REVISS Services
Quality and Regulatory Group

Technical Memorandum

Performance of the R7021 Transport Container Lifting Features

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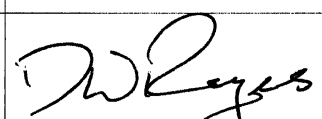
Signature		Signature	
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1. PURPOSE AND SCOPE

This document assesses the performance of lifting features of the R7021 transport container against various packaging regulations for the transport of radioactive materials. It analyses the stresses in the load bearing components under normal conditions of transport and quantifies their performance and their fatigue life against the design criteria.

2. DESCRIPTION

The design consists of a shielded, stainless steel flask mounted on a pallet and protected from heat and impact by a jacket and top shield (Figure 1). The maximum gross weight of the design is 4,600kg.

The flask has four lifting eyes equally disposed around its top. No other features could be used for lifting.

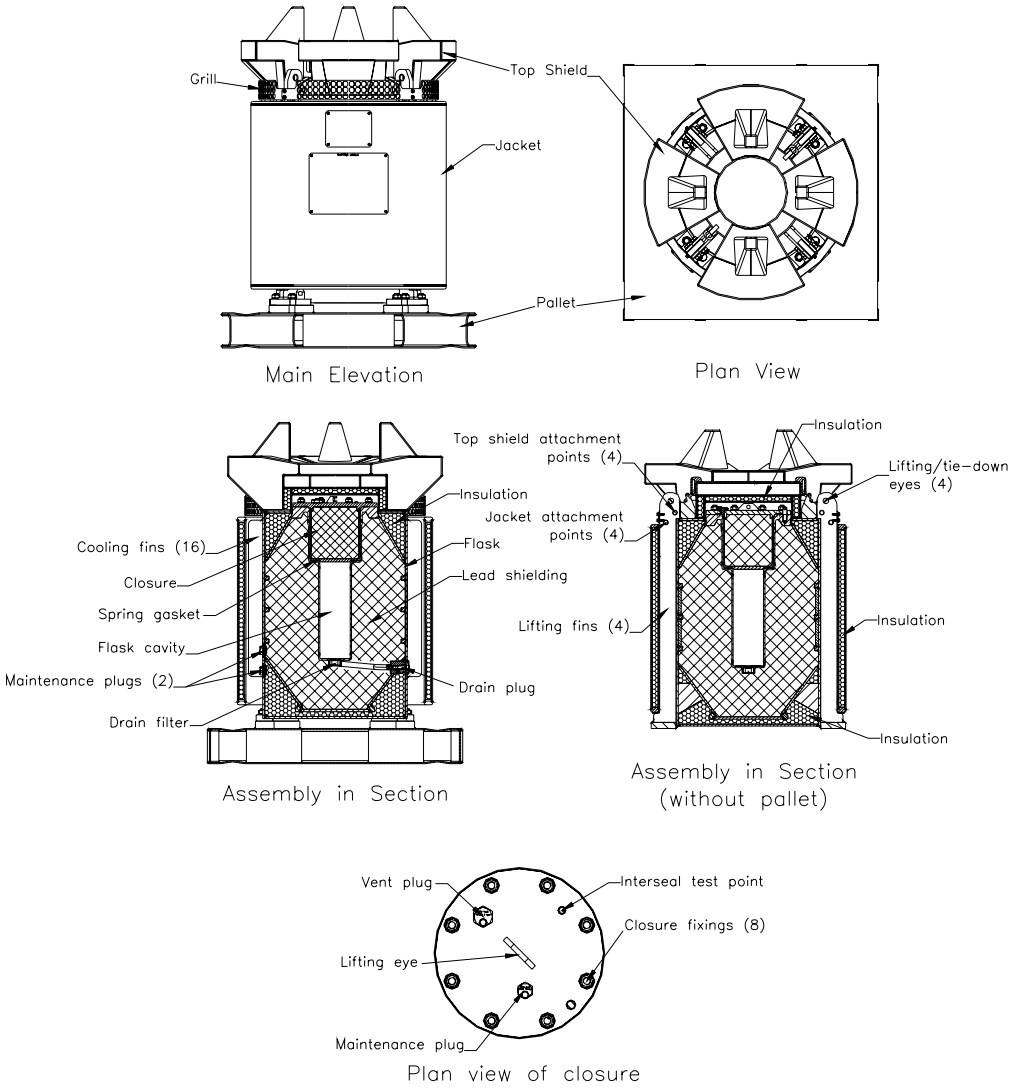

Figure 1: R7021 Assembly

3. ASSESSMENT

3.1 CRITERIA

- Factor of safety: The design strength (yield) shall not be exceeded with a snatch factor of 3. This exceeds TS-G-1.1 recommendations and the UK applicants guide requirements (snatch factor of 2) by a factor of 1.5 and satisfies the US requirements (10 CFR 71.45 (a)).
- Temperature: Material strength shall be taken at normal conditions of transport temperature.
- Failure: 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 lifting features, or any other features, be overloaded to failure.

3.2 ASSUMPTIONS

- Included angle of slings: The angle shall not exceed 90°.
- Unequal load distribution: Loads from 4-point slings will be distributed equally over two opposite lifting points.
