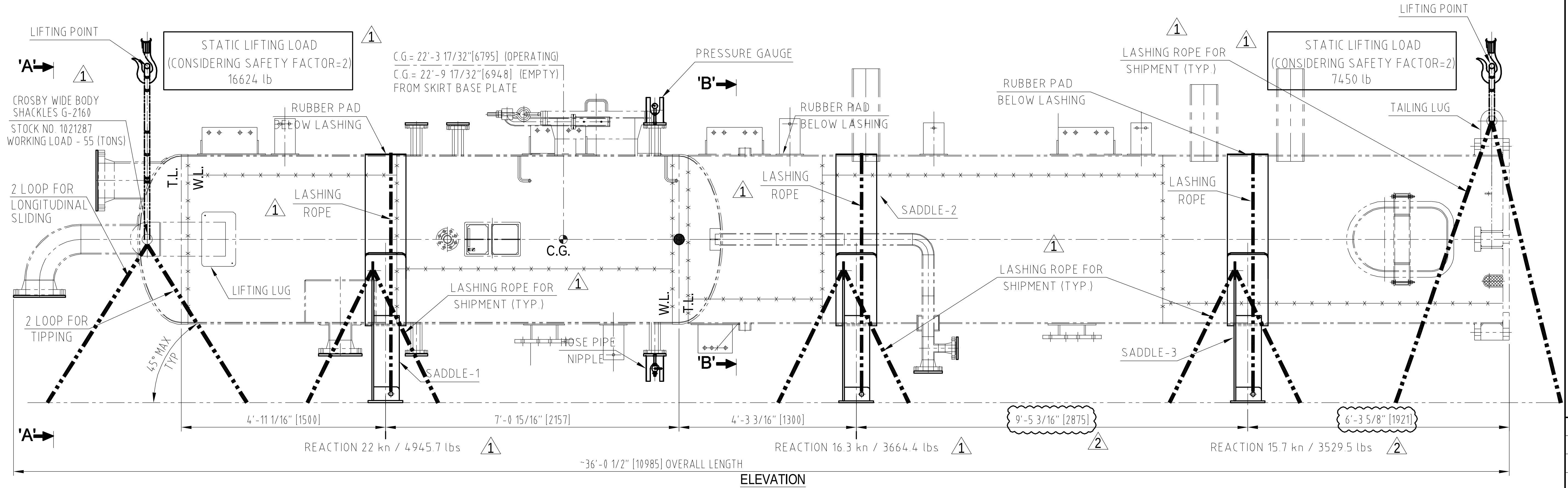
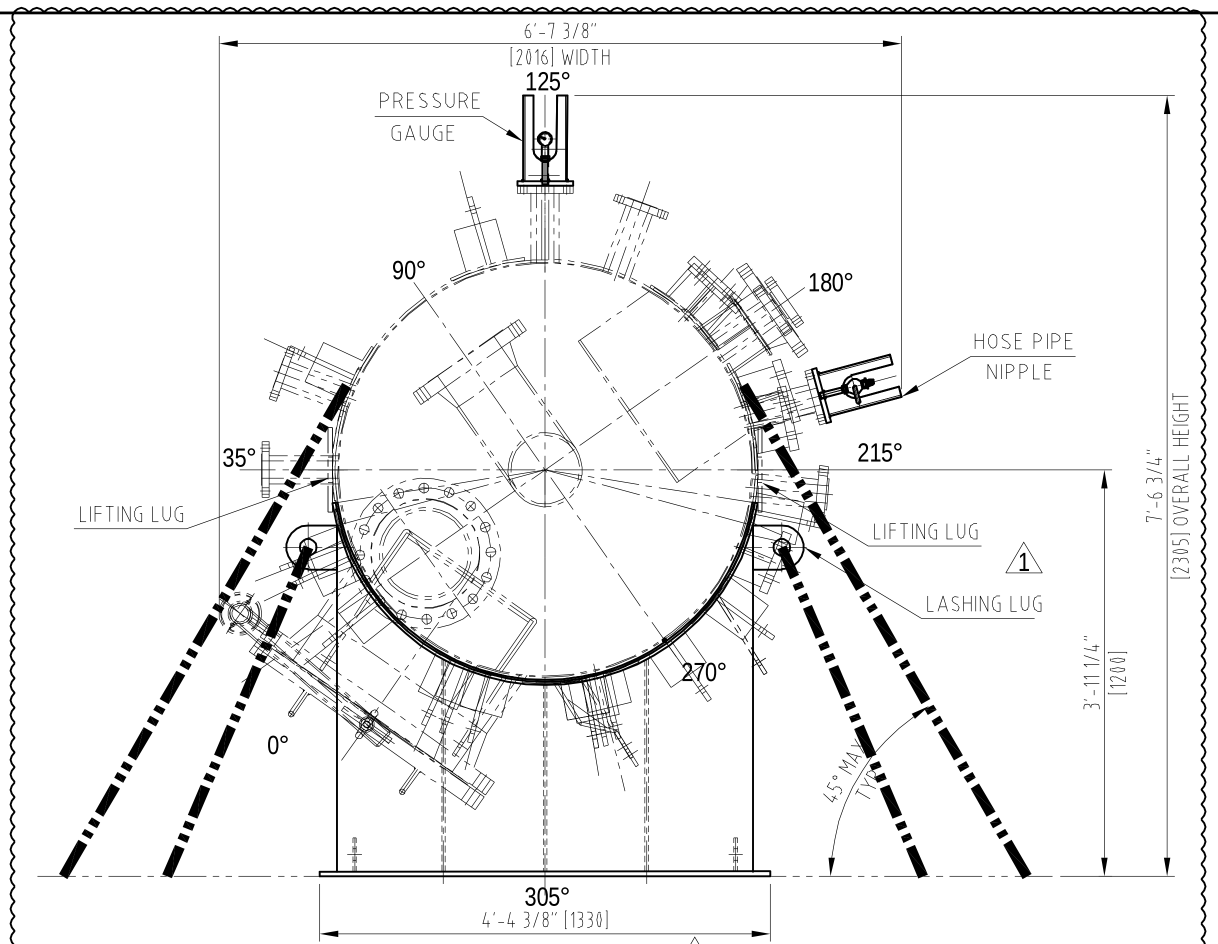
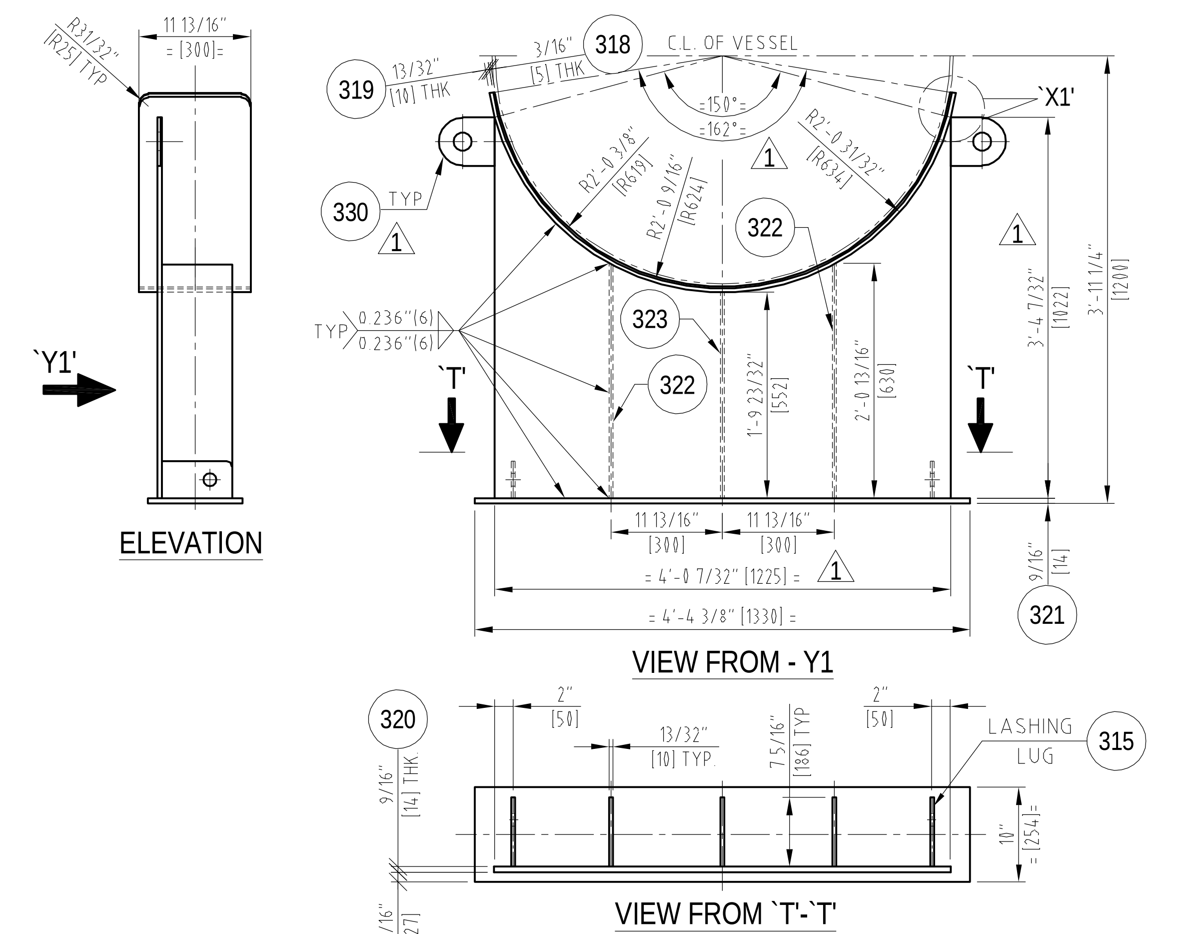


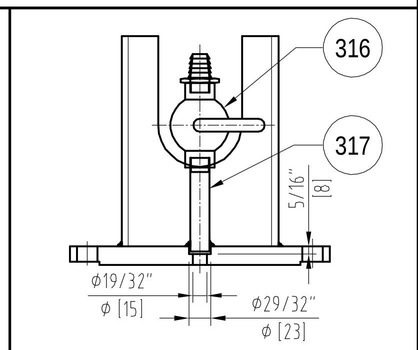
ELEVATION



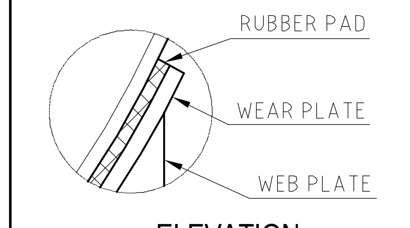
VIEW FROM `A'-`A'



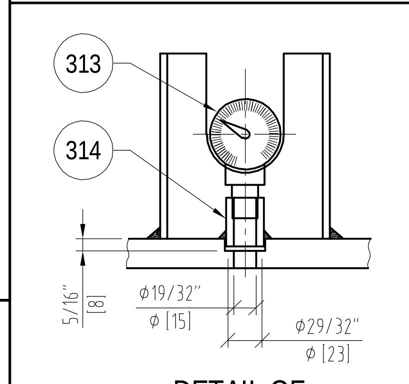
VIEW FROM `T'-`T'
DETAIL FOR SADDLE 2 & 3



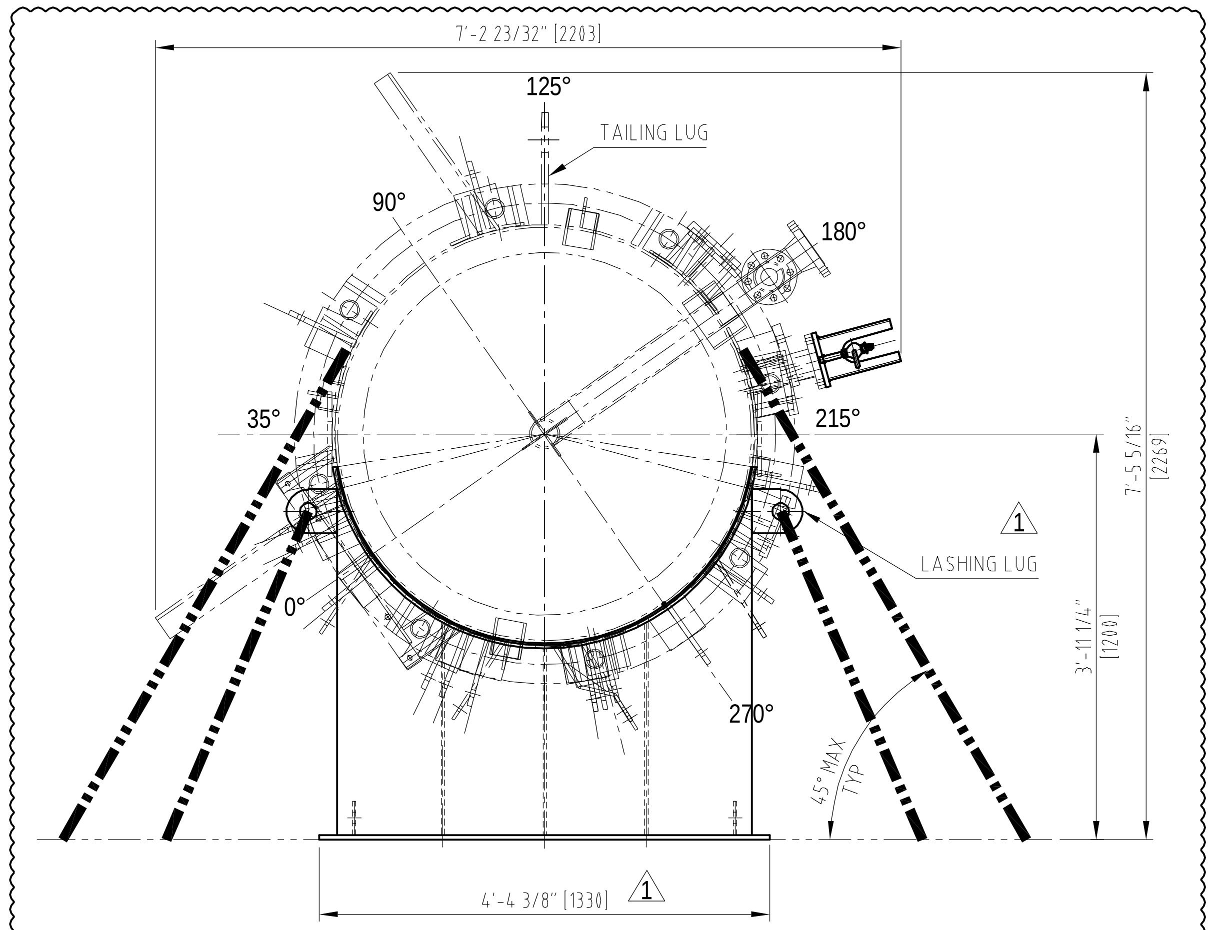
DETAIL OF HOSE PIPE NIPPLE



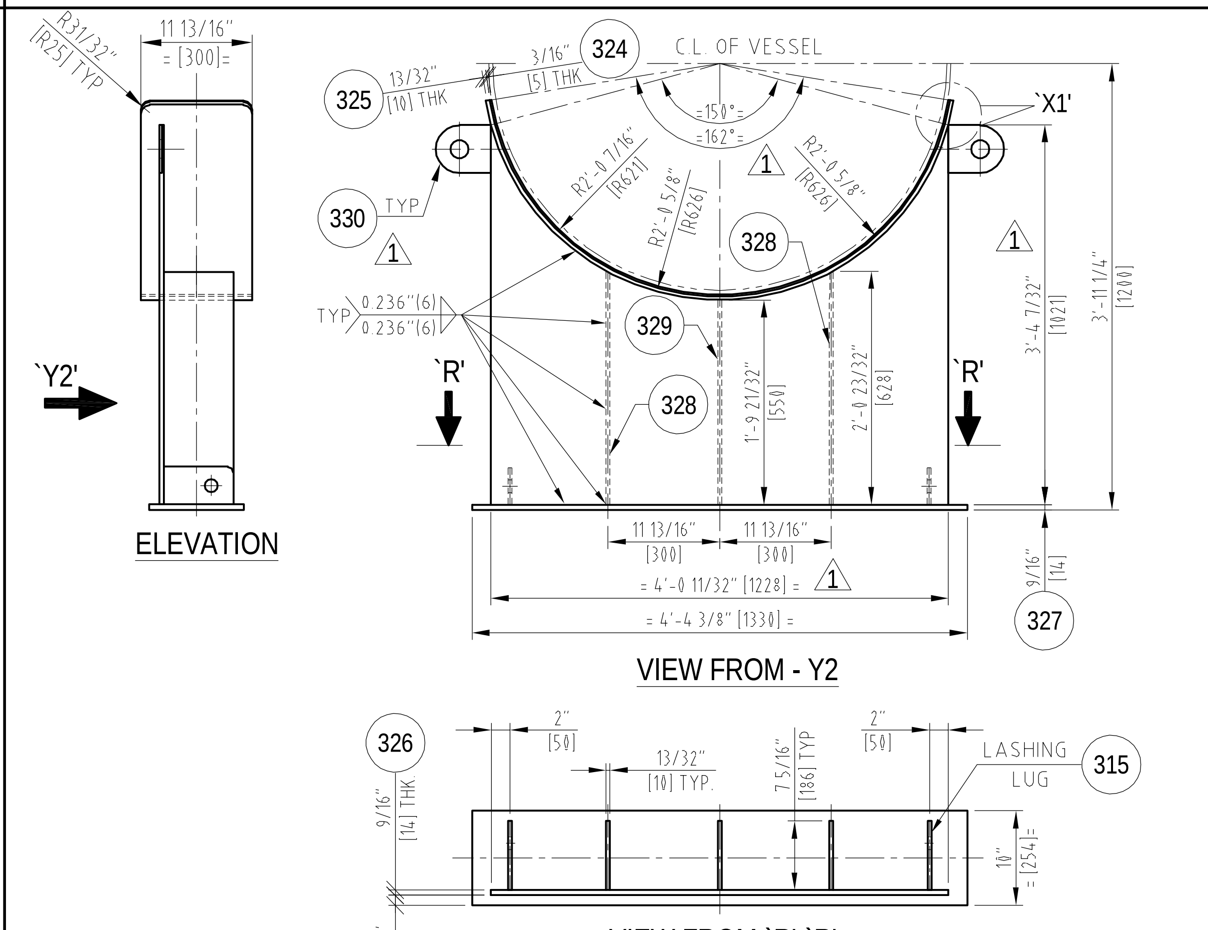
ELEVATION
TYP. DETAIL OF `X1'



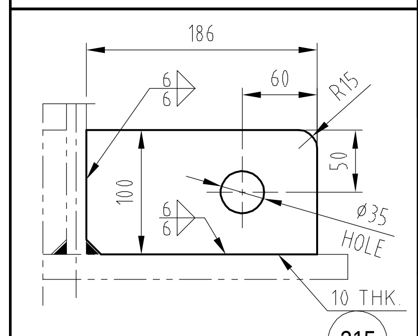
DETAIL OF PRESSURE GAUGE



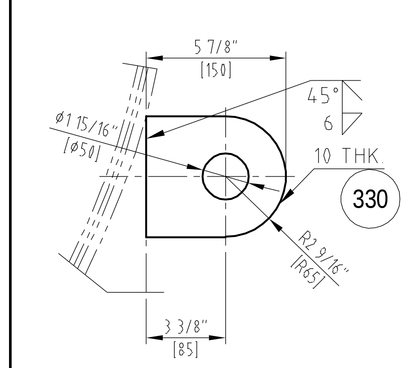
VIEW FROM `B'-`B'



VIEW FROM `R'-`R'
DETAIL FOR SADDLE 1



LASHING LUG DETAIL



TOP SIDE LASHING LUG

NOTES:-
1) ALL DIMENSIONS ARE IN INCH / [mm]. UNLESS OTHERWISE SPECIFIED.
2) FOR ALL NOTES REF. SHEET NO. - 2

EQPT. SHIPPING WT. = ~10225 [4640] lb [kg]
TOTAL WT. FOR SUPPORT = ~1808[820] lb [kg]
GROSS WT = ~10225 [4640] + ~1808[820] = ~12037 [5460] lb [kg]

OVERALL SIZE OF EQUIPMENT-
WITHOUT INSULATION:
LENGTH ~ 36'-0 1/2" [10985]
WIDTH ~7'-4 19/32" [2250]
HEIGHT ~7'-6 17/32" [2300]

