MDS Nordion IS/TR 1190 F400/F390 (1)

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Qualification Test Report of the F-400/F-390 Type 'A' Transport Package

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Document History

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1. INTRODUCTION

This report summarizes the results of a series of tests performed on the F-400 Type A transport package containing the Therasphere F-390 Lead Pot and Administering Kit. The objectives of the tests were to demonstrate that this configuration of the F-400 meets the requirements of the Transport Packaging of Radioactive Materials Regulations for Type A Packages [1] and the corresponding IAEA requirements for Type A Packages [2].

The tests were performed by Farid Khan in March 1991.

All photographs referenced in this report can be found in the Package Engineering Photographs binder [3].

2. DESCRIPTION

The F-400 is a universal overpack designed to carry Type A quantities of radioisotopes and their radiation shields. The approved contents of the F-400 series of packages are listed in Nordion specification IN/DS 0044 F400 [4]. When the F-400 is used for shipping the Therasphere product, it has the following components:

1. Vial
2. Acrylic Shielding
3. F-390 Lead Pot
4. Fiber Tape (to secure lead pot)
5. Expanded Polystyrene Insert
6. Therasphere Administration Kit
7. Chip Board Inserts
8. Fiberboard Box
9. Polyester Tape (to seal Box)

Table 2.1 summarizes the photographs of various components of the package.

TABLE 2.1: Photograph Reference for F-400 Assembly

Description	Photograph
lucite shield and F-390 lead pot	303
F-390 lead pot showing taped seam	304
F-400 Therasphere assembly	305
internal assembly	306
polystyrene insert	307

3. TEST PROCEDURE

The prototypes were prepared in accordance with IS/PP 0036 F400 [5]. Coloured water was used in the vial to represent the radioactive material.

The test procedure is described in more detail in Appendix A.

3.1 Water Spray Test

The apparatus for the water spray test is shown in Photo 308. A maximum of three F-400 overpacks could be tested at one time.

The apparatus was calibrated by placing a 5 gallon pail under the spray nozzle and measuring the depth of water in the pail after a set period of time. The water flow rate was required to be greater than 5 cm/hr.

Each prototype was sprayed for one hour. The package was rotated every 10 minutes so that all surfaces were evenly sprayed. Drop and penetration tests were performed immediately after the water spray test.

3.2 Drop Test

Modified drop tests were conducted in accordance with references 1 and 2. The total height of the fall was 9 m. The target was a 36" x 36" x 1/8" steel plate.

3.3 Penetration Test

Penetration tests were conducted in accordance with references 1 and 2. The test piece was supported above ground level to allow the bar to pass through the package.

4. RESULTS

In the following subsections, test results are discussed for the F-400/F-390. For simplicity, the discussions of test results are arranged by test type rather than in the actual order of testing.

Summaries of the photographs taken during the testing process are listed in Tables 4.1, 4.2, and 4.3.

4.1 Water Spray Test

Test Summary	
Container 1	Pass
Container 2	Pass

In general, the water spray test caused little damage to the F-400. There was some water absorption in the fiberboard, however the tape continued to adhere to the packaging. All stapled corners remained intact.

The ambient temperature on the test day was approximately 5°C. No ice formed on the F-400 package during the test.

TABLE 4.1: Photograph Reference for Water Spray Test

Subject	Description	Photograph
Apparatus	water spray test apparatus during testing	308
Container 1	side view showing stapled seam	309
"	corner view showing taped seams	310
Container 2	side view showing stapled and taped seams	311
"	bottom view showing taped seams	312

4.2 9 m Drop Test

Test Summary	
Container 1	Pass
Container 2	Pass

The drop tests were conducted immediately after the water spray test. The tests were conducted in the Cobalt-Operations shipping bay at Nordion's KIPF building. Each container was supported in a sling (evident on photo 317) which served as a means to attach the F-400 to the drop test release mechanism. The sling was loosely tied so that it would not support the fiberboard in any way. The impact surface was the concrete floor of the shipping bay.

In general, the drop tests resulted in minimal damage to the F-400. The package is most susceptible to damage from a corner drop. Direct impact on a surface has little effect on the integrity of the package since the impact forces are distributed over a relatively large area.

Detailed descriptions of damage resulting from the drop testing are summarized below.

4.2.1 Drop Test Results for Container 1

The container was subjected to one drop from a height of 9 m.

Release of the container to initiate the drop was smooth and little rotation was observed during free-fall.

The F-400 impacted the ground on a bottom corner and was deflected upwards about 0.5 m before rolling to a rest position approximately 2 m from the point of impact.

Damage to Container

1. Crushing of fiberboard and polystyrene insert at corner of impact to a depth of approximately 2 cm. Fiberboard and taped seams remained intact over impact surface. Photo 314

2. Some damage to surface layer of fiberboard near top taped seam. Photo 315.

3. Isolated separation of tape on top surface of F-400. Photo 316.

Comments

In general, the fiberboard remained intact over the entire surface of the F-400. Some separation occurred at one taped seam, but was limited to the surface layer only.

