RTL-001-CALC-ST-0201 Rev 5

ENERCON Excellence—Every project. Every day.	CALCULATION COVER SHEET	CALC. NO. RTL-001-CALC-ST-0201
		REV. 5

Title:	RT-100 Lifting Structural Evaluation	Client:	Robatel Technologies, LLC
		Project:	RTL-001

Item	Cover Sheet Items	Yes	No
1	Does this calculation contain any open assumptions that require confirmation? (If **YES**, Identify the assumptions) ______	☐	☒
2	Does this calculation serve as an "Alternate Calculation"? (If **YES**, Identify the design verified calculation.) **Design Verified Calculation No.** ______	☐	☒
3	Does this calculation Supersede an existing Calculation? (If **YES**, identify the superseded calculation.) **Superseded Calculation No.** ______	☐	☒

Scope of Revision:

Update reference drawing revision numbers.

Revision Impact on Results:

N/A

Study Calculation ☐ **Final Calculation** ☒

Safety-Related ☒ **Non-Safety Related** ☐

(Print Name and Sign)

Originator: David Hartmangruber [signature]	**Date: 01/03/2014**
Design Verifier: Curt Lindner [signature]	**Date: 01/03/2014**
Approver: Nand Lambha [signature]	**Date: 01/03/2014**

CALCULATION REVISION STATUS

REVISION	DATE	DESCRIPTION
0	9-12-2012	Initial Issue
1	10/08/2012	Update vendor drawings, update associated calculations
2	08/13/2013	1. Revise calculations to incorporate design changes. 2. Add and update references (Section 3) and assumptions as needed to support the calculations.
3	08/30/2013	1. Revise calculation to incorporate design changes: material properties 2. Add and update references.
4	09/13/2013	1. Revise calculation to incorporate design changes: design of lifting pocket and pin 2. Update references
5	01/03/2014	Update reference drawing and bill of material revision numbers.

PAGE REVISION STATUS

PAGE NO.	REVISION	PAGE NO.	REVISION
All	5		

APPENDIX REVISION STATUS

APPENDIX NO.	PAGE NO.	REVISION NO.	APPENDIX NO.	PAGE NO.	REVISION NO.
1	1	4			
2	1-2	4			
3	1-2	4			

ENERCON Excellence—Every project Every day	CALCULATION DESIGN VERIFICATION CHECKLIST	CALC. NO.	RTL-001-CALC-ST-0201
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Item	CHECKLIST ITEMS	Yes	No	N/A
1	**Design Inputs -** Were the design inputs correctly selected, referenced (latest revision), consistent with the design basis, and incorporated in the calculation?	X		
2	**Assumptions** - Were the assumptions reasonable and adequately described, justified and/or verified, and documented?	X		
3	**Quality Assurance** - Were the appropriate QA classification and requirements assigned to the calculation?	X		
4	**Codes, Standards, and Regulatory Requirements** - Were the applicable codes, standards, and regulatory requirements, including issue and addenda, properly identified and their requirements satisfied?	X		
5	**Construction and Operating Experience** - Have applicable construction and operating experience been considered?	X		
6	**Interfaces** - Have the design-interface requirements been satisfied, including interactions with other calculations?	X		
7	**Methods** - Was the calculation methodology appropriate and properly applied to satisfy the calculation objective?	X		
8	**Design Outputs** - Was the conclusion of the calculation clearly stated, did it correspond directly with the objectives, and are the results reasonable compared to the inputs?	X		
9	**Radiation Exposure** - Has the calculation properly considered radiation exposure to the public and plant personnel?			X
10	**Acceptance Criteria** - Are the acceptance criteria incorporated in the calculation sufficient to allow verification that the design requirements have been satisfactorily accomplished?	X		
11	**Computer Software**- Is a computer program or software used, and if so, are the requirements of CSP 3.02 met?			X

COMMENTS

	(Print Name and Sign)	
Design Verifier: **Curt Lindner** [signature]	**Date:**	**01/03/2014**
Others:	**Date:**	

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1.0 Purpose and Scope

Robatel Technologies is designing the RT-100 transport cask to transport radioactive waste in the form of dewatered resins and filters. The purpose of this calculation is to structurally qualify the fully-loaded RT-100 transport cask for the loadings associated with lifting activities, including dead weight and payload weight, for the normal lifting conditions.

The RT-100 transport cask is required to meet the requirements of 10 CFR Part 71 (Ref. 3.1). This calculation demonstrates that this package satisfies the requirements of 10 CFR 71.45 under the normal lifting conditions. The NRC requirements in 10 CFR 71.45 state that any lifting attachment that is a structural part of the package must be designed to withstand lifting stresses with appropriate safety factors. The RT-100 package is designed with two lifting pockets, attached to the cask sidewall, for lifting the assembled cask and with three removable lifting rings each on the upper impact limiter, lower impact limiter, primary lid and secondary lid. Failure of the lifting mechanism under excessive load must not impair the ability of the cask to meet the requirements of Subpart E of 10 CFR 71.45. Any other structural part that could be used to lift the package must be capable of being rendered inoperable for lifting the package during transport, or must be designed with strength equivalent to that required for lifting attachments.

As an additional requirement, Robatel Technologies has committed to the NRC to meet the intent of the requirements of the special stress limits contained in ASME B&PV Code Section III, Division 1 – Subsection NF Subparagraph 3223.2 “Pure Shear”.

2.0 Summary of Results and Conclusions

All structural members have a factor of safety of greater than 3.0 against yield under the most adverse effects from the lifting activities to satisfy 10 CFR 71.45 requirements. The minimum factor of safety is 8.26 at the lifting pockets for the bearing stress during lifting of the assembled cask. All welds and connections are qualified for the design loads. The minimum weld factor of safety is 4.80 against yield at the lifting pocket weld. The minimum bolt factor of safety is 1.45 at the lifting ring for the secondary lifting mechanisms (lids, impact limiters, etc.). The failure of the structural lifting attachments under excessive loads does not impair the ability of the cask to meet the other regulatory requirements of the cask. The results of the analysis show that the RT-100 cask can withstand the required lifting activities for the normal lifting conditions.

Therefore, the members and welds of the RT-100 transport cask are adequate for their design function under the normal lifting condition.

3.0 References

3.1 Nuclear Regulatory Commission, 10 CFR Part 71, "Packaging and Transportation of Radioactive Material"

3.2 ROBATEL Industries Drawing RT100 PE 1001-1, "ROBATEL Transport Package RT100 General Assy Sheet 1/2," Rev. H

3.3 ROBATEL Industries Drawing RT100 PE 1001-2, "ROBATEL Transport Package RT100 General Assy Sheet 2/2," Rev. H

3.4 ROBATEL Industries Drawing 102885 PD 1012, "ROBATEL Transport Package RT100 S/E Emballage Details Couvercle Primaire," Rev. B

3.5 ROBATEL Industries Drawing 102885 PD 1013, "ROBATEL Transport Package RT100 S/E Emballage Details Couvercle Secondaire," Rev. B

3.6 ROBATEL Industries Drawing 102885 PD 1031, "ROBATEL Transport Package RT100 S/E Emballage Details Capot Inferieur," Rev. B

3.7 ROBATEL Industries Drawing 102885 PD 1032, "ROBATEL Transport Package RT100 S/E Emballage Details Capot Superieur," Rev. B

3.8 ROBATEL Industries Drawing 102885 PE 3101, "WCS USA Transport Package RT100 S/E Palonnier Ensemble General," Rev. A

3.9 ROBATEL Industries Drawing 102885 PD 3114, "WCS USA Transport Package RT100 S/E Palonnier Details Axe Fixation Palonnier," Rev. B (Appendix 3)