TRANSPORTATION BILL OF MATERIAL

SR. NO	DESCRIPTION	QTY	UOM	MAT.CODE	MATL. DESC	SIZE (MM)	WT	REMARKS	TDC
330	LASHING LUG	6	EA	5007417	PLATE-IS2062-E250-BR-T10	150 x 130 x 10	9.2	CUT TO SUIT	N.A.
329	GUSSET PLATE	1	EA	5007417	PLATE-IS2062-E250-BR-T10	550 x 186 x 10	6	CUT TO SUIT	N.A.
328	GUSSET PLATE	2	EA	5007417	PLATE-IS2062-E250-BR-T10	628 x 186 x 10	14	CUT TO SUIT	N.A.
327	BASE PLATE	1	EA	5007419	PLATE-IS2062-E250-BR-T14	1330 x 254 x 14	37	CUT TO SUIT	N.A.
326	WEB PLATE	1	EA	5007419	PLATE-IS2062-E250-BR-T14	1228 x 1021 x 14	138	CUT TO SUIT	N.A.
325	WEAR PLATE	1	EA	5007417	PLATE-IS2062-E250-BR-T10	1800 x 300 x 10	46	CUT TO SUIT	N.A.
324	RESTING RUBBER	1	EA	5023756	NATURAL RUBBER SHEET THK-5MM	1800 x 300 x 5	--	CUT TO SUIT	N.A.
323	GUSSET PLATE	2	EA	5007417	PLATE-IS2062-E250-BR-T10	552 x 186 x 10	16	CUT TO SUIT	N.A.
322	GUSSET PLATE	4	EA	5007417	PLATE-IS2062-E250-BR-T10	630 x 186 x 10	40	CUT TO SUIT	N.A.
321	BASE PLATE	2	EA	5007419	PLATE-IS2062-E250-BR-T14	1330 x 254 x 14	74	CUT TO SUIT	N.A.
320	WEB PLATE	2	EA	5007419	PLATE-IS2062-E250-BR-T14	1225 x 1022 x 14	276	CUT TO SUIT	N.A.
319	WEAR PLATE	2	EA	5007417	PLATE-IS2062-E250-BR-T10	1800 x 300 x 10	92	CUT TO SUIT	N.A.
318	RESTING RUBBER	2	EA	5023756	NATURAL RUBBER SHEET THK-5MM	1800 x 300 x 5	--	CUT TO SUIT	N.A.
317	BARREL-NIPPLE	1	EA	--	BARREL-NIPPLE-NPT-AISI304-1/4IN-S40-100L		--	STD.	N.A.
316	NEEDLE-VALVE	1	EA	--	NEEDLE-VALVE-SS304-1/4"-NPT (F)		--	STD.	N.A.
315	LASHING LUG	6	EA	5007417	PLATE-IS2062-E250-BR-T10	186 x 100 x 10	8.5	CUT TO SUIT	N.A.
314	HALF COUPLING	1	EA	--	H-CPLNG-BSP-AISI304-1/4IN		--	STD.	N.A.
313	PRESSURE GAUGE	1	EA	--	PRESSURE-GAUGE		--	STD.	N.A.
312	10" TSD	1	EA	5007419	PLATE-IS2062-E250-BR-T14	OD 445 x 14	17	CIRCLE	N.A.
311	8" TSD	1	EA	5007419	PLATE-IS2062-E250-BR-T14	OD 380 x 14	13	CIRCLE	N.A.
310	6" TSD	1	EA	5007419	PLATE-IS2062-E250-BR-T14	OD 320 x 14	9	CIRCLE	N.A.
309	3" TSD	1	EA	5007419	PLATE-IS2062-E250-BR-T14	OD 210 x 14	4	CIRCLE	N.A.
308	2" TSD	2	EA	5007419	PLATE-IS2062-E250-BR-T14	OD 165 x 14	5	CIRCLE	N.A.
307	2" TSD	6	EA	5007419	PLATE-IS2062-E250-BR-T14	OD 165 x 14	14	CIRCLE	N.A.
306	10" TSD	1	EA	5164920	GASKET-RN-SPLW-SS316-GRPH-T4.5-10"-#300		--	STD.	0603
305	8" TSD	1	EA	5213161	GSK-SPLW-IR+OR-SS316-FGR-T4.5-NPS8-#300		--	STD.	0603
304	6" TSD	1	EA	5213160	GSK-SPLW-IR+OR-SS316-FGR-T4.5-NPS6-#300		--	STD.	0603
303	3" TSD	1	EA	5213159	GSK-SPLW-IR+OR-SS316-FGR-T4.5-NPS3-#300		--	STD.	0603
302	2" TSD	2	EA	5213158	GSK-SPLW-IR+OR-SS316-FGR-T4.5-NPS2-#300		--	STD.	0603
301	2" TSD	6	EA	5141047	GSKT-RN-SPLW-SS316-GRPH-T4.5-2"#600		--	STD.	0603

SALES ORDER No	Item No.	Material No.
30002551	10	9006696

REVISIONS

REV. NO.	DESCRIPTION	ZONE NO.	DRAWN	CHKD.	APPD.	DATE
2	REVISED AS MARKED	1-10 TO A-H	NSM	AVM/SRW	BK	09-03-2023
1	REVISED AS PER CLIENT COMMENTS	1-10 TO A-H	RKC	AVM/SRW	BK	18-11-2022
0	ISSUED FOR APPROVAL	--	RKC	AVM/SSJ	BK	08-09-2022

MANUFACTURING ADDRESS :-
PRAJ INDUSTRIES LTD. SEZ UNIT-I,
PLOT NO.307 TO 314, SECTOR IV, KANDLA SPECIAL ECONOMIC ZONE,
GANDHIDHAM, KUTCH, GUJARAT, 370230, INDIA
MANUFACTURER'S SERIAL NUMBER :-
E-22063-18-D-271 (QTY - 1 No.)

ASME

CLIENT : WORLD ENERGY PARAMOUNT
EQUIPMENT OWNER : AIR PRODUCTS MANUFACTURING LLC
PROJECT : WORLD ENERGY RENEWABLES PROJECT
PROJECT LOCATION : WORLD ENERGY, PARAMOUNT , CA, USA

P.O. NO. : 4505426379
PROJECT DOC. NO. : EN207122-PRAJ-9V3-00070
CLIENT REV. NO. :

THIS DWG. IS THE PROPERTY OF PRAJ INDUSTRIES LTD. AND SHOULD NOT BE REPRODUCED WITHOUT WRITTEN CONSENT FROM
PRAJ INDUSTRIES LTD.
``PRAJ TOWER'', Bhumkar Chowk-Hinjewadi Road, Hinjewadi, Pune-411 057. (INDIA)

TITLE : **TRANSPORTATION DETAIL DRAWING FOR 18-D-271 ARG1 AMINE REGEN REFLUX DRUM**

DRAWING SIZE : A2
SCALE NTS
PIL JOB CODE E-22064-ME-11-TSD-0001
DWG. NO. E-22064-ME-11-TSD-0001
SHEET 1 OF 2
REV. 0 1 2

1. GENERAL NOTES :

1) ALL DIMENSIONS ARE IN INCH / [mm]. UNLESS OTHERWISE SPECIFIED.
2) SIZE/MOC ELEVATION OF WIRE ROPE, TURN BUCKLE & CLAMPS TO BE DECIDED BY MFG. IN CONSULTATION WITH TRANSPORTATION CONTRACTOR.
3) RIB SUPPORTS SHALL HAVE PROFILE ON TOP SIDE TO MATCH WITH RESTING PLATE AS PER GIVEN RADIUS.
4) ALL SHARP CORNERS TO BE ROUNDED OFF.
5) FILLET WELD SHALL BE 1/4"[6] mm (MINIMUM) UNLESS OTHERWISE SPECIFIED.
6) GIVEN BILL OF MATERIAL IS FOR 1 No. EQUIPMENT ONLY & TOTAL EQUIPMENT QTY IS 1 No.
7) EQUIPMENT SHALL BE SUITABLY TIED TO TRAILER DURING TRANSPORT.
8) EACH SHIPPING PACKAGE SHALL CONTAIN 2 LISTS OF CONTENTS, ONE INSIDE AND ONE OUTSIDE THE PACKAGE. ITEM NO AND PURCHASE ORDER NO SHALL BE MENTIONED ON PACKAGE.
9) ERECTION & COMMISSIONING SPARES SHALL BE PACKED SEPARATELY AND LABELLED RESPECTIVELY. LIST SHALL BE PROVIDED ON THE OUTSIDE OF PACKAGE.
10) EQUIPMENT WEIGHT SHALL BE VERIFIED BEFORE TRANSPORT.THE WEIGHT OF THE EQUIPMENT SHALL BE DETERMINED TO WITHIN +2% OR BETTER ACCURACY. THIS SHALL BE BY CALCULATION (USING ACTUAL THICKNESSES) OR BY THE USE OF CALIBRATED LOAD CELLS ON THE CORNERS OF THE EQUIPMENT. OTHER METHODS THAT RESULT IN THE SAME ACCURACY ARE ACCEPTABLE. WHEN PROVIDING VERIFIED WEIGHTS, THE VENDORS WILL PROVIDE EQUIPMENT CALIBRATION VERIFICATION AND/OR SCALE ACCURACY INFORMATION.
11) ALL EQUIPMENT WEIGHING OVER 16,000 KG (17.5 SHORT TONS) SHALL BE WEIGHED PRIOR TO SHIPMENT.
12) ALL TEMPORARY METAL COVER PLATES AND BOLTING SHALL BE PAINTED LUMINOUS YELLOW' RAL 1026 OR SIMILAR.
13) ALL LIFTING ATTACHMENT WELDS SHALL BE CRACK DETECTED. MAGNETIC PARTICLE INSPECTION (MPI) TECHNIQUES SHALL BE USED WHEREVER POSSIBLE, OTHERWISE USE DYE PENETRANT INSPECTION (DPI). A SEPARATE TEST CERTIFICATE FOR LIFTING LUG ATTACHMENTS WELDS SHALL BE SHIPPED WITH EQUIPMENT.
14) 2 CRANES WILL BE USED IN SHOP FOR LOADING EQUIPMENT FOR TRANSPORTATION. SAME CAN BE CONSIDERED FOR SITE ERECTION.

2. LASHINGS NOTES : -

1) NO LASHINGS ARE PERMITTED ON EQUIPMENT NOZZLES. LASHINGS SHALL NOT BE IN DIRECT CONTACT WITH EQUIPMENT.
2) EQUIPMENT LASHING POINTS SHOULD BE PAINTED IN RED.
3) LASHING WRAPPED AROUND EQUIPMENT ARE NOT ALLOWED.
4) EQUIPMENT SHALL ONLY BE SECURED USING THE FURNISHED LASHING POINTS AS INDICATED ON EQUIPMENT SHIPPING DRAWING.
5) IN ALL CASES CARE MUST BE TAKEN TO MINIMIZE PAINT OR SURFACE DAMAGE ON THE EQUIPMENT. LASHING SHALL NOT BE PERMITTED TO CONTACT THE EQUIPMENT SHELL. RUBBER PADS CAN BE USED TO PROTECT THE SHELL FROM WIRE/CHAIN DAMAGE.
6) ALL LASHINGS MUST BE PRELOADED WITH TURNBUCKLES OR RACHET TENSIONERS. TIPPING LASHINGS MUST BE GIVEN SUFFICIENT PRELOAD TO COUNTERACT AT LEAST 0.5g VERTICAL UPLOAD.
7) LASHING SHALL BE NEITHER SLACK NOT OVER-TENSIONED.
8) EQUIPMENT SHALL BE LASHED AND SECURED AS SOON AS POSSIBLE AFTER LOADING. THE LASHING SHALL BE LEFT IN PLACE UNTIL IMMEDIATELY PRIOR TO UNLOADING.
9) LASHING AND SECURING SHALL BE IN ACCORDANCE WITH THE LATEST IMO CODE OF SAFE PRACTICE FOR CARGO STOWAGE AND SECURING AND THE GUIDELINES CONTAINED IN THE NAUTICAL INSTITUTE PUBLICATION "LASHING AND SECURING OF DECK CARGOES
10) ALL LASHINGS SHALL BE STEEL CHAIN, WIRE ROPE, OR WEBBING BELT.
11) THE CARRIER SHALL SUPPLY ALL NECESSARY LASHINGS AND FITTINGS NOT ALREADY WELDED TO THE EQUIPMENT (FOR EXAMPLE SHACKLES, TURNBUCKLES, AND LEVER OR RATCHET TENSIONERS).
12) KNOTS SHALL NOT BE TIED IN CHAIN, WIRE ROPE OR WEBBING. LASHINGS AND FITTINGS MUST BE REGULARLY INSPECTED FOR WEAR, ELONGATION, DEFECTS, DAMAGE, DISTORTION, AND CORROSION.

3. SHIPPING NOTES

1) EQUIPMENT SHALL BE CLEANED AS SPECIFIED IN PROJECT SPECIFICATION A8KM-PP-000-50801-A
2) PRESSURIZED SHIPPING IS REQUIRED FOR VESSELS. DETAILED PRESSURIZED SHIPPING REQUIREMENTS ARE PROVIDED IN 4WGN-10001, SPEC-ENG-DOC001 & A8KM-PP-00-50801-A
3) PRESSURIZED SHIPPING: VESSELS SHALL BE PRESSURIZED WITH 0.5 BAR G (7 PSIG) OF DRY, OIL-FREE AIR OR NITROGEN. OPENINGS SHALL BE SUITABLY COVERED AND SEALED TO HOLD THE SHIPPING PRESSURE AND TO PREVENT THE ENTRANCE OF DIRT OR OTHER FOREIGN MATERIAL DURING SHIPMENT..
4) FLANGED OPENINGS SHALL BE SEALED USING A TEMPORARY METAL PLATE SHIPPING BLIND THAT SHALL BE FULLY BOLTED IN CONJUNCTION WITH SERVICE GASKETS.
5) EQUIPMENT THAT HAS BEEN PRESSURIZED FOR SHIPPING SHALL CARRY A WARNING NOTICE AT EACH BLINDED CONNECTION CLEARLY INDICATING THAT THE UNIT IS PRESSURIZED WITH EITHER AIR OR NITROGEN.
6) DRY, OIL FREE AIR OR NITROGEN MEANS; IT HAS A DEW POINT OF -40 DEG C (-40 DEG F) OR LOWER (WHICH IS CLASS 2 HUMIDITY AND WATER LEVEL TO ISO 8573-1) AND A TOTAL OIL CONTENT (AEROSOL, LIQUID, VAPOUR) <5MG/M3, WHICH IS CLASS 4 TOTAL OIL CONTENT TO ISO 8573-1.
7) A DIAPHRAGM-TYPE PRESSURE GAUGE WITH FULL SCALE READING OF 1 BAR G (15 PSIG) SHALL BE PROVIDED TO MONITOR THE PURGE PRESSURE. A PRESSURIZATION CONNECTION (WITH SELF-SEALING OR MANUAL VALVE) SHALL BE PROVIDED.
8) THE PRESSURE GAUGE AND PRESSURIZATION VALVE SHALL BE LOCATED SO THAT THEY CAN BE EASILY ACCESSED FROM GROUND LEVEL.
9) ALL TEMPORARY NOZZLE BLINDS (WHETHER WELDED OR BOLTED) IN EXCESS OF 22.7 KG (50 POUNDS) IN WEIGHT THAT ARE LEFT IN PLACE FOR SHIPPING PURPOSES, SHALL BE FURNISHED WITH LIFTING LUGS TO ENABLE SAFE REMOVAL AT SITE.
10) DELETED
11) TRANSPORT VEHICLE SELECTION & POSITIONING OF THE EQUIPMENT ON VEHICLE SHALL BE SUCH THAT THE EQUIPMENT WILL NOT BE SUBJECT TO DYNAMIC LOADING EXCEEDING THE DESIGN LOADING STATED ON THIS DRAWING (FOR OCEAN SHIPMENT THIS MEANS THE EQUIPMENT SHOULD NOT BE PLACED NEAR THE BOW OR STERN OF SMALL SHIPS). THE EQUIPMENT AXIS SHALL ALWAYS WITH THE TRANSPORT VEHICLE'S LONGITUDINAL AXIS.
12) PACKAGING OF THE EQUIPMENT SHALL COMPLY TO THE REQUIREMENTS OF AP SPECIFICATION NO. 4WGN-10001 & 4WEQ-1016. IN CASE OF CONFLICT BETWEEN THE TECHNICAL REQUIREMENT, MORE STRINGENT REQUIREMENTS SHALL GOVERN. EXPORT PACKING IS APPLICABLE BY DEFAULT FOR ALL EQUIPMENTS."
13) SHIP/TRANSPORT VEHICLE LASHING ANCHORAGE POINTS SHALL BE IN GOOD CONDITION AND OF ADEQUATE STRENGTH, SUFFICIENT IN NUMBER, COMPATIBLE WITH THE LASHING EQUIPMENT USED AND ABLE TO ACCOMMODATE THE LASHING CONFIGURATION SHOWN IN THE SHIPPING DRAWING.
14) WHERE SPREADER BEAM IS USED FOR LIFTING TRANSVERSE TO THE EQUIPMENT AT EACH LIFT LOCATION WIRE ROPES, SLINGS OR CHAINS MAY NOT DEVIATE BY MORE THAN ± 3 DEGREES FROM THE VERTICAL FOR LIFTING LUGS, OR -0/+5 DEGREES FOR TRUNNIONS (WITH THE POSITIVE DIRECTION AWAY FROM THE EQUIPMENT).

4. PRAJ REFERENCE DRAWING

MANUFACTURER DRAWINGS AND DOCUMENTS		
TITLE	DOCUMENT NO.	AIR PRODUCTS DOC. NO.
GENERAL ARRANGEMENT DRAWING FOR 18-D-271 ARG1 AMINE REGEN REFLUZ DRUM	E-22064-ME-11-GAD-0001	EN207122-PRAJ-9V3-00020
MECHANICAL DESIGN CALCULATIONS FOR 18-D-271 ARG1 AMINE REGEN REFLUZ DRUM	E-22064-ME-11-CAL-0001	EN207122-PRAJ-9V3-00012
FABRICATION DETAILS DRAWING FOR 18-D-271 ARG1 AMINE REGEN REFLUZ DRUM	E-22064-ME-11-WFD-0001	EN207122-PRAJ-9V3-00035
MANHOLE DETAILS DRAWING FOR 18-D-271 ARG1 AMINE REGEN REFLUZ DRUM	E-22064-ME-11-WFD-0002	EN207122-PRAJ-9V3-00047
DEVELOPMENT DRAWING FOR 18-D-271 ARG1 AMINE REGEN REFLUZ DRUM	E-22064-ME-11-DEV-0001	EN207122-PRAJ-9V3-00065
MANUFACTURER'S NAME PLATE DETAIL DRAWING FOR 18-D-271 ARG1 AMINE REGEN REFLUZ DRUM	E-22064-ME-11-NPD-0001-SHT-1	EN207122-PRAJ-9V3-00066
ASME NAME PLATE DETAIL DRAWING FOR 18-D-271 ARG1 AMINE REGEN REFLUZ DRUM	E-22064-ME-11-NPD-0001-SHT-2	EN207122-PRAJ-9V3-00066

5. AIR PRODUCTS APPLICABLE SPECIFICATIONS:-

1) TRANSPORTATION AND TRANSFER LIFTING ARRANGEMENTS FOR PRESSURE EQUIPMENT - A8KM-PP-000-500005-A
2) PREPARATION FOR SHIPPING OF SHOP- FABRICATED PRESSURE VESSELS, HEAT EXCHANGERS AND PROCESS PACKAGES: A8KM-PP-000-50801-A & SPEC-ENG-DOC001
3) SHIPMENT AND PACKING SPECIFICATION FOR EQUIPMENT AND MATERIALS BEING EXPORTED DIRECTLY BY VENDORS- 4WGN-10001

6. MARKING

1) EACH VESSEL SHALL BE IDENTIFIED WITH THE AIR PROJECT NUMBER, AIR PRODUCTS PURCHASE ORDER NO. AND VESSEL TAG NUMBERS PAINTED ON USING 75 MM (3 IN) HIGH LETTERS.THIS IDENTIFICATION MARKING SHALL BE AT THE 90 AND THE 270 ANGLE POSITIONS AND LOCATED APPROXIMATELY MIDWAY BETWEEN TANGENT LINES (TO THE RIGHT OF ANY CENTRE OF GRAVITY MARKS). ALL VESSELS SHALL HAVE THEIR CENTERS OF GRAVITY (EMPTY CONDITION AS PER GA DRAWING) MARKED.
2) ALL VESSELS USING A POSITIVE PRESSURE INERT INTERNAL ATMOSPHERE SHALL HAVE THE FOLLOWING NOTICE PAINTED S" ON TWO SIDES OF THE SHELL AND INSULATION COVERING, IF PRESENT, IN THREE-INCH (75MM) HIGH LETTERS VISIBLE IN THE SHIPPING POSITION FROM GRADE. "CAUTION - UNDER INERT ATMOSPHERE - DO NOT OPEN WITHOUT PROPER PRECAUTION THE SAME NOTICE SHALL BE STAMPED ONTO STAINLESS STEEL TAGS SECURELY ATTACHED (BY WIRE OR OTHER MEANS) TO EACH FLANGE AND OPENING
3) MACHINED SURFACES, FLANGE FACES, THREADED SURFACES, AND OTHER FINISHED OR DELICATE PARTS SHALL BE WELL-GREASED AND PROTECTED AGAINST RUSTING AND DAMAGE DURING SHIPMENT.
4) COLOR OF PAINT FOR MARKING SHALL CONSPICUOUSLY CONTRAST WITH VESSEL SURFACE
5) HORIZONTAL VESSEL SHALL HAVE ONE HEAD MARKED NORTH, SOUTH, EAST, OR WEST AS SHOWN ON THE VESSEL DRAWING

AIR PRODUCTS PURCHASE ORDER NO. :- 4505426379
AIR PRODUCTS PROJECT NUMBER :- EN207122
ITEM TAG NUMBER:- 18-D-271
DESTINATION :- WORLD ENERGY, PARAMOUNT , CA, USA
EMPTY WEIGHT:- 17960 lbs [8150 kg]
INSIDE DIAMETER :- 48" [1219.2 mm]
OVERALL LENGTH :- 36'-0 1/2" [10985 mm]

CROSBY WIDE BODY SHACKLES G-2160

SR. NO.	STOCK NO.	WORKING LOAD
A	1021287	55 TONS / 123200 lbs
B	1021287	55 TONS / 123200 lbs

TRANSPORTATION LOADING		
BARGE TRANSPORT	0.4g LONGITUDINAL	7.6 kn / 1708.5 lbs
	0.75g LATERAL	14.25 kn / 3203.5 lbs
	2g VERTICAL	38.02 kn / 8547.2 lbs
OCEAN	0.4g LONGITUDINAL	7.6 kn / 1708.5 lbs
	0.75g LATERAL	14.25 kn / 3203.5 lbs
	2g VERTICAL	38.02 kn / 8547.2 lbs
ROAD TRANSPORT	1.8g LONGITUDINAL	34.22 kn / 7692.9 lbs
	0.3g LATERAL	5.7 kn / 1281.4 lbs
	1.7g VERTICAL	32.32 kn / 7265.8 lbs

REV. NO.	DESCRIPTION	ZONE NO.	DRAWN	CHKD.	APPD.	DATE
2	REVISED AS PER CLIENT COMMENTS	--	RKC	AVM/SRW	BK	09-03-2023
1	REVISED AS PER CLIENT COMMENTS	4-10 TO A-H	RKC	AVM/SRW	BK	18-11-2022
0	ISSUED FOR APPROVAL	--	RKC	AVM/SSJ	BK	08-09-2022

REVISIONS

MANUFACTURING ADDRESS :-
PRAJ INDUSTRIES LTD. SEZ UNIT-I,
PLOT NO.307 TO 314, SECTOR IV, KANDLA SPECIAL ECONOMIC ZONE,
GANDHIDHAM, KUTCH, GUJARAT, 370230, INDIA
MANUFACTURER'S SERIAL NUMBER :-
E-22063-18-D-271 (QTY - 1 No.)

