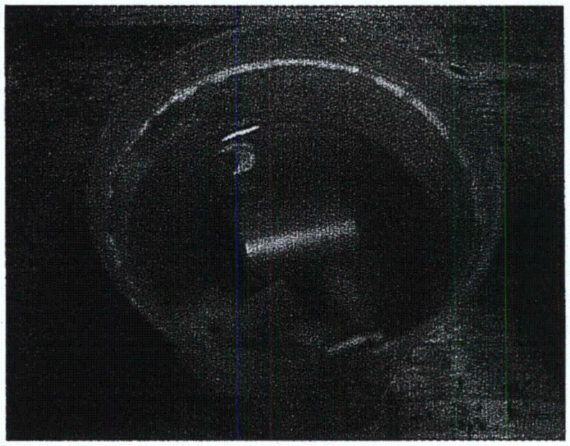


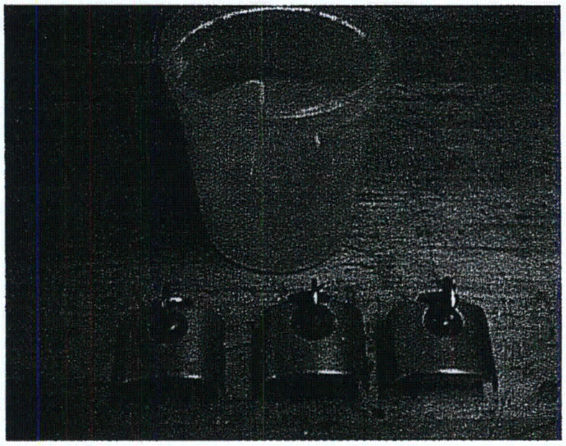
Two different tests were conducted:

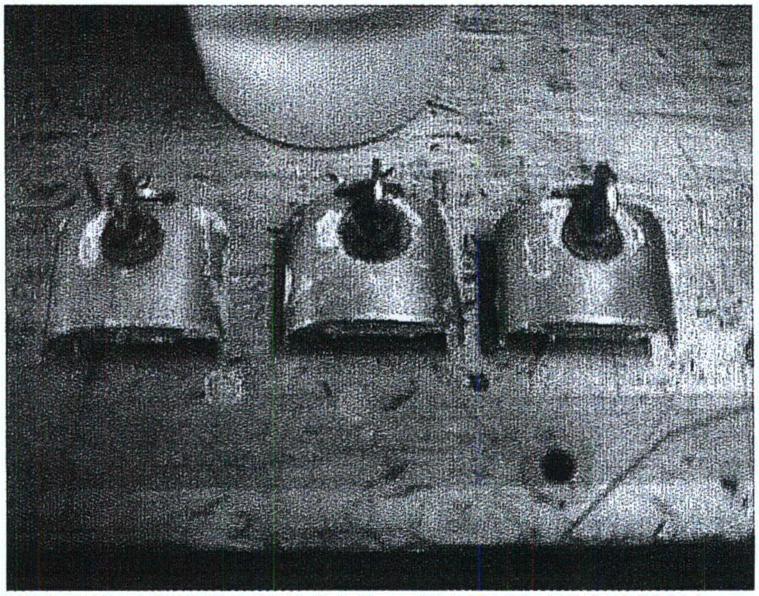
a. One each of the three different designs were submerged into a heavy salt water mixture for a period of 3 days. Each day the solution was stirred, as to fully coat the samples. On the fourth day the test samples were set on a table at ambient temperature to dry for a period of four hours. The samples were then placed in an oven and were subjected to a temperature of approximately 140 degrees Fahrenheit for a period of 4 hours.

The above process was to simulate exposure to a marine environment. The test samples did have some minor corrosion occur between the brass lock plunger and the aluminum housing. The brass lock plunger also had some discoloring around the key area but had little effect in operation.

See pictures below.......



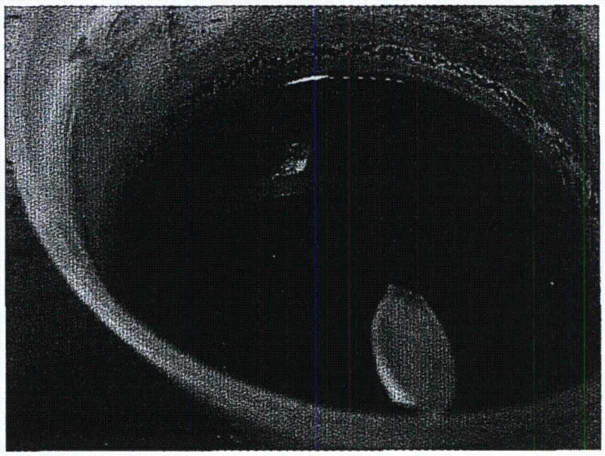


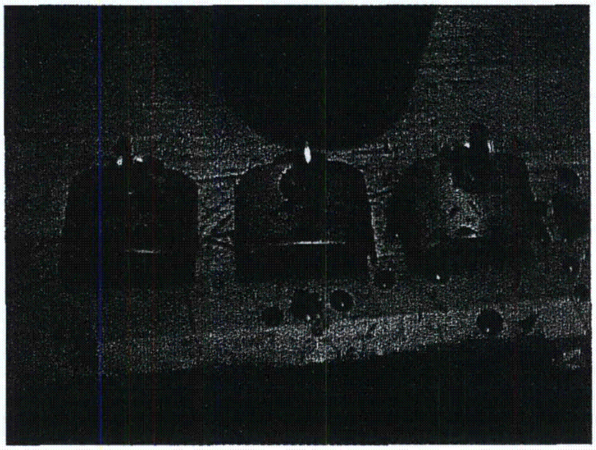


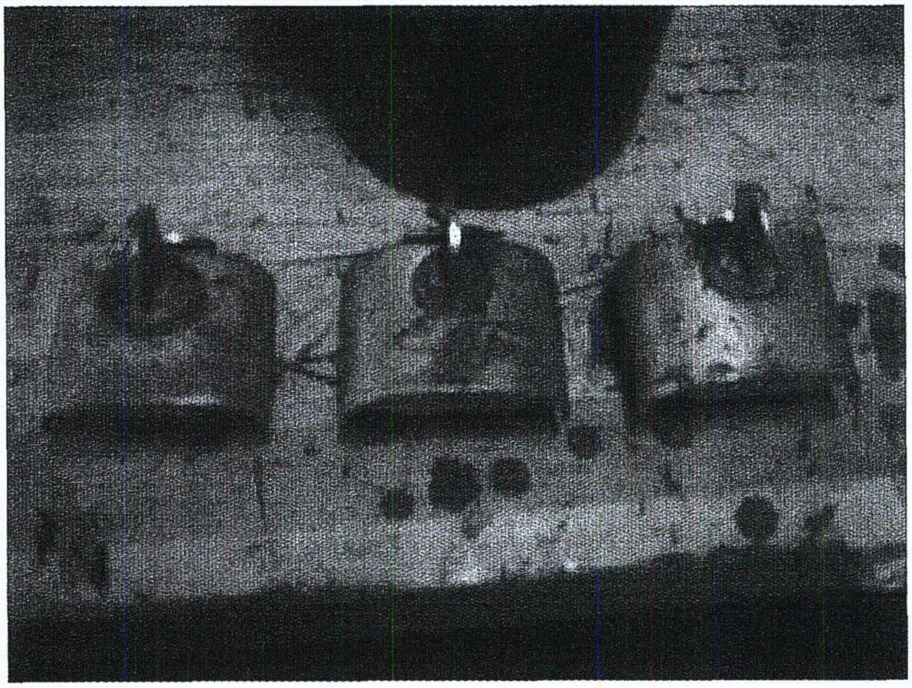
b. One each of the three different designs were submerged into a thick mud mixture for a period of 3 days. Each day the solution was stirred, as to fully coat the samples. On the fourth day the test samples were set on a table at ambient temperature to dry for a period of four hours. The samples were then placed in an oven and were subjected to a temperature of approximately 140 degrees Fahrenheit for a period of 4 hours.

The above process was to simulate exposure to dirt and mud for long periods of time. A drying cycle was introduced as a normal occurrence during storage or non-use.

See pictures below…….







4.0 INITIAL INPUT

The first sample, which is our normal production part was tested without any modifications. It was assembled by applying a petroleum (AEROSHELL Grease 7) lubricant to the perimeter of the hole on the aluminum lock mount. The brass plunger was than inserted into the hole and secured in place by a 6-32 hex slot machine screw through the side of the assembly.

The second sample, #88022 (Rev. 6) lock mount had the 0.858 diameter drill hole opened to .880 +.000/-.003 x .930 deep. A stainless steel sleeve #88022-1 (Rev. 1) with an outside diameter of 0.875 +.000/-.005 was bonded with a 5 minute epoxy into the .880 hole. The #66001-11 lock plunger was than inserted into the lubricated (AEROSHELL) stainless steel sleeve and secured in place with a 6-32 machine screw.

The third sample, #88022 (Rev. 5) lock mount was modified to accept an o-ring (Green Rubber #AS568-210) approximately 1/8" from the top edge of the .758 diameter hole. Upon insertion of the o-ring the 0.758 diameter hole was greased with the lubricant (AEROSHELL) and the brass lock plunger was secured in place as above.

See attached drawings for more information.

5.0 RESULTS / DISCUSSION

5.1 The parts were first evaluated (not cleaned) while still warm from the oven.

All the salt covered test sample's lock plungers were hard to turn with the key and did not actuate properly. The Stainless steel sleeve sample did however work the best after only a few iterations. The normal production sample was very stiff while turning the key and did not actuate fully. The o-ring sample did not turn or actuate at all.

The mud covered test sample's lock plungers turned easily with the key but did not actuate fully on the current design and the o-ring designed test sample. The stainless steel sample however actuated fully without any effort.

5.2 The parts were then cleaned (washed with water) while turning the key and actuating the lock plunger.

The salt covered stainless steel insert test sample and the o-ring test sample worked well after cleaning. The normal production sample however, never worked properly even after being rinsed thoroughly with water. The production sample was then disassembled, re-cleaned, and reassembled. At which point it worked as designed.

The mud samples were evaluated to find that the regular production sample's key turned fine but did not actuate completely. The o-ring design worked well. The o-ring kept out most of the mud and water enabling it to function properly. The sample with the stainless steel insert worked best. The key turned easily and the lock plunger actuated smoothly.

6.0 REFERENCES

Not applicable.

7.0 CONCLUSION

The overall conclusion is that the #88022 lock mount assembly should be kept clean as possible during normal operation. After use, the radiographic unit and it's lock mount assembly should be washed to remove any dirt, salt, and grime to insure proper functioning.

The conclusion from testing different designs is that the #88026 lock mount should be modified from it's original design to include the #88002-1 stainless steel insert. The stainless steel insert was quoted at approximately $5.00 each and will be incorporated at the time of assembly. The aluminum lock mount presently is being produced as a finished casting. The light weight aluminum design is both desirable and is a functional alternative to an all solid stainless steel design.

Section 12. APPENDIX F – ORIGINAL TEST PLAN

TEST PLAN 125 (Rev. B)
Model 880 Type B Container
With 88070 Foot Button Assembly
And 88022 Lock Mount Modification
10CFR71, ISO 3999-1
Transport Conditions

TABLE OF CONTENTS

1.0 Purpose

The purpose of these tests is to assess the Model 880 transport container with the addition of the #88070 foot control button assembly. With the addition of these components and the modification of the #88022 lock mount, they will not adversely affect the packages ability as a "Type B" transport container.

The tests will be conducted and witnessed by at least one Engineer (the originator), one Regulatory, and one Quality person. The results of the test will be written in a test report and distributed through the engineering, quality, and regulatory departments for review.

We will test to 10CFR71 regulations for 71.73(1) *free drop*, 71.73(3) *puncture*, and 71.71(10) *penetration*. These tests will follow a random order except that the 71.73(3) puncture test will follow the 71.73(1) free drop test. Also, testing will be performed according to ISO 3999-1 regulations for 6.4.6.1 *horizontal shock.*

This test is a revision to Test Plan 125A. In this test plan, AEA Technology QSA will revert back to the original test plan (TP125) for it's #88070 component design with the following exception. The #88070-4 Shaft which was made of 304 stainless steel will be manufactured from phenolic (G-10 fiberglass) rod stock.

In reference to TP125A, the test failed when the 88070-4 Shaft made impact with the 88024 Titanium lock slide, pushing it through the 88026 Selector ring causing a failure. By manufacturing the Shaft out of G-10 material it would fail first before any damage could occur to the lock slide or the selector ring. See drawing #88070-4 (Rev. 3) for details of the improved design.

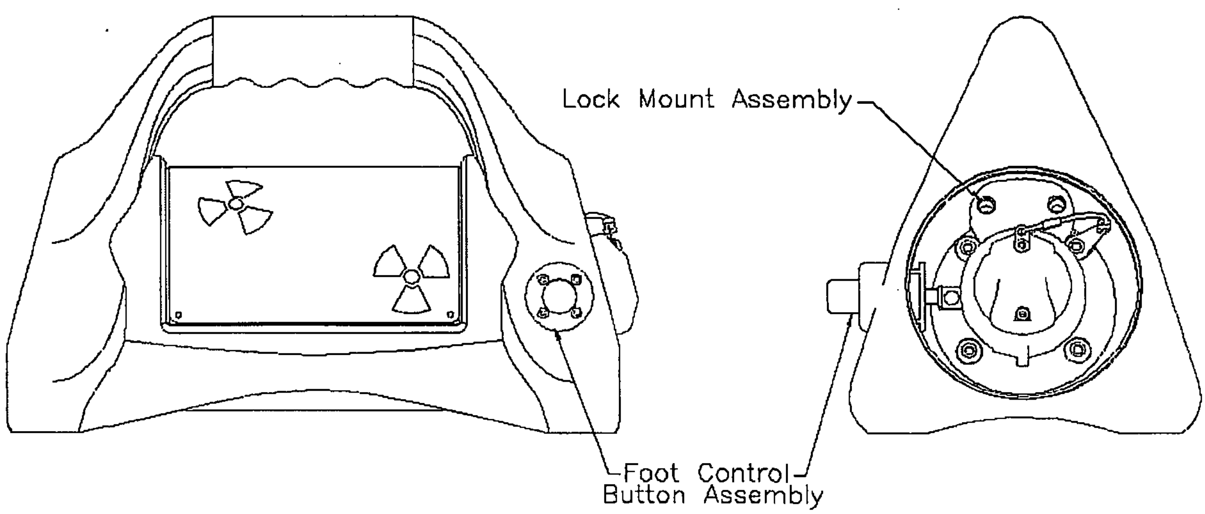
Testing not performed under this test (and necessary to demonstrate compliance with 10CFR71, ISO 3999-1, 49CFR and IAEA ~~TR-S-1~~) will be addressed in an assessment located in the final test report. TS-R-1

23 Oct 02

2.0 Product Design Description

The Model 880 "Delta" source projector, drawing #TP125A (weighted dummy unit) consists of the following components:

- 5" Dia. stainless steel body weldment with a "lead core" containing an S-tube.
- Stainless steel front and rear plate assemblies (with modified lock mount).
- #88041 Polyurethane jacket.
- #88070 foot control button assembly.



3.0 Failures of Interest

3.1 Foot Control Button Assembly

If the lock slide were to be forced from it's locked position, the source wire could become free to float inside the unit.

The drop test will show that the compressive load being transmitted through the 88070 foot control button assembly will not damage the 88024 lock slide located inside the 88020 rear plate assembly.

3.2 Lock Mount

If the aluminum lock mount receives a blow which damages this component and prevents the locking mechanism from actuating properly then the operator might be unable to use the radiographic camera as specified in the operations manual.

The ISO 3999-1 (6.4.6.1) horizontal shock test will show that with the addition of a stainless steel insert, that this will aid in better structural integrity to the lock mount assembly. See drawing 88022-1 for insert information.

Because the lock mount is designed not to extend beyond the surface of the camera body, the ISO 3999-1 (6.4.2) lock-breaking test, 10CFR 71 (71.73.1) free drop and (71.73.3) puncture test would not be relevant tests therefore will not performed.

Moreover, the ISO 3999-1 horizontal shock test is more severe than the 10CFR71 (71.71.10) penetration test. Because of this, the penetration test will not be performed.

4.0 Test Conditions and Orientations

The Foot Control Button Assembly (F.C.B.A.) was designed to thrust the lock slide into it's active position during operation. The F.C.B.A. was also designed to bottom out when the lock slide was fully actuated. With the new design (phenolic) of the lock slide, the force from actuating the F.C.B.A. cannot be translated directly to the lock slide.

4.1 Free Drop Test (3)

The 880 radiographic unit will be oriented so that the F.C.B.A. will be facing downward toward the test pad (T10261 SN01) for the 9m (30 ft.) drop test (see section 8.0). This will expose the assembled unit so the F.C.B.A. will receive an impact similar to a slap down effect. See section 3.2 for lock mount testing information.

4.2 Puncture Test (4)

According to the Purpose (Section 1.0 paragraph 4) section of this test plan an evaluation will be made before this test is performed. Unless stated in the test report, the following will most likely be performed. The 880 unit will be oriented in a similar angled fashion as above for the 1m (40 in.) drop test. The unit will be dropped onto a test billet (T10119 SN01) so as the F.C.B.A. sustains the full initial impact. See section 3.2 for lock mount testing information.

4.3 Penetration Test (2)

The 880 unit will be oriented so as the foot control button assembly will be facing upward while the jacket will be supported on an unyielding surface. The hemispherical end of a vertical steel cylinder (AEA Technology QSA Drawing #BT10129) of 3.2 cm (1.25 in) diameter and 6 kg (13 lbs.) mass will be dropped from a height of 1 m (40 in) onto the surface of the F.C.B.A. See section 3.2 for lock mount testing information.

4.4 Horizontal Shock Test (1)

The 880 unit will be oriented so the (1) F.C.B.A. and the (2) Lock Mount will impact the end-face of (T10333 SN01) 50 mm (2 in) diameter steel bar. The criteria is 300 mm (12 in) in length lying horizontally, that is fixed or welded to a rigid mass at least ten times the mass of the 880. The 880 will be suspended from a fixed point so that, when at rest, the F.C.B.A. and Lock Mount just touches the target. The 880 will be moved from its resting position until its center of gravity is 100 mm (4 in) higher than in the resting position and let loose, so that it swings in a pendulum movement against the target. This will be carried out for a total of twenty (20) times.

5.0 Pass and Fail Criteria

A final assessment shall be made upon the completion of the tests to evaluate the specimen's performance against the test requirements and determine a pass or fail judgement. The specimen(s) shall be considered passing the test requirement if the specimen meets the following criteria:

5.1 Foot Control Button Assembly

The lock slide must not be damaged in a way that the source wire assembly becomes free to move.

The radiographic unit must remain operational after the horizontal shock test. This means either with the actuation of the F.C.B.A. or by manual operation of the lock slide mechanism.

5.2 Lock Mount Assembly

The corbin lock mechanism must actuate freely after being subjected to the horizontal shock test. Also the stainless steel insert must stay in position. The Lock Mount and stainless steel insert will be secured in place with a dog point hex set screw. Loctite will also be added to a set screw prior to assembly. Moreover, the set screw in the Lock Mount assembly cannot back out of position after assembly because the Lock Mount seats up against the 88031 Front Plate.

Final assembly configuration will be noted on QC inspection/acceptance forms. The production unit will be assembled to comply with the tested configuration.

6.0 Test Specimen

The test specimen will be a fully weighted dummy "lead core" 880 Delta radiographic camera (reference AEA Technology QSA Drawing No. TP125A). The core will have no depleted uranium, however the lead core will encapsulate a titanium s-tube. The test specimen shall be examined after the test and any defects will be noted.

The test specimen was developed under drawing #88017XLS but stated that the unit was a Safety Class "C". The test unit should be a Safety Class "A" for traceability reasons. Therefore drawing TP125A was developed as a prototype drawing of the test unit with a Safety Class A.

AEA Technology QSA used a lead unit for this test for the soul evaluation of the Mechanical testing of exterior components. Therefore the unit did not need to be profiled.

Lead was also used to replicate the weight of the unit. The lead billet is orientated (center of gravity) in the same location as a DU unit. Moreover, the billet is mechanically attached with the same pins and hardware as a DU unit. Therefore the test unit will react in the same manner as the DU unit.

7.0 Testing Safety and Waste Disposal

Testing Safety

The tests will not be conducted with any radioactive sources. Instead, the testing of the Model 880 unit will use a dummy source wire assembly.

The weight of the testing will require lifting heavy objects. Proper lifting techniques shall be used to prevent injury.

Some tests of this plan may result in heavy falling objects and flying debris. Safety glasses and a safe distance must be used in these cases.

Waste Disposal

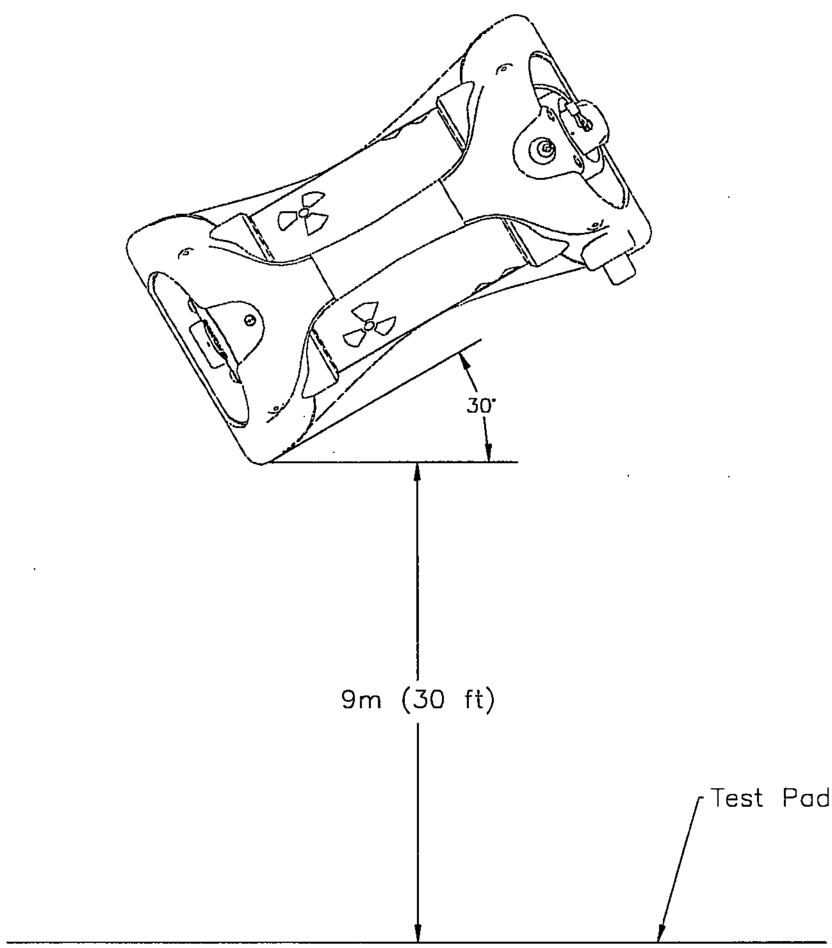
The test Model 880 and accessories will be kept and stored for reference until authorization by the engineering and regulatory department to dispose. No radioactive material will be used in the testing so the test specimens do not need to be kept in any special radiation storage areas.

Once approved for disposal by the engineering department and the regulatory department, the entire test units can be disposed of as standard garbage except for the lead shielding. The lead shall be removed from the Model 880 device and kept for the production department to melt down for other applications if applicable. If the unit remains in good condition, the unit will be repaired if necessary and used for future demo purposes.

8.0 Test Procedures

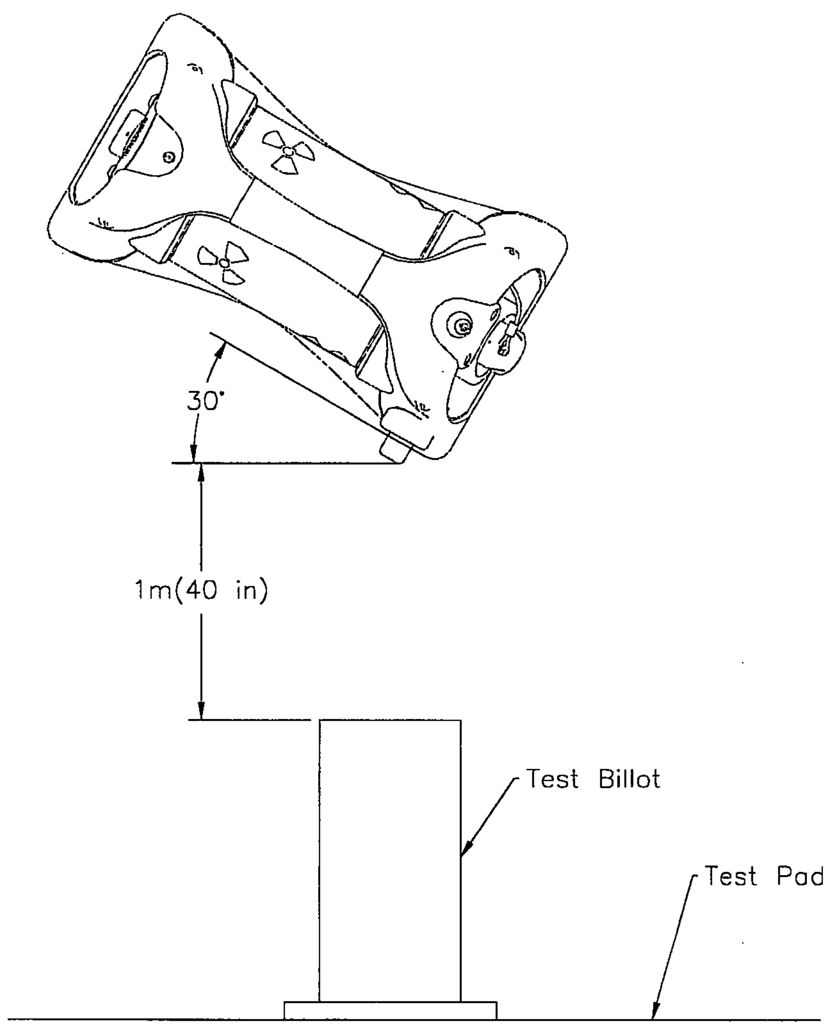
Free Drop Test 9m

1. Prepare test device by placing device into a sling device.
2. Hold test specimen orientated toward impact surface at a height of 9 m (30 ft) from the top of the drop pad surface to the bottom of the test specimen.
3. Drop the test specimen onto the rigid target surface.
4. Examine test specimen and evaluate to test requirements.
5. Record the results of the test.



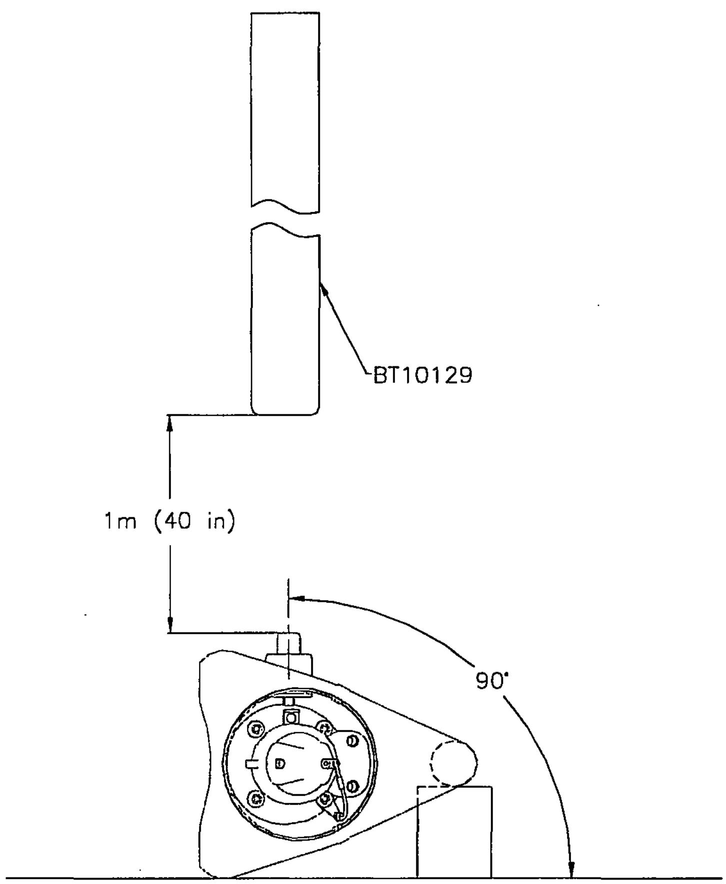
Puncture Test 1m

1. Prepare test device by placing device into sling device.
2. Hold test specimen orientated toward impact surface at a height of 1 m (40 in.) from the top of the test billet surface to the bottom of the test specimen.
3. Drop the test specimen onto the test billet surface.
4. Examine test specimen and evaluate to test requirements.
5. Record the results of the test.



