Base Load Power Hub (BLPH)

MECHANICAL CALCULATION
HYDROGEN VENT

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AN ENCORE COMBUSTION COMPANY

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Revision / Change Log

Rev.	Description
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1 INTRODUCTION

1.1 Project Overview

Crosswind, a Shell and Eneco joint venture, was awarded the tender to develop the offshore Hollandse Kust Noord (HKN) wind farm, located 18.5km off the coast of Netherlands near the town of Egmond aan Zee. The consortium plans to have HKN operational in 2023 with an installed capacity of 759MW generating at least 3.3TWh per year. This is sufficient renewable power to supply more than 1 million Dutch households with green electricity.

Offshore wind farms produce intermittent electricity and balancing these dips and peaks and integrating this electricity into the national energy system requires new technologies. For this reason, the offshore wind farm will include several new technologies that could be implemented at full-scale in the future. The new technologies being explored include a floating solar park, a short-duration battery storage as well as long-term storage via green hydrogen produced by water electrolysis and subsequently consumed in a fuel cell. The combination of these individual measures, herein referred to as the Base Load Power Hub (BLPH) will ensure a continuous power supply regardless of the wind situation.

1.1.1 Project Location

The Hollandse Kust Noord (HKN) wind farm is located 18.5km off the coast of the Netherlands near the town of Egmond aan Zee.

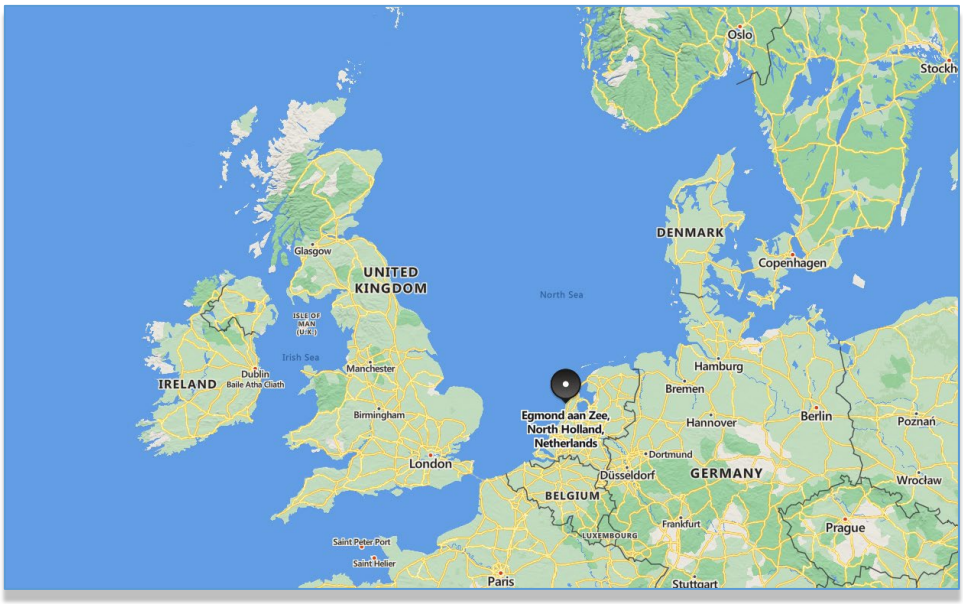


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

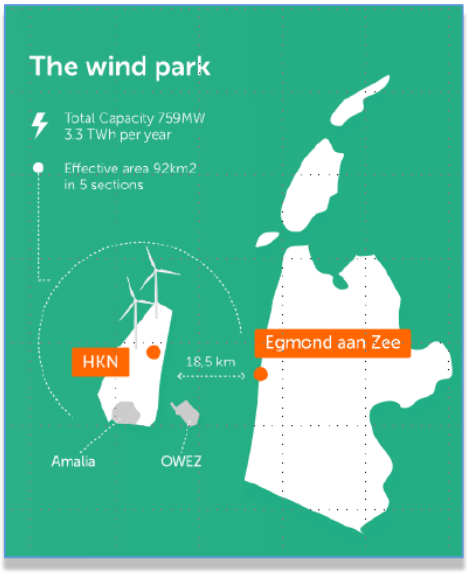


Figure 2 - Wind Park Details

The wind farm will consist of No. 69 x 11.5MW wind turbine generators each to be installed on a dedicated monopile structure. A 70th monopile located on coordinates E 590719.1, N 5841602.3 is reserved for installing the platform accommodating the BLPH. The monopile structure was designed and installed by Van Oord Offshore Wind (VooW) and therefore not part of the BLPH scope.