ASME

CLIENT : WORLD ENERGY PARAMOUNT
EQUIPMENT OWNER : AIR PRODUCTS MANUFACTURING LLC
PROJECT : WORLD ENERGY RENEWABLES PROJECT
PROJECT LOCATION : WORLD ENERGY, PARAMOUNT , CA, USA

P.O. NO. : 4505426379
PROJECT DOC. NO. : EN207122-PRAJ-9V3-00070
CLIENT REV. NO. :

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PRAJ INDUSTRIES LTD.
``PRAJ TOWER'', Bhumkar Chowk-Hinjewadi Road, Hinjewadi, Pune-411 057. (INDIA)

TITLE : **TRANSPORTATION DETAIL DRAWING FOR 18-D-271 ARG1 AMINE REGEN REFLUX DRUM**

DRAWING SIZE : A2
SCALE NTS
PIL JOB CODE E-22064-ME-11-TSD-0001
DWG. NO. E-22064-ME-11-TSD-0001
SHEET 2 OF 2
REV. ~~0~~ ~~1~~ 2

Table of Contents

DESIGN CALCULATION

In Accordance with ASME Section VIII Division 1

ASME Code Version : 2019

Analysis Performed by : #Replace this text with your company name and th

Job File : \\PTNETAPP\PROJECTWIP\CPES\FY-2122\CPES\E-22064\

Date of Analysis : Nov 18,2022 12:48pm

PV Elite 2020 SP2,August 2020

Vessel Design Summary:

ASME Code, Section VIII Division 1, 2019

Diameter Spec : 48.118 x 48.354 in. ID		
Vessel Design Length, Tangent to Tangent	32.00	ft.
Specified Datum Line Distance	20.00	ft.
Internal Design Temperature	500	°F
Internal Design Pressure	105.000	psig
External Design Temperature	300	°F
External Design Pressure	15.000	psig
Wind Design Code	No Wind Loads	
Earthquake Design Code	No Seismic	

Materials of Construction:

Component Type	Material	Class	Thickness	UNS #	Normalized	Impact Tested
Shell	SA-516 70	...	...	K02700	Yes	No
Head	SA-516 70	...	...	K02700	Yes	No
Nozzle	SA-106 B	...	...	K03006	No	No
Nozzle	SA-105	...	...	K03504	No	No
Nozzle	SA-516 70	...	...	K02700	No	No
Re-Pad	SA-516 70	...	...	K02700	No	No
Nozzle Flg	SA-105	...	...	K03504	Yes	No
Hrz Bolting	SA-193 B7	...	...	G41400	No	No

Normalized is determined based on the UCS-66 material curve selection and Figure UCS-66.
Impact Tested is based on material selection and material data properties.

Element Pressures and MAWP (psig & in.):

Element Description or Type	Design Pressure + Stat. head	Ext. Press.	Element M.A.W.P	Corrosion Allowance	Str. Flg. Gov.	In Creep Range
SKIRT	0.000	0.00	No Calc	0.0591	N/A	No
BOT DISHED END	5.000	0.00	No Calc	0.0000	No	No
MAIN SHELL	5.000	0.00	No Calc	0.0000	N/A	No
TOP DISHED END	5.000	0.00	No Calc	0.0000	No	No

Element Types and Properties:

Element Type	"To" Elev ft.	Element Length ft.	Nominal Thickness in.	Finished Thickness in.	Reqd Thk Internal in.	Reqd Thk External in.	Long Eff	Circ Eff
Cylinder	0.00	20.000	0.315	0.315	0.122	...	0.60	0.60
Ellipse	0.16	0.164	0.472	0.315	0.062	0.062	1.00	0.85
Cylinder	11.84	11.672	0.315	0.315	0.062	...	0.85	0.85
Ellipse	12.00	0.164	0.472	0.315	0.062	0.062	1.00	0.85

Saddle Parameters:

Saddle Width	7.874	in.
Saddle Bearing Angle	150.000	deg.
Centerline Dimension	43.307	in.
Wear Pad Width	13.780	in.
Wear Pad Thickness	0.394	in.

Wear Pad Bearing Angle	162.000	deg.
Distance from Saddle to Tangent	62.835	in.
Baseplate Length	47.244	in.
Baseplate Thickness	0.551	in.
Baseplate Width	10.000	in.
Number of Ribs (including outside ribs)	3	
Rib Thickness	0.394	in.
Web Thickness	0.551	in.
Height of Center Web	18.504	in.

Baseplate Sketch

```
|------------------ 47.244 in. --------------------|
----------------------------------------------------- ---
|                                                   |
|                                                   | 10.000 in.
|                                                   |
----------------------------------------------------- ---
```

Baseplate Plan View

```
----------------------------------------------------- ---
|                                                   | 0.551 in.
----------------------------------------------------- ---
```

Baseplate Side View

Summary of Maximum Saddle Loads, Operating Case:

Maximum Vertical Saddle Load	4329.37	lb.
Maximum Transverse Saddle Shear Load	0.00	lb.
Maximum Longitudinal Saddle Shear Load	0.00	lb.

Summary of Maximum Saddle Loads, Operating Case, Un-Factored:

Maximum Vertical Saddle Load	4824.88	lb.
Maximum Transverse Saddle Shear Load	0.00	lb.
Maximum Longitudinal Saddle Shear Load	0.00	lb.

Local Stress Analysis Results:

Description	Analysis Type	Max Stress Ratio	High Stress Location	Pass Fail
Lift Lug	WRC-107/537	0.439	n/a	Passed
Noz B2-3in.	WRC-107/537	0.184	n/a	Passed
Noz L2-2"	WRC-297	0.564	Shell	Passed
Noz S-2"	WRC-297	0.564	Shell	Passed
Noz B3-2"	WRC-297	0.564	Shell	Passed
Noz L1-2"	WRC-297	0.564	Shell	Passed
Noz A-6in.	WRC-297	0.564	Shell	Passed
Noz B4-2"	WRC-297	0.564	Shell	Passed
Noz B1-8in.	WRC-107/537	0.291	n/a	Passed
Noz V-10in.	WRC-107/537	0.295	n/a	Passed

Weights:

Fabricated - Bare W/O Removable Internals	12162.3	lbm
Shop Test - Fabricated + Water (Full)	38540.4	lbm
Shipping - Fab. + Rem. Intls.+ Shipping App.	12162.3	lbm
Erected - Fab. + Rem. Intls.+ Insul. (etc)	12162.3	lbm
Empty - Fab. + Intls. + Details + Wghts.	12162.3	lbm
Operating - Empty + Operating Liquid (No CA)	12162.3	lbm
Field Test - Empty Weight + Water (Full)	38408.8	lbm

PV Elite Vessel Analysis Program: Input Data

Design Internal Pressure (for Hydrotest)	105	psig
Design Internal Temperature	500.0	°F
Type of Hydrotest	not Specified	
Hydrotest Position	Horizontal	
Projection of Nozzle from Vessel Top	0	in.
Projection of Nozzle from Vessel Bottom	0	in.
Minimum Design Metal Temperature	32.0	°F
Type of Construction	Welded	
Special Service	None	
Degree of Radiography	RT-4	
Use Higher Longitudinal Stresses (Flag)	N	
Select t for Internal Pressure (Flag)	N	
Select t for External Pressure (Flag)	N	
Select t for Axial Stress (Flag)	N	
Select Location for Stiff. Rings (Flag)	N	
Consider Vortex Shedding	N	
Perform a Corroded Hydrotest	N	

Load Case 1	NP+EW+WI+FW+BW
Load Case 2	NP+EW+EE+FS+BS
Load Case 3	NP+OW+WI+FW+BW
Load Case 4	NP+OW+EQ+FS+BS
Load Case 5	NP+HW+HI
Load Case 6	NP+HW+HE
Load Case 7	IP+OW+WI+FW+BW
Load Case 8	IP+OW+EQ+FS+BS
Load Case 9	EP+OW+WI+FW+BW
Load Case 10	EP+OW+EQ+FS+BS
Load Case 11	HP+HW+HI
Load Case 12	HP+HW+HE
Load Case 13	IP+WE+EW
Load Case 14	IP+WF+CW
Load Case 15	IP+VO+OW
Load Case 16	IP+VE+EW
Load Case 17	NP+VO+OW
Load Case 18	FS+BS+IP+OW
Load Case 19	FS+BS+EP+OW

Wind Design Code	No Wind Loads
Seismic Design Code	No Seismic
Design Pressure + Static Head	Y
Consider MAP New and Cold in Noz. Design	N
Consider External Loads for Nozzle Des.	Y
Use ASME VIII-1 Appendix 1-9	N
Material Database Year	Current w/Addenda or Code Year

Configuration Directives:

Do not use Nozzle MDMT Interpretation VIII-1 01-37	No
Use Table G instead of exact equation for "A"	Yes
Shell Head Joints are Tapered	Yes
Compute "K" in corroded condition	Yes
Use Code Case 2286	No
Use the MAWP to compute the MDMT	No
For thickness ratios <= 0.35, MDMT will be -155F (-104C)	Yes
For PWHT & P1 Materials the MDMT can be < -55F (-48C)	No
Using Metric Material Databases, ASME II D	No
Calculate B31.3 type stress for Nozzles with Loads	Yes

Reduce the MDMT due to lower membrane stress	Yes
Consider Longitudinal Stress in MDMT calcs. (Div. 1)	Yes

Complete Listing of Vessel Elements and Details:

Element From Node	10	
Element To Node	20	
Element Type	Cylinder	
Description	SKIRT	
Distance "FROM" to "TO"	20	ft.
Inside Diameter	48.118	in.
Element Thickness	0.315	in.
Internal Corrosion Allowance	0.05906	in.
Nominal Thickness	0.315	in.
External Corrosion Allowance	0	in.
Design Internal Pressure	0	psig
Design Temperature Internal Pressure	77	°F
Design External Pressure	0	psig
Design Temperature External Pressure	77	°F
Effective Diameter Multiplier	1.0	
Material Name	SA-516 70	[Normalized]
Allowable Stress, Ambient	20000	psi
Allowable Stress, Operating	20000	psi
Allowable Stress, Hydrotest	34200	psi
Material Density	0.28	lb./in³
P Number Thickness	1.142	in.
Yield Stress, Operating	38000	psi
UCS-66 Chart Curve Designation	D	
External Pressure Chart Name	CS-2	
UNS Number	K02700	
Product Form	Plate	
Efficiency, Longitudinal Seam	0.6	
Efficiency, Circumferential Seam	0.6	
Weld is pre-Heated	No	

Element From Node	10	
Detail Type	Saddle	
Detail ID	Saddle-3	
Dist. from "FROM" Node / Offset dist	5.2362	ft.
Width of Saddle	7.874	in.
Height of Saddle at Bottom	43.307	in.
Saddle Contact Angle	150.0	
Height of Composite Ring Stiffener	0	in.
Width of Wear Plate	13.78	in.
Thickness of Wear Plate	0.3937	in.
Contact Angle, Wear Plate (degrees)	162.0	
Friction coefficient	0.0	
Moment Factor	3.0	
Dimension E at base (optional)	0	in.
Circumferential Eff. over Saddle	1.0	
Circumferential Eff. at Midspan	1.0	
Tangent to Tangent dist. (optional)	0	ft.

Element From Node	10	
Detail Type	Saddle	
Detail ID	Saddle-2	
Dist. from "FROM" Node / Offset dist	15.735	ft.
Width of Saddle	7.874	in.
Height of Saddle at Bottom	43.307	in.
Saddle Contact Angle	150.0	
Height of Composite Ring Stiffener	0	in.
Width of Wear Plate	13.78	in.
Thickness of Wear Plate	0.3937	in.
Contact Angle, Wear Plate (degrees)	162.0	
Friction coefficient	0.0	
Moment Factor	3.0	

```
     Dimension E at base (optional)                       0  in.
     Circumferential Eff. over Saddle                   1.0
     Circumferential Eff. at Midspan                    1.0
     Tangent to Tangent dist. (optional)                  0  ft.

     Element From Node                                   10
     Detail Type                                     Weight
     Detail ID                                   BASE BLOCK
     Dist. from "FROM" Node / Offset dist                 0  ft.
     Miscellaneous Weight                              1381  lb.
     Offset from Element Centerline                       0  in.

 --------------------------------------------------------------------

 Element From Node                                       20
 Element To Node                                         30
 Element Type                                      Elliptical
 Description                                   BOT DISHED END
 Distance "FROM" to "TO"                              0.164  ft.
 Inside Diameter                                     48.354  in.
 Element Thickness                                    0.315  in.
 Internal Corrosion Allowance                             0  in.
 Nominal Thickness                                   0.4724  in.
 External Corrosion Allowance                             0  in.
 Design Internal Pressure                                 5  psig
 Design Temperature Internal Pressure                    77  °F
 Design External Pressure                                 0  psig
 Design Temperature External Pressure                    77  °F
 Effective Diameter Multiplier                          1.0
 Material Name                                    SA-516 70 [Normalized]
 Efficiency, Longitudinal Seam                          1.0
 Efficiency, Circumferential Seam                      0.85
 Elliptical Head Factor                                 2.0
 Weld is pre-Heated                                      No

     Element From Node                                   20
     Detail Type                                     Lining
     Detail ID                                     CLADDING
     Dist. from "FROM" Node / Offset dist           -1.0074  ft.
     Height/Length of Lining                         1.1714  ft.
     Thickness of Lining                             0.1575  in.
     Density                                         499.38  lb./ft³

     Element From Node                                   20
     Detail Type                                     Nozzle
     Detail ID                                  Noz B2-3in.0
     Dist. from "FROM" Node / Offset dist                 0  in.
     Nozzle Diameter                                      3  in.
     Nozzle Schedule                                     80
     Nozzle Class                                       300
     Layout Angle                                       0.0
     Blind Flange (Y/N)                                   N
     Weight of Nozzle ( Used if > 0 )                102.16  lb.
     Grade of Attached Flange                        GR 1.1
     Nozzle Matl                                   SA-106 B

 --------------------------------------------------------------------

 Element From Node                                       30
 Element To Node                                         40
 Element Type                                      Cylinder
 Description                                     MAIN SHELL
 Distance "FROM" to "TO"                             11.672  ft.
 Inside Diameter                                     48.354  in.
 Element Thickness                                    0.315  in.
 Internal Corrosion Allowance                             0  in.
```

```
Nominal Thickness                                    0.315  in.
External Corrosion Allowance                             0  in.
Design Internal Pressure                                 5  psig
Design Temperature Internal Pressure                    77  °F
Design External Pressure                                 0  psig
Design Temperature External Pressure                    77  °F
Effective Diameter Multiplier                          1.0
Material Name                                  SA-516 70 [Normalized]
Efficiency, Longitudinal Seam                         0.85
Efficiency, Circumferential Seam                      0.85
Weld is pre-Heated                                      No

    Element From Node                                   30
    Detail Type                                     Saddle
    Detail ID                                     Saddle-1
    Dist. from "FROM" Node / Offset dist            6.9167  ft.
    Width of Saddle                                  7.874  in.
    Height of Saddle at Bottom                      43.307  in.
    Saddle Contact Angle                             150.0
    Height of Composite Ring Stiffener                   0  in.
    Width of Wear Plate                              13.78  in.
    Thickness of Wear Plate                         0.3937  in.
    Contact Angle, Wear Plate (degrees)              162.0
    Friction coefficient                               0.0
    Moment Factor                                      3.0
    Dimension E at base (optional)                       0  in.
    Circumferential Eff. over Saddle                   1.0
    Circumferential Eff. at Midspan                    1.0
    Tangent to Tangent dist. (optional)                  0  ft.

    Element From Node                                   30
    Detail Type                                     Lining
    Detail ID                                     CLADDING
    Dist. from "FROM" Node / Offset dist                 0  ft.
    Height/Length of Lining                         11.672  ft.
    Thickness of Lining                              0.126  in.
    Density                                         499.38  lb./ft³

    Element From Node                                   30
    Detail Type                                     Nozzle
    Detail ID                                  Noz LT2-2"
    Dist. from "FROM" Node / Offset dist            0.4193  ft.
    Nozzle Diameter                                      2  in.
    Nozzle Schedule                                   None
    Nozzle Class                                       300
    Layout Angle                                     145.0
    Blind Flange (Y/N)                                   N
    Weight of Nozzle ( Used if > 0 )                21.719  lb.
    Grade of Attached Flange                        GR 1.1
    Nozzle Matl                                     SA-105

    Element From Node                                   30
    Detail Type                                     Nozzle
    Detail ID                                   Noz L2-2"
    Dist. from "FROM" Node / Offset dist            0.4193  ft.
    Nozzle Diameter                                      2  in.
    Nozzle Schedule                                   None
    Nozzle Class                                       600
    Layout Angle                                     125.0
    Blind Flange (Y/N)                                   N
    Weight of Nozzle ( Used if > 0 )                21.719  lb.
    Grade of Attached Flange                        GR 1.1
    Nozzle Matl                                     SA-105

    Element From Node                                   30
    Detail Type                                     Nozzle
```

```
Detail ID                                      Noz S-2"
Dist. from "FROM" Node / Offset dist             0.4193  ft.
Nozzle Diameter                                       2  in.
Nozzle Schedule                                    None
Nozzle Class                                        600
Layout Angle                                       35.0
Blind Flange (Y/N)                                    N
Weight of Nozzle ( Used if > 0 )                 22.743  lb.
Grade of Attached Flange                         GR 1.1
Nozzle Matl                                      SA-105

Element From Node                                    30
Detail Type                                      Nozzle
Detail ID                                   Noz M-24in.0
Dist. from "FROM" Node / Offset dist              1.836  ft.
Nozzle Diameter                                      24  in.
Nozzle Schedule                                    None
Nozzle Class                                        150
Layout Angle                                      340.0
Blind Flange (Y/N)                                    Y
Weight of Nozzle ( Used if > 0 )                 850.46  lb.
Grade of Attached Flange                         GR 1.1
Nozzle Matl                                   SA-516 70

Element From Node                                    30
Detail Type                                      Nozzle
Detail ID                                     Noz B3-2"
Dist. from "FROM" Node / Offset dist             5.1693  ft.
Nozzle Diameter                                       2  in.
Nozzle Schedule                                    None
Nozzle Class                                        600
Layout Angle                                      220.0
Blind Flange (Y/N)                                    N
Weight of Nozzle ( Used if > 0 )                 22.743  lb.
Grade of Attached Flange                         GR 1.1
Nozzle Matl                                      SA-105

Element From Node                                    30
Detail Type                                      Nozzle
Detail ID                                    Noz LT1-2"
Dist. from "FROM" Node / Offset dist             6.1693  ft.
Nozzle Diameter                                       2  in.
Nozzle Schedule                                    None
Nozzle Class                                        300
Layout Angle                                      200.0
Blind Flange (Y/N)                                    N
Weight of Nozzle ( Used if > 0 )                 21.719  lb.
Grade of Attached Flange                         GR 1.1
Nozzle Matl                                      SA-105

Element From Node                                    30
Detail Type                                      Nozzle
Detail ID                                     Noz L1-2"
Dist. from "FROM" Node / Offset dist             6.1693  ft.
Nozzle Diameter                                       2  in.
Nozzle Schedule                                    None
Nozzle Class                                        600
Layout Angle                                      125.0
Blind Flange (Y/N)                                    N
Weight of Nozzle ( Used if > 0 )                 21.719  lb.
Grade of Attached Flange                         GR 1.1
Nozzle Matl                                      SA-105

Element From Node                                    30
Detail Type                                      Nozzle
Detail ID                                    Noz A-6in.0
```

```
     Dist. from "FROM" Node / Offset dist            8.0026  ft.
     Nozzle Diameter                                      6  in.
     Nozzle Schedule                                     80
     Nozzle Class                                       300
     Layout Angle                                     180.0
     Blind Flange (Y/N)                                   N
     Weight of Nozzle ( Used if > 0 )                73.077  lb.
     Grade of Attached Flange                        GR 1.1
     Nozzle Matl                                   SA-106 B

     Element From Node                                   30
     Detail Type                                     Nozzle
     Detail ID                                    Noz B4-2"
     Dist. from "FROM" Node / Offset dist            5.4193  ft.
     Nozzle Diameter                                      2  in.
     Nozzle Schedule                                   None
     Nozzle Class                                       600
     Layout Angle                                     180.0
     Blind Flange (Y/N)                                   N
     Weight of Nozzle ( Used if > 0 )                22.743  lb.
     Grade of Attached Flange                        GR 1.1
     Nozzle Matl                                     SA-105

     Element From Node                                   30
     Detail Type                                     Nozzle
     Detail ID                                   Noz LT4-2"
     Dist. from "FROM" Node / Offset dist            0.4193  ft.
     Nozzle Diameter                                      2  in.
     Nozzle Schedule                                   None
     Nozzle Class                                       300
     Layout Angle                                      55.0
     Blind Flange (Y/N)                                   N
     Weight of Nozzle ( Used if > 0 )                21.719  lb.
     Grade of Attached Flange                        GR 1.1
     Nozzle Matl                                     SA-105

     Element From Node                                   30
     Detail Type                                     Nozzle
     Detail ID                                   Noz LT3-2"
     Dist. from "FROM" Node / Offset dist            6.1693  ft.
     Nozzle Diameter                                      2  in.
     Nozzle Schedule                                   None
     Nozzle Class                                       300
     Layout Angle                                      55.0
     Blind Flange (Y/N)                                   N
     Weight of Nozzle ( Used if > 0 )                21.719  lb.
     Grade of Attached Flange                        GR 1.1
     Nozzle Matl                                     SA-105

 --------------------------------------------------------------------

 Element From Node                                       40
 Element To Node                                         50
 Element Type                                    Elliptical
 Description                                 TOP DISHED END
 Distance "FROM" to "TO"                              0.164  ft.
 Inside Diameter                                     48.354  in.
 Element Thickness                                    0.315  in.
 Internal Corrosion Allowance                             0  in.
 Nominal Thickness                                   0.4724  in.
 External Corrosion Allowance                             0  in.
 Design Internal Pressure                                 5  psig
 Design Temperature Internal Pressure                    77  °F
 Design External Pressure                                 0  psig
 Design Temperature External Pressure                    77  °F
 Effective Diameter Multiplier                          1.0
```

Material Name	SA-516 70 [Normalized]	
Efficiency, Longitudinal Seam	1.0	
Efficiency, Circumferential Seam	0.85	
Elliptical Head Factor	2.0	
Weld is pre-Heated	No	

Element From Node	40	
Detail Type	Lining	
Detail ID	CLADDING	
Dist. from "FROM" Node / Offset dist	0	ft.
Height/Length of Lining	1.1714	ft.
Thickness of Lining	0.1575	in.
Density	499.38	lb./ft³

Element From Node	40	
Detail Type	Nozzle	
Detail ID	Noz B1-8in.0	
Dist. from "FROM" Node / Offset dist	0	in.
Nozzle Diameter	8	in.
Nozzle Schedule	80	
Nozzle Class	300	
Layout Angle	0.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	146.14	lb.
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	

Element From Node	40	
Detail Type	Nozzle	
Detail ID	Noz V-10in.0	
Dist. from "FROM" Node / Offset dist	17	in.
Nozzle Diameter	10	in.
Nozzle Schedule	80	
Nozzle Class	300	
Layout Angle	0.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	179.73	lb.
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	

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ASME Horizontal Vessel Analysis: Stresses for the Left Saddle
(per ASME Sec. VIII Div. 2 based on the Zick method.)