Penetration Test

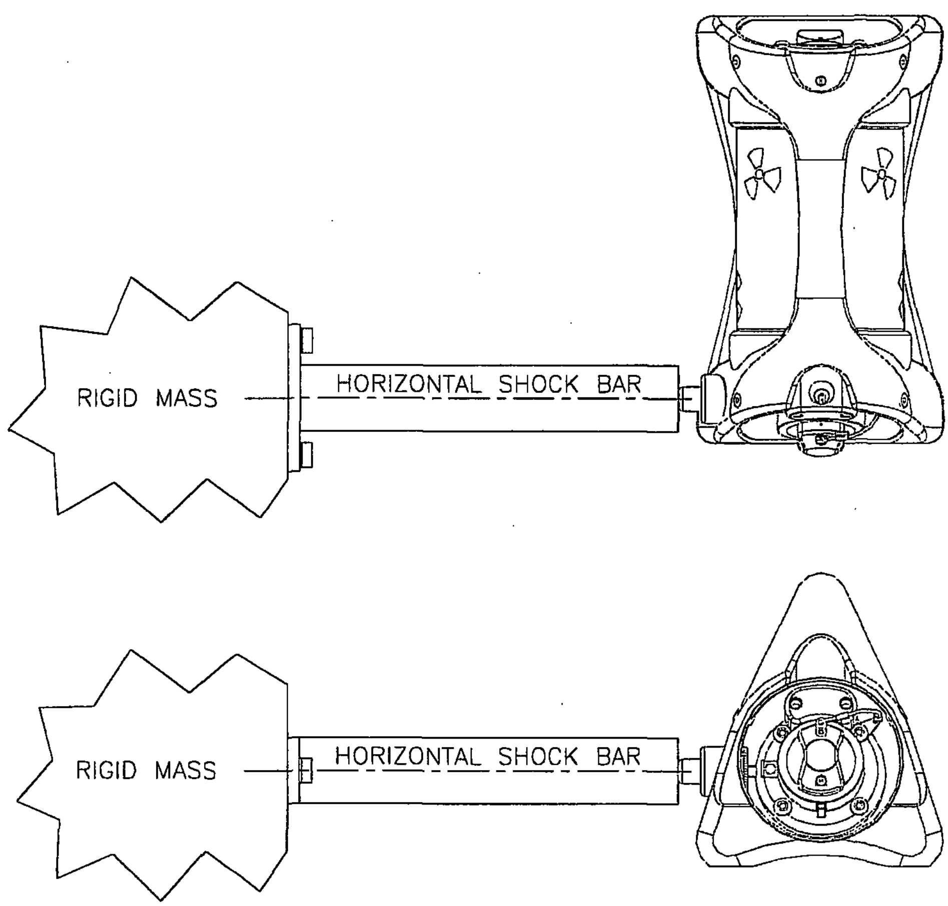
1. Prepare test device by placing device on an unyielding surface.
2. Orient F.C.B.A. in a vertical position while supporting handle of jacket.
3. Drop steel cylinder (T10129) from a height of 1m (40 in) onto the F.C.B.A.
4. Examine test specimen and evaluate to test requirements.
5. Record the results of the test.



Horizontal Shock Test

1. Prepare test device by placing device into a sling device.
2. Orient by suspending the F.C.B.A. in a horizontal position while touching (T10333) horizontal shock bar.
3. Move the 880 unit until its center of gravity is 100 mm (4 in) higher than its resting position.
4. Let it loose, so that it swings in a pendulum movement against the target for a total of 20 times.
5. Examine test specimen and evaluate to the test requirements.
6. Record the results of the test.

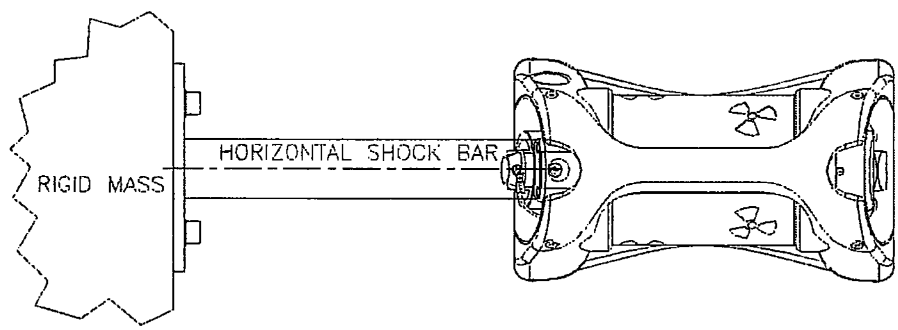
Foot Button Assembly (1)

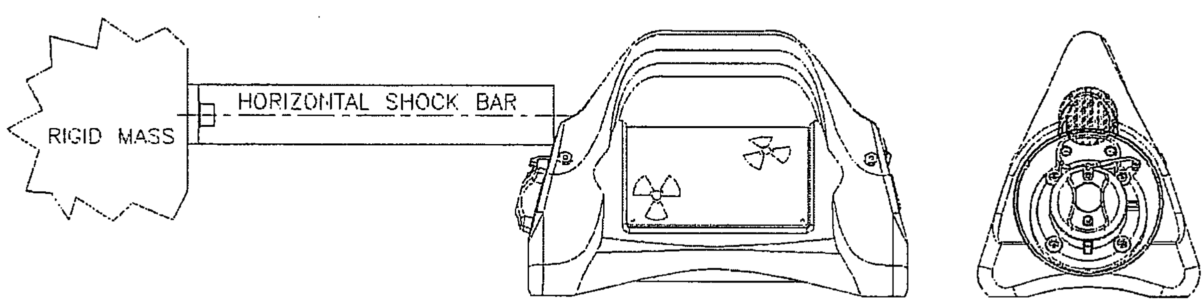


Horizontal Shock Test

1. Prepare test device by placing device into a sling device.
2. Orient by suspending the Lock Mount in a horizontal position while touching (T10333) horizontal shock bar.
3. Move the 880 unit until its center of gravity is 100 mm (4 in) higher than its resting position.
4. Let it loose, so that it swings in a pendulum movement against the target for a total of 20 times.
5. Examine test specimen and evaluate to the test requirements.
6. Record the results of the test.

Lock Mount (2)





Free Drop Test
10CRF71

Test Specimen:

Drawing No. ____________________ Rev. _______ Serial Number: ______________

Test weight ________________________ Scale Used ____________________

Test Setup:

Set up per: 10CFR71 (71.73(1)) free drop test procedure.

Pictures: ______________

Notes:

____

____

Drop surface:

Drawing No. ____________________ Rev. _______ Location: ____________________

Test Period:

Date & time: ____________________

Specimen Damage:

____

____

____

Recorded by:	Date:
Witnessed by:	Date:
Regulatory reviewed by:	Date:
Q.A. reviewed by:	Date:

Puncture Test
10CRF71

Test Specimen:

Drawing No. ____________________ Rev. _______ Serial Number: ______________

Test weight ________________________ Scale Used ____________________

Test Setup:

Set up per: 10CR71 (71.73(3)) puncture test procedure and assessed configuration.

Pictures: ______________

Notes (assessed configuration):

____

____

Drop surface:

Drawing No. ____________________ Rev. _______ Location: ____________________

Test Period:

Date & time: ________________________

Specimen Damage:

____

____

____

Post test assessment:

____

____

Recorded by:	Date:
Witnessed by:	Date:
Regulatory reviewed by:	Date:
Q.A. reviewed by:	Date:

Penetration Test **10CRF71**	
Test Specimen: Drawing No. ____________ Rev. ______ Serial Number: ____________ Test weight ____________ Scale Used ____________	
Test Setup: Set up per: 10CR71 (71.71(10)) penetration test procedure. Pictures: ____________ Notes: ____________ ____________	
Drop surface: Drawing No. ____________ Rev. ______ Location: ____________	
Test Period: Date & time: ____________	
Specimen Damage: ____________ ____________ ____________	
Post test assessment: ____________ ____________	
Recorded by:	Date:
Witnessed by:	Date:

Horizontal Shock Test
ISO 3999-1

Test Specimen:

Drawing No. ______________________ Rev. ______ Serial Number: ____________

Test weight __________________________ Scale Used _____________________

Test Setup:

Set up per: ISO 3999-1 (6.4.6.1) horizontal shock test procedure.

Pictures: ____________

Notes:

____

____

Horizontal Test Bar:

Drawing No. ______________________ Rev. ______ Location: _________________

Test Period:

Date & time: _____________________

Specimen Damage:

____

____

____

Post test assessment:

____

____

Recorded by:	Date:
Witnessed by:	Date:
Regulatory reviewed by:	Date:
Q.A. reviewed by:	Date:

Final Test Assessment

Test Specimen:

Serial Number(s): ____________________

Foot Control Button evaluation:

Spring (61lb.): ____________________
Spring (19lb.): ____________________
Stainless steel components: ____________________
F.C.B.A. working condition after Horizontal shock. ____________________

Foot Control Button Assembly evaluation:

Is the F.C.B.A. in working condition?

Comments:

Engineering Review by:	Date:
SME Review by:	Date:
Regulatory Review by:	Date:
Q.A. Review by:	Date:

Final Test Assessment

Test Specimen:

Serial Number(s): ______________________________

Lock Mount Assembly evaluation:

Aluminum housing: ______________________________
Stainless steel insert: ______________________________
Corbin lock: ______________________________
Lock Mount Assembly working condition after Horizontal shock. ____________________

Lock Mount evaluation:

Is the lock mount assembly in working condition?

Comments:

____
____
____
____
____
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____
____
____
____
____
____
____

Engineering Review by:	Date:
SME Review by:	Date:
Regulatory Review by:	Date:
Q.A. Review by:	Date:

10.0 Appendix: 10CFR71, ISO 3999-1, Technical Report #40, and F.C.B.A. Instruction Sheet.

2.12.7 Test Plan Report 74 (Feb 1998)

SENTINEL

	TEST PLAN NO. 74
TEST PLAN COVER SHEET	
TEST TITLE: Model 660 Hypothetical Accident Condition Tests	
PRODUCT MODEL: 660 (with stainless steel screws)	
ORIGINATED BY: S. Gomez	DATE: 17 DEC 1997
TEST PLAN REVIEW	
ENGINEERING APPROVAL: [signature]	DATE: 17 Dec 97
QUALITY ASSURANCE APPROVAL: [signature]	DATE: 17 Dec 97
REGULATORY AFFAIRS APPROVAL: C. Rongman	DATE: 17 Dec 97
COMMENTS:	
TEST RESULTS REVIEW	
ENGINEERING APPROVAL: [signature]	DATE: 18 Feb 98
QUALITY ASSURANCE APPROVAL: [signature] Changes - CMR [initials] KNA	DATE: 17 Feb 98 18 Feb 98
REGULATORY AFFAIRS APPROVAL: C. Rongman	DATE: 18 Feb 98

Amersham QSA

Test Plan #74 Results

This document describes the results of package design tests conducted for Hypothetical Accident Conditions (10 CFR 71.73) by Amersham to determine whether Model 660 Series projectors meet NRC requirements for Type B(U) packages.

The Model 660 Series includes the following models: 660, 660A, 660B, 660E, 660AE, and 660BE. Reference Certificate of Compliance 9033.

The tests were conducted in accordance with Amersham Test Plan #74 (dated December 16, 1997). The test plan also covers the criteria stated in IAEA, Safety Series 6 (1985, as amended 1990).

The purpose of the plan was to evaluate the performance of the Model 660 Series projectors that incorporate a proposed design change in which stainless steel end-plate screws are used instead of carbon steel screws.

This document reports on the manufacturing and acceptance of the test specimens, execution of the tests, test inspections, and assessment of the units as to their conformity with the requirements of 10 CFR 71.

Section 1 Transport Package Overview

The Model 660 Series projector consists of a source tube enclosed in a depleted-uranium shield, an end-plate with a lock assembly, a second end-plate with a storage plug assembly, four steel connecting rods, a sheet metal shell and foam packing material (Figure 1).

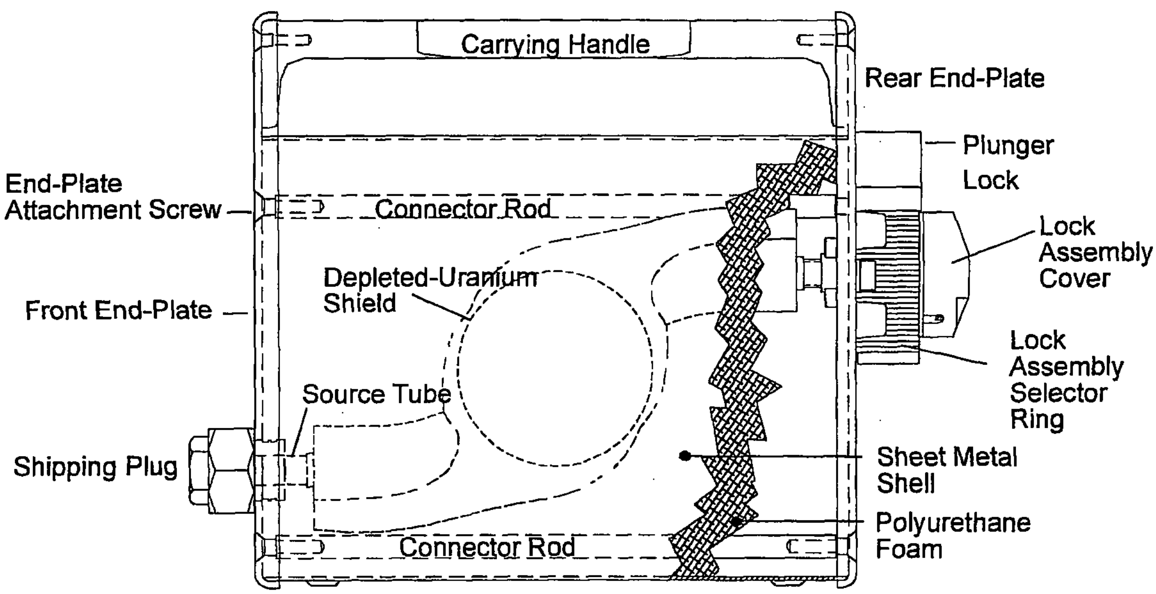


Figure 1: Side View of a Model 660 Series Projector

The shield consists of a 1/2-inch outside diameter source tube with its mid-section set in depleted uranium. One end of the source tube is inserted into a 1/2-inch hole in the lock assembly at the rear end-plate. The other end of the shield's source tube is inserted into another 1/2-inch hole in the shipping plug at the front end-plate. Both 1/2-inch holes allow enough radial clearance for a slip fitting attachment. There is approximately 1/8-inch axial clearance at the front end for assembly.

The source is contained in a special-form, encapsulated capsule assembly which is attached to the source wire assembly. This source wire assembly is secured in the package by the lock assembly. The lock assembly, in turn, is attached to the rear end-plate by four #10 stainless steel screws. There are two versions of the lock assembly used on the Model 660 series projectors. The size, material and location of the end-plate screws are identical on both versions.

The shield, end-plates and the sheet metal shell are connected by four 3/8-inch thick steel rods which are threaded at each end to accept 1/4-inch screws securing the end-plates to the rods.

A polyurethane foam is used to fill the space around the shield and to fill the void within the sheet metal shell. The foam acts as an impact absorber.

The depleted-uranium shield provides the primary radiation protection for the Model 660 Series projector. The shield accomplishes this by limiting the transmission of gamma rays to a dose level at or below 200 mR/hr at the package surface and limiting the dose level at or below 10 mR/hr at one meter from the surface of the package.

The location of the source relative to its stored position in the shield is also an important safety element. A large displacement of the source relative to its stored position could elevate the dose at the surface of the package above regulatory limits.

There are two possible scenarios to displace the source relative to its stored position:

- The shield could move away from the source if the source tubes were bent or fractured during testing.
- The source could move away from the shield if the lock assembly became loose or was removed from the end-plate or if the end-plates themselves became loose or were removed during testing.

The tests in this plan focused on damaging those components of the package which could cause the displacement of the source relative to its stored position within the shield.

Section 2 Test Specimen Production and Acceptance

The test units specified for this plan were seven test specimens manufactured for the Normal Transport Conditions testing under Test Plan #73.

The tests in Test Plan #74 were designed to further the damage inflicted on the units in Test Plan #73. The tests units were manufactured in the Amersham Burlington, Mass., facility in accordance with Amersham Drawing TP73, Rev. A.

As required in both test plans, the TP73 test units are standard Model 660B projectors with the following modifications:

- Shields weighing 37 to 39 pounds
- Supplemental lead added to the shield to increase shield assembly weight to 40 pounds
- Stainless steel screws used for end-plate fasteners instead of carbon steel screws
- End-plate screws with torque values set to either 10 in-lbs or 120 in-lbs

These modifications enabled us to produce test specimens that weighed at least 54 pounds, and to test the use of stainless steel end-plate screws as original equipment and as retrofit components.

Four test units (A, B, C and D) and three spares (S1, S2 and S3) were built according to the Drawing TP73, Rev. A. The units enabled us to test two different impact targets on units with end-plate screws set to different torque values (Table 1).

Table 1: TP73 Units

End-plate screw torque value	120 in-lbs (±10 in-lbs)	10 in-lbs (±2 in-lbs)
Impact bottom edge of rear plate	Specimens A, S1 and S3	Specimens C and S2
Impact top edge of front plate	Specimen B	Specimen D

The test specimens were manufactured in accordance with the Amersham Quality Assurance Program. The program provides for documentation of the manufacturing process, assures that the units comply with the relevant drawings and manufacturing instructions, and specifies radiological profiling of the completed product. Table 2 summarizes key manufacturing and profiling data.

Table 2: Test Specimen Manufacturing Data

Specimen	A	B	C	D	S1	S2	S3
Completion Date	12/16/97	12/16/97	12/16/97	12/16/97	12/16/97	12/16/97	1/6/98
Total Weight	55.1 lbs	54.9 lbs	55.3 lbs	54.9 lbs	54.8 lbs	55.1 lbs	55.3 lbs
Profile Data, Maximum Readings							
Package Surface (mR/hr)	142.5	142.5	133.0	133.0	152.0	152.0	147.0
At One Meter (mR/hr)	1.6	1.7	1.5	1.3	1.5	1.6	1.6

At the conclusion of Test Plan #73, representatives from Engineering, Quality Assurance and Regulatory Affairs reviewed test inspections and damage assessments on the test specimens. The assessment included radiation profiles on Specimens A, B, C, and D in accordance with Amersham Work Instruction Q09. The radiation profile worksheets are included in Appendix A. The maximum readings for each specimen are shown in Table 3. These readings, which are corrected for maximum capacity, demonstrate that the units met the requirements of 10 CFR 71.71 for normal conditions of transport.

Specimens S1, S2 and S3 were not subjected to Test Plan #73 testing until they were required as spares in Test Plan #74. The units were not profiled at the conclusion of the Normal Transport Conditions tests, as the purpose of the testing was to qualify the units for use in Test Plan #74 and profiling of A, B, C and D had already demonstrated conformity with 10 CFR 71.71 for all orientations.

Table 3: Maximum Readings from Test Plan #73 Final Test Inspection

Specimen	A	B	C	D	S1	S2	S3
Package Surface (mR/hr)	159.0	174.0	188.0	188.0	N/A	N/A	N/A
At One Meter (mR/hr)	1.4	1.2	1.5	1.3	N/A	N/A	N/A

Representatives from Engineering, Quality Assurance and Regulatory Affairs jointly confirmed that:

- The seven units selected for Test Plan #74 were adequately tested under Test Plan #73.
- There were no changes to the units since the final test inspections and assessments performed under Test Plan #73.
- No changes in orientation were required for the hypothetical accident conditions tests in Test Plan #74 because of damage sustained in Test Plan #73 testing.

Section 3 Hypothetical Accident Conditions

The TP73 test units underwent Hypothetical Accident Conditions tests in December 1997 and January 1998.

The testing demonstrated that the stainless steel end-plate screws maintained the end-plate connection throughout the tests. However, Specimen A had unacceptable radiation profile measurements after the thermal tests. Based on the data available, it is inconclusive whether the specimen failed because of a design flaw or because of damage incurred during handling and shipment.

This section describes the execution of the tests, results and the assessments made by representatives from Engineering, Regulatory Affairs and Quality Assurance.

3.1 Test Execution

The following Hypothetical Accident Conditions tests were conducted to meet the requirements of 10 CFR 71.73 and Test Plan #74:

- 30-foot free drop
- Puncture test
- Thermal test

Table 4 summarizes information about execution of the tests. In the table, package orientation is described as:

BRE where the impact surface is the bottom edge of the rear end-plate

TFE where the impact surface is the top edge of the front end-plate

NTP for normal transport position, that is, resting on the bottom

Table 4: Hypothetical Accident Conditions Tests (10 CFR 71.73)

Specimen	A	B	C	D	S1	S2	S3
30-foot Free Drop (Valley Tree, Groveland, Mass.)							
Test Date	12/23/97	12/24/97	12/23/97	12/24/97	1/8/98	12/24/97	1/11/98
Attempts	One	One	One	Two	One	One	Two
Orientation	BRE	TFE	BRE	TFE	BRE	BRE	BRE
Comments	Good hit	Good hit	Missed hit Replaced by S2	1st hit on right side; 2nd hit good	Missed hit Replaced by S3	Good hit	1st hit toward base; 2nd toward lock

Table 4: Hypothetical Accident Conditions Tests (10 CFR 71.73) (Continued)

Specimen	A	B	C	D	S1	S2	S3
Puncture Test (Valley Tree, Groveland, Mass)							
Test Date	12/23/97	12/23/97	Not Tested	12/24/97	Not Tested	12/24/97	1/11/98
Attempts	One	One		One		One	One
Orientation	BRE	TFE	BRE	TFE	BRE	BRE	BRE
Thermal Test (Manufacturing Science, Oak Ridge, Tenn.)							
Test Date	12/30/97	Not Tested	See Note1	12/30/97	Not Tested	12/30/97	1/13/98
Orientation	NTP			NTP		NTP	NTP

Note 1: Specimen C was subjected to the thermal test only to provide information to help in evaluating other specimens.

Testing began on December 23, 1997, with the four units that were used in the first round of Test Plan #73 testing. In the 30-foot free drop, Specimen C missed its intended impact surface, and was replaced by Specimen S2. S2 underwent normal testing under Test Plan #73 and on December 24, 1997, began testing under Test Plan #74.

The puncture test orientation for Specimens B and D was changed after the 30-foot drop to impact the top edge of the front end-plate to induce more damage, specifically to peel back the area of the end-plate left by the removed handle.

Specimen B did not undergo the thermal test because it was not as damaged as the other units. Specifically, there was no opening between the end-plate and the package, and therefore, it would sustain less damage from thermal testing.

Specimens A, D and S2 underwent thermal testing on December 30, 1997. The units were positioned in the normal transport position, that is, upright and resting on the bottom, to allow optimal airflow in and around the open gap created by damage to the shell and end-plates.

The units were shipped to Amersham's Burlington, Mass., facility on January 2, 1998, for radiographs and profiling. Amersham personnel were not on site in Oak Ridge to supervise the packaging and shipment of the test units.

The radiographs after the thermal tests showed displacement of the shield relative to the positions shown in radiographs taken after the puncture tests. In all three cases, a significant portion of the displacement was on the horizontal plane, indicating that the movement may have been caused during handling or shipment from Oak Ridge to Burlington. The thermal test orientation for these specimens would not have caused movement in the horizontal plane.

Profile results of Specimen A showed 9.3 R/hr at one meter. The other units (Specimens B and D) were within acceptable levels. To determine whether handling during transport caused the failure of Specimen A, we prepared Specimen S1 for testing and planned to measure the source position after the thermal test and before shipment.

In the 30-foot free drop, Specimen S1 missed its impact surface, creating the need for another substitution. A new unit, Specimen S3, was built and subjected to testing under Test Plan #73. The new unit underwent the 30-foot free drop and puncture test on January 11 and the thermal test on January 13.

The Specimen S3 was radiographed on site to determine source location before shipment and then radiographed upon receipt in Burlington. Comparison of the two radiographs showed no significant movement of the source. Subsequently the unit passed the radiation profile.

3.2 Damage Inspections

The test units incurred levels of mechanical damage as a result of the 30-foot free drop that were seen in previous testing:

- The rear end-plates were bowed on Specimens A, S2 and S3, producing a 3/16-inch (maximum) gap between the shell and end-plate.
- The tops of both end-plates were bent on Specimens B and D. No gap was produced on B; there was a 1/2-inch (maximum) gap on D.
- End-plate corners were crushed on Specimens S1 and C when these units missed their target impact surfaces. Both units were replaced.

In addition, the handle of Specimen B broke.

No additional mechanical damage to the tested units was evident as a result of the puncture test.

All of the stainless steel end-plate screws, including those set to 10 in-lb torque values, held the end-plates to the connecting rods, and there was no breakage.

Inspection of the units, including radiographs, showed that they maintained their structural integrity throughout the 30-foot drop and puncture test, that is, the source remained in the secured and shielded position and the end-plate screws held.

Four units were subjected to the thermal test: A, D, S2 and S3. As expected, the handle melted on each of the four units, and all or some of the foam burned off. There was no substantial oxidation of the shields as occurred in Test Plan #70. The end-plate-screws held the end-plates to the package throughout the testing and did not allow for increased airflow around the shield.

3.3 Test Assessment

The primary area of interest was the performance of the stainless steel end-plate screws. The test proved that the design change resolves the problem of shield performance caused by oxidation as occurred in Test Plan #70 and reported in the Test Plan #70 Test Results. In Test Plan #70, the oxidation occurred when the end-plate was not fully secured because of the breaks in the carbon steel end-plate screws.

Appendix A includes the worksheets for the radiation profiles taken as part of the final test inspection. Table 5 shows the maximum radiation measured in these profiles. The readings have been corrected for maximum capacity.

Table 5: Maximum Readings from Test Plan #74 Final Test Inspection

Specimen	A	B	C	D	S1	S2	S3
Profile date	1/5/98	1/5/98	Not profiled	1/7/98	Not profiled	Not profiled	1/19/98
Package Surface (mR/hr)	3000	390		281			1862
At One Meter (mR/hr)	9300	2.7		4.7			9.3

The evaluation of Specimen A and the subsequent testing of Specimen S3 did not resolve whether the movement of the source from its ideal shielded position was the result of a design flaw or the result of damage caused in handling and transport of the package. We were unable to exactly replicate the mechanical damage to Specimen A.

The measurement after the S3 thermal test showed that the source had moved only 0.2 inch, which resulted in acceptable levels of radiation. Test inspection revealed that the source wire had severed. The Specimen A source wire did not break and remained engaged in the lock assembly when the shield moved, pulling the source from the center of the shield which provides maximum shielding.

Although Specimen S3 satisfactorily met all of the test requirements, the damage was not identical to to Specimen A, and therefore, it could not be used as a replacement for Specimen A.

No conclusion can be drawn as to whether the Specimen A failed because of transport damage.

3.4 Conclusions

Based on the testing performed under Test Plan #74, the team concluded that:

- The stainless steel end-plate screws satisfactorily met all of the test requirements and the screws should be used on all Model 660 Series projectors.
- The torque value of the screws is not a significant factor in their performance and retrofitting of projectors with new screws can be accomplished in the field.
- Because of the difficulty of replicating specific mechanical damage, continued testing of TP73 units will probably not resolve the question of whether Specimen A failed because of design or damage from handling.
- Amersham should proceed with design evaluation *as if* Specimen A had failed because of its design, and examine design changes that would restrict shield movement during thermal testing.

Appendix A: Radiation Profile Worksheets

SENTINEL

660/660B DEVICE PROFILING FORM

B3587 (LMA) 12 Jan 98

TP73"A"

Device Model No.: 660B Device Serial No.: ~~After~~ Thermal

Ti0163

Model ~~424-9~~ Source Serial Number: X0016 Activity: 93.2 Ci

<500 mR/hr

~~Surface~~ Survey Instrument: AN/PDR 27T Serial No: SM-392401 Cal Due: 3/18/98

k) ≥ 500 mR/hr

~~One Meter~~ Survey Instrument: Tech-50 Serial No: B-814-S Cal Due: 7/22/98

Capacity Corr. Factor

1.5

	SURFACE READINGS mR/hr Extrapolated ~~Allowed~~ For Capacity only	Actual	ONE METER READINGS mR/hr Extrapolated ~~Allowed~~	Actual
TOP	780	520*		
RIGHT	3 R/hr	2 R/hr*		
FRONT	40.5	27	1.4	0.9
LEFT	3 R/hr	2 R/hr*		
REAR	3 R/hr	2 R/hr*	9.3 R/hr	6.2 R/hr*
BOTTOM	1.8 R/hr	1.2 R/hr*	18	12.0

>1 R/hr. No add'l measurements taken on device.

INSPECTOR: L. [signature] DATE: 5 Jan 98 NCR No.: ______

Comments:

- No surface corrections made. Actual surface enclosed in plastic bagging which varied in thickness from ½-1".

- Surface doses for general info only. Primary purpose of profile was for 1 meter readings. Surface levels on sides and rear may be higher than recorded. Radiation was a finely collimated beam from S-tube out the rear of the device which was difficult to quantify precisely without receiving

(VA) 12 Jan 98

Amersham QSA

WI-Q05

SENTINEL

660/660B DEVICE PROFILING FORM

B3588 (KNA) 12 Jan 98

Device Model No.: 660B Device Serial No.: ~~After Thermal~~ TP73 "B" After 30 Ft & Puncture LP 5 Jan

Model ~~424-9~~ T10163 Source Serial Number: X0016 Activity: 93.2C

Surface Survey Instrument: AN/PDR 27T Serial No: SM-392401 Cal Due: 3/18/98

One Meter Survey Instrument: Same Serial No: — Cal Due: —

* Non-leaded plug used during profile.

