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Safety Analysis Report for F430/GC-40 Transport Package

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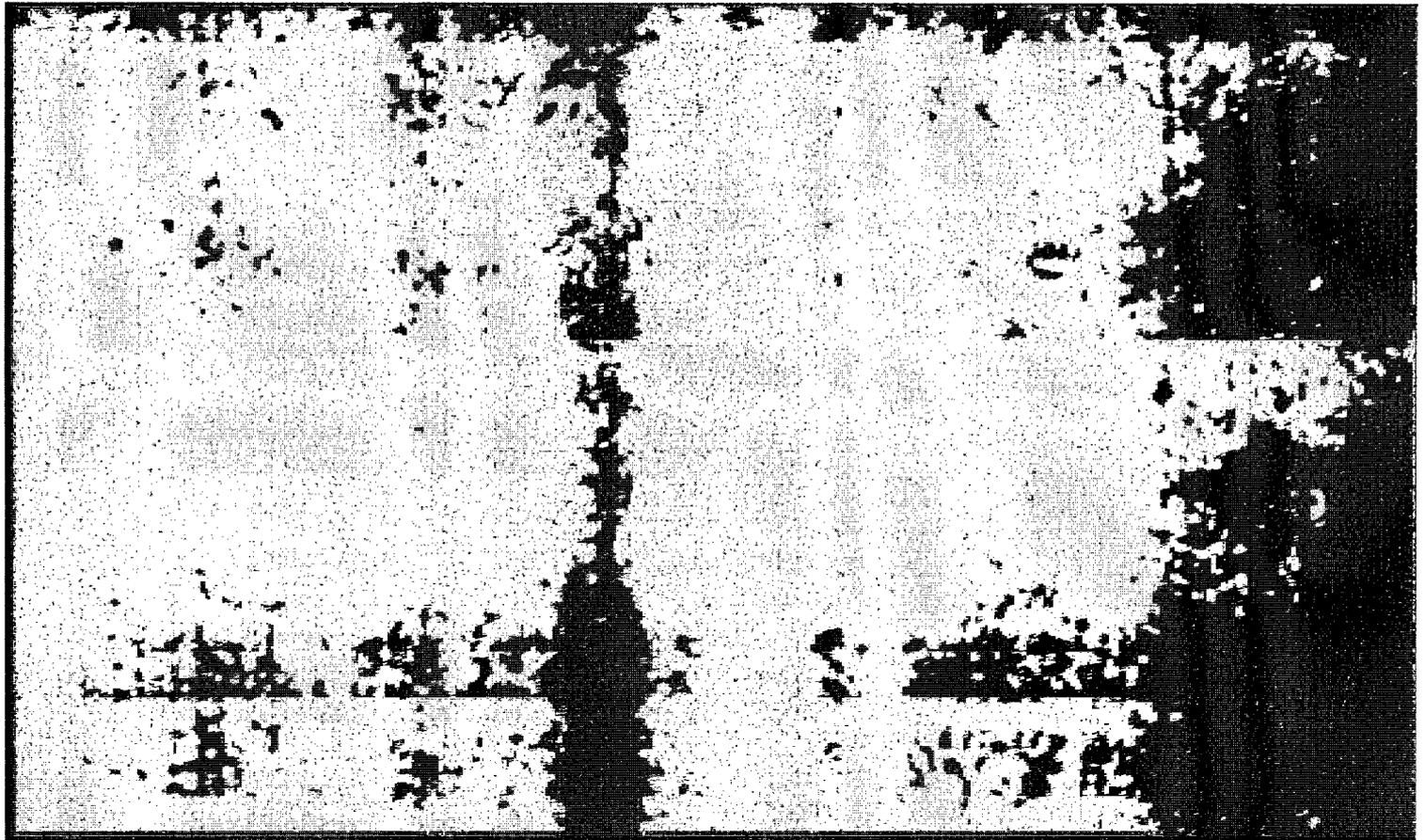
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NOTE: The portion of this text affected by changes is indicated by a vertical line in the margin.

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2.1.2.2 Miscellaneous Structural Failure Modes

2.1.2.2.1 Brittle Fracture

The Cs-137 source capsules, [REDACTED], are fabricated of type 304L or 304 austenitic stainless steel. Since austenitic stainless steel does not exhibit ductile-to-brittle transition in the temperature range of interest (down to -40°C), it is safe from brittle fracture.

The closure bolts [REDACTED]

[REDACTED]

2.1.2.2.2 Fatigue

Normal operating [REDACTED]

[REDACTED]

2.1.2.2.3 Buckling

[REDACTED]

2.2 WEIGHTS AND CENTERS OF GRAVITY

The total design weight of the MDS Nordion F-430 package, including a payload of 18kN (4000lb), is 31kN (7000lb). The container is nearly symmetrical, therefore, the center of gravity (cog.) is very near the geometric center of the container. The center of gravity (cog.) of F-430 package is 58cm (23") from top of the removable (shipping) skid, or 80cm (31.5") from the ground.

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2.3 MECHANICAL PROPERTIES OF MATERIALS

The MDS Nordion F-430 package is

[REDACTED]

Table 2.1: Mechanical Properties of Materials

Item	Materials	Min. UTS (Mpa)*	Min. YS (Mpa)*	Reference
1	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
2	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
3	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
4	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
5	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
6	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
7	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

* Properties at 23°C

**Compressive stress at 50% strain

The carbon steel material is ASTM A-36; this is not an ASME material, however it is acceptable for use as it is used for the removable shipping skid. Other material used in the package is neoprene used as a gasket for both covers. The purpose of

[REDACTED]

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e) Valves

There are no valves or pressure relief devices on the F-430 package.

f) Package Performance under Normal Conditions of Transport

See section 2.6 for demonstration of the package performance under normal conditions of transport it is demonstrated that:

- There would be no loss or dispersal of radioactive contents.
- There would be no significant increase in external radiation levels.
- There would be no substantial reduction in the effectiveness of the packaging.
- There would be no increase in external radiation levels in excess of 20%.

g) Temperature of Accessible Surface of the Package

In Appendix 3.7.1 it is demonstrated that the temperature of the accessible surface of the package, with the package loaded with 2000 Ci of Cs-137, and in still air at 38°C (100°F) and in the shade, is less than the 50°C (122°F) limit, for non-exclusive use shipment, and for shipment by air.

h) Features for Continuous Venting during Transport

There are no features on the F-430 package to allow for continuous venting during transport.

2.4.1 CHEMICAL AND GALVANIC REACTIONS

The [REDACTED]

[REDACTED]

[REDACTED]

2.4.2 POSITIVE CLOSURE

Closure of the components of the package is maintained using threaded fasteners at the following locations:

- Main cover is fixed to the main body [REDACTED].
- Inner cover is fixed to the main body [REDACTED].

A wire seal is incorporated into the cocoon closure to ensure that it cannot be inadvertently opened. The Preparation for Shipment Procedure is found in Chapter 7.

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3.2 TIE-DOWN COLLAR STRESSES

The highest stresses in the model occur in one of the tie-down collar lugs. Figures A2.10.3-4 and A2.10.3-5 show the stresses in the lug that is loaded with the tie-down chain with the highest load. In Figures A2.10.3-4 and A2.10.3-5, the maximum stress shown is 124,000 psi. However this high stress is the result of a singularity caused by the chain load being applied at a single point in the model. In order to analyze more accurately the stresses in this tie-down lug, a refined and more realistic model was created. In this case the load from the tie-down chain was applied over a 30° sector in the hole through the tie-down lug, as shown in Figure A2.10.3-6. The results of this analysis are shown in Figure A2.10.3-7. The maximum stress in the tie-down lug is [REDACTED]

Away from the tie-down lug discussed above, the maximum stress in the tie-down collar is [REDACTED]

[REDACTED] Figure A2.10.3-9 shows the stresses through the cross-section of the tie-down collar at this location.

The stress in the bolts that fasten together the two halves of the tie-down collar must also be considered. This stress will be calculated. It is assumed that only one bolt per side bears the entire load. Furthermore, the reduction in the bolt load due to the friction between the collar and the F-430 skin will be neglected.

The maximum load in the tie-down chains is 27,750 lb. The horizontal and vertical components of this force are 19,620 lb. each. Since the vertical component of the tie-down force is borne by the oblong bosses, the bolts are subjected mainly to tension.

$$\sigma = F/A$$

where

σ = stress in the bolt

F = the load in the bolt = 19,620 lb.

A = stress area of the bolt, based on the root dia. = 0.431 in.² (root dia. = 0.741 in.)

Therefore,

$$\sigma = 45,496 \text{ psi}$$

The bolts ([REDACTED])

Therefore, the Safety Factor for the bolts is

[REDACTED]

This analysis is very conservative since only one of the bolts was considered.

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5. CONCLUSIONS

The maximum stress in the body of the F-430 package is 17,920 psi when the package and its payload are subjected to the prescribed accelerations. This stress is safely below the minimum yield strength [REDACTED].

The maximum stress in the tie-down collar is 52,990 psi when the package and its payload are subjected to the prescribed accelerations. This is safely below the minimum yield strength of [REDACTED].

The maximum stress in the tie-down collar bolts is less than 45,496 psi when the package and its payload are subjected to the prescribed accelerations. This is safely below the minimum yield strength [REDACTED].

Therefore the tie-down system for the package satisfies the requirements of 10 CFR 71.45(b)(1).

6. REFERENCES FOR APPENDIX 2.10.3

- [1] 10 CFR (Code of Federal Regulations), Chapter 1, Part 71 - Packaging and Transportation of Radioactive Material, 1-1-99 Edition.
- [2] Pro/MECHANICA STRUCTURE Version 23.3(311), Parametric Technologies Corp. Waltham MA, 2001.

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7.3 LOADING THE GC40 INTO THE F430 AND PREPARING THE PACKAGE FOR SHIPMENT

The F430 overpack is designed to carry the upper or lower head of GC40 irradiator. Two F430 overpacks are required for the shipment of one complete GC40 irradiator. The packaging arrangement is shown in Figure 7.1.

To prepare the GC40, GC40E and GC40E+ in the F430 overpack, some special tools and equipment are necessary. A 15/16" socket is required to remove or install bolts securing the two overpack covers. To lift the GC40 lower head with its brace, two 5.5m long nylon endless slings, 1134kg minimum lift capacity each are required. Slings should choke the body of the GC40 lower head at the front and back (see Figure 7.2), and should be left in place inside the overpack.

7.3.1 LOADING PROCEDURE

1. Determine the level of non-fixed radioactive contamination by wiping an area on the external surface of the upper and lower head assemblies.

The level of non-fixed contamination shall be determined by wiping an area of 300 cm² of the external surface by hand with a dry filter paper or a wad of dry cotton wool or any other material of this nature. The maximum permissible level of removable contamination on the wipe is 0.4 Bq/cm² (10⁻⁵ μCi/cm²).

2. Ensure that the following steps are carried out on both the upper and lower heads of the GC40, GC40E or GC40E+.

[REDACTED]

[REDACTED]

[REDACTED]

3. Place internal steel brace over each head of GC40.
4. Put the internal fixing brace on the lower head, sling around both ends of the lower head cylinder, and place the lower head into the transport cavity of the container together with the brace (Figure 7.2). Position the lower head in the overpack body so as to align two corners of the square base of the GC40 against the protective pads at the bottom of the cavity. Leave slings inside the overpack and ship them with the unit.
5. Close cavity with internal cover and secure cover with [REDACTED]
[REDACTED]
6. Close the container with the main cover and secure it with [REDACTED]
[REDACTED]
7. Check the radiation fields on the external surface of the overpack and at 1m, to determine which of the Radioactive I or II or III Category labels is appropriate (see). The maximum field at the surface of the package must be less than 200 mrem/h. The maximum field 1m from the surface of the package must be less than 10 mrem/h.

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7.4 INSTRUCTIONS FOR SECURING THE PACKAGE ON ROAD VEHICLES

7.4.1 SECURING THE PACKAGE ON THE VEHICLE

1. The F430/GC40 transport package shall be positioned on the vehicle such that it is facing direction of travel, i.e. the skid legs are parallel to the direction of travel. Chocks shall be used at the base of the feet. These shall be firmly fastened to the bed of the vehicle.
2. Bracing, if applicable, shall be in accordance with local and national regulations.
3. If the package is tied down (rather than braced) the tie-down collar must be fitted on the F-430. The angle of the chain to the vertical should be between 40 and 50 degrees.
4. Tension the chains equally, to the point that each one is taut, with all visible sag removed.

The appropriate reference documents may be supplied to the carrier by the shipper, if not already in their possession. Other guidelines and regulations may apply in other jurisdictions.

7.4.2 ADDITIONAL INSTRUCTIONS

1. Any additional instructions with respect to the shipment as per Competent Authority Certificates of Compliance must be observed.
2. All applicable documents must be provided to the carrier or his agent.
3. Attach Radioactive Placards to the vehicle. Transport vehicles and freight containers carrying radioactive material transport packages must display placards in accordance with the applicable transport regulations. In case of road transport within North America, the trailer of the transport vehicle must display placards on both sides, and front and rear, indicating that it carries radioactive materials.
In Canada, the transport vehicle must be placarded on all four sides when Radioactive I (white), or Radioactive II (yellow), or Radioactive III (yellow) packages are transported.
In USA, the transport vehicle must be placarded on all four sides only when Radioactive III (yellow) labelled packages are transported.

7.5 PROCEDURES FOR UNLOADING THE F430/GC40 PACKAGE

7.5.1 RECEIPT OF F430/GC40 TRANSPORT PACKAGE

1. Visually inspect the F430/GC40 transport package for damage and deterioration. Damage and deterioration, if any, are designated as either superficial or integrity-related. Immediately contact MDS Nordion's Package Engineering regarding any damage or deterioration that may affect the integrity of the package.
2. Check and verify that the tamper-proof seal is intact. If the tamper-proof seal is not intact, contact the RSO at the customer's site or MDS Nordion for further disposition.
3. Ensure that any damage or deterioration is properly documented.