Horizontal Vessel Stress Calculations : Road Transport

Note: There are more than two saddles present in this model. The load on the saddle supports has been taken as the total weight divided by the number of saddles. Insure that this is an appropriate assumption for this vessel model.

Input and Calculated Values:

Vessel Mean Radius	Rm	24.22	in.
Stiffened Vessel Length per 4.15.6	L	32.00	ft.
Distance from Saddle to Vessel tangent	a	62.83	in.
Saddle Width	b	7.87	in.
Saddle Bearing Angle	theta	150.00	degrees
Wear Plate Width	b1	13.78	in.
Wear Plate Bearing Angle	theta1	162.00	degrees
Wear Plate Thickness	tr	0.3937	in.
Wear Plate Allowable Stress	Sr	17000.00	psi
Shell Allowable Stress used in Calculation		20000.00	psi
Head Allowable Stress used in Calculation		0.00	psi
Circumferential Efficiency in Plane of Saddle		1.00	
Circumferential Efficiency at Mid-Span		1.00	
Distance from Saddle Base to Centerline	B	43.31	in.
Coefficient of Friction	mu	0.00	
Saddle Force Q for this Transportation Case		11540.69	lb.
Shipping Longitudinal Acceleration	gx	1.80	g
Shipping Transverse Acceleration	gz	0.30	g
Shipping Vertical Acceleration	gy	1.70	g
Vertical Acceleration Acting with Transverse	gw	1.00	g
Internal Pressure during Transport		5.00	psig

Horizontal Vessel Analysis Results:	Actual psi	Allowable psi
Long. Stress at Top of Midspan	-482.58	-36100.00
Long. Stress at Top of Midspan	482.58	20000.00
Long. Stress at Bottom of Midspan	867.01	20000.00
Long. Stress at Top of Saddles	1370.40	20000.00
Long. Stress at Bottom of Saddles	-485.72	-36100.00
Long. Stress at Bottom of Saddles	485.72	20000.00
Tangential Shear in Shell	813.15	16000.00
Circ. Stress at Horn of Saddle	1663.95	30000.00
Circ. Compressive Stress in Shell	981.86	20000.00

Intermediate Results: Saddle Reaction Q due to Road Transport Load:

Transverse Force due to Lateral Acceleration [Ft]:
```
  = gz * saddle Load * gw
  = 0.3 * 4274.33 * 1.0
  = 1282.3 lb.
```

Longitudinal Force due to Axial Acceleration [Fl]:
```
  = gx * saddle Load * gw
  = 1.8 * 4274.33 * 1.0
```

```
  = 7693.8 lb.
```

Transverse Saddle Reaction Force due to Lateral Acceleration [Fwt]:
```
  = Ft/Num of Saddles * B / E
  = 1282.3/3 * 43.3071/47.2441
  = 391.8 lb.
```

Saddle Reaction Force due to Transport Load [Fwl]:
```
  = Fl * B / Ls
  = 7694 * 43.3071/367.9575
  = 905.5 lb.
```

Saddle Reaction Force due to Vertical Transportation Acceleration [Fsl]:
```
  = Saddle Load * gy
  = 4274.3 * 1.7
  = 7266.363 lb.
```

Load Combination Results due to Transport Loading [Q]:
```
  = Saddle Load + max( Fwl, Fwt, Fsl )
  = 4274 + max( 906, 392, 7266 )
  = 11540.7 lb.
```

Summary of Loads at the base of this Saddle:

Vertical Load (including saddle weight)		12035.47	lb.
Transverse Shear Load Saddle	Ft	0.00	lb.
Longitudinal Shear Load Saddle		7693.80	lb.

Formulas and Substitutions for Horizontal Vessel Analysis:

Note: Wear Plate is not Welded to the Shell, k = 1.0

Saddle Dimension [E]:
```
  = Baseplate Length
  = 47.244 in.
```

The Computed K values from Table 4.15.1:

K1 = 0.1607	K2 = 0.7988	K3 = 0.4851	K4 = 0.2952
K5 = 0.6733	K6 = 0.0317	K7 = 0.0317	K8 = 0.3021
K9 = 0.2177	K10 = 0.0355	K1* = 0.2792	K6p = 0.0252
K7p = 0.0252			

The suffix 'p' denotes the values for a wear plate if it exists.

Note: Dimension a is greater than or equal to Rm / 2.

Moment per Equation 4.15.3 [M1]:
```
  = -Q*a [1 - (1- a/L + (Rm²-h2²)/(2a*L))/(1+(4h2)/3L)]
  = -11541*5.24[1-(1-5.24/32.0+(2.018²-0.0²)/
    (2*5.24*32.0))/(1+(4*0.0)/(3*32.0))]
  = -9153.8 ft.lb.
```

Moment per Equation 4.15.4 [M2]:
```
  = Q*L/4(1+2(Rm²-h2²)/(L²))/(1+(4h2)/( 3L))-4a/L
  = 11541*32.0/4(1+2(2.018²-0.0²)/(32.0²))/(1+(4*0.0)/
    (3*32.0))-4*5.24/32.0
  = 32630.3 ft.lb.
```

Longitudinal Stress at Top of Shell (4.15.6) [Sigma1]:
```
  = P * Rm/(2t) - M2/(pi*Rm²t)
  = 5.0 * 24.217/(2* 0.315) - 391564.1/(pi*24.2²* 0.315)
  = -482.58 psi
```

Longitudinal Stress at Bottom of Shell (4.15.7) [Sigma2]:
```
  = P * Rm/(2t) + M2/(pi * Rm² * t)
  = 5.0 * 24.217/(2 * 0.315) + 391564.1/(pi * 24.2² * 0.315 )
```

```
  = 867.01 psi
```

Longitudinal Stress at Top of Shell at Support (4.15.10) [Sigma*3]:
```
  = P * Rm/(2t) - M1/(K1*pi*Rm²t)
  = 5.0*24.217/(2*0.315)--109846.0/(0.1607*pi*24.2²*0.315)
  = 1370.40 psi
```

Longitudinal Stress at Bottom of Shell at Support (4.15.11) [Sigma*4]:
```
  = P * Rm/(2t) + M1/(K1* * pi * Rm² * t)
  = 5.0*24.217/(2*0.315)+-109846.0/(0.2792*pi*24.2²*0.315)
  = -485.72 psi
```

Maximum Shear Force in the Saddle (4.15.5) [T]:
```
  = Q(L-2a)/(L+(4*h2/3))
  = 11541( 32.0 - 2 * 5.24)/(32.0 + ( 4 * 0.0/3))
  = 7763.8 lb.
```

Shear Stress in the shell no rings, not stiffened (4.15.14) [tau2]:
```
  = K2 * T / ( Rm * t )
  = 0.7988 * 7763.85/( 24.2165 * 0.315 )
  = 813.15 psi
```

Decay Length (4.15.22) [x1,x2]:
```
  = 0.78 * sqrt( Rm * t )
  = 0.78 * sqrt( 24.217 * 0.315 )
  = 2.154 in.
```

Effective reinforcing plate width (4.15.1) [B1]:
```
  = min( b + 1.56 * sqrt( Rm * t ), 2a   )
  = min( 7.87 + 1.56 * sqrt( 24.217 * 0.315 ), 2 * 62.835 )
  = 12.18 in.
```

Wear Plate/Shell Stress ratio (4.15.29) [eta]:
```
  = min( Sr/S, 1 )
  = min( 17000.0/20000.0, 1 )
  = 0.8500
```

Circumferential Stress at Saddle Base with Wear Plate (4.15.26) [sigma6,r]:
```
  = -K5 * Q * k / ( B1( t + eta * tr ) )
  = - 0.6733 * 11541 * 1.0/( 12.182( 0.315 + 0.85 * 0.394 ) )
  = -981.86 psi
```

Circ. Comp. Stress at Horn of Saddle, L>=8Rm (4.15.27) [sigma7,r]:
```
  = -Q/(4(t+eta*tr)b1) - 3*K7*Q/(2(t+eta*tr)²)
  = -11541/(4( 0.315 + 0.85 * 0.394)12.182) -
     3 * 0.032 * 11541/(2( 0.315 + 0.85 * 0.394)²)
  = -1663.95 psi
```

Results for Vessel Ribs, Web and Base:

Baseplate Length	Bplen	47.2441	in.
Baseplate Thickness	Bpthk	0.5512	in.
Baseplate Width	Bpwid	10.0000	in.
Number of Ribs (inc. outside ribs)	Nribs	3	
Rib Thickness	Ribtk	0.3937	in.
Web Thickness	Webtk	0.5512	in.
Web Location	Webloc	Side	
Saddle Yield Stress	Sy	34800.0	psi
Height of Web at Center	Hw,c	18.5	in.
Friction Coefficient	mu	0.000	

Note: In the tables below Io is I for the rectangle + Area * Centroid Distance^2

Moment of Inertia of Saddle - Transverse Direction (90 degrees to long axis)

	B	D	Y	A	AY	Io

Shell	18.0738	0.3150	0.1575	5.6925	0.8965	324.0760
Wearplate	13.7795	0.3937	0.5118	5.4250	2.7766	280.5464
Web	0.5512	17.9882	9.7028	9.9148	96.2005	307.0317
BasePlate	10.0000	0.5512	18.9725	5.5118	104.5726	700.2507
Totals	...	...	...	26.5441	204.4461	1611.9049

Distance to Centroid [C1]:
```
  = AY / A
  = 204.446/26.544
  = 7.702 in.
```

Angle [beta]:
```
  = 180 - Saddle Angle/2
  = 180 - 150.0/2
  = 105.0
```

Saddle Splitting Coefficient [K1]:
```
  = ( 1 + cos(beta) - 0.5*sin(beta)² )/(pi - beta + sin(beta)cos(beta) )
  = ( 1 + cos(105.0) - 0.5*sin(105.0)² )/(pi - 1.833 + sin(105.0)cos(105.0) )
  = 0.2594
```

Saddle Splitting Force [Fh]:
```
  = K1 * Q
  = 0.259 * 11540.693
  = 2993.3369 lb.

 Tension Stress, St = ( Fh/As )       =        143.5545  psi
 Allowed Stress, Sa = 0.6 * Yield Str =      20880.0000  psi
```

Saddle Splitting Dimension [d]:
```
  = B - R * sin(theta/2)/(theta/2 in radians)
  = 43.3 - 24.06 * sin(150.0/2)/1.309
  = 25.554 in.

 Bending Moment, M  = Fh * d          =       6374.2134  ft.lb.

 Bending Stress, Sb = ( M * C1 / I  ) =        365.4932  psi
 Allowed Stress, Sa = 2/3 * Yield Str =      23200.0000  psi
```

Minimum Thickness of Baseplate per Moss:
```
  = ( 3( Q + Saddle_Wt )BasePlateWidth / ( 2 * BasePlateLength * AllStress ))½
  = ( 3(11541 + 495)10.0/( 2 * 47.244 * 23200.0 ))½
  = 0.406 in.
```

Calculation of Axial Load, Intermediate Values and Compressive Stress:

Web Length Dimension [Web Length]:
```
  = 2 * cos( 90 - Saddle Angle/2 )( Inside Radius + Shell Thk + Wear Plate Thk )
  = 2 * cos( 90 - 150.0/2 )( 24.059 + 0.315 + 0.394 )
  = 47.848 in.
```

Distance between Ribs [e]:
```
  = Web Length / ( Nribs - 1 )
  = 47.8476/( 3 - 1 )
  = 23.924 in.
```

Baseplate Pressure Area [Ap]:
```
  = e * Bpwid / 2
  = 23.9238 * 10.0/2
  = 119.619 in²
```

Bearing Pressure [Bp]:
```
  = Q / ( BasePlateLength * BasePlateWidth )
  = 11540.693/( 47.244 * 10.0 )
  = 24.428 lb./in²
```

Axial Load [P]:
```
  = Ap * Bp
  = 119.6 * 24.43
  = 2922.026 lb.
```

Area of the Rib and Web [Ar]:
```
  = Rib Area + Web Area
  = 2.883 + 6.593
  = 9.476 in²
```

Compressive Stress [Sc]:
```
  = P/Ar
  = 2922.0/9.4762
  = 308.355 psi
```

Check of Outside Ribs:

Inertia of Saddle, Outer Ribs - Longitudinal Direction

	B	D	Y	A	AY	Io
Rib	0.3937	7.3228	4.2126	2.8830	12.1450	35.3646
Web	11.9619	0.5512	0.2756	6.5932	1.8170	9.6261
Totals	...	...	...	9.4762	13.9620	44.9907

Rib dimension [D]:
```
  = Saddle Width - Web Thickness
  = 7.874 - 0.551
  = 7.323 in.
```

Distance to Centroid from Datum [ytot]:
```
  = AY / A
  = 13.962/9.476
  = 1.473 in.
```

Distance to Centroid [C1]:
```
  = max( ytot, Saddle Width - ytot )
  = max( 1.473, 7.874 - 1.473 )
  = 6.401 in.
```

Radius of Gyration [r]:
```
  = sqrt( Total Inertia / Total Area )
  = sqrt( 45.0/9.476 )
  = 2.179 in.
```

Intermediate Term [Cc]:
```
  = sqrt( 2 * pi² * Elastic Modulus / Yield Stress )
  = sqrt( 2 * pi² * 29000000/34800.0 )
  = 128.255
```

Slenderness ratio [KL/r]:
```
  = KL/r
  = 1 * 17.917/2.179
  = 8.223
```

Bending Moment [Rm]:
```
  = Fl /( 2 * Bplen ) * e * L / 2
  = 7693.8/( 2 * 47.24 ) * 23.924 * 17.92/2
  = 1454.312 ft.lb.
```

Compressive Allowable, KL/r < Cc (8.223 < 128.255) per AISC E2-1 [Sca]:
```
  = ( 1-(Klr)²/(2*Cc²))Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
  = ( 1-( 8.22 )²/(2 * 128.25² ))34800/
    ( 5/3+3*(8.22)/(8* 128.25)-( 8.22³)/(8*128.25³)
```

```
  = 20541 psi
```

AISC Unity Check of Outside Ribs (must be <= 1)

```
  = Sc/Sca + ( Rm * C1 / I )/Sba
  = 308.36/20541.17 + ( 17451.74 * 6.401/44.991 )/23200.0
  = 0.122
```

Check of Inside Ribs:

Inertia of Saddle, Inner Ribs - Axial Direction

	B	D	Y	A	AY	Io
Rib	0.3937	7.3228	4.2126	2.8830	12.1450	43.8230
Web	23.9238	0.5512	0.2756	13.1863	3.6340	6.9127
Totals	...	...	...	16.0693	15.7790	50.7357

Distance to Centroid from Datum [ytot]:

```
  = AY / A
  = 15.779/16.069
  = 0.982 in.
```

Distance to Centroid [C1]:

```
  = max( ytot, abs( Saddle Width - ytot ) )
  = max( 0.982, abs( 7.874 - 0.982 ) )
  = 6.892 in.
```

Length of Inner Rib [L]:

```
  = Saddle Height - Outside Radius - Bpthk
  = 43.307 - cos( 24.768/2 )( 0.551 + 0.0 + 0.0 ) - 0.0
  = 17.988 in.
```

Radius of Gyration [r]:

```
  = sqrt( Total Inertia / Total Area )
  = sqrt( 50.7/16.069 )
  = 1.777 in.
```

Slenderness ratio [KL/r]:

```
  = KL/r
  = 1 * 17.988/1.777
  = 10.123
```

Unit Force [Force,u]:

```
  = Fl / ( 2 * Baseplate Length )
  = 7693.796/( 2 * 47.244 )
  = 81.426 lb./in.
```

Moment at base of inner Rib [Mbase,c]:

```
  = Unit Force * e * L
  = 81.426 * 23.924 * 17.988
  = 35041.324 in.lbs
```

Bending Stress due to Transverse Force and Weight Load [SigmaB,base,c]:

```
  = Bending Moment / Section Modulus
  = 35041.324/7.361
  = 4760.117 psi
```

Compressive Allowable, KL/r < Cc (10.1235 < 128.255) per AISC E2-1 [Sca]:

```
  = ( 1-(Klr)²/(2*Cc²))Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
  = ( 1-( 10.12 )²/(2 * 128.25² ))34800/
    ( 5/3+3*(10.12)/(8* 128.25)-( 10.12³)/(8*128.25³)
  = 20452 psi
```

AISC Unity Check of Inside Ribs (must be <= 1)

```
  = Sc/Sca + ( Mbase,c * C1/I )/Sba
  = 353.91/20452.48 + ( 35041.32 * 6.892/50.736 )/23200.0
```

= 0.222

ASME Horizontal Vessel Analysis: Stresses for the Right Saddle
(per ASME Sec. VIII Div. 2 based on the Zick method.)

*Warning - Distance to Saddle (a) > 0.25 * Tangent Distance (L) - 4.15.3.2*

Input and Calculated Values:

Vessel Mean Radius	Rm	24.33	in.
Stiffened Vessel Length per 4.15.6	L	12.00	ft.
Distance from Saddle to Vessel tangent	a	59.05	in.
Saddle Width	b	7.87	in.
Saddle Bearing Angle	theta	150.00	degrees
Wear Plate Width	b1	13.78	in.
Wear Plate Bearing Angle	theta1	162.00	degrees
Wear Plate Thickness	tr	0.3937	in.
Wear Plate Allowable Stress	Sr	17000.00	psi
Inside Depth of Head	h2	1.01	ft.
Shell Allowable Stress used in Calculation		20000.00	psi
Head Allowable Stress used in Calculation		20000.00	psi
Circumferential Efficiency in Plane of Saddle		1.00	
Circumferential Efficiency at Mid-Span		1.00	
Distance from Saddle Base to Centerline	B	43.31	in.
Coefficient of Friction	mu	0.00	
Saddle Force Q for this Transportation Case		11540.69	lb.
Shipping Longitudinal Acceleration	gx	1.80	g
Shipping Transverse Acceleration	gz	0.30	g
Shipping Vertical Acceleration	gy	1.70	g
Vertical Acceleration Acting with Transverse	gw	1.00	g
Internal Pressure during Transport		5.00	psig

Horizontal Vessel Analysis Results:	Actual psi	Allowable psi
Long. Stress at Top of Midspan	691.10	20000.00
Long. Stress at Bottom of Midspan	-304.79	-36100.00
Long. Stress at Bottom of Midspan	304.79	20000.00
Long. Stress at Top of Saddles	3420.65	20000.00
Long. Stress at Bottom of Saddles	-1663.97	-36100.00
Long. Stress at Bottom of Saddles	1663.97	20000.00
Tangential Shear in Shell	194.56	16000.00
Circ. Stress at Horn of Saddle	2120.92	30000.00
Circ. Compressive Stress in Shell	981.02	20000.00

Intermediate Results: Saddle Reaction Q due to Road Transport Load:

Transverse Force due to Lateral Acceleration [Ft]:
= gz * saddle Load * gw
= 0.3 * 4274.33 * 1.0
= 1282.3 lb.