Capacity Corr. Factor 1.50

SURFACE READINGS mR/hr	Surf Corr Fact	Extrapolated ~~Allowed~~	Actual
TOP	1.16	104.4	60
RIGHT	1.28	153.6	80
FRONT	1.13	389.9	230
LEFT	1.28	115.2	60
REAR	1.13	152.6	90
BOTTOM	1.19	107.1	60

ONE METER READINGS mR/hr	Extrapolated ~~Allowed~~	Actual
TOP	1.0	0.7
RIGHT	0.9	0.6
FRONT	2.7	1.8
LEFT	0.75	0.5
REAR	1.5	1.0
BOTTOM	0.9	0.6

INSPECTOR: L. Pedrolet DATE: 5 Jan 98 NCR No.: ______

Comments:

(KNA) 12 Jan 98

Amersham QSA

SENTINEL

660/660B DEVICE PROFILING FORM

B3590 (KNA) 12 Jan 98

Device Model No.: 660B   Device Serial No.: TP73 "D" After Thermal

Model ~~424-9~~ T10163 Source Serial Number: X0016   Activity: 89.7 Ci

Surface Survey Instrument: ~~Bicron~~ Tech-50   Serial No: B-814-S   Cal Due: 7/22/98

One Meter Survey Instrument: Same   Serial No: –   Cal Due: –

Capacity Corr. Factor
1.56

	SURFACE READINGS mR/hr		ONE METER READINGS mR/hr	
	~~Allowed~~	Actual	Extrapolated ~~Allowed~~	Actual
TOP		130	2.3	1.5
RIGHT		180	1.9	1.2
FRONT		80	2.7	1.7
LEFT		50	2.2	1.4
REAR		90	4.7	3.0
BOTTOM		50	1.7	1.1

INSPECTOR: [signature]   DATE: 9 Jan 98   NCR No.: ______

Comments:

* Surface of unit enclosed in multiple layers of plastic bags for contamination control of uranium oxide. Thickness varies from 1/4" to 1".

* Surface readings taken for exposure control and general information purposes only.

(KNA) 12 Jan 98

Amersham QSA

WI-Q05

SENTINEL

660/660B DEVICE PROFILING FORM

TP74 + TP73 "S3" — Serial# B3586 (KMA 21 Jan 98)

Device Model No.: 660B Device Serial No.: After Thermal

Model ~~424-9~~ T10163 Source Serial Number: X0017 Activity: 105.0 Ci

Surface Survey Instrument: AN/PDR-27T Serial No: SM-392401 Cal Due: 18 Mar 98

One Meter Survey Instrument: AN/PDR-27T Serial No: SM-392401 Cal Due: 18 Mar 98

Capacity Corr. Factor
1.33

SURFACE READINGS mR/hr

	~~Allowed~~	Actual
TOP		70 mR/hr
RIGHT		80 mR/hr
FRONT		940 mR/hr Δ
LEFT		110 mR/hr
REAR		1400 mR/hr Δ
BOTTOM		130 mR/hr

ONE METER READINGS mR/hr

	Extrapolated ~~Allowed~~	Actual
TOP	1.9	1.4 mR/hr
RIGHT	1.5	1.1 mR/hr
FRONT	5.6	4.2 mR/hr
LEFT	1.3	1.0 mR/hr
REAR	9.3	7.0 mR/hr
BOTTOM	1.6	1.2 mR/hr

INSPECTOR: [signature] DATE: 19 Jan 98 NCR No.: NA

Comments:

* Surface readings taken for exposure control and general information purposes only.

Δ Measurements taken with Model # ND 3000, S/N 9837 (Next cal date 23 Sept 98) [initials] 19 Jan 98

Amersham QSA

Table of Contents

List of Figures and Tables

Amersham Test Plan #74

This document describes additional package design testing for Sentinel Model 660 Series projectors to meet NRC requirements for Type B(U) packages under Hypothetical Accident Conditions (10 CFR 71.73). Testing under Normal Transport Conditions (10 CFR 71.71) is described in Amersham Test Plan #73.

The test plan also covers the criteria stated in IAEA, Safety Series 6 (1985, as amended 1990). Quality Assurance will be involved in all aspects of this test plan and its execution.

The Model 660 Series includes the following models: 660, 660A, 660B, 660E, 660AE, and 660BE. Reference Certificate of Compliance 9033.

The tests in this plan evaluate a Model 660 Series design change that resulted from tests performed under Amersham Test Plan #70. In that testing, the 30-foot free drop caused failure of the end-plate screws on Specimen D, and subsequent oxidation and loss of the shield during the thermal test. The design change involves the use of stainless steel end-plate screws instead of the carbon steel screws used in the Test Plan #70 specimens.

We are specifying Military Standard screws, MS 51959-81 (1/4-20 x 3/4" long). The specification is included in Appendix B: Selected Fasteners. The tensile strength of these screws is twice that of the nominal strength of the carbon steel screws (110,000 psi versus 55,000 psi). In addition, at room temperature, the toughness of stainless steel is 40% greater than that of carbon steel; at -40° C, the stainless steel's toughness is four times greater than carbon steel's. Refer to the toughness versus temperature curve in Appendix B: Selected Fasteners.

As noted in the failure analysis by Packaging Technology, Inc. (November 25, 1997), the Specimen D shield experienced a deceleration of 200g in the 30-foot free drop in Test Plan #70. If the two end-plate screws closest to the lock assembly experience the full extent of the shield deceleration load, the tensile stress induced in these screws is calculated as follows:

$$\begin{aligned} \text{stress} &= \text{(shield mass) (impact deceleration) / tensile area} \\ &= \text{(40 lbs) (200g x cos 39°) / (2 x 0.0318 in}^2\text{)} \\ &= \text{97,800 psi} \end{aligned}$$

The induced stress is less than the ultimate strength of the two stainless steel screws (110,000 psi).

This document outlines the testing scenario, justifies the package orientations, and provides test worksheets to record key steps in the testing sequence.

1.0 Current Transport Package Overview

The Model 660 Series projector consists of a source tube enclosed in a depleted-uranium shield, an end plate with a lock assembly, a second end plate with a storage-plug assembly, four steel connecting rods, a sheet metal shell and foam packing material (Figure 1).

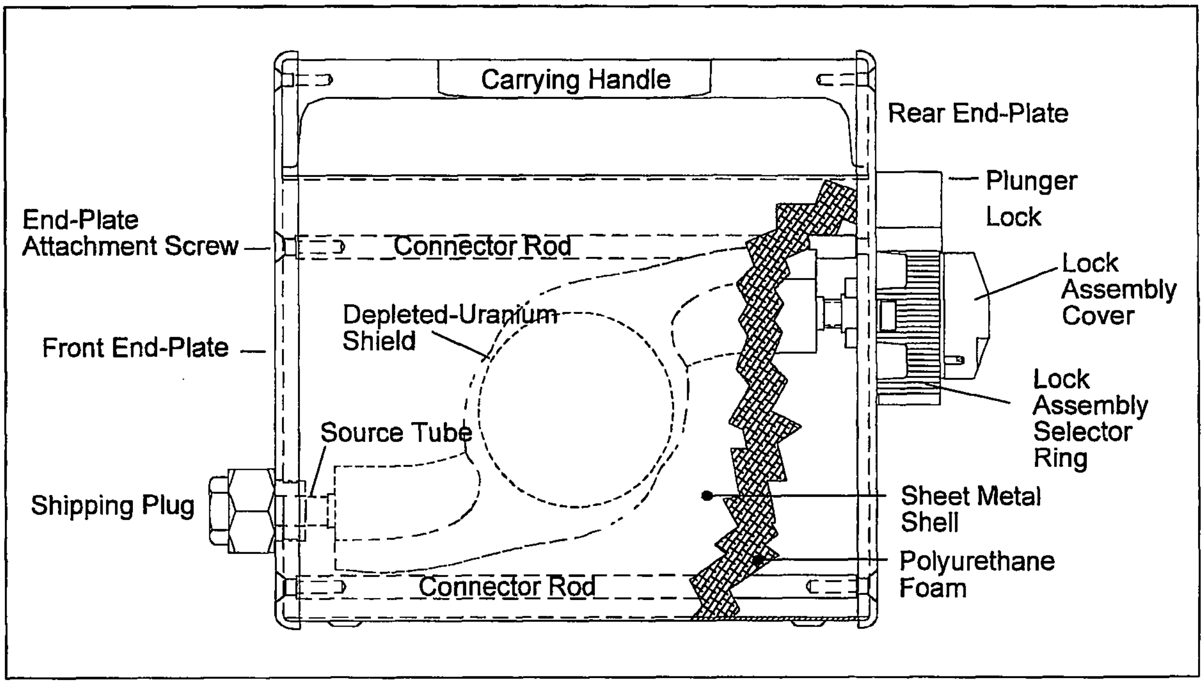


Figure 1: Side View of a Model 660 Series Projector

The shield consists of a 1/2-inch outside diameter source tube with its mid-section set in depleted uranium. One end of the source tube is inserted into a 1/2-inch hole in the lock assembly at the rear end-plate. The other end of the shield's source tube is inserted into another 1/2-inch hole in the shipping plug at the front end-plate. Both 1/2-inch holes allow enough radial clearance for a slip fitting attachment. There is approximately 1/8-inch axial clearance at the front end for assembly.

The source is contained in a special-form, encapsulated capsule assembly which is attached to the source wire assembly. This source wire assembly is secured in the package by the lock assembly. The lock assembly, in turn, is attached to the rear end-plate by four #10 stainless steel screws. There are two versions of the lock assembly used on the Model 660 series projectors. The size, material and location of the end-plate screws are identical on both versions.

The shield, end plates and the sheet metal shell are connected by four 3/8-inch thick steel rods which are threaded at each end to accept 1/4-inch screws securing the end plates to the rods.

A polyurethane foam is used to fill the space around the shield and fill void within the sheet metal shell. The foam acts as an impact absorber.

The depleted-uranium shield provides the primary radiation protection for the Model 660 Series projector. The shield accomplishes this by limiting the transmission of gamma rays to a dose level at or below 200 mR/hr at the package surface and limiting the dose level at or below 10 mR/hr at one meter from the surface of the package. A fracture of the shield could compromise this protection.

The location of the source relative to its stored position in the shield is also an important safety element. A large displacement of the source relative to its stored position could elevate the dose at the surface of the package above regulatory limits.

There are two possible scenarios to displace the source relative to its stored position:

- The shield could move away from the source if the source tubes were bent or fractured during testing.
- The source could move away from the shield if the lock assembly became loose or was removed from the end plate or if the end plates themselves became loose or were removed during testing.

The tests in this plan focus on damaging those components of the package which could cause the displacement of the source relative to its stored position within the shield and which affect the integrity of the shield itself.

2.0 Purpose

The purpose of this plan, which was developed in accordance with Amersham SOP-E005, is to test and evaluate modifications to the Model 660 Series projectors so that the Type B transport package requirements of 10 CFR 71 are met.

The series includes these models: 660, 660A, 660B, 660E, 660AE, and 660BE. Refer to Appendix A for descriptive drawings of these models.

The Normal Transport Conditions tests (10 CFR 71.71) have been performed on the test specimens as part of Amersham Test Plan #73. These tests included the compression test, penetration test and four-foot free drop.

The Hypothetical Accident Conditions tests (10 CFR 71.73) to be performed are the 30-foot free drop, puncture test, and thermal test.

The crush test (10 CFR 71.73(c)(2)) is not performed because the radioactive contents are special-form radioactive material.

The immersion test and all other conditions specified in 10 CFR 71 will be separately evaluated in accordance with Amersham Work Instruction WI-E08.

3.0 System Failure of Interest

The possible system failure tested in this plan is the failure of the end-plate screws. Failure of the end-plate screws on either plate could cause exposure of the shield to damage during the thermal test, especially if the foam burns.

Two package orientations are specified in this plan:

- Specimen D orientation in Test Plan #70, the orientation that caused the end-plate screw failure.
- Inversion of the Test Plan #70 Specimen D orientation. The impact surface is the top edge of the front plate.

Other orientations that were considered but rejected include:

- End plate sides. Because these surfaces are curved, they provide very small impact surfaces compared to the top or bottom edge of either plate.
- Top edge of the rear plate. The load on the screws provided by this orientation would be less than the load created by the orientation for Specimens B and D.

Figure 2 through Figure 5 show the four possible orientations to impact either the top or the bottom edge of an end-plate. With each figure is a calculation of the loading on the screws of interest. The calculations assume that the end plate is attached only at point **a**.

For sake of illustration, the calculations use 56 pounds for the vertical force. In the calculations:

$\mathbf{f_x}$ is the component force loading parallel with the axis of the screws.

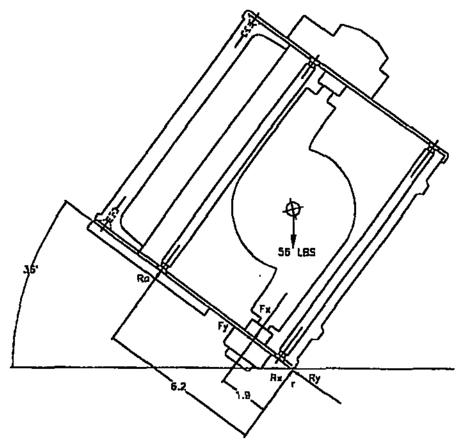
$\mathbf{f_y}$ is the component force loading perpendicular to the axis of the screws.

Summing the moments around the impact point (**r**) and equating it to zero determines the resultant force at the point of the screws (**a**).

Figures 3 and 4 demonstrate the worst-case loading on the end-plate screws of interests. These are the orientations selected for this test plan.

Two units are to be tested with each orientation, one with the end-plate screws torqued to 120 in-lbs (±10 in-lbs), the other with the end-plate screws tightened to 10 in-lbs (±2 in-lbs).

The orientations in this test plan are designed to further the damage to the end-plate screws caused during the execution of Test Plan #73.

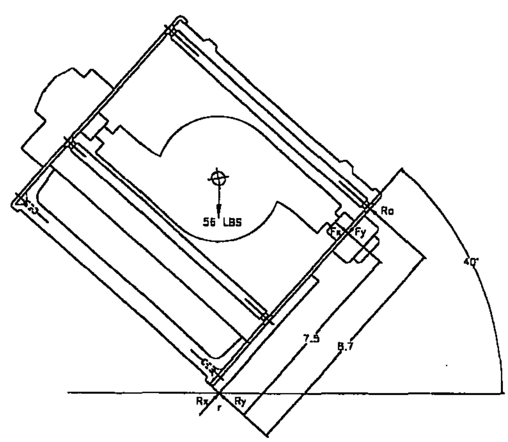


$Fx = 56 \cos(36°) = 45$ LBS
$Fy = 56 \sin(36°) = 33$ LBS

$Mr = 0 = (1.9)*(45) - (6.2)*(Ra) = 0$
$Ra = 13.8$ LBS

IMPACT ON BOTTOM FRONT EDGE

Figure 2: Impact on Bottom Edge of Front End Plate



$Fx = 56 \cos(40°) = 43$ LBS
$Fy = 56 \sin(40°) = 36$ LBS

$Mr = 0 = (7.5)*(43) - (8.7)*(Ra) = 0$
$Ra = 37.1$ LBS

IMPACT ON TOP FRONT EDGE
(ORIENTATION B&D)

Figure 3: Impact on Top Edge of the Front Plate

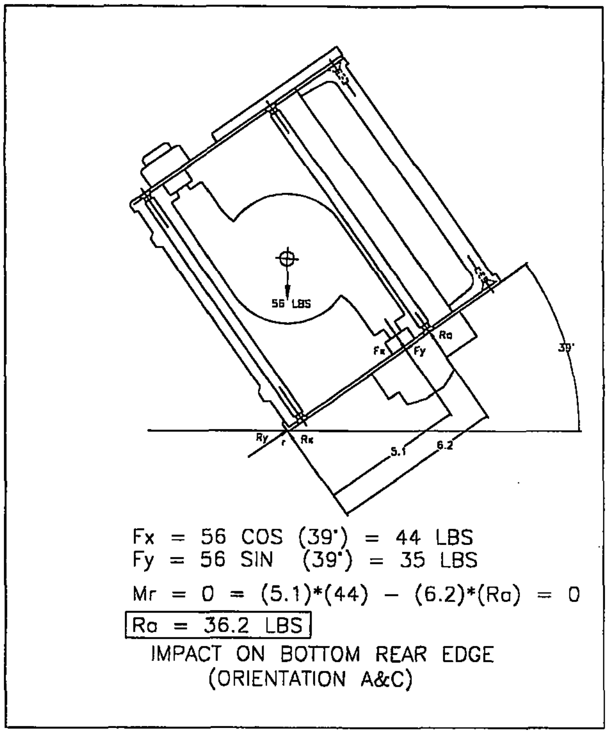


Figure 4: Impact on Bottom Edge of Rear Plate

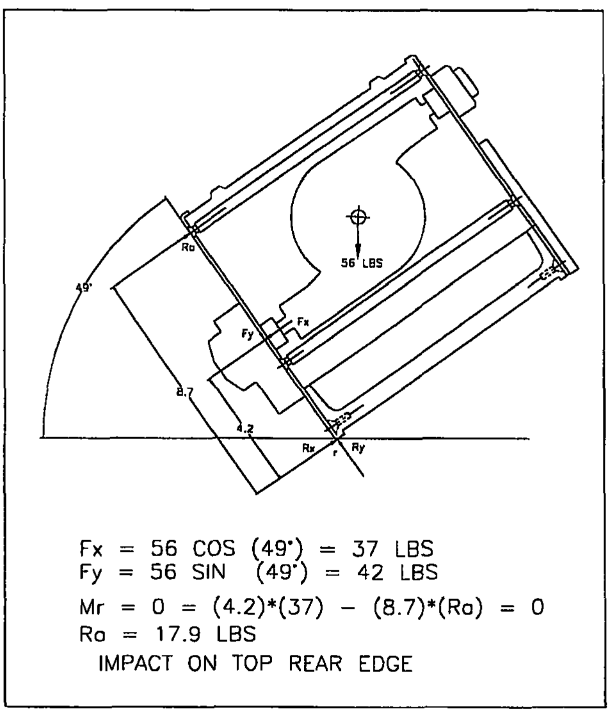


Figure 5: Impact on Top Edge of the Rear Plate

4.0 Construction and Condition of Test Specimens

The test specimens will be the Model 660B units built for the Normal Transport Conditions tests in Test Plan #73. These units were constructed in accordance with Amersham Drawing TP73, Rev. A (Drawing TP73). With the exception of the stainless steel end-plate screws, the units specified in Drawing TP73 are in accordance with the NRC-approved design.

Drawing TP73, specifies the Model 660 Series in its worst-case transport condition, that is, with supplemental lead added to the shield. The added weight induces higher loads during dynamic testing.

For the 30-foot free drop and the puncture tests, the test temperature of specimen must be at or below -40° C at the time of each test, a minimum temperature required by IAEA, Safety Series 6 (1985, as amended 1990). The low temperature represents the worst-case condition for the package because of the potential for reduction in strength of the end-plate screws.

Four test units and two spares were built according to the Drawing TP73 and the Amersham Quality Assurance Program:

End-plate screw torque value	120 in-lbs (±10 in-lbs)	10 in-lbs (±2 in-lbs)
Impact bottom edge of rear plate	Specimen A	Specimen C
Impact top edge of front plate	Specimen B	Specimen D
Spare unit	Specimen S1	Specimen S2

- The tests for Specimens A and C attack the end-plate screws by targeting the bottom edge of the rear end-plate.
- The tests for Specimens B and D attack the top edge of the front plate.

The package orientations specified in this plan are designed to further the damage inflicted on the TP73 test units in testing under Normal Transport Conditions.

NOTE: *Because each test is designed to add to damage inflicted on a specific component or assembly in the preceding test, it is important that each specimen maintain its identity throughout the battery of tests and that the setup instructions specific to the specimen are strictly followed.*

Table 1 lists the differences between the test specimens and other 660 Series models.

Table 1: Model 660 Series Variations

Feature	Test Specimen per Drawing TP73	660 Series Models
Shell Material	Stainless steel	Models 660AE, 660BE and 660E have wires and connectors attached to ends plates for automatic actuation. Models 660, 660A and 660B do not have actuator wires and connectors.
Lock Assembly	Posilok™	The Model 660 and 660E use a non Posilok lock assembly. All other models feature the Posilok lock assembly.
Actuator Wires and Connectors	No actuator wires and connectors	Models 660AE, 660BE and 660E have wires and connectors attached to ends plates for automatic actuation. Models 660, 660A and 660B do not have actuator wires and connectors.
Shield Capacity	140 Curie	The following models have 120-Curie capacity shields: 660, 660A, 660AE and 660E. The following models have 140-Curie capacity shields: 660B and 660BE.
Body Width	Standard width (5 1/4 inches)	Some Model 660s and Model 660Es have a narrow-body design (4 3/4 inches wide). All other models only use the standard-width body (5 1/4 inches).
Source Tube Material	Titanium	Prior to 1980, the Models 660, 660A, 660AE and 660E were manufactured with zircaloy source tubes. All other units have titanium source tubes.
Use of Lead	Supplemental lead added	Prior to June 1992, some units in the Model 660 Series had lead added to supplement the shielding. The maximum amount of lead added was three pounds. The amount was also limited by a maximum shield weight of 40 pounds and a maximum package weight of 56 pounds.
Weight	54 pounds minimum	Over the last five years, the average package weight has been approximately 50 pounds. Earlier in the product history, the average weight was approximately 53 pounds.
End-plate fasteners	Stainless steel screws MS 51959-81	Standard Model 660 Series projectors have commercial carbon steel end-plate screws.

Table 1: Model 660 Series Variations (Continued)

Feature	Test Specimen per Drawing TP73	660 Series Models
End-plate screw torque value	Specimens A, B and S1 end-plate screws tightened to 120 in-lbs (±10 in-lbs) Specimens C, D and S2 end-plate screws tightened to 10 in-lbs (±2 in-lbs)	Carbon steel screws used in the standard Model 660 Series projectors are torqued to 80 in-lbs (±10 in-lbs)

The differences listed in Table 1 impact the testing or are made for the following reasons:

- **Shell Materials**: The shell thickness is 1/16-inch for the carbon steel and stainless steel versions. The likelihood of a crack or brittle flaw increases with the thickness of the section and is a problem in sections greater than 1/8-inch. Additionally, the temperature for transition from ductile to brittle failure is lower for the thinner sections. The thicker carbon steel end plates will reach the ductile-to-brittle transition temperature long before the shell does. The end plates are structural members, while the shell is not structurally significant.
- **Lock Style**: Damage to the Posilok lock assembly used on the test specimen would represent damage to any Model 660 Series lock assembly, including the non Posilok style assemblies used on the Model 660 and the Model 660E.

  The internal components of both lock assemblies are protected by the same lock assembly cover and practically the same selector ring. The cover and selector ring must be significantly damaged before an impact can disrupt the internal components' securement of the source. Because of the strength of the cover and the selector ring, damage to the source securement is more likely to occur from the failure of the lock assembly screws. All models use the same type and size screws in the same locations.
- **Actuator Wires and Connectors:** The additional parts used for automatic actuation provide no structural support.
- **Shield Capacity:** The lower-capacity shields are either lighter than or the same weight as the shield used on the Model 660B, making the 660B the worst case for shield failures of interest in these tests.
- **Body Width:** The end plates and shells of the narrow-body versions of the Model 660 and the Model 660E would provide smaller impact surfaces than the standard-width plates and shell used in the test specimen. The smaller impact surfaces would result in greater surface deformation and less deceleration on impact. As a result there would be less transfer of impact forces that could affect the integrity of the source securement.

- **Source Tube Material:** The Model 660 Series projectors have been manufactured with titanium source tubes exclusively since 1980. Because this represents our current manufacturing methods and because the majority of Model 660 Series units currently in use have titanium source tubes, the test specimens will be manufactured with titanium source tubes. Based on an evaluation of the damage caused by the tests, we will assess the implications for previously fabricated packages which utilized zircaloy.

  Note that although listed on the descriptive drawings, stainless steel source tubes have never been used in the fabrication of Model 660 Series units, nor do we intend to use them in future fabrication.

- **Supplemental Lead:** Prior to June 1992, supplemental lead was used in the production of Model 660 Series projectors with the depleted-uranium shield. Although the addition of supplemental lead is no longer a production technique, the test specimens will be fabricated with the supplemental lead to ensure the maximum device mass.

- **Package Weight:** Because of more efficient casting and the elimination of supplemental lead shielding, the average weight of Model 660 units produced in the last five years is three pounds less than the average weight for units produced in the early years of the series history. Two steps will be taken to build test specimens that will weigh at least 54 pounds:

  - Heavier depleted-uranium shields will be fabricated.
  - Supplemental lead will be added to the shield.

  The TP73 will be consistent with current manufacturing procedures and will represent the heavier units in the Model 660 population. Ninety-seven percent of all 660 units produced weigh 54 pounds or less.

- **End-plate screws:** Stainless steel end-plate screws are being used on the TP73 to test the ability of these fasteners to prevent the failure of the end-plate screws seen in TP70 Specimen D.

- **End-plate screw torque values:** The greater strength of the selected stainless steel end-plate screws allows tightening to a higher torque value than the carbon steel screws. The higher value is being tested with Specimens A and B to evaluate a new manufacturing standard. A low torque value is being tested with Specimens C and D to simulate an untorqued assembly.

5.0 Material and Equipment List

The test worksheets in Section 7.0 list the key materials and equipment specified in 10 CFR 71 and the necessary measurement instruments.

When video recording is specified in the following tests, select video cameras with the highest shutter speed practical to record testing.

Additional materials and equipment may be used to facilitate the tests.

6.0 Test Procedure

Four units are tested in parallel with the same sequence but with two different package orientations that test the use of stainless steel end-plate screws, as described in Section 3.0. The tests have the following sequence:

1. Test specimen preparation and inspection
2. 30-foot free drop (10 CFR 71.73(c)(1))
3. Puncture test (10 CFR 71.73(c)(3))
4. Intermediate test inspection
5. Thermal test (10 CFR 71.73(c)(4))
6. Final test inspection

6.1 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 ensure compliance with 10 CFR 71, other regulatory requirements and the Amersham Quality Assurance Program.
- Engineering, Regulatory Affairs and Quality Assurance are jointly responsible for assessing test and specimen conditions relative to 10 CFR 71.
- Quality Control, a function that reports directly to Quality Assurance, is responsible for measuring and recording test and specimen data throughout the test cycle.
- The managers directly responsible for Engineering, Regulatory Affairs and Quality Assurance will identify and document personnel who are qualified to represent their departments in carrying out this test plan.

6.2 Test Specimen Preparation and Inspection

To prepare the test units:

1. Select the units tested under Amersham Test Plan #73.
2. Inspect the test units to ensure that they match the units described on the Test Plan #73 worksheets and attached damage assessments.
3. Confirm that a radiation profile was performed and recorded in accordance with Amersham Work Instruction WI-Q09 at the conclusion of Test Plan #70.
4. Measure and record the weight of each test specimen.
5. Prepare the packages for transport.

6.3 30-foot Free Drop Test (10 CFR 71.73(c)(1))

The first Hypothetical Accident Conditions test is the 30-foot free drop as described in 10 CFR 71.73(c)(1). This drop compounds any damage caused in the three Normal Transport Conditions tests in Test Plan #73.

Use *Checklist 1: 30-foot Free Drop* on page 27 to ensure that the test sequence is followed. Date and initial all action items, and record required data on the worksheet.

Figure 6 illustrates the orientation for Specimens A and C. Figure 7 shows the orientation for Specimen B and D. The orientations are the same as those for the four-foot free drop in Test Plan #73 except the package is raised 30 feet above the drop surface.

This test requires that test specimens be at or below -40° C at the time of the drop. Follow the Worksheet instructions for measuring and recording the specimen temperature before and after the drop.

6.3.1 30-foot Free Drop Setup

To set up a package for the 30-foot drop test:

1. Use the drop surface specified in Drawing AT10122, Rev B.
2. Measure and record the weight of test specimen.
3. Measure and record the specimen's internal and surface temperature, and ensure that the package is at or below -40° C.
4. Place the specimen on the drop surface and position it according to the appropriate orientation.

   Refer to Figure 6 for Specimens A and C.

   Refer to Figure 7 for Specimens B and D.
5. Align the selected center-of-gravity marker as shown in the referenced drawing.
6. Raise the package so that the impact target is 30 to 32 feet above the drop surface.

6.3.2 Orientation for the 30-foot Free Drop: Specimens A & C

Figure 6 shows the package orientation for Specimens A and C for the 30-foot free drop.

This orientation targets the bottom edge of the rear end-plate with the objective of loosening or shearing the end-plate screws which hold the plate to the steel connecting rods. The bottom edge of the plate provides the greatest surface area for a direct hit, and thus the most rapid deceleration, and was proven to be the most damaging to the unit during previous testing in Test Plan#70.

Make sure the center of gravity is directly over the point of impact.