- Shackle pin diameter: Taken as 28.6 mm (1⅛").
- Special lifting equipment: Not required. The analysis will be based on the use of conventional multi-leg slings.

3.3 DATA

3.3.1 Design Strength

Under normal conditions of transport the flask tie-down eyes are at a maximum temperature of 93°C (RTM 120). The flask is fabricated from 1.4307 (304L) plate to BS EN 10088-2. The minimum room temperature yield strength of the lifting eyes is 200 N/mm^2. This reduces to 178 N/mm^2 at a temperature of 93°C (using by proportion the reduction in design strength cited in PD 5500 for a similar grade steel (304-S11) up to 100°C). The yield strength of the lifting fin welds similarly reduces to 141 N/mm^2 at their mid-height temperature of 153°C.

Element	Normal Conditions Temperature (°C)	Design Strength (N/mm^2)		
		Tension		Shear* (NCT)
		RT	NCT	
Flask lifting eyes	93	200	178	103
Flask lifting fin welds	153	200	141	81.4

* Using a factor of 0.577 on tensile strength based on Von Mises' theorem.

3.3.2 Load Paths

Lifting loads are taken by the lifting eyes and through the fin welds into the flask body.

3.3.3 Loads

Lifting Feature	Supported Mass (kg)	Maximum Load (kN)
Flask lifting eyes	4,600	135
Flask lifting fin welds	4,600	135

3.4 FLASK LIFTING POINTS

Pull-out shear stress is generated in the lifting eye and shear stresses in the welds securing the lifting fin to the flask body.

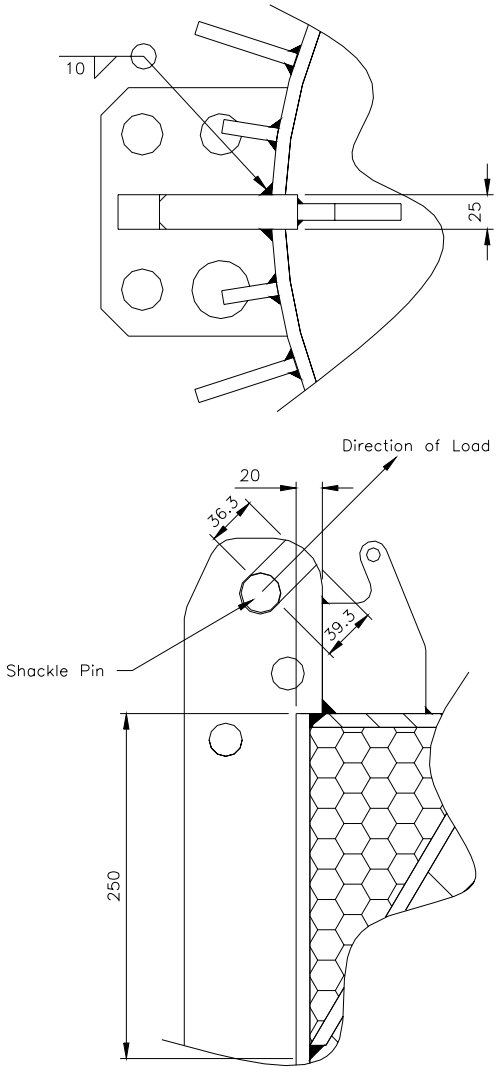

Figure 2: Flask Lifting Eye Details

3.4.1 Load on each lifting eye (W_1)

$$W_1 = \frac{W}{N \times \sin a}$$

where
W = maximum lifting load = 135 kN
N = minimum number of lifting points over which load is distributed = 2
a = angle of lifting member to horizontal (90° included angle) = 45°