Longitudinal Force due to Axial Acceleration [Fl]:
= gx * saddle Load * gw
= 1.8 * 4274.33 * 1.0
= 7693.8 lb.

Transverse Saddle Reaction Force due to Lateral Acceleration [Fwt]:

```
  = Ft/Num of Saddles * B / E
  = 1282.3/3 * 43.3071/47.2441
  = 391.8 lb.
```

Saddle Reaction Force due to Transport Load [Fwl]:

```
  = Fl * B / Ls
  = 7694 * 43.3071/367.9575
  = 905.5 lb.
```

Saddle Reaction Force due to Vertical Transportation Acceleration [Fsl]:

```
  = Saddle Load * gy
  = 4274.3 * 1.7
  = 7266.363 lb.
```

Load Combination Results due to Transport Loading [Q]:

```
  = Saddle Load + max( Fwl, Fwt, Fsl )
  = 4274 + max( 906, 392, 7266 )
  = 11540.7 lb.
```

Summary of Loads at the base of this Saddle:

```
 Vertical Load (including saddle weight)              12036.21  lb.
 Transverse Shear Load Saddle            Ft               0.00  lb.
 Longitudinal Shear Load Saddle                        7693.80  lb.
```

Formulas and Substitutions for Horizontal Vessel Analysis:

Note: Wear Plate is not Welded to the Shell, k = 1.0

Saddle Dimension [E]:

```
  = Baseplate Length
  = 47.244 in.
```

The Computed K values from Table 4.15.1:

```
 K1  = 0.1607     K2  = 0.7988     K3  = 0.4851     K4  = 0.2952
 K5  = 0.6733     K6  = 0.0317     K7  = 0.0317     K8  = 0.3021
 K9  = 0.2177     K10 = 0.0355     K1* = 0.2792     K6p = 0.0252
 K7p = 0.0252
```

The suffix 'p' denotes the values for a wear plate if it exists.

Note: Dimension a is greater than or equal to Rm / 2.

Moment per Equation 4.15.3 [M1]:

```
  = -Q*a [1 - (1- a/L + (Rm²-h2²)/(2a*L))/(1+(4h2)/3L)]
  = -11541*4.92[1-(1-4.92/12.0+(2.028²-1.007²)/
    (2*4.92*12.0))/(1+(4*1.01)/(3*12.0))]
  = -25321.2 ft.lb.
```

Moment per Equation 4.15.4 [M2]:

```
  = Q*L/4(1+2(Rm²-h2²)/(L²))/(1+(4h2)/( 3L))-4a/L
  = 11541*12.0/4(1+2(2.028²-1.007²)/(12.0²))/(1+(4*1.007)/
    (3*12.0))-4*4.92/12.0
  = -24314.0 ft.lb.
```

Longitudinal Stress at Top of Shell (4.15.6) [Sigma1]:

```
  = P * Rm/(2t) - M2/(pi*Rm²t)
  = 5.0 * 24.335/(2* 0.315) - -291767.8/(pi*24.3²* 0.315)
  = 691.10 psi
```

Longitudinal Stress at Bottom of Shell (4.15.7) [Sigma2]:

```
  = P * Rm/(2t) + M2/(pi * Rm² * t)
  = 5.0 * 24.335/(2 * 0.315) + -291767.8/(pi * 24.3² * 0.315 )
  = -304.79 psi
```

Longitudinal Stress at Top of Shell at Support (4.15.10) [Sigma*3]:

```
  = P * Rm/(2t) - M1/(K1*pi*Rm²t)
  = 5.0*24.335/(2*0.315)--303854.0/(0.1607*pi*24.3²*0.315)
  = 3420.65 psi
```

Longitudinal Stress at Bottom of Shell at Support (4.15.11) [Sigma*4]:

```
  = P * Rm/(2t) + M1/(K1* * pi * Rm² * t)
  = 5.0*24.335/(2*0.315)+-303854.0/(0.2792*pi*24.3²*0.315)
  = -1663.97 psi
```

Maximum Shear Force in the Saddle (4.15.5) [T]:

```
  = Q(L-2a)/(L+(4*h2/3))
  = 11541( 12.0 - 2 * 4.92)/(12.0 + ( 4 * 1.01/3))
  = 1866.7 lb.
```

Shear Stress in the shell no rings, not stiffened (4.15.14) [tau2]:

```
  = K2 * T / ( Rm * t )
  = 0.7988 * 1866.69/( 24.3346 * 0.315 )
  = 194.56 psi
```

Decay Length (4.15.22) [x1,x2]:

```
  = 0.78 * sqrt( Rm * t )
  = 0.78 * sqrt( 24.335 * 0.315 )
  = 2.159 in.
```

Effective reinforcing plate width (4.15.1) [B1]:

```
  = min( b + 1.56 * sqrt( Rm * t ), 2a  )
  = min( 7.87 + 1.56 * sqrt( 24.335 * 0.315 ), 2 * 59.051 )
  = 12.19 in.
```

Wear Plate/Shell Stress ratio (4.15.29) [eta]:

```
  = min( Sr/S, 1 )
  = min( 17000.0/20000.0, 1 )
  = 0.8500
```

Circumferential Stress at Saddle Base with Wear Plate (4.15.26) [sigma6,r]:

```
  = -K5 * Q * k / ( B1( t + eta * tr ) )
  = - 0.6733 * 11541 * 1.0/( 12.193( 0.315 + 0.85 * 0.394 ) )
  = -981.02 psi
```

Circ. Comp. Stress at Horn of Saddle, L<8Rm (4.15.28) [sigma7,r*]:

```
  = -Q/(4(t+eta*tr)b1) - 12*K7*Q*Rm/(L(t+eta*tr)²)
  = -11541/(4( 0.315+ 0.85* 0.394)12.193) -
     12*0.032*11541*24.335/(12.0(0.315+0.85*0.394)²)
  = -2120.92 psi
```

Results for Vessel Ribs, Web and Base:

Baseplate Length	Bplen	47.2441	in.
Baseplate Thickness	Bpthk	0.5512	in.
Baseplate Width	Bpwid	10.0000	in.
Number of Ribs (inc. outside ribs)	Nribs	3	
Rib Thickness	Ribtk	0.3937	in.
Web Thickness	Webtk	0.5512	in.
Web Location	Webloc	Side	
Saddle Yield Stress	Sy	34800.0	psi
Height of Web at Center	Hw,c	18.5	in.
Friction Coefficient	mu	0.000	

Note: In the tables below Io is I for the rectangle + Area * Centroid Distance^2

Moment of Inertia of Saddle - Transverse Direction (90 degrees to long axis)

	B	D	Y	A	AY	Io
Shell	18.0843	0.3150	0.1575	5.6958	0.8970	319.7759

Wearplate	13.7795	0.3937	0.5118	5.4250	2.7766	276.4725
Web	0.5512	17.8701	9.6437	9.8497	94.9872	301.2778
BasePlate	10.0000	0.5512	18.8543	5.5118	103.9216	692.1118
Totals	...	...	...	26.4823	202.5823	1589.6379

Distance to Centroid [C1]:
```
  = AY / A
  = 202.582/26.482
  = 7.650 in.
```

Angle [beta]:
```
  = 180 - Saddle Angle/2
  = 180 - 150.0/2
  = 105.0
```

Saddle Splitting Coefficient [K1]:
```
  = ( 1 + cos(beta) - 0.5*sin(beta)² )/(pi - beta + sin(beta)cos(beta) )
  = ( 1 + cos(105.0) - 0.5*sin(105.0)² )/(pi - 1.833 + sin(105.0)cos(105.0) )
  = 0.2594
```

Saddle Splitting Force [Fh]:
```
  = K1 * Q
  = 0.259 * 11540.693
  = 2993.3369 lb.

 Tension Stress, St = ( Fh/As )       =        144.0041  psi
 Allowed Stress, Sa = 0.6 * Yield Str =      20880.0000  psi
```

Saddle Splitting Dimension [d]:
```
  = B - R * sin(theta/2)/(theta/2 in radians)
  = 43.3 - 24.18 * sin(150.0/2)/1.309
  = 25.466 in.

 Bending Moment, M  = Fh * d          =       6352.4727  ft.lb.

 Bending Stress, Sb = ( M * C1 / I  ) =        366.8354  psi
 Allowed Stress, Sa = 2/3 * Yield Str =      23200.0000  psi
```

Minimum Thickness of Baseplate per Moss:
```
  = ( 3( Q + Saddle_Wt )BasePlateWidth / ( 2 * BasePlateLength * AllStress ))½
  = ( 3(11541 + 496)10.0/( 2 * 47.244 * 23200.0 ))½
  = 0.406 in.
```

Calculation of Axial Load, Intermediate Values and Compressive Stress:

Web Length Dimension [Web Length]:
```
  = 2 * cos( 90 - Saddle Angle/2 )( Inside Radius + Shell Thk + Wear Plate Thk )
  = 2 * cos( 90 - 150.0/2 )( 24.177 + 0.315 + 0.394 )
  = 48.076 in.
```

Distance between Ribs [e]:
```
  = Web Length / ( Nribs - 1 )
  = 48.0757/( 3 - 1 )
  = 24.038 in.
```

Baseplate Pressure Area [Ap]:
```
  = e * Bpwid / 2
  = 24.0379 * 10.0/2
  = 120.189 in²
```

Bearing Pressure [Bp]:
```
  = Q / ( BasePlateLength * BasePlateWidth )
  = 11540.693/( 47.244 * 10.0 )
  = 24.428 lb./in²
```

Axial Load [P]:

```
  = Ap * Bp
  = 120.2 * 24.43
  = 2935.961 lb.
```

Area of the Rib and Web [Ar]:

```
  = Rib Area + Web Area
  = 2.883 + 6.625
  = 9.508 in²
```

Compressive Stress [Sc]:

```
  = P/Ar
  = 2936.0/9.5076
  = 308.801 psi
```

Check of Outside Ribs:

Inertia of Saddle, Outer Ribs - Longitudinal Direction

	B	D	Y	A	AY	Io
Rib	0.3937	7.3228	4.2126	2.8830	12.1450	35.4272
Web	12.0189	0.5512	0.2756	6.6246	1.8257	9.6092
Totals	...	...	...	9.5076	13.9706	45.0364

Rib dimension [D]:

```
  = Saddle Width - Web Thickness
  = 7.874 - 0.551
  = 7.323 in.
```

Distance to Centroid from Datum [ytot]:

```
  = AY / A
  = 13.971/9.508
  = 1.469 in.
```

Distance to Centroid [C1]:

```
  = max( ytot, Saddle Width - ytot )
  = max( 1.469, 7.874 - 1.469 )
  = 6.405 in.
```

Radius of Gyration [r]:

```
  = sqrt( Total Inertia / Total Area )
  = sqrt( 45.0/9.508 )
  = 2.176 in.
```

Intermediate Term [Cc]:

```
  = sqrt( 2 * pi² * Elastic Modulus / Yield Stress )
  = sqrt( 2 * pi² * 29000000/34800.0 )
  = 128.255
```

Slenderness ratio [KL/r]:

```
  = KL/r
  = 1 * 18.044/2.176
  = 8.291
```

Bending Moment [Rm]:

```
  = Fl /( 2 * Bplen ) * e * L / 2
  = 7693.8/( 2 * 47.24 ) * 24.038 * 18.04/2
  = 1471.555 ft.lb.
```

Compressive Allowable, KL/r < Cc (8.2905 < 128.255) per AISC E2-1 [Sca]:

```
  = ( 1-(Klr)²/(2*Cc²))Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
  = ( 1-( 8.29 )²/(2 * 128.25² ))34800/
    ( 5/3+3*(8.29)/(8* 128.25)-( 8.29³)/(8*128.25³)
  = 20538 psi
```

AISC Unity Check of Outside Ribs (must be <= 1)
```
  = Sc/Sca + ( Rm * C1 / I )/Sba
  = 308.8/20538.08 + ( 17658.66 * 6.405/45.036 )/23200.0
  = 0.123
```

Check of Inside Ribs:

Inertia of Saddle, Inner Ribs - Axial Direction

	B	D	Y	A	AY	Io
Rib	0.3937	7.3228	4.2126	2.8830	12.1450	43.8743
Web	24.0379	0.5512	0.2756	13.2492	3.6514	6.8943
Totals	...	...	...	16.1322	15.7963	50.7686

Distance to Centroid from Datum [ytot]:
```
  = AY / A
  = 15.796/16.132
  = 0.979 in.
```

Distance to Centroid [C1]:
```
  = max( ytot, abs( Saddle Width - ytot ) )
  = max( 0.979, abs( 7.874 - 0.979 ) )
  = 6.895 in.
```

Length of Inner Rib [L]:
```
  = Saddle Height - Outside Radius - Bpthk
  = 43.307 - cos( 24.886/2 )( 0.551 + 0.0 + 0.0 ) - 0.0
  = 17.870 in.
```

Radius of Gyration [r]:
```
  = sqrt( Total Inertia / Total Area )
  = sqrt( 50.8/16.132 )
  = 1.774 in.
```

Slenderness ratio [KL/r]:
```
  = KL/r
  = 1 * 17.87/1.774
  = 10.073
```

Unit Force [Force,u]:
```
  = Fl / ( 2 * Baseplate Length )
  = 7693.796/( 2 * 47.244 )
  = 81.426 lb./in.
```

Moment at base of inner Rib [Mbase,c]:
```
  = Unit Force * e * L
  = 81.426 * 24.038 * 17.87
  = 34977.250 in.lbs
```

Bending Stress due to Transverse Force and Weight Load [SigmaB,base,c]:
```
  = Bending Moment / Section Modulus
  = 34977.25/7.363
  = 4750.236 psi
```

Compressive Allowable, KL/r < Cc (10.0734 < 128.255) per AISC E2-1 [Sca]:
```
  = ( 1-(Klr)²/(2*Cc²))Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
  = ( 1-( 10.07 )²/(2 * 128.25² ))34800/
    ( 5/3+3*(10.07)/(8* 128.25)-( 10.07³)/(8*128.25³)
  = 20455 psi
```

AISC Unity Check of Inside Ribs (must be <= 1)
```
  = Sc/Sca + ( Mbase,c * C1/I )/Sba
  = 354.25/20454.87 + ( 34977.25 * 6.895/50.769 )/23200.0
  = 0.222
```

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ASME Horizontal Vessel Analysis: Stresses for the Left Saddle
(per ASME Sec. VIII Div. 2 based on the Zick method.)

Horizontal Vessel Stress Calculations : Barge Transport

Note: There are more than two saddles present in this model. The load on the saddle supports has been taken as the total weight divided by the number of saddles. Insure that this is an appropriate assumption for this vessel model.

Input and Calculated Values:

```
 Vessel Mean Radius                              Rm       24.22  in.
 Stiffened Vessel Length per 4.15.6               L       32.00  ft.
 Distance from Saddle to Vessel tangent           a       62.83  in.

 Saddle Width                                     b        7.87  in.
 Saddle Bearing Angle                         theta      150.00  degrees

 Wear Plate Width                                b1       13.78  in.
 Wear Plate Bearing Angle                    theta1      162.00  degrees
 Wear Plate Thickness                            tr      0.3937  in.
 Wear Plate Allowable Stress                     Sr    17000.00  psi

 Shell Allowable Stress used in Calculation            20000.00  psi
 Head Allowable Stress used in Calculation                 0.00  psi
 Circumferential Efficiency in Plane of Saddle             1.00
 Circumferential Efficiency at Mid-Span                    1.00

 Distance from Saddle Base to Centerline          B       43.31  in.
 Coefficient of Friction                         mu        0.00

 Saddle Force Q for this Transportation Case           12822.99  lb.
 Shipping Longitudinal Acceleration              gx        0.40  g
 Shipping Transverse Acceleration                gz        0.75  g
 Shipping Vertical Acceleration                  gy        2.00  g
 Vertical Acceleration Acting with Transverse    gw        1.00  g
 Internal Pressure during Transport                        5.00  psig

 Horizontal Vessel Analysis Results:        Actual |    Allowable |
                                               psi |          psi |
 ----------------------------------------------------------------
 Long. Stress at Top    of Midspan         -557.55 |    -36100.00 |
 Long. Stress at Top    of Midspan          557.55 |     20000.00 |
 Long. Stress at Bottom of Midspan          941.99 |     20000.00 |
 Long. Stress at Top    of Saddles         1501.31 |     20000.00 |
 Long. Stress at Bottom of Saddles         -561.04 |    -36100.00 |
 Long. Stress at Bottom of Saddles          561.04 |     20000.00 |
 ----------------------------------------------------------------
 Tangential Shear in Shell                  903.50 |     16000.00 |
 Circ. Stress at Horn of Saddle            1848.84 |     30000.00 |
 Circ. Compressive Stress in Shell         1090.96 |     20000.00 |
 ----------------------------------------------------------------
```

Intermediate Results: Saddle Reaction Q due to Barge Transport Load:

Transverse Force due to Axial Acceleration [Ft]:
```
  = gx * tsc * saddle Load * gw
  = 0.75 * 4274.33 * 1.0
  = 3205.7 lb.
```

Longitudinal Force due to Axial Acceleration [Fl]:
```
  = gz * saddle Load * gw
  = 0.4 * 4274.33 * 1.0
```

```
  = 1709.7 lb.
```

Transverse Saddle Reaction Force due to Lateral Acceleration [Fwt]:
```
  = Ft/Num of Saddles * B / E
  = 3205.7/3 * 43.3071/47.2441
  = 979.5 lb.
```

Saddle Reaction Force due to Transport Load [Fwl]:
```
  = Fl * B / Ls
  = 1710 * 43.3071/367.9575
  = 201.2 lb.
```

Saddle Reaction Force due to Vertical Transportation Acceleration [Fsl]:
```
  = Saddle Load * gy
  = 4274.3 * 2.0
  = 8548.662 lb.
```

Load Combination Results due to Transport Loading [Q]:
```
  = Saddle Load + max( Fwl, Fwt, Fsl )
  = 4274 + max( 201, 980, 8549 )
  = 12823.0 lb.
```

Summary of Loads at the base of this Saddle:

Vertical Load (including saddle weight)		13317.77	lb.
Transverse Shear Load Saddle	Ft	0.00	lb.
Longitudinal Shear Load Saddle		1709.73	lb.

Formulas and Substitutions for Horizontal Vessel Analysis:

Note: Wear Plate is not Welded to the Shell, k = 1.0

Saddle Dimension [E]:
```
  = Baseplate Length
  = 47.244 in.
```

The Computed K values from Table 4.15.1:

K1 = 0.1607	K2 = 0.7988	K3 = 0.4851	K4 = 0.2952
K5 = 0.6733	K6 = 0.0317	K7 = 0.0317	K8 = 0.3021
K9 = 0.2177	K10 = 0.0355	K1* = 0.2792	K6p = 0.0252
K7p = 0.0252			

The suffix 'p' denotes the values for a wear plate if it exists.

Note: Dimension a is greater than or equal to Rm / 2.

Moment per Equation 4.15.3 [M1]:
```
  = -Q*a [1 - (1- a/L + (Rm²-h2²)/(2a*L))/(1+(4h2)/3L)]
  = -12823*5.24[1-(1-5.24/32.0+(2.018²-0.0²)/
    (2*5.24*32.0))/(1+(4*0.0)/(3*32.0))]
  = -10170.9 ft.lb.
```

Moment per Equation 4.15.4 [M2]:
```
  = Q*L/4(1+2(Rm²-h2²)/(L²))/(1+(4h2)/( 3L))-4a/L
  = 12823*32.0/4(1+2(2.018²-0.0²)/(32.0²))/(1+(4*0.0)/
    (3*32.0))-4*5.24/32.0
  = 36255.9 ft.lb.
```

Longitudinal Stress at Top of Shell (4.15.6) [Sigma1]:
```
  = P * Rm/(2t) - M2/(pi*Rm²t)
  = 5.0 * 24.217/(2* 0.315) - 435071.2/(pi*24.2²* 0.315)
  = -557.55 psi
```

Longitudinal Stress at Bottom of Shell (4.15.7) [Sigma2]:
```
  = P * Rm/(2t) + M2/(pi * Rm² * t)
  = 5.0 * 24.217/(2 * 0.315) + 435071.2/(pi * 24.2² * 0.315 )
```

```
  = 941.99 psi
```

Longitudinal Stress at Top of Shell at Support (4.15.10) [Sigma*3]:
```
  = P * Rm/(2t) - M1/(K1*pi*Rm²t)
  = 5.0*24.217/(2*0.315)--122051.1/(0.1607*pi*24.2²*0.315)
  = 1501.31 psi
```

Longitudinal Stress at Bottom of Shell at Support (4.15.11) [Sigma*4]:
```
  = P * Rm/(2t) + M1/(K1* * pi * Rm² * t)
  = 5.0*24.217/(2*0.315)+-122051.1/(0.2792*pi*24.2²*0.315)
  = -561.04 psi
```

Maximum Shear Force in the Saddle (4.15.5) [T]:
```
  = Q(L-2a)/(L+(4*h2/3))
  = 12823( 32.0 - 2 * 5.24)/(32.0 + ( 4 * 0.0/3))
  = 8626.5 lb.
```

Shear Stress in the shell no rings, not stiffened (4.15.14) [tau2]:
```
  = K2 * T / ( Rm * t )
  = 0.7988 * 8626.5/( 24.2165 * 0.315 )
  = 903.50 psi
```

Decay Length (4.15.22) [x1,x2]:
```
  = 0.78 * sqrt( Rm * t )
  = 0.78 * sqrt( 24.217 * 0.315 )
  = 2.154 in.
```

Effective reinforcing plate width (4.15.1) [B1]:
```
  = min( b + 1.56 * sqrt( Rm * t ), 2a   )
  = min( 7.87 + 1.56 * sqrt( 24.217 * 0.315 ), 2 * 62.835 )
  = 12.18 in.
```

Wear Plate/Shell Stress ratio (4.15.29) [eta]:
```
  = min( Sr/S, 1 )
  = min( 17000.0/20000.0, 1 )
  = 0.8500
```

Circumferential Stress at Saddle Base with Wear Plate (4.15.26) [sigma6,r]:
```
  = -K5 * Q * k / ( B1( t + eta * tr ) )
  = - 0.6733 * 12823 * 1.0/( 12.182( 0.315 + 0.85 * 0.394 ) )
  = -1090.96 psi
```

Circ. Comp. Stress at Horn of Saddle, L>=8Rm (4.15.27) [sigma7,r]:
```
  = -Q/(4(t+eta*tr)b1) - 3*K7*Q/(2(t+eta*tr)²)
  = -12823/(4( 0.315 + 0.85 * 0.394)12.182) -
     3 * 0.032 * 12823/(2( 0.315 + 0.85 * 0.394)²)
  = -1848.84 psi
```

Results for Vessel Ribs, Web and Base:

Baseplate Length	Bplen	47.2441	in.
Baseplate Thickness	Bpthk	0.5512	in.
Baseplate Width	Bpwid	10.0000	in.
Number of Ribs (inc. outside ribs)	Nribs	3	
Rib Thickness	Ribtk	0.3937	in.
Web Thickness	Webtk	0.5512	in.
Web Location	Webloc	Side	
Saddle Yield Stress	Sy	34800.0	psi
Height of Web at Center	Hw,c	18.5	in.
Friction Coefficient	mu	0.000	

Note: In the tables below Io is I for the rectangle + Area * Centroid Distance^2

Moment of Inertia of Saddle - Transverse Direction (90 degrees to long axis)

B	D	Y	A	AY	Io

Shell	18.0738	0.3150	0.1575	5.6925	0.8965	324.0760
Wearplate	13.7795	0.3937	0.5118	5.4250	2.7766	280.5464
Web	0.5512	17.9882	9.7028	9.9148	96.2005	307.0317
BasePlate	10.0000	0.5512	18.9725	5.5118	104.5726	700.2507
Totals	...	...	...	26.5441	204.4461	1611.9049

Distance to Centroid [C1]:
= AY / A
= 204.446/26.544
= 7.702 in.

