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Quality and Regulatory Group

Technical Memorandum

Compression Performance of the R7021 Transport Container

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1. PURPOSE AND SCOPE

This document analyses the stresses generated in the R7021 transport container in the IAEA compression test. It calculates the stresses in the load path and compares them with the design criteria.

2. DESCRIPTION

The R7021 consists of a lead shielded, stainless steel flask, with carbon steel top shield, jacket and pallet (Figure 1). The maximum gross weight is 4,600 kg.

3. ASSESSMENT

3.1 DESIGN CRITERIA

Stresses shall not exceed yield when the R7021, at normal conditions temperature, is subjected to the compression load test specified in TS-R-1, para 723.

3.2 TEST LOAD

The assembly must withstand the greater of either:

- Five times the maximum gross weight, i.e. $5 \times 4{,}600 = 23{,}000$ kg
- 1,300 kg/m^2 over the package vertically projected area, i.e. $1{,}300 \times 1.26^2 = 2{,}064$ kg

Therefore the test load is 23,000 kg.

3.3 ASSUMPTIONS

The load is evenly distributed.

3.4 LOAD PATH

With the R7021 in its normal upright position the compression load is taken on the four top shield cones, comprising a mixture of vertical and angled plates, from whence it passes into the top shield and there to the flask outer wall. The load is then transferred from the flask into the flask feet and thence to the pallet top plate, from which it passes through the channels and into the pallet base.

3.5 YIELD STRENGTHS

Under normal conditions of transport the upper surfaces of the top shield and pallet may reach temperatures up to 100°C (RTM 120). The minimum room temperature yield strength of these components is 400 N/mm^2 (drawings R7021/004 & R7021/005). This reduces to 371 N/mm^2 at a temperature of 100°C (using by proportion the reduction in design strength cited in PD 5500 for a similar grade steel (223, 490A) up to 100°C).

The flask wall is at a maximum temperature of 153°C (RTM 120). The flask is fabricated from 1.4307 (304L) plate to BS EN 10088-2 (drawing R7021/002). The minimum room temperature yield strength is 200 N/mm^2. This reduces to 141 N/mm^2 at a temperature of 153°C (using by proportion the reduction in design strength cited in PD 5500 for a similar grade steel (304-S11) up to 200°C).