3.10 ROBATEL Industries Drawing RT100 PRS 1011, "ROBATEL Transport Package RT100 Cask Sub Assy Weld Map Cask Body," Rev. E

3.11 ROBATEL Industries RT100 NM1000, "Robatel RT100 NM 1000 Bill of Materials," Rev. F

3.12 Omer W. Blodgett, "Design of Welded Structures", 1966

3.13 ENERCON Calculation RTL-001-CALC-ST-0202 Rev. 4, "Tie-Down Structural Evaluation"

3.14 Erik Oberg, et. al., "Machinery's Handbook", 26th Edition

3.15 ASME B&PV Code, Section II, 2007

3.16 ASME B&PV Code, Section III, Division 1 – Subsection NF, "Supports," 2007

3.17 Joseph Edward Shigley & Larry D. Mitchell, "Mechanical Engineering Design", 4th Edition

3.18 ASME B1.13M-2005, "Metric Screw Threads: M Profile"

3.19 Warren C. Young and Richard G. Budynas, "Roark's Formulas for Stress and Strain", 7th Edition

3.20 ANSI N14.6-1978, "American National Standard for Special Lifting Devices for Shipping Containers Weighing 10000 pounds (4500 kg) or More for Nuclear Materials"

3.21 KTA 3905, "Load Attaching Points on Loads in Nuclear Power Plants," Safety Standards of the (German) Nuclear Safety Standards Commission, June 1999 Edition including rectification of July 2000

3.22 ENERCON Calculation RTL-001-CALC-ST-0101 Rev. 0, "RT-100 Weight and Center of Gravity Calculation"

3.23 AISC, "Guide to Design Criteria for Bolted and Riveted Joints," 2nd Edition, 2007

4.0 Assumptions

4.1. The weight of the cask for the lifting evaluation is considered as the total weight of the cask and the maximum payload less the weight of the upper impact limiter. The cask lifting pockets can only be used with the upper impact limiter removed due to the configuration of the cask components. (Ref. 3.2) This assumption is acceptable without further evaluation.

4.2. The cask lifting yoke (Ref. 3.8) is used to lift the cask. The lifting yoke is designed to ensure that the lifting loads remain parallel to the sidewalls of the cask. The design of the lifting yoke is beyond the scope of this calculation and is not considered further.

4.3. It is possible for the center of gravity of the payload to shift ±10% of the interior dimensions of the cask containment (Ref. 3.22). The payload is significantly lighter than the fully loaded cask. Therefore, this shift has no significant effect on the lifting conditions since the change in payload location will have an inconsequential effect of the center of gravity of the fully-assembled, loaded cask, resulting in a maximum change of less than 4 cm in the overall center of gravity, which is approximately a 2.5% change (Ref. 3.22). Only the overall center of gravity location is used for this calculation. This assumption is acceptable without further evaluation.

4.4. A Dynamic Load Factor (DLF) of 1.35 is applied to the lift forces that act on the cask components during movement. ANSI N14.6 (Ref. 3.20) requires additional safety features for handling of critical loads. One option identified is to apply increased stress design factors on the load-bearing members; however, the standard does not recommend a value for the stress design factor. The German Nuclear Safety Standards Commission provides standard KTA-3905 for lifting loads in nuclear power plants. (Ref. 3.21) This standard requires a live load factor of 1.35 for dead weight lifts. This calculation uses the KTA-3905 live load factor value as the dynamic load factor. The dynamic load factor is applied to all load bearing members.

5.0 Design Inputs

5.1. The maximum weight of the fully assembled, loaded cask is 41,500 kg (91,492 lbs) (Ref. 3.2).

5.2. The nominal weight of the upper impact limiter is 2541 kg (5602 lbs) (Ref. 3.2).

5.3. The nominal weight of the lower impact limiter is 2448 kg (5397 lbs) (Ref. 3.2).

5.4. The nominal weight of the primary lid is 3648 kg (8042 lbs) (Ref. 3.2).

5.5. The nominal weight of the secondary lid is 857 kg (1889 lbs) (Ref. 3.2).

5.6. Per 10 CFR 71.45(a) (Ref. 3.1), any lifting attachment that is a structural part of a package must be designed with a minimum safety factor of three (3) against yielding when used to lift the package in the intended manner. Per ANSI N14.6, a factor of five (5) against ultimate stress shall also be used. A factor of three against yielding stress and a factor of five against ultimate stress will therefore be used in the calculation of the cask lifting load.

5.7. The material properties used for the cask shell, the lead shielding and the lid bolts shall be as given in Table 1, unless noted otherwise. The allowable values used are for the 50°C (Ref 3.1, Section 71.43 (g)).

5.8. A value of 9.81 m/s^2 will be used for the gravitational acceleration.

Table 1: Material Properties

Material	Temp (°C)	Strength (MPa) [1]		
		Yield (S_y)	Ultimate (S_u)	Membrane Allowable (S_m)
ASTM A240 Type 304/304L (Dual Certified) (Cask shell, lift pockets,)	-30	207	517	138
	40	207	517	138
	50	199	511	138
	65	184	492	138
	100	170	485	138
	150	154	456	138
	200	144	442	129
	250	135	437	122
ASTM AS-240 Type 304L (primary and secondary lid, upper and lower impact limiters outer shells)	-30	172	483	115
	40	172	483	115
	50	162	470	115
	65	157	463	115
	100	146	452	115
	150	132	421	115
	200	121	406	110
	250	114	398	103
ASTM SA-354 Grade BD (Bolting material)	-30	896	1030	299 = 2Sy/3
	40	896	1030	299
	50	869	1030	292
	65	855	1030	288
	100	816	1030	272
	150	792	1030	264
	200	768	1030	256
	250	737	1030	245
SA-479 Grade ER308 UNS S30880 (Weld material)	-30 to 40	205	515	----

[1] Material properties are taken from ASME B&PV Code, Section II, Part D (Ref. 3.15) by interpolation.

6.0 Methodology

The RT-100 transport cask is a safety-related structure in accordance with 10 CFR Part 71 (Ref. 3.1). The cask consists of a stainless steel containment structure with a lead shielding panel between the inner and outer cask wall, ductile stainless steel and foam upper and lower impact limiters, a pair of concentric, removable stainless steel cask lids and a pair of stainless steel lifting pockets on opposite sides of the cask body. Per Assumption 4.1, the upper impact limiter is removed and lifted separately during lifting operations. Per Design Input 5.6, a safety factor of three against yielding is used in determining the weight of the assembled cask for lifting, for each of the impact limiters and for each of the cask lids. (Ref. 3.2, 3.4, 3.5, 3.6, 3.7)

The evaluation of the RT-100 cask lifting pockets and outer shell is provided in this document to show that they meet all of the applicable requirements of 10 CFR 71.45 (Ref. 3.1) for the combined weight of the cask and the payload. The evaluations of the RT-100 upper impact limiter, lower impact limiter, primary lid and secondary lid lifting rings are provided in this document to show that they meet all of the applicable requirements of 10 CFR 71.45 (Ref. 3.1) for the dead weight of the component being lifted. The lifting rings and bolts utilized for lifting are checked for lifting mechanism failure, cask tear out failure and weld failure, as applicable. An evaluation is provided to demonstrate that failure of the lifting pockets under excessive load does not impair the cask's ability to meet the other applicable requirements of 10 CFR 71.45.