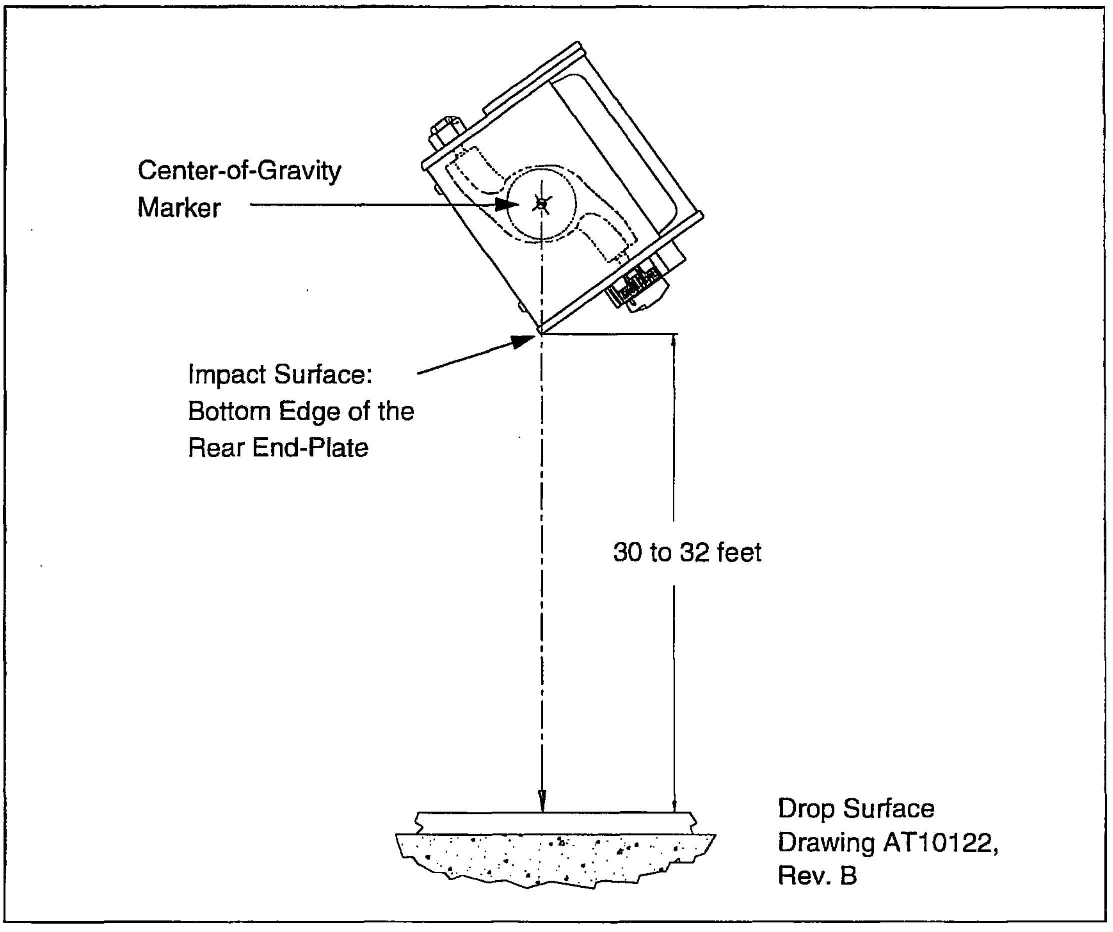


Figure 6: Orientation for the 30-foot Free Drop: Specimens A & C

6.3.3 Orientation for the 30-foot Free Drop: Specimens B & D

Figure 7 shows the package orientation for Specimens B and D for the 30-foot free drop.

This orientation targets the top edge of the front end-plate. The drop is designed to cause deformation of the end plate, which in turn will create multiple loads paths on the end-plate screws.

Make sure the center of gravity is directly over the point of impact.

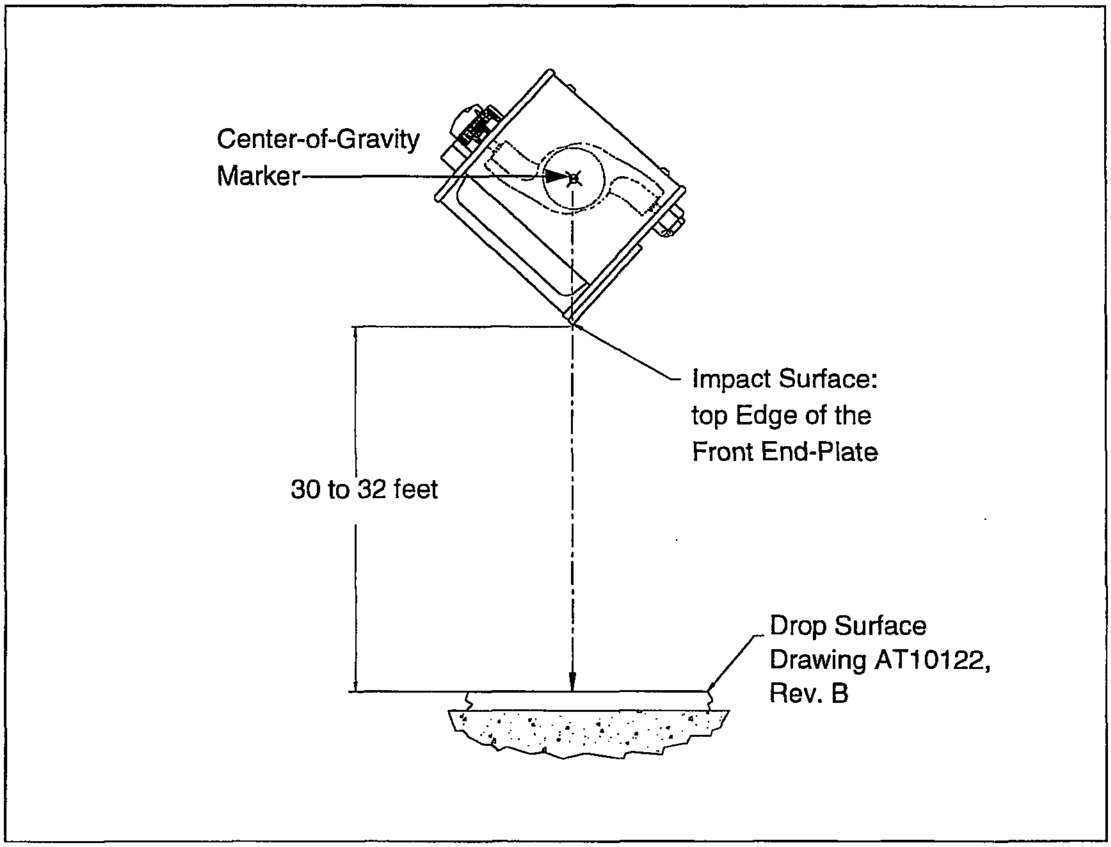


Figure 7: Orientation for the 30-foot Free Drop: Specimens B & D

6.3.4 30-foot Free Drop Test Assessment

Upon completion of the test, Engineering, Regulatory Affairs and Quality Assurance team members will jointly perform the following tasks:

- Review the test execution to ensure that the test was performed in accordance with 10 CFR 71. Units S1 and S2 may need to be tested, possibly with torque adjustments, to ensure test compliance.
- Make a preliminary evaluation of the specimen relative to the requirements of 10 CFR 71.
- Assess the damage to the specimen to decide whether testing of that specimen is to continue.
- Evaluate the condition of the specimen to determine what changes are necessary in package orientation in the puncture test to achieve maximum damage.

6.4 Puncture Test (10 CFR 71.73(c)(3))

The 30-foot free drop is followed by the puncture test per 10 CFR 71.73(c)(3), in which the package is dropped from a height of at least 40 inches onto the puncture billet specified in Drawing CT10119, Rev. C.

The billet is to be bolted to the drop surface used in the free drop tests (Figure 8).

Use *Checklist 2: Puncture Test* on page 31 to ensure that test sequence is followed. Date and initial all action items, and record required data.

6.4.1 Puncture Test Setup

There are two different package orientations for the puncture test. Each orientation assures that the package lands on the component or assembly of interest.

NOTE: *Because each test is designed to add to damage inflicted on a specific component or assembly in the preceding test, it is important that each specimen maintain its identity throughout the battery of tests and that the setup instructions specific to the specimen are strictly followed.*

This test requires that the test specimens be at or below -40° C at the time of the test. The worksheet calls for measuring and recording the specimen temperature before and after the test.

This test uses the 12-inch high puncture billet (Drawing CT10119, Rev. C). The billet meets the minimum height (8 inches) required in 10 CFR 71.73(c)(3). The specimen has no projections or overhanging members longer than 8 inches which could act as impact absorbers, thus allowing the billet to cause the maximum damage to the specimen.

To set up a package for the puncture test:

1. Measure and record the weight of the package.
2. Measure and record the specimen's internal and surface temperature, and ensure that the package is at or below -40° C.
3. Position the unit according to the appropriate orientation:

   For Specimens A and C, refer to Figure 8 on Page 18.

   For Specimens B and D, refer to Figure 9 on Page 19.
4. Check the alignment of the specified center-of-gravity marker with the targeted point of impact.
5. Raise the package so that there is 40 to 42 inches between the package and the top of the puncture billet.

6.4.2 Orientation for the Puncture Test: Specimens A & C

The orientation for Specimens A and C (Figure 8) targets the bottom edge of the rear end-plate to distort the end plate and possibly loosen or shear the end-plate screws.

The bottom edge provides the largest unobstructed flat surface on the plate. The impact will crush the bottom of the end plate into the polyurethane foam, the softest material in the package, and cause the maximum distortion of the plate. Attacking the top edge was rejected because the flat surface area is less than half that of the bottom edge and the carrying handle would deflect much of the energy.

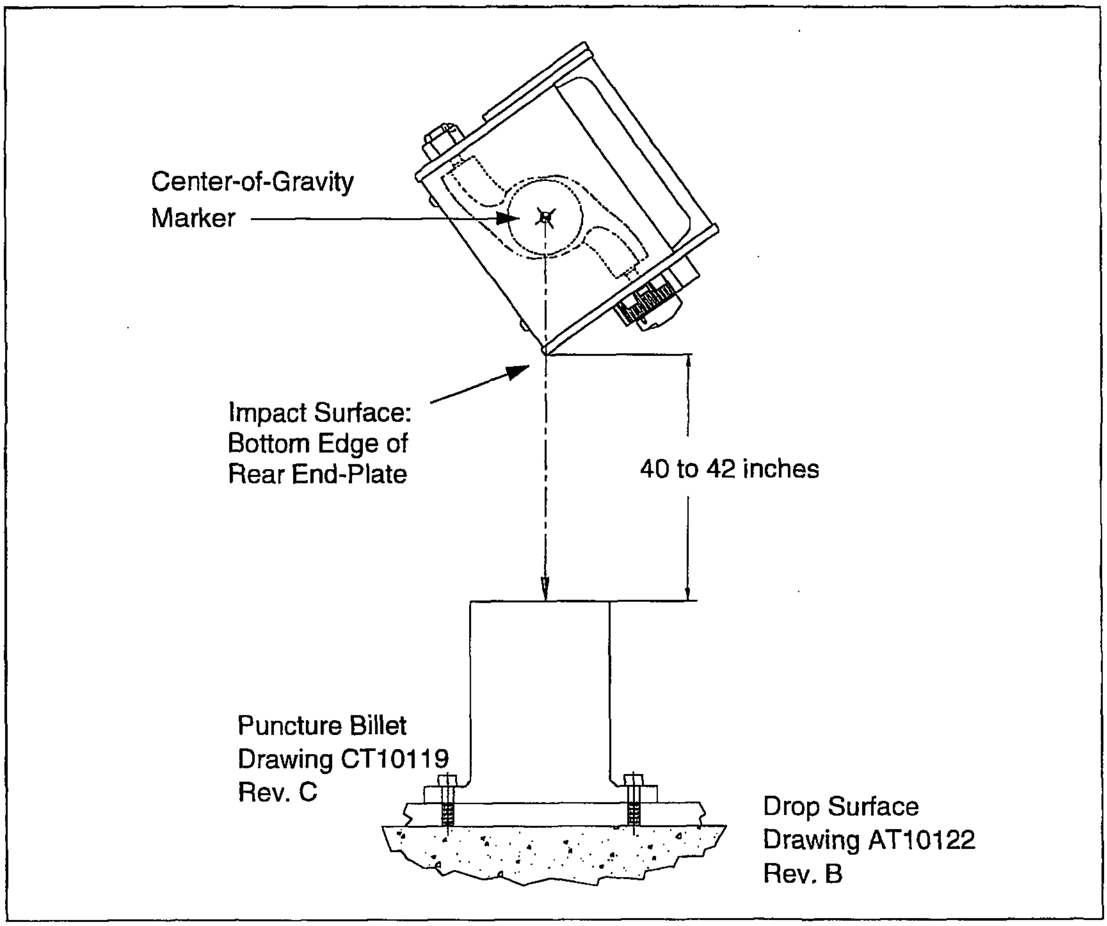


Figure 8: Orientation for the Puncture Test: Specimens A & C

6.4.3 Orientation for the Puncture Test: Specimens B & D

For Specimen B and D, the puncture test impact point is the lower left corner of the rear end-plate (Figure 9). This orientation continues the attack on the bottom left screw on the rear end plate that was inflicted with the penetration test and the two free drops. The impact will also have the effect of increasing any gap between the end plate and the shell caused by the previous tests.

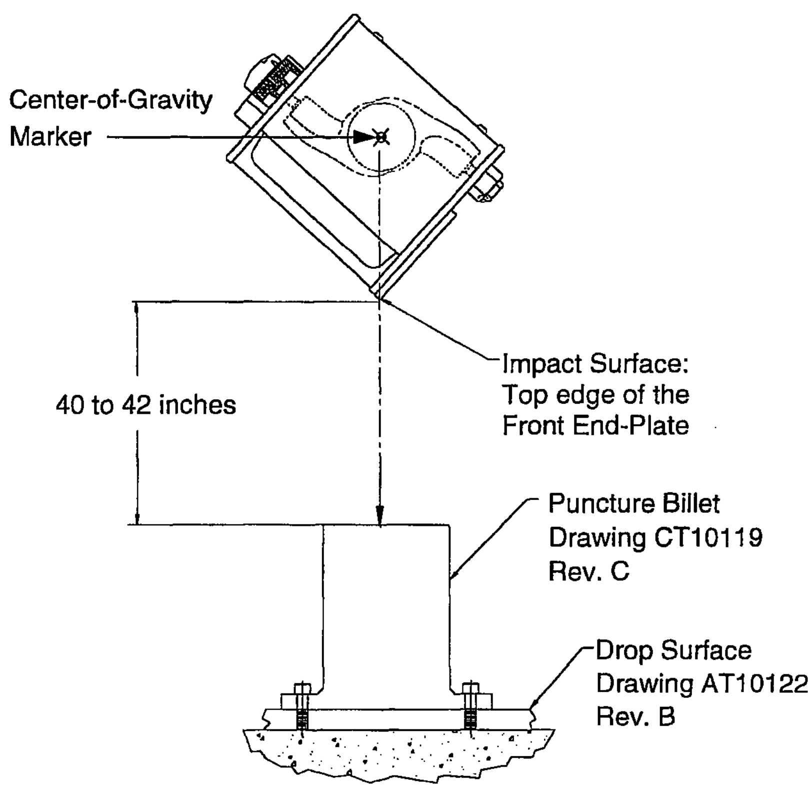


Figure 9: Orientation for the Puncture Test: Specimens B & D

6.4.4 Puncture Test Assessment

Upon completion of the test, Engineering, Regulatory Affairs and Quality Assurance team members will jointly perform the following tasks:

- Review the test execution to ensure that the test was performed in accordance with 10 CFR 71.73.
- Make a preliminary evaluation of the specimen relative to the requirements of 10 CFR 71.73.
- Assess the damage to the specimen to decide whether testing of that specimen is to continue.
- Evaluate the condition of the specimen to determine whether the thermal test should be performed with the specimen.
- Evaluate the condition of the specimen to determine the package orientation for the thermal test to achieve maximum damage.

As part of the evaluation, measure the weight of the specimen.

6.5 Intermediate Test Inspection

Perform an intermediate test inspection after the puncture test.

1. Measure and record any damage to the test specimen.
2. If a source can be installed without affecting the integrity of the test specimen, profile the package using an active source in accordance with Amersham Work Instruction WI-Q09.
3. Assess the significance of any change in radiation at the surface or at one meter from the package.

6.6 Thermal Test (10 CFR 71.73(c)(4))

The final requirement is the thermal test specified in 10 CFR 71.73(c)(4).

To ensure sufficient heat input to the test specimens, each specimen will be pre-heated to a temperature of at least 800° C and held to at least that temperature for 30 minutes. This test condition provides heat input in excess of the requirements specified in 10 CFR 71.73(c)(4), which does not include a pre-heat condition. The pre-heat condition assures equivalent heat input regardless of emissivity and absorptivity coefficients.

The test environment is a vented electric oven operating greater than 800° C. There will be sufficient air flow to allow combustion. Air will be forced into the oven at a minimum rate of 9.6 cubic feet per minute to ensure sufficient oxygen to fully combust all package materials that are capable of burning. This rate is based on the following analysis:

1. The only combustible material in the TP73 is the polyurethane foam.
2. The chemical composition of polyurethane is $[C_{26}H_{33}NO_{13}]_n$.
3. The products of combustion are carbon dioxide (CO_2) and water (H_2O) and the molecular weights of the component materials are:

   C = 12   H = 1   O = 16   N = 14
4. The maximum mass of the polyurethane in a TP73 is 988 grams. The maximum amounts of carbon and hydrogen present in the polyurethane are computed as follows:

Polyurethane	C_{26}	H_{33}	N	O_{13}
Molecular Weight	(26x12) +	(33x1)+	(1x14)+	(13x16)
567 =	312 +	33 +	14 +	208
Percent by Mass	55.0%	5.8%	2.5%	36.7%
988 g =	543g +	57g +	25g +	363g

5. The amount of oxygen required to fully combust the carbon to carbon dioxide is computed as follows:

Carbon Dioxide	C	O_2
Molecular Weight	(1x12) +	(2x16)
44 =	12 +	32

For a given mass of carbon, 32/12 = 2.67 times that mass of oxygen is required to fully combust the carbon to carbon dioxide. For a TP73 containing 543 grams of carbon, full combustion would require 1450 grams of oxygen.

6. The amount of oxygen required to fully convert the hydrogen to water is computed as follows:

Water	H_2	O
Molecular Weight	(2x1) +	16
18 =	2 +	16

For a given mass of hydrogen, 16/2 = 8 times that mass of oxygen is required to fully convert the hydrogen to water. For a TP73 with 57 grams of hydrogen, full combustion would require 456 grams of oxygen.

7. The sum of these oxygen requirements (1450g + 456 g) less the oxygen supplied by the polyurethane (-363 g) equals 1543 grams of oxygen to assure sufficient oxygen to burn the polyurethane foam. At standard conditions, the composition of air is 23.2% oxygen by mass[1]. Therefore, 6650 grams of air are required.

8. The volume of air is computed at a density of 1.225 grams/liter to be 192 cubic feet:

   $6650 g/1.225 g/l = 5430\ l = 5.43 m^3 = 192\ ft^3$

9. A 50% safety factor is added and the volume is distributed over the 30-minute test period to determine a minimum air flow rate of 9.6 cubic feet per minute:

   $(192\ ft^3)\ (1.5)\ /\ 30\ min. = 9.6\ ft^3/min.$

The air will be introduced as compressed air passing through a flowmeter and into the oven via metal tubing. A sufficient length of tubing will be inside the oven to ensure sufficient preheating.

The temperature of the package's exterior surface closest to the air entry point will be monitored throughout the test to ensure that the package remains above 800° C.

If the specimen is burning when it is removed, the unit is allowed to extinguish by itself and then cool naturally. The final evaluation of the package is performed when the specimen reaches ambient temperature.

---

1. Avallone, Eugene A., and Theodore Baumeister III, Editors, *Marks' Standard Handbook for Mechanical Engineers*, Ninth Edition (New York: McGraw-Hill Book Company, 1987), page 4-27

6.6.1 Thermal Test

To perform the thermal test:

1. Bring the oven temperature above 800° C.
2. Attach thermocouples to the package's internal and external measurement locations, and inside the oven.
3. Place the package in the oven and close the door.
4. When the internal temperature of the package goes above 800° C, start air flow and start a 30-minute timer.
5. Measure and record the oven temperature, test specimen internal and external temperatures, and the air flow rate. Record whether there is any combustion.
6. Monitor the specimen's internal and external temperatures, and the oven temperature throughout the 30-minute test period to ensure that all temperatures remain above 800° C.
7. Monitor the airflow rate throughout the test period to ensure that it remains above 9.6 ft^3/minute.
8. At the end of the 30 minutes, repeat Step 5.
9. Remove the test specimen from the oven.
10. Allow the package to self-extinguish and cool.

6.6.2 Thermal Test Assessment

Upon completion of the test, Engineering, Regulatory Affairs and Quality Assurance team members will jointly perform the following task:

- Review the test execution to ensure that the test was performed in accordance with 10 CFR 71.

6.7 Final Test Inspection

Perform the following inspections after completion of the thermal test:

1. Measure and record any damage to the test specimen.
2. Profile the package using an active source in accordance with Amersham Work Instruction WI-Q09.
3. Assess the significance of any change in radiation at one meter from the package.
4. Determine whether it is necessary to dismantle the test specimen for inspection of hidden component damage or failure.
5. If you decide to proceed with the inspection, record and photograph the process of removing any component.
6. Measure and record any damage or failure found in the process of dismantling the test specimen.

6.8 Final Assessment

Engineering, Regulatory Affairs, and Quality Assurance team members will make a final assessment of the test specimen, and jointly determine whether the specimen meets the requirements of 10 CFR 71.73.

7.0 Worksheets

Use the following worksheets for executing these tests. There are two worksheets for each test: an equipment list and a test procedure checklist.

Use the test equipment list to record the serial number of each measurement device used. Attach a copy of the relevant inspection report or calibration certificate after you have verified the range and accuracy of the equipment.

Quality Control will initial each step on the checklist as it is executed and record data as required. The Engineering, Regulatory Affairs and Quality Assurance representatives must witness all testing to ensure the testing is performed in accordance with this test plan and 10 CFR 71.

Make copies of the forms for additional attempts. Maintain records of all attempts.

Equipment List 1: 30-foot Free Drop

Description	Enter the Model and Serial Number	Attach Inspection Report or Calibration Certificate
Drop Surface, Drawing AT10122, Rev. B		
Weight Scale		
Thermometer		
Thermocouple flexible probe		
Thermocouple surface probe		
Record any additional tools used to facilitate the test and attach the appropriate inspection report or calibration certificate.		
Verified by:	Signature	Date
Engineering		
Regulatory Affairs		
Quality Assurance		

Checklist 1: 30-foot Free Drop

Test Location: **Attempt Number:**

Step	Specimen A	Specimen B	Specimen C	Specimen D
1. Measure and record test specimen's weight.				
Record the specimen's weight:				
Note the instrument used:				
2. Immerse the test specimen in dry ice as needed to bring specimen temperature below -40° C.				
Steps 1 through 2 witnessed by:				
Engineering				
Regulatory Affairs				
Quality Assurance				
3. Measure the ambient temperature.				
Record ambient temperature:				
Note the instrument used:				
4. Attach the test specimen to the release mechanism.				
5. Begin video recording of test so that the impact is recorded.				
6. Measure the temperature of the specimen. Ensure that the specimen is below -40° C.				
Record the specimen's internal temperature:				
Note the instrument used:				
Record the specimen's surface temperature.				
Note the instrument used:				
7. Lift and orient the test specimen as shown in the referenced figure for the specimen.	Figure 6 on Page 14	Figure 7 on Page 15	Figure 6 on Page 14	Figure 7 on Page 15
8. Inspect the orientation setup and verify the drop height.				
9. Photograph the setup in at least two perpendicular planes.				

Checklist 1: 30-foot Free Drop (Continued)

Test Location: **Attempt Number:**

Step	Specimen A	Specimen B	Specimen C	Specimen D
Steps 3 through 9 witnessed by:				
Engineering				
Regulatory Affairs				
Quality Assurance				
10. Release the test specimen.				
11. Measure the surface temperature of the test specimen.				
Record the surface temperature:				
Note the instrument used:				
12. Measure and record the test specimen's weight.				
Record the specimen's weight:				
Note the instrument used:				
13. Pause the video recorder. Ensure that the point of impact and orientation specified in the plan have been achieved and recorded.				
14. Record damage to test specimen on a separate sheet and attach.				
Steps 10 through 14 witnessed by:				
Engineering				
Regulatory Affairs				
Quality Assurance				

Checklist 1: 30-foot Free Drop (Continued)

Test Location: **Attempt Number:**

Step	Specimen A	Specimen B	Specimen C	Specimen D
15. Engineering, Regulatory Affairs and Quality Assurance make a preliminary assessment relative to 10 CFR 71. Record the assessment on a separate sheet and attach. Determine what changes are necessary in package orientation for the puncture test to achieve maximum damage.				

Test Data Accepted by (Signature):	Date:
Engineering	
Regulatory Affairs	
Quality Assurance	

Equipment List 2: Puncture Test

Description	Enter the Model and Serial Number	Attach Inspection Report or Calibration Certificate
Drop Surface, Drawing AT10122, Rev. B		
Puncture Billet, Drawing CT10119, Rev. C		
Weight Scale		
Thermometer		
Thermocouple flexible probe		
Thermocouple surface probe		
Record any additional tools used to facilitate the test and attach the appropriate inspection report or calibration certificate.		
Verified by:	Signature	Date
Engineering		
Regulatory Affairs		
Quality Assurance		

Checklist 2: Puncture Test

Test Location: **Attempt Number:**

Step	Specimen A	Specimen B	Specimen C	Specimen D
1. Immerse the test specimen in dry ice as need to bring the specimen's temperature below -40° C.				
Step 1 witnessed by:				
Engineering				
Regulatory Affairs				
Quality Assurance				
2. Measure the weight of the specimen.				
Record the specimen's weight:				
Note instrument used:				
3. Measure the ambient temperature.				
Record ambient temperature:				
Note the instrument used:				
4. Attach the test specimen to the release mechanism.				
5. Begin video recording of test so that the impact is recorded.				
6. Measure the surface temperature of the specimen. Ensure that the specimen is below -40° C.				
Record the specimen surface temperature:				
Note the instrument used:				
7. Lift and orient the test specimen as shown in the referenced figure for the specimen.	Figure 8 on Page 18	Figure 9 on Page 19	Figure 8 on Page 18	Figure 9 on Page 19
8. Inspect the orientation setup and verify drop height.				

Checklist 2: Puncture Test (Continued)

Test Location: **Attempt Number:**

Step	Specimen A	Specimen B	Specimen C	Specimen D
9. Photograph the setup in at least two perpendicular planes.				
Steps 2 through 9 witnessed by:				
Engineering				
Regulatory Affairs				
Quality Assurance				
10. Release the test specimen.				
11. Measure the surface temperature of the test specimen.				
Record the surface temperature:				
Note the instrument used:				
12. Measure and record the test specimen's weight.				
Record the specimen's weight:				
Note the instrument used:				
13. Pause the video recorder. Ensure that the point of impact and orientation specified in the plan have been achieved and recorded.				
14. Record damage to test specimen on a separate sheet and attach.				
Steps 10 through 14 witnessed by:				
Engineering				
Regulatory Affairs				
Quality Assurance				

Checklist 2: Puncture Test (Continued)

Test Location:

Attempt Number:

Step	Specimen A	Specimen B	Specimen C	Specimen D
15. Engineering, Regulatory Affairs and Quality Assurance make a preliminary assessment relative to 10 CFR 71. Record the assessment on a separate sheet and attach. Determine the package orientation for the thermal test that will achieve maximum damage.				

Test Data Accepted by (Signature):	Date:
Engineering	
Regulatory Affairs	
Quality Assurance	

Equipment List 3: Thermal Test

Description	Enter the Model and Serial Number	Attach Inspection Report or Calibration Certificate
Air Flowmeter		
Thermocouple (internal)		
Thermocouple (external)		
Thermocouple (oven)		
Temperature recorder		
Record any additional tools used to facilitate the test and attach the appropriate inspection report or calibration certificate.		
Verified by:	Signature	Date
Engineering		
Regulatory Affairs		
Quality Assurance		

Checklist 3: Thermal Test

Test Location: **Attempt Number:**

Step	Specimen A	Specimen B	Specimen C	Specimen D
1. Pre-heat the oven to a temperature above 800° C.				
2. Attach the thermocouples the specimen's internal and external measuring points.				
3. Place the package in the oven and close the oven door.				
Record the date and time that the package is placed in oven.				
4. When the specimen's internal temperature exceeds 800° C, start the air flow into the oven. Record the time.				
Steps 1 through 4 witnessed by:				
Engineering				
Regulatory Affairs				
Quality Assurance				
5. Measure the oven temperature, the specimen's internal and external temperatures and the air flow rate.				
Record the oven temperature:				
Note instrument used:				
Record the specimen's internal temperature:				
Note instrument used:				
Record the specimen's external temperature:				
Note instrument used:				
Record airflow rate:				
Note instrument used:				
6. Monitor the internal and external temperatures of the specimen and the oven temperature throughout the 30-minute period to ensure that they are above 800° C.				

Checklist 3: Thermal Test (Continued)

Test Location: **Attempt Number:**

Step	Specimen A	Specimen B	Specimen C	Specimen D
7. Monitor the airflow throughout the 30-minute period to ensure a rate of at least 9.6 ft^3/min.				
8. At the end of the 30-minute period, repeat step 5 using the same measurement devices.				
Record the oven temperature:				
Record the specimen's internal temperature:				
Record the specimen's external temperature:				
Record intake air flow velocity:				
Steps 5 through 8 witnessed by:				
Engineering				
Regulatory Affairs				
Quality Assurance				
9. Remove test specimen from the oven.				
Record time the specimen is removed.				
Describe combustion when door is opened to remove specimen.				
NOTE: If specimen continues to burn, let it self-extinguish and cool naturally.				
10. Measure the ambient temperature.				
Record the ambient temperature:				
Note the instrument used:				
11. Photograph the test specimen and any subsequent damage				
12. Record damage to test specimen on a separate sheet and attach.				
Steps 9 through 12 witnessed by:				
Engineering				
Regulatory Affairs				
Quality Assurance				

Checklist 3: Thermal Test (Continued)

Test Location: **Attempt Number:**

Step	Specimen A	Specimen B	Specimen C	Specimen D
13. Engineering, Regulatory Affairs and Quality Assurance make a preliminary assessment relative to 10 CFR 71. Record the assessment on a separate sheet and attach.				