1.1.2Project Concept

All components included in the BLPH will be integrated onshore on a topsides and installed in an offshore location within the boundaries of the HKN wind farm. At its simplest, the BLPH will store energy during periods of high electricity generation from renewable sources (a wind turbine generator and the floating solar PV farm) and release it during periods of low generation. In practice. It is expected that the energy stored will supplement generation from renewable sources to ensure that at least 1.0MW of power is exported to the electrical grid regardless of wind/solar availability.

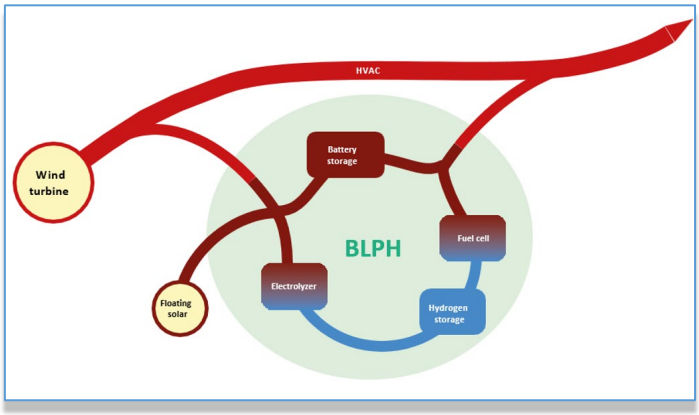


Figure 3 – BLPH Concept

Electricity in the BLPH will be stored in the form of electrons in a battery energy storage system (BESS) as well as converted into green hydrogen via water electrolysis. When the power output from the connecting wind turbine drops to below 1 MWe, the BLPH will return its stored energy to supplement the remaining power output. This will be by discharging the BESS, while stored hydrogen will be converted back into electricity using a fuel cell to extend the discharge duration.

The purpose of the BLPH s to function as a testbed for the integration of energy storage technologies with renewable generation. It is expected that equipment installed on the BLPH will operate as Normally Unmanned Installation for at least two (2) years with no or minimal maintenance and it will have its own independent control room with the ability to communicate with Crosswind's control room.

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2. DOCUMENT SCOPE

The aim of this document is to show the mechanical calculation for the hydrogen vent stack

2.1 References

Doc. No.	Description
1724000887-MAC-DA-00003	GENERAL ARRANGEMENT DRAWINGS, INCLUDING FOUNDATION LOADS-HYDROGEN VENT

Table 1 - Reference Documents

2.2 Definitions and Abbreviations

COMPANY - CPY	CrossWind
CONTRACTOR - CTR	ROSETTI MARINO S.p.A. -
PROJECT:	HOLLANDSE KUST NOORD WIND PARK Project
ETE	Encore Thermoengineering srl
ASME	American Society of Mechanical Engineers
HKN	Hollandse Kust Noord
BLPH	Base Load Power Hub
B.O.P.	Bottom of Baseplate
BESS	Battery Energy Storage System
COG	Center of Gravity
DNV	Det Norske Veritas (notified body)
EDMS	Electronic Document Management System
HW	Hydrotest
ID	Inside Diameter
PV	Pressure Vessel
LRFD	Load and Resistance Factor Design

MAWP	Maximum allowable working Pressure
MDMT	Minimum Design Metal Temperature
MSL	Mean Sea Level
NP	No Pressure
OD	Outside Diameter
PP	Plot Plans
PVP	Pressure Vessel and Piping
SP	Specification
ST	Structural
THK	Thickness
TP	Transport Protocol
VooW	Van Oord Offshore Wind
W	Wind
Wt	Weight

Table 2 - Definitions and Abbreviations

2.3 Code and Rules

Doc. No.	Description
/1/ BS EN ISO 19900	General requirements for offshore structures - 2019
/2/ BS EN ISO 19901-1	Specific requirements for offshore structures - Part 1: Metocean design and operating considerations - 2015
/3/ BS EN ISO 19901-2	Seismic design procedures and criteria
/4/ BS EN ISO 19901-3	Specific requirements for offshore structures – Part 3: Topsides structure - 2014
/5/ BS EN ISO 19901-5	Specific requirements for offshore structures – Part 5: Weight Management - 2021
/6/ BS EN ISO 19901-6	Specific requirements for offshore structures – Part 6: Marine Operations – 2009

