REVISS Services
Quality and Regulatory Group

Technical Memorandum

Performance of the Shielding Modifications to the R7021 Flask in IAEA Drop Testing

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1. PURPOSE AND SCOPE

This document assesses the structural security of the plates added around the base of the R7021 flask (to optimise its radiation shielding) under the IAEA accident conditions of transport drop testing detailed in TS-R-1.

2. DESCRIPTION

The package design consists of a lead shielded, stainless steel flask mounted on a pallet and protected from heat and impact by a jacket and top shield (Figure 1). The modifications to the flask consist of four stainless steel plates formed to fit around the flask lower cone and welded between the four webs (see Figure 2). One of the plates has a lead plate set into a cut-out and covered with a capping sheet. In addition a stainless steel disc is welded under the flask base.

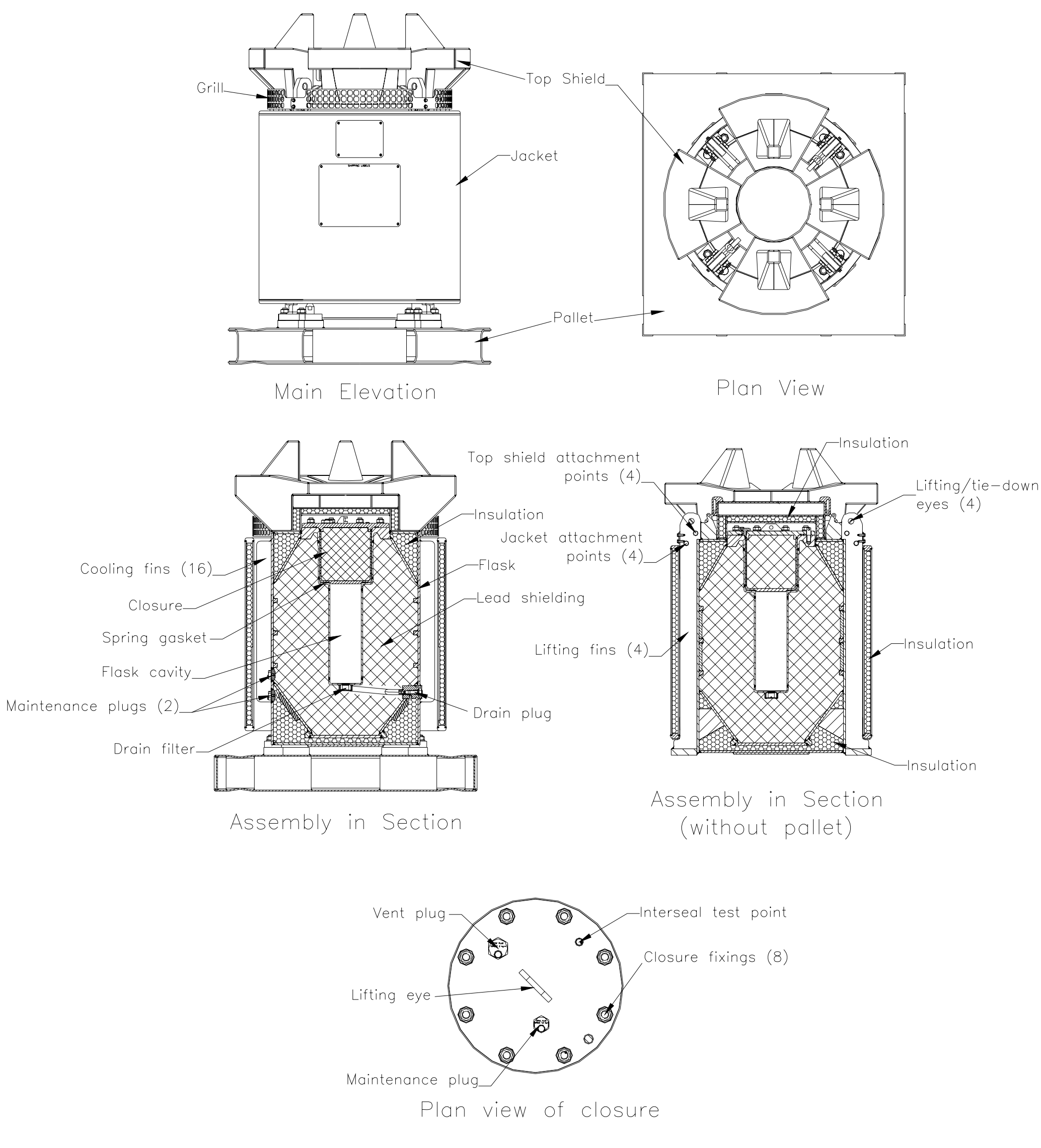

Figure 1: R7021 Assembly

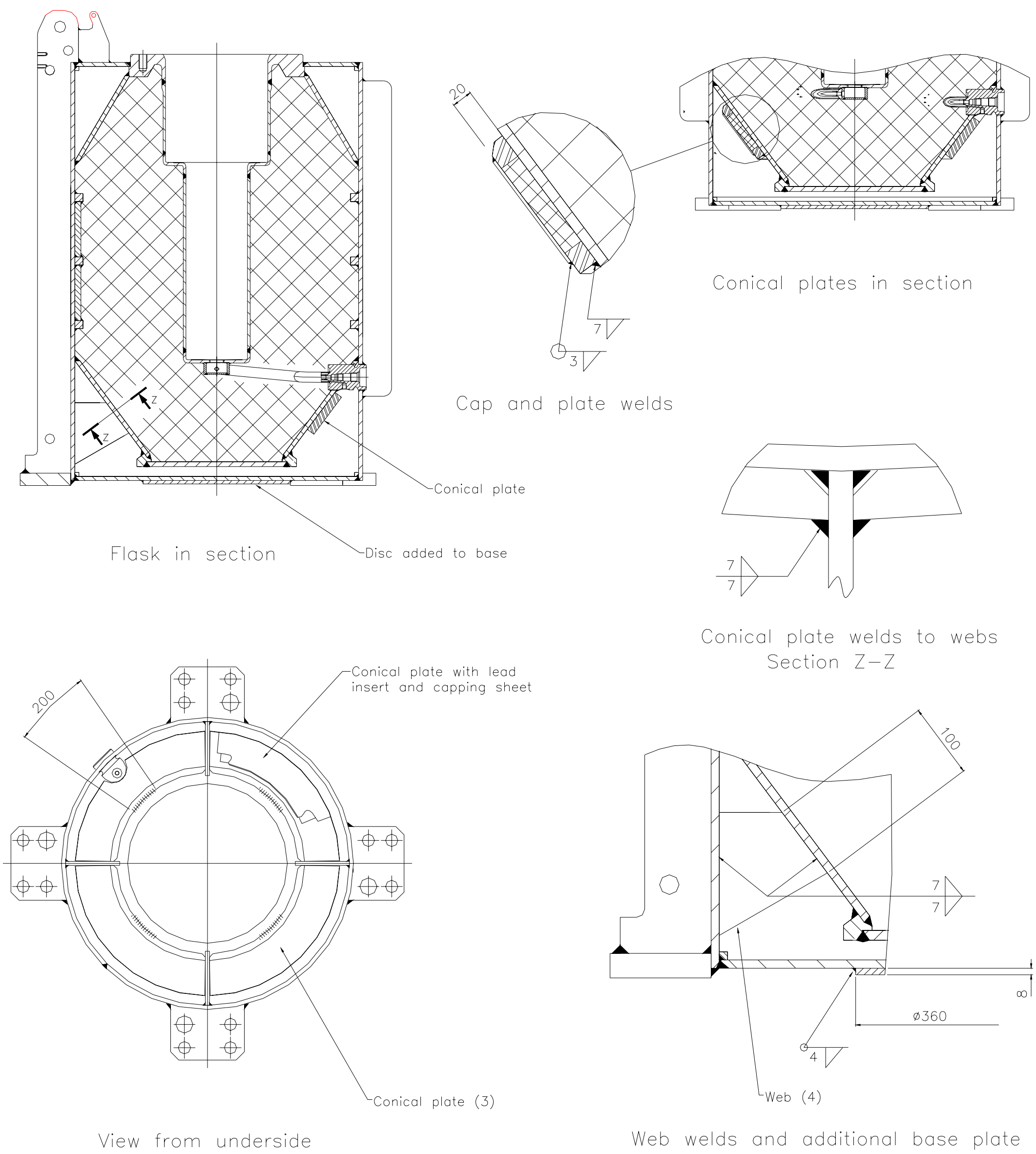

Figure 2: R7021 Flask Modifications (from drawing R7021/002 issue E)

3. Assessment

3.1 Test Requirements

Para. 657 of TS-R-1 requires the R7021 be able to withstand Drops I & II, specified in para. 727, subject to certain containment and shielding criteria. As the maximum impact forces (decelerations) were generated in Drop I, the 9m test, and the modifications are all in areas untouched by Drop II, the punch test, this assessment will only consider Drop I.