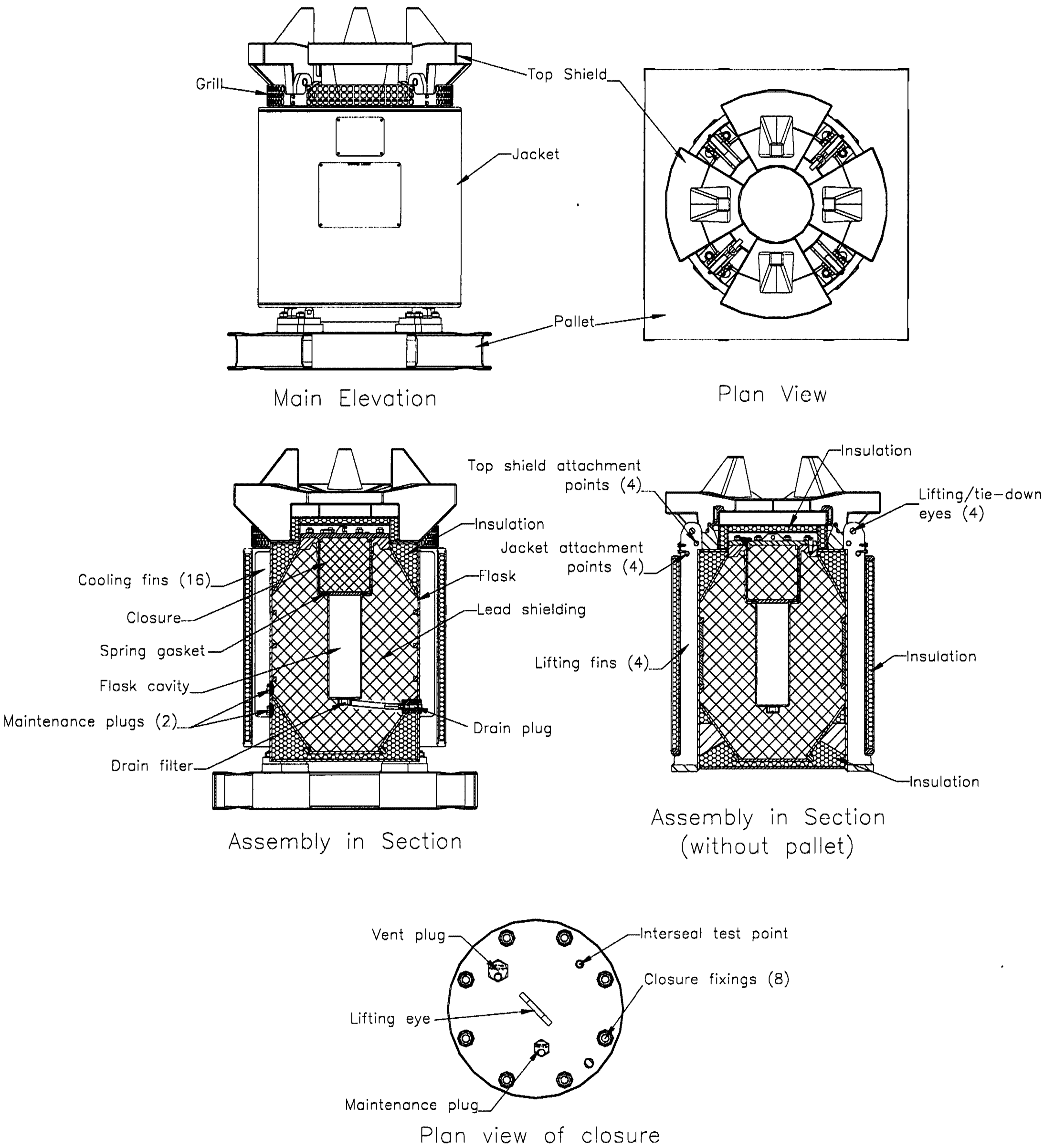

Figure 1: R7021 Assembly

4. ANALYSIS

4.1 TOP SHIELD CONES

The cones consist of a vertical plate and three angled plates welded to each other and to the top shield. The highest stress will be where the cross section is least, i.e. at the top. The compressive stress, S_1, is calculated as follows:

$$S_1 = \frac{W}{A}$$

where

W = compression load = 23,000 x 9.81 = 226 kN

A = cross-sectional area of load path

$= N \times ((w \times t) + (w \times t \times \cos\alpha^o) + (2 \times w \times t \times \cos\beta^o))$