/7/ BS EN ISO 19902	Petroleum and natural gas industries - Fixed steel offshore structures – 2020
/8/ ISO 19906:2019	Petroleum and natural gas industries – Arctic offshore structures
/9/ ANSI / AISC 360-16	Specification for Structural Steel Buildings - July 2016
/10/ API RP 2A-WSD	Recommended practice for planning, designing and constructing fixed offshore platforms – Working stress design – 22nd edition – 2014
/11/ DNVGL-ST-N001	DNV GL - Marine operation and marine warranty - 2021
/12/ EN 1991-1-3:2003 & A1:2015	EN, Eurocode 1 – Actions on Structures – Part 1-3: General actions – Snow loads - Incorporating corrigenda December 2004 and March 2009, December 2015.
/13/ DNV-ST-0145	DNV, Offshore substations
/14/ DNV-RP-C201	DNV, Buckling Strength of Plated Structures, October 2010.
/15/ DNVGL-RP-C203	DNV GL, Fatigue design of offshore steel structures, September 2019 and Amendment January 2020
/16/ DNVGL-RP-C204	DNVGL-RP-C204 Design against accidental loads – 2019
/17/ DNVGL-RP-C205	DNV GL - Environmental conditions and environmental loads - September 2019, amended September 2021.
/18/ DNV-OS-C101	Design of offshore steel structures, general- LRFD method, 2021
/19/ DNV-OS-B101	Metallic materials, 2021
/20/ DNVGL-ST-0126	Support structures for wind turbine, 2018

2.4 Company Specifications

Doc. No.	Description
/21/ DEP 37.19.00.12	Gen - Offshore Topsides Structures
/22/ DEP 37.19.00.30	Gen - Fixed Steel Offshore Structures (Adoption of IOGP S-631-11, Amendments / Supplements to ISO 19902:2020).

/23/ DEP 37.81.10.19	Gen - Marine Operations Requirements – Loadout, Transportation and Installation of Offshore Structures (Amendments / Supplements to ISO 19901-6)
/24/ DEP 37.91.10.11	Mobile Mooring Systems (Amendments / Supplements to API RP 2SK, API RP 2SM AND API RP 2I)

2.5 Project Documents

Doc. No.	Description
/25/ 123A90-DDL-MD-RE-01006	Weight Control Report
/26/ 123A90-PML-MD-PRO-01002	Weight Control Procedure
/27/ 123A90-DDL-PP-DS-70070	Plot Plans
/28/ Pending	Handling Philosophy Report
/29/ 123A90-DDL-ST-SP-90018	Structural Material Specification for Topside
/30/ Pending	Structural Material Specification for Transition Piece
/31/ 123A90-DDL-ST-SP-90019	Structural Fabrication Specification
/32/ 123A90-DDL-TI-SP-99014	Specification for TP, Topside and Caissons Transportation and Installation

2.6 Other Documents

Doc. No.	Description
/33/ K559–2254-ST-PHI-001	BLPH Structural Topsides Design & Installation Philosophy, Rev.1, 09 December 2022
/34/ K559–2254-ST-REP-001	BLPH Structural Topsides and Transition Piece Design and Analysis Report, Rev.0, 27 February 2023
/35/ 144671-VOOW-TF-ENG-REP-1011	Design Basis Part C, Re.4, 05-07-2021