3.2 RETENTION STRESSES

Stress levels, S, in the welds retaining the various plates may be calculated as follows:

$$S = \frac{W}{A} \text{ N/mm}^2$$

where
W = maximum impact load = M.a.g
where
M = retained mass (kg)
a = maximum deceleration (g)
g = gravitational acceleration = 9.81 m/s^2
A = cross-sectional area of material under load (mm^2)

3.3 RETAINED MASSES

The masses of the additional items are as follows:

Element	Mass, M
Conical plate	9.9 kg
Conical plate with lead insert and capping sheet	12.7 kg
Lead insert and capping sheet	7.5 kg
Disc	6.5 kg

3.4 IMPACT DECELERATIONS IN DROP I

The performance of the package prior to modification was modelled using finite element analysis previously benchmarked against 17 normal and accident conditions drop tests performed on the prototype unit. AMEC report C15578/TR/0002 provides the following peak decelerations in the seven Drop I test orientations modelled:

Orientation	Angled Side (slap-down)	Side onto Pallet Corner	Angled Upright	Upright	Inverted	Angled Inverted	Side onto Pallet Edge
Peak deceleration	61g	95g	82g	1110g*	85g	105g	90g
Average deceleration	26g	23g	21g	72g	71g	49g	48g

* Shock wave resulting from the modelled perfectly flat pallet base impacting the perfectly flat target face exactly parallel. It lasted 70µs and made no significant difference to the average deceleration.

The analysis shows that in general the maximum flask deceleration, 105g, was in the angled inverted orientation. The shock wave in the vertical upright orientation however had a peak instantaneous acceleration of 1110g.

3.5 RETAINING LOADS

The retaining loads (M x 1110 x 9.81) are therefore:

Element	Retaining Load, W
Conical plate	108 kN
Conical plate with lead insert and capping sheet	138 kN
Lead insert and capping sheet	82 kN
Disc	71 kN

3.6 RETAINING WELDS

Acceleration loads in the four conical plates are taken into the base cone by a weld along the inner diameter and into the four webs by welds along each side. Loads from the lead insert are taken into the conical plate by the capping sheet circumferential weld. Loads from the disc are taken into the flask base by the circumferential weld.

The shear area of the retaining welds (0.707 x fillet weld size x weld length) are as follows:

Element	Fillet	Length	Qty	Shear Area of Retaining Welds, A
Conical plates	7 mm	100 mm	2	1980 mm^2
	7 mm	200 mm	1	
Capping sheet	3 mm	823 mm	1	1750 mm^2
Base plate	4 mm	1130 mm	1	3200 mm^2

3.7 RETENTION STRESSES

Element	Retaining Stress, S
Conical plate	54 N/mm^2
Conical plate with lead insert and capping sheet	70 N/mm^2
Lead insert and capping sheet	47 N/mm^2
Disc	22 N/mm^2

3.8 DESIGN STRESS

This is determined by the component temperature under normal conditions of transport. RTM 120 demonstrates that the modifications make no difference to normal or accident conditions temperatures in all key components. The normal conditions temperature field is illustrated in Figure A1.2, FTT Report R7410/1.1. The flask base cone is at the same temperature as the drain seal (they are both inside the base thermal insulation and are in close proximity). Under normal conditions of transport the drain seal is at 152°C (R7410/1.1). The flask is fabricated from 1.4307 (304L) plate to BS EN 10088-2. The minimum room temperature yield strength is 200 N/mm^2. This reduces to 155 N/mm^2 (applying the reduction in design strength cited in PD 5500 for the same grade steel, 304-S11, at 150°C). The yield stress in shear therefore will be 90 N/mm^2 (using a factor of 0.577 on tensile strength based on Von Mises' theorem).

3.9 SAFETY FACTORS

Using a design shear strength of 90 N/mm^2 the safety factors are as follows:

Element	Safety Factor
Conical plate	1.66
Conical plate with lead insert and capping sheet	1.30
Lead insert and capping sheet	1.91
Base plate	4.09

4. CONCLUSIONS

- General impact loads: The plates added around the base of the R7021 flask will be securely retained in position through the decelerations generated in TS-R-1 Drop I & II tests in any orientation.
- Shock wave load: The plates added around the base of the R7021 flask will be retained securely in position through the shock wave generated in the TS-R-1 Drop I test in the vertical upright orientation.

5. REFERENCES

- BS EN 10088-2: 2005: "Stainless steels. Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes", British Standards Institution.
- C15578/TR/0002 issue 2: "Impact assessment of the REVISS R7021 package", AMEC Ltd.
- PD 5500: 2009: "Specification for unfired fusion welded pressure vessels", British Standards Institution.
- R7021/002 issue E: "Body", Manufacturing drawing, REVISS Services (UK) Ltd.
- R7410/1.1: "Thermal Analysis of the R7021 Radioactive Materials Transport Container at 3074W Internal Heat Load", FTT Technology.
- RTM 120: "Thermal performance of the R7021 transport container", REVISS Services (UK) Ltd.
- TS-R-1: "Regulations for the Safe Transport of Radioactive Material", 2005 Edition, IAEA, Vienna.