As an additional requirement, Robatel Technologies has committed to the NRC to meet the intent of the requirements of the special stress limits contained in ASME B&PV Code Section III, Division 1 – Subsection NF Subparagraph 3223.2 "Pure Shear"; or:

1. The average primary shear stress across a section loaded in pure shear, experienced as a result of Design Loadings, Test Loadings, or any Service Loadings, except those for which Level D Limits are designated, shall be limited to $0.6S_m$.
2. The maximum primary shear, experienced as a result of Design Loadings, Test Loadings, or any Service Loadings except those for which Level D Limits are designated, exclusive of stress concentration at the periphery of a solid circular section in torsion, shall be limited to $0.8S_m$. Primary plus secondary shear stresses shall be converted to stress intensities (equal to two times pure shear stress) and as such shall not exceed the basic stress limits of Tables NF- 3522(b)-1 and NF-3622(b)-1.

7.0 Calculations

NOTE: In many cases, calculations are developed using exact values, not the rounded numbers shown. In certain situations the numbers displayed may not be capable of providing the final solution. Using exact numbers, however, provides the most accurate solution possible.

7.1 Load Calculation

See Section 5.0 Design Inputs of this calculation for a list of all applicable loads and Section 6.0 (Methodology) for the applicable methodology and lifting conditions. The detailed calculation of loads follows.

Cask Weight (fully assembled and loaded), $W_c = 41{,}500$ kg (Design Input 5.1)

Upper Impact Limiter Weight, $W_{UL} = 2541$ kg (Design Input 5.2)

Total Lifting Weight, $W = W_c - W_{UL} = 38{,}959$ kg, use 39,500 kg

7.2 Tie-Down Arm Lifting Evaluation

Per 10 CFR 71.45(a) (Ref. 3.1), any structural part of the package, other than those components designated and designed for lifting activities, that could be used to lift the package must be capable of being rendered inoperable for lifting the package during transport, or must be designed with strength equivalent to that required for lifting attachments. The tie-down arms can be rendered inoperable through the use of padlocks on the tie-down eyes provided in each of the tie-down arms for securing the load (Refs. 3.2 and 3.13). The tie-down arms shall not be used for lifting and therefore do not need to be designed for the lifting loads. The tie-down arms are acceptable without further evaluation.

7.3 Primary Lid Lifting Evaluation

The primary lid can be lifted separately from the rest of the cask by the three removable M20 lifting rings described in Reference 3.11. The primary lid is evaluated for the working load limit in the lifting rings and for the tear-out stresses in the lid from the lifting activities. The lifting rings for the primary lid can only be used when the cask lid is separated from the cask body. The secondary cask lid is also removable, so the primary lid may be lifted with the secondary lid attached or separated from the primary lid. Conservatively, the combined primary and secondary lid is used for the lifting evaluation.

Primary Lid Design Information

Primary Lid Weight, $W_{PL} = 3648$ kg (Design Input 5.4)

Secondary Lid Weight, $W_{SL} = 857$ kg (Design Input 5.5)

Total Lid Lifting Weight, $W_L = W_{PL} + W_{SL} = 4505$ kg, use 4,600 kg

Number of Lifting Rings, $n_r = 3$ (Ref. 3.11)

Dynamic Load Factor, $DLF = 1.35$ (Assumption 4.4)

Primary Lid Lifting Ring Working Loads

The lifting rings on the primary lid are only used for lifting when the lid is detached from the cask body, and are rendered inoperable by removing the rings from the lid when the cask is assembled. The rings are therefore not considered to be a structural part of the package and do not need to be designed for the factor of safety against yielding (Design Input 5.6).

$$\text{Lifting Ring Load, } P_r = \frac{W_L \times DLF}{n_r} = \frac{4600 \times 1.35}{3} = 2070 \text{ kg}$$

$\text{Ring Working Load Limit, } P_{r,max} = 3000 \text{ kg}$ (Ref. 3.11)

$$\text{Factor of Safety, FS} = \frac{P_{r,max}}{P_r} = \frac{3000}{2070} = 1.45 > 1.0$$

Primary Lid Metal Tear-out Stresses

The primary lid is manufactured from ASTM A240 Type 304L material. (Ref. 3.11) This material is weaker than the M20 lifting ring material (ASTM A-354 Gr. BD), so failure will occur at the root of the primary lid material threads. The minimum required thread engagement length that prevents primary lid material failure is determined using the equation below. This equation is developed from the engagement length equation in Formula 1 from the Machinery's Handbook (Ref. 3.14 page 1490) and the internal thread stripping reduction, J, of Formula 3 and Formula 4 (pages 1490 and 1491) which apply when the internal thread material is weaker than the external thread material of the bolt.

$$\text{Minimum Engagement Length, } L_e = \frac{S_{bt} \times 2 \times A_b}{S_{Lt} \times \pi \times n \times D_{s,min} \times \left[\frac{1}{2 \times n} + 0.57735 \times (D_{s,min} - E_{n,max})\right]}$$

Where:

S_{bt} = Bolt external thread tensile strength, psi

A_b = Stress area of bolt external threads, in^2

S_{Lt} = Primary Lid internal thread tensile strength, psi

n = Number of threads per inch

$D_{s,min}$ = Minimum major bolt diameter, in

$E_{n,max}$ = Maximum pitch diameter of internal thread, in

The tensile strength of the primary lid and M20 bolt materials is the Ultimate Strength of the materials as given in Table 1. The constants in the equation assume customary units, so the metric units are converted.

$S_{bt} = 1030 \text{ MPa} = 150{,}000 \text{ psi}$ (Table 1)

$A_b = 245.0 \text{ mm}^2 = 0.38 \text{ in}^2$ (Ref. 3.17)

$S_{Lt} = 470 \text{ MPa} = 69{,}000 \text{ psi}$ (Table 1)

$p = \text{Thread Pitch} = 2.5 \text{ mm} = 0.098 \text{ in}$ (Ref. 3.17)

$n = \frac{1}{p} = \frac{1}{0.098} = 10.16$ Threads per inch

$D_{s,min} = 19.623 \text{ mm} = 0.773 \text{ in}$ (Ref. 3.18, Table 14)

$E_{n,max} = 17.744 \text{ mm} = 0.699 \text{ in}$ (Ref. 3.18, Table 15)

Using the equation for Minimum Engagement Length, L_e,

$$L_e = \frac{150{,}000 \times 2 \times 0.38}{69{,}000 \times \pi \times 10.16 \times 0.773 \times \left[\frac{1}{2 \times 10.16} + 0.57735 \times (0.773 - 0.699)\right]} = 0.73 \text{ in}$$
$$= 18.5 \text{ mm}$$

Provided Engagement Length, $L_{ep} = 32.0$ mm (Appendix 2 Part 07730-20)

$$\text{Factor of Safety, FS} = \frac{L_{ep}}{L_e} = \frac{32.0}{18.5} = 1.73 > 1.0$$

Therefore, it is concluded that the RT-100 primary lid lifting rings are acceptable for the applied loads during the required lifting activities.

7.4 Secondary Lid Lifting Evaluation

The secondary lid can be lifted separately from the rest of the cask by the three removable M20 lifting rings described in Reference 3.11. The primary and secondary lids can be lifted together or independently, as needed. The combined primary and secondary lid are evaluated for lifting in Section 7.3, so this evaluation is only considering the lifting of the secondary lid. The secondary lid is evaluated for the working load limit in the lifting rings and for the tear-out stresses in the lid from lifting activities. The lifting rings for the secondary lid can only be used when the cask lid is separated from the cask body.