Test Data Accepted by (Signature):	Date:
Engineering	
Regulatory Affairs	
Quality Assurance	

Appendix A: Drawings

Test Specimen
TP73, Rev. A

Model 660 Gamma Ray Projector Shipping Container Descriptive Assembly
C66025, Rev. F (3 sheets)

Model 660 Gamma Ray Projector Shipping Container Descriptive Assembly
C66025, Rev. B (4 sheets)

Model 660 Gamma Ray Projector Shipping Container Descriptive Assembly
C66030, Rev. D (3 sheets)

Model 660 Gamma Ray Projector Shipping Container Descriptive Assembly
C66030, Rev. A (3 sheets)

Model 660 Gamma Ray Projector Shipping Container Descriptive Assembly
C66030, Rev. – (4 sheets)

Security-Related Information
Figure Withheld Under 10 CFR 2.390

USED ON: TEST PLAN #73	AMERSHAM CORPORATION BURLINGTON, MA 01803 **SENTINEL**
MATERIALS: SEE NOTE 1	DWG. TITLE
SURFACE TEXTURE: UNLESS OTHERWISE STATED	MODEL 660 TEST SPECIMEN
FINISH: FINISH	
REMOVE ALL BURRS	

DRAWN	APPROVED DRAWING ON FILE	UNLESS OTHERWISE NOTED DIMENSIONS ARE IN INCHES TOLERANCES ARE:
CHECKED		.X ± 0.1
APPROVED		.XX ± 0.01
		.XXX ± 0.005
		ANGLES ± 1°
		FRACT ± 1/64

SAFETY CLASS	SIZE	DWG. NO.	REV
A	C	TP73	A
SCALE NONE		SHEET 1 OF 1	

Security-Related Information

Figure Withheld Under 10 CFR 2.390

NOTED	[redacted]
	MODEL 660 GAMMA RAY PROJECTOR SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY
	C | 66025 | E

Security-Related Information
Figure Withheld Under 10 CFR 2.390

MATERIALS: NOTED	TECHNICAL OPERATIONS INC. RADIATION PRODUCTS DIVISION, BURLINGTON, MA. 01803
FINISH	DWG TITLE: MODEL 660 GAMMA RAY PROJECTOR SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY
DRAWN BY	
CHECKED BY	CLASSIFICATION / SIZE: C / DWG. NO.: 66025 / REV.: F
APPROVED BY	SCALE: 2:1 / SHEET 2 OF 3

Security-Related Information
Figure Withheld Under 10 CFR 2.390

MATERIALS: AS NOTED	Tech/Ops, Inc. RADIATION PRODUCTS DIVISION BURLINGTON, MA 01803
FINISH: "	DWG TITLE: MODEL 660 GAMMA RAY PROJECTOR SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY
DRAWN BY	CLASSIFICATION / SIZE: C / DWG. NO. 66025 / REV. E
CHECKED BY	SCALE 1:1 / SHEET 3 OF 3
APPROVED BY	

Security-Related Information
Figure Withheld Under 10 CFR 2.390

MATERIALS: NOTED	TECHNICAL OPERATIONS INC. RADIATION PRODUCTS DIVISION BURLINGTON, MA 01803
FINISH	DWG TITLE: MODEL 660 GAMMA RAY PROJECTOR SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY
DRAWN BY	UNLESS OTHERWISE SPECIFIED TOLERANCES ARE: .X ±; .XX ±; .XXX ±; ANGLES ±; FRACTIONS ±
CHECKED BY	CLASSIFICATION; SIZE: C; DWG. NO. 66025; REV.
APPROVED BY	SCALE 1; SHEET 1 OF 4

Security-Related Information
Figure Withheld Under 10 CFR 2.390

MATERIALS: NOTED		TECHNICAL OPERATIONS INC. RADIATION PRODUCTS DIVISION BURLINGTON, MA 01803
FINISH: —		DWG TITLE: MODEL 660 GAMMA RAY PROJECTOR SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY
DRAWN BY: 6-27-78	UNLESS OTHERWISE SPECIFIED TOLERANCES ARE	
	.X ±	
CHECKED BY	.XX ±	
	.XXX ±	CLASSIFICATION: — SIZE: C DWG. NO.: 66025 REV.: B
APPROVED BY	ANGLES ±	
	FRACTIONS ±	SCALE 2:1 SHEET 2 OF 4

Security-Related Information

Figure Withheld Under 10 CFR 2.390

MATERIALS NOTED		TECHNICAL OPERATIONS INC. RADIATION PRODUCTS DIVISION BURLINGTON, MA 01803
FINISH		DWG TITLE MODEL 660 GAMMA RAY PROJECTOR SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY
DRAWN BY [illegible] 6-27-78	UNLESS OTHERWISE SPECIFIED TOLERANCES ARE	
	.X ±	
CHECKED BY	.XX ±	
	.XXX ±	CLASSIFICATION / SIZE C / DWG. NO. 66025 / REV. B
APPROVED BY	ANGLES ±	
	FRACTIONS ±	SCALE / SHEET 1 OF 4

Security-Related Information
Figure Withheld Under 10 CFR 2.390

MATERIALS: NOTED	TECHNICAL OPERATIONS INC. RADIATION PRODUCTS DIVISION BURLINGTON, MA
FINISH	DWG. TITLE: MODEL 660 GAMMA RAY PROJECTOR SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY
DRAWN BY	
CHECKED BY	CLASSIFICATION / SIZE: C / DWG. NO.: 66025 / REV.
APPROVED BY / ANGLES / FRACTIONS	SCALE: 2:1 / SHEET 3 OF 4

Security-Related Information

Figure Withheld Under 10 CFR 2.390

MATERIALS: AS NOTED	Tech Ops — Tech/Ops, Inc. RADIATION PRODUCTS DIVISION BURLINGTON, MA 01803
FINISH: "	DWG TITLE: MODEL 660 GAMMA RAY PROJECT SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY
DRAWN BY / CHECKED BY / APPROVED BY	CLASSIFICATION: — SIZE: C DWG. NO. 66025 REV. B
.X ± / .XX ± / .XXX ± / ANGLES ± / FRACTIONS ±	SCALE: 1:1 SHEET 4 OF 4

Security-Related Information

Figure Withheld Under 10 CFR 2.390

MATERIALS: NOTED	[redacted]
FINISH	DWG TITLE: MODEL 660 GAMMA RAY PROJECTC SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY
CLASSIFICATION	SIZE: C
DWG NO.	66030
SCALE	2:1
SHEET	2 of 3

Security-Related Information
Figure Withheld Under 10 CFR 2.390

NOTED

[redacted]

MODEL 660 GAMMA RAY PROJECTOR
SHIPPING CONTAINER
DESCRIPTIVE ASSEMBLY

SIZE	DWG. NO.	REV.
C	66030	D

Security-Related Information
Figure Withheld Under 10 CFR 2.390

AS NOTED

RADIATION PRODUCTS DIVISION

MODEL 660 GAMMA RAY PROJECTOR
SHIPPING CONTAINER
DESCRIPTIVE ASSEMBLY

C

...66030

1:1

SHEET 3 OF 3

Security-Related Information
Figure Withheld Under 10 CFR 2.390

MATERIAL: NOTED

[redacted] RADIATION PRODUCTS DIVISION

MODEL 660 GAMMA RAY PROJECTOR
SHIPPING CONTAINER
DESCRIPTIVE ASSEMBLY

SIZE: C
DWG. NO. 66030

SHEET 2 OF 3

Security-Related Information

Figure Withheld Under 10 CFR 2.390

AS NOTED	RADIATION PRODUCTS DIVISION
	MODEL 660 GAMMA RAY PROJECTOR SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY

Security-Related Information
Figure Withheld Under 10 CFR 2.390

NOTED	[redacted] TECHNICAL OPERATIONS INC. RADIATION PRODUCTS DIVISION BURLINGTON, MA
	TITLE: MODEL 660 GAMMA RAY PROJECTOR SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY
.X ▲ / .XX ▲ / .XXX ▲ / ANGLES ▲ / FRACTIONS ▲	SIZE: C — DWG. NO. 66030
APPROVED BY	SCALE 1 — SHEET 1 OF 4

Security-Related Information
Figure Withheld Under 10 CFR 2.390

NOTED	TECHNICAL OPERATIONS, INC. RADIATION PRODUCTS DIVISION BURLINGTON, MA
	MODEL 660 GAMMA RAY PROJECTO SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY
	SIZE: C DWG. NO.: 66030
	SCALE: 2:1 SHEET 2 OF 4

Security-Related Information

Figure Withheld Under 10 CFR 2.390

NOTED

[redacted] TECHNICAL OPERATIONS INC.
RADIATION PRODUCTS DIVISION

MODEL 660 GAMMA RAY PROJECTOR
SHIPPING CONTAINER
DESCRIPTIVE ASSEMBLY

C 66030

SHEET OF 4

Security-Related Information

Figure Withheld Under 10 CFR 2.390

AS NOTED

RADIATION PRODUCTS DIVISION

MODEL 660 GAMMA RAY PROJECTOR
SHIPPING CONTAINER
DESCRIPTIVE ASSEMBLY

C | 66030

SCALE 1:1 | SHEET 4 OF 4

Appendix B: Selected Fasteners

The stainless steel screw selected for the end-plate fasteners is 51959-81 as specified in Military Standard 51959, a copy of which is included in this appendix. The item is highlighted on page 2 of the specification.

The toughness versus temperature curve below shows the consistent toughness of stainless steel over a wide range of temperatures. The curve is excerpted from Deutschman, Aaron D, Walter J. Michels, and Charles E. Wilson, *Machine Design: Theory and Practice* (New York: Macmillan Publishing Co., Inc. 1975), page 136.

Low temperature effects

As the temperature is lowered, there is an increase in yield strength, tensile strength, elastic modulus, and hardness and a decrease in ductility for metals such as aluminum and aluminum alloys, nickel alloys, austenitic steels, lead, and copper. Carbon and low alloy steels tend to become embrittled at much higher temperatures than the aforementioned metals. Embrittlement is measured by loss of toughness over a small temperature range (for example, see Section 3.21) when tested by the Charpy or Izod machines. The transition temperature is taken to be that for which the impact energy is reduced by 50% of its ductile value. Figure 3-43 shows some average value curves of toughness (energy in foot-pounds) versus temperature for a variety

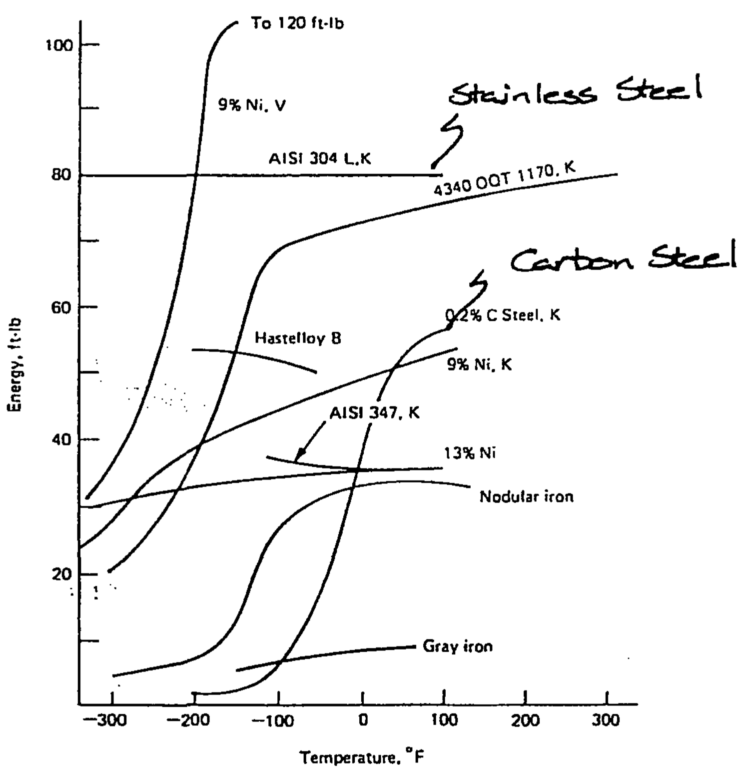


Figure 3-43 Toughness versus temperature for several metals. Note the sharp drop in toughness that takes place within a narrow temperature range. [From V. M. Faires: *Design of Machine Elements*, 4th ed. The Macmillan Company, New York, 1965.]

REVIEWER: AV, EL, GL, IS, MI, SSA
USER: AS, AT, MC, ME, MI, OS, YD

Security-Related Information
Figure Withheld Under 10 CFR 2.390

P.A. VC Other Cust SH AZ	TITLE SCREW, MACHINE-FLAT COUNTERSUNK HEAD, 82°, CROSS-RECESSED, CORROSION RESISTING STEEL, UNC-2A	MILITARY STANDARD MS 51959
PROCUREMENT SPECIFICATION FF-S-92	SUPERSEDES: MS35200 and in part: MS35240, MS35358, MS35363 and AN505	SHEET 1 OF 4

DD 672-1

REVIEWER: AV, EL, GL, IS, MI, NSA
USER: AS, AT, MC, ME, MT, OS, YD

Security-Related Information
Figure Withheld Under 10 CFR 2.390

Other Cust SH 82	TITLE SCREW, MACHINE-FLAT COUNTERSUNK HEAD, 82°, CROSS-RECESSED, CORROSION RESISTING STEEL, UNC-2A	MILITARY STANDARD MS 51959
PROCUREMENT SPECIFICATION FF-S-92	SUPERSEDES: MS35200 and in part: MS35249, MS35358, MS35363 and AN505	SHEET 2 OF

DD FORM 672-1 (Continued)

REVIEWER: AV, EL, GL, IS, ME, SSA
USER: AS, AT, MC, MC, MO, OS, YD

Security-Related Information
Figure Withheld Under 10 CFR 2.390

P.A. VC Other Cust SH 82	TITLE SCREW, MACHINE-FLAT COUNTERSUNK HEAD, 82°, CROSS-RECESSED, CORROSION RESISTING STEEL, UNC-2A		MILITARY STANDARD MS 51959
PROCUREMENT SPECIFICATION FF-S-92	SUPERSEDES: MS35200 and in part: MS35249, MS35358, MS35363 and AN505		SHEET 3 OF

DD FORM 672-1 (Coordinated)

Security-Related Information
Figure Withheld Under 10 CFR 2.390

P.A. MC Other Cust SH EZ	TITLE SCREW, MACHINE-FLAT COUNTERSUNK HEAD, 82°, CROSS-RECESSED, CORROSION RESISTING STEEL, UNC-2A	MILITARY STANDARD MS 51959
PROCUREMENT SPECIFICATION FF-S-92	SUPERSEDES: MS35200 and in part: MS35249, MS3535?, MS353?1 and AN505	SHEET 4 OF

DD FORM 672-1 (Continued)

☆ U. S. GOVERNMENT PRINTING OFFICE: 1964 541-514/A-3540

Appendix C: Referenced Materials

The following is an excerpt from Avallone, Eugene A., and Theodore Baumeister III, Editors, *Marks' Standard Handbook for Mechanical Engineers*, Ninth Edition (New York: McGraw-Hill Book Company, 1987), page 4-27.

Table 4.1.5 Approximate Inversion-Curve Locus for Air

P, bar	0	25	50	75	100	125	150	175	200	225
T_L, K	(112)*	114	117	120	124	128	132	137	143	149
T_U, K	653	641	629	617	606	594	582	568	555	541
P, bar	250	275	300	325	350	375	400	425	432	
T_L, K	156	164	173	184	197	212	230	265	300	
T_U, K	526	509	491	470	445	417	386	345	300	

*Hypothetical low-pressure limit.

Loss Due to Throttling A throttling process in a cycle of operations always introduces a loss of efficiency. If T_0 is the temperature corresponding to the back pressure, the loss of available energy is the product of T_0 and the increase of entropy during the throttling process. The following example illustrates the calculation in the case of ammonia passing through the expansion valve of a refrigerating machine.

EXAMPLE. The liquid ammonia at a temperature of 70°F passes through the valve into the brine coil in which the temperature is 20 deg and the pressure is 48.21 psia. The initial enthalpy of the liquid ammonia is $h_{f1} = 120.5$, and therefore the final enthalpy is $h_{f2} + x_2 h_{fg2} = 64.7 + 553.1x_2 = 120.5$, whence $x_2 = 0.101$. The initial entropy is $s_{f1} = 0.254$. The final entropy is $s_{f2} + (x_2 h_{fg2}/T_2) = 0.144 + 0.101 \times 1.153 = 0.260$. $T_0 = 20 + 460 = 480$; hence the loss of refrigerating effect is $480 \times (0.260 - 0.254) = 2.9$ Btu.

COMBUSTION

REFERENCES: Chigier, "Energy, Combustion and Environment," McGraw-Hill, 1981. Campbell, "Thermodynamic Analysis of Combustion Engines," Wiley, 1979. Glassman, "Combustion," Academic Press, New York, 1977. Lefebvre, "Gas Turbine Combustion," McGraw-Hill, New York, 1983. Strehlow, "Combustion Fundamentals," McGraw-Hill, New York, 1984. Williams et al., "Fundamental Aspects of Solid Propellant Rockets," *Agardograph*, 116, Oct. 1969. Basic thermodynamic table type information needed in this area is found in Glushko et al., "Thermodynamic and Thermophysical Properties of Combustion Products," Moscow, and IPST translation; Gordon, NASA Technical Paper 1906, 1982; "JANAF Thermochemical Tables," NSRDS-NBS-37, 1971.

Fuels For special properties of various fuels, see Sec. 7. In general, fuels may be classed under three heads: (1) gaseous fuels, (2) liquid fuels, and (3) solid fuels.

The combustible elements that characterize fuels are carbon, hydrogen, and, in some cases, sulphur. The complete combustion of carbon gives, as a product, carbon dioxide, CO_2; the combustion of hydrogen gives water, H_2O.

Combustion of Gaseous and Liquid Fuels

Combustion Equations The approximate molecular weights of the important elements and compounds entering into combustion calculations are:

Material	C	H_2	O_2	N_2	CO	CO_2	H_2O	CH_4	C_2H_4	C_2H_6O	S	NO	NO_2	SO_2
Molecular weight	12	2	32	28	28	44	18	16	28	46	32	30	46	64

For the elements C and H, the equations of complete combustion are

$$\begin{cases} C + O_2 = CO_2 & H_2 + \tfrac{1}{2}O_2 = H_2O \\ 12\text{ lb} + 32\text{ lb} = 44\text{ lb} & 2\text{ lb} + 16\text{ lb} = 18\text{ lb} \end{cases}$$

For a combustible compound, as CH_4, the equation may be written

$$CH_4 + x \cdot O_2 = y \cdot CO_2 + z \cdot H_2O$$

Taking, as a basis, 1 molecule of CH_4 and making a balance of the atoms on the two sides of the equation, it is seen that

$$y = 1 \qquad z = 2 \qquad 2x = 2y + z \qquad \text{or} \qquad x = 2$$

Hence,

$$\begin{cases} CH_4 + 2O_2 = CO_2 + 2H_2O \\ 16\text{ lb} + 64\text{ lb} = 44\text{ lb} + 36\text{ lb} \end{cases}$$

The coefficients in the combustion equation give the combining volumes of the gaseous components. Thus, in the last equation 1 ft³ of CH_4 requires for combustion 2 ft³ of oxygen and the resulting gaseous products of combustion are 1 ft³ of CO_2 and 2 ft³ of H_2O. The coefficients multiplied by the corresponding molecular weights give the combining weights. These are conveniently referred to 1 lb of the fuel. In the combustion of CH_4, for example, 1 lb of CH_4 requires $64/16 = 4$ lb of oxygen for complete combustion and the products are $44/16 = 2.75$ lb of CO_2 and $36/16 = 2.25$ lb of H_2O.

Air Required for Combustion The composition of air is approximately 0.232 O_2 and 0.768 N_2 on a pound basis, or 0.21 O_2 and 0.79 N_2 by volume. For exact analyses, it may be necessary sometimes to take account of the water vapor mixed with the air, but ordinarily this may be neglected.

The minimum amount of air required for the combustion of 1 lb of a fuel is the quantity of oxygen required, as found from the combustion equation, divided by 0.232. Likewise, the minimum volume of air required for the combustion of 1 ft³ of a fuel gas is the volume of oxygen divided by 0.21. For example, in the combustion of CH_4 the air required per pound of CH_4 is $4/0.232 = 17.24$ lb and the volume of air per cubic foot of CH_4 is $2/0.21 = 9.52$ ft³. Ordinarily, more air is provided than is required for complete combustion. Let a denote the minimum amount required and xa the quantity of air admitted; then $x - 1$ is the excess coefficient.

Products of Combustion The products arising from the complete combustion of a fuel are CO_2, H_2O, and, if sulphur is present, SO_2. Accompanying these are the nitrogen brought in with the air and the oxygen in the excess of air. Hence the products of complete combustion are principally CO_2, H_2O, N_2, and O_2. The presence of CO indicates incomplete combustion. In simple calculations the reaction of nitrogen with oxygen to form noxious oxides, often termed NO_x, such as nitric oxide (NO), nitrogen peroxide (NO_2), etc., is neglected. In practice, an automobile engine is run at a lower compression ratio to reduce NO_x formation. The reduced pollution is bought at the

Specimen S1 Serial #B3591

Equipment List 1: 30-foot Free Drop

Description	Enter the Model and Serial Number	Attach Inspection Report or Calibration Certificate
Drop Surface, Drawing AT10122, Rev. B	01	SEE ATTACH
Weight Scale	OHAUS / 35014	SEE ATTACH
Thermometer	OMEGA / ENG-12	SEE ATTACH
Thermocouple flexible probe	OMEGA / ENG-11	SEE ATTACH
Thermocouple surface probe	OMEGA / ENG-13	SEE ATTACH
Record any additional tools used to facilitate the test and attach the appropriate inspection report or calibration certificate.		
THERMOCOUPLE STRAIGHT PROBE	OMEGA / ENG-14	SEE ATTACH

Verified by:	Signature	Date
Engineering	S. Grani	12 JAN 98
Regulatory Affairs	L. [illegible]	12 Jan 98
Quality Assurance	K. [illegible]	12 Jan 98

Checklist 1: 30-foot Free Drop

Test Location: VALLEY TREE GROVELAND MA **Attempt Number:** 1

Step	Specimen A (Serial # B3591 / S1)	Specimen B	Specimen C	Specimen D
1. Measure and record test specimen's weight.	DW 8 JAN 98	N/A	N/A	N/A
Record the specimen's weight:	54.5 lbs			
Note the instrument used:	35014	35014	35014	35014
2. Immerse the test specimen in dry ice as needed to bring specimen temperature below -40° C.	DW 8 JAN 98			
Steps 1 through 2 witnessed by:				
Engineering	SD 12 JAN 98			
Regulatory Affairs	LR 12 Jan 98			
Quality Assurance	KAA 12 Jan 98			
3. Measure the ambient temperature.	DW 8 JAN 98			
Record ambient temperature:	36.9° F			
Note the instrument used:	~~ENG-12~~ ENG-14	~~ENG-12~~ ENG-14	~~ENG-12~~ ENG-14	~~ENG-12~~ ENG-14
4. Attach the test specimen to the release mechanism.	DW 8 JAN 98			
5. Begin video recording of test so that the impact is recorded.	DW 8 JAN 98			
6. Measure the temperature of the specimen. Ensure that the specimen is below -40° C.	DW 8 JAN 98			
Record the specimen's internal temperature:	-71.4°C			
Note the instrument used:	~~ENG-12~~ ENG-11	~~ENG-12~~ ENG-11	~~ENG-12~~ ENG-11	~~ENG-12~~ ENG-11
Record the specimen's surface temperature.	-64.7°C			
Note the instrument used:	~~ENG-12~~ ENG-13	~~ENG-12~~ ENG-13	~~ENG-12~~ ENG-13	~~ENG-12~~ ENG-13
7. Lift and orient the test specimen as shown in the referenced figure for the specimen.	Figure 6 on Page 14	Figure 7 on Page 15	Figure 6 on Page 14	Figure 7 on Page 15
8. Inspect the orientation setup and verify the drop height.	DW 8 JAN 98			
9. Photograph the setup in at least two perpendicular planes.	DW 8 JAN 98			

Checklist 1: 30-foot Free Drop (Continued)

Test Location: GROVELAND, MA. **Attempt Number:** 1

Step	Specimen A (DW 8 JAN 98) S1	Specimen B	Specimen C	Specimen D
Steps 3 through 9 witnessed by:		N/A	N/A	N/A
Engineering	(initials) 12 JAN 98			
Regulatory Affairs	(initials) 12 Jan 98			
Quality Assurance	KMA 12 Jan 98			
10. Release the test specimen.	DW 8 JAN 98			
11. Measure the surface temperature of the test specimen.	DW 8 JAN 98			
Record the surface temperature:	-39.6 °C			
Note the instrument used:	~~ENG-12~~ ENG-13	~~ENG-12~~ ENG-13	~~ENG-12~~ ENG-13	~~ENG-12~~ ENG-13
12. Measure and record the test specimen's weight.	DW 8 JAN 98			
Record the specimen's weight:	54.5 lbs			
Note the instrument used:	35014	35014	35014	35014
13. Pause the video recorder. Ensure that the point of impact and orientation specified in the plan have been achieved and recorded.	DW 8 JAN 98			
14. Record damage to test specimen on a separate sheet and attach.	DW 8 JAN 98			
Steps 10 through 14 witnessed by:				
Engineering	(initials) 12 JAN 98			
Regulatory Affairs	(initials) 12 Jan 98			
Quality Assurance	KMA 12 Jan 98			

Checklist 1: 30-foot Free Drop (Continued)

Test Location: GROVELAND, MA. **Attempt Number:** 1

Step	Specimen A	Specimen B	Specimen C	Specimen D
15. Engineering, Regulatory Affairs and Quality Assurance make a preliminary assessment relative to 10 CFR 71. Record the assessment on a separate sheet and attach. Determine what changes are necessary in package orientation for the puncture test to achieve maximum damage.	18Feb98 see attached	N/A	N/A	N/A

Test Data Accepted by (Signature):		Date:
Engineering	S. Gran	18 Feb 98
Regulatory Affairs	[signature]	22 Jan 98
Quality Assurance	C. [signature]	18 Feb 98

Serial #B3591

30 FOOT FREE DROP. (JO) 9 JAN 97

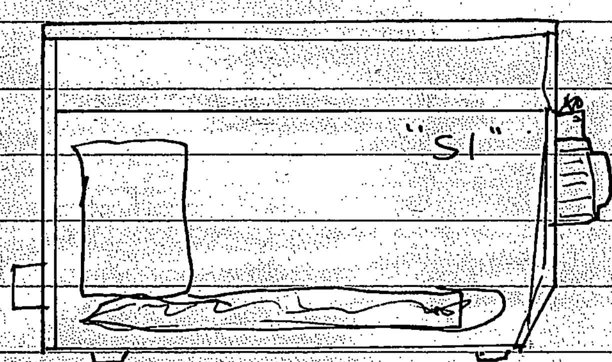
SPECIMEN
"A" ORIENTATION

S1: HIT ON ANGLE REAR END PLATE BOTTOM RIGHT SIDE

DENTED IN 35°

.165 GAP BETWEEN SHELL & REAR END PLATE

FRONT NUT WILL NOT ROTATE



(KNA) 14 Jan 98

ASSESSMENT: S1, 30 FOOT FREE DROP

TEST EXECUTED PER TEST PLAN #7A, therefore it WAS PERFORMED IN ACCORDANCE WITH 10 CFR 71.

(SD) 14FEB98
DROP ~~ORIENTATION~~ MISSED IMPACT HIT ORIENTATION.

BASED ON DAMAGE AND MISSED HIT, THE GROUP AGREED TO NOT PROCEED TO NEXT ~~TESTS~~ (SD) 14FEB98 TESTS.

