REVISS

REVISS SERVICES (UK) LTD

UK TYPE B(U) DESIGN APPROVAL APPLICATION

FOR THE R7021 TRANSPORT CONTAINER

Prepared by:

....Date: 16/09/2010

Reviewed by:

....Date: 17/09/10

Quality Representative:

....Date: 17/09/2010

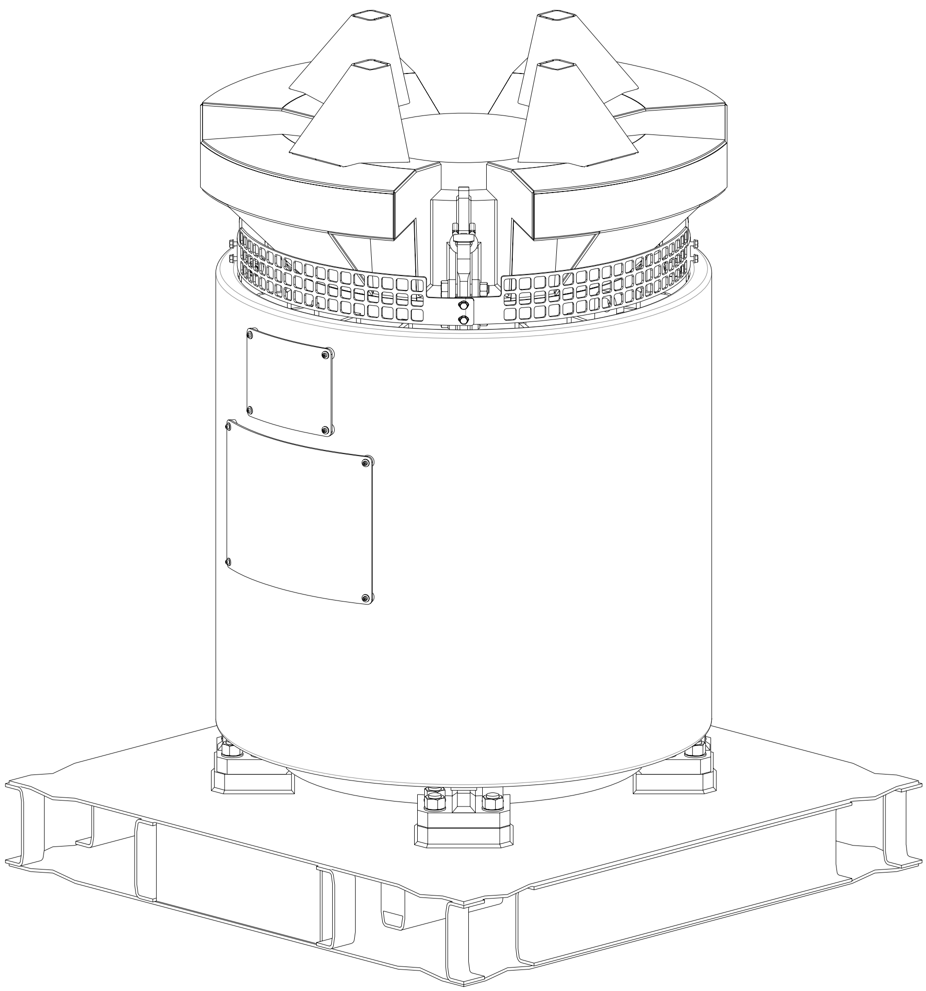
Packaging, Transport & Regulatory Mgr:

....Date: 17/09/2010

DESCRIPTION

The R7021 transport container is designed for shipping the nuclide cobalt-60 which is used for the sterilisation of medical, food and blood products. The radioactive material is normally contained within welded, stainless steel capsules that meet the IAEA requirements for Special Form radioactive material however the flask has its own containment system that is not dependent on the nature of the contents. The R7021 transport container conforms to the criteria for Type B(U) packaging as specified in TS-R-1.

Shielding is provided by lead with a radial thickness of 265mm. The flask is a stainless steel fabrication with a shielded closure at the top. The flask is protected by a carbon steel pallet, jacket and top shield incorporating shock absorbing features and thermal insulation.



R7021 Transport Container

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INTRODUCTION

INTRODUCTION

This application is in accordance with Part II of the 'Guide to an Application for UK Competent Authority Approval of Radioactive Materials Transport (IAEA 1996 Regulations), " Package Design Approval" (DETR/RMTD/0003 issue 1 - January 2001) produced by the UK Department of Environment, Transport and the Regions. These guidelines are written in compliance with the IAEA TS-R-1, (ST-1 Revised) - Regulations for the Safe Transport of Radioactive Materials 1996 Edition, (Revised Standard). Numbering follows the Guide.

SECTION 1 - ADMINISTRATIVE INFORMATION

1.1 PACKAGE TITLE

R7021.

1.2 ADDRESSES

1.2.1 Applicant

REVISS Services (UK) Ltd
6, Chiltern Court
Asheridge Road,
Chesham,
Buckinghamshire HP5 2PX

1.2.2 Designer

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1.2.3 Manufacturer (principal contractor for each package).

The prototype 3981/01 was manufactured by Colston Engineering Ltd. together with a spare pallet and top shield, 3981/02. A batch of ten packages, 3981/03-12, is currently being manufactured by the same manufacturer.

1.3 STATE THE LOCATION OF THE PACKAGE DURING MANUFACTURE

At manufacturer's premises in Chippenham, Wilts.

1.4 STATE TYPE OF APPROVAL REQUIRED:-

Type B(U).

1.5 MODES OF TRANSPORT

All modes.

1.6 STATE THE COMPETENT AUTHORITY MARK

GB/3981A/B(U)-96.

1.7 SPECIFY THE APPLICABLE QUALITY ASSURANCE PROGRAMMES

The design, manufacture, testing, use, maintenance and inspection of all transport packages is controlled through the REVISS Services Quality System which meets the requirements of the current edition of BS EN ISO9001

The REVISS Services Quality Manual defines the policy of REVISS Services with respect to quality assurance and regulatory compliance and outlines or references the system & operational procedures by which this policy is implemented.

1.8 SERIAL NUMBER NOTIFICATION

The applicant will advise the Transport Radiological Advisor of all serial numbers issued for manufacture by email.

1.9 DATE APPROVAL REQUIRED

September 2010.

1.10 DATE OF APPLICATION

Jan 2010.

SECTION 2 - SPECIFICATION OF RADIOACTIVE CONTENTS

2.1 GENERAL NATURE OF CONTENTS

Encapsulated irradiation sources as Special Form or non-Special Form material. For full specification of the permitted contents see OP 381.

2.2 DETAILS OF CONTENTS

2.2.1 Radionuclide	2.2.2 Physical state	2.2.3 Chemical composition	2.2.4 Quantity (g)	2.2.5 Maximum activity (Bq)
^{60}Co	Solid (non-SF)	Metal	141	5.92 PBq *1
^{60}Co	Solid (SF)	Metal	176	7.40 PBq *1
^{137}Cs	Solid (SF)	Chloride	2295	7.40 PBq *2

*1: Limited to 1.2 PBq for air transport (see also Section 3.5, OP381).
*2: Limited to 6.0 PBq for air transport (see also Section 3.5, OP381).

2.3 A_1 AND A_2 VALUES

Listed in TS-R-1.

2.4 NATURE OF RADIATION EMITTED

Beta and gamma.

2.5 EFFECT OF MATERIALS PRESENT ON RADIATION EMITTED

The effect of the materials present, stainless steel and lead, is to attenuate the emitted radiation only.

2.6 DAUGHTER PRODUCT HAZARD

None.

2.7 IRRADIATED NUCLEAR FUEL

Not applicable. Irradiated fuel is not carried.