Taped seams remained intact with some separation occurring at the top surface. Separation was not from the fiberboard but from the surface of another taped seam orthogonal to the separated tape.

4.2.2 Drop Test Results for Container 2

The second F-400/F-390 package was subjected to two drops from a height of 9 m.

No rotation of the container was observed during free-fall.

The F-400 impacted directly on the bottom surface. Little rebound was observed after impact.

Drop 1: Container 2

Damage to Container and Comments

1. No observable damage occurred to the package with the exception of some minor scrapes to the fiberboard at the bottom surface. Photo 317.

2. In general, the package suffered no damage from the drop since the impact was distributed over the entire bottom surface.

3. Since very little damage resulted from the drop, the container was subjected to a second 9 m drop test.

Drop 2: Container 2

The package landed on a bottom corner. The corner was crushed inwards and adjacent sides were indented. Little rotation was observed during free-fall.

After impact, the F-400 was deflected to the side and rolled to its rest position approximately 2.5 m from the point of impact.

Damage to Container

1. Crushing to a depth of 2 cm on impact corner. Fiberboard and taped seams remained intact over impact corner. Photos 318, 319, 320.

2. Separation of tape from fiberboard occurred on side adjacent to impact corner. Bottom of F-400 remained secured by tape. Photos 318, 319.

3. Some minor crushing of bottom corner adjacent to impact corner was noted resulting from secondary impact on rebound from 9 m drop. No damage to fiberboard or separation of taped seams. Photo 319.

Comments

In general, the fiberboard remained intact and fully secured by the tape. Some separation of the tape was observed but this occurred away from any seams on the F-400.

TABLE 4.2: Photograph Reference for Drop Test

Subject	Description	Photograph
Container 1	side view showing damage from drop test	313
"	bottom view showing damage to corner	314
"	side view showing separation of tape	315
"	top view showing slight separation of tape	316
Container 2	damage from first drop test	317
"	damage from second drop test	318
"	side view showing separation of tape	319
"	damage to corner from second drop test	320

4.3 Penetration Test

Test Summary	
Container 1	Pass
Container 2	Pass

Penetration tests were conducted immediately after the 9 m drop tests in the Cobalt-Operations shipping bay.

In general, the penetration tests caused significantly more damage to the transport package than did the 9 m drop tests. The bar used for the penetration tests would easily pierce the fiberboard F-400 container, pass through the polystyrene insert and directly impact the lead pot.

As a subsequent test, the F-390 lead pot was subjected to two penetration tests without the F-400 packaging.

4.3.1 Penetration Test Results for Container 1

Penetration Test 1: Container 1

The container was subjected to one penetration test.

The impact occurred on the side opposite to the administration kit.

The bar pierced the container to a depth of approximately 20 cm but did not pass completely through the container.

Damage to Container

1. Penetration of bar to a depth of 20 cm. Photos 321, 322
2. Separation of top taped seam at opposite side to impact point. Photos 324, 325.
3. Significant damage to polystyrene insert. Photos 326, 327.

Glancing blow to F-390 lead pot. Insignificant damage to lid. Photos 327, 328.

Comments

Bar was intended to impact the lead pot on the seam between the lid and body. During penetration, the bar was deflected upwards and caused only a glancing blow to the lead pot. There was minimal damage to the lead pot.

To further test the integrity of the package, two penetration tests were conducted on the lead pot without an overpack.

4.3.2 Penetration Test on F-390 Lead Pot Without F-400 Overpack

Test 1:

The bar impacted the lead pot at its center. A circular impression approximately 4 mm deep resulted. Photo 329.

Test 2:

The bar impacted the lead pot at the seam between the lid and body. The lid was partially separated from the body. Photos 330, 331.

Comments

The lead pot suffered considerably more damage from the direct impact of the bar, especially on an impact to the lid-body seam. Damage to the lucite shield, however was limited to cracking at the top surface. The vee-vial containing the coloured liquid was not damaged.

4.3.3 Penetration Test Results for Container 2

Container number 2 was subjected to two penetration tests at adjacent sides. The tests were conducted in succession, after which, the package was opened to determine the extent of the damage.

Penetration Test 1: Container 2

The bar penetrated the F-400, and passed completely through the overpack. The lead pot was deflected to one side on impact. Photos 332, 333, 334.

Penetration Test 2: Container 2

The bar penetrated the F-400 and was stopped by the lead pot.

Damage from Penetration Tests

1. Substantial damage to polystyrene insert. Photos 335, 336.

2. Minimal damage to the lead pot. First penetration test impacted the lead pot and deflected it towards one side. Photo 337. Second penetration test resulted in direct impact at center of the lead pot. Minimal damage to pot and no damage to lucite shield resulted .. Photos 338, 339.