Angle [beta]:
= 180 - Saddle Angle/2
= 180 - 150.0/2
= 105.0

Saddle Splitting Coefficient [K1]:
= (1 + cos(beta) - 0.5*sin(beta)²)/(pi - beta + sin(beta)cos(beta))
= (1 + cos(105.0) - 0.5*sin(105.0)²)/(pi - 1.833 + sin(105.0)cos(105.0))
= 0.2594

Saddle Splitting Force [Fh]:
= K1 * Q
= 0.259 * 12822.993
= 3325.9299 lb.

Tension Stress, St = (Fh/As) = 159.5050 psi
Allowed Stress, Sa = 0.6 * Yield Str = 20880.0000 psi

Saddle Splitting Dimension [d]:
= B - R * sin(theta/2)/(theta/2 in radians)
= 43.3 - 24.06 * sin(150.0/2)/1.309
= 25.554 in.

Bending Moment, M = Fh * d = 7082.4595 ft.lb.

Bending Stress, Sb = (M * C1 / I) = 406.1035 psi
Allowed Stress, Sa = 2/3 * Yield Str = 23200.0000 psi

Minimum Thickness of Baseplate per Moss:
= (3(Q + Saddle_Wt)BasePlateWidth / (2 * BasePlateLength * AllStress))½
= (3(12823 + 495)10.0/(2 * 47.244 * 23200.0))½
= 0.427 in.

Calculation of Axial Load, Intermediate Values and Compressive Stress:

Web Length Dimension [Web Length]:
= 2 * cos(90 - Saddle Angle/2)(Inside Radius + Shell Thk + Wear Plate Thk)
= 2 * cos(90 - 150.0/2)(24.059 + 0.315 + 0.394)
= 47.848 in.

Distance between Ribs [e]:
= Web Length / (Nribs - 1)
= 47.8476/(3 - 1)
= 23.924 in.

Baseplate Pressure Area [Ap]:
= e * Bpwid / 2
= 23.9238 * 10.0/2
= 119.619 in^2

Bearing Pressure [Bp]:
= Q / (BasePlateLength * BasePlateWidth)
= 12822.993/(47.244 * 10.0)
= 27.142 $lb./in^2$

Axial Load [P]:
```
  = Ap * Bp
  = 119.6 * 27.14
  = 3246.696 lb.
```

Area of the Rib and Web [Ar]:
```
  = Rib Area + Web Area
  = 2.883 + 6.593
  = 9.476 in²
```

Compressive Stress [Sc]:
```
  = P/Ar
  = 3246.7/9.4762
  = 342.617 psi
```

Check of Outside Ribs:

Inertia of Saddle, Outer Ribs - Longitudinal Direction

	B	D	Y	A	AY	Io
Rib	0.3937	7.3228	4.2126	2.8830	12.1450	35.3646
Web	11.9619	0.5512	0.2756	6.5932	1.8170	9.6261
Totals	...	...	...	9.4762	13.9620	44.9907

Rib dimension [D]:
```
  = Saddle Width - Web Thickness
  = 7.874 - 0.551
  = 7.323 in.
```

Distance to Centroid from Datum [ytot]:
```
  = AY / A
  = 13.962/9.476
  = 1.473 in.
```

Distance to Centroid [C1]:
```
  = max( ytot, Saddle Width - ytot )
  = max( 1.473, 7.874 - 1.473 )
  = 6.401 in.
```

Radius of Gyration [r]:
```
  = sqrt( Total Inertia / Total Area )
  = sqrt( 45.0/9.476 )
  = 2.179 in.
```

Intermediate Term [Cc]:
```
  = sqrt( 2 * pi² * Elastic Modulus / Yield Stress )
  = sqrt( 2 * pi² * 29000000/34800.0 )
  = 128.255
```

Slenderness ratio [KL/r]:
```
  = KL/r
  = 1 * 17.917/2.179
  = 8.223
```

Bending Moment [Rm]:
```
  = Fl /( 2 * Bplen ) * e * L / 2
  = 1709.7/( 2 * 47.24 ) * 23.924 * 17.92/2
  = 323.180 ft.lb.
```

Compressive Allowable, KL/r < Cc (8.223 < 128.255) per AISC E2-1 [Sca]:
```
  = ( 1-(Klr)²/(2*Cc²))Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
  = ( 1-( 8.22 )²/(2 * 128.25² ))34800/
    ( 5/3+3*(8.22)/(8* 128.25)-( 8.22³)/(8*128.25³)
```

```
  = 20541 psi
```

AISC Unity Check of Outside Ribs (must be <= 1)

```
  = Sc/Sca + ( Rm * C1 / I )/Sba
  = 342.62/20541.17 + ( 3878.16 * 6.401/44.991 )/23200.0
  = 0.040
```

Check of Inside Ribs:

Inertia of Saddle, Inner Ribs - Axial Direction

	B	D	Y	A	AY	Io
Rib	0.3937	7.3228	4.2126	2.8830	12.1450	43.8230
Web	23.9238	0.5512	0.2756	13.1863	3.6340	6.9127
Totals	...	...	...	16.0693	15.7790	50.7357

Distance to Centroid from Datum [ytot]:

```
  = AY / A
  = 15.779/16.069
  = 0.982 in.
```

Distance to Centroid [C1]:

```
  = max( ytot, abs( Saddle Width - ytot ) )
  = max( 0.982, abs( 7.874 - 0.982 ) )
  = 6.892 in.
```

Length of Inner Rib [L]:

```
  = Saddle Height - Outside Radius - Bpthk
  = 43.307 - cos( 24.768/2 )( 0.551 + 0.0 + 0.0 ) - 0.0
  = 17.988 in.
```

Radius of Gyration [r]:

```
  = sqrt( Total Inertia / Total Area )
  = sqrt( 50.7/16.069 )
  = 1.777 in.
```

Slenderness ratio [KL/r]:

```
  = KL/r
  = 1 * 17.988/1.777
  = 10.123
```

Unit Force [Force,u]:

```
  = Fl / ( 2 * Baseplate Length )
  = 1709.732/( 2 * 47.244 )
  = 18.095 lb./in.
```

Moment at base of inner Rib [Mbase,c]:

```
  = Unit Force * e * L
  = 18.095 * 23.924 * 17.988
  = 7786.962 in.lbs
```

Bending Stress due to Transverse Force and Weight Load [SigmaB,base,c]:

```
  = Bending Moment / Section Modulus
  = 7786.962/7.361
  = 1057.804 psi
```

Compressive Allowable, KL/r < Cc (10.1235 < 128.255) per AISC E2-1 [Sca]:

```
  = ( 1-(Klr)²/(2*Cc²))Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
  = ( 1-( 10.12 )²/(2 * 128.25² ))34800/
    ( 5/3+3*(10.12)/(8* 128.25)-( 10.12³)/(8*128.25³)
  = 20452 psi
```

AISC Unity Check of Inside Ribs (must be <= 1)

```
  = Sc/Sca + ( Mbase,c * C1/I )/Sba
  = 393.24/20452.48 + ( 7786.96 * 6.892/50.736 )/23200.0
```

= 0.065

ASME Horizontal Vessel Analysis: Stresses for the Right Saddle
(per ASME Sec. VIII Div. 2 based on the Zick method.)

*Warning - Distance to Saddle (a) > 0.25 * Tangent Distance (L) - 4.15.3.2*

Input and Calculated Values:

Vessel Mean Radius	Rm	24.33	in.
Stiffened Vessel Length per 4.15.6	L	12.00	ft.
Distance from Saddle to Vessel tangent	a	59.05	in.
Saddle Width	b	7.87	in.
Saddle Bearing Angle	theta	150.00	degrees
Wear Plate Width	b1	13.78	in.
Wear Plate Bearing Angle	theta1	162.00	degrees
Wear Plate Thickness	tr	0.3937	in.
Wear Plate Allowable Stress	Sr	17000.00	psi
Inside Depth of Head	h2	1.01	ft.
Shell Allowable Stress used in Calculation		20000.00	psi
Head Allowable Stress used in Calculation		20000.00	psi
Circumferential Efficiency in Plane of Saddle		1.00	
Circumferential Efficiency at Mid-Span		1.00	
Distance from Saddle Base to Centerline	B	43.31	in.
Coefficient of Friction	mu	0.00	
Saddle Force Q for this Transportation Case		12822.99	lb.
Shipping Longitudinal Acceleration	gx	0.40	g
Shipping Transverse Acceleration	gz	0.75	g
Shipping Vertical Acceleration	gy	2.00	g
Vertical Acceleration Acting with Transverse	gw	1.00	g
Internal Pressure during Transport		5.00	psig

Horizontal Vessel Analysis Results:	Actual psi	Allowable psi
Long. Stress at Top of Midspan	746.43	20000.00
Long. Stress at Bottom of Midspan	-360.12	-36100.00
Long. Stress at Bottom of Midspan	360.12	20000.00
Long. Stress at Top of Saddles	3779.26	20000.00
Long. Stress at Bottom of Saddles	-1870.32	-36100.00
Long. Stress at Bottom of Saddles	1870.32	20000.00
Tangential Shear in Shell	216.18	16000.00
Circ. Stress at Horn of Saddle	2356.58	30000.00
Circ. Compressive Stress in Shell	1090.02	20000.00

Intermediate Results: Saddle Reaction Q due to Barge Transport Load:

Transverse Force due to Axial Acceleration [Ft]:
= gx * tsc * saddle Load * gw
= 0.75 * 4274.33 * 1.0
= 3205.7 lb.

Longitudinal Force due to Axial Acceleration [Fl]:
= gz * saddle Load * gw
= 0.4 * 4274.33 * 1.0
= 1709.7 lb.

Transverse Saddle Reaction Force due to Lateral Acceleration [Fwt]:

```
  = Ft/Num of Saddles * B / E
  = 3205.7/3 * 43.3071/47.2441
  = 979.5 lb.
```

Saddle Reaction Force due to Transport Load [Fwl]:

```
  = Fl * B / Ls
  = 1710 * 43.3071/367.9575
  = 201.2 lb.
```

Saddle Reaction Force due to Vertical Transportation Acceleration [Fsl]:

```
  = Saddle Load * gy
  = 4274.3 * 2.0
  = 8548.662 lb.
```

Load Combination Results due to Transport Loading [Q]:

```
  = Saddle Load + max( Fwl, Fwt, Fsl )
  = 4274 + max( 201, 980, 8549 )
  = 12823.0 lb.
```

Summary of Loads at the base of this Saddle:

Vertical Load (including saddle weight)		13318.51	lb.
Transverse Shear Load Saddle	Ft	0.00	lb.
Longitudinal Shear Load Saddle		1709.73	lb.

Formulas and Substitutions for Horizontal Vessel Analysis:

Note: Wear Plate is not Welded to the Shell, k = 1.0

Saddle Dimension [E]:

```
  = Baseplate Length
  = 47.244 in.
```

The Computed K values from Table 4.15.1:

```
 K1  = 0.1607     K2  = 0.7988     K3  = 0.4851     K4  = 0.2952
 K5  = 0.6733     K6  = 0.0317     K7  = 0.0317     K8  = 0.3021
 K9  = 0.2177     K10 = 0.0355     K1* = 0.2792     K6p = 0.0252
 K7p = 0.0252
```

The suffix 'p' denotes the values for a wear plate if it exists.

Note: Dimension a is greater than or equal to Rm / 2.

Moment per Equation 4.15.3 [M1]:

```
  = -Q*a [1 - (1- a/L + (Rm²-h2²)/(2a*L))/(1+(4h2)/3L)]
  = -12823*4.92[1-(1-4.92/12.0+(2.028²-1.007²)/
    (2*4.92*12.0))/(1+(4*1.01)/(3*12.0))]
  = -28134.6 ft.lb.
```

Moment per Equation 4.15.4 [M2]:

```
  = Q*L/4(1+2(Rm²-h2²)/(L²))/(1+(4h2)/( 3L))-4a/L
  = 12823*12.0/4(1+2(2.028²-1.007²)/(12.0²))/(1+(4*1.007)/
    (3*12.0))-4*4.92/12.0
  = -27015.5 ft.lb.
```

Longitudinal Stress at Top of Shell (4.15.6) [Sigma1]:

```
  = P * Rm/(2t) - M2/(pi*Rm²t)
  = 5.0 * 24.335/(2* 0.315) - -324186.4/(pi*24.3²* 0.315)
  = 746.43 psi
```

Longitudinal Stress at Bottom of Shell (4.15.7) [Sigma2]:

```
  = P * Rm/(2t) + M2/(pi * Rm² * t)
  = 5.0 * 24.335/(2 * 0.315) + -324186.4/(pi * 24.3² * 0.315 )
  = -360.12 psi
```

Longitudinal Stress at Top of Shell at Support (4.15.10) [Sigma*3]:

```
  = P * Rm/(2t) - M1/(K1*pi*Rm²t)
  = 5.0*24.335/(2*0.315)--337615.6/(0.1607*pi*24.3²*0.315)
  = 3779.26 psi
```

Longitudinal Stress at Bottom of Shell at Support (4.15.11) [Sigma*4]:

```
  = P * Rm/(2t) + M1/(K1* * pi * Rm² * t)
  = 5.0*24.335/(2*0.315)+-337615.6/(0.2792*pi*24.3²*0.315)
  = -1870.32 psi
```

Maximum Shear Force in the Saddle (4.15.5) [T]:

```
  = Q(L-2a)/(L+(4*h2/3))
  = 12823( 12.0 - 2 * 4.92)/(12.0 + ( 4 * 1.01/3))
  = 2074.1 lb.
```

Shear Stress in the shell no rings, not stiffened (4.15.14) [tau2]:

```
  = K2 * T / ( Rm * t )
  = 0.7988 * 2074.1/( 24.3346 * 0.315 )
  = 216.18 psi
```

Decay Length (4.15.22) [x1,x2]:

```
  = 0.78 * sqrt( Rm * t )
  = 0.78 * sqrt( 24.335 * 0.315 )
  = 2.159 in.
```

Effective reinforcing plate width (4.15.1) [B1]:

```
  = min( b + 1.56 * sqrt( Rm * t ), 2a  )
  = min( 7.87 + 1.56 * sqrt( 24.335 * 0.315 ), 2 * 59.051 )
  = 12.19 in.
```

Wear Plate/Shell Stress ratio (4.15.29) [eta]:

```
  = min( Sr/S, 1 )
  = min( 17000.0/20000.0, 1 )
  = 0.8500
```

Circumferential Stress at Saddle Base with Wear Plate (4.15.26) [sigma6,r]:

```
  = -K5 * Q * k / ( B1( t + eta * tr ) )
  = - 0.6733 * 12823 * 1.0/( 12.193( 0.315 + 0.85 * 0.394 ) )
  = -1090.02 psi
```

Circ. Comp. Stress at Horn of Saddle, L<8Rm (4.15.28) [sigma7,r*]:

```
  = -Q/(4(t+eta*tr)b1) - 12*K7*Q*Rm/(L(t+eta*tr)²)
  = -12823/(4( 0.315+ 0.85* 0.394)12.193) -
     12*0.032*12823*24.335/(12.0(0.315+0.85*0.394)²)
  = -2356.58 psi
```

Results for Vessel Ribs, Web and Base:

Baseplate Length	Bplen	47.2441	in.
Baseplate Thickness	Bpthk	0.5512	in.
Baseplate Width	Bpwid	10.0000	in.
Number of Ribs (inc. outside ribs)	Nribs	3	
Rib Thickness	Ribtk	0.3937	in.
Web Thickness	Webtk	0.5512	in.
Web Location	Webloc	Side	
Saddle Yield Stress	Sy	34800.0	psi
Height of Web at Center	Hw,c	18.5	in.
Friction Coefficient	mu	0.000	

Note: In the tables below Io is I for the rectangle + Area * Centroid Distance^2

Moment of Inertia of Saddle - Transverse Direction (90 degrees to long axis)

	B	D	Y	A	AY	Io
Shell	18.0843	0.3150	0.1575	5.6958	0.8970	319.7759

Wearplate	13.7795	0.3937	0.5118	5.4250	2.7766	276.4725
Web	0.5512	17.8701	9.6437	9.8497	94.9872	301.2778
BasePlate	10.0000	0.5512	18.8543	5.5118	103.9216	692.1118
Totals	...	...	...	26.4823	202.5823	1589.6379

Distance to Centroid [C1]:
```
  = AY / A
  = 202.582/26.482
  = 7.650 in.
```

Angle [beta]:
```
  = 180 - Saddle Angle/2
  = 180 - 150.0/2
  = 105.0
```

Saddle Splitting Coefficient [K1]:
```
  = ( 1 + cos(beta) - 0.5*sin(beta)² )/(pi - beta + sin(beta)cos(beta) )
  = ( 1 + cos(105.0) - 0.5*sin(105.0)² )/(pi - 1.833 + sin(105.0)cos(105.0) )
  = 0.2594
```

Saddle Splitting Force [Fh]:
```
  = K1 * Q
  = 0.259 * 12822.993
  = 3325.9299 lb.

 Tension Stress, St = ( Fh/As )       =        160.0046  psi
 Allowed Stress, Sa = 0.6 * Yield Str =      20880.0000  psi
```

Saddle Splitting Dimension [d]:
```
  = B - R * sin(theta/2)/(theta/2 in radians)
  = 43.3 - 24.18 * sin(150.0/2)/1.309
  = 25.466 in.

 Bending Moment, M  = Fh * d          =       7058.3032  ft.lb.

 Bending Stress, Sb = ( M * C1 / I  ) =        407.5950  psi
 Allowed Stress, Sa = 2/3 * Yield Str =      23200.0000  psi
```

Minimum Thickness of Baseplate per Moss:
```
  = ( 3( Q + Saddle_Wt )BasePlateWidth / ( 2 * BasePlateLength * AllStress ))½
  = ( 3(12823 + 496)10.0/( 2 * 47.244 * 23200.0 ))½
  = 0.427 in.
```

Calculation of Axial Load, Intermediate Values and Compressive Stress:

Web Length Dimension [Web Length]:
```
  = 2 * cos( 90 - Saddle Angle/2 )( Inside Radius + Shell Thk + Wear Plate Thk )
  = 2 * cos( 90 - 150.0/2 )( 24.177 + 0.315 + 0.394 )
  = 48.076 in.
```

Distance between Ribs [e]:
```
  = Web Length / ( Nribs - 1 )
  = 48.0757/( 3 - 1 )
  = 24.038 in.
```

Baseplate Pressure Area [Ap]:
```
  = e * Bpwid / 2
  = 24.0379 * 10.0/2
  = 120.189 in²
```

Bearing Pressure [Bp]:
```
  = Q / ( BasePlateLength * BasePlateWidth )
  = 12822.993/( 47.244 * 10.0 )
  = 27.142 lb./in²
```

Axial Load [P]:

```
  = Ap * Bp
  = 120.2 * 27.14
  = 3262.179 lb.
```

Area of the Rib and Web [Ar]:

```
  = Rib Area + Web Area
  = 2.883 + 6.625
  = 9.508 in²
```

Compressive Stress [Sc]:

```
  = P/Ar
  = 3262.2/9.5076
  = 343.112 psi
```

Check of Outside Ribs:

Inertia of Saddle, Outer Ribs - Longitudinal Direction

	B	D	Y	A	AY	Io
Rib	0.3937	7.3228	4.2126	2.8830	12.1450	35.4272
Web	12.0189	0.5512	0.2756	6.6246	1.8257	9.6092
Totals	...	...	...	9.5076	13.9706	45.0364

Rib dimension [D]:

```
  = Saddle Width - Web Thickness
  = 7.874 - 0.551
  = 7.323 in.
```