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/36/ SR.20.01165 (not received)	Meteocean criteria for Hollandse Kust Noord Wind Farm zone (shell), Rev A03, 05-02-2021
/37/ K559–2254-WC-REP-001	BLPH Weight Control Report, Rev.2, 17 March 2023
/38/ 144671-VOOW-TF-ENG-REP-1051	Design Basis Part C for BLPH, Rev. 3, 28 June 2022
/39/ 144671-VOOW-TF-ENG-REP-1052	Wave Loads and Effects for BLPH, Rev. 0, 16 December 2021
/40/ 144671-VOOW-TF-ENG-REP-1016	Wave Run-up Study, Rev.2, 29 November 2021
/41/ 144671-VOOW-TF-ENG-REP-1103	Wave Impact Analysis, Rev.1, 7 May 2021
/42/ 144671-VOOW-TF-ENG-REP-1053	Axial Pile Capacity Assessment for BLPH, Rev.3, 07 July 2022
/43/ 144671-VOOW-TF-ENG-REP-1054	Foundation Load Document for BLPH, Rev.1, 07 April 2022
/44/ 144671-VOOW-TF-ENG-REP-1055	Design Verification Primary Steel for BLPH, Rev.1, 13 April 2022
/45/ 144671-VOOW-TF-ENG-REP-1056	Ship Impact for BLPH, Rev.0, 07 March 2022
/46/ 144671-VOOW-TF-ENG-REP-1502	Main Access Platform – Wave Run-up Braces
/47/ 144671-VOOW-GEN-SUR-REP-0074	Foundation As-built Survey CW70 HNA6
/48/ K559-2254-PM-PLN-003	Basic Design Engineering Package, Rev2, 06 July 2023

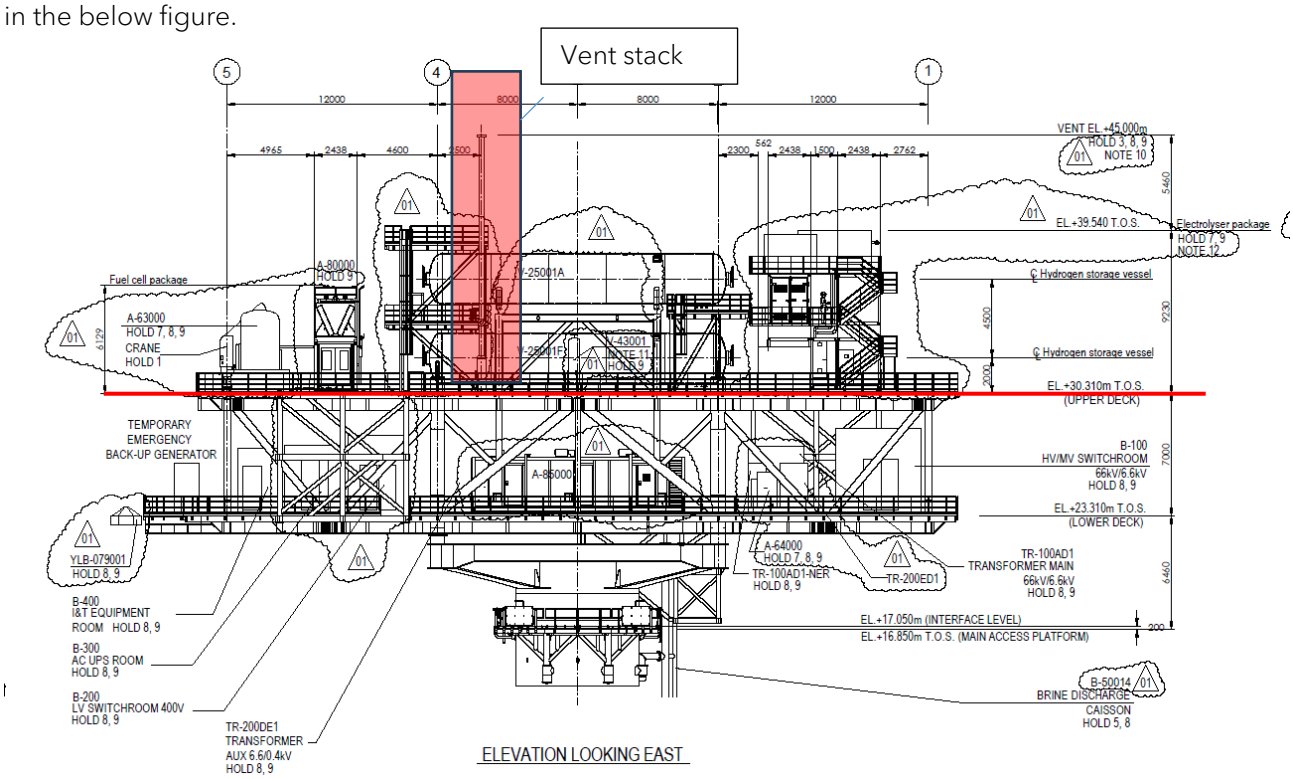
2.7 Code for Calculation of Equipment Under Pressure

This design of the bottom adheres to the guidelines and standards set forth by ASME Section VIII, Division 1, which governs the construction of pressure vessels. ASME (American Society of Mechanical Engineers) Section VIII, Division 1, is an internationally recognized code that provides detailed criteria for the design, fabrication, inspection, and testing of pressure vessels, thereby ensuring the safety, reliability, and efficiency of the equipment under pressure.