2.8 MAXIMUM HEAT LOAD

Radionuclide	Maximum activity (para 2.2)	Heat load	
		Heating rate (see RTM 025)	Maximum heat load (watts)
^{60}Co	5.92 PBq	416 mW/TBq	2,460
^{60}Co	7.40 PBq	416 mW/TBq	3,075

Radionuclide	Maximum activity (para 2.2)	Heat load	
		Heating rate (see RTM 025)	**Maximum heat load (watts)**
^{137}Cs	7.40 PBq	131 mW/TBq	969

2.9 EFFECT OF 'NORMAL' AND 'ACCIDENT' CONDITIONS OF TRANSPORT ON THE CONTENTS

Special Form material: The containment afforded by such material will not be lost or reduced by normal or accident conditions of transport. Package drop testing included a simulation of the contents but not their containment system. Contents performance is assessed instead by comparing Special Form test requirements against the environment inside the package under accident conditions of transport (normal conditions are ignored as they are less demanding).

Test	Package	Special Form
Drop I	9m drop onto an unyielding surface, any orientation.	9m drop onto an unyielding surface, any orientation.
Assessment	Although the requirements are essentially the same the flask contents benefit from shock absorption afforded by the pallet, jacket and top shield. These are deformable structures incorporating shock absorption components which provide protection for the flask. Whilst it is difficult to accurately quantify the consequent reduction in impact forces it is evident that the unprotected impact demanded of Special Form material represents the extreme situation. Impact inside the flask will only be less demanding.	
Drop II	1m drop onto 15 cm diameter puncture, any orientation.	25mm diameter, 1.4 kg bar dropped 1m, any orientation.
Assessment	The contents are fully protected by the package. Drop testing demonstrated that, although the puncture was able to penetrate the outer cladding of the pallet, jacket and top shield, there was no significant flask damage (see 5.1.4).	
Thermal test	800°C environment for 30 mins.	800°C environment for 10 mins.
Assessment	The thermal protection afforded by the package ensures that the contents temperature does not exceed 437°C (see 5.1.4). Although the time at temperature is more than 10 mins the nature of Special Form encapsulation (316L stainless steel for these type of sources), regardless of the inert gas flask backfill (see OP 381), is such that they are able to endure almost continuous temperatures of this magnitude.	

Non-Special Form material: Such material must be encapsulated (see OP 381). Although the package affords considerable protection to the contents it is not possible to demonstrate that the encapsulation would survive accident conditions of transport without leakage (hence the leak testing requirement prior to shipment (OP 381).

2.10 OTHER HAZARDS

The contents have no non-radioactive hazards.

SECTION 3 - SPECIFICATION OF THE PACKAGING

3.1 SPECIFICATION

3.1.1 Design specification

The R7021 is designed to ship Co^{60} sources to and from irradiation plant. It may also be used to ship Cs^{137} sources. The R7021 is designed to comply with all current and anticipated international regulations.

The outer components of the R7021, a cylindrical, insulated jacket, a top shield (with energy absorbing structures and insulation), and a pallet, are constructed predominantly from carbon steel. There is also a stainless steel grill around the top of the jacket to restrict access to hot surfaces. The flask is a stainless steel, lead shielded, upright, finned cylinder with a conventional plug type closure in the top and thermal insulation built into its top and bottom corners. The closure has a vent point and the cavity has a drain tube to allow the flask to be operated in ponds as well as in cells. The cylindrical cavity holds encapsulated radioactive material in a basket. Although primarily intended to carry Special Form capsules, the flask has a containment system as it may also be used to carry non-Special Form encapsulated material. The closure and the vent and drain plugs are therefore equipped with testable O-ring seals. In addition, to prevent the migration of particulate material past the shielding, the top of the drain tube is fitted with a mesh filter and a spring gasket is used to seal the gap under the closure around the top of the cavity.

The purpose of the R7021 is to provide robust, readily handled and maintained, cell or pond-operable transport for bulk Co^{60} and Cs^{137}. The design satisfies these requirements.

3.1.2 Document reference list

All documents and drawings referenced in this application are listed in Appendix A and are attached to this application. All published documents referenced are listed in Appendix B.

3.2 PACKAGING MAKE UP

3.2.1 Components

Item	Description	Drawing number	Overall dimensions (mm)	Weight (kg)	No. per assy.
Package	Assembly	R7021/001	1260 x 1260 x 1670	4600	1
Inner	Flask	R7021/002	960 x 960 x 1160	3564	1
	Closure	R7021/003	ϕ416 x 322	163	1
Innermost	Basket *	Various	ϕ150 x 476 max	25max	1
	Capsules *		Various		Various

* See OP 381 for more details.

3.2.2 Packaging weight

4575 kg (max).

3.2.3 Maximum gross weight (including contents)

4600 kg.

3.2.4 Design life

The R7021 design life is a nominal 50 years. The flask is stainless steel and the pallet, jacket and top shield are carbon steel. Carbon steel surfaces are protected either by a paint system or galvanising and are regularly inspected and made good. Fixings are either stainless steel or cadmium plated carbon steel and are regularly inspected and replaced as necessary.

Note: All components are inspected before each use (see OP 381) and are replaced when necessary. The criterion for replacement is based solely on the condition of the item, not on any notional design life.

3.3 DRAWINGS

3.3.1 Design drawings

See drawing list, QS 7021.

3.3.2 Package illustration

This is provided as a separate Word file.

3.4 SECURITY SEAL

Padlocks provide evidence that the assembly has not been opened or tampered with in transport (see OP 381).

SECTION 4 - TRANSPORT OPERATIONS

4.1 HANDLING

4.1.1 Handling attachments

The flask has four lifting eyes which are used to lift the assembly. The top shield has two lifting shackles which are disabled for transport (see OP 381). The jacket lifting eyes are not accessible in transport.

4.1.2 Special lifting equipment

No special lifting equipment is required.

4.1.3 Strength of lifting attachments in normal and overload conditions

RTM 123 shows the strength of the lifting points to be adequate in normal use and that the package performance remains unaffected under overload conditions.

4.1.4 Analytical evaluation

RTM 123 analyses the strength of the various structural elements under lifting loads and demonstrates an acceptable minimum factor of safety over the maximum allowable stress in package lifting operations (see also 4.1.9 below).

4.1.5 Criteria used

- Stress levels shall not exceed yield when:
  - The package is at its maximum normal operating temperature.
  - The package is at its maximum gross weight.
  - The maximum safety factor is applied.
- The ability of the design to comply with the Type B test requirements shall not be impaired should the lifting points be overloaded to failure.

4.1.6 Fatigue Loading

Fatigue failure from lifting is not credible during the R7021 design life (see RTM 123).

4.1.7 Simplifications made

- Loads spread over four lifting points are taken on two opposite points only.
- Maximum included angle of slings is 90°.

4.1.8 Other external features

There are no other features that could be used for lifting.

4.1.9 Verifiable evidence

The maximum stresses and minimum factors of safety of the components in the lifting load path are summarised below (see also RTM 123):

Component	Maximum Stress (N/mm^2)	Design Stress (N/mm^2)	Safety Factor
Flask lifting eyes (bearing)	134	178	1.33
Flask lifting eyes (pull-out)	50.5	103	1.44
Flask lifting fin welds	25.1	81.4	2.31

Note: All lifting points are proof tested at manufacture.

4.2 TIE-DOWN SYSTEM

4.2.1 Tie-down points

The lifting eyes are used for tie-down.

4.2.2 Tie-down system

The general tie-down system consists of chocking and securing from the lifting eyes (see also Figure 2, RTM 122).

4.2.3 Tie-down loading conditions

The worst case loading condition is taken to be the simultaneous application of the static loads generated by the maximum IAEA acceleration in each of the three principle axis.