Distance to Centroid from Datum [ytot]:

```
  = AY / A
  = 13.971/9.508
  = 1.469 in.
```

Distance to Centroid [C1]:

```
  = max( ytot, Saddle Width - ytot )
  = max( 1.469, 7.874 - 1.469 )
  = 6.405 in.
```

Radius of Gyration [r]:

```
  = sqrt( Total Inertia / Total Area )
  = sqrt( 45.0/9.508 )
  = 2.176 in.
```

Intermediate Term [Cc]:

```
  = sqrt( 2 * pi² * Elastic Modulus / Yield Stress )
  = sqrt( 2 * pi² * 29000000/34800.0 )
  = 128.255
```

Slenderness ratio [KL/r]:

```
  = KL/r
  = 1 * 18.044/2.176
  = 8.291
```

Bending Moment [Rm]:

```
  = Fl /( 2 * Bplen ) * e * L / 2
  = 1709.7/( 2 * 47.24 ) * 24.038 * 18.04/2
  = 327.012 ft.lb.
```

Compressive Allowable, KL/r < Cc (8.2905 < 128.255) per AISC E2-1 [Sca]:

```
  = ( 1-(Klr)²/(2*Cc²))Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
  = ( 1-( 8.29 )²/(2 * 128.25² ))34800/
    ( 5/3+3*(8.29)/(8* 128.25)-( 8.29³)/(8*128.25³)
  = 20538 psi
```

AISC Unity Check of Outside Ribs (must be <= 1)

```
  = Sc/Sca + ( Rm * C1 / I )/Sba
  = 343.11/20538.08 + ( 3924.15 * 6.405/45.036 )/23200.0
  = 0.041
```

Check of Inside Ribs:

Inertia of Saddle, Inner Ribs - Axial Direction

	B	D	Y	A	AY	Io
Rib	0.3937	7.3228	4.2126	2.8830	12.1450	43.8743
Web	24.0379	0.5512	0.2756	13.2492	3.6514	6.8943
Totals	...	...	...	16.1322	15.7963	50.7686

Distance to Centroid from Datum [ytot]:

```
  = AY / A
  = 15.796/16.132
  = 0.979 in.
```

Distance to Centroid [C1]:

```
  = max( ytot, abs( Saddle Width - ytot ) )
  = max( 0.979, abs( 7.874 - 0.979 ) )
  = 6.895 in.
```

Length of Inner Rib [L]:

```
  = Saddle Height - Outside Radius - Bpthk
  = 43.307 - cos( 24.886/2 )( 0.551 + 0.0 + 0.0 ) - 0.0
  = 17.870 in.
```

Radius of Gyration [r]:

```
  = sqrt( Total Inertia / Total Area )
  = sqrt( 50.8/16.132 )
  = 1.774 in.
```

Slenderness ratio [KL/r]:

```
  = KL/r
  = 1 * 17.87/1.774
  = 10.073
```

Unit Force [Force,u]:

```
  = Fl / ( 2 * Baseplate Length )
  = 1709.732/( 2 * 47.244 )
  = 18.095 lb./in.
```

Moment at base of inner Rib [Mbase,c]:

```
  = Unit Force * e * L
  = 18.095 * 24.038 * 17.87
  = 7772.722 in.lbs
```

Bending Stress due to Transverse Force and Weight Load [SigmaB,base,c]:

```
  = Bending Moment / Section Modulus
  = 7772.722/7.363
  = 1055.608 psi
```

Compressive Allowable, KL/r < Cc (10.0734 < 128.255) per AISC E2-1 [Sca]:

```
  = ( 1-(Klr)²/(2*Cc²))Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
  = ( 1-( 10.07 )²/(2 * 128.25² ))34800/
    ( 5/3+3*(10.07)/(8* 128.25)-( 10.07³)/(8*128.25³)
  = 20455 psi
```

AISC Unity Check of Inside Ribs (must be <= 1)

```
  = Sc/Sca + ( Mbase,c * C1/I )/Sba
  = 393.61/20454.87 + ( 7772.72 * 6.895/50.769 )/23200.0
  = 0.065
```

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ASME Horizontal Vessel Analysis: Stresses for the Left Saddle
(per ASME Sec. VIII Div. 2 based on the Zick method.)

Horizontal Vessel Stress Calculations : Ocean Transport

Note: There are more than two saddles present in this model. The load on the saddle supports has been taken as the total weight divided by the number of saddles. Insure that this is an appropriate assumption for this vessel model.

Input and Calculated Values:

```
 Vessel Mean Radius                              Rm       24.22  in.
 Stiffened Vessel Length per 4.15.6               L       32.00  ft.
 Distance from Saddle to Vessel tangent           a       62.83  in.

 Saddle Width                                     b        7.87  in.
 Saddle Bearing Angle                         theta      150.00  degrees

 Wear Plate Width                                b1       13.78  in.
 Wear Plate Bearing Angle                    theta1      162.00  degrees
 Wear Plate Thickness                            tr      0.3937  in.
 Wear Plate Allowable Stress                     Sr    17000.00  psi

 Shell Allowable Stress used in Calculation            20000.00  psi
 Head Allowable Stress used in Calculation                 0.00  psi
 Circumferential Efficiency in Plane of Saddle             1.00
 Circumferential Efficiency at Mid-Span                    1.00

 Distance from Saddle Base to Centerline          B       43.31  in.
 Coefficient of Friction                         mu        0.00

 Saddle Force Q for this Transportation Case           12822.99  lb.
 Shipping Longitudinal Acceleration              gx        0.40  g
 Shipping Transverse Acceleration                gz        0.75  g
 Shipping Vertical Acceleration                  gy        2.00  g
 Vertical Acceleration Acting with Transverse    gw        1.00  g
 Internal Pressure during Transport                        5.00  psig

 Horizontal Vessel Analysis Results:       Actual |    Allowable |
                                              psi |          psi |
 ----------------------------------------------------------------
 Long. Stress at Top    of Midspan        -557.55 |    -36100.00 |
 Long. Stress at Top    of Midspan         557.55 |     20000.00 |
 Long. Stress at Bottom of Midspan         941.99 |     20000.00 |
 Long. Stress at Top    of Saddles        1501.31 |     20000.00 |
 Long. Stress at Bottom of Saddles        -561.04 |    -36100.00 |
 Long. Stress at Bottom of Saddles         561.04 |     20000.00 |
 ----------------------------------------------------------------
 Tangential Shear in Shell                 903.50 |     16000.00 |
 Circ. Stress at Horn of Saddle           1848.84 |     30000.00 |
 Circ. Compressive Stress in Shell        1090.96 |     20000.00 |
 ----------------------------------------------------------------
```

Intermediate Results: Saddle Reaction Q due to Ocean Transport Load:

Transverse Force due to Axial Acceleration [Ft]:

```
  = gx * saddle Load * gw
  = 0.75 * 4274.33 * 1.0
  = 3205.7 lb.
```

Longitudinal Force due to Axial Acceleration [Fl]:

```
  = gz * saddle Load * gw
  = 0.4 * 4274.33 * 1.0
```

```
  = 1709.7 lb.
```

Transverse Saddle Reaction Force due to Lateral Acceleration [Fwt]:

```
  = Ft/Num of Saddles * B / E
  = 3205.7/3 * 43.3071/47.2441
  = 979.5 lb.
```

Saddle Reaction Force due to Transport Load [Fwl]:

```
  = Fl * B / Ls
  = 1710 * 43.3071/367.9575
  = 201.2 lb.
```

Saddle Reaction Force due to Vertical Transportation Acceleration [Fsl]:

```
  = Saddle Load * gy
  = 4274.3 * 2.0
  = 8548.662 lb.
```

Load Combination Results due to Transport Loading [Q]:

```
  = Saddle Load + max( Fwl, Fwt, Fsl )
  = 4274 + max( 201, 980, 8549 )
  = 12823.0 lb.
```

Summary of Loads at the base of this Saddle:

Vertical Load (including saddle weight)		13317.77	lb.
Transverse Shear Load Saddle	Ft	0.00	lb.
Longitudinal Shear Load Saddle		1709.73	lb.

Formulas and Substitutions for Horizontal Vessel Analysis:

Note: Wear Plate is not Welded to the Shell, k = 1.0

Saddle Dimension [E]:

```
  = Baseplate Length
  = 47.244 in.
```

The Computed K values from Table 4.15.1:

K1 = 0.1607	K2 = 0.7988	K3 = 0.4851	K4 = 0.2952
K5 = 0.6733	K6 = 0.0317	K7 = 0.0317	K8 = 0.3021
K9 = 0.2177	K10 = 0.0355	K1* = 0.2792	K6p = 0.0252
K7p = 0.0252			

The suffix 'p' denotes the values for a wear plate if it exists.

Note: Dimension a is greater than or equal to Rm / 2.

Moment per Equation 4.15.3 [M1]:

```
  = -Q*a [1 - (1- a/L + (Rm²-h2²)/(2a*L))/(1+(4h2)/3L)]
  = -12823*5.24[1-(1-5.24/32.0+(2.018²-0.0²)/
    (2*5.24*32.0))/(1+(4*0.0)/(3*32.0))]
  = -10170.9 ft.lb.
```

Moment per Equation 4.15.4 [M2]:

```
  = Q*L/4(1+2(Rm²-h2²)/(L²))/(1+(4h2)/( 3L))-4a/L
  = 12823*32.0/4(1+2(2.018²-0.0²)/(32.0²))/(1+(4*0.0)/
    (3*32.0))-4*5.24/32.0
  = 36255.9 ft.lb.
```

Longitudinal Stress at Top of Shell (4.15.6) [Sigma1]:

```
  = P * Rm/(2t) - M2/(pi*Rm²t)
  = 5.0 * 24.217/(2* 0.315) - 435071.2/(pi*24.2²* 0.315)
  = -557.55 psi
```

Longitudinal Stress at Bottom of Shell (4.15.7) [Sigma2]:

```
  = P * Rm/(2t) + M2/(pi * Rm² * t)
  = 5.0 * 24.217/(2 * 0.315) + 435071.2/(pi * 24.2² * 0.315 )
```

```
  = 941.99 psi
```

Longitudinal Stress at Top of Shell at Support (4.15.10) [Sigma*3]:
```
  = P * Rm/(2t) - M1/(K1*pi*Rm²t)
  = 5.0*24.217/(2*0.315)--122051.1/(0.1607*pi*24.2²*0.315)
  = 1501.31 psi
```

Longitudinal Stress at Bottom of Shell at Support (4.15.11) [Sigma*4]:
```
  = P * Rm/(2t) + M1/(K1* * pi * Rm² * t)
  = 5.0*24.217/(2*0.315)+-122051.1/(0.2792*pi*24.2²*0.315)
  = -561.04 psi
```

Maximum Shear Force in the Saddle (4.15.5) [T]:
```
  = Q(L-2a)/(L+(4*h2/3))
  = 12823( 32.0 - 2 * 5.24)/(32.0 + ( 4 * 0.0/3))
  = 8626.5 lb.
```

Shear Stress in the shell no rings, not stiffened (4.15.14) [tau2]:
```
  = K2 * T / ( Rm * t )
  = 0.7988 * 8626.5/( 24.2165 * 0.315 )
  = 903.50 psi
```

Decay Length (4.15.22) [x1,x2]:
```
  = 0.78 * sqrt( Rm * t )
  = 0.78 * sqrt( 24.217 * 0.315 )
  = 2.154 in.
```

Effective reinforcing plate width (4.15.1) [B1]:
```
  = min( b + 1.56 * sqrt( Rm * t ), 2a   )
  = min( 7.87 + 1.56 * sqrt( 24.217 * 0.315 ), 2 * 62.835 )
  = 12.18 in.
```

Wear Plate/Shell Stress ratio (4.15.29) [eta]:
```
  = min( Sr/S, 1 )
  = min( 17000.0/20000.0, 1 )
  = 0.8500
```

Circumferential Stress at Saddle Base with Wear Plate (4.15.26) [sigma6,r]:
```
  = -K5 * Q * k / ( B1( t + eta * tr ) )
  = - 0.6733 * 12823 * 1.0/( 12.182( 0.315 + 0.85 * 0.394 ) )
  = -1090.96 psi
```

Circ. Comp. Stress at Horn of Saddle, L>=8Rm (4.15.27) [sigma7,r]:
```
  = -Q/(4(t+eta*tr)b1) - 3*K7*Q/(2(t+eta*tr)²)
  = -12823/(4( 0.315 + 0.85 * 0.394)12.182) -
     3 * 0.032 * 12823/(2( 0.315 + 0.85 * 0.394)²)
  = -1848.84 psi
```

Results for Vessel Ribs, Web and Base:

Baseplate Length	Bplen	47.2441	in.
Baseplate Thickness	Bpthk	0.5512	in.
Baseplate Width	Bpwid	10.0000	in.
Number of Ribs (inc. outside ribs)	Nribs	3	
Rib Thickness	Ribtk	0.3937	in.
Web Thickness	Webtk	0.5512	in.
Web Location	Webloc	Side	
Saddle Yield Stress	Sy	34800.0	psi
Height of Web at Center	Hw,c	18.5	in.
Friction Coefficient	mu	0.000	

Note: In the tables below Io is I for the rectangle + Area * Centroid Distance^2

Moment of Inertia of Saddle - Transverse Direction (90 degrees to long axis)

B	D	Y	A	AY	Io

Shell	18.0738	0.3150	0.1575	5.6925	0.8965	324.0760
Wearplate	13.7795	0.3937	0.5118	5.4250	2.7766	280.5464
Web	0.5512	17.9882	9.7028	9.9148	96.2005	307.0317
BasePlate	10.0000	0.5512	18.9725	5.5118	104.5726	700.2507
Totals	...	...	...	26.5441	204.4461	1611.9049

Distance to Centroid [C1]:
```
  = AY / A
  = 204.446/26.544
  = 7.702 in.
```

Angle [beta]:
```
  = 180 - Saddle Angle/2
  = 180 - 150.0/2
  = 105.0
```

Saddle Splitting Coefficient [K1]:
```
  = ( 1 + cos(beta) - 0.5*sin(beta)² )/(pi - beta + sin(beta)cos(beta) )
  = ( 1 + cos(105.0) - 0.5*sin(105.0)² )/(pi - 1.833 + sin(105.0)cos(105.0) )
  = 0.2594
```

Saddle Splitting Force [Fh]:
```
  = K1 * Q
  = 0.259 * 12822.993
  = 3325.9299 lb.

 Tension Stress, St = ( Fh/As )       =        159.5050  psi
 Allowed Stress, Sa = 0.6 * Yield Str =      20880.0000  psi
```

Saddle Splitting Dimension [d]:
```
  = B - R * sin(theta/2)/(theta/2 in radians)
  = 43.3 - 24.06 * sin(150.0/2)/1.309
  = 25.554 in.

 Bending Moment, M  = Fh * d          =       7082.4595  ft.lb.

 Bending Stress, Sb = ( M * C1 / I  ) =        406.1035  psi
 Allowed Stress, Sa = 2/3 * Yield Str =      23200.0000  psi
```

Minimum Thickness of Baseplate per Moss:
```
  = ( 3( Q + Saddle_Wt )BasePlateWidth / ( 2 * BasePlateLength * AllStress ))½
  = ( 3(12823 + 495)10.0/( 2 * 47.244 * 23200.0 ))½
  = 0.427 in.
```

Calculation of Axial Load, Intermediate Values and Compressive Stress:

Web Length Dimension [Web Length]:
```
  = 2 * cos( 90 - Saddle Angle/2 )( Inside Radius + Shell Thk + Wear Plate Thk )
  = 2 * cos( 90 - 150.0/2 )( 24.059 + 0.315 + 0.394 )
  = 47.848 in.
```

Distance between Ribs [e]:
```
  = Web Length / ( Nribs - 1 )
  = 47.8476/( 3 - 1 )
  = 23.924 in.
```

Baseplate Pressure Area [Ap]:
```
  = e * Bpwid / 2
  = 23.9238 * 10.0/2
  = 119.619 in²
```

Bearing Pressure [Bp]:
```
  = Q / ( BasePlateLength * BasePlateWidth )
  = 12822.993/( 47.244 * 10.0 )
  = 27.142 lb./in²
```

Axial Load [P]:
= Ap * Bp
= 119.6 * 27.14
= 3246.696 lb.

Area of the Rib and Web [Ar]:
= Rib Area + Web Area
= 2.883 + 6.593
= 9.476 in²

Compressive Stress [Sc]:
= P/Ar
= 3246.7/9.4762
= 342.617 psi

Check of Outside Ribs:

Inertia of Saddle, Outer Ribs - Longitudinal Direction

	B	D	Y	A	AY	Io
Rib	0.3937	7.3228	4.2126	2.8830	12.1450	35.3646
Web	11.9619	0.5512	0.2756	6.5932	1.8170	9.6261
Totals	...	...	...	9.4762	13.9620	44.9907

Rib dimension [D]:
= Saddle Width - Web Thickness
= 7.874 - 0.551
= 7.323 in.

Distance to Centroid from Datum [ytot]:
= AY / A
= 13.962/9.476
= 1.473 in.

Distance to Centroid [C1]:
= max(ytot, Saddle Width - ytot)
= max(1.473, 7.874 - 1.473)
= 6.401 in.

Radius of Gyration [r]:
= sqrt(Total Inertia / Total Area)
= sqrt(45.0/9.476)
= 2.179 in.

Intermediate Term [Cc]:
= sqrt(2 * pi² * Elastic Modulus / Yield Stress)
= sqrt(2 * pi² * 29000000/34800.0)
= 128.255

Slenderness ratio [KL/r]:
= KL/r
= 1 * 17.917/2.179
= 8.223

Bending Moment [Rm]:
= Fl /(2 * Bplen) * e * L / 2
= 1709.7/(2 * 47.24) * 23.924 * 17.92/2
= 323.180 ft.lb.

Compressive Allowable, KL/r < Cc (8.223 < 128.255) per AISC E2-1 [Sca]:
= (1-(Klr)²/(2*Cc²))Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
= (1-(8.22)²/(2 * 128.25²))34800/
(5/3+3*(8.22)/(8* 128.25)-(8.22³)/(8*128.25³)

```
  = 20541 psi
```

AISC Unity Check of Outside Ribs (must be <= 1)

```
  = Sc/Sca + ( Rm * C1 / I )/Sba
  = 342.62/20541.17 + ( 3878.16 * 6.401/44.991 )/23200.0
  = 0.040
```

Check of Inside Ribs:

Inertia of Saddle, Inner Ribs - Axial Direction

	B	D	Y	A	AY	Io
Rib	0.3937	7.3228	4.2126	2.8830	12.1450	43.8230
Web	23.9238	0.5512	0.2756	13.1863	3.6340	6.9127
Totals	...	...	...	16.0693	15.7790	50.7357

Distance to Centroid from Datum [ytot]:

```
  = AY / A
  = 15.779/16.069
  = 0.982 in.
```

Distance to Centroid [C1]:

```
  = max( ytot, abs( Saddle Width - ytot ) )
  = max( 0.982, abs( 7.874 - 0.982 ) )
  = 6.892 in.
```

Length of Inner Rib [L]:

```
  = Saddle Height - Outside Radius - Bpthk
  = 43.307 - cos( 24.768/2 )( 0.551 + 0.0 + 0.0 ) - 0.0
  = 17.988 in.
```

Radius of Gyration [r]:

```
  = sqrt( Total Inertia / Total Area )
  = sqrt( 50.7/16.069 )
  = 1.777 in.
```

Slenderness ratio [KL/r]:

```
  = KL/r
  = 1 * 17.988/1.777
  = 10.123
```

Unit Force [Force,u]:

```
  = Fl / ( 2 * Baseplate Length )
  = 1709.732/( 2 * 47.244 )
  = 18.095 lb./in.
```

Moment at base of inner Rib [Mbase,c]:

```
  = Unit Force * e * L
  = 18.095 * 23.924 * 17.988
  = 7786.962 in.lbs
```

Bending Stress due to Transverse Force and Weight Load [SigmaB,base,c]:

```
  = Bending Moment / Section Modulus
  = 7786.962/7.361
  = 1057.804 psi
```

Compressive Allowable, KL/r < Cc (10.1235 < 128.255) per AISC E2-1 [Sca]:

```
  = ( 1-(Klr)²/(2*Cc²))Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
  = ( 1-( 10.12 )²/(2 * 128.25² ))34800/
    ( 5/3+3*(10.12)/(8* 128.25)-( 10.12³)/(8*128.25³)
  = 20452 psi
```

AISC Unity Check of Inside Ribs (must be <= 1)

```
  = Sc/Sca + ( Mbase,c * C1/I )/Sba
  = 393.24/20452.48 + ( 7786.96 * 6.892/50.736 )/23200.0
```

= 0.065

ASME Horizontal Vessel Analysis: Stresses for the Right Saddle
(per ASME Sec. VIII Div. 2 based on the Zick method.)