TABLE 4.3: Photograph Reference for Penetration Test

Subject	Description	Photograph
Container 1	penetration of bar	321
"	depth of penetration	322
"	damage at entry point	323
"	damage to opposite side	324
"	side view showing separation of seam	325
"	damage to polystyrene insert	326
"	internal damage: insert and lead pot	327
"	impact to lead pot	328
F-390 w/o F-400	first impact without F-400 overpack	329
"	second impact on lid-body seam	330
"	damage to lead pot and lucite shield	331
Container 2	penetration test 1: penetration of bar	332
"	depth of penetration	333
"	external damage	334
"	internal damage to insert	335
"	damage to insert after two penetration tests	336
"	damage to lead pot from first penetration test	337
"	damage to lead pot from second penetration test	338
"	lead pot and lucite shield after two tests	339

5. DISCUSSION

The F-400/F-390 transport package is robust enough to endure the accumulated effects of a water spray test, a 9 m drop and a penetration test.

The package is most vulnerable to the penetration test. Damage to the container from the water spray and 9 m tests were insignificant when compared to the penetration test. During the penetration test the bar easily pierced the fiberboard F-400 package, passed through the polystyrene insert and directly impacted the lead pot. The cylindrical F-390 lead pot was usually deflected to one side by the bar which continues through the F-400 package. There was significant damage to the polystyrene insert during a penetration test.

The F-390 lead pot, lucite shield and contents suffered no visible damage from the water spray tests or from the 9 meter drop test. Minimal damage to the surface of the lead pot occurred from the impact of the bar during penetration tests.

To further test the integrity of the lead pot and lucite shield, two additional penetration tests were conducted without the F-400 packaging. Impact at the center of the lead pot caused no damage to the shielding integrity of the F-390 and the radioactive material (coloured water) was contained. An impact at the lid-body seam caused partial separation of the lid and some cracking of the lucite shield. The radioactive material (coloured water) was still contained in the vee-vial.

The F-400 transport package is well suited to safely transport the F-390 lead pot for Theraspheres.

6. CONCLUSIONS

The F-400/F-390 transport package prepared in accordance to the Preparation for Shipment procedures as outlined in reference 6 meets all requirements for Type A Packages.

7. REFERENCES

1. Transport Packaging of Radioactive Materials Regulations, Atomic Energy Control Act, SOR/83-740, 29 Sept, 1983.

2. Regulations for the Safe Transport of Radioactive Materials, 1985 Revised Edition (As Amended 1990), IAEA Safety Series No. 6, Vienna 1990.

3. Package Engineering Photographs binder.

4. Nordion Procedure IS/DS 0044 F400, Approved Contents for the F-400 Type 'A' Package.

5. Nordion Procedure IS/PP 0036 F400, Preparation for Shipment of the F-400 Type 'A' Package, revision B, March 1990

6. Nordion Procedure IS/PP 0036 F400, Preparation for Shipment of the F-400 Type 'A' Package, revision C, May 1991.

APPENDIX A

Test Procedures

THERASPHERE F-390/F-400 DROP TEST

Test Procedures

Testing is to be conducted using two (2) assembled F-400/F-390 Type 'A' transport containers. The contents of the two containers will be as follows:

Container 1

1. F-400 cardboard carton
2. Polystyrene insert (F-390)
3. F-390 lead pot
4. F-390 Lucite dose vial shield
5. Therasphere dose vial (0.3 ml vee-vial) half-filled with coloured liquid
6. Administration set
7. Two wraps of 1-1/2 in. (38 mm) wide fibre reinforced tape
8. 2 in. (50 mm) wide polyester tape on all edges and seams

Container 2

1. F-400 cardboard carton
2. Polystyrene insert (F-390)
3. F-390 lead pot
4. F-390 Lucite dose vial shield
5. Therasphere dose vial (0.3 ml vee-vial) half-filled with coloured liquid
6. Two wraps of 1-1/2 in. (38 mm) wide fibre reinforced tape
7. 2 in. (50 mm) wide polyester tape on all edges and seams

1.0 Water Spray Test

Subject both containers to water spray for a total of one hour (10 min. each side) at flow rate of at least 5 cm/hr in a 5 gallon pail. Record and photograph any areas of damage to the F-400 in particular to the bonding of the tape and the integrity of the seams on the cardboard carton.

2.0 9 m Drop Test

Container 1

Drop once from 9 m. Record and photograph areas of damage on external surfaces. Open container and photograph any damage to polystyrene insert, lead pot, or Lucite dose vial.

Container 2

Drop several times from 9 m. Attempt to have impact on side, top and corner. Open container and photograph any damage to polystyrene insert, lead pot, or Lucite dose vial.

3.0 Penetration Test

Container 1

1. Penetration test through opposite side from administration kit at level of lead pot lid. Open package and photograph any resulting damage.

2. Penetration test on F-390 lead pot without F-400 packaging at mid point of lead pot. Photograph damage to lead pot.

3. Penetration test on F-390 lead pot without F-400 packaging at level of lead pot lid. Photograph damage to lead pot. Remove and photograph Lucite dose vial shield.

Container 2

1. Penetration test through administration kit cavity at mid level of lead pot.

2. Impact at mid point of lead pot at level of dose vial through administration kit cavity. Open package and photograph any resulting damage.