Secondary Lid Design Information

Secondary Lid Weight, $W_{SL} = 857$ kg, use 900 kg (Design Input 5.5)

Number of Lifting Rings, $n_r = 3$ (Ref. 3.11)

Dynamic Load Factor, DLF = 1.35 (Assumption 4.4)

Lifting Ring Working Loads

The lifting rings on the secondary lid are only used for lifting when the lid is detached from the cask and are rendered inoperable by removing the rings from the lid when the cask is assembled. The rings are therefore not considered to be a structural part of the package and do not need to be designed for the factor of safety against yielding (Design Input 5.6).

$$\text{Lifting Ring Load, } P_r = \frac{W_{SL} \times DLF}{n_r} = \frac{900 \times 1.35}{3} = 405 \text{ kg}$$

Ring Working Load Limit, $P_{r,max} = 3000$ kg (Ref. 3.11)

$$\text{Factor of Safety, FS} = \frac{P_{r,max}}{P_r} = \frac{3000}{405} = 7.4 > 1.0$$

Secondary Lid Metal Tear-out Stresses

The secondary lid may be manufactured from either ASTM A240 Dual Certified Type 304/304L material or from ASTM SA-240 304L. (Ref. 3.11) Both of these materials are weaker than the M20 lifting ring material (ASTM A-354 Gr. BD), so failure will occur at the root of the secondary lid material threads. Since the ASTM SA-240 304L is the weaker of the two materials, it will be used as the material in the following calculations. The minimum required thread engagement length that prevents secondary lid material failure is determined using the equation below. This equation is developed from the engagement length equation in Formula 1 from the Machinery's Handbook (Ref. 3.14 page 1490) and the internal thread stripping reduction, J, of Formula 3 and Formula 4 (pages 1490 and 1491) which apply when the internal thread material is weaker than the external thread material of the bolt.

Minimum Engagement Length, L_e

$$= \frac{S_{bt} \times 2 \times A_b}{S_{Lt} \times \pi \times n \times D_{s,min} \times \left[\frac{1}{2 \times n} + 0.57735 \times (D_{s,min} - E_{n,max})\right]}$$

Where:

S_{bt} = Bolt external thread tensile strength, psi

A_b = Stress area of bolt external threads, in^2

S_{Lt} = Secondary lid internal thread tensile strength, psi

n = Number of threads per inch

$D_{s,min}$ = Minimum major bolt diameter, in

$E_{n,max}$ = Maximum pitch diameter of internal thread, in

The tensile strength of the secondary lid and M20 bolt materials is the Ultimate Strength of the materials as given in Table 1. The constants in the equation assume customary units, so the metric units are converted.

$S_{bt} = 1030\ \text{MPa} = 150{,}000\ \text{psi}$ (Table 1)

$A_b = 245.0\ \text{mm}^2 = 0.38\ \text{in}^2$ (Ref. 3.17)

$S_{Lt} = 470\ \text{MPa} = 69{,}000\ \text{psi}$ (Table 1)

p = Thread Pitch = 2.5 mm = 0.098 in (Ref. 3.17)

$n = \frac{1}{p} = \frac{1}{0.098} = 10.16$ Threads per inch

$D_{s,min} = 19.623\ \text{mm} = 0.773\ \text{in}$ (Ref. 3.18, Table 14)

$E_{n,max} = 17.744\ \text{mm} = 0.699\ \text{in}$ (Ref. 3.18, Table 15)

Using the equation for Minimum Engagement Length, L_e,

$$L_e = \frac{150{,}000 \times 2 \times 0.38}{69{,}000 \times \pi \times 10.16 \times 0.773 \times \left[\frac{1}{2 \times 10.16} + 0.57735 \times (0.773 - 0.699)\right]} = 0.73\ \text{in}$$

$$= 18.5\ \text{mm}$$

Provided Engagement Length, $L_{ep} = 32.0$ mm (Appendix 2 Part 07730-20)

Factor of Safety, $FS = \frac{L_{ep}}{L_e} = \frac{32.0}{18.5} = 1.73 > 1.0$

Therefore, it is concluded that the RT-100 secondary lid lifting rings are acceptable for the applied loads during the required lifting activities.

7.5 Upper Impact Limiter Lifting Evaluation

The upper impact limiter can be lifted separately from the rest of the cask by the three removable M20 lifting rings described in Reference 3.11. The upper impact limiter is evaluated for the working load limit in the lifting rings and for tear-out stresses in the impact limiter from the lifting activities. The lifting rings for the impact limiter can only be used when the impact limiter is separated from the cask body.

Upper Impact Limiter Design Information

Impact Limiter Weight, $W_{UL} = 2541$ kg, use 2,700 kg (Design Input 5.2)

Number of Lifting Rings, $n_r = 3$ (Ref. 3.11)

Dynamic Load Factor, DLF = 1.35 (Assumption 4.4)

Lifting Ring Working Loads

The lifting rings on the upper impact limiter are only used for lifting when the impact limiter is detached from the cask body, and are rendered inoperable by removing the rings from the impact limiter when the cask is assembled. The rings are therefore not considered to be a structural part of the package and do not need to be designed for the factor of safety against yielding (Design Input 5.6).

Lifting Ring Load, $P_r = \frac{W_{UL} \times DLF}{n_r} = \frac{2700 \times 1.35}{3} = 1215$ kg

Ring Working Load Limit, $P_{r,max} = 3000$ kg (Ref. 3.11)

Factor of Safety, $FS = \frac{P_{r,max}}{P_r} = \frac{3000}{1215} = 2.47 > 1.0$

Upper Impact Limiter Metal Tear-out Stresses

The upper impact limiter is manufactured from ASTM A240 Type 304L material. (Ref. 3.11) This material is weaker than the M20 lifting ring material (ASTM A-354 Gr. BD), so failure will occur at the root of the upper impact limiter material threads. The minimum required thread engagement length that prevents upper impact limiter material failure is determined using the equation below. This equation is developed from the engagement length equation in Formula 1 from the Machinery's Handbook (Ref. 3.14 page 1490) and the internal thread stripping reduction, J, of Formula 3 and Formula 4 (pages 1490 and 1491) which apply when the internal thread material is weaker than the external thread material of the bolt.

Minimum Engagement Length, L_e

$$= \frac{S_{bt} \times 2 \times A_b}{S_{Lt} \times \pi \times n \times D_{s,min} \times \left[\frac{1}{2 \times n} + 0.57735 \times (D_{s,min} - E_{n,max})\right]}$$

Where:

S_{bt} = Bolt external thread tensile strength, psi

A_b = Stress area of bolt external threads, in^2

S_{Lt} = Upper impact limiter internal thread tensile strength, psi

n = Number of threads per inch

$D_{s,min}$ = Minimum major bolt diameter, in

$E_{n,max}$ = Maximum pitch diameter of internal thread, in

The tensile strength of the upper impact limiter and M20 bolt materials is the Ultimate Strength of the materials as given in Table 1. The constants in the equation assume customary units, so the metric units are converted.

$S_{bt} = 1030 \text{ MPa} = 150{,}000 \text{ psi}$ (Table 1)

$A_b = 245.0 \text{ mm}^2 = 0.38 \text{ in}^2$ (Ref. 3.17)

$S_{Lt} = 470 \text{ MPa} = 69{,}000 \text{ psi}$ (Table 1)

p = Thread Pitch = 2.5 mm = 0.098 in (Ref. 3.17)

$$n = \frac{1}{p} = \frac{1}{0.098} = 10.16 \text{ Threads per inch}$$

$D_{s,min} = 19.623 \text{ mm} = 0.773 \text{ in}$ (Ref. 3.18, Table 14)

$E_{n,max} = 17.744 \text{ mm} = 0.699 \text{ in}$ (Ref. 3.18, Table 15)

Using the equation for Minimum Engagement Length, L_e,

$$L_e = \frac{150{,}000 \times 2 \times 0.38}{69{,}000 \times \pi \times 10.16 \times 0.773 \times \left[\frac{1}{2 \times 10.16} + 0.57735 \times (0.773 - 0.699)\right]} = 0.73 \text{ in} = 18.5 \text{ mm}$$

Provided Engagement Length, $L_{ep} = 32.0 \text{ mm}$ (Appendix 2 Part 07730-20)

$$\text{Factor of Safety, FS} = \frac{L_{ep}}{L_e} = \frac{32.0}{18.5} = 1.73 > 1.0$$

Therefore, it is concluded that the RT-100 upper impact limiter lifting rings are acceptable for the applied loads during the required lifting activities.