(SD) 18 FEB 98

Equipment List 1: 30-foot Free Drop

Specimen S2 Serial#B35

Description	Enter the Model and Serial Number	Attach Inspection Report or Calibration Certificate
Drop Surface, Drawing AT10122, Rev. B	01	SEE ATTACH
Weight Scale	35014	SEE ATTACH
Thermometer	ENG-12	SEE ATTACH
Thermocouple flexible probe	ENG-11	SEE ATTACH
Thermocouple surface probe	ENG-13	
Record any additional tools used to facilitate the test and attach the appropriate inspection report or calibration certificate.		
THERMOCOUPLE STRAIGHT PROBE	ENG-14	SEE ATTACH

Verified by:	Signature	Date
Engineering	[signature]	14 Jan 98
Regulatory Affairs	[signature]	12 Jan 98
Quality Assurance	[signature]	12 Jan 98

Checklist 1: 30-foot Free Drop

Test Location: VALLEY TREE GROVELAND MA **Attempt Number:** 1

Step	Specimen A (Spec 52)	Specimen B	Specimen C	Specimen D
1. Measure and record test specimen's weight.	DW 24 DEC 97	NA	NA	NA
Record the specimen's weight:	55.5 lb			
Note the instrument used:	35014	35014	35014	35014
2. Immerse the test specimen in dry ice as needed to bring specimen temperature below -40° C.	DW 24 DEC 97			
Steps 1 through 2 witnessed by:				
Engineering	14 Jan 98			
Regulatory Affairs	12 Jan 98			
Quality Assurance	KNA 12 Jan 98			
3. Measure the ambient temperature.	24 Dec 97 MB			
Record ambient temperature:	35.6 °F			
Note the instrument used:	ENG-12 ENG-14	ENG-12 ENG-14	ENG-12 ENG-14	ENG-12 ENG-14
4. Attach the test specimen to the release mechanism.	DW 24 DEC 97			
5. Begin video recording of test so that the impact is recorded.	DW 24 DEC 97			
6. Measure the temperature of the specimen. Ensure that the specimen is below -40° C.	24 Dec 97 MB			
Record the specimen's internal temperature:	-65.6 °C			
Note the instrument used:	ENG-12 ENG-11	ENG-12 ENG-11	ENG-12 ENG-11	ENG-12 ENG-11
Record the specimen's surface temperature.	-57.1 °C			
Note the instrument used:	ENG-12 ENG-13	ENG-12 ENG-13	ENG-12 ENG-13	ENG-12 ENG-13
7. Lift and orient the test specimen as shown in the referenced figure for the specimen.	Figure 6 on Page 14	Figure 7 on Page 15	Figure 6 on Page 14	Figure 7 on Page 15
8. Inspect the orientation setup and verify the drop height.	DW 24 DEC 97			
9. Photograph the setup in at least two perpendicular planes.	DW 24 DEC 97			

Equipment List 1: 30-foot Free Drop

Specimen D Serial # B3590

Description	Enter the Model and Serial Number	Attach Inspection Report or Calibration Certificate
Drop Surface, Drawing AT10122, Rev. B	01	SEE ATTACH
Weight Scale	35014	SEE ATTACH
Thermometer	ENG-12	SEE ATTACH
Thermocouple flexible probe	ENG-11	SEE ATTACH
Thermocouple surface probe	ENG-13	
Record any additional tools used to facilitate the test and attach the appropriate inspection report or calibration certificate.		
THERMOCOUPLE STRAIGHT PROBE	ENG-14	SEE ATTACH

Verified by:	Signature	Date
Engineering	[signature]	14 Jan 98
Regulatory Affairs	[signature]	12 Jan 98
Quality Assurance	[signature]	12 Jan 98

Checklist 1: 30-foot Free Drop

Test Location: VALLEY TREE GROVELAND MA **Attempt Number:** 2nd

Step	Specimen A	Specimen B	Specimen C	Serial #B3590 Specimen D
1. Measure and record test specimen's weight.	NA	NA	NA	24 Dec 97 MB
Record the specimen's weight:				54.84 lb
Note the instrument used:	35014	35014	35014	35014
2. Immerse the test specimen in dry ice as needed to bring specimen temperature below -40° C.				DW 24 DEC 97
Steps 1 through 2 witnessed by:				
Engineering				[signature] 14 Jan 98
Regulatory Affairs				[signature] 12 Jan 98
Quality Assurance				KNA 12 Jan 98
3. Measure the ambient temperature.				24 Dec 97 MB
Record ambient temperature:				38.6°F
Note the instrument used:	ENG-12 / ENG-14	ENG-12 / ENG-14	ENG-12 / ENG-14	ENG-12 / ENG-14
4. Attach the test specimen to the release mechanism.				DW 24 DEC 97
5. Begin video recording of test so that the impact is recorded.				DW 24 DEC 97
6. Measure the temperature of the specimen. Ensure that the specimen is below -40° C.				24 Dec 97 MB
Record the specimen's internal temperature:				-72.5°C
Note the instrument used:	ENG-12 / ENG-11	ENG-12 / ENG-11	ENG-12 / ENG-11	ENG-12 / ENG-11
Record the specimen's surface temperature.				-50.3°C
Note the instrument used:	ENG-12 / ENG-13	ENG-12 / ENG-13	ENG-12 / ENG-13	ENG-12 / ENG-13
7. Lift and orient the test specimen as shown in the referenced figure for the specimen.	Figure 6 on Page 14	Figure 7 on Page 15	Figure 6 on Page 14	Figure 7 on Page 15
8. Inspect the orientation setup and verify the drop height.				DW 24 DEC 97
9. Photograph the setup in at least two perpendicular planes.				DW 24 DEC 97

Checklist 1: 30-foot Free Drop (Continued)

Test Location: GROVELAND, MA. **Attempt Number:** 2

Step	Specimen A	Specimen B	Specimen C	Specimen D
Steps 3 through 9 witnessed by:	NA	NA	NA	
Engineering				[signature] 14 Jan 98
Regulatory Affairs				[signature] 12 Jan 98
Quality Assurance				KNA 12 Jan 98
10. Release the test specimen.				[initials] 24 DEC 97
11. Measure the surface temperature of the test specimen.				24 DEC 97 [initials]
Record the surface temperature:				-48.3°C
Note the instrument used:	~~ENG-12~~ ENG-13	~~ENG-12~~ ENG-13	~~ENG-12~~ ENG-13	~~ENG-12~~ ENG-13
12. Measure and record the test specimen's weight.				24 DEC 97 [initials]
Record the specimen's weight:				53.75 lb
Note the instrument used:	35014	35014	35014	35014
13. Pause the video recorder. Ensure that the point of impact and orientation specified in the plan have been achieved and recorded.				[initials] 24 DEC 97
14. Record damage to test specimen on a separate sheet and attach.				[initials] 24 DEC 97
Steps 10 through 14 witnessed by:				
Engineering				[signature] 14 Jan 98
Regulatory Affairs				[signature] 12 Jan 98
Quality Assurance				KNA 12 Jan 98

Specimen A Serial# B3587
B #B3588
C #B3589
D #B35

Equipment List 1: 30-foot Free Drop

Description	Enter the Model and Serial Number	Attach Inspection Report or Calibration Certificate
Drop Surface, Drawing AT10122, Rev. B	01	See Attach.
Weight Scale	35014	See Attach.
Thermometer	ENG - 12	See Attach.
Thermocouple flexible probe	ENG - 11	See Attach.
Thermocouple surface probe	ENG - 13	
Record any additional tools used to facilitate the test and attach the appropriate inspection report or calibration certificate.		
Thermocouple Straigt Probe	ENG - 14	See Attach.
Verified by:	Signature	Date
Engineering	[signature]	14 Jan 98
Regulatory Affairs	L. Pidolak	12 Jan 98
Quality Assurance	KN [signature]	12 Jan 98

Checklist 1: 30-foot Free Drop

Test Location: Valley Tree Groveland MA **Attempt Number:** 1

Step (Serial #)	#3587 Specimen A	#3588 Specimen B	#3589 Specimen C	#3590 Specimen D
1. Measure and record test specimen's weight.	23 DEC 97 MRB	24 DEC 97 MRB	23 DEC 97 MRB	24 DEC 97 MRB
Record the specimen's weight:	55.20 lb	54.90 lb	55.60 lb	54.85 lb
Note the instrument used:	35014	35014	35014	35014
2. Immerse the test specimen in dry ice as needed to bring specimen temperature below -40° C.	DW 23 DEC 97	DW 24 DEC 97	DW 23 DEC 97	DW 24 DEC 97
Steps 1 through 2 witnessed by:				
Engineering	[signature] 14 Jan 98	[signature] 14 Jan 98	[signature] 14 Jan 98	[signature] 14 Jan 98
Regulatory Affairs	[signature] 12 Jan 98	[signature] 12 Jan 98	[signature] 12 Jan 98	[signature] 12 Jan 98
Quality Assurance	KNA 12 Jan 98	KNA 12 Jan 98	KNA 12 Jan 98	KNA 12 Jan 98
3. Measure the ambient temperature.	23 DEC 97 MRB	24 DEC 97 MRB	23 DEC 97 MRB	24 DEC 97 MRB
Record ambient temperature:	32.2°F	35.4°F	35.1°F	38.6°F
Note the instrument used:	ENG 12 ENG 114	ENG 12 ENG 14	ENG 12 ENG 14	ENG 12 ENG 14
4. Attach the test specimen to the release mechanism.	DW 23 DEC 97	DW 24 DEC 97	DW 23 DEC 97	DW 24 DEC 97
5. Begin video recording of test so that the impact is recorded.	DW 23 DEC 97	DW 24 DEC 97	DW 23 DEC 97	DW 24 DEC 97
6. Measure the temperature of the specimen. Ensure that the specimen is below -40° C.	DW 23 DEC 97	24 DEC 97 MRB	DW 23 DEC 97	24 DEC 97 MRB
Record the specimen's internal temperature:	-74.1°C	-54.6°C	-71.6°C (*)	-72.5°C
Note the instrument used:	ENG 12 ENG 11	ENG 12 ENG 11	ENG 12 ENG 11	ENG 12 ENG 11
Record the specimen's surface temperature.	-52.9°C	-56.9°C	-70.6°C	-67.5°C
Note the instrument used:	ENG 12 ENG 13	ENG 12 ENG 13	ENG 12 ENG 13	ENG 12 ENG 13
7. Lift and orient the test specimen as shown in the referenced figure for the specimen.	Figure 6 on Page 14	Figure 7 on Page 15	Figure 6 on Page 14	Figure 7 on Page 15
8. Inspect the orientation setup and verify the drop height.	DW 23 DEC 97	DW 24 DEC 97	DW 23 DEC 97	DW 24 DEC 97
9. Photograph the setup in at least two perpendicular planes.	23 DEC 97 MRB	24 DEC 97 MRB	23 DEC 97 MRB	DW 24 DEC 97

(*) KNA for M 12 Jan

Checklist 1: 30-foot Free Drop (Continued)

Test Location: VALLEY TREE GROVELAND MA **Attempt Number:** 1

Step	Specimen A	Specimen B	Specimen C	Specimen D
Steps 3 through 9 witnessed by:				
Engineering	[signature] 14 Jan 98	[signature] 14 Jan 98	[signature] 14 Jan 98	[signature] 14 Jan 98
Regulatory Affairs	[signature] 12 Jan 98	[signature] 12 Jan 98	[signature] 12 Jan 98	[signature] 12 Jan 98
Quality Assurance	KNA 12 Jan 98	KNA 12 Jan 98	KNA 12 Jan 98	KNA 12 Jan 98
10. Release the test specimen.				
11. Measure the surface temperature of the test specimen.	DW 23 DEC 97	24 Dec 97 MTB	DW 23 DEC 97	24 Dec 97 MTB
Record the surface temperature:	-44.2°C	-54.9°C	-42.6°C	-60.0°C
Note the instrument used:	ENG 12 ENG 13	ENG 12 ENG 13	ENG 12 ENG 13	ENG 12 ENG 13
12. Measure and record the test specimen's weight.	DW 23 DEC 97	24 Dec 97 MTB	DW 23 DEC 97	24 Dec 97 MTB
Record the specimen's weight:	55.25 lb	54.50 lb	55.50 lb	54.84 lb
Note the instrument used:	35014	35014	35014	35014
13. Pause the video recorder. Ensure that the point of impact and orientation specified in the plan have been achieved and recorded.	DW 23 DEC 97	DW 24 DEC 97	DW 23 DEC 97	DW 24 DEC 97
14. Record damage to test specimen on a separate sheet and attach.	DW 29 DEC 97	DW 29 DEC 97	DW 29 DEC 97	DW 29 DEC 97
Steps 10 through 14 witnessed by:				
Engineering	[signature] 14 Jan 98	[signature] 14 Jan 98	[signature] 14 Jan 98	[signature] 14 Jan 98
Regulatory Affairs	[signature] 12 Jan 98	[signature] 12 Jan 98	[signature] 12 Jan 98	[signature] 12 Jan 98
Quality Assurance	KNA 12 Jan 98	KNA 12 Jan 98	KNA 12 Jan 98	KNA 12 Jan 98

Checklist 1: 30-foot Free Drop (Continued)

Test Location: Valley Tree Greenland, MA **Attempt Number:** 1

Step	Specimen A	Specimen B	Specimen C	Specimen D
15. Engineering, Regulatory Affairs and Quality Assurance make a preliminary assessment relative to 10 CFR 71. Record the assessment on a separate sheet and attach. Determine what changes are necessary in package orientation for the puncture test to achieve maximum damage.	See	Attached	[signature] 14 Jan 98	

Test Data Accepted by (Signature):	Date:
Engineering [signature]	14 Jan 98
Regulatory Affairs [signature]	22 Jan 98
Quality Assurance [signature]	14 Jan 98

30-foot Free Drop Test Assessment

The test was executed per test plan #74, therefore it was performed in accordance with 10 CFR 71.

Unit S2 was needed for replacing Unit C, since Unit C did not hit the target impact point. There was no adjustment to the torque values of the end plate screws. The penetration test and 4-foot free drop test was performed on S2 before the 30-foot free drop test.

Unit D was dropped twice since it did not hit the target impact point. Second attempt hit same impact point as previous. This produced worst damage of all attempts.

Based on assessment of damage, there is no indication of any damage that would alter original acceptance of test specimens to meet requirements of 10 CFR 71.

As there is no structural damage to the dropped units, conclude that testing will continue as described in test plan 74.

Except for specimen B and D, there was no change in orientation for the puncture test. Orientations for specimen B and D was changed to try to peel back the area of the end plate left by the removed handle.

14 Jan 98

KMA 14 Jan 98

22 Jan 98

Intermediate Test Inspection

Damage recorded for each test specimen. See attached.

It was decided to delay the radiation profile of the test specimen, since it could possibly affect their structural integrity and affect the outcome of the thermal test.

AJB 14 Jan 98

KNA 14Jan98

[illegible] 22 Mar 98

30 FOOT FREE DROP & PUNCTURE TEST (DO) 29 DEC 97

SPECIMEN A HIT REAR PLATE BOTTOM Serial# B3587	VISUAL: BOTTOM SHELL CONVEXED (DO 29 DEC 97) 1/4" CENTER OF SHELL (BOTTOM) LEFT SIDE .168 GAP OPENING BETWEEN SHELL & REAR PLATE, CROWN OF REAR PLATE 3 3/4" RIGHT SIDE .149 GAP BETWEEN SHELL & REAR PLATE CROWN OF REAR PLATE 4" 10.280 W FRONT TO REAR
SPECIMEN B HIT FRONT PLATE TOP Serial# B3588	VISUAL: HANDLE BROKEN OFF, FRONT PLATE TOP BENT IN 45° REAR END PLATE BENT OUT 13° (1/8 GAP ON TOP REAR) NO GAP ON SHELL & FRONT, OR REAR PLATES 10" W FRONT TO REAR CROWN FRONT PLATE 3 1/2 HIGH CONVEX 1/16", FRONT NUT DOESN'T SPIN
SPECIMEN S2 HIT REAR PLATE BOTTOM Serial# B3592	GAP .147 BOTH SIDES CROWN 4" HIGH (CONVEXED) BOTTOM SHELL CONVEXED 1/4" → 1/2" FROM MID POINT TO REAR FRONT NUT SPINS FREELY 10.255 / 10.270 W FRONT TO REAR
SPECIMEN "D" HIT FRONT PLATE TOP RIGHT SIDE Serial# B3590	GAP .480 FRONT PLATE TO SHELL 4 1/8" TO CROWN FROM BASE .094 GAP TOP SHELL TO REAR PLATE, SHELL TWIST APPROX 1/8"

(KNA) 12 Jan 98

[signature] 12 Jan 98

[signature] 14 Jan 98

30 FT FREE DROP 29 DEC 97

SPECIMEN C
HIT BOTTOM REAR PLATE CORNER
Serial #B3589

VISUAL: DAMAGE TO BOTTOM LEFT CORNER OF REAR PLATE & SHELL

DIDN'T HIT ON TARGET

.200 GAP BETWEEN SHELL & REAR PLATE

DENT APPROX 1" REAR PLATE LEFT BOTTOM

(KNA) 12 Jan 98

[signature] 12 Jan 98

[signature] 14 Jan 98

Specimen A serial #B3587
B #B3588
D #B3590
S2 #B3592

Equipment List 2: Puncture Test

Description	Enter the Model and Serial Number	Attach Inspection Report or Calibration Certificate
Drop Surface, Drawing AT10122, Rev. B	SN-01	SEE ATTACH
Puncture Billet, Drawing CT10119, Rev. C	SN-01	SEE ATTACH
Weight Scale	OHAUS DS10 #35014	SEE ATTACH
Thermometer	OMEGA HH21 # ENG-12	SEE ATTACH
Thermocouple flexible probe	#ENG-11	SEE ATTACH
Thermocouple surface probe	#ENG-13	SEE ATTACH
Record any additional tools used to facilitate the test and attach the appropriate inspection report or calibration certificate.		
Thermocouple Straight Probe	#ENG-14	SEE ATTACH

Verified by:	Signature	Date
Engineering	[signature]	14 Jan 98
Regulatory Affairs	[signature]	12 Jan 98
Quality Assurance	[signature]	12 Jan 98

Checklist 2: Puncture Test

Test Location: GROVE LAND MA **Attempt Number:** 1

Serial #	B3587	B3588	B3592	B3590
Step	Specimen A	Specimen B	Specimen ~~C~~ 24 MAB 24 Dec 97 S-2	Specimen D
1. Immerse the test specimen in dry ice as need to bring the specimen's temperature below -40° C.	DW 24 DEC 97	DW 24 DEC 97	DW 24 DEC 97	DW 24 DEC 97
Step 1 witnessed by:				
Engineering	[signature] 14 Jan 98	[signature] 14 Jan 98	[signature] 14 Jan 98	[signature] 14 Jan 98
Regulatory Affairs	[signature] 12 Jan 98	[signature] 12 Jan 98	[signature] 12 Jan 98	[signature] 12 Jan 98
Quality Assurance	KNA 12 Jan 98	KNA 12 Jan 98	KNA 12 Jan 98	KNA 12 Jan 98
2. Measure the weight of the specimen.	24 Dec 97 MAB	24 Dec 97 MAB	24 Dec 97 MAB	24 Dec 97 MAB
Record the specimen's weight:	55.20 lb	54.50 lb	55.01 lb	54.84 lb
Note instrument used:	#35014	# 35014	# 35014	#35014
3. Measure the ambient temperature.	DW 24 DEC 97	DW 24 DEC 97	DW 24 DEC 97	DW 24 DEC 97
Record ambient temperature:	36.8 °F	35.6 °F	35.3 °F	31.6 °F
Note the instrument used:	ENG-12 ~~#ENG-14~~	ENG-12 ~~#ENG-14~~	ENG-12 ~~#ENG-14~~	ENG-12 ~~#ENG-14~~
4. Attach the test specimen to the release mechanism.	DW 24 DEC 97	DW 24 DEC 97	DW 24 DEC 97	DW 24 DEC 97
5. Begin video recording of test so that the impact is recorded.	DW 24 DEC 97	DW 24 DEC 97	DW 24 DEC 97	DW 24 DEC 97
6. Measure the surface temperature of the specimen. Ensure that the specimen is below -40° C.	24 Dec 97 MAB	24 Dec 97 MAB	24 Dec 97 MAB	24 Dec 97 MAB
Record the specimen surface temperature:	-70.4 °C	-42.2 °C	-57.2 °C	-58.5 °C
Note the instrument used:	ENG-12 ~~#ENG-13~~	ENG-12 ~~#ENG-13~~	ENG-12 ~~#ENG-13~~	ENG-12 ~~#ENG-13~~
7. Lift and orient the test specimen as shown in the referenced figure for the specimen.	Figure 8 on Page 18	Figure 9 on Page 19	Figure 8 on Page 18	Figure 9 on Page 19
8. Inspect the orientation setup and verify drop height.	DW 24 DEC 97	DW 24 DEC 97	DW 24 DEC 97	DW 24 DEC 97

Checklist 2: Puncture Test (Continued)

Test Location: VALLEY TREE GROVE LAND, MA. **Attempt Number:** 1

Step	Specimen A	Specimen B	Specimen ~~C~~ S-2 (MRB 24 Dec 97)	Specimen D
9. Photograph the setup in at least two perpendicular planes.	DW 24 DEC 97	DW 24 DEC 97	DW 24 DEC 97	DW 24 DEC 97
Steps 2 through 9 witnessed by:				
Engineering	[signature] 14 Jan 98	[signature] 14 Jan 98	[signature] 14 Jan 98	[signature] 14 Jan 98
Regulatory Affairs	[signature] 12 Jan 98	[signature] 12 Jan 98	[signature] 12 Jan 98	[signature] 12 Jan 98
Quality Assurance	KNA 12 Jan 98	KNA 12 Jan 98	KNA 12 Jan 98	KNA 12 Jan 98
10. Release the test specimen.	DW 24 DEC 97	DW 24 DEC 97	DW 24 DEC 97	DW 24 DEC 97
11. Measure the surface temperature of the test specimen.	24 Dec 97 MRB	24 Dec 97 MRB	24 Dec 97 MRB	24 Dec 97 MRB
Record the surface temperature:	-65.2 °C	-42.2 °C	-40.1 °C	-48.7 °C
Note the instrument used:	ENG-12 #ENG-13	ENG-12 #ENG-13	ENG-12 #ENG-13	ENG-12 #ENG-13
12. Measure and record the test specimen's weight.	24 Dec 97 MRB	24 Dec 97 MRB	24 Dec 97 MRB	24 Dec 97 MRB
Record the specimen's weight:	55.05 lb	53.91 lb	55.05 lb	55.20 lb
Note the instrument used:	#35014	#35014	#35014	#35014
13. Pause the video recorder. Ensure that the point of impact and orientation specified in the plan have been achieved and recorded.	DW 24 DEC 97	DW 24 DEC 97	DW 24 DEC 97	DW 24 DEC 97
14. Record damage to test specimen on a separate sheet and attach.	DW 29 DEC 97	DW 29 DEC 97	DW 29 DEC 97	DW 29 DEC 97
Steps 10 through 14 witnessed by:				
Engineering	[signature] 14 Jan 98	[signature] 14 Jan 98	[signature] 14 Jan 98	[signature] 14 Jan 98
Regulatory Affairs	[signature] 12 Jan 98	[signature] 12 Jan 98	[signature] 12 Jan 98	[signature] 12 Jan 98
Quality Assurance	KNA 12 Jan 98	KNA 12 Jan 98	KNA 12 Jan 98	KNA 12 Jan 98

Checklist 2: Puncture Test (Continued)

Test Location: VALLEY TREE GROVELAND, MA. **Attempt Number:** 1

Step	Specimen A	Specimen B	Specimen C	Specimen D
15. Engineering, Regulatory Affairs and Quality Assurance make a preliminary assessment relative to 10 CFR 71. Record the assessment on a separate sheet and attach. Determine the package orientation for the thermal test that will achieve maximum damage.	see	attached	[signature] 14 Jan 98	

Test Data Accepted by (Signature):	Date:
Engineering [signature]	14 Jan 98
Regulatory Affairs [signature]	22 Jan 98
Quality Assurance [signature]	14 Jan 98

Puncture Test Assessment

The puncture test was executed per test plan #74, therefore it was performed in accordance with 10 CFR 71.

Based on assessment of damage, there is no indication of any damage that would alter original acceptance of test specimens to meet requirements of 10 CFR 71.

As there is no structural damage to the dropped units, conclude that testing will continue as described in test plan 74.

Since the damage for specimen B did not produce a gap in the shell or end plates, It was decided to not perform the thermal test on this specimen.

There is no special orientation for the thermal test. All specimen to be oriented on their feet. This will allow optimal air flow in and around open gap areas of the damaged shell and end plates.

14 Jan 98

KMA 14Jan98

22Jan98

Specimen A Serial#B3587
D #B3590
S2 #B3592

Equipment List 3: Thermal Test

Description	Enter the Model and Serial Number	Attach Inspection Report or Calibration Certificate
Air Flowmeter	3367 /ENG-08	SEE ATTACH
Thermocouple (internal)	ENG-18A	SEE ATTACH
Thermocouple (external)	ENG-17A	SEE ATTACH
Thermocouple (oven)	ENG-16A	SEE ATTACH
Temperature recorder	ENG-16/ENG-17/ENG-18	SEE ATTACH
Record any additional tools used to facilitate the test and attach the appropriate inspection report or calibration certificate.		
THERMOMETER	ENG-12	SEE ATTACH
THERMOCOUPLE PROBE	ENG-14	SEE ATTACH

Verified by:	Signature	Date
Engineering	[signature]	14 Jan 98
Regulatory Affairs	[signature]	12 Jan 98
Quality Assurance	[signature]	12 Jan 98

Checklist 3: Thermal Test

Test Location: MFG SCIENCES OAKRIDGE, TN. **Attempt Number:** 1

Step	Specimen A #B3587	Specimen B	Specimen C #B3592	Specimen D #B3590
1. Pre-heat the oven to a temperature above 800° C.	DW 3:24 PM 902.2°C		DW 3:24 PM 902.2	DW 3:24 PM 902.2°c
2. Attach the thermocouples the specimen's internal and external measuring points.	DW 30 DEC 97		DW 30 DEC 97	DW 30 DEC 97
3. Place the package in the oven and close the oven door.	DW 30 DEC 97		DW 30 DEC 97	DW 30 DEC 97
Record the date and time that the package is placed in oven.	3:25 PM 844°c		6:16 PM 807.9°c	4:50 PM 852° c
4. When the specimen's internal temperature exceeds 800° C, start the air flow into the oven. Record the time.	4:06 PM DW 30 DEC 97		7:25 PM DW 30 DEC 97	5:34 pm DW 30 DEC 97
Steps 1 through 4 witnessed by:				
Engineering	[signature] 14 Jan 98		[signature] 14 Jan 98	[signature] 14 Jan 98
Regulatory Affairs	[signature] 12 Jan 98		[signature] 12 Jan 98	[signature] 12 Jan 98
Quality Assurance	KMA 12 Jan 98		KMA 12 Jan 98	KMA 12 Jan 98
5. Measure the oven temperature, the specimen's internal and external temperatures and the air flow rate.	DW 30 DEC 97		DW 30 DEC 97	DW 30 DEC 97
Record the oven temperature:	904°c		900.7°c	900.0°c
Note instrument used:	~~ENG-16~~ ENG-16A		~~ENG-16~~ ENG-16A	~~ENG-16~~ ENG-16A
Record the specimen's internal temperature:	800°c		800.7°c	801.1°c
Note instrument used:	~~ENG-18~~ ENG-18A		~~ENG-18~~ ENG-18A	~~ENG-18~~ ENG-18A
Record the specimen's external temperature:	844.3°c		823.8°c	842.2°c
Note instrument used:	~~ENG-17~~ ENG-17A		~~ENG-17~~ ENG-17A	~~ENG-17~~ ENG-17A
Record airflow rate:	10 CFM		10 CFM	10 CFM
Note instrument used:	~~3367~~ ENG-08		~~3367~~ ENG-08	~~3367~~ ENG-08
6. Monitor the internal and external temperatures of the specimen and the oven temperature throughout the 30-minute period to ensure that they are above 800° C.	DW 30 DEC 97		DW 30 DEC 97	DW 30 DEC 97

Checklist 3: Thermal Test (Continued)

Test Location: MFG SCIENCES OAKRIDGE, TN. **Attempt Number:** 1

Step	Specimen A	Specimen B	Specimen ~~C~~ 52	Specimen D
7. Monitor the airflow throughout the 30-minute period to ensure a rate of at least 9.6 ft^3/min.	DW 30 DEC 97		DW 30 DEC 97	DW 30 DEC 97
8. At the end of the 30-minute period, repeat step 5 using the same measurement devices.	DW 30 DEC 97		DW 30 DEC 97	DW 30 DEC 97
Record the oven temperature:	905.2°C		901.5°C	907.1°C
Record the specimen's internal temperature:	841.2°C		857.0°C	842.5°C
Record the specimen's external temperature:	850.4°C		843.0°C	850.4°C
Record intake air flow velocity:	10 CFM		10 CFM	10 CFM
Steps 5 through 8 witnessed by:				
Engineering	[signature] 12 Jan 98		[signature] 12 Jan 98	[signature] 12 Jan 98
Regulatory Affairs	[signature] 12 Jan 98		[signature] 12 Jan 98	[signature] 12 Jan 98
Quality Assurance	KNA 12 Jan 98		KNA 12 Jan 98	KNA 12 Jan 98
9. Remove test specimen from the oven.	DW 30 DEC 97		DW 30 DEC 97	DW 30 DEC 97
Record time the specimen is removed.	4:36 PM		7:55 pm	6:04
Describe combustion when door is opened to remove specimen.	RED HOT NO FLAMES		RED HOT FLAMES INSIDE	RED HOT SOME FLAMES @ REAR
NOTE: If specimen continues to burn, let it self-extinguish and cool naturally.				
10. Measure the ambient temperature.	DW 30 DEC 97		DW	DW 30 DEC 97
Record the ambient temperature:	62.3°F		62.3°F	61.9°F
Note the instrument used:	ENG-12 / ENG-14		ENG-12 / ENG-14	ENG-12 / ENG-14
11. Photograph the test specimen and any subsequent damage	DW 30 DEC 97		DW 30 DEC 97	DW 30 DEC 97
12. Record damage to test specimen on a separate sheet and attach.	See photos + videos			
Steps 9 through 12 witnessed by:				
Engineering	[signature] 18 Feb 98		[signature] 18 Feb 98	[signature] 18 Feb 98
Regulatory Affairs	[signature] 12 Jan 98		[signature] 12 Jan 98	[signature] 12 Jan 98
Quality Assurance	KNA 12 Jan 98		KNA 12 Jan 98	KNA 12 Jan 98

Checklist 3: Thermal Test (Continued)

Test Location: MFG SCIENCES OAK RIDGE, TN. **Attempt Number:** 1

Step	Specimen A	Specimen B	Specimen ~~C~~ S2	Specimen D
13. Engineering, Regulatory Affairs and Quality Assurance make a preliminary assessment relative to 10 CFR 71. Record the assessment on a separate sheet and attach.	see attached		see attached	see attached

Test Data Accepted by (Signature):		Date:
Engineering	S. Ga[illegible]	18 FEB 98
Regulatory Affairs	C. [illegible]	18 FEB 98
Quality Assurance	[illegible]	02 MAR 98

Post Thermal Temp. at Mfg. Sciences

8:35 AM 31 Dec 97 Room Temp 17.8

serial #B3587 Specimen A: Internal temp 17.6°C

serial #B3590 Specimen D: Internal temp ~~54.1~~ [initials] 31 Dec 97
541.3°C

Serial #B3592 Specimen S2: Internal temp ~~417.3°C~~ [initials] 31 Dec 97
417.5°C

~~Spec~~ [initials] 31 DEC 97

(KNA) 31 Dec 97

Assessment - Specimen A (Thermal results)
Serial #B3587

Based on physical appearance of Specimen A, it is probable that additional movement of the shield was due to transport / handling.

The shield in Specimen A appears (based on radiographs) to have experienced lateral movement from time of concluding puncture test to arrival back at Amersham after thermal testing. The evidence of lateral movement is the distance the front shield was displaced from the front nut. Comparisons of this position after thermal (and transport) to radiographs taken after puncture indicate an approximate 1/4 inch movement. As the thermal test was performed with the 660 flat, there were no forces or loads produced during thermal that could have produced this degree of lateral movement.

In order to validate that the lateral movement was a result of handling and transport, additional specimens will be subject to the thermal test.