thus

$W_1 = \frac{135 \times 10^3}{2 \times \sin 45°} = 95.5$ kN

3.4.2 Bearing stress in flask lifting eyes (S_1)

$S_1 = \frac{W_1}{A_1}$

where
A_1 = projected contact area of shackle pin = D x T

where
D = shackle pin diameter = 28.6 mm.
T = length of contact = 25mm

thus
$A_1 = 28.6 \times 25 = 1{,}120$ mm^2

thus
$S_1 = \frac{95.5 \times 10^3}{715} = 134$ N/mm^2

3.4.3 Pull-out stress in flask lifting eyes (S_2)

$S_2 = \frac{W_1}{A_2}$

where
A_2 = total area of material in shear planes (Figure 2) = (25 x 36.3) + (25 x 39.3)
= 1,890mm^2

thus
$S_2 = \frac{95.5 \times 10^3}{1{,}890} = 50.5$ N/mm^2

3.4.4 Shear stress in lifting fin weld (S_3)

$S_3 = \frac{W_1}{A_3}$

where
A_3 = cross-sectional area of weld = l x t

where
l = weld length = 2(250 + 20) = 540 mm (stressed vertical length of weld is taken as 250mm on each side of the fin)
t = weld throat width = 10 x 0.707 = 7.07 mm

thus
$A_3 = 540 \times 7.07 = 3{,}820$ mm^2

thus

$S_3 = \frac{95.5 \times 10^3}{3{,}800} = 25.1 \text{ N/mm}^2$

3.7 SUMMARY:

The maximum stresses and minimum factors of safety of the key lifting components in the R7021 are:

Component	Maximum Stress (N/mm^2)	Design Stress (N/mm^2)	Safety Factor
Flask lifting eyes (bearing)	134 (S_1)	178	1.33
Flask lifting eyes (pull-out)	50.5 (S_2)	103	1.44
Flask lifting fin welds	25.1 (S_3)	81.4	2.31

Failure under overload:

The table demonstrates the flask lifting eyes would fail under overload. This would have no adverse effect on the ability of the design to meet all other Type B requirements.

4. FATIGUE

An R7021 is unlikely to be shipped more than twelve times in a year. A single shipment is unlikely to require more than ten lifting operations. With a nominal design life of fifty years the lifting points therefore may reasonably be expected to be subject to a maximum of 10 x 12 x 50 = 6,000 cycles.

Using Appendix C "Recommendations for the assessment of vessels subject to fatigue" and Figure C.3 in PD 5500 the maximum stress range for 6,000 cycles is 300 N/mm^2. It is evident therefore that the lifting points are not at risk from fatigue failure during the design life.

5. CONCLUSIONS

- Safety factor: The R7021 lifting points have a minimum factor of safety of 1.33 above any regulatory requirement.
- Overload: Should the lifting points be overloaded to the point of failure in lifting the lifting eyes would fail first leaving all key mechanical features of the assembly substantially intact. This would not impair its ability to meet all other Type B(U) requirements.
- Other features: There are no other features or attachments that could be used for lifting that, if used in their intended manner, would exceed their design limits under normal lifting conditions or, under overload conditions, would fail in manner that would impair the ability of the design to meet all other requirements.
- Fatigue: No component is at risk from fatigue failure from lifting during the design life.

6. REFERENCES

- 10 CFR: Code of Federal Regulations, Parts 51 to 199, 2004, Nuclear Regulatory Commission.

- 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.
- DETR/RMTD/0003: Guide to an Application for UK Competent Authority Approval of Radioactive Material in Transport (IAEA 1996 Regulations).
- PD 5500: 2009: Specification for unfired fusion welded pressure vessels, British Standards Institution.
- RTM 120 issue 2: Thermal performance of the R7021 transport container, REVISS Services (UK) Ltd.
- TS-G-1.1 (Rev. 1): "Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material", IAEA, Vienna, 2008.
- TS-R-1: "Regulations for the Safe Transport of Radioactive Material", 2005 Edition, IAEA, Vienna.