71-3076

Michelle DeBose

From: fred.ferate@dot.gov
Sent: Wednesday, May 21, 2008 9:18 AM
To: Nancy Osgood
Subject: Status of Evaluation of F-458 packages
Attachments: 1030697.pdf; POP - Leakers - Nordion.wpd; Recommendation 5a for the Certificate USA/0697/B(U)-96 for the F-458 Transport Package; Recommendation 5a for the Certificate USA/0697/B(U)-96 for the F-458 Transport Package; RE: Recommendation 5b for the Certificate USA/0697/B(U)-96 for the F-458 Transport Package; MDS Nordion F-458 Package

Hi Nancy,

As you know, DOT and NRC had a meeting with MDS Nordion at DOT on March 7, 2007, to discuss the several conditions we had placed on their use of the F-458 suite of packages described in Canadian Certificate of Competent Authority CDN/2078/B(U)-96. At the time they agreed to work on some of the issues and, with certain limitations, DOT issued them a US revalidation of the Canadian certificate on June 20, 2007 (attached), valid for one year; this US revalidation certificate will expire on June 30, 2008. I have also attached, for completeness, the NRC internal document you had sent me describing the conclusions of the meeting.

Since then, MDS Nordion has submitted Information on tie-downs on Nov. 26, 2007, and on leak-testing on April 7, 2008, which I passed on to you.

For completeness again, I have attached several e-mails (which themselves contain attachments) documenting the various exchanges of information. (Even though some of the attached e-mail files have the same name, the e-mails themselves are different.)

In light of this information, and taking into account the fact that DOT's temporary revalidation of the Canadian certificate is due to expire on June 30, may I ask that you and your staff give me a status report on your evaluation of these changes proposed by MDS Nordion? In particular, are they satisfactory and sufficiently complete, or do you recommend that we request additional information from MDS Nordion.

Thanks,

Fred Ferate, Ph.D., CHP
PHMSA/Radioactive Materials Branch
U.S. Department of Transportation
East Building, E21-208, PHH-23
1200 New Jersey Avenue, S.E.
Washington, D.C. 20590-0001
Phone: 202-366-4498
Fax: 202-366-3753

LIM5501
o NMSS

U.S. Department
of Transportation

**Pipeline and
Hazardous Materials
Safety Administration**

East Building, PHH-23
1200 New Jersey Avenue Southeast
Washington, D.C. 20590

**COMPETENT AUTHORITY CERTIFICATION
FOR A TYPE B(U)
RADIOACTIVE MATERIALS PACKAGE DESIGN
CERTIFICATE USA/0697/B(U)-96, REVISION 2**

**REVALIDATION OF CANADIAN COMPETENT AUTHORITY
CERTIFICATE CDN/2078/B(U)-96**

This certifies that the radioactive material package design described is hereby approved for use within the United States for import and export shipments only. Shipments must be made in accordance with the applicable regulations of the International Atomic Energy Agency[1] and the United States of America[2].

1. Package Identification - MDS Nordion F-458/F-245, F-458/F-247, F-458/F-251, F-458/F-251 MK2, F-458/F-318 and F-458/F-448 Transport Packages.

2. Package Description and Authorized Radioactive Contents - as described in Canada Certificate of Competent Authority CDN/2078/B(U)-96, 2 (attached).

3. General Conditions -

   a. Each user of this certificate must have in his possession a copy of this certificate and all documents necessary to properly prepare the package for transportation. The user shall prepare the package for shipment in accordance with the documentation and applicable regulations.

   b. Each user of this certificate, other than the original petitioner, shall register his identity in writing to the Office of Hazardous Materials Technology, (PHH-23), Pipeline and Hazardous Materials Safety Administration, U.S. Department of Transportation, Washington D.C. 20590-0001.

   c. This certificate does not relieve any consignor or carrier from compliance with any requirement of the Government of any country through or into which the package is to be transported.

---

[1] "Regulations for the Safe Transport of Radioactive Material, 1996 Edition (Revised), No. TS-R-1 (ST-1, Revised)," published by the International Atomic Energy Agency(IAEA), Vienna, Austria.

[2] Title 49, Code of Federal Regulations, Parts 100-199, United States of America.

d. Records of Quality Assurance activities required by Paragraph 310 of the IAEA regulations[1] shall be maintained and made available to the authorized cfficials for at least three years after the last shipment authorized by this certificate. Consignors in the United States exporting shipments under this certificate shall satisfy the applicable requirements of Subpart H of 10 CFR 71.

4. Special Conditions -

a. The leak proof insert O-ring must be tested to demonstrate a leakage rate not more than 1E-7 ref-cm3/s prior to use. This test may be performed prior to loading the contents in the leakproof insert. This condition is waived for contents consisting only of solid or liquid Iodine 125 or Iodine 131.

b. All shipments of normal form radioactive material must be in leakproof inserts. The maximum heat load of normal form radioactive material in a leak proof insert is 6.1 Watts.

c. After loading and prior to each shipment of normal form Sr-90, the seals of the F-248, F-250, F-256, and F-320 containment vessels must show no leakage when tested to a sensitivity of at least 1E-3 ref-cm3/s.

d. The shipper must provide the consignee special instructions for safely opening the package. The instructions must give special consideration to any byproducts generated by the radiolysis of water.

5. Marking and Labeling - The package shall bear the marking USA/0697/B(U)-96 in addition to other required markings and labeling.

6. Expiration Date - This certificate expires on June 30, 2008.

CERTIFICATE USA/0697/B(U)-96, REVISION 2

This certificate is issued in accordance with paragraph 808 of the IAEA Regulations and Section 173.473 of Title 49 of the Code of Federal Regulations, in response to the June 07, 2007 petition by MDS Nordion, Ottawa, Ontario, and in consideration of other information on file in this Office.

Certified By:

Bob Richard
Deputy Associate Administrator for Hazardous Materials Safety

Jun 20 2007
(DATE)

Revision 2 - Issued to revalidate Canadian Certificate of Competent Authority CDN/2078/B(U)-96, Rev. 2, with the indicated conditions, for a period of one year.

Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

Canadian Certificate No.	Issue Date	Expiry Date	CNSC File
CDN/2078/B(U)-96 (Rev. 2)	**May-02-2007**	**Oct-31-2011**	**30-A2-243-0**

Certificate
for
Transport Package Design

The transport package design identified below is certified by the Canadian Nuclear Safety Commission pursuant to paragraph 21(1)(h) of the *Nuclear Safety and Control Act* and Section 7 of the *Packaging and Transport of Nuclear Substances Regulations*, and to the 1996 Edition (Revised) of the IAEA *Regulations for the Safe Transport of Radioactive Material*.

REGISTRATION OF USE OF PACKAGES

All users of this authorization shall register their identity in writing with the Canadian Nuclear Safety Commission prior to the first use of this authorization and shall certify that they possess the instructions necessary for preparation of the package for shipment.

PACKAGE IDENTIFICATION

Designer: **MDS Nordion**
Make/Model: **F-458/F-245; F-247; F-251; F-251 MK2; F-318 and F-448**
Mode of Transport: **Air, Sea, Road, Rail**

IDENTIFICATION MARK

The package shall bear the competent authority identification mark **"CDN/2078/B(U) - 96"**.

PACKAGE DESCRIPTION

The packaging, comprising of four major sub-assemblies consists of the containment system, the shielding vessel, the outer container and the fire shield.

The containment system consists of a special form capsule, or a C-133 welded sealed capsule within the F-336 tungsten alloy insert, or an F-248, F-250, F-242, F-256 or F-320 leak proof insert. The leak proof insert consists of a stainless steel body and cap that are threaded together and sealed with an O-ring.

The shielding is provided by a cylindrical vessel encased in stainless steel sheet. The F-251, F-251 MK2, F-318, F-245 and F-247 shielding vessels are depleted uranium vessels and the F-448 is a lead filled vessel.

The F-458 outer container consists of a double skinned cylindrical stainless steel keg with two lifting apertures in the top. A lid is bolted with six M10 stainless steel bolts.

Canada

The fire shield is provided by polyurethane foam filled between the double skins of the stainless steel keg. Two vent holes in the lid and two in the body of the cylinder are provided with plastic pipe thread plugs. The various packaging models are further shown on MDS Nordion Drawing Nos. F-458/F245: F624501-002; F-458/F247: F624701-002; F-458/F251 and F251 MK2: F625101-002; F-458/F318: F631801-002 and F-458/F448: F644801-002.

The total mass of the package for various model types are as shown in the attached MDS Nordion Drawing No. F-458, (Issue 7).

The package is further described and the other essential technical requirements for design, manufacturing, maintenance, inspection are listed in MDS Nordion Document No. IS/DS 1789 F-458 (9) "Design, Manufacturing and Operating Specification for the F-458 Family of Transport Package".

The configuration of the F-458 packaging is as follows:

Shape:	**Cylinder**	Shielding:	**Lead or Depleted Uranium**
Mass:	**n/a**	Outer Casing:	**Stainless Steel**
Length:	**n/a**	Height:	**494 mm**
Width:	**n/a**	Diameter:	**400 mm**

AUTHORIZED RADIOACTIVE CONTENTS

The radioactive contents for the various configurations of the F-458 Transport Packages are listed in Appendix A attached.

QUALITY ASSURANCE

Quality assurance for the design, manufacture, testing, documentation, use, maintenance and inspection of the package shall be in accordance with:

- MDS Nordion Document No. IN/QA 0224 Z000 (6)* "Radioactive Material Transport Package Quality Plan"
- MDS Nordion Document No. IS/DS 1789 F458 (9) "Design, Manufacturing and Operating Specification for the F-458 Family of Transport Package"
- Canadian Packaging and Transport of Nuclear Substances Regulations
- IAEA Regulations
- * or latest current revision

Canada

Canadian Certificate No.	Issue Date	Expiry Date	CNSC File
CDN/2078/B(U)-96 (Rev. 2)	**May-02-2007**	**Oct-31-2011**	**30-A2-243-0**

SHIPMENT

The preparation for shipment of the package shall be in accordance with:

- MDS Nordion Document No. IS/DS 1789 F458 (9) "Design, Manufacturing and Operating Specification for the F-458 Family of Transport Package"
- Canadian Packaging and Transport of Nuclear Substances Regulations
- IAEA Regulations

This certificate does not relieve the shipper from any requirement of the government of any country through or into which the package will be transported.

A. Régimbald
Designated Officer pursuant to paragraph 37(2)(a)
of the Nuclear Safety and Control Act

Canada

Appendix A

The radioactive contents for the various configurations of the F-458 Transport Packages are listed in the following tables:

Package Configurations and Authorized Radioactive Contents for F-458/F-251 and F-458/F-318

Isotope	Package Configuration			Chemical and Physical Form
	F-251 or F-318 with F-248 insert	F-251 or F-318 with F-320 insert or F-251 with F-250 insert	F-251 or F-318 with F-368 insert	
I-131	20 TBq (540 Ci)	20 TBq (540 Ci)	20 TBq (540 Ci)	Solid
I-131	7.4 TBq (200 Ci)	13 TBq (351 Ci)	--	Aqueous NaOH solution or aqueous NaOH with up to 0.02 M Na_2SO_4
Ir-192	--	--	300 TBq (8100 Ci)	Special Form capsule
Mo-99/ Tc-99m	37 TBq (1000 Ci)	55.5 TBq (1500 Ci)	--	Solid or aqueous NaOH solution or aqueous NaOH with up to 1 M NH_4NO_3 or up to 0.4% NaOCl
Sr-90/ Y-90	18.5 TBq (500 Ci)	18.5 TBq (500 Ci)	--	Solid
Sr-90/ Y-90	6.4 TBq (173 Ci)	11.1 TBq (300 Ci)	--	Liquid in up to 1 N HCl
Y-90	18.5 TBq (500 Ci)	18.5 TBq (500 Ci)	--	Solid
Y-90	6.4 TBq (173 Ci)	11.1 TBq (300 Ci)	--	Liquid in 0.04 N HCl

Package Configurations and Authorized Radioactive Contents for F-458/F-245 and F-458/F-247