In addition observations of the unpacking operation at Amersham of the test units indicate that the test specimens had been packaged with an end plate down, i.e. not on its normal resting position on the feet.

The additional test specimens include:

(1) S_3 - this is a specimen that was originally
Serial #B3586

edge drop. Based on the orientation miss, the puncture test was not performed. Upon examination of C through radiographs and visual observation and mechanical measurements, it was determined that although the damage was not exactly as in Specimen A prior to B thermal test, it would provide information on the amount of possible movement as a result of the thermal test. The S tube location in the front nut was similar to that seen on Specimen A. The rear plate on C was not bowed out in the same location as on A, but as the strike was disengaged from the boss of the lock assembly it appeared that the shield would have room to move downward. The teleflex engagement of C was severed.

(SD) 18 FEB 98
CMR 18 FEB 98
(KNA) 02 MAR 98

was corrupted during transport/ handling.

If it doesn't pass profile, information will not be used as it was subjected to four 30 foot drop tests and had ~~the~~ excessive damage. Other test specimens subjected to 1 or 2 30 foot drops did not exhibit the extent of damage shown by EX-1

Radiographs of all three specimens were taken prior to transport to thermal testing. Source position was also taken prior to transport. The source position was taken upon receipt at Manufacturing Sciences to determine actual position prior to thermal.

Radiographs and ~~LA~~ source position will be taken when units are cooled down after thermal test to record source position prior to any movement or transport.

(CB) 18 FEB 98

cmr 19 Feb 98

(KMA) 02-MAR-98

TEST PLAN # 74

SPECIMEN "D" - PROFILE RESULTS INDICATE THIS TEST SPECIMEN PASSED THE TEST REQUIREMENTS OF 10 CFR 71.73.

Serial# B3590

SPECIMEN "S2" - THE TEAM AGREED TO NOT PROFILE THIS TEST SPECIMEN. THIS IS BECAUSE THE RESULTS PROBABLY WOULD NOT HAVE MATTERED SINCE THE RESULTS OF SPECIMEN "A" WAS QUESTIONABLE. ALSO, ~~PRESONAL~~ PERSONAL SAFETY WAS CONSIDERED IN THE DECISION NOT TO PROFILE "S2".

Serial# B3592

(SD) 18FEB98

(SD) 18 FEB 98

CMR 19 FEB 98

(KMA) 02 MAR 98

SENTINEL

WORKSHEET

I. Device Model ~~Stylo~~ 660 Capacity 140 Ci Isotope IR-192 Source Model 424-9 T10763

II. Maximum acceptable surface reading: 200 mR/hr * If used to show compliance wi[th] normal transport requirements

Maximum acceptable meter reading: 10 mR/hr * For normal transport

1 R/hr * For hypothetical accident conditions of 10CFR71.

III. Surface Correction Factors:

(applicable for normal transport only).

Top	1.16
Right	1.28
Front	1.13
Left	1.28
Rear	1.13
Bottom	1.19

IV. Specific Instructions for loading/unloading:

See Attachment

V. Approved By:

[signature] 9 Jan 98
Engineering Date

[signature] 9 Jan 98
Regulatory Date

C. [signature] 9 Jan 98
Quality Assurance Date

Amersham QSA

Profile Worksheet Supplement (PEF-003/97) Supplement # PWS-1/98

4. ALARA Justification

Step 1:

Assuming surface intensity of 5 R/hr, source securement/unsecurement time of 2 minute and working behind supplemental shielding to reduce body intensities to less than 500 mR/hr, exposure estimates for operation as follows:

$$E_{WB} = \left(500\ \frac{mR}{hr} \times\ 0.033\ hr\right) = 17\ mR$$

$$E_{Hand} = \left(5{,}000\ \frac{mR}{hr} \times\ 0.033\ hr\right) = 165\ mR$$

Step 2 and 3:

Dose to personnel the same as general cutting cell work.

Profile Operation:

5 minutes for assessment of surface dose rates and general handling/adjustment at average intensity of 1 R/hr, whole body average dose rate of 200 mR/hr for 15 minutes for one meter dose rate readings.

$$E_{WB} = \left(200\ \frac{mR}{hr} \times\ 0.25\ hr\right) = 50\ mR$$

$$E_{Hand} = \left(1{,}000\ \frac{mR}{hr} \times\ 0.083\ hr\right) = 83\ mR$$

RHP Approval Initials & Date: [signature] 9 Jan 98

Profile Worksheet Supplement (PEF-003/97)	Supplement # PWS-1/98
5.	**Authorized Individuals:** Profile: ☐ RT Qualified & Operationally Approved for Device Profiles ☒ Others: RSO, RAM, E. Shaffer, R. Kelly Steps 2 & 3: ☐ RT Qualified & Operationally Approved for Cutting Cell Procedure ☒ Others: E. Shaffer, R. Kelly, RSO, RAM
6.	**Operational Hold-points:** None.
7.	**Other Applicable Comments/Criteria:** None.

RHP Approval Initials & Date: [signature] 9 Jan 98

SENTINEL

660/660B DEVICE PROFILING FORM

B3588 (KNA) 12 Jan 98

Device Model No.: 660B Device Serial No.: ~~After Thermal~~ TP73 "B" After 30 Ft + Puncture LP 5 Jan

Model ~~424-9~~ TI0163 Source Serial Number: X0016 Activity: 93.2C

Surface Survey Instrument: AN/PDR 27T Serial No: SM-392401 Cal Due: 3/18/98

One Meter Survey Instrument: Same Serial No: — Cal Due: —

* Non-leaded plug used during profile.

Capacity Corr. Factor 1.50

	Surf Corr. Fact	SURFACE READINGS mR/hr Extrapolated ~~Allowed~~	Actual		ONE METER READINGS mR/hr Extrapolate ~~Allowed~~	Actual
TOP	1.16	104.4	60	TOP	1.0	0.7
RIGHT	1.28	153.6	80	RIGHT	0.9	0.6
FRONT	1.13	389.9	230	FRONT	2.7	1.8
LEFT	1.28	115.2	60	LEFT	0.75	0.5
REAR	1.13	152.6	90	REAR	1.5	1.0
BOTTOM	1.19	107.1	60	BOTTOM	0.9	0.6

INSPECTOR: L. Padolak DATE: 5 Jan 98 NCR No.: ______

Comments:

(KNA) 12 Jan 98

Amersham QSA

WI-Q05

SENTINEL

660/660B DEVICE PROFILING FORM

B3587 (LNA) 12 Jan 98

Device Model No.: 660B Device Serial No.: ~~After~~ Thermal TP73"A"

Model ~~424-9~~ T10163 Source Serial Number: X0016 Activity: 93.2 Ci

~~Surface~~ <500 mR/hr Survey Instrument: AN/PDR 27T Serial No: SM-392401 Cal Due: 3/18/98

*) ~~One Meter~~ ≥ 500 mR/hr Survey Instrument: Tech-50 Serial No: B-814-S Cal Due: 7/22/98

Capacity Corr. Factor 1.5

	SURFACE READINGS mR/hr		ONE METER READINGS mR/hr	
	~~Allowed~~ Extrapolated For Capacity only	Actual	~~Allowed~~ Extrapolated	Actual
TOP	780	520*		
RIGHT	3 R/hr	2 R/hr*		
FRONT	40.5	27	1.4	0.9
LEFT	3 R/hr	2 R/hr*		
REAR	3 R/hr	2 R/hr*	(9.3 R/hr)	6.2 R/hr*
BOTTOM	1.8 R/hr	1.2 R/hr*	18	12.0

> 1 R/hr. No add'l measurements taken on device.

INSPECTOR: [signature] DATE: 5 Jan 98 NCR No.: ______

Comments:

- No surface corrections made. Actual surface enclosed in plastic bagging which varied in thickness from 1/2 - 1".

- Surface doses for general info only. Primary purpose of profile was for 1 meter readings. Surface levels on sides and rear may be higher than recorded. Radiation was a finely collimated beam from S-tube out the rear of the device which was difficult to quantify precisely without receiving add'l. extremity exposure.

(LNA) 12 Jan 98

Amersham QSA

WI-Q05

SENTINEL

660/660B DEVICE PROFILING FORM

B3590 (KNA) 12 Jan 98

Device Model No.: 660B **Device Serial No.:** TP73 "D" After Thermal

Model ~~424-9~~ T70163 **Source Serial Number:** X0016 **Activity:** 89.7 Ci

Surface Survey Instrument: ~~Bicron~~ Tech-50 **Serial No:** B-814-S **Cal Due:** 7/22/98

One Meter Survey Instrument: Same **Serial No:** – **Cal Due:** –

Capacity Corr. Factor
1.56

SURFACE READINGS mR/hr

	~~Allowed~~	Actual
TOP		130
RIGHT		180
FRONT		80
LEFT		50
REAR		90
BOTTOM		50

ONE METER READINGS mR/hr

	Extrapolated ~~Allowed~~	Actual
TOP	2.3	1.5
RIGHT	1.9	1.2
FRONT	2.7	1.7
LEFT	2.2	1.4
REAR	4.7	3.0
BOTTOM	1.7	1.1

INSPECTOR: [signature] **DATE:** 9 Jan 98 **NCR No.:** ______

Comments:

* Surface of unit enclosed in multiple layers of plastic bags for contamination control of uranium oxide. Thickness varies from 1/4" to 1".

* Surface readings taken for exposure control and general information purposes only.

(KNA) 12 Jan 98

Amersham QSA

WI-Q05

Equipment List 1: 30-foot Free Drop S3 Serial#B3586

Description	Enter the Model and Serial Number	Attach Inspection Report or Calibration Certificate
Drop Surface, Drawing AT10122, Rev. B	01	SEE ATTACH
Weight Scale	OHAUS / 35014	SEE ATTACH
Thermometer	OMEGA / ENG-12	SEE ATTACH
Thermocouple flexible probe	OMEGA / ENG-11	SEE ATTACH
Thermocouple surface probe	OMEGA / ENG-13	SEE ATTACH
Record any additional tools used to facilitate the test and attach the appropriate inspection report or calibration certificate.		
THERMOCOUPLE STRAIGHT PROBE	OMEGA / ENG-14	SEE ATTACH

Verified by:	Signature	Date
Engineering	[signature]	14 Jan 98
Regulatory Affairs	[signature]	12 Jan 98
Quality Assurance	[signature]	14 Jan 98

Checklist 1: 30-foot Free Drop

Test Location: VALLEY TREE GROVELAND MA Serial #B3586 **Attempt Number:** *

Step	*1 Specimen ~~A~~ 11 JAN 98 53	*2 Specimen ~~B~~ 11 JAN 98 53	Specimen C	Specimen D
1. Measure and record test specimen's weight.	55.3 lbs	55.25 lbs	N/A	N/A
Record the specimen's weight:	DW 11 JAN 98	DW 11 JAN 98		
Note the instrument used:	35014	35014	35014	35014
2. Immerse the test specimen in dry ice as needed to bring specimen temperature below -40° C.	DW 11 JAN 98	DW 11 JAN 98		
Steps 1 through 2 witnessed by:				
Engineering	14 Jan 98	14 Jan 98		
Regulatory Affairs	12 Jan 98	12 Jan 98		
Quality Assurance	14 Jan 98	14 Jan 98		
3. Measure the ambient temperature.	11 JAN 98	11 JAN 98		
Record ambient temperature:	42.6°F	42.6°F		
Note the instrument used:	~~ENG-12~~ ENG-14	~~ENG-12~~ ENG-14	~~ENG-12~~ ENG-14	~~ENG-12~~ ENG-14
4. Attach the test specimen to the release mechanism.	DW 11 JAN 98	DW 11 JAN 98		
5. Begin video recording of test so that the impact is recorded.	DW 11 JAN 98	DW 11 JAN 98		
6. Measure the temperature of the specimen. Ensure that the specimen is below -40° C.	11 JAN 98	11 JAN 98		
Record the specimen's internal temperature:	-77.1°C	-77.1°C		
Note the instrument used:	~~ENG-12~~ ENG-11	~~ENG-12~~ ENG-11	~~ENG-12~~ ENG-11	~~ENG-12~~ ENG-11
Record the specimen's surface temperature.	-58.2°C	-51.1°C		
Note the instrument used:	~~ENG-12~~ ENG-13	~~ENG-12~~ ENG-13	~~ENG-12~~ ENG-13	~~ENG-12~~ ENG-13
7. Lift and orient the test specimen as shown in the referenced figure for the specimen.	Figure 6 on Page 14	Figure 7 on Page ~~15~~ 14	Figure 6 on Page 14	Figure 7 on Page 15
8. Inspect the orientation setup and verify the drop height.	DW 11 JAN 98	DW 11 JAN 98		
9. Photograph the setup in at least two perpendicular planes.	DW 11 JAN 98	DW 11 JAN 98		

Checklist 1: 30-foot Free Drop (Continued)

Test Location: GROVELAND, MA. **Attempt Number:** *

Step	Specimen 53 ~~A~~ *1 DW 11 JAN 98	Specimen 53 ~~B~~ *2 DW 11 JAN 98	Specimen C	Specimen D
Steps 3 through 9 witnessed by:			N/A	N/A
Engineering	[signature] 14 Jan 98	[signature] 14 Jan 98		
Regulatory Affairs	[signature] 12 Jan 98	[signature] 12 Jan 98		
Quality Assurance	CMR 14 Jan 98	CMR 14 Jan 98		
10. Release the test specimen.	DW 11 JAN 98	DW 11 JAN 98		
11. Measure the surface temperature of the test specimen.	F 11 JAN 98	F 11 JAN 98		
Record the surface temperature:	-45.4°C	-26.2°C		
Note the instrument used:	~~ENG-12~~ ENG-13	~~ENG-12~~ ENG-13	~~ENG-12~~ ENG-13	~~ENG-12~~ ENG-13
12. Measure and record the test specimen's weight.	F 11 JAN 98	F 11 JAN 98		
Record the specimen's weight:	55.25 lbs	55.4 lbs		
Note the instrument used:	35014	35014	35014	35014
13. Pause the video recorder. Ensure that the point of impact and orientation specified in the plan have been achieved and recorded.	DW 11 JAN 98	DW 11 JAN 98		
14. Record damage to test specimen on a separate sheet and attach.	DW 11 JAN 98	DW 11 JAN 98		
Steps 10 through 14 witnessed by:				
Engineering	[signature] 14 Jan 98	[signature] 14 Jan 98		
Regulatory Affairs	[signature] 12 Jan 98	[signature] 12 Jan 98		
Quality Assurance	CMR 14 Jan 98	CMR 14 Jan 98		

Checklist 1: 30-foot Free Drop (Continued)

Test Location: GROVELAND, MA. **Attempt Number:** *

Step	Specimen S3 ~~A~~ *1 DO 11 JAN 98	Specimen S3 ~~B~~ *2 DO 11 JAN 98	Specimen C	Specimen D
15. Engineering, Regulatory Affairs and Quality Assurance make a preliminary assessment relative to 10 CFR 71. Record the assessment on a separate sheet and attach. Determine what changes are necessary in package orientation for the puncture test to achieve maximum damage.	DO 11 JAN 98	DO 11 JAN 98	N/A	N/A

Test Data Accepted by (Signature):	Date:
Engineering [signature]	14 Jan 98
Regulatory Affairs [signature]	22 Jan 98
Quality Assurance C. Rompson	17 Feb 98

TP 74 - S3 11 Jan 98

30 foot drop 1st attempt

Impact was on rear plate bottom, with a following slap down effect towards the front plate along the bottom of the device but did not produce the bowing of rear plate seen with previous specimen A and S1 of TP 74. Visually the specimen S3 has minor deformation at bottom edge, bottom of shell bent upwards into rear plate

Will attempt another 30 foot drop to try and recreate damage seen from specimen A, as CoG was not directly over planned impact point.

30 foot drop 2nd Attempt

Impact was on the rear plate bottom, with a secondary impact on the lock cover, ~~following by a full rotation and a third impact on the rear plate bottom.~~ followed [initialed, 14 Jan] The rear end plate bowed and the bottom of the plate and shell deformed further.

The temperature after this 2nd attempt was -26.2°C (above the -40°C requirement). However, the team did not see this as detrimental to the test because brittle fracture of the screws,

TP 74 11 Jan 98
S3

Assessment:

Orientation For Puncture Test -

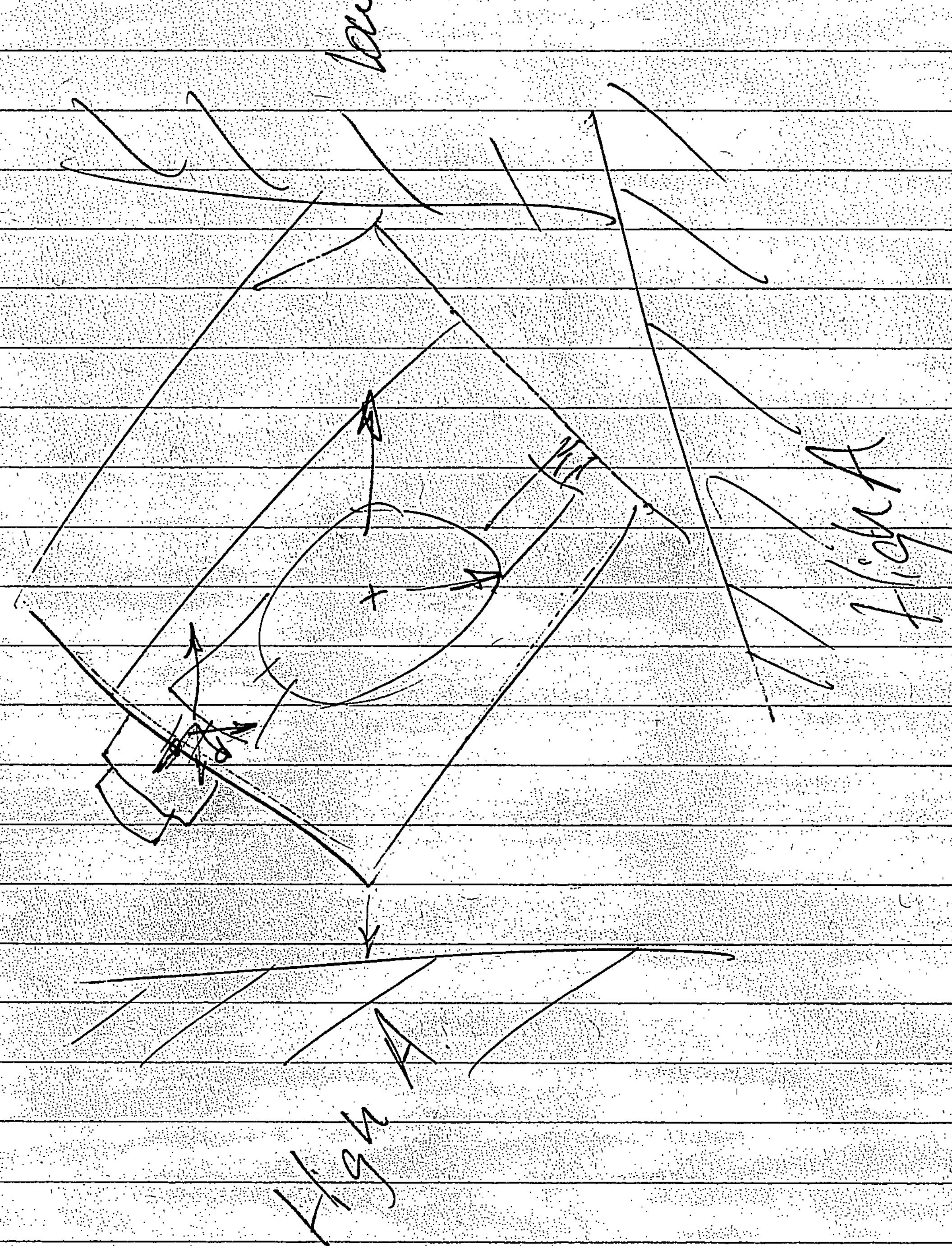
Team assessed condition of specimen to determine worst case orientation for puncture - An alternate orientation was suggested on the front plate bottom. The intent of this drop would be to try and drive tube out of boss of rear plate, ie disengaging tube to rear plate connection.
The team evaluated and ~~cont~~ unanimously determined that the bottom edge drop orientation (ie continue on with original orientation) would be worse to continue on with already incurred damage.

The worst case for thermal would be to disengage connection of rear plate to shield, continuing on damage to the tube, based on radiographs from earlier test specimens ie A, S_1 - tube was damaged from 30 foot and puncture.

As puncture is only a one meter drop, any minor damage to the front would not result in worst case for thermal. The drop on

11 JAN 98 (DW)

SPECIMEN "S3" PUNCTURE TEST



Equipment List 2: Puncture Test S3 Serial #B3586

Description	Enter the Model and Serial Number	Attach Inspection Report or Calibration Certificate
Drop Surface, Drawing AT10122, Rev. B	01	SEE ATTACH
Puncture Billet, Drawing CT10119, Rev. C	01	SEE ATTACH
Weight Scale	#35014 / OHAUS	SEE ATTACH
Thermometer	ENG-12 / OMEGA	SEE ATTACH
Thermocouple flexible probe	ENG-11 / OMEGA	SEE ATTACH
Thermocouple surface probe	ENG-13 / OMEGA	SEE ATTACH
Record any additional tools used to facilitate the test and attach the appropriate inspection report or calibration certificate.		
THERMOCOUPLE STRAIGHT PROBE	ENG-14 / OMEGA	SEE ATTACH

Verified by:	Signature	Date
Engineering	[signature]	14 Jan 98
Regulatory Affairs	[signature]	12 Jan 98
Quality Assurance	C. Kaufman	14 Jan 98

Checklist 2: Puncture Test

Test Location: VALLEY TREE GROVELAND MA

Attempt Number: 1

Serial #B3586

Step	Specimen A (DW 11 JAN 98) S3	Specimen B	Specimen C	Specimen D
1. Immerse the test specimen in dry ice as need to bring the specimen's temperature below -40° C.	DW 11 JAN 98	N/A	N/A	N/A
Step 1 witnessed by:				
Engineering	[signature] JAN 98			
Regulatory Affairs	[signature] 12 Jan 98			
Quality Assurance	[signature] 14 Jan 98			
2. Measure the weight of the specimen.	DW 11 JAN 98			
Record the specimen's weight:	55.40 lbs			
Note instrument used:	#35014	#35014	#35014	#35014
3. Measure the ambient temperature.	42.6° F			
Record ambient temperature:	DW 11 JAN 98			
Note the instrument used:	~~ENG-12~~ ENG-14	~~ENG-12~~ ENG-14	~~ENG-12~~ ENG-14	~~ENG-12~~ ENG-14
4. Attach the test specimen to the release mechanism.	DW 11 JAN 98			
5. Begin video recording of test so that the impact is recorded.	DW 11 JAN 98			
6. Measure the surface temperature of the specimen. Ensure that the specimen is below -40° C.	DW 11 JAN 98			
Record the specimen surface temperature:	-66.7° C			
Note the instrument used:	~~ENG-12~~ ENG-13	~~ENG-12~~ ENG-13	~~ENG-12~~ ENG-14	~~ENG-12~~ ENG-14
7. Lift and orient the test specimen as shown in the referenced figure for the specimen.	Figure 8 on Page 18	Figure 9 on Page 19	Figure 8 on Page 18	Figure 9 on Page 19
8. Inspect the orientation setup and verify drop height.	DW 11 JAN 98			

Checklist 2: Puncture Test (Continued)

Test Location: VALLEY TREE GROVELAND MA **Attempt Number:** 1

Step	Specimen A-53	Specimen B	Specimen C	Specimen D
9. Photograph the setup in at least two perpendicular planes.	DW 11 JAN 98	N/A	N/A	N/A
Steps 2 through 9 witnessed by:				
Engineering	[signature] 14 Jan 98			
Regulatory Affairs	[signature] 12 Jan 98			
Quality Assurance	[signature] 14 Jan 98			
10. Release the test specimen.	DW 11 JAN 98			
11. Measure the surface temperature of the test specimen.	DW 11 JAN 98			
Record the surface temperature:	-58.2°C			
Note the instrument used:	ENG-12 / ENG-13	ENG-12 / ENG-13	ENG-12 / ENG-13	ENG-12 / ENG-13
12. Measure and record the test specimen's weight.	DW 11 JAN 98			
Record the specimen's weight:	55.3 lbs			
Note the instrument used:	#35014	#35014	#35014	#35014
13. Pause the video recorder. Ensure that the point of impact and orientation specified in the plan have been achieved and recorded.	DW 11 JAN 98			
14. Record damage to test specimen on a separate sheet and attach.	DW 11 JAN 98			
Steps 10 through 14 witnessed by:				
Engineering	[signature] 14 Jan 98			
Regulatory Affairs	[signature] 12 Jan 98			
Quality Assurance	[signature] 14 Jan 98			

Checklist 2: Puncture Test (Continued)

Test Location: VALLEY TAGE GROVELAND MA **Attempt Number:** 1

Step	Specimen A 53	Specimen B	Specimen C	Specimen D
15. Engineering, Regulatory Affairs and Quality Assurance make a preliminary assessment relative to 10 CFR 71. Record the assessment on a separate sheet and attach. Determine the package orientation for the thermal test that will achieve maximum damage.	[signature] 14 Jan 98	N/A	N/A	N/A

Test Data Accepted by (Signature):	Date:
Engineering [signature]	14 Jan 98
Regulatory Affairs [signature]	22 Jan 98
Quality Assurance C. Longhran	17 Feb 98

Puncture Test Assessment - Specimen S3 Serial# B3586

Impacted in accordance with Test Plan 7A. Little damage noted.

Orientation for thermal test should be normal upright position. This will allow the shield to move downward due to the force of gravity.

[signature] 14 Jan 98

CMR 14 Jan 98
RLB 22 Jan 98

serial #B3586

SPECIMEN S3 Dave [signature]

"A" ORIENTATION 11 JAN 98

PENETRATION TEST

SIX ATTEMPTS BEFORE TARGET HIT LIGHT DENT ABOVE TARGET AND ON TARGET, NO DAMAGE TO SCREW

FOUR FOOT FREE DROP

DROP ON TARGET 1ST DROP PAINT CHIPPED ON BOTTOM OF REAR PLATE, NO ADDITIONAL DAMAGE VISIBLE.

30' FREE DROP

1ST DROP HIT ON BOTTOM OF REAR PLATE EVENLY ON EACH SIDE

CENTER OF GRAVITY SLIGHTLY TO BOTTOM OF DEVICE,

BOTTOM OF REAR PLATE & SHELL DENTED IN, NO GAP BETWEEN SHELL & REAR PLATE

2ND DROP 30' HIT ON BOTTOM OF REAR PLATE ON TARGET

BOTTOM OF REARPLATE & SHELL DENTED,

SHELL CONVEXED ON BOTTOM,

FRONT NUT DOESN'T TURN,

D@ 12 JAN 89 REL

PUNCTURE TEST

NO ADDITIONAL DAMAGE VISIBAL.

SENTINEL

660/660B DEVICE PROFILING FORM

TP74 + TP73 "S3"　　Serial# B3586 (KMA) 21 Jan 98

Device Model No.: 660B **Device Serial No.:** After Thermal

Model ~~424-9~~ TI0163 **Source Serial Number:** X0017 **Activity:** 105.0 C.

Surface Survey Instrument: AN/PDR-27T **Serial No:** SM-392401 **Cal Due:** 18 Mar 98

One Meter Survey Instrument: AN/PDR-27T **Serial No:** SM-392401 **Cal Due:** 18 Mar 98

Capacity Corr. Factor
1.33

	SURFACE READINGS mR/hr		ONE METER READINGS mR/hr	
	~~Allowed~~	Actual	Extrapolated ~~Allowed~~	Actual
TOP		70 mR/hr	1.9	1.4 mR/hr
RIGHT		80 mR/hr	1.5	1.1 mR/hr
FRONT		940 mR/hr Δ	5.6	4.2 mR/hr
LEFT		110 mR/hr	1.3	1.0 mR/hr
REAR		1400 mR/hr Δ	9.3	7.0 mR/hr
BOTTOM		130 mR/hr	1.6	1.2 mR/hr

INSPECTOR: [signature] **DATE:** 19 Jan 98 **NCR No.:** NA

Comments:

* Surface readings taken for exposure control and general information purposes only.

Δ Measurements taken with Model # ND 3000, S/N 9837 (Next cal date 23 Sept 98) [initials] 19 Jan 98

Amersham QSA

WI-Q05

19 Jan 98

Serial # 83586

S3 Source position measurement

0,362 unthreaded strip plug length
6,802 teleflex wire off tool.