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3. SYSTEM DESCRIPTION

The bottom of the vent stack is located on the topside at el. 30.310 m B.O.P. (Bottom of baseplate) as shown in the below figure.



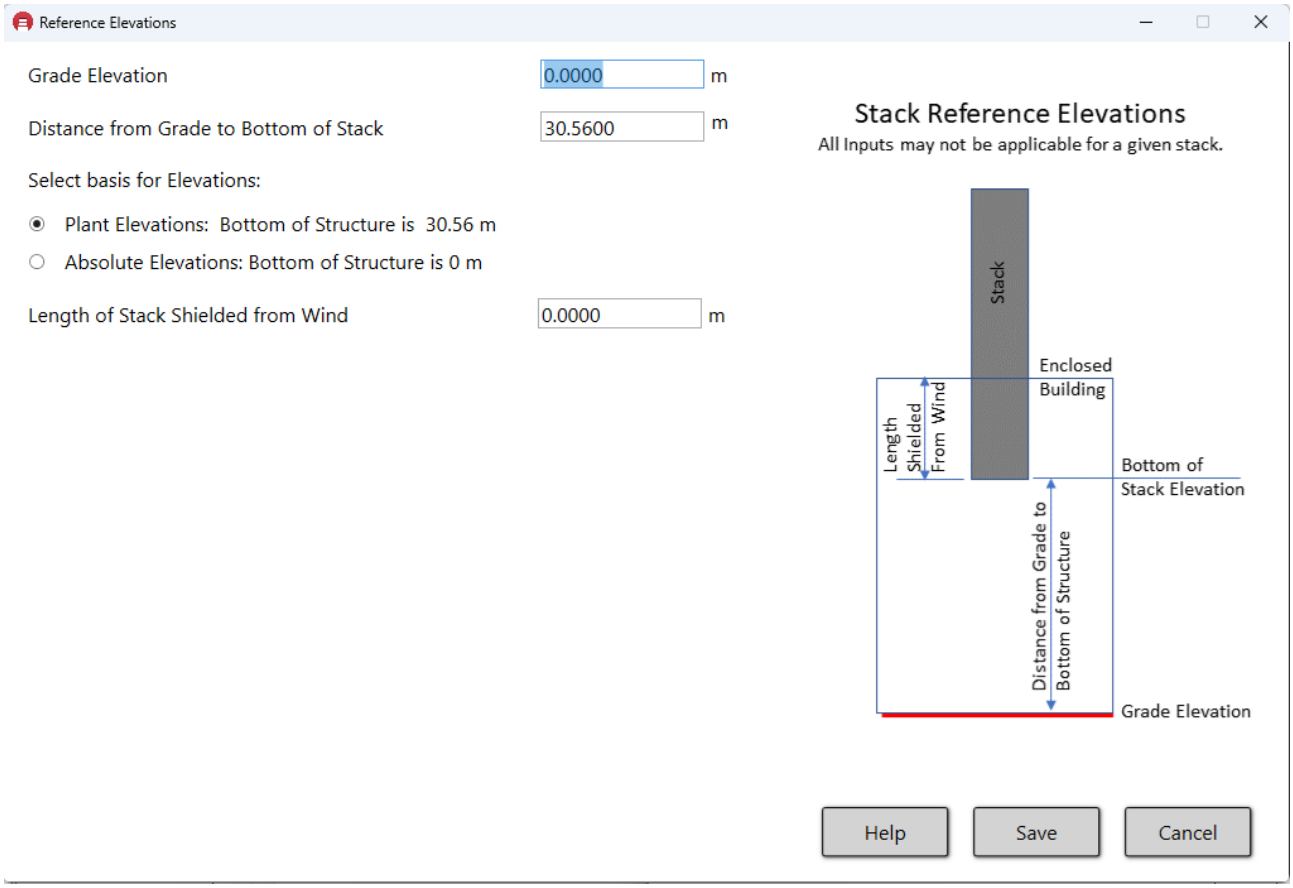