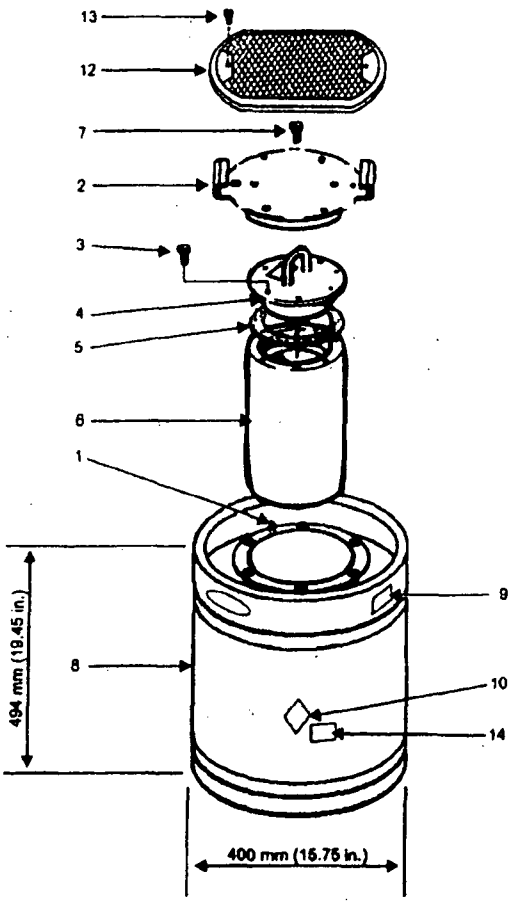
Isotope	Package Configuration			Chemical and Physical Form
	F-245 with F-248insert	F-247 with F-242 insert	F-245 with F-336 insert	
Co-60	--	--	275 GBq (7.4 Ci)	Solid
I-131	7500 GBq (202 Ci)	3300 GBq (89 Ci)	--	Solid or aqueous NaOH solution or aqueous NaOH with up to 0.2 M Na_2S0_4
Ir-192	--	37 TBq (1000 Ci)	--	Solid pellets
Ir-192	--	--	300 TBq (8100 Ci)	Solid pellets in a C-133 capsule
Ir-192	--	110 TBq (2970 Ci)	300 TBq (8100 Ci)	Special form capsule
Mo-99/ Tc-99m	37 TBq (1000 Ci)	25 TBq (676 Ci)	--	Solid or aqueous NaOH solution or aqueous NaOH solution with up to 1 M NH_4NO_3 or up to 0.4% NaOCl

Package Configurations and Authorized Radioactive Contents for F-458/F-448 in F-256 Leakproof Insert

Isotope	Package Configuration		
	F-448/F-256	F-448/F-256/F-389	Chemical and Physical Form
I-125	7,400 GBq (200 Ci)	7,400 GBq (200 Ci)	Solid or Aqueous NaOH solution
I-131	5,180 GBq (140 Ci)	10,000 GBq (270 Ci)	Solid or Aqueous NaOH solution or Aqueous NaOH solution with 0.02 M Na_2SO_4
Mo-99/ Tc-99m	555 GBq (15 Ci)	1,110 GBq (30 Ci)	Solid or Aqueous NaOH solution or Aqueous NaOH with 1 M NH_4NO_3 or up to 0.4% NaOCl
Y-90	16,000 GBq (432 Ci)	--	Solid or Liquid in 0.04 N HCl
Sr-90/Y-90	16,000 GBq (432 Ci)	--	Solid or Liquid in 1 N HCl

Package Configurations and Authorized Radioactive Contents for F-458/F-448 in Special Form Sealed Sources

Isotope	Package Configuration			
	F-448	F-448/F-174	F-448-F/286	F-448/F-382
Co-60	4.0 GBq (0.1 Ci)	15.0 GBq (0.4 Ci)	4.0 GBq (0.1 Ci)	15.0 GBq (0.4 Ci)
Ir-192	2,405 GBq (65 Ci)	9,250 GBq (250 Ci)	4,800 GBq (130 Ci)	33,300 GBq (900 Ci)
Sb-124	7.4 GBq (0.2 Ci)	11.1 GBq (0.3 Ci)	7.4 GBq (0.2 Ci)	44.4 GBq (1.2 Ci)
Y-90	18,000 GBq (486 Ci)	18,000 GBq (486 Ci)	18,000 GBq (486 Ci)	18,000 GBq (486 Ci)
Sr-90/Y-90	18,000 GBq (486 Ci)	18,000 GBq (486 Ci)	18,000 GBq (486 Ci)	18,000 GBq (486 Ci)



Parts List

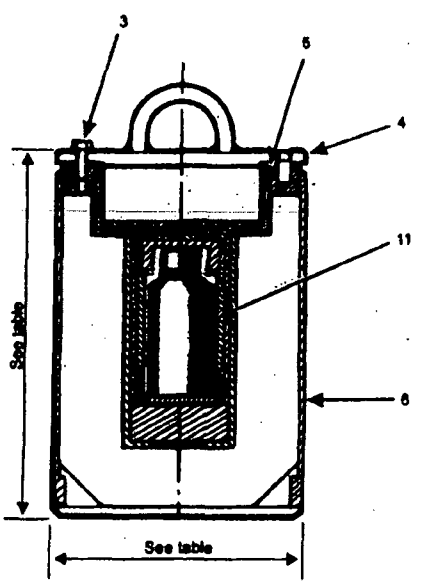
1. Wire seal on guide pin
2. Lid
3. 3/8 - 16UNC hex head cap screws, SAE J429, Gr. 5, (F-245, F-247 and F-251 – 4 pcs., F-448, F-251 MKII and F-318 – 6 pcs.)
4. Shielded plug
5. Neoprene gasket
6. Shielding vessel
7. Stainless steel bolt M10 x 30 mm long (6)
8. Stainless steel cylinder
9. Shipping container identification and radiation caution label (2)
10. Radioactive Category Labels (2): on two opposite sides
11. Leakproof insert and radioactive contents
12. Heat screen. See Note 5.
13. Stainless steel bolt M8 x 16 mm long (2)
14. UN Number Labels (2): one next to each of the radioactive category label

Notes

1. Meets IAEA Type B(U) requirements
2. CNSC Certificate CDN/2078/B(U)-96
3. Prepare for shipment in accordance with IS/PP 1693 F458
4. Supplemental shielding inserts may be used in some configurations
5. Supplemental heat screen to be used for shipments of Ir-192 in excess of 150 TBq