⇒ Removed section from shield = 4 3/8"
(source dummy wire from "S3" specimen)

[signature] 19 Jan 98

Serial #B3586 and #B3589
S3 and C

Equipment List 3: Thermal Test

Description	Enter the Model and Serial Number	Attach Inspection Report or Calibration Certificate
Air Flowmeter	HEDLAND / 3367 / WINTERS ENG-08	SEE ATTACH
Thermocouple (internal)	OMEGA / ENG-18 A	SEE ATTACH
Thermocouple (external)	OMEGA / ENG-17 A	SEE ATTACH
Thermocouple (oven)	OMEGA / ENG-16 A	SEE ATTACH
Temperature recorder	OMEGA / ENG - 16, 17, 18	SEE ATTACH
Record any additional tools used to facilitate the test and attach the appropriate inspection report or calibration certificate.		
THERMOMETER	OMEGA / ENG-12	SEE ATTACH
THERMOCOUPLE STRAIGHT PROBE	OMEGA / ENG-14	SEE ATTACH
SOURCE LOCATION TOOL / DIGITAL CALIPER	710142 / # 277	SEE ATTACH
Verified by:	Signature	Date
Engineering	[signature]	13 Jan 98
Regulatory Affairs	C. Roughan	14 Jan 98
Quality Assurance	[signature]	13 Jan 98

SOURCE LOCATION BEFORE THERMAL TEST "S3" 5.922 / "C" 5.824

Checklist 3: Thermal Test

Test Location: MFG SCIENCES OAK RIDGE TN Spcml #B3586 **Attempt Number:** 1
Spcml #B3589

Step	Specimen A	Specimen S3 ~~B~~ DC 13 JAN 98	Specimen C	Specimen D
1. Pre-heat the oven to a temperature above 800° C.	N/A	DC 13 JAN 98	DC 13 JAN 98	N/A
2. Attach the thermocouples the specimen's internal and external measuring points.		DC 13 JAN 98	DC 13 JAN 98	
3. Place the package in the oven and close the oven door.		DC 13 JAN 98	DC 13 JAN 98	
Record the date and time that the package is placed in oven.		13 JAN 98 424 pm	13 JAN 98 2:51PM	
4. When the specimen's internal temperature exceeds 800° C, start the air flow into the oven. Record the time.		453 pm 13 JAN 98	347PM DC 13 JAN 98	
Steps 1 through 4 witnessed by:				
Engineering		[signature] 13 Jan 98	[signature] 13 Jan 98	
Regulatory Affairs		C. Kaufman 13 Jan 98	C. Kaufman 13 Jan 98	
Quality Assurance		KNA 13 Jan 98	KNA 13 Jan 98	
5. Measure the oven temperature, the specimen's internal and external temperatures and the air flow rate.		DC 13 JAN 98	DC 13 JAN 98	
Record the oven temperature:		891.4°c	896.7°c	
Note instrument used:	~~ENG-16~~ ENG-16A	~~ENG-16~~ ENG-16A	~~ENG-16~~ ENG-16A	~~ENG-16~~ ENG-16A
Record the specimen's internal temperature:		803.5°c	800.9°c	
Note instrument used:	~~ENG-18~~ ENG-18A	~~ENG-18~~ ENG-18A	~~ENG-18~~ ENG-18A	~~ENG-18~~ ENG-18A
Record the specimen's external temperature:		838.3°c	834.9°c	
Note instrument used:	~~ENG-17~~ ENG-17A	~~ENG-17~~ ENG-17A	~~ENG-17~~ ENG-17A	~~ENG-17~~ ENG-17A
Record airflow rate:		11 CFM	11 CFM	
Note instrument used:	~~3367~~ ENG-08	~~3367~~ ENG-08	~~3367~~ ENG-08	~~3367~~ ENG-08
6. Monitor the internal and external temperatures of the specimen and the oven temperature throughout the 30-minute period to ensure that they are above 800° C.		DC 13 JAN 98	DC 13 JAN 98	

Checklist 3: Thermal Test (Continued)

Test Location: MFG SCIENCES OAK RIDGE TN **Attempt Number:** 1

Step	Specimen A	Specimen ~~B~~ S3 (DC 13 JAN 98)	Specimen C	Specimen D
7. Monitor the airflow throughout the 30-minute period to ensure a rate of at least 9.6 ft^3/min.	N/A	DC 13 JAN 98	DC 13 JAN 97	N/A
8. At the end of the 30-minute period, repeat step 5 using the same measurement devices.		DC 13 JAN 98	DC 13 JAN 97	
Record the oven temperature:		904.7°c	902.8°c	
Record the specimen's internal temperature:		844.1°	853.5°c	
Record the specimen's external temperature:		836.2°c	850.9°c	
Record intake air flow velocity:		11 CFM	11 CFM	
Steps 5 through 8 witnessed by:				
Engineering		[signature] 13 Jan 98	[signature] 13 Jan 98	
Regulatory Affairs		C. Kaufman 13 Jan 98	C. Kaufman 13 Jan 98	
Quality Assurance		KMA 13 Jan 98	KMA 13 Jan 98	
9. Remove test specimen from the oven.		DC 13 JAN 98	DC 13 JAN 98	
Record time the specimen is removed.		5 25 PM	4:17 PM	
Describe combustion when door is opened to remove specimen.		DC 13 JAN 98 RED HOT	DC 13 JAN 98 RED HOT	
NOTE: If specimen continues to burn, let it self-extinguish and cool naturally.				
10. Measure the ambient temperature.	N/A	DC 13 JAN 98	DC 13 JAN 98	N/A
Record the ambient temperature:		65.7°F	67.2°F	
Note the instrument used:	~~ENG-12~~ ENG-14	~~ENG-12~~ ENG-14	~~ENG-12~~ ENG-14	~~ENG-12~~ ENG-14
11. Photograph the test specimen and any subsequent damage		DC 13 JAN 98	DC 13 JAN 98	
12. Record damage to test specimen on a separate sheet and attach.		DC 15 JAN 98	DC 15 JAN 98	
Steps 9 through 12 witnessed by:				
Engineering		[signature] 17 Feb 98	[signature] 17 Feb 98	
Regulatory Affairs		C. Kaufman 17 Feb 98	C. Kaufman 17 Feb 98	
Quality Assurance				

Checklist 3: Thermal Test (Continued)

Test Location:

Attempt Number:

Step	Specimen A	Specimen B	Specimen C	Specimen D
13. Engineering, Regulatory Affairs and Quality Assurance make a preliminary assessment relative to 10 CFR 71. Record the assessment on a separate sheet and attach.	NA	see attached		NA

Test Data Accepted by (Signature):	Date:
Engineering S. Gr[illegible]	18 FEB 98
Regulatory Affairs C. [illegible]	18 Feb 98
Quality Assurance [illegible]	02 MAR 98

15 Jan 98
at Mfg. Sciences

Specimen Ex-1

max length 10.534 (right side)
gap (rt side) .378
height to gap 3.220 right - to crown
height to gap - 3.105 left - to crown
max length 10.450 (left side)
gap (left side) - .272

observation - oxide is soft on left side

Specimen S3 Serial# B3586

Max length 10.132" (left side)
No gap
Max length 10.138" (Right side)
Boring height 3.438" left
(crown)

Boring (crown) height 3.505" Right

15 Jan 98
at Mfg. Sciences

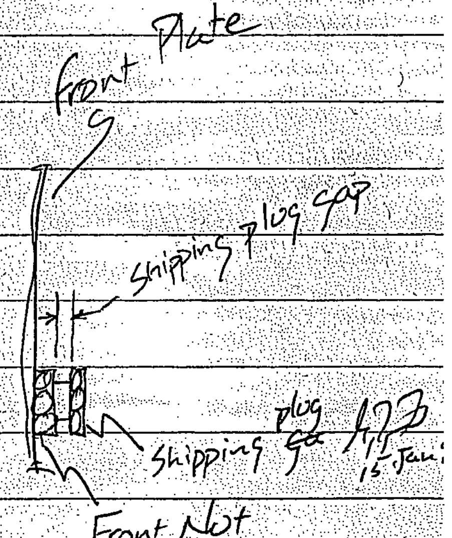
Specimen C #B3589

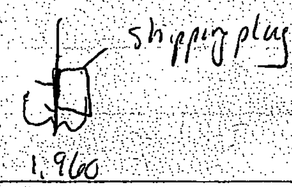
gap	.288"	Right
Max length	16.397"	Right
height [Crown]	2.705"	Right
Max length	9.936"	left
No gap	———	left
height (Crown)	3.234"	left

~~Shipping plug~~ (initials) 15 Jan 98
Specimen "C" #B3589
Source location (Partial measurement) 2.580"
due to obstruction in the "S-tube".

Specimen S3 #B3586

Front plate - loose
Source location 6.610" - .150 = 6.460"
Shipping plug gap = .150"





Ex-1

wire inserted through front nut
went in 1.960 (~~front~~ from outside of front
nut (shipping plug)

<u>Specimen C</u> #B3589

Distance from face of front nut to dummy source = 7.822" [illegible] 15 Jan 98
(measured with piece of wire)

(DA) 12 JAN 98

SOURCE LOCATION

	C	S3	~~EX1~~ EX1 (DA 14 JAN 98)
2 AMERSHAM 12 JAN 98	5.829	5.897	5.620
B Mfg. Same [illegible] 13 JAN 98	5.824	~~5.921~~ 5.922 (DA 13 JAN 98)	5.650

14 Jan 98

Unit Temp

8:45	"C"	17.3 °C
8:47	"S3" * "[illegible]"	17.4 °C
8:49	"EX-1" * "1/4 [illegible]"	60.6 °C

Note: Surface Thermocouple was used to measure the internal & surface Temp. (KNA) 14 Jan 98

* ~~Surface temp~~ (KNA) 14 Jan 98

OMR 18Feb98 18FEB98. KNA 02MAR98

17 Feb 98

Assessment - Part 71

S3 / Specimen C after Thermal Test

~~Serial #B3586~~ Serial #B3589

As specimen C has not gone through all the testing, ie no puncture test, the thermal was performed for informational purposes only and is not a valid test specimen. Therefore no assessment to 10 CFR 71 is required.

Specimen S3 underwent the full range of testing and successfully passed the radiation profile, indicating this specific unit passes all the Type B tests.

However the specimen S3 was tested to try and exactly mimic the damage seen in Specimen of A of TP 73/74 in order to validate / assess the liklihood of transport damage to Specimen A.
S3 damage from all testing was not an exact replica of damage seen from A, and therefore cannot conclusively determine ~~that~~ Specimen A from TP 73/TP 74 would have passed the tests if it had not been subjected to transport damage.

Conclusion is ~~that~~ S3 passes the Type B testing but cannot conclude that Specimen A would have passed all the Type B test.

Equipment List 3: Thermal Test EX-1 R&D Unit

Description	Enter the Model and Serial Number	Attach Inspection Report or Calibration Certificate
Air Flowmeter	HEDLAND / 3367 / WINTERS ENG-08	SEE ATTACH
Thermocouple (internal)	OMEGA / ENG-18 A	SEE ATTACH
Thermocouple (external)	OMEGA / ENG-17 A	SEE ATTACH
Thermocouple (oven)	OMEGA / ENG-16 A	SEE ATTACH
Temperature recorder	OMEGA / ENG - 16, 17, 18	SEE ATTACH
Record any additional tools used to facilitate the test and attach the appropriate inspection report or calibration certificate.		
THERMOMETER	OMEGA / ENG-12	SEE ATTACH
THERMOCOUPLE STRAIGHT PROBE	OMEGA / ENG-14	SEE ATTACH
SOURCE LOCATION TOOL / DIGITAL CALIPER	T10142 / #277	SEE ATTACH
Verified by:	Signature	Date
Engineering	[signature]	13 Jan 98
Regulatory Affairs	C. Rongham	14 Jan 98
Quality Assurance	[signature]	13 Jan 98

EX1 SOURCE LOCATION BEFORE THERMAL TEST 5.650 DW 14 JAN 98

Checklist 3: Thermal Test

Test Location: MFG SCIENCES OAK RIDGE TN R&D Unit **Attempt Number:** 1

Step	Specimen A (13 JAN 98 EX1)	Specimen B	Specimen C	Specimen D
1. Pre-heat the oven to a temperature above 800° C.	DW 13 JAN 98			
2. Attach the thermocouples the specimen's internal and external measuring points.	DW 13 JAN 98			
3. Place the package in the oven and close the oven door.	DW 13 JAN 98			
Record the date and time that the package is placed in oven.	DW 13 JAN 98 5:35 PM			
4. When the specimen's internal temperature exceeds 800° C, start the air flow into the oven. Record the time.	13 JAN 98 608 PM			
Steps 1 through 4 witnessed by:				
Engineering	[signature] 13 Jan 98			
Regulatory Affairs	C [signature] 14 Jan 98			
Quality Assurance	KMA 13 Jan 98			
5. Measure the oven temperature, the specimen's internal and external temperatures and the air flow rate.	DW 13 JAN 98			
Record the oven temperature:	898.9° C			
Note instrument used:	ENG-16 / ENG-16A	ENG-16 / ENG-16A	ENG-16 / ENG-16A	ENG-16 / ENG-16A
Record the specimen's internal temperature:	803.9			
Note instrument used:	ENG-18 / ENG-18A	ENG-18 / ENG-18A	ENG-18 / ENG-18A	ENG-18 / ENG-18A
Record the specimen's external temperature:	845.2°			
Note instrument used:	ENG-17 / ENG-17A	ENG-17 / ENG-17A	ENG-17 / ENG-17A	ENG-17 / ENG-17A
Record airflow rate:	10 CFM			
Note instrument used:	3367 / ENG-08	3367 / ENG-08	3367 / ENG-08	3367 / ENG-08
6. Monitor the internal and external temperatures of the specimen and the oven temperature throughout the 30-minute period to ensure that they are above 800° C.	DW 13 JAN 98			

Checklist 3: Thermal Test (Continued)

Test Location: MFG SKEAZES R&D UNIT **Attempt Number:** 1

Step	Specimen A (EX1)	Specimen B	Specimen C	Specimen D
7. Monitor the airflow throughout the 30-minute period to ensure a rate of at least 9.6 ft^3/min.	DO 13 JAN 98	N/A	N/A	N/A
8. At the end of the 30-minute period, repeat step 5 using the same measurement devices.	DO 13 JAN 98			
Record the oven temperature:	904.0°C			
Record the specimen's internal temperature:	849.9°C			
Record the specimen's external temperature:	856.5°C			
Record intake air flow velocity:	10.5 CFM			
Steps 5 through 8 witnessed by:				
Engineering	[signature] 18 Feb 98			
Regulatory Affairs	C. Rouquet 13 Jan 98			
Quality Assurance	KMA 13 Jan 98			
9. Remove test specimen from the oven.	13 JAN 98 6:38 PM			
Record time the specimen is removed.	DO 6:38 pm			
Describe combustion when door is opened to remove specimen.	NO FLAME RED HOT DO 13 JAN 98			
NOTE: If specimen continues to burn, let it self-extinguish and cool naturally.				
10. Measure the ambient temperature.	DO 13 JAN 98			
Record the ambient temperature:	63.1° F			
Note the instrument used:	ENG-12 / ENG-14	ENG-12 / ENG-14	ENG-12 / ENG-14	ENG-12 / ENG-14
11. Photograph the test specimen and any subsequent damage	DO 13 JAN 98			
12. Record damage to test specimen on a separate sheet and attach.	DO 15 JAN 98			
Steps 9 through 12 witnessed by:				
Engineering	[signature] 18 Feb 98			
witnessed on 15 Jan 98 Regulatory Affairs	CMR 18 Feb 98			
Quality Assurance				

Checklist 3: Thermal Test (Continued)

Test Location: MFG SIENCES OAK RIDGE TN R&D **Attempt Number:** 1

Step	Specimen BJA 98 EX-1	Specimen B	Specimen C	Specimen D
13. Engineering, Regulatory Affairs and Quality Assurance make a preliminary assessment relative to 10 CFR 71. Record the assessment on a separate sheet and attach.	NA*	N/A	N/A	N/A

Test Data Accepted by (Signature):	Date:
Engineering	
Regulatory Affairs	
Quality Assurance	

* NA - as test unit was experimental and not a valid test specimen in the TP 74

CMR 18 Feb 98

2.12.8 Test Plan 80 Rev 1 (Mar 1999)

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

March 16, 1999

Mr. William M. McDaniel,
Facility Manager
AEA Technology, QSA Inc.
40 North Avenue
Burlington, MA 01803

Dear Mr. McDaniel:

This is to acknowledge receipt of your plan No. 80, Revision 1, dated March 12, 1999, for testing the Model No. 650L package. This plan was submitted in response to our Confirmatory Action Letter No. 97-7-005, dated June 10, 1997.

We have reviewed your test plan and found it to be acceptable.

If you have any questions regarding this matter, please contact me at (301)-415-8510.

Sincerely,

Cass R. Chappell

Cass R. Chappell, Chief
Package Certification Section
Spent Fuel Project Office
Office of Nuclear Material Safety
and Safeguards

cc: 71-9269

AEA TECHNOLOGY QSA

TEST PLAN NO. 80 REV. 1	
TEST PLAN COVER SHEET	
TEST TITLE: TEST PLAN 80, REVISION 1, MODEL 650L SOURCE CHANGER TYPE B TRANSPORT TESTS	
PRODUCT MODEL: 650L	
ORIGINATED BY: [signature] (MPR)	DATE: 12 MAR 99
TEST PLAN REVIEW	
ENGINEERING APPROVAL: [signature] Nicholas J. Marrons	DATE: 12 MAR 99
QUALITY ASSURANCE APPROVAL: Daniel W. Kurtz	DATE: 12 Mar 99
REGULATORY APPROVAL: [signature]	DATE: 12 Mar 99
COMMENTS:	
TEST RESULTS REVIEW	
ENGINEERING APPROVAL:	DATE:
QUALITY ASSURANCE APPROVAL:	DATE:
REGULATORY APPROVAL:	DATE:

SENTINEL

Test Plan 80

Revision 1

Model 650L

Source Changer

Type B Transport Tests

March 1999

Prepared By: [signature] Date 12 MAR 99

C. SCHLASEMAN
MPR

Checked By: Date 12 MAR 99

E. CLAUDE [signature]
MPR

Approved By: Date

N. MARRONE [signature] 12 MAR 99
MPR

Test Plan 80

Revision 1

Model 650L

Source Changer

Type B Transport Tests

March 1999

Prepared By: Date

C. SCHLASEMAN
MPR

Checked By: Date

E. CLAUDE
MPR

Approved By: Date

N. MARRONE
MPR

Contents

List of Figures, Tables and Worksheets

AEA Technology/QSA Test Plan 80

1.0 Introduction

This document describes Type B(U) transport package testing of the SENTINEL Model 650L Source Changer, Certificate of Compliance Number 9269. The purpose of the testing is to demonstrate that the package meets the NRC requirements for Type B(U) packages under Normal Conditions of Transport (10 CFR 71.71), Hypothetical Accident Conditions (10 CFR 71.73), and the criteria stated in IAEA, Safety Series 6 (1985, as amended 1990).

The test plan specifies the test package configurations, testing equipment and scenarios, justifies the package orientations, and provides test worksheets to record key steps in the testing sequence.

Refer to Appendix A for a drawing of the test specimen.

2.0 Transport Package Description

The Model 650L source changer shown in Appendix A is 13 ¼" high, 10" long, and 8 ¼" wide in overall dimension, and has a maximum weight of 90 lb. The package consists of the following components:

- Source Capsule and Shield Assembly: The Special Form Source is contained in a capsule and is attached to the source wire assembly. The source is shielded by a Titanium "U" tube that is enclosed in a depleted uranium (DU) shield.

- Outer Casing: The shield assembly is encased in two Carbon Steel shells. The inner shell is rectangular and is 0.135" thick. The outer shell is circular and is 0.048" thick. The shells are positioned between two, Stainless Steel, 0.135" thick top and bottom plates. The plates are secured with four 5/16-18 hex head stainless steel through-bolts. The voids between the depleted uranium shield and the inner and outer shells are filled with a rigid 8 pound Polyurethane foam.

- Protective Lid: During transport, the locking assembly is protected by a 0.135" thick, Carbon Steel lid. The lid is secured to the top plate by four 3/8-16 hex head strain-hardened stainless steel bolts.

- Source Locking Assembly: Model 650L has two Stainless Steel locking assemblies that keep the source inside the Titanium "U" tube. Each locking assembly is secured to the top plate by four ¼-20 Stainless Steel screws.

The 650L package is shown below in Figure 1.

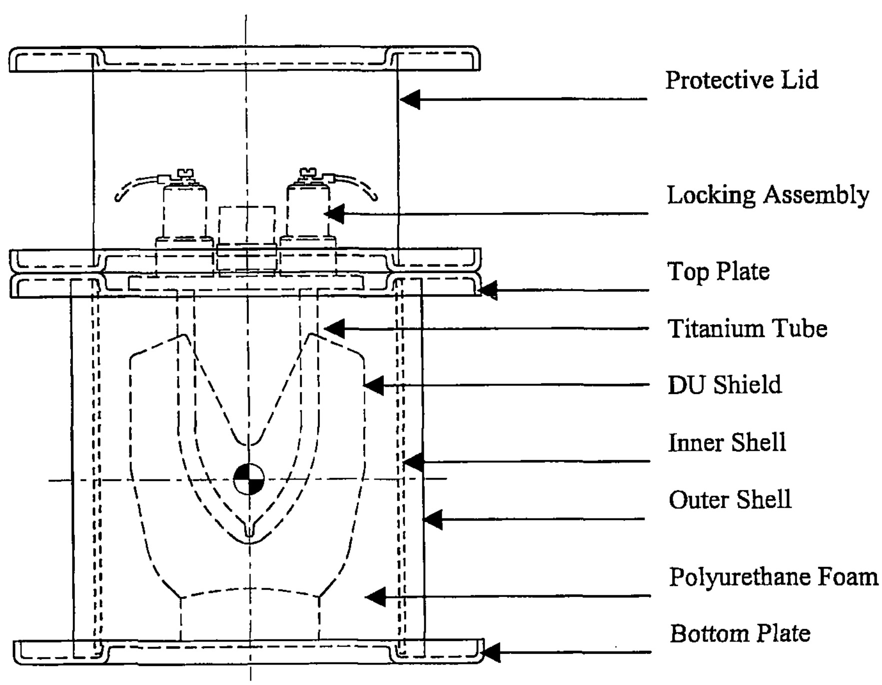


Figure 1. Side View of Model 650L Package

3.0 Regulatory Compliance

The purpose of this plan, which was developed in accordance with AEAT/QSA SOP-E005, is to ensure that the Model 650L Source Changer shown in the descriptive drawing provided in Appendix A meets the Type B(U) transport package requirements of 10 CFR 71 and IAEA Safety Series No. 6 (1985, as amended 1990).

The Normal Conditions of Transport tests (10 CFR 71.71) to be performed are the compression test, penetration test, and 1.2 meter (4 foot) free drop.

Water spray preconditioning of the package is not performed as the Model 650L packages are constructed of waterproof materials throughout. The water spray would not contribute to any degradation in structural integrity.

The Hypothetical Accident Tests (10 CFR 71.73) to be performed are the 9 meter (30 foot) free drop, puncture test, and thermal test.

The crush test (10 CFR 71.73(c)(2)) is not performed because the radioactive contents are special-form radioactive material.

The immersion test and all other conditions specified in 10 CFR 71 will be evaluated separately.

4.0 System Failures and Package Orientations

The location of the source relative to its stored position in the shield is an important safety element. Displacement of the source and/or shield from its original stored position could elevate the dose rate at the surface of the package above regulatory limits. Tests in this plan focus on damaging those components of the package which could cause displacement of the source, relative to its stored position, within the shield and which affect the integrity of the shield itself.

System failures that could affect package integrity and cause radiological dose rates to exceed the regulatory limits include:

- Oxidation of DU Shield during the thermal test could occur if either distortion/local buckling of the inner and outer shells, or failure of the through-bolts during drop testing results in a large, open path to the DU shield.

- Source Pull-Out from Shield could occur if there is significant relative displacement between the shield and the top cover plate penetration and locking assembly.

Three orientations are considered most likely to cause damage during the 1.2 meter and 9 meter drop tests, i.e., the most likely to cause unacceptable external dose rates. For all three orientations, the worst case temperature is the lower limit of -40°C due to embrittlement of the DU and Carbon Steel components.

- Case 1, Horizontal, Long-Side Down: The DU shield could move through the foam during impact, which could result in source pullout from titanium tubes. Also, due to the low testing temperature, brittle failure of the inner and outer shells could occur. The failure(s) may be sufficient to open a significant path to the depleted uranium shield during thermal test and cause burning of the DU shield. The Long-Side Down orientation is selected because the long side of the package has a stiffer configuration than the short side, which will result in a shorter deceleration and a higher impact load.

- Case 2, Vertical, Upside Down: Deformation of the lid weldment, crushing of the foam between the depleted uranium shield and top plate, deformation (bowing upward) of the top plate due to the impact load of the DU shield applied through titanium source tubes and foam, failure of the through-bolts, and failure of the locking assembly could occur. When the package is turned upright for the thermal test, the DU shield and its integral titanium tubes could drop down to their original positions while the source is pulled out of the tubes by the bowed top plate or failed locking assembly. Also, a lead shim (which will melt during thermal testing) under the DU shield could cause additional source pullout.

- Case 3, Vertical, Top Corner Down: Failure of lid or lid closure bolts could expose the locking assembly to damage during the puncture bar test. Failure of the locking assembly could result in source pullout. Additionally, this orientation will load the through-bolts in tension, and could cause them to fail.

The following orientations are planned for the puncture tests. These orientations will be modified, if necessary, based on the results of the engineering assessments conducted after the 9 meter drop tests. The puncture test orientations will be selected to maximize damage to the test specimens.

- Case 1, Horizontal, Long-Side Down: This orientation is the same as for the Case 1, 1.2 meter and 9 meter drop tests.

- Case 2, Underside of Top Plate at Lid Bolt: The top plate could be pried up, and, as a minimum, load the through-bolts in tension. The impact on the lid bolt rivnut could damage the lid bolt connection.

- Case 3, Bottom of Package: Impact on the four Stainless Steel rivnuts could damage the through-bolt connection. If the lid is removed during the Case 3 9 meter drop, the test specimen will be dropped upside down such that the lock assemblies strike the puncture bar.

The limiting orientation for the penetration bar test is discussed in Section 8.6.2.

5.0 Assessment of Package Conformance

The Model 650L Source Changer must meet the Type B(U) transport package requirements of 10 CFR 71. The conformance criteria are detailed in the following two sections.

5.1 Regulatory Requirements

- Normal Conditions of Transport Tests (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.

- 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 1 meter from the external surface when the package contains its maximum design radioactive contents.

5.2 Test Package Contents

The Model 650L is designed to carry Special Form Sources. Containment of the radioactive source is tested at manufacture. The source capsules have been certified by the Competent Authority in accordance with the performance requirements for Special Form as specified in 10 CFR Part 71 and 49 CFR.

The test plan therefore does not discuss/specify tests of the containment of the radioactive source. The purpose of the tests is to demonstrate that the shielding remains effective within the limits specified by the regulations, and that the source capsule remains contained within the source changer.

A simulated source will be used during testing of the package. The radiation levels after the test will be monitored by replacing the simulated source with an active source.

6.0 Construction and Condition of Test Specimens

The Test Plan 80 (TP 80) test specimens will be Model 650L units constructed in accordance with AEAT/QSA Drawing R-TP80, Revision D.

Drawing TP650L specifies the Model 650L package in its worst case transport conditions, which vary depending on the Test Case. Lead shielding placement should be as described below:

Test Case	Lead Shielding Placement	Rationale
1—Horizontal, Long-Side Down Specimen TP80(A)	No lead between DU shield and long side of inner shell.	Lead between DU and shell or through-bolts might stop DU from travelling through foam during drop impact.
2—Vertical, Upside Down Specimen TP80(B)	Thickest lead under DU shield, use heavy package.	Lead under DU may melt during thermal test and could allow DU to settle, which could allow source pullout. Impact force will be larger for heavier packages, which would result in larger top plate deflection.
3—Top Corner Down Specimen TP80(C)	Any location, use heavy package.	Lead placement will not affect lid failure, and impact force will be larger for heavier packages.

For all Drop Test Cases the temperature of the specimen must be below -40°C at the time of each test, a minimum temperature required by IAEA, Safety Series 6 (1985, as amended 1990). The low temperature represents the worst-case condition for the package because of the potential for brittle fracture of the shield and Carbon Steel lid.

7.0 Material and Equipment List

The equipment checklists, test worksheets, and data sheets in Section 9.0 list the key materials and equipment specified in 10 CFR 71 and the necessary measurement instruments.

When video recording is specified, select video cameras with the highest shutter speed practical to record testing.

Additional materials and equipment may be used to facilitate the tests.

8.0 Test Procedure

Three specimens are to be tested to determine the transport integrity of the package. The testing sequence is shown below:

1. Test specimen preparation and inspection
2. Compression test (10 CFR 71.71(c)(9))
3. Penetration test (10 CFR 71.71(c)(10))
4. 1.2 Meter (4 foot) free drop test (10 CFR 71.71(c)(7))
5. First intermediate test inspection
6. 9 Meter (30 foot) free drop test (10 CFR 71.73(c)(1))
7. Puncture test (10 CFR 71.73(c)(3))
8. Second intermediate test inspection
9. Thermal test (10 CFR 71.73(c)(4)) (If applicable, see Section 8.12.1)
10. Final test inspection

Each specimen must be put through the entire test sequence, unless the thermal test is considered unnecessary based on the test specimen condition after the puncture test and the assessment by Engineering, Quality Assurance and Regulatory Affairs. If test conditions such as the orientation at impact are not met during the test of a particular specimen, it may be replaced with a specimen of equivalent construction. The replacement must go through the entire test sequence.

8.1 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 ensure compliance with AEAT/QSA Quality Assurance Program.

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

- **Quality Control**, a function that reports directly to Quality Assurance, is responsible for measuring and recording test and specimen data throughout the test cycle.

8.2 Specimen Temperature Measurement

The penetration, drop, and puncture tests are to be carried out while the package is at or below -40°C. Temperature measurements will be made by positioning thermocouples on the package surface and the shield (inside the source tube).

8.3 Test Specimen Preparation and Inspection

Refer to the *Specimen Preparation List* in Section 9.0 to ensure that test sequence is followed. Sign and date the list when completed.

To prepare the test units:

1. Inspect the test units to ensure that they comply with the requirements of Drawing R-TP80, Revision D.

2. Weigh the test package, including the lid.

3. Perform and record the radiation profile in accordance with AEAT/QSA Work Instruction WI-Q09.

4. **Quality Control, Engineering, Regulatory Affairs**, and **Quality Assurance** will jointly verify that the test specimens comply with Drawing R-TP80, Revision D, and the AEAT/QSA Quality Assurance Program.

5. Measure and record the location of the simulated source.

6. Place thermocouples on package surface and inside one of the source tubes.

7. Prepare the package for transport.

8. Clearly and indelibly mark the units with identification.