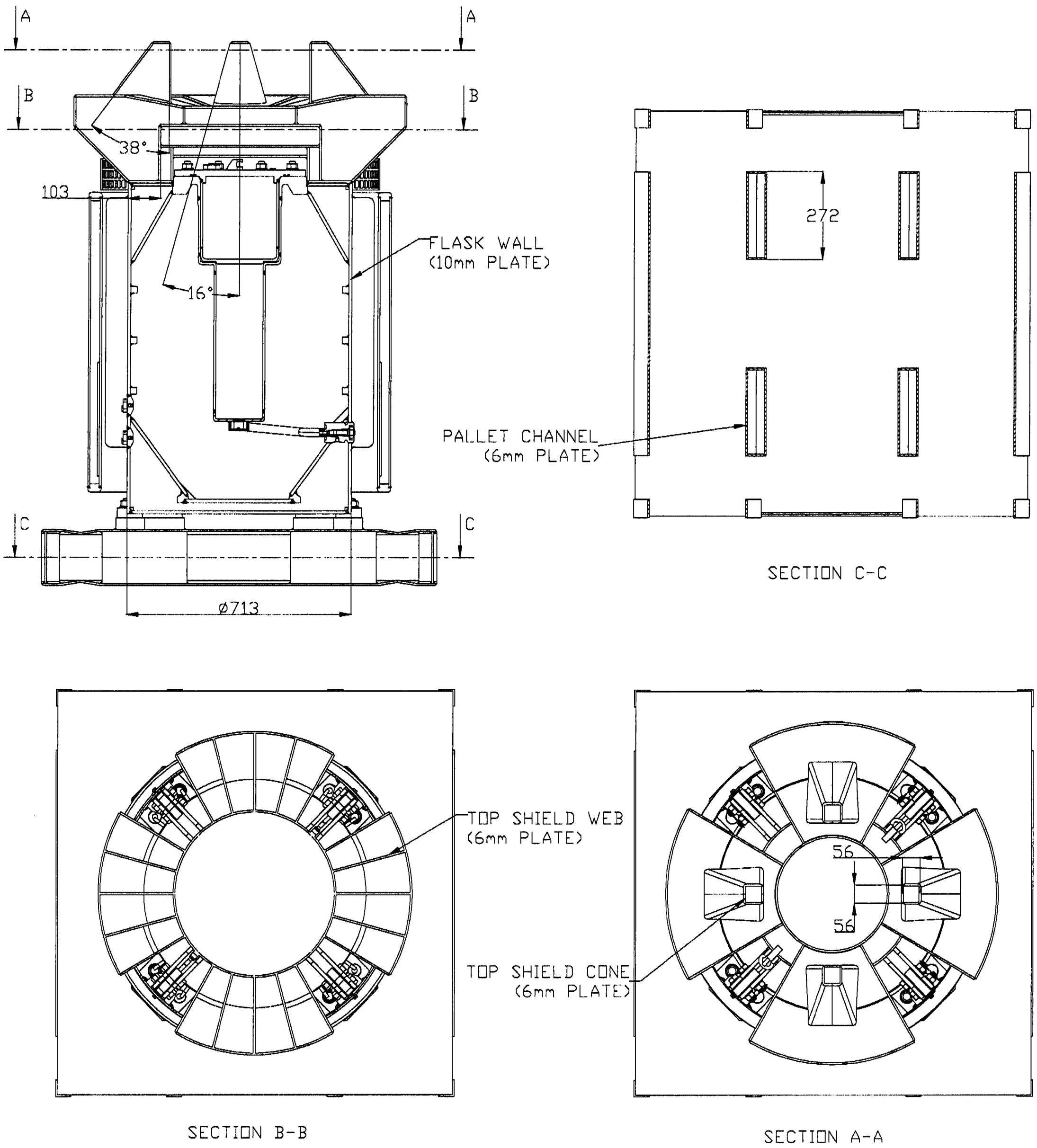

Figure 2: Load Path

where

N	= number of cones = 4
w	= plate width = 56 mm
t	= plate thickness = 6 mm
α	= angle from vertical of outboard plate = 40°
β	= angle from vertical of side plates = 18°

thus

$$S_1 = \frac{W}{N \times ((w \times t) + (w \times t \times \cos\alpha^\circ) + (2 \times w \times t \times \cos\beta^\circ))}$$

$$= \frac{226 \times 10^3}{4 \times ((56 \times 6) + (56 \times 6 \times \cos 38^\circ) + (2 \times 56 \times 6 \times \cos 16^\circ))} = 45.3 \text{ N/mm}^2$$

4.2 TOP SHIELD

The top shield load path comprises four quadrants inside each of which are five vertical webs, three of which are under the cone. The webs are constrained against buckling by being welded on all sides, except the top horizontal, to the surrounding structure. The compressive stress in the plates, S_2, is calculated as follows:

$$S_2 = \frac{W}{A}$$

where
W = compression load = 226 kN
A = cross-sectional area of load path = N x w x t
where
N = number of load bearing vertical plates = 12
w = load bearing width of plates = 103 mm
t = plate thickness = 6 mm
thus

$$S_2 = \frac{226 \times 10^3}{12 \times 103 \times 6} = 30.5\ \text{N/mm}^2$$

4.3 FLASK

The outer wall of the flask is an upright cylinder. The compressive stress in the wall, S_3, is calculated as follows:

$$S_3 = \frac{W}{A}$$

where
W = compression load = 226 kN
A = cross-sectional area of load path = D x π x t
where
D = diameter of outer wall = 703 mm
t = wall thickness = 10 mm
thus

$$S_3 = \frac{226 \times 10^3}{703 \times 3.14 \times 10} = 10.2\ \text{N/mm}^2$$

4.4 PALLET

The pallet has channel sections directly beneath the flask feet. The compressive stress in these sections, S_4, is calculated as follows:

$$S_4 = \frac{W}{A}$$

where
W = compression load = 226 kN
A = cross-sectional area of load path = N x l x t
where
N = number of vertical channel sections = 8
l = length of channels = 272 mm
t = plate thickness = 6 mm

thus

$$S_4 = \frac{226 \times 10^3}{8 \times 272 \times 6} = 17.3 \text{ N/mm}^2$$

4.5 SUMMARY

Component	Stress (N/mm²)		Safety Factor
	Calculated	Yield	
Top shield cones, S_1	45.3	371	8.19
Top shield structure, S_2	30.5	371	12.2
Flask wall, S_3	10.2	141	13.8
Pallet channels, S_4	17.3	371	21.4

5. CONCLUSIONS

The R7021 is capable of supporting the compression load specified in TS-R-1, para 723, with a minimum factor of safety of 8.19. This is sufficient to compensate for any calculational inaccuracies or simplifications.

6. 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.
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