Shielding Vessels & Inserts

Package Model Type	Package Total Weight (kg)	Shielding Vessel Diameter (mm)	Shielding Vessel Height (mm)	Leakproof Insert Type	Shielding Insert Type
F-458/F-251 F-458/F-251MKII	167	184	274	F-320 F-250 F-248	F-368
F-458/F-318	164	171	268	F-320 F-248	F-368
F-458/F-245	153	181	245	F-248	F-336
F-458/F-247	125	165	218	F-242	
F-458/F-448	138	184	256	F-256	F-174 F-286 F-382 F-389



CROSS SECTION THROUGH ITEM 6

MDS Nordion
447 March Road, P.O. Box 13500
Kanata, Ontario, Canada, K2K 1X8
Tel: (613) 592-2790 · Fax. (613) 592-6937

TITLE

F-458 Transport Packaging

REF. IS/SS 1699 F458 F545801-001		REVISED OCT 05	DC 19847
DATE Nov 00		No. F-458	ISSUE 7
DRAWN SW	CHECKED KG XG	APPROVED ML MK	SHEET 1 OF 1

U.S. Department
of Transportation

**Pipeline and
Hazardous Materials
Safety Administration**

**East Building, PHH-23
1200 New Jersey Avenue Southeast
Washington, D.C. 20590**

CERTIFICATE NUMBER: USA/0697/B(U)-96, Revision 2

ORIGINAL REGISTRANT(S):

Mr. Marc-Andre Charette
Manager, Regulatory Affairs
MDS Nordion
447 March Road
Ottawa, K2K 1X8
CANADA

F-458 Family of Transport Packages
Package Design Certificate No. CDN/2078/B(U)-96, Rev. 1
Docket No. 71-3076

This package is not leak tested - so in our recommendation to DOT, we identified specific conditions that should be imposed via DOT's competent authority approval (see the list of our recommended conditions at the end of this paper). In March we met with Nordion and the Department of Transportation. Nordion proposed the following resolutions to our technical problems concerning leak testing of the package.

1. Starting immediately, Nordion will leak test each O-ring seal to leak-tight criterion prior to loading the contents. This is intended to satisfy the annual leakage test specified in ANSI N14.5 (it is close). *This satisfies Condition No. 1.*

2. Starting immediately, Nordion will package all normal form radioactive material in leakproof inserts. *This satisfies Condition No. 3.*

3. Starting immediately, Nordion agreed to leak test all packages of Type B quantities of Sr-90 in normal form prior to shipment. *This satisfies Condition No. 4.*

4. Nordion is currently evaluating methods and equipment for leak testing packages of Mo-99. There is significant work to do, and hot cell modifications must be made before this can be implemented. DOT will probably grant an extension of the Competent Authority Certificate without the leak testing requirement, provided Nordion can show good faith effort to implement this condition. *This is intended to satisfy Condition No. 5(b) for molybdenum shipments.*

5. Nordion stated that the hot cell used for iodine preparations cannot be modified to accommodate leak test equipment. Nordion proposes to limit iodine shipments to radioactive quantities less than 30 x A2. Note that the 30 x A2 value is the "cutoff" value for a Category III vessel, as defined in NUREG-1609, Chapter 1, Table 1.1. The idea is that limiting the contents would provide additional confidence that, in addition to the low probability of such a leak, leakage would not be a significant radiological problem. *This is intended to provide reasonable assurance that the package meets the containment requirements, and to satisfy the intent of Condition No. 5(b) for iodine shipments.*

FOR REFERENCE - THESE ARE THE CONDITIONS WE RECOMMENDED TO DOT:

Condition No. 1: *The leakproof insert O-ring must be tested to demonstrate a leakage rate not more than 1 x 10^{-7} ref-cm^3/s prior to use. This test may be performed prior to loading the contents in the leakproof insert.*

Condition No. 2: *This authorization is for consignments by MDS Nordion only.*

Condition No. 3: *All shipments of normal form radioactive material must be in leakproof inserts. The maximum heat load of normal form radioactive material in a leak proof insert is 6.1 Watts.*

Condition No. 4: *After loading and prior to each shipment of normal form Sr-90, the*

seals of the F-248, F-250, F-256, and F-320 containment vessels must show no leakage when tested to a sensitivity of at least $1x10^{-3}$ ref-cm^3/s.

Condition No. 5: *This authorization is limited to CDN/2078/B(U)-96, Rev. 1. Upon renewal of CDN/2078/B(U)-96 when it expires on October 31, 2007, the following conditions will apply:*

a) *MDS Nordion must demonstrate the package tie-downs meet the tie-down loads as described in Table V.2 of IAEA safety Guide No. TS-G-1.1 (ST-2), "Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material."*

b) *After loading and prior to each shipment of normal form radioactive material, the seals of the F-242, F-248, F-250, F-256, and F-320 containment vessels must show no leakage when tested to a sensitivity of at least $1x10^{-3}$ ref-cm^3/s.*

Condition No. 6: *The shipper must provide the consignee special instructions for safely opening the package under the presence of combustible gases.*

Michelle DeBose

From: Marc.CHARETTE@mdsinc.com
Sent: Monday, November 26, 2007 4:15 PM
To: rick.boyle@dot.gov; fred.ferate@dot.gov
Cc: Luc.Desgagne@mdsinc.com; Scott.MCGHEE@mdsinc.com
Subject: Recommendation 5a for the Certificate USA/0697/B(U)-96 for the F-458 Transport Package
Attachments: appendix 10-4 Handle Tie-down test v2.doc

Dear Mr. Boyle,

As discussed during our March 7, 2007, meeting, please find attached the Appendix 10.4 which will be added to the Safety Analysis Report for the F-458, IS/TR 1791 F458. Appendix 10.4 contains the results of the physical testing that MDS Nordion performed on the F-458 package to demonstrate compliance with the 10-5-2g tie-down requirement per Table V.2 of the IAEA Safety Guide TS-G-1.1 (ST-2), "Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material." The test result show that the F-458 packages passes with an applied load of more than 30% greater than the required load for 10-5-2. MDS Nordion believe that this demonstrates that the F-458 handles can withstand the tiedown requirements.

Please contact me by telephone (613) 592-3400 ext. 2421 or by email if you have any questions.