*Warning - Distance to Saddle (a) > 0.25 * Tangent Distance (L) - 4.15.3.2*

Input and Calculated Values:

```
Vessel Mean Radius                              Rm        24.33  in.
Stiffened Vessel Length per 4.15.6               L        12.00  ft.
Distance from Saddle to Vessel tangent           a        59.05  in.

Saddle Width                                     b         7.87  in.
Saddle Bearing Angle                         theta       150.00  degrees

Wear Plate Width                                b1        13.78  in.
Wear Plate Bearing Angle                    theta1       162.00  degrees
Wear Plate Thickness                            tr       0.3937  in.
Wear Plate Allowable Stress                     Sr     17000.00  psi

Inside Depth of Head                            h2         1.01  ft.

Shell Allowable Stress used in Calculation             20000.00  psi
Head Allowable Stress used in Calculation              20000.00  psi
Circumferential Efficiency in Plane of Saddle              1.00
Circumferential Efficiency at Mid-Span                     1.00

Distance from Saddle Base to Centerline          B        43.31  in.
Coefficient of Friction                         mu         0.00

Saddle Force Q for this Transportation Case            12822.99  lb.
Shipping Longitudinal Acceleration              gx         0.40  g
Shipping Transverse Acceleration                gz         0.75  g
Shipping Vertical Acceleration                  gy         2.00  g
Vertical Acceleration Acting with Transverse    gw         1.00  g
Internal Pressure during Transport                         5.00  psig

Horizontal Vessel Analysis Results:        Actual |    Allowable |
                                              psi |          psi |
-----------------------------------------------------------------
Long. Stress at Top    of Midspan          746.43 |     20000.00 |
Long. Stress at Bottom of Midspan         -360.12 |    -36100.00 |
Long. Stress at Bottom of Midspan          360.12 |     20000.00 |
Long. Stress at Top    of Saddles         3779.26 |     20000.00 |
Long. Stress at Bottom of Saddles        -1870.32 |    -36100.00 |
Long. Stress at Bottom of Saddles         1870.32 |     20000.00 |
-----------------------------------------------------------------
Tangential Shear in Shell                  216.18 |     16000.00 |
Circ. Stress at Horn of Saddle            2356.58 |     30000.00 |
Circ. Compressive Stress in Shell         1090.02 |     20000.00 |
-----------------------------------------------------------------
```

Intermediate Results: Saddle Reaction Q due to Ocean Transport Load:

Transverse Force due to Axial Acceleration [Ft]:
= gx * saddle Load * gw
= 0.75 * 4274.33 * 1.0
= 3205.7 lb.

Longitudinal Force due to Axial Acceleration [Fl]:
= gz * saddle Load * gw
= 0.4 * 4274.33 * 1.0
= 1709.7 lb.

Transverse Saddle Reaction Force due to Lateral Acceleration [Fwt]:

```
  = Ft/Num of Saddles * B / E
  = 3205.7/3 * 43.3071/47.2441
  = 979.5 lb.
```

Saddle Reaction Force due to Transport Load [Fwl]:

```
  = Fl * B / Ls
  = 1710 * 43.3071/367.9575
  = 201.2 lb.
```

Saddle Reaction Force due to Vertical Transportation Acceleration [Fsl]:

```
  = Saddle Load * gy
  = 4274.3 * 2.0
  = 8548.662 lb.
```

Load Combination Results due to Transport Loading [Q]:

```
  = Saddle Load + max( Fwl, Fwt, Fsl )
  = 4274 + max( 201, 980, 8549 )
  = 12823.0 lb.
```

Summary of Loads at the base of this Saddle:

```
 Vertical Load (including saddle weight)             13318.51  lb.
 Transverse Shear Load Saddle           Ft               0.00  lb.
 Longitudinal Shear Load Saddle                       1709.73  lb.
```

Formulas and Substitutions for Horizontal Vessel Analysis:

Note: Wear Plate is not Welded to the Shell, k = 1.0

Saddle Dimension [E]:

```
  = Baseplate Length
  = 47.244 in.
```

The Computed K values from Table 4.15.1:

```
 K1  = 0.1607     K2  = 0.7988     K3  = 0.4851     K4  = 0.2952
 K5  = 0.6733     K6  = 0.0317     K7  = 0.0317     K8  = 0.3021
 K9  = 0.2177     K10 = 0.0355     K1* = 0.2792     K6p = 0.0252
 K7p = 0.0252
```

The suffix 'p' denotes the values for a wear plate if it exists.

Note: Dimension a is greater than or equal to Rm / 2.

Moment per Equation 4.15.3 [M1]:

```
  = -Q*a [1 - (1- a/L + (Rm²-h2²)/(2a*L))/(1+(4h2)/3L)]
  = -12823*4.92[1-(1-4.92/12.0+(2.028²-1.007²)/
    (2*4.92*12.0))/(1+(4*1.01)/(3*12.0))]
  = -28134.6 ft.lb.
```

Moment per Equation 4.15.4 [M2]:

```
  = Q*L/4(1+2(Rm²-h2²)/(L²))/(1+(4h2)/( 3L))-4a/L
  = 12823*12.0/4(1+2(2.028²-1.007²)/(12.0²))/(1+(4*1.007)/
    (3*12.0))-4*4.92/12.0
  = -27015.5 ft.lb.
```

Longitudinal Stress at Top of Shell (4.15.6) [Sigma1]:

```
  = P * Rm/(2t) - M2/(pi*Rm²t)
  = 5.0 * 24.335/(2* 0.315) - -324186.4/(pi*24.3²* 0.315)
  = 746.43 psi
```

Longitudinal Stress at Bottom of Shell (4.15.7) [Sigma2]:

```
  = P * Rm/(2t) + M2/(pi * Rm² * t)
  = 5.0 * 24.335/(2 * 0.315) + -324186.4/(pi * 24.3² * 0.315 )
  = -360.12 psi
```

Longitudinal Stress at Top of Shell at Support (4.15.10) [Sigma*3]:

```
  = P * Rm/(2t) - M1/(K1*pi*Rm²t)
  = 5.0*24.335/(2*0.315)--337615.6/(0.1607*pi*24.3²*0.315)
  = 3779.26 psi
```

Longitudinal Stress at Bottom of Shell at Support (4.15.11)   [Sigma*4]:

```
  = P * Rm/(2t) + M1/(K1* * pi * Rm² * t)
  = 5.0*24.335/(2*0.315)+-337615.6/(0.2792*pi*24.3²*0.315)
  = -1870.32 psi
```

Maximum Shear Force in the Saddle (4.15.5)   [T]:

```
  = Q(L-2a)/(L+(4*h2/3))
  = 12823( 12.0 - 2 * 4.92)/(12.0 + ( 4 * 1.01/3))
  = 2074.1 lb.
```

Shear Stress in the shell no rings, not stiffened (4.15.14)   [tau2]:

```
  = K2 * T / ( Rm * t )
  = 0.7988 * 2074.1/( 24.3346 * 0.315 )
  = 216.18 psi
```

Decay Length (4.15.22)   [x1,x2]:

```
  = 0.78 * sqrt( Rm * t )
  = 0.78 * sqrt( 24.335 * 0.315 )
  = 2.159 in.
```

Effective reinforcing plate width (4.15.1)   [B1]:

```
  = min( b + 1.56 * sqrt( Rm * t ), 2a   )
  = min( 7.87 + 1.56 * sqrt( 24.335 * 0.315 ), 2 * 59.051 )
  = 12.19 in.
```

Wear Plate/Shell Stress ratio (4.15.29)   [eta]:

```
  = min( Sr/S, 1 )
  = min( 17000.0/20000.0, 1 )
  = 0.8500
```

Circumferential Stress at Saddle Base with Wear Plate (4.15.26)   [sigma6,r]:

```
  = -K5 * Q * k / ( B1( t + eta * tr ) )
  = - 0.6733 * 12823 * 1.0/( 12.193( 0.315 + 0.85 * 0.394 ) )
  = -1090.02 psi
```

Circ. Comp. Stress at Horn of Saddle, L<8Rm (4.15.28)   [sigma7,r*]:

```
  = -Q/(4(t+eta*tr)b1) - 12*K7*Q*Rm/(L(t+eta*tr)²)
  = -12823/(4( 0.315+ 0.85* 0.394)12.193) -
     12*0.032*12823*24.335/(12.0(0.315+0.85*0.394)²)
  = -2356.58 psi
```

Results for Vessel Ribs, Web and Base:

Baseplate Length	Bplen	47.2441	in.
Baseplate Thickness	Bpthk	0.5512	in.
Baseplate Width	Bpwid	10.0000	in.
Number of Ribs (inc. outside ribs)	Nribs	3	
Rib Thickness	Ribtk	0.3937	in.
Web Thickness	Webtk	0.5512	in.
Web Location	Webloc	Side	
Saddle Yield Stress	Sy	34800.0	psi
Height of Web at Center	Hw,c	18.5	in.
Friction Coefficient	mu	0.000	

Note: In the tables below Io is I for the rectangle + Area * Centroid Distance^2

Moment of Inertia of Saddle - Transverse Direction (90 degrees to long axis)

	B	D	Y	A	AY	Io
Shell	18.0843	0.3150	0.1575	5.6958	0.8970	319.7759

Wearplate	13.7795	0.3937	0.5118	5.4250	2.7766	276.4725
Web	0.5512	17.8701	9.6437	9.8497	94.9872	301.2778
BasePlate	10.0000	0.5512	18.8543	5.5118	103.9216	692.1118
Totals	...	...	...	26.4823	202.5823	1589.6379

Distance to Centroid [C1]:
 = AY / A
 = 202.582/26.482
 = 7.650 in.

Angle [beta]:
 = 180 - Saddle Angle/2
 = 180 - 150.0/2
 = 105.0

Saddle Splitting Coefficient [K1]:
 = (1 + cos(beta) - 0.5*sin(beta)^2)/(pi - beta + sin(beta)cos(beta))
 = (1 + cos(105.0) - 0.5*sin(105.0)^2)/(pi - 1.833 + sin(105.0)cos(105.0))
 = 0.2594

Saddle Splitting Force [Fh]:
 = K1 * Q
 = 0.259 * 12822.993
 = 3325.9299 lb.

Tension Stress, St = (Fh/As) = 160.0046 psi
Allowed Stress, Sa = 0.6 * Yield Str = 20880.0000 psi

Saddle Splitting Dimension [d]:
 = B - R * sin(theta/2)/(theta/2 in radians)
 = 43.3 - 24.18 * sin(150.0/2)/1.309
 = 25.466 in.

Bending Moment, M = Fh * d = 7058.3032 ft.lb.

Bending Stress, Sb = (M * C1 / I) = 407.5950 psi
Allowed Stress, Sa = 2/3 * Yield Str = 23200.0000 psi

Minimum Thickness of Baseplate per Moss:
 = (3(Q + Saddle_Wt)BasePlateWidth / (2 * BasePlateLength * AllStress))½
 = (3(12823 + 496)10.0/(2 * 47.244 * 23200.0))½
 = 0.427 in.

Calculation of Axial Load, Intermediate Values and Compressive Stress:

Web Length Dimension [Web Length]:
 = 2 * cos(90 - Saddle Angle/2)(Inside Radius + Shell Thk + Wear Plate Thk)
 = 2 * cos(90 - 150.0/2)(24.177 + 0.315 + 0.394)
 = 48.076 in.

Distance between Ribs [e]:
 = Web Length / (Nribs - 1)
 = 48.0757/(3 - 1)
 = 24.038 in.

Baseplate Pressure Area [Ap]:
 = e * Bpwid / 2
 = 24.0379 * 10.0/2
 = 120.189 in^2

Bearing Pressure [Bp]:
 = Q / (BasePlateLength * BasePlateWidth)
 = 12822.993/(47.244 * 10.0)
 = 27.142 lb./in^2

Axial Load [P]:

```
  = Ap * Bp
  = 120.2 * 27.14
  = 3262.179 lb.
```

Area of the Rib and Web [Ar]:

```
  = Rib Area + Web Area
  = 2.883 + 6.625
  = 9.508 in²
```

Compressive Stress [Sc]:

```
  = P/Ar
  = 3262.2/9.5076
  = 343.112 psi
```

Check of Outside Ribs:

Inertia of Saddle, Outer Ribs - Longitudinal Direction

	B	D	Y	A	AY	Io
Rib	0.3937	7.3228	4.2126	2.8830	12.1450	35.4272
Web	12.0189	0.5512	0.2756	6.6246	1.8257	9.6092
Totals	...	...	...	9.5076	13.9706	45.0364

Rib dimension [D]:

```
  = Saddle Width - Web Thickness
  = 7.874 - 0.551
  = 7.323 in.
```

Distance to Centroid from Datum [ytot]:

```
  = AY / A
  = 13.971/9.508
  = 1.469 in.
```

Distance to Centroid [C1]:

```
  = max( ytot, Saddle Width - ytot )
  = max( 1.469, 7.874 - 1.469 )
  = 6.405 in.
```

Radius of Gyration [r]:

```
  = sqrt( Total Inertia / Total Area )
  = sqrt( 45.0/9.508 )
  = 2.176 in.
```

Intermediate Term [Cc]:

```
  = sqrt( 2 * pi² * Elastic Modulus / Yield Stress )
  = sqrt( 2 * pi² * 29000000/34800.0 )
  = 128.255
```

Slenderness ratio [KL/r]:

```
  = KL/r
  = 1 * 18.044/2.176
  = 8.291
```

Bending Moment [Rm]:

```
  = Fl /( 2 * Bplen ) * e * L / 2
  = 1709.7/( 2 * 47.24 ) * 24.038 * 18.04/2
  = 327.012 ft.lb.
```

Compressive Allowable, KL/r < Cc (8.2905 < 128.255) per AISC E2-1 [Sca]:

```
  = ( 1-(Klr)²/(2*Cc²))Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
  = ( 1-( 8.29 )²/(2 * 128.25² ))34800/
    ( 5/3+3*(8.29)/(8* 128.25)-( 8.29³)/(8*128.25³)
  = 20538 psi
```

AISC Unity Check of Outside Ribs (must be <= 1)
```
  = Sc/Sca + ( Rm * C1 / I )/Sba
  = 343.11/20538.08 + ( 3924.15 * 6.405/45.036 )/23200.0
  = 0.041
```

Check of Inside Ribs:

Inertia of Saddle, Inner Ribs - Axial Direction

	B	D	Y	A	AY	Io
Rib	0.3937	7.3228	4.2126	2.8830	12.1450	43.8743
Web	24.0379	0.5512	0.2756	13.2492	3.6514	6.8943
Totals	...	...	...	16.1322	15.7963	50.7686

Distance to Centroid from Datum [ytot]:
```
  = AY / A
  = 15.796/16.132
  = 0.979 in.
```

Distance to Centroid [C1]:
```
  = max( ytot, abs( Saddle Width - ytot ) )
  = max( 0.979, abs( 7.874 - 0.979 ) )
  = 6.895 in.
```

Length of Inner Rib [L]:
```
  = Saddle Height - Outside Radius - Bpthk
  = 43.307 - cos( 24.886/2 )( 0.551 + 0.0 + 0.0 ) - 0.0
  = 17.870 in.
```

Radius of Gyration [r]:
```
  = sqrt( Total Inertia / Total Area )
  = sqrt( 50.8/16.132 )
  = 1.774 in.
```

Slenderness ratio [KL/r]:
```
  = KL/r
  = 1 * 17.87/1.774
  = 10.073
```

Unit Force [Force,u]:
```
  = Fl / ( 2 * Baseplate Length )
  = 1709.732/( 2 * 47.244 )
  = 18.095 lb./in.
```

Moment at base of inner Rib [Mbase,c]:
```
  = Unit Force * e * L
  = 18.095 * 24.038 * 17.87
  = 7772.722 in.lbs
```

Bending Stress due to Transverse Force and Weight Load [SigmaB,base,c]:
```
  = Bending Moment / Section Modulus
  = 7772.722/7.363
  = 1055.608 psi
```

Compressive Allowable, KL/r < Cc (10.0734 < 128.255) per AISC E2-1 [Sca]:
```
  = ( 1-(Klr)²/(2*Cc²))Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
  = ( 1-( 10.07 )²/(2 * 128.25² ))34800/
    ( 5/3+3*(10.07)/(8* 128.25)-( 10.07³)/(8*128.25³)
  = 20455 psi
```

AISC Unity Check of Inside Ribs (must be <= 1)
```
  = Sc/Sca + ( Mbase,c * C1/I )/Sba
  = 393.61/20454.87 + ( 7772.72 * 6.895/50.769 )/23200.0
  = 0.065
```

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LASHING CALCULATIONS

TAG NO. - 18-D-271

References: Transportation Drawing (EN207122-PRAJ-9V3-00070)
IMO rules Annex 13 section 7 “Advanced Calculation Method”

Transportation Acceleration Values

Mode of Transort	Longitudinal (a_x)	Transverse (a_y)	Vertical (a_z)
Ocean	0.40 g	0.75 g	2.00 g
Road Transport	1.80 g	0.30 g	1.70 g

As Ocean transportation accelertion values are governing, we will anaysise it.

Shipping Weight of Vessel	m	6	ton
Longitudianl Sliding Force	$F_x = m * a_x$	2.4	kN
Transverse Sliding Force	$F_y = m * a_y$	4.5	kN
Vertical Force	$F_z = m * a_z$	12	kN

Coefficient of friction (Steel)	μ	0.3		
Gravity Acceleration of Earth	g	9.81	m/s^2	
Calculated Strength of Single Lashing	CS	6	ton	Ref: 4WEQ-1014
Lashing angle in Transverse Direction	α	45	Deg	
Function of friction coeff. & vertical securing angle.	f	μsinα + cosα		

Lashing Check Against Transverse Sliding

$$F_y \leq \mu * m * g + CS_1 * f_1 + CS_2 * f_2 + \ldots\ldots + CS_n * f_n$$

There are Two no. of single lashings around vessel to resist Transverse Sliding
1 No. of lashing on saddle & 1 no. on Lifting Lug provided on shell .

	CS_1, ton	α_1, deg	f_1
Skirt Lashing	6	45	32.53

	CS_2, ton	α_2, deg	f_2
Lug Lashing	6	45	32.53

These lashings are tied at angle 45° (α) to horizontal

$$\mu * m * g + CS_1 * f_1 + CS_2 * f_2 + \ldots\ldots + CS_n * f_n$$

= (0.3 * 6 * 9.81) + (6 * 32.53) + (6 * 32.53)
= 408.02 kN

$$F_y \leq \mu * m * g + CS_1 * f_1 + CS_2 * f_2 + \ldots\ldots + CS_n * f_n$$

4.5 < 408.02
Above equation is satisfied. Hence vessels is safe for Transverse sliding. SAFE

LASHING CALCULATIONS

TAG NO. - 18-D-271

Lashing Check Against Transverse Tipping

$$F_y * a \leq b * m * g + CS_1 * c_1 + CS_2 * c_2 + \ldots\ldots + CS_n * c_n$$

There are Two no. of single lashings around vessel to resist Transverse tipping.
1 No. of lashing on saddle & 1 no. on Lifting Lug provided on shell .

	CS_1 , ton	c_1 , m
Skirt Lashing	6	2.319

	CS_2 , ton	c_2 , m
Lug Lashing	6	2.319

Leverarm of Stableness	b	0.665	m
Leverarm of securing Force (Skirt Lashing)	c_1	2.319	m
Leverarm of securing Force (Lug Lashing)	c_2	2.319	m
Leverarm of tipping	a	1.2	m

$$b * m * g + CS_1 * c_1 + CS_2 * c_2 + \ldots\ldots + CS_n * c_n$$

= (0.665 * 6 * 9.81) + (6 * 2.319) + (6 * 2.319)

= 66.97 kN.m

$$F_y * a$$

= 4.5 * 1.2
= 5.4 kN.m

$$F_y * a \leq b * m * g + CS_1 * c_1 + CS_2 * c_2 + \ldots\ldots + CS_n * c_n$$

5.4 < 66.97
Above equation is satisfied. Hence vessels is safe for Transverse tipping. SAFE

Lashing Check Against Longitudinal Sliding

$$F_x \leq \mu * (m * g - F_z) + CS_1 * f_1 + CS_2 * f_2 + \ldots\ldots + CS_n * f_n$$

There are Three no. of single lashings around vessel to resist Longitudinal Sliding
1 no. on Lifting Lug provided on shell & another 2 saddle plate.

	CS_1 , ton	α_1 , deg	f_1
Skirt Lashing-1	6	45	0.92

	CS_2 , ton	α_2 , deg	f_2
Skirt Lashing-2	6	45	0.92

LASHING CALCULATIONS

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	CS_3 , ton	α_3 , deg	f_3
Lug Lashing	6	45	0.92

These lasings are tied at angle 45° (α) to horizontal

$$\mu * (m * g - F_z) + CS_1 * f_1 + CS_2 * f_2 + \ldots\ldots + CS_n * f_n$$

= 0.3 * (6 *9.81 - 12) + (6 * 0.92) + (6 * 0.92) + (6 * 0.92)

= 30.62 kN.m

$$F_x \leq \mu * (m * g - F_z) + CS_1 * f_1 + CS_2 * f_2 + \ldots\ldots + CS_n * f_n$$

2.4 < 30.62

Above equation is satisfied. Hence vessels is safe for Longitudinal Sliding. SAFE

Lashing Check Against Wind Forces

Overall Length of Vessel	l	m	10.985	
Overall Width of Vessel	w	m	1.95	
Overall Height of Vessel	h	m	2.3	
Wind force acting on each m^2 area		kN	1	Ref: IMO standard
Area exposed to wind in Longitudinal direction	w x h	m^2	4.49	

Wind force in Longitudinal direction = 1 kN x Longitudinal Exposed area of vessel
= 1 * 4.49

Wind force in Longitudinal direction F_{wx} kN 4.49

Wind force in longitudinal direction will cause Tranverse sliding on vessel.
Hence below equation should be satisfied

$$F_{wx} < \mu * m * g + CS_1 * f_1 + CS_2 * f_2 + \ldots\ldots + CS_n * f_n$$

4.49 < 408.02

Since above equation is satified, design is safe for longitudinal wind force. SAFE

Area exposed to wind in Transverse direction h x l m^2 25.27

Wind force in Transverse direction = 1 kN x Transverse Exposed area of vessel
= 1 * 25.27

Wind force in Transverse direction F_{wy} kN 25.27

Wind force in Transverse direction will cause Longitudinal sliding on vessel.
Hence below equation should be satisfied

$$F_{wy} < \mu * (m * g - F_z) + CS_1 * f_1 + CS_2 * f_2 + \ldots\ldots + CS_n * f_n$$

25.27 < 30.62

Since above equation is satified, design is safe for longitudinal wind force. SAFE