7.6 Lower Impact Limiter Lifting Evaluation

The lower impact limiter can be lifted separately from the rest of the cask by the use of three of the twelve M36 bolts, evenly spaced around the perimeter of the lower impact limiter, shown in Reference 3.6. The lower impact limiter is evaluated for the bolt stresses and for tear-out stresses in the lower impact limiter from the lifting activities. The bolts can only be used for lifting when the impact limiter is separated from the cask body.

Lower Impact Limiter Design Information

Lower Impact Limiter Weight, W_{LL} = 2448 kg, use 2600 kg (Design Input 5.3)

Number of Lifting Bolts, $n_b = 3$

Gravitational Acceleration, $g = 9.81\ m/s^2$ (Design Input 5.8)

Dynamic Load Factor, DLF = 1.35 (Assumption 4.4)

Bolt Stresses

The bolts on the lower impact limiter are only used for lifting when the lower impact limiter is detached from the cask body, and are rendered inoperable by securing them to the cask body as part of the assembled cask. The bolts are therefore not considered to be a structural part of the package with respect to lifting and do not need to be designed for the factor of safety against yielding (Design Input 5.6). Since the arrangement of the cables or straps used to lift the lower impact limiter may vary, the total lifting load is conservatively considered simultaneously in the vertical and horizontal directions.

$$\text{Bolt Tension}, T = \frac{W_{LL} \times DLF \times g}{n_b} = \frac{2600 \times 1.35 \times 9.81}{3} = 11477.7\ N$$

$$\text{Bolt Shear}, V = \frac{W_{LL} \times DLF \times g}{n_b} = \frac{2600 \times 1.35 \times 9.81}{3} = 11477.7\ N$$

$$\text{Bolt Stress Area}, A_b = 817.0\ mm^2 = 0.000817\ m^2$$ (Ref. 3.17)

$$\text{Bolt Tensile Stress}, \sigma_1 = \frac{T}{A_b} = \frac{11477.7}{0.000817 \times 1000} = 14048.6 \frac{kN}{m^2} = 14.0\ MPa$$

$$\text{Bolt Shear Stress}, \tau = \frac{V}{A_b} = \frac{11477.7}{0.000817 \times 1000} = 14048.6 \frac{kN}{m^2} = 14.0\ MPa$$

$$\text{Maximum Principal Stress}, \sigma_{p1} = \frac{1}{2} \times \left[\sigma_1 + \sqrt{\sigma_1^2 + 4 \times \tau^2}\right]$$ (Ref. 3.19)

$$= \frac{1}{2} \times \left[14.0 + \sqrt{14.0^2 + 4 \times 14.0^2}\right] = 22.7\ MPa$$

$$\text{Maximum Principal Stress}, \sigma_{p2} = \frac{1}{2} \times \left[\sigma_1 - \sqrt{\sigma_1^2 + 4 \times \tau^2}\right]$$ (Ref. 3.19)

$$= \frac{1}{2} \times \left[14.0 - \sqrt{14.0^2 + 4 \times 14.0^2}\right] = -8.7\ MPa$$

$$\text{Maximum Shear Stress}, \tau_{max} = \frac{\sigma_{p1} - \sigma_{p2}}{2} = \frac{22.7 - (-8.7)}{2}$$ (Ref. 3.19)

$$= 15.7\ MPa$$

Bolt Yield Stress $S_y = 896\ MPa$ (Table 1)

$$\text{Allowable Shear Stress}, S_a = 0.6 \times S_y = 0.6 * 896 = 537.6\ MPa$$

$$\text{Factor of Safety}, FS = \frac{S_a}{\tau_{max}} = \frac{537.6}{15.7} = 34.2 > 3.0$$

Lower Impact Limiter Metal Tear-out Stresses

The lower impact limiter is manufactured from ASTM A240 Type 304L material. (Ref. 3.11) This material is weaker than the M36 bolt material (ASTM A-354 Gr. BD), so failure will occur at the root of the lower impact limiter material threads. The

minimum required thread engagement length that prevents lower impact limiter material failure is determined using the equation below. This equation is developed from the engagement length equation in Formula 1 from the Machinery's Handbook (Ref. 3.14 page 1490) and the internal thread stripping reduction, J, of Formula 3 and Formula 4 (pages 1490 and 1491) which apply when the internal thread material is weaker than the external thread material of the bolt.

Minimum Engagement Length, L_e

$$= \frac{S_{bt} \times 2 \times A_b}{S_{Lt} \times \pi \times n \times D_{s,min} \times \left[\frac{1}{2 \times n} + 0.57735 \times (D_{s,min} - E_{n,max})\right]}$$

Where:

S_{bt} = Bolt external thread tensile strength, psi

A_b = Stress area of bolt external threads, in^2

S_{Lt} = Lower impact limiter internal thread tensile strength, psi

n = Number of threads per inch

$D_{s,min}$ = Minimum major bolt diameter, in

$E_{n,max}$ = Maximum pitch diameter of internal thread, in

The tensile strength of the lower impact limiter and M36 bolt materials is the Ultimate Strength of the materials as given in Table 1. The constants in the equation assume customary units, so the metric units are converted.

S_{bt} = 1,030 MPa = 150,000 psi (Table 1)

A_b = 817.0 mm^2 = 1.27 in^2 (Ref. 3.17)

S_{ct} = 470 MPa = 69,000 psi (Table 1)

p = Thread Pitch = 4.00 mm = 0.157 in (Ref. 3.17)

$n = \frac{1}{p} = \frac{1}{0.157} = 6.35$ Threads per inch

$D_{s,min}$ = 35.465 mm = 1.396 in (Ref. 3.18, Table 14)

$E_{n,max}$ = 33.342 mm = 1.313 in (Ref. 3.18, Table 15)

Using the equation for Minimum Engagement Length, L_e,

$$L_e = \frac{150{,}000 \times 2 \times 1.27}{69{,}000 \times \pi \times 6.35 \times 1.396 \times \left[\frac{1}{2 \times 6.35} + 0.57735 \times (1.396 - 1.313)\right]} = 1.56 \text{ in}$$
$$= 39.5 \text{ mm}$$

Provided Engagement Length, L_{ep} = 75.0 mm (Ref. 3.6)

$$\text{Factor of Safety, FS} = \frac{L_{ep}}{L_e} = \frac{75.0}{39.5} = 1.90 > 1.0$$

Therefore, it is concluded that the RT-100 lower impact limiter bolts are acceptable for the applied loads during the required lifting activities.

7.7 Assembled Cask Lifting Evaluation

The cask is lifted by using the two lifting pockets that are welded to the cask exterior sidewall on opposite sides of the cask body. The assembled and loaded cask is lifted with the upper impact limiter removed to accommodate the connection between the lift yoke and the lifting pockets. The cask lifting load is the total weight of the fully assembled cask, including the payload, but with the upper impact limiter load removed. The upper impact limiter is lifted separately (Section 7.5). The lifting pockets are evaluated for the tear-out stress, bearing stress, and weld stress due to the required lifting activities. The lifting pockets are also evaluated for pure shear stress as described in ASME Section III Subsection NF.