Sincerely,
Marc-Andre

APPENDIX 10.4:
F-458 Overpack Tie-Down Test
Tests November 2007

TEST REPORT

Requirements:

The handle openings of the F-458 overpack are assessed with respect to the tie-down loads specified in Table V.2 of the IAEA Safety Guide TS-G-1.1 (ST-2), "Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material". Package retention systems of Type B packages being transported in the USA must withstand simultaneous acceleration of 10g in the direction of travel, 5g lateral to the direction of travel, and 2g vertically upwards. Structural components of the package must not yield when subjected to this loading.

The IAEA guidance material provides a method to calculate the resultant load force on the tie-down members for this acceleration condition. Based on the calculated net resultant load, a static test was performed to simulate this loading condition.

Calculation of Resultant Loads:

The heaviest configuration in the F-458 family of transport packages is the F-458/F-251, with maximum gross mass of 171 kg. The F-458 package has nominal dimensions of 400 mm (15.75 in) diameter and 494 mm (19.45 in) height. The center of gravity for the package was determined empirically. An F-458/F-251/F-368 package configuration was assembled. The package was suspended from a single handle by a single chain. A vertical line was projected down from the single chain and marked on the circumference of the F-458 package. This process was repeated for the opposite handle, forming an "X" marking on the side of the package. The point of intersection of the two lines, the center of gravity, was measured at 229 mm (9.0 inches) from the base of the F-458 package.

The analysis follows the example given in Appendix V of the IAEA Advisory Material TS-G-1.1 (ST-2). In the tie-down configuration considered, a pair of ratchet straps are looped through the handles and are attached at four floor locations. The straps make an angle of 45 degrees relative to the floor, and relative to the direction of travel (see Figure 10.4-1). The base of the package is assumed to be chocked.

Considering first the loads in the X and Z directions, assume that the package is on the verge of tipping about the A-A axis. Assume that there are no pre-loads at the moment of the acceleration forces are applied. The F_x and F_z loads will be balanced by tension in tie-downs T1 and T4, and there will be no force in tie-downs T2 and T3. For no movement of the package, the sum of all moments about axis A-A is zero. It is assumed that the reaction forces of T1 and T4 are equal, due to symmetry.

$$\sum M_{AA} = 0$$

$$F_X \cdot Z_{CG} + F_Z \cdot R_{F458} = F_G \cdot R_{F458} + 2T1_X \cdot Z_{Top} + 2T1_Z \cdot D_{F458}$$

where

$$T1_X = T1 \cdot \cos 45 \cdot \cos 45 = 0.5T1$$

$$T1_Z = T1 \cdot \sin 45 = 0.707T1$$

$$F_X = M \cdot 10g, \quad F_Z = M \cdot 2g$$

$$M = 171kg, Z_{CG} = 0.229\ m,\ Z_{Top} = 0.494\ m, R_{F458} = 0.2\ m, D_{F458} = 0.4\ m$$

Then solving for T1:

$$171 \cdot 10 \cdot 9.81 \cdot 0.229 + 171 \cdot 2 \cdot 9.81 \cdot 0.2 = 171 \cdot 9.81 \cdot 0.2 + 2 \cdot 0.5T1 \cdot 0.494 + 2 \cdot 0.707T1 \cdot 0.4$$

$$T1 = 3942\ N$$

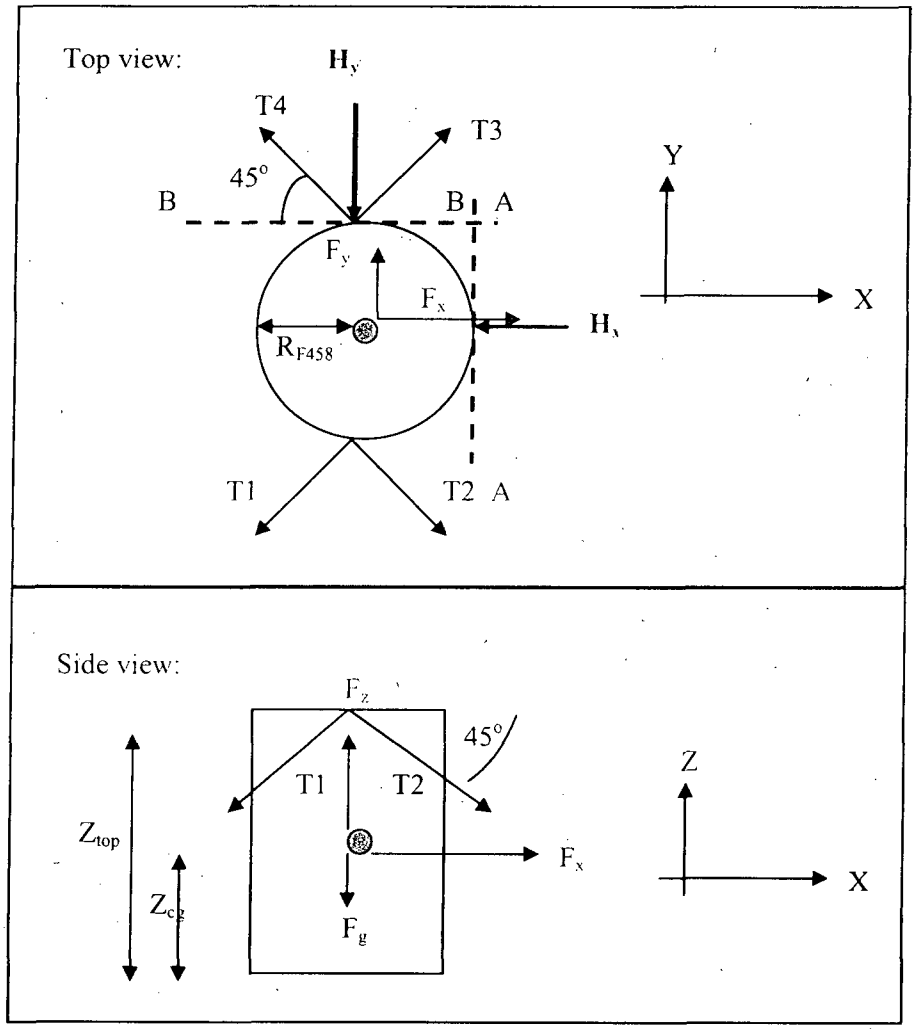


Figure 10.4-1 — F-458 Tie-down configuration

Therefore the reaction force in tie-down T1 due to the forces in the X and Z direction is 3942 N.