4.2.4 Applied accelerations

The accelerations used are 5g (longitudinal), 2g (lateral) & 2g (vertical, not allowing for gravity) as these give the maximum resultant of any mode of transport specified in Table IV.1, TS-G-1.1, when applied simultaneously.

4.2.5 Analytical criteria

- No component stress shall exceed yield at the component maximum normal operating temperature when the assembly is subjected simultaneously to static loads representing the acceleration factors in each axis.
- The ability of the design to comply with the requirements specified in TS-R-1 for Type B(U) packaging shall not be impaired should the tie-down points be overloaded to failure.

4.2.6 Analytical simplifications

- Loads spread over more than one component are equally distributed.
- Tie-down members are aligned with the axis of the attachment point.
- The pallet is chocked.
- The contribution from friction between components clamped together is ignored.
- Upward accelerations are ignored, as the load path is straight through the pallet into the flask.

4.2.7 Strength of tie down points in normal and overload conditions

RTM 122 shows that, in the event of overload, the tie-down eyes would fail first. This would not impair the ability of the design to meet all other Type B(U) requirements.

4.2.8 Fatigue

i) Lifting

RTM 123 shows that the R7021 is not at risk from fatigue failure during its anticipated design life. In addition the scheduled inspection, OP 381, requires all lifting points to be inspected visually for freedom from cracks.

ii) Tie down

RTM 122 shows that the R7021 is not at risk from fatigue failure during its anticipated design life. In addition the scheduled inspection, OP 381, requires all tie-down points to be inspected visually for freedom from cracks.

iii) Fasteners

RTM 119 shows that the R7021 fasteners are not at risk from fatigue failure during its anticipated design life. In addition the scheduled inspection, OP 381, requires all fasteners to be inspected visually for freedom from cracks.

iv) Cyclic thermal loading

RTM 119 shows that the R7021 is not at risk from fatigue failure due to cyclic thermal loading during its anticipated design life.

4.2.9 Verifiable evidence

Structural Element	Design Strength (N/mm^2)	Stress Type	Maximum Stress (N/mm^2)	Safety Factor
Tie-down eyes	178	bearing	130	1.37
	103	shear	25.9	1.80
Fin welds	103	shear	24.3	3.98
Pallet-to-pad welds	214	shear	20.5	10.4
Flask-to-pallet studs	335	shear	54.1	6.19
Flask feet welds	103	shear	11.8	8.73
Minimum Safety Factor				1.37

4.3 STOWAGE PROVISIONS

4.3.1 Surface heat flux

Envelope dimensions (l x b x h) = 1.26 x 1.26 x 1.67 m
Surface area (sides and top) = 10.0 m^2
Heat load = 3075 W (see 2.8)
Surface heat flux = 3075/10.0 = 308 W/m^2

4.3.2 Special stowage instructions

The package shall not be oversheeted (see OP 381) when loaded.

4.4 ACTION REQUIRED BY THE CONSIGNOR BEFORE EACH SHIPMENT

None.

4.4.1 Packing instructions

See OP 381, Sections 5, 6 & 7 (loaded) or Sections 8 & 9 (empty).

4.4.2 Thermal equilibrium

The package may be shipped before equilibration is attained though it is unlikely given the typical time taken to prepare it for shipment. From a cold start the flask will take approximately twelve hours to warm to within 90% of its equilibrium operating temperature. Further equilibration is minor and takes place over the following twelve hours.

4.5 ACTION REQUIRED DURING SHIPMENT

None, except as detailed in 4.3.2 above.

4.6 EMERGENCY INSTRUCTIONS

Before shipment a suitable emergency plan should have been drawn up by the consignor (see section 7.3, OP 381). In the event of an accident, or other emergency, the plan must be activated. Otherwise the appropriate emergency services must be notified.

REVISS Services subscribes to RADSAFE or an equivalent scheme.

4.7 EXCLUSIVE USE CONDITIONS

Required for contents exceeding 2.08 PBq Co^{60} (see RTM 120 and Section 2.08, OP 381).

SECTION 5 – TESTING

5.1 REGULATORY COMPLIANCE TESTING

5.1.1 Evidence for compliance

The evidence for compliance with the regulatory test requirements is by means of stress analysis, mechanical testing, leak testing, shielding testing, measurements, finite element impact analysis, thermal testing and CFD thermal analysis.

Drop Testing

The R7021 prototype, 3981/01, was subjected to a programme of 17 drop tests. The first sequence, normal conditions consisted of three 0.9m free drop and one penetration test followed by inspection, leaktesting and strip down. The second sequence, accident conditions, consisted of four sets of one 1m puncture test, one 9m free drop test and one 1m puncture test each set testing a particular orientation identified in the test plan, RTM 118. One additional puncture test was included at the end to test a particular orientation not previously identified. The testing was again followed by inspection, leaktesting and strip down. All tests were conducted at ambient temperature. Throughout the testing all components and fixings remained intact and secure. After testing the flask displayed no significant reduction in shielding efficiency (see RTM 124) and no loss of containment (see RTM 126) other than the drain tube outer weld which failed in tension. The only other concern was the proximity of top shield deformation to the vent plug and jacket deformation to the drain plug.

Modifications to the original design made purely for testing purposes were captured in the manufacturing drawings specified in QS7021 issue 2. The significant changes were as follows:

- A reduced strength grade material was used for the closure studs and nuts (see also RTM 118), to allow for their temperature and the maximum internal pressure.
- The contents were represented by solid stainless steel bars in a typical basket, to represent a full load of R2089 cobalt sources.
- The flask had a connection to the shielding space, to facilitate leaktesting.
- The flask closure had an extra connection to the cavity space, to facilitate leaktesting.
- The closure had two plates added to increase its weight, to compensate for being manufactured slightly short and consequently under the design weight.
- The four label plates were omitted from the jacket, to ensure they did not interfere with the performance.
- The pallet, jacket and top shield were painted in a primer only, to facilitate photography.

Modifications to the design made during testing were as follows:

- After normal conditions testing it was observed that the weld between the flask top flange and the side wall of the closure counterbore had started to fail, indicating poor fusion. The weld was machined out, remade and leaktested before commencing accident conditions testing.
- The pallet and top shield and their fixings were replaced after Drop 10 when there was a risk of previous damage interfering with the remaining tests.

All modifications are detailed in the inspection and test reports.

Other than as detailed above the specimen was not dismantled, repaired or modified during the test programme.

Before and after drop testing the shielding efficiency was surveyed, the length of the closure studs was measured and the containment system was leak tested. The results demonstrated that shielding efficiency was not significantly affected, the closure fixings displayed no evidence of plastic strain and the containment boundary (with the exception of the outer drain tube weld) and O-ring seals remained helium leaktight.

Design Development

Subsequent to the mechanical testing a number of modifications were made to improve performance and consistency (see RTM 151 for full details). The new design was then finite element modelled to demonstrate its impact performance (after benchmarking the model against the entire test programme and conducting an orientation analysis). The modifications, other than reversing the temporary changes detailed above, were as follows:

- Flask:
  - The weld between the flask top flange and the side wall of the closure counterbore was redesigned, to strengthen it and to facilitate through wall NDT.
  - All other key welds in the containment boundary were redesigned, to facilitate through wall NDT.
  - The drain tube was sleeved, to introduce a gap between it and the lead shielding (the weld at the outer end of the tube having failed due to lead movement).
  - The drain plug was recessed into the drain point, to reduce its proximity to jacket deformation from the puncture test.
  - Permanent connections points were added, to enable routine leaktesting of the containment boundary.
- Closure:
  - Key welds in the containment boundary were redesigned, to facilitate through wall NDT.
  - A permanent connection point was added, to enable routine leaktesting of the containment boundary.
- Pallet:
  - The welds in the channels under the flask feet were moved and redesigned, to take them out of the major stress zones, to facilitate manufacture and to improve consistency and energy absorption in side drops.
  - The stiffening plates in the channels under the flask feet were joined together, to increase their effect and increase energy absorption in upright drops.
  - The shallow transverse grooves in the top and bottom plates were repeated longitudinally, to ensure similar performance in either axis in side drops.
  - The dowels were changed from stainless to high tensile carbon steel, the thread diameter was increased and their register deepened, to improve shear protection for the flask fixings in side drops.
- Jacket:
  - Reinforcement was added in front of the drain plug, to reduce puncture deformation.

- Top shield:
    - The diameter was increased slightly, the cladding welds were increased to full thickness and the inner plate welds changed to continuous double sided fillets, to reduce the degree of weld failure, to increase energy absorption and to improve consistency in inverted and side drops.
    - An additional central upper plate was added, to reduce puncture deformation.
    - The height of the cones was increased slightly, to improve energy absorption in inverted drops
- All:
    - Minimum material properties, based on test data from the prototype, were introduced for all carbon and stainless steel structural components, to ensure performance consistent with the prototype.

5.1.2 Target

The target was a 50mm thick carbon steel plate anchored to a cuboid, reinforced concrete block total weight 113,000 kg (drawing R8085/001). The plate thickness was 8 times the wall thickness of the top shield, jacket and pallet, and 5 times the wall thickness of the flask, on the basis that, being any thicker it could not cause any more damage to the package (see also RTM 118). It complied fully with the recommendations of TS-G-1.1, para 717.1 & 2 exceeding the weight of the specimen by a factor of 25.

5.1.3 Justification - 'normal conditions of transport'

The test plan, RTM 118, discusses the prototype package design, conducts a failure mode analysis and justifies and details the test programme and pass criteria. The subsequent modifications (see above) only serve to improve performance and consistency.

Water spray test

The water spray test was not performed. All the materials used in the construction of the R7021 are unaffected by water.

1.2m free drop test

3981/01 was dropped 1.2m upright, vertical inverted and on its side (see test reports RTR 233, 234 & 235). The only damage was minor deformation of the pallet and top shield (see inspection report IR 0673). None of the subsequent modifications could affect this result..

Stacking test

The load path and stresses from the stacking load have been analysed (see RTM 127) and demonstrate the R7021 is capable of supporting the compression load specified in TS-R-1, para 723, with a minimum factor of safety of 7.6.

1m penetration test

3981/01 was subjected to a single penetration test aimed at the jacket immediately over the drain plug (see test report RTR 236). Damage was limited to a mark on the paint. None of the subsequent modifications could affect this result.

9m free drop test

Not applicable. The R7021 is designed to transport solid radioactive materials only.

1.7m penetration test

Not applicable. The R7021 is designed to transport solid radioactive materials only.

5.1.4 Justification - 'accident conditions of transport'

The test plan, RTM 118, discusses the prototype package design, conducts a failure mode analysis and justifies and details the test programme and pass criteria. The finite element analysis (see AMEC report C15788/TR/0001, modelled the prototype design through the entire test programme to benchmark the model and the underlying assumptions and material properties before the new design could be modelled.

Drop I (9m free drop test)

3981/01 was subjected to the free drop test in four different attitudes (see test reports RTR 240, 243, 246 & 249 and inspection report IR 0675) each test being preceded and followed by a 1m puncture test. In the first test (upright) the pallet was crushed. In the second test (inverted) the top shield cones were crushed. In the third test (angled inverted) the cones and one of the top shield quadrants suffered varying degrees of deformation. In the fourth test (side horizontal) the pallet, top shield and jacket all suffered deformation and some of the flask fins were distorted at the top. Throughout the testing all components and fixings remained intact and secure and there was no evidence for any cause for concern. Dismantling and inspection took place after Drop II testing. Model benchmarking in the subsequent finite element analysis produced the following conclusions:

- Modelled deformations closely matched the recorded results.
- Modelled velocity curves and decelerations closely matched those derived from high speed video footage of the tests (see RTM 130).
- The lead shielding was capable of a little over a millimetre of movement due to the gap caused by differential contraction after it was cast into the flask body. This was confirmed by ultrasound gap measurements on the prototype (see Caparo report REV/011/0609 UT).
- Failure of the outer drain tube weld was clearly indicated in the side impact (Drop 15) when it was subjected to a tensile load by shielding movement and the accumulated true strain in that area exceeded 70%. The direction of weld failure was confirmed by electron microscope inspection of the failed faces (see Caparo report L91805).
- A small degree of weld failures in the pallet and top shield gave their performance a potential for variability which would better minimised, i.e. by ensuring energy was absorbed by deformation rather than tearing.
- The pallet needed longitudinal deformation initiating grooves like the lateral grooves if it was to perform similarly in a drop on the side rather than on an end face.
- The pallet dowels needed to be strengthened if they were to protect the flask fixings from shear loads when friction was omitted (though the prototype dowels performed as intended).

When the design was modified (see 5.1.1) the finite element model was updated and an orientation analysis conducted. The model was then analysed in the four original test orientations plus an additional three identified also identified as worst case. The analysis demonstrates that in any orientation:

- There is no risk of the pallet, jacket or top shield becoming detached.
- Stresses in the containment boundary, including the drain tube, remained within acceptable limits.
- Stresses in the closure fixings remained within acceptable limits.
- Energy absorption in all orientations is slightly improved and consistency has been enhanced by minimising weld tearing.

Drop II (1m puncture test)

3981/01 was subjected to the puncture test in four orientations before, and five orientations after, the 9m drop tests (see test reports RTR 240, 241, 242, 244, 245, 247, 248, 250 & 251 and inspection report IR 0675). Damage was restricted to penetration of the pallet base plate and deformation of the top plate, penetration of the top shield centre plate and deformation of internal plates, local deformation of the jacket top ring and adjacent fixing and penetration of one or both jacket plates (depending on impact angle).

Throughout the testing all components and fixings remained intact and secure. After testing the flask displayed no significant reduction in shielding efficiency (see RTM 124) and no loss of containment (see RTM 126) other than the drain tube weld failure mentioned earlier. The only evidence for any cause for concern was the proximity of top shield deformation to the vent plug and the jacket deformation to the drain plug.

When the design was modified (see 5.1.1) the updated finite element model was analysed in these two orientations. The analysis demonstrates that there is no risk of the punch impacting either the vent or drain plug.

Drop III (dynamic crush test)

Not applicable. The assembly weight exceeds 500 kg.

Thermal test

The performance of the R7021 in the thermal test has been modelled by finite element computational fluid dynamics analysis (see RTM 120). The results show that the R7021 meets all of its design criteria:

Key Aspects	Criteria	Performance
O-Ring temperature	270°C	262°C
Lead temperature	327°C	302°C
Capsule temperature	800°C	471°C

15m immersion test

The maximum stress in the flask at this depth is the hoop stress in the outer wall, 5.28 N/mm^2 (see RTM 119), representing 4.3% of the maximum design stress.

The flask has an O-ring containment system which will readily resist the 1.5 bar water pressure and keep the contents dry. In the event of the contents being Special Form material there is no requirement to test the O-rings at despatch and therefore the possibility exists that they might not be leaktight. In this event there are two issues:

- Internal pressure from steam generation: In the event of the contents generating sufficient heat to turn incoming water into steam an internal pressure would arise. This would however be self-limiting. As soon as the pressure inside equalled the external pressure water ingress would lose its driving pressure differential.

- Effect of water/steam on the contents: Special Form contents would not be affected by 1.5 bar pressure water or steam.

200m immersion test

Not applicable. The R7021 is not designed to carry irradiated nuclear fuel.

Water leakage test

Not applicable. The R7021 is not designed to carry fissile radioactive materials.

5.2 PERFORMANCE TESTS BEFORE FIRST SHIPMENT

See also 7.2.1, performance tests during manufacture and construction.

5.2.1 Containment system

- Special Form material: As specified by the individual capsule design (see also Section 6.3).
- O-ring seals: The three flask seals are leak tested to 2.6 x 10^{-7} atm.cc/s at manufacture (see drawing R7021/001).
- The containment boundary is helium leak tested to 2.6 x 10^{-7} atm.cc/s at manufacture (see drawings R7021/002 & 003).

5.2.2 Radiation shield

The radiation shield is surveyed at manufacture (see drawing R7021/001) in accordance with OP 214.

5.2.3 Thermal shield

The pallet, jacket and top shield, and the thermal insulation built into the flask, provide thermal shielding. The materials of construction, form and presence are verified by physical inspection during manufacture.

5.2.4 Heat dissipation characteristics

The flask fins promote heat dissipation. Their form and presence is verified by physical inspection during manufacture. Their performance is verified at manufacture (see drawing R7021/001) in accordance with OP 219.

5.2.5 The Confinement System (see Part III)

Not Applicable.

5.2.6 Presence of Neutron Poisons (see Part III)

Not Applicable.

SECTION 6 - DESIGN

6.1 STRUCTURAL EVALUATION

i) Analytical structural evaluation.

- Lifting - see Section 4.1.
- Tie down - see Section 4.2.
- Fatigue and thermal cycling - see Section 4.2.8.
- Pressurisation - see Section 6.6.1.

ii) Impact evaluation criteria - see Section 6.7.

iii) Computer analysis - see Section 6.7.

iv) The centre of gravity of the R7021 is 0.756m above the base (see drawing R7021/001).

6.2 RADIATION SHIELDING

i) Design intent, including design criteria.

- The maximum dose level at the surface of the package shall not exceed 2.0 mSv/h.
- The maximum dose level at 1m from the surface of the package shall not exceed 100 μSv/h.
- The maximum dose level at the surface of the package shall not increase by more than 20% after normal conditions tests.
- The maximum dose level at 1m from the package after accident conditions tests shall not exceed 10 mSv/h.
- The maximum lead temperature during accident conditions of transport shall not exceed 327°C.
- The drain filter and spring gasket shall not allow particles greater than 0.1mm in diameter to pass through after either normal or accident conditions of transport.
- Stresses in the spring gasket shall not exceed the design strength (yield) at maximum accident conditions temperature.
- Closure load from the spring gasket shall not exceed 10% of closure weight.

ii) Evaluation - see RTM 124.

iii) Simplifications - see RTM 124.

iv) Degradation in post-test conditions - The design is not at risk from degradation in post-test conditions by virtue of its all-metal construction and its condition after mechanical testing.

v) Verification
The shielding efficiency of the test specimen was surveyed prior to and following mechanical testing and found not to be significantly changed (see RTM 124).

6.2.1 Position and size of the source

The contents are carried in individual locations in the basket within the flask cavity (see also OP 381.

6.2.2 Shielding material and thickness

Radially the flask has 265 mm of lead (see RTM 124). Additional shielding is provided by the stainless steel of the flask structure and the carbon steel of the pallet, jacket and top shield.

6.2.3 Melting point of shielding materials

Material	Melting Point (ºC)	Reference
Lead	327	Metals Handbook
Stainless steel	1,375	Metals Handbook

6.2.4 Radiation levels at maximum activity loading

a) Seal Positions:

Surface	Radiation Levels (from RTM 124) (mSv/h)
Closure	3.98
Vent plug	3.98
Drain plug	4.53

b) Package surface:

Surface	Radiation Levels (from RTM 124) (mSv/h)
Side	1.27
Top	1.02
Bottom	0.86
Regulatory limit	2.0

c) At 1m from package surface:

Surface	Radiation Levels (from RTM 124) (µSv/h)
Side	73.6
Top	82.5
Bottom	49.0
Regulatory limit	100

6.2.5 Security of radiation shield

There is one removable shielding component, the closure, which is retained by eight M20 studs. These are independent of any other packaging structure and cannot be opened unintentionally or by pressure within the flask.

There are two other components that have a shielding function, both for non-Special Form contents only, by restricting the migration of active material. The drain filter protects the drain tube and the filter gasket the gap up the side of the closure. These also are independent of any other packaging structure and cannot be opened unintentionally or by pressure within the flask.

6.2.6 Radiation levels following 'normal conditions of transport' testing

Normal conditions of transport mechanical testing resulted only in superficial damage to the pallet and top shield (see Section 5.1.2). Radiation levels were not significantly affected by accident conditions tests so may be assumed to be unaffected by normal conditions. The drain filter and filter gasket remained undamaged and securely located.

6.2.7 Radiation levels following 'accident conditions of transport' testing

Accident conditions mechanical testing resulted only in the deformation of non-shielding related components (see Section 5.1.3). Shielding surveys performed prior to and following the mechanical tests (see RTM 124) demonstrated that shielding efficiency was unaffected. Measurement on the closure fixings before and after testing confirmed the absence of plastic deformation. Both the drain filter and filter gasket remained undamaged and securely located.

6.2.8 Post Accident Radiation Levels Met for Type C Packages

Not Applicable

6.3 CONTAINMENT SYSTEM

- When transporting Special Form material the containment system is the nature of the contents as defined in TS-R-1.
- When transporting non-Special Form material the containment system comprises the flask and closure inner surfaces, the closure fixings, the vent and drain plugs and the three inner O-ring seals (see RTM 126 for an illustration).

Flask Containment System Components		
Item	Drg. No.	Item Nos.
Closure nuts	R7021/001	20
Closure O-Ring	R7021/001	28
Vent Plug O-Ring	R7021/001	30
Drain Plug O-Ring	R7021/001	32
Flask	R7021/002	14, 18, 19, 20 , 21, 23 & 29
Closure	R7021/003	1, 2 & 6
Drain Plug	R7021/008	-
Vent Plug	R7021/009	-
Closure studs	R7021/011	-
Drain tube assembly	R7021/020	1, 2 & 4

6.3.1 Containment components of the packaging

- When transporting Special Form material the containment components are as defined in each individual Special Form license.
- When transporting non-Special Form material the containment components are those defined in the Table above.

6.3.2 Special Form radioactive material

Any Special Form capsule may be used subject to fitting in the cavity and being located in an appropriate basket (see sections 4.3 & 4.4, OP 381). A typical REVISS cobalt design is the R2089.

6.3.3 Sealing and closing the containment system

- Special Form capsules are stainless steel assemblies sealed by welding. The precise details of sealing and closing are specific to each individual capsule design.
- The containment system is closed by the closure and the vent and drain plugs (see section 5.4, OP 381 for assembly details).

6.3.4 Containment system at reduced ambient pressure

- Under regulatory testing at 800°C Special Form capsules are subjected to a pressure differential of 269 kPa (101 x (((800 + 273) ÷ (20 + 273)) - 1)).
- At an ambient pressure of 5 kPa the pressure differential in the flask containment system (95kPa) generates a maximum stress of 2.95 N/mm^2 in the closure studs (see RTM 119). No stresses are generated in rest of the containment boundary as the flask outer wall is leaktight and is not challenged by the pressure differential (see RTM 119). The O-ring seals are supported by their grooves which maintain a minimum compression greater than 10% under all regulatory environments. They therefore may reasonably be expected to withstand pressure differentials up to 20 MPa. They will not be challenged by the 95 kPa differential.

6.3.5 Enhanced Immersion Test

Not applicable. The R7021 contents are less than 10^5 A_2.

6.3.6 Filters or mechanical cooling system

Compliance with permitted activity release does not rely upon filters or a mechanical cooling system.

6.3.7 Pressure Relief System

No such pressure relief system is fitted.

6.3.8 Strain Levels at MNOP

- Special Form contents: MNOP for Special Form contents is the internal pressure at a temperature of 411°C (RTM 120), which is 142 kPa. Special Form testing at 800ºC ensures that the levels of strains in the containment system at MNOP temperature are well within the capacity of the material

- Non-Special Form contents: For conservatism MNOP within the flask cavity is assumed the same as in the capsules, i.e. 135 kPa (RTM 119). This pressure generates a maximum tensile stress of 4.19 N/mm^2 in the closure fixings (RTM 119). Stresses in the cavity wall do not exceed 1.62 N/mm^2 . Strain in all components is neglible.

6.3.9 Internal Pressure at MNOP

- Special Form contents: 135 kPa (RTM 119).
- Non-Special Form contents: 135 kPa (RTM 119).

6.4 LEAKTIGHTNESS

- Special Form contents: The leaktightness of individual Special Form capsule designs is assured by the performance requirements specified in TS-R-1.
- Non-Special Form contents: The closure, vent and drain plug seals are tested periodically and at each shipment (see OP 381). Their general performance is described and assessed in RTM 126 where consideration is given to temperature extremes, radiation damage, compression set, groove fill, accident conditions damage and test criteria. The key design criteria and performance are detailed in the table below:

Design Aspect	Performance	Criteria
Material Compatibility	Suitable	Compatible with water, water vapour, air and noble gases
Radiation Resistance	260 Rads	≤10^6 Rads
Long Term Temperature	144°C	≤204°C
Peak Temperature	262°C	≤270°C
Temperature Duration above 250°C	83 mins	≤120 mins
Minimum Compression	10.6%	≥10%
Maximum Compression	23.9%	≤30%
Maximum Groove Fill	86.4%	≤90%
Accident Conditions	Unaffected	Unaffected by mechanical tests

- The containment boundary is required to be tested periodically to verify a total helium leaktightness of 1.0 x 10^{-5} atm.cc/s (see OP 381), hence the flask body and closure are fitted with connection points to the shielding space. As the drain tube is enclosed by an outer sleeve the flask has two test points; one directly into the shielding space and one into the space between the drain tube and sleeve. These allows the entire containment boundary to be tested.

- RTM 126 demonstrates that the R7021 containment system meets all relevant Type B(U) regulatory criteria and guidelines for transporting up to 5.92 PBq of Co^{60} as non-Special Form material.

6.4.1 Leak tightness

- Special Form contents: At maximum normal operating pressure (paragraph 6.6.1, MNOP), the pressure differential between the contents and the environment is no greater than that at which each design would be tested for regulatory compliance.
- Non-Special Form contents: The procedures and pass/fail criteria are specified in sections 5.3 & 11.3 of the operating instructions, OP 381. The value at loading, 5.0 x 10^{-4} mbar.l/s

of helium at 1 bar differential, is the value accepted by the DfT for solids and particulates. The value at scheduled maintenance, 1.0 x 10^{-5} mbar.l/s of helium at 1 bar differential, is the value recommended by para 657.13 TSG 1.1for leaktightness for solid particulate material.

6.4.2 Special filling and closing procedures

- Special Form contents: Specific to each individual Special Form capsule design.
- Non-Special Form contents: The flask containment system closing and testing procedure is detailed in section 5.4 of OP 381.

6.5 THERMAL CONSIDERATIONS

The thermal performance of the R7021 is described and analysed in RTM 120. Consideration is given to analysis assumptions, thermal radiation, thermal convection (natural and forced), insolation and sensitivity of the design to key thermal features and flask damage.

i) Criteria:

- If any accessible surface exceeds 50°C under normal conditions of transport in the shade the shipment must be made under “Exclusive Use” conditions.
- No accessible surface temperature shall exceed 85°C under normal conditions of transport in the shade.
- Thermal performance shall not be affected by adjacent cargo.
- Thermal performance shall not be sensitive to damage from normal or accident conditions mechanical testing.

ii) Code:

The performance in the thermal test was modelled using the ANSYS CFD finite element computational fluid dynamics program. Its handling of natural and forced convection as well as thermal radiation shadowing and re-emission makes it particularly appropriate for the R7021.

iii) Validation:

ANSYS CFD is the latest version of what used to be CFX TASC-Flow which has a satisfactory history of being used to model radioactive packaging thermal performance. Steady state test results from the prototype, 3981/01, were used to benchmark the model.

6.5.1 Limits for selection of materials and contents

- Ambient temperature ranges between -40°C to +38°C.
- The limits for selection of materials and contents are -40°C to +70°C.

6.5.2 Insolation

Insolation data is from TS-R-1, Table 11. The effect of insolation on the R7021 was modelled (see RTM 120), which demonstrated that the maximum surface temperature was 103°C.

6.5.3 Temperature of packaging and contents

Values are taken from RTM 120.

Location	Normal Form - Peak Temperatures [°C]		
	Equilibrium in the shade (@ 38°C)	Equilibrium in the sun (@ 38°C)	Thermal Test (maximum with or without drop test damage)
Closure flange (50mm from outer edge)	135	142	259
Drain point (centre of cylinder, 80mm from outer surface)	139	144	262
Maximum reverse gradient in closure flange	-	-	3
	Special Form - Peak Temperatures [°C]		
Capsule wall	409	411	471
Cavity wall (mid-height)	201	205	316
Maximum lead temperature	186	191	302
Closure flange (50mm from outer edge)	141	150	270
Flask wall (mid-height, midway between fins)	149	153	287
Lifting fin (40mm from top edge, 55mm from outer edge)	79	93	-
Flask foot (top surface, 30mm from outer edge)	50	67	-
Top shield (top surface centre)	57	100	-

6.5.4 Maximum surface temperature

79°C (lifting points, paragraph 6.5.3).

6.5.5 Low temperature

Special Form capsules by their mechanical test criteria will not be affected by a temperature of -40°C under normal conditions of transport. The performance of the containment system is justified in RTM 126.

The R7021 constructional materials are carbon steel and austenitic stainless steel. Stainless steel is not susceptible to brittle fracture at low temperatures. All carbon steel structural components have a low temperature ductility requirement of not less than 27 Joules at -40°C (see individual manufacturing drawings) in the Charpy V-notch test.

6.5.6 Thermal protective shield

The pallet, jacket and top shield are not significantly affected by the normal or accident conditions mechanical tests, except for the puncture test in which the punch partially penetrated the pallet and top shield outer plates and partially penetrated the jacket inner and outer plates and the side drop which partially flattened the pallet, jacket and top shield. The damage was modelled as follows:

- Upright drop and puncture tests: The pallet upper plate was lowered close to the lower plate in the centre section and a hole was made in the centre of the lower plate.
- Inverted drop and puncture tests: The top shield cones were removed and a hole was made in the centre of the upper plate.

- Side drop and puncture tests: The top shield, jacket and pallet were flattened on one side and a partial penetration made through the jacket inner and outer plates.

The modelling approach, justification and results are detailed in RTM 120. The pallet, jacket and top shield are not affected by ripping, cutting, skidding abrasion or rough handling.

6.5.7 Primary heat transfer medium

Not applicable

6.6 PRESSURE CONSIDERATIONS

6.6.1 Pressure effects on packaging

Pressure in the containment system will arise from the effect of elevated temperature on the constant volume of the enclosed gas. Assuming it was closed at 20°C, and using the temperatures given in paragraph 6.5.3, the pressure in the containment system will be:

- Special Form contents (RTM 119):

Conditions	Containment temperature	Pressure (kPa gauge)
Prior to shipment	409°C	140
During normal transport (MNOP)	411°C	141
During and subsequent to 'accident conditions'	471°C	161

These pressures will have no adverse effect on the contents which will have been proven to withstand 800°C as part of their design qualification.

- Non-Special Form contents (RTM 119):

Assumed the same as for Special Form contents for simplicity.

Maximum stresses are generated when MNOP is combined with the minimum external pressure of 5 kPa. The maximum stress in the closure fixings is 7.14 N/mm^2 (see RTM 119) which represents 1.53% of the design stress. The maximum stress in the flask inner and outer walls is 5.59 N/mm^2 which represents 3.96% of the design stress.
The stresses generated by pressure differential are not significant to the performance of the containment system.

6.6.2 Precautions against the effects of corrosion and radiolysis

- Special Form contents:

The contents are sealed in capsules approved as Special Form and the stainless steel flask is vacuum backfilled with an inert gas (see section 5.4, OP 381). There is no possibility of corrosion or radiolysis.

- Non-Special Form contents:

The contents are sealed in welded stainless steel capsules and the stainless steel flask is vacuum backfilled with an inert gas. There is no possibility of corrosion or radiolysis.

6.6.3 Containment system material specification

- Special Form contents:

Special Form containment systems are generally manufactured from type 316L austenitic stainless steel. Strength values at elevated temperatures may be taken from ASME II, Part D.

- Non-Special Form contents:

The containment system is fabricated entirely from 304L, austenitic stainless steel (see manufacturing drawings for detailed specification).

6.6.4 Strength of material at maximum normal operating pressure

- Special Form contents:

All Special Form capsules are heated to 800ºC as part of their regulatory testing.

- Non-Special Form contents:

The nominal design strengths for containment system materials are taken from the pressure vessel design standard, PD 5500, with due allowance for temperature. PD 5500 uses various safety factors depending on temperature and material properties which are detailed in Appendix K.

6.7 IMPACT EVALUATION

The criteria applied for impact evaluation (see RTM 118) were:

Following 'normal conditions of transport tests' tests:

- Pallet, jacket, top shield, closure and vent and drain plugs to remain securely attached.
- Shielding performance to be unaffected.
- Leaktightness to be unaffected.
- Drain filter and spring gasket to be securely located and undamaged.

Following 'accident conditions of transport' tests:

- Pallet, jacket, top shield, closure and vent and drain plugs to remain securely attached.
- Maximum dose rate to have increased by not more than 100%.
- Closure studs to stretch by no more than 0.2%.
- Flask seals to be helium leaktight to 2.6×10^{-7} atm.cc/s.
- Containment boundary to be helium leaktight to 2.6×10^{-7} atm.cc/s.
- Drain filter and spring gasket to be securely located and undamaged.

6.7.1 Comparison to Similar Packages

No comparison to similar packages is used.

6.7.2 Prototype testing

The R7021 prototype, 3981/01, was drop tested 17 times (see 5.1).

6.7.3 Model testing

No model testing was carried out.

6.7.4 Analysis

Impact performance of the modified design has been numerically modelled (see 5.1)

6.8 TYPE B(M) PACKAGES

Not applicable.

6.9 TYPE B(U) AND TYPE B(M) PACKAGES - GENERAL

6.9.1 General design requirements

Ease and safety of handling/tie-down
See Sections 4.1 and 4.2.

Strength of lifting attachments and ultimate failure mode
See Section 4.1.

Strength of other external features
See Section 4.1.8.

Freedom from protruding features and ease of decontamination
There are no significant protruding features other than handling points. All surfaces may be decontaminated easily.

Retention of water
There are no features that might accumulate water.

Added features
No other features may be added.

Effect of vibration in transport
All fasteners are torqued down to prevent loosening in transport (see section 5.3, OP 381).

Physical and chemical compatibility of all package materials
All contacting materials are physically and chemically compatible under all conditions of transport.

Unauthorised operation of valves
Not applicable.

Non-radioactive dangerous properties
None. See Section 2.10.

6.9.2 Type A requirements

Temperature of accessible surfaces (air transport only)
The surface temperature may exceed 50°C in the shade (see Section 6.5.3).

Containment system at -40°C to +55°C (air transport only)
Neither the Special Form encapsulation or the flask containment system is affected by ambient temperatures from -40°C to +55°C (see Section 6.5.1).

Ambient pressure reduction to 5kPa (air transport only)
Neither the Special Form encapsulation or the flask containment system is affected by ambient pressure reduction to 5 kPa (see Section 6.3.4).

General requirements for Type A packages
The Type A requirements specified in [524] are fully addressed elsewhere.

Minimum external dimension
The minimum external dimension is not less than 10 cm (see Section 3.2.1).

External security seal
See Section 3.4.

Effect of tie down stresses on the package performance
See Section 4.2.

Effect of temperature range from -40°C to +70°C on package materials
See Section 6.5.5.

Design, fabrication and manufacturing standards
See Section 7.1.1.

Security of the closure of the containment system
See Section 6.3.3.

Special Form material
See Section 6.3.2.

Independence of containment system closure
See Section 6.3.1.

Radiolytic decomposition of contents
See Section 6.6.2.

Efficiency of containment system at an ambient pressure of 60kPa
See Section 6.3.4.

Enclosure around all valves
Not applicable.

Closure of radiation shield
See Section 6.2.5.

Containment and shielding efficiency after 'Type A' testing
See Sections 6.4 and 6.2.6.

Ullage for liquid contents
Not applicable

Containment and shielding efficiency after additional 'Type A' testing (liquid contents)
Not applicable.

Absorber and secondary containment (liquid contents)
Not applicable.

Containment and shielding efficiency after additional 'Type A' testing (gaseous contents)]
Not applicable.

6.9.3 Trefoil symbol

A trefoil is engraved on two stainless steel plates (see drawing R7021/015) on opposite sides of the jacket.

SECTION 7 - QUALITY ASSURANCE

7.1 GENERAL

7.1.1 Applicant's Quality Assurance programme

The design, manufacture, testing, use, maintenance and inspection of R7021 is within the scope of REVISS Services Quality Assurance system, which complies with the requirements of current edition of BS EN ISO9001.

7.1.2 Other Quality Assurance programmes

OP 381 details the operation and maintenance instructions.

7.1.3 Verification of the design

The R7021 transport container design meets all requirements of TS-R-1 and all recommendations of TS-G-1.1. This document details the drawings and documentation verifying the design performance.

7.1.4 Level of Quality Assurance

REVISS Services Quality Assurance systems define the controls applied to all packaging design and procurement activities. No Quality Assurance level grading system is operated.

7.2 QUALITY CONTROL IN MANUFACTURE AND CONSTRUCTION

7.2.1 Detail of Quality Assurance tests

i) Containment System.

- Special Form material is leak tested at manufacture as required by the individual manufacturing specification.
- The containment system (boundary and seals) is helium leak tested at manufacture to 2.6×10^{-7} atm.cc/s (see drawing R7021/001).

ii) Radiation Shielding.

Shielding performance is tested at manufacture in accordance with OP 214.

iii) Insulation, Thermal Shielding and Heat Transfer Characteristics.

Heat dissipation performance is tested at manufacture in accordance with OP 219.

iv) Internal pressure

As the stresses generated by internal pressure are less than 10% of the nominal design stresses the containment system is not categorised as a pressure vessel and there is no need to test it at manufacture.

All acceptance tests and examinations are specified in the manufacturing drawings and associated documentation.

7.2.2 Test results

These are retained within the applicant's manufacturing Quality Dossiers.

7.3 MAINTENANCE

Inspection and maintenance is defined in Sections 10 & 11 of OP 381.

7.4 CONTROL OF USE AND CARE OF PACKAGES

The R7021 packaging is operated and maintained in accordance with OP 381 which ensures continued compliance assurance.

APPENDIX A: ATTACHMENTS

Document	Issue	Title
2209	27/11/08	Test Report (vibration and shock testing), Product Assessment and Reliability Centre (PARC).
22550C	30/11/09	Compression Set testing on V1289-75 compound using Type A Buttons at 270°C, Ceetak Ltd.
9060433	29/06/09	6mm Plate Test Report, Sheffield Testing Laboratories.
9060436	29/06/09	Drain Tube Weld Test Report, Sheffield Testing Laboratories.
9060549	02/07/09	M24 HT Studs Test Report, Sheffield Testing Laboratories.
C15578/TR/0002	2	Impact assessment of the REVISS R7021 package, AMEC Ltd.
INORG/W000925RL001	07/01/09	Determination of Cobalt and Nickel contents on filter papers by ICP-OES, Intertek MSG.
IR 0671	1	Inspection Report: 3981/01 closure bolt lengths before normal conditions drop testing, REVISS Services (UK) Ltd.
IR 0672	1	Inspection Report: 3981/01 assembly prior to normal conditions drop testing, REVISS Services (UK) Ltd.
IR 0673	1	Inspection Report: 3981/01 inspection after normal conditions drop testing, REVISS Services (UK) Ltd.
IR 0674	1	Inspection Report: 3981/01 assembly prior to accident conditions drop testing, REVISS Services (UK) Ltd.
IR 0675	1	Inspection Report: 3981/01 inspection after accident conditions drop testing, REVISS Services (UK) Ltd.
IR 0676	1	Inspection Report: 3981/01 closure bolt lengths after accident conditions drop testing, REVISS Services (UK) Ltd.
L91805	06/03/09	R7021 Transport Package - Jacket and Drain Tube Weld Strength Assessment, Caparo Testing Technologies.
OP 214	7	Transport container shielding test procedure, REVISS Services (UK) Ltd.
OP 219	4	Transport container thermal test procedure, REVISS Services (UK) Ltd.
OP 225	1	Transport container drop test procedure, REVISS Services (UK) Ltd.
OP 381	2	Operating and maintenance instructions R7021 transport container, REVISS Services (UK) Ltd.
PS/W000339RL001	12/01/09	Isolation and chemical analysis of fragments of metal particles produced during the vibration testing of cobalt pellets, Intertek MSG.
QS 7021	5	Drawings list R7021 transport container (and associated drawings), REVISS Services (UK) Ltd.
QS 8062	2	Drawings list basket design R8062 (and associated drawings), REVISS Services (UK) Ltd.

Document	Issue	Title
QS 8085	1	Drawings list R8085 drop test target (and associated drawings), REVISS Services (UK) Ltd.
R7110	1.1	Thermal Analysis of the R7021 Radioactive Materials Transport Container, FTT Technology CC.
R7410	1.1	Thermal Analysis of the R7021 Radioactive Materials Transport Container at 3074W Internal Heat Load, FTT Technology CC.
R8083/004	B	Bar for IAEA penetration test, REVISS Services (UK) Ltd.
R8099/002	A	Drop test punch, REVISS Services (UK) Ltd.
R8099/003	A	R2089 dummy source, REVISS Services (UK) Ltd.
RC 19356A	02/09/09	Low Temperature testing of Parker V1289-75 O-rings, Ceetak Ltd.
REV/011/060 9UT	23/06/09	Certificate of Inspection, Caparo Testing Technologies.
RTM 025	1	Nuclide heating, REVISS Services (UK) Ltd.
RTM 118	2	Test plan for the R7021 transport container, REVISS Services (UK) Ltd.
RTM 119	2	Internal stresses in the R7021 transport container, REVISS Services (UK) Ltd.
RTM 120	2	Thermal performance of the R7021 transport container, REVISS Services (UK) Ltd.
RTM 122	3	Performance of the R7021 (GB3981) transport container under IAEA tie-down loads, REVISS Services (UK) Ltd.
RTM 123	3	Performance of the R7021 transport container lifting features, REVISS Services (UK) Ltd.
RTM 124	2	Shielding performance of the R7021 transport container, REVISS Services (UK) Ltd.
RTM 126	3	Justification of the R7021 containment system, REVISS Services (UK) Ltd.
RTM 127	2	Compression performance of the R7021 transport container, REVISS Services (UK) Ltd.
RTM 130	2	Analysis of high-speed video footage from R7021 drop testing, REVISS Services (UK) Ltd.
RTM 151	2	R7021 Design Justification, REVISS Services (UK) Ltd.
RTR 225	30/10/08	R7021 thermal survey record, REVISS Services (UK) Ltd.
RTR 233	1	3981/01 1.2m Free Drop Test – Upright, REVISS Services (UK) Ltd.
RTR 234	1	3981/01 1.2m Free Drop Test - Side Horizontal, REVISS Services (UK) Ltd.
RTR 235	1	3981/01 1.2m Free Drop Test - Vertical Inverted, REVISS Services (UK) Ltd.
RTR 236	1	3981/01 1.0m Penetration Bar on to Jacket, REVISS Services (UK) Ltd.
RTR 239	1	3981/01 1.0m Punch Test - Angled Upright, REVISS Services (UK) Ltd.
RTR 240	1	3981/01 9.0m Free Drop Test – Upright, REVISS Services (UK) Ltd.
RTR 241	1	3981/01 1.0m Punch Test - Angled Upright, REVISS Services (UK) Ltd.

Document	Issue	Title
RTR 242	1	3981/01 1.0m Punch Test - Angled Inverted, REVISS Services (UK) Ltd.
RTR 243	1	3981/01 9.0m Free Drop Test - Vertical Inverted, REVISS Services (UK) Ltd.
RTR 244	1	3981/01 1.0m Punch Test - Angled Inverted, REVISS Services (UK) Ltd.
RTR 245	1	3981/01 1.0m Punch Test - Angled Inverted, REVISS Services (UK) Ltd.
RTR 246	1	3981/01 9.0m Free Drop Test - Angled Inverted, REVISS Services (UK) Ltd.
RTR 247	1	3981/01 1.0m Punch Test - Angled Inverted, REVISS Services (UK) Ltd.
RTR 248	1	3981/01 1.0m Punch Test - Angled Side, REVISS Services (UK) Ltd.
RTR 249	1	3981/01 9.0m Free Drop Test - Side Horizontal, REVISS Services (UK) Ltd.
RTR 250	1	3981/01 1.0m Punch Test - Angled Side, REVISS Services (UK) Ltd.
RTR 251	1	3981/01 1.0m Punch Test - Angled Inverted, REVISS Services (UK) Ltd.
RTR 260	17/11/08	Test report, 3981/01 vacuum rise leak test before normal conditions drop testing, RUVAC S.R.L.
RTR 261	17/11/08	Test report, 3981/01 vacuum rise leak test, RUVAC S.R.L.
RTR 262	18/11/08	Test report, 3981/01 vacuum rise leak test, RUVAC S.R.L.
RTR 263	21/11/08	Test report, 3981/01 vacuum rise leak test after normal and accident conditions drop testing, RUVAC S.R.L.
RTR 264	23/12/08	R7021 shielding survey record, REVISS Services (UK) Ltd.
SS 022	4	Supply specification welding for transport containers, REVISS Services (UK) Ltd.
SS 023	5	Supply specification surface finish requirements for transport containers, REVISS Services (UK) Ltd.
SS 024	2	Supply specification marking techniques for transport containers, REVISS Services (UK) Ltd.
SS 030	2	Supply specification low carbon stainless steels, REVISS Services (UK) Ltd.

APPENDIX B: REFERENCES

Reference	Issue	Title
10 CFR	2004	Code of Federal Regulations, Parts 51 to 199, Nuclear Regulatory Commission.
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