Lifting Pocket Design Information

The lifting pockets are manufactured from blocks of ASTM A240 Dual Certified Type 304/304L stainless steel that are welded to opposite sides of the outer shell of the cask body, also manufactured from ASTM A240 Dual Certified Type 304/304L stainless steel. The weld material is SA-479 Grade ER308 UNS S30880. Of these two materials, the lifting pockets and cask outer shell are manufactured from the weaker material; therefore the lifting pockets are the subject of the following evaluations. The welds extend down both sides and along the bottom of the lifting pockets, forming a "U" shape. The lifting pockets have a cutout that allows the lifting yoke to pass downward and through the lifting pocket. The connection is completed with a rectangular shaped retaining pin that is inserted through cutouts in both the lifting pocket and the lifting yoke. Figure 1 provides the configuration and dimensions of the lifting pockets and shows the cutouts for the lifting yoke and retaining pin.

Total Cask Lifting Weight, $W = 39{,}500\ \text{kg}$ (Section 7.1)

Number of Lifting Pockets, $n_p = 2$ (Ref. 3.8)

Gravitational Acceleration, $g = 9.81\ \text{m/s}^2$ (Design Input 5.8)

Dynamic Load Factor, $DLF = 1.35$ (Assumption 4.4)

$$\text{Vertical Shear Load, } P_v = \frac{W \times DLF \times g}{n_p} = \frac{39500 \times 1.35 \times 9.81}{2} \times \frac{1\ \text{kN}}{1000\ \text{N}}$$
$$= 261.6\ \text{kN per pocket}$$

304/304L Yield Strength, $S_{yL} = 199\ \text{MPa}$ (Table 1)

304/304L Ultimate Tensile Strength, $S_{uL} = 511\ \text{MPa}$ (Table 1)

Yielding Factor of Safety, $f_{sy} = 3$ (Design Input 5.6)

Ultimate Factor of Safety, $f_{su} = 5$ (Design Input 5.6)

The critical dimensions for the weld evaluation are as follows. These dimensions ignore the dimensions of the welds.

Lifting Pocket Length, $L_p = 191\ \text{mm} = 0.191\ \text{m}$ (Figure 1)

Lifting Pocket Edge Distance, $d_p = 55\ \text{mm} = 0.055\ \text{m}$ (Figure 1)

Lifting Pocket Eye Length, $L_e = 84\ \text{mm} = 0.084\ \text{m}$ (Figure 1)

$\text{Retaining Pin Dimensions}, W_p = 60 \text{ mm}$ (Ref. 3.9)

The "eye" refers to the rectangular cutout in the lifting pocket for the retaining pin and the eye length is the vertical height of the eye. The lifting pocket length is the distance from the horizontal centerline of the retaining pin eye to the top of the lifting pocket. The lifting pocket edge distance refers to the vertical height of the recessed cap on the lifting pocket.

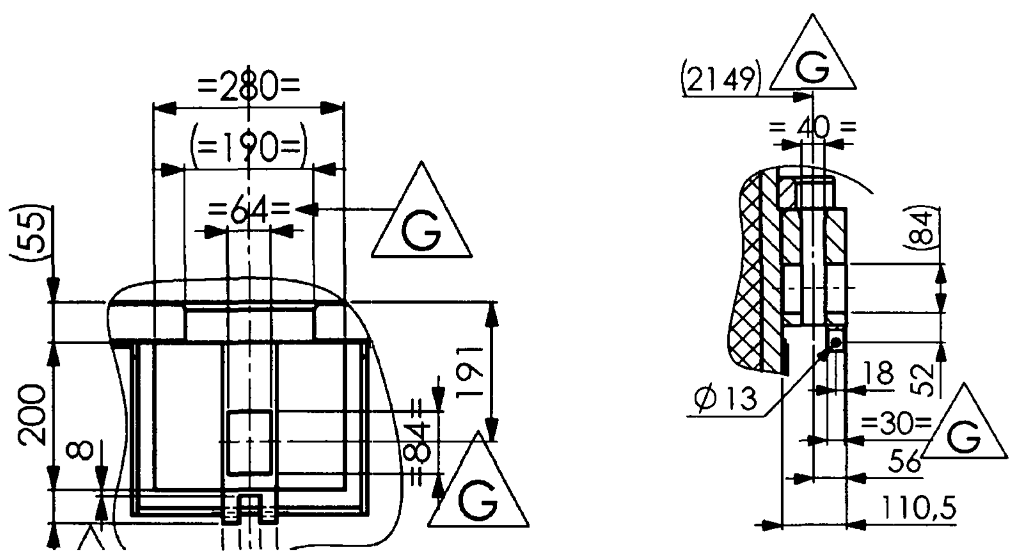


Figure 1. Lifting pocket with cutout for lifting yoke and retaining pin (Ref. 3.3)

Lifting Pocket Tear-out Stresses

The lifting pockets are used for lifting the assembled and loaded cask body, without the upper impact limiter, and are rendered inoperable by removing the lifting attachment from the lifting pocket during transport. The lifting pockets are considered to be a structural part of the package with respect to lifting and shall be designed for the factor of safety against yielding and ultimate stresses (Design Input 5.6). A lifting yoke is used to lift the assembled cask body and to ensure that the lifting straps or cables remain parallel to the body of the cask during lifting operations. (Assumption 4.2) The tear-out stresses for the lifting pocket retaining pin hole are as follows:

The critical tear-out area for each cask lifting pocket is determined from Reference 3.3.

$$\text{Lifting Eye Tear} - \text{out distance}, d_{to} = L_p - d_p - \frac{L_e}{2} = 0.191 - 0.055 - \frac{0.084}{2} = 0.0940 \text{ m}$$

$$\text{Lifting Pocket Thickness}, t_p = 110.5 - 40 = 70.5 \text{ mm} = 0.071 \text{ m}$$

$$\text{Lifting Eye Tear} - \text{out Area}, A_{to} = d_{to} \times t_p = 0.0940 \times 0.071 = 0.00663 \text{ m}^2$$

The tear-out stresses for the lifting pocket are calculated:

$$\text{Nominal Tear – out Stress}, \tau_{to} = \frac{P_v}{2 \times A_{to}} = \frac{261.6}{2 \times 0.00663} = 19734 \frac{kN}{m^2} = 19.7\ MPa$$

$$\text{Allowable Yield Stress}, \sigma_y = 0.6 \times S_{yL} = 119\ MPa \qquad \text{(Table 1)}$$

$$\text{Allowable Ultimate Stress}, \sigma_u = 0.6 \times S_{uL} = 307\ MPa \qquad \text{(Table 1)}$$

$$\text{Yield Factor of Safety, FS} = \frac{\sigma_y}{\tau_{to}} = \frac{119}{19.7} = 6.05\ > 3.0$$

$$\text{Ultimate Factor of Safety, FS} = \frac{\sigma_u}{\tau_{to}} = \frac{307}{19.7} = 15.54\ > 5.0$$

Lifting Pocket Bearing Stresses

The bearing stress in the lifting pocket from the yoke retaining pin is calculated as follows. The acceptance criterion for the pocket bearing stress is yield for loads in bearing. The factor of safety for these calculations is 1.0.

$$\text{Lifting Pocket Bearing Area}, A_b = W_p \times t_p = 0.06 \times 0.071 = 0.00423\ m^2$$

$$\text{Nominal Bearing Stress}, \tau_b = \frac{P_v}{A_b} = \frac{261.6}{0.00423} = 61834 \frac{kN}{m^2} = 61.8\ MPa$$

$$\text{Allowable Yield Stress}, \tau_y = S_{yL} = 199\ MPa \qquad \text{(Table 1)}$$

$$\text{Allowable Ultimate Stress}, \tau_{Au} = S_{uL} = 511\ MPa \qquad \text{(Table 1)}$$

$$\text{Yield Factor of Safety, FS} = \frac{\tau_y}{\tau_b} = \frac{199}{61.8} = 3.22\ > 1.0$$

$$\text{Ultimate Factor of Safety, FS} = \frac{\tau_{Au}}{\tau_b} = \frac{511}{61.8} = 8.26\ > 1.0$$