Similarly, considering the loads in the Y and Z directions, assume that the package is on the verge of tipping about the B-B axis. Assume that there are no pre-loads at the moment of the acceleration forces are applied. The F_y and F_z loads will be balanced by tension in tie-downs T1 and T2, and there will be no force in tie-downs T3 and T4. For no movement of the package, the sum of all moments about axis B-B is zero. It is assumed that the reaction forces of T1 and T2 are equal, due to symmetry.

$$\sum M_{BB} = 0$$

$$F_Y \cdot Z_{CG} + F_Z \cdot R_{F458} = F_G \cdot R_{F458} + 2T1_Y \cdot Z_{Top} + 2T1_Z \cdot D_{F458}$$

where

$$T1_Y = T1 \cdot \cos 45 \cdot \cos 45 = 0.5T1$$

$$T1_Z = T1 \cdot \sin 45 = 0.707T1$$

$$F_Y = M \cdot 5g, \quad F_G = M \cdot 2g$$

$$M = 171kg, Z_{CG} = 0.229\,m, Z_{Top} = 0.494\,m, D_{F458} = 0.4\,m$$

Then solving for T1:

$$171 \cdot 5 \cdot 9.81 \cdot 0.229 + 171 \cdot 2 \cdot 9.81 \cdot 0.2 = 171 \cdot 9.81 \cdot 0.2 + 2 \cdot 0.5T1 \cdot 0.494 + 2 \cdot 0.707T1 \cdot 0.4$$
$$T1 = 2129\ N$$

Therefore the reaction force in tie-down T1 due to the forces in the Y and Z direction is 2129 N.

The total load in tie-down T1 is the sum of the X and Y components (which is conservative, since the vertical Z component is counted in both values). Therefore

$T1_{total}$ = 3942 + 2129 N = 6071 N.

The maximum tie-down force is therefore 6071 N. Since the assumed ratchet strap is continuous, the tension in member T2 is the same as in member T1 (T1 = T2).

The net load on the handle is calculated from the T1 and T2 loads applied simultaneously; it is then the vector sum of loads $T1_{total}$ and $T2_{total}$. The net load on the handle acts at an angle to the ground of

$\tan\theta = \sqrt{2}$, or θ = 54.7 degrees. The net load on the handle is then

$$P_{net} = 2 \times \frac{T1_{total} \cdot \sin 45 \cdot \cos 45}{\cos 54.7} = 10{,}514 \text{ N.}$$

Each F-458 package tie-down point must therefore withstand **10,514 N (2364 lb) acting at an angle of 54.7 degrees from the ground** (and radial from the center of gravity), without yield, to satisfy the tie-down requirements for Type B packages in the USA. This forms the acceptance criterion for the subsequent tie-down tests.

Test Equipment:

- F-458 overpack, no serial number, selected randomly from inventory before entering service.
- F-168 container, including skid, gross mass 5445 kg.
- Porta-Weigh scale, model MSI 3400, MDSN tool number 13531 (calibrated).
- Overhead crane, lifting straps, attachment hardware.

Test Procedure:

The following test procedure was performed for the tie-down configuration assessed.

1. Measure the F-458 package diameter and height at the tie-down points before the test. Inspect the package in the region of the tie-down points for damage and distortion.
2. Place the F-458 package in the middle of the modified steel plate (2" thick mild steel plate with lifting rings and fully-rounded edges).
3. Lift the steel plate in a "basket" configuration using lifting straps using the overhead crane.
4. Zero the scale on the overhead crane.
5. Attach the F-458 tie-downs to a second pair of lifting straps. The angle of attachment to the F-458 package shall be as close as possible to 35 degrees relative to the package (54.7 degrees to ground). Connect these straps to an F-168 package (or similar) sitting underneath. Use appropriate clevis hardware.

6. Raise the crane slowly until the scale reading is greater than 5000 lb. Note that the straps will stretch and therefore the reading will decrease slowly with time. Do not raise the F-168 package off the ground.

7. After taking photos of the test, and noting the maximum sustained load on the scale, lower the crane and disassemble.

8. Measure the F-458 package diameter and height at the tie-down points after the test. Inspect the package in the region of the tie-down points for damage and distortion.

A test was performed on November 9, 2007. Figure 10.4-2 shows the test schematic.

Results:

A photo of the test in progress is shown in Figure 10.4-3, with the projectile shield removed for clarity. The angle of the tie-down strap relative to the package was approximately 40 degrees. In the tie-down configuration (see Figure 10.4-5), straps were passed through each of the handle openings to apply load to the handles.

The diameter at the top of the F-458 overpack was measured in several locations prior to testing, and was uniformly round at 398 mm. The height at each handle was measured at 492 mm. The lid on the package was in place but without any screws installed. There was no damage or distortion of the rim.

The scale was zeroed with the F-458 sitting on the steel plate. After attaching the F-458 to the F-168 (dead weight), the crane raised the steel plate. The straps passing over the rounded edge of the steel plate (see Figure 10.4-4) transmitted the load from the dead weight. The total load applied exceeded 6200 lb (27.6 kN) temporarily, and gradually fell as the straps stretched. The total applied load stabilized at 5670 lb (25.22 kN) after several minutes (see Figure 10.4-6).

After releasing the load and removing the lifting straps, the F-458 package was re-measured. There was no change to the diameter of the top of the package, and the shape remained circular. The height of the F-458 package also did not change for either handle. There did not appear to be any local deformation, cracking, or crushing of the package at the contact areas or surrounding rim.

The test was performed by William Allin, with assistance from Jason Brydges and Paul St. Gelais. The test was witnessed by Scott McGhee.

Discussion:

The load applied to the F-458 tie-down points was transmitted by the lifting straps passing over the rounded edge of the steel plate (see Figure 10.4-4). This rounded edge was ground smooth to reduce the friction of the strap over the edge. Due to the relatively large radius of curvature (approximately 2 inches) and the smoothness of the surface, the friction of the lifting strap on the steel plate would be small. Therefore it is reasonable to conclude that the tension in the lifting strap was approximately uniform throughout its length.

Furthermore, the load applied to either side of the F-458 package must be very close to equal, since any inequality in tension would cause the F-458 package to shift in its position on the plate (it was not fixed to the plate). Differences in the lengths of the two lifting straps on opposing sides are negated when the crane lifts the plate. The hanging steel plate will be forced to shift laterally until the load is balanced between the two lifting straps.

Therefore the tension in each strap is approximately equal to half of the measured load, as indicated on the crane's scale.

Conclusions:

The F-458 package handles were tested with respect to the IAEA Safety Guide TS-G-1.1 (ST-2) guidelines for packages being transported through the USA. The resultant load for a simultaneous 10g, 5g, 2g acceleration for the heaviest F-458 package configuration was calculated. The required net load on the handle was determined to be **2364 lb (10.51 kN)** at an angle 35-degrees downward from the tie-down point.

Physical tests of an F-458 package were performed. The package was selected randomly from the stock of F-458 overpacks prior to entering service (not yet serialized). The applied load on each tie-down point was greater than **3100 lb (13.79 kN)** for a brief time, applied at an angle of approximately 40 degrees to the package. The load stabilized at 2835 lb (12.61 kN) after several minutes. The temporary and stabilized loads were significantly higher than the calculated required net load.

The diameter and height of the F-458 package was measured before and after all tests, and was found to be unchanged. No deformation or damage was observed. It is therefore concluded that the F-458 package satisfies the requirements for tie-down for Type B packages in the USA.

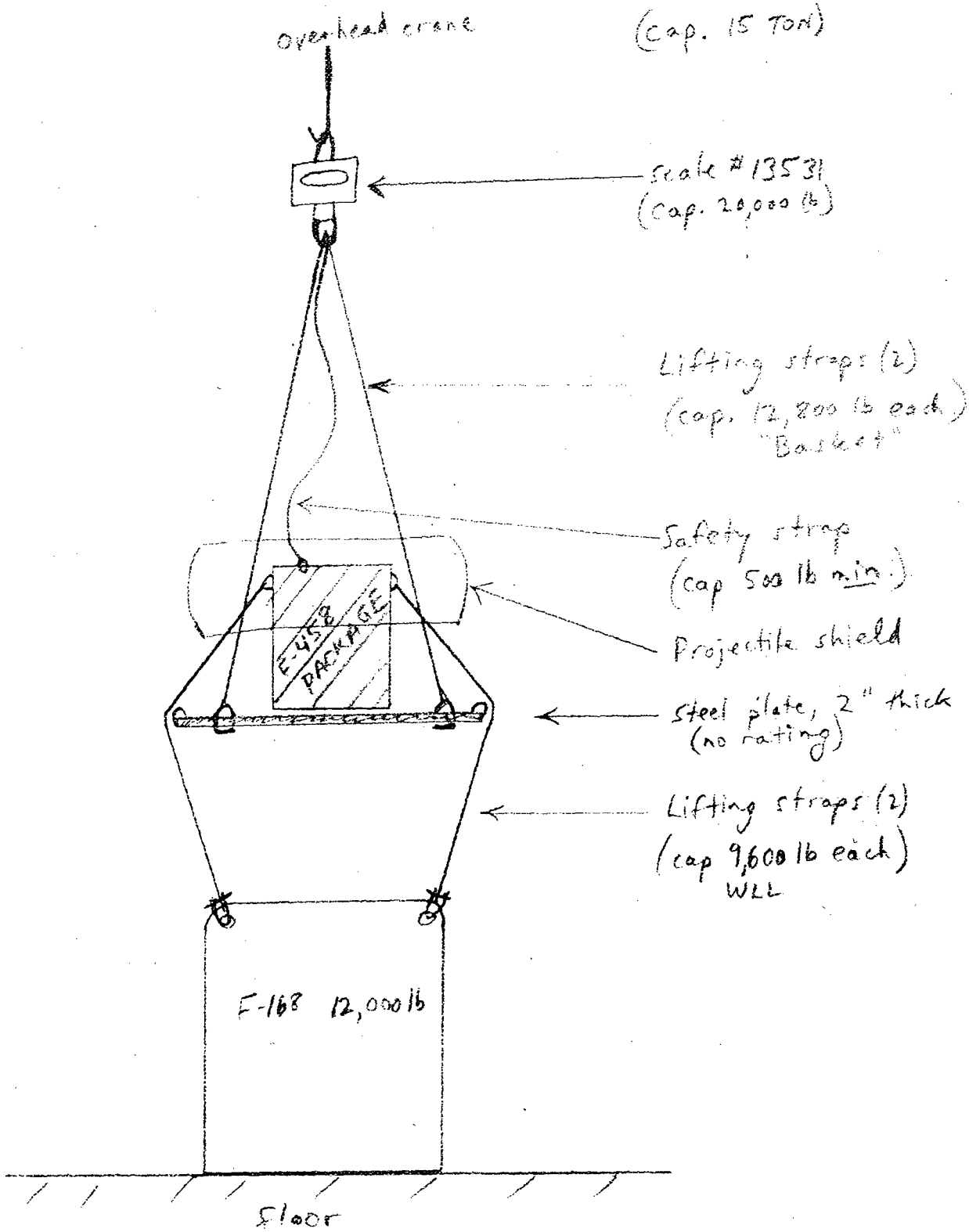


Figure 10.4-2 — F-458 Tie-down test schematic

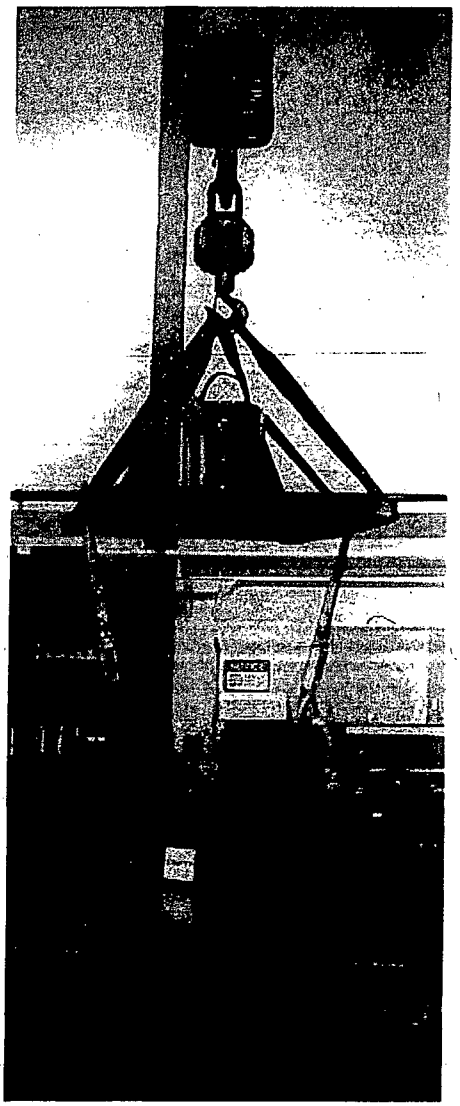


Figure 10.4-3 — F-458 Tie-down Test in Progress

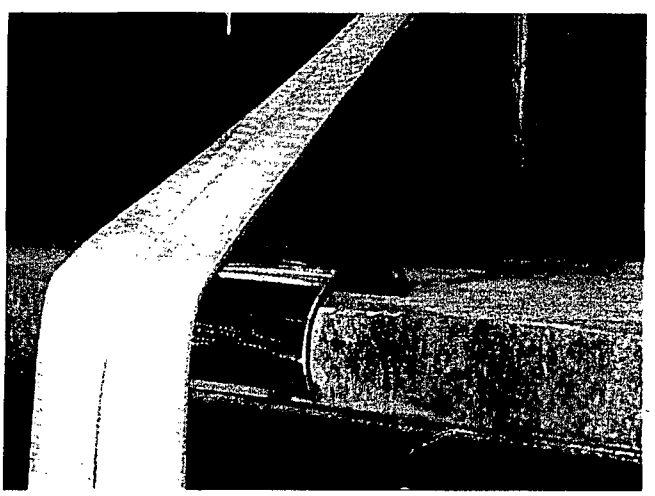


Figure 10.4-4 — Rounded edge of Steel Plate (Straps pulled aside)

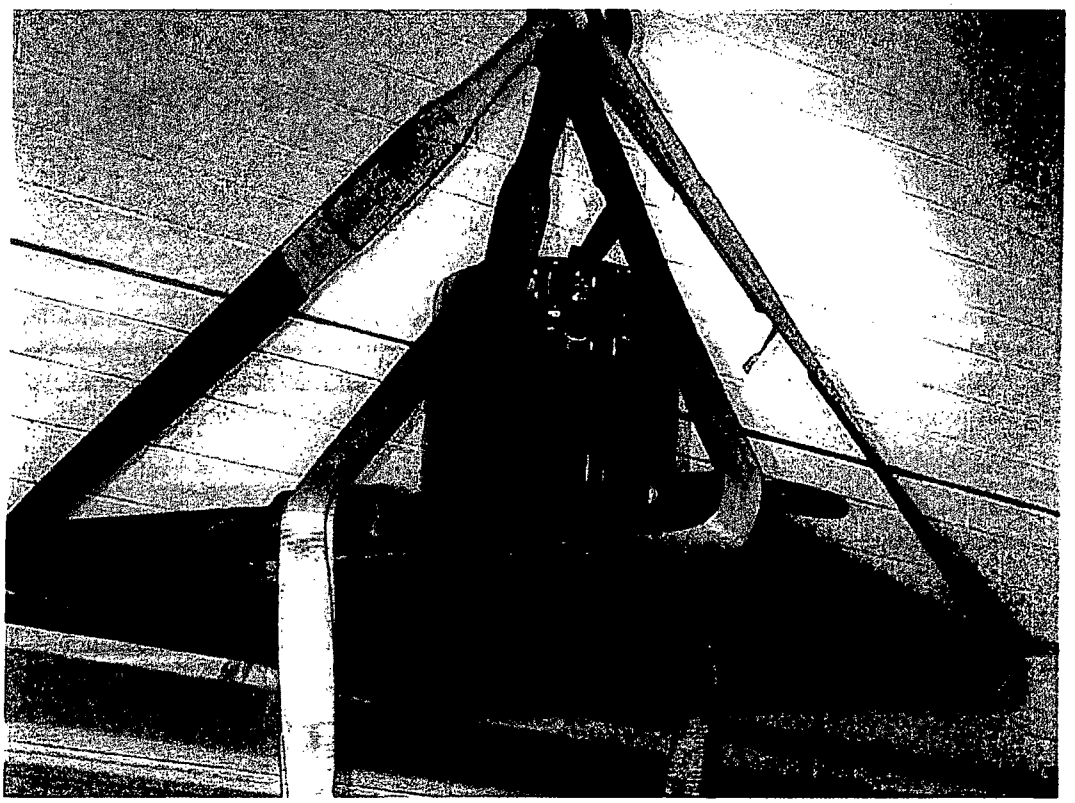


Figure 10.4-5 — F-458 package Tie-down test, Handle

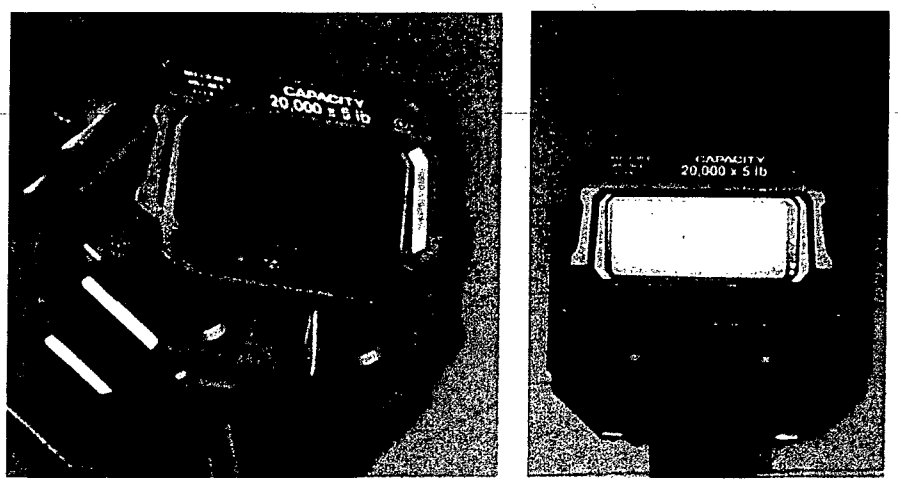


Figure 10.4-6 — Scale during Tie-down test, Transient (6245 lb) and Stabilized (5670 lb)