Lifting Pocket Weld Stresses

The stresses in the welds attaching the lifting pocket to the cask outer shell are found by applying the shear load from the lifting pockets to the weld around the perimeter of the plate. Based on the safety factors for the lifting pocket, yielding will control the weld evaluation.

$$\text{Weld Lifting Load}, P_w = P_v = 261.6\ kN$$

$$\text{Cask Yield Strength}, S_{yL} = 199\ MPa \qquad \text{(Table 1)}$$

$$\text{Cask Ultimate Strength}, S_{uL} = 511\ MPa \qquad \text{(Table 1)}$$

$$\text{Weld Yield Strength}, S_{wy} = 205\ MPa \qquad \text{(Table 1)}$$

$$\text{Weld Ultimate Strength}, S_{wu} = 515\ MPa \qquad \text{(Table 1)}$$

Conservatively, the upper section of the pocket is considered to take the full lifting load. The lifting pocket is seal welded to and bears upon the cask bolting ring. The lifting load is therefore shared between the lifting pocket weld and the bolting ring. Conservatively, the full load is considered to be taken by the lifting pocket weld only.

The stresses in the welds attaching the lifting pocket to the cask outer shell are found by applying the shear load from the lifting pockets to the weld around the perimeter of

the lifting pocket. Based on the safety factors for the lifting pocket, yielding controls the weld evaluation. The welds on the lifting pockets are evaluated as a line force on the weld as described in Reference 3.12 (pages 7.4-6 and 7, Tables 4 and 5). Since the cask is lifted using a yoke that maintains the force in a vertical direction, there are no bending or twisting loads, so the section Modulus and the polar moment of inertia are zero and can be ignored.

Lifting Pocket Weld Design Features (Ref. 3.8)

Refer to Figure 2 for the related dimensions for the lift pocket weld.

Length of horizontal weld, $b = 0.28$ m

Length of vertical weld, $d = 0.20$ m

Length of weld, $A_w = b + 2d = 0.68$ m

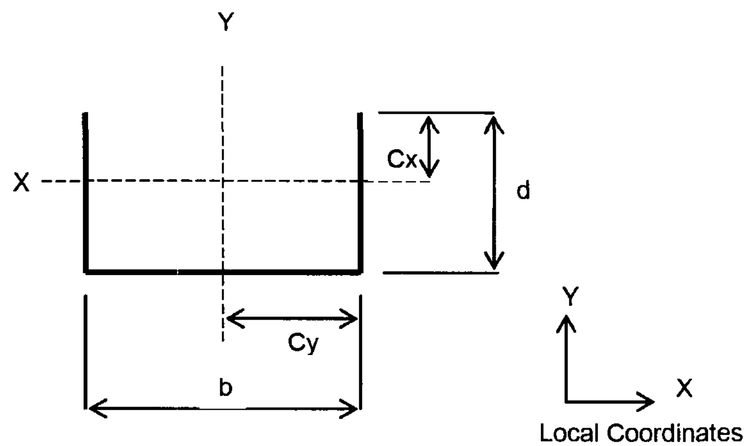


Figure 2. Weld Dimensions

Refer to Figure 3 for a description of the weld throat size and base metal thickness. The calculation uses the smaller of the weld size or the base metal thickness.

Weld Throat Size, $T_w = 0.015$ m (Figure 3) (Ref. 3.10)

Base Metal (Cask Wall) Thickness, $T_c = 0.035$ m

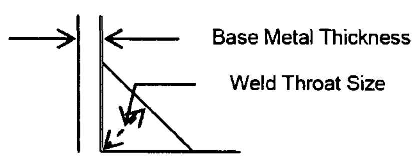


Figure 3. Weld Throat

Loading at center of pattern (using local coordinate previously defined)

$F_y = 261.6$ kN

The force on the weld is calculated as follows:

$$f_{vy} = \frac{F_y}{A_w} = \frac{261.6}{0.68} = 384.71 \frac{kN}{m}$$

Weld Allowable Yield Stress, $\tau_{wya} = 0.6 \times S_{wy} \times T_w \times 1000$

$$= 0.6 \times 205 \times 0.015 \times 1000 = 1845 \text{ kN/m}$$

Weld Allowable Ultimate Stress, $\tau_{wua} = 0.6 \times S_{wu} \times T_w \times 1000$
$= 0.6 \times 515 \times 0.015 \times 1000 = 4635 \text{ kN/m}$

$$\text{Cask Allowable Yield Stress, } \tau_{yaL} = \frac{0.6 \times S_{yL} \times T_c \times 1000}{0.7071} = \frac{0.6 \times 199 \times 0.035 \times 1000}{0.7071}$$
$= 5910 \text{ kN/m}$

$$\text{Cask Allowable Ultimate Stress, } \tau_{uaL} = \frac{0.6 \times S_{uL} \times T_c \times 1000}{0.7071}$$
$$= \frac{0.6 \times 511 \times 0.035 \times 1000}{0.7071} = 15{,}176 \text{ kN/m}$$

$$\text{FS for Weld Yield Stress} = \frac{\tau_{wya}}{f_w} = \frac{1845}{384.71} = 4.80 > 3.0$$

$$\text{FS for Weld Ultimate Stress} = \frac{\tau_{wua}}{f_w} = \frac{4635}{384.71} = 12.05 > 5.0$$

$$\text{FS for Cask Yield Stress} = \frac{\tau_{yaL}}{f_w} = \frac{5910}{384.71} = 15.36 > 3.0$$

$$\text{FS for Cask Ultimate Stress} = \frac{\tau_{uaL}}{f_w} = \frac{15{,}176}{384.71} = 39.45 > 5.0$$

Lifting Pocket Average Pure Shear

The lifting pocket average pure shear is evaluated in accordance with ASME Section III Subsection NF Subparagraph 3223.2 and is limited to 0.6 S_m. The factor of safety is determined by comparing the pure shear to the lifting pocket tear out stress. For the lifting pocket weld evaluation, the average pure shear is evaluated as follows.

Cask Membrane Strength, $S_m = 115$ MPa (Table 1)

Cask Allowable Pure Shear, $S_{ap} = 0.6 \times S_m = 0.6 \times 115 = 69.0$ MPa

$$\text{FS for Cask Pure Shear} = \frac{S_{ap}}{\tau_{to}} = \frac{69.0}{19.7} = 3.50 > 1.0 \text{ cask pure shear is OK}$$

Summary of Results

Table 2 provides a summary of the Factors of Safety for each of the lifting conditions that are evaluated for the assembled cask. The table shows that all of the lifting conditions meet the required factor of safety: greater than 3.0 against yield and greater than 5.0 against ultimate stress for the tear out and weld stresses and a greater than 1.0 for the bearing stresses and average pure shear.

Table 2. Summary of results for lifting assembled cask

	Factor of Safety	
Lifting Condition Evaluated	**Yield (>3)**	**Ultimate (>5)**
Lifting Pocket Tear-out Stresses	6.05	15.54
Lifting Pocket Weld Stresses: Weld	4.80	12.05
Lifting Pocket Weld Stresses: Cask	15.36	39.45
	Factor of Safety (>1)	
Lifting Pocket Bearing Stresses	3.22	8.26
Lifting Pocket Average Pure Shear	3.50	

7.8 Failure of Cask Lifting Pockets Under Excessive Loads

The lifting pocket has a factor of safety of 7.4 against yield for lifting eye tear-out and 4.80 against yield for weld failure (Section 7.7). Under excessive load, the first component to reach yield would be the weld attaching the lifting pocket to the cask body. As the weld starts to deform, the pocket would become engaged under the impact limiter attachment ring, providing additional support. The next stress to exceed yield would be the tear out stress in the lifting pocket, causing the lifting yoke and pin to tear free of the cask. This scenario would not impair the ability of the cask to perform its function.

Therefore, the RT-100 cask meets the excessive load requirements of Section 71.45(a) of Reference 3.1.

Appendix 1

DELETED

Appendix 2

Lifting Ring Design Information

norelem Anneau de levage

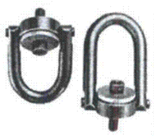
nlm 07730

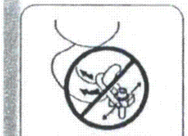
Matière:
Acier de traitement.

Finition:
Bruni.

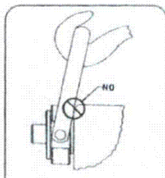
Exemple de commande:
nlm 07730-10

Nota:
Chaque anneau fait l'objet, après le contrôle de charge (coefficient de sécurité 1,5) d'un contrôle visuel. Chaque anneau de levage est accompagné d'une fiche technique de sécurité pour l'installation.
Ne pas utiliser de rondelle ou d'entretoise entre l'anneau et la surface d'appui.
Les vis sont à serrer au couple indiqué. Elles doivent être contrôlées et resserrées à intervalles réguliers. Après le montage, il y a lieu de vérifier si l'anneau pivote librement dans tous les sens.
Soulever avec précaution!
Eviter les chocs!
Ne dépasser sous aucun prétexte la charge admissible poinçonnée sur l'anneau.

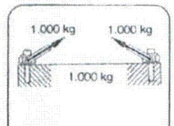




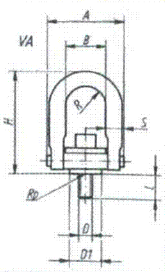
Attention ! N'utilisez en aucun cas des élingues ou autres dispositifs de levage trop grands, qui risqueraient d'écarter l'anneau ou de provoquer l'ouverture de l'arceau en U.



Vérifiez la liberté de rotation / de pivotement de l'anneau dans tous les sens.



Evitez les angles trop aigus. Pour élinguer une charge de 1.000 kg attachée en deux points avec un angle de 30°, chaque suspension doit supporter une charge de 1.000 kg.

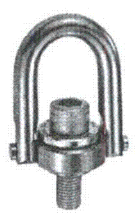


Référence Standard	Référence Long	D	D_1	A	B	H		L	R	S	Charge admis. max. en kg	Couple de serrage M_A (Nm)	kg Standard
						Standard	Long						
07730-08	–	M 8	19,0	46,7	22	67,8	–	12,5	10,9	9,7	400	9,81	0,153
07730-10	–	M10	19,0	46,7	22	67,8	–	17,5	10,9	9,7	450	16,70	0,162
07730-12	07730-112	M12	38,1	89,4	46	121,4	170,7	19,0	22,4	19,0	1050	37,30	1,057
07730-16	07730-116	M16	38,1	89,4	46	121,4	170,7	29,0	22,4	19,0	1900	80,40	1,103
07730-201	07730-1201	M20	38,1	89,4	46	121,4	170,7	34,0	22,4	19,0	2150	133,00	3,112
07730-20	07730-120	M20	58,7	130,6	70	165,6	206,0	32,0	35,6	25,4	3000	133,00	3,112
07730-24	07730-124	M24	58,7	130,6	70	165,6	206,0	37,0	35,6	25,4	4200	304,00	3,203
07730-30	–	M30	81,0	165,1	90	221,7	–	41,9	44,5	31,7	7000	588,00	6,300
07730-36	–	M36	106,4	217,2	115	316,7	–	63,5	57,2	44,4	11000	981,00	15,500
07730-42	–	M42	106,4	217,2	115	316,7	–	68,0	57,2	44,4	12500	981,00	16,000
07730-48	–	M48	106,4	217,2	115	316,7	–	88,0	57,2	44,4	13500	981,00	16,800

norelem Anneau de levage

à revêtement Envirolox®

nlm 07735



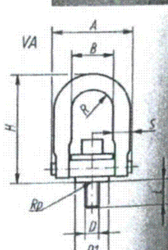
Matière:
Acier de traitement.

Finition:
Anneau: revêtu Envirolox®.
Rondelle: bichromaté.

Exemple de commande:
nlm 07735-10

Nota:
Chaque anneau fait l'objet, après le contrôle de charge (coefficient de sécurité 2) d'un contrôle visuel. Le nouveau revêtement de protection Envirolox® procure une meilleure protection contre les conditions d'environnement sévères. Applications possibles: Atmosphère corrosive, comme p. ex. dans le transport maritime, dans l'industrie chimique etc.

Consignes de sécurité: voir nlm 07730.



Référence	A	B	D	D_1	H	L	R	S	Charge max. admissible en kg	Couple de serrage M_A (Nm)	kg
07735-08	46,7	22,0	M 8	19,0	67,8	12,5	10,9	9,7	400	9,81	0,153
07735-10	46,7	22,0	M10	19,0	67,8	17,5	10,9	9,7	450	16,70	0,162
07735-12	89,4	46,0	M12	38,1	121,4	19,0	22,4	19,0	1050	37,30	1,057
07735-16	89,4	46,0	M16	38,1	121,4	29,0	22,4	19,0	1900	80,40	1,103
07735-20	89,4	46,0	M20	38,1	121,4	34,0	22,4	19,0	2150	133,00	3,112
07735-120	130,6	70,0	M20	58,7	165,6	32,0	35,6	25,4	3000	133,00	3,112
07735-24	130,6	70,0	M24	58,7	165,6	37,0	35,6	25,4	4200	304,00	3,203
07735-30	165,1	90,0	M30	81,0	221,7	41,9	44,5	31,7	7000	588,00	6,300
07735-130	165,1	90,0	M30	81,0	221,7	61,7	44,5	31,7	7000	588,00	6,350
07735-36	217,2	115,0	M36	106,4	316,7	63,5	57,2	44,4	11000	981,00	15,500
07735-42	217,2	115,0	M42	106,4	316,7	68,0	57,2	44,4	12500	981,00	16,000
07735-48	217,2	115,0	M48	106,4	316,7	88,0	57,2	44,4	13500	981,00	16,80[illegible]
07735-64	297,6	152,4	M64	146,0	419,1	96,0	76,2	57,2	22500	2845,00	40,0[illegible]

Appendix 3

Lifting Pin Design Dimensions

Rick Van Galder

From:	Christopher Dane <cdane@robateltech.com>
Sent:	Friday, September 13, 2013 8:29 AM
To:	Curt Lindner
Cc:	JF.Damon - ROBATEL
Subject:	RE: lifting calculation

Curt,

The dimensions of the pin are the ones sent for the calculation R4 (60 x 80) and the pin drawing revision is one revision up
102885 MD 3114-C1-B
Whatever the revision was, it is one rev up.

BR
Chris

From: Christopher Dane [mailto:cdane@robateltech.com]
Sent: Wednesday, September 11, 2013 10:02 AM
To: alangston@tliusa.com
Cc: clindner@enercon.com
Subject: lifting calculation
Importance: High

Please find attached for review

BR

Christopher Dane

Engineering Manager
Robatel Technologies LLC

v: 540.989.2878 x1005
m: 540.525.9522

Please consider the environment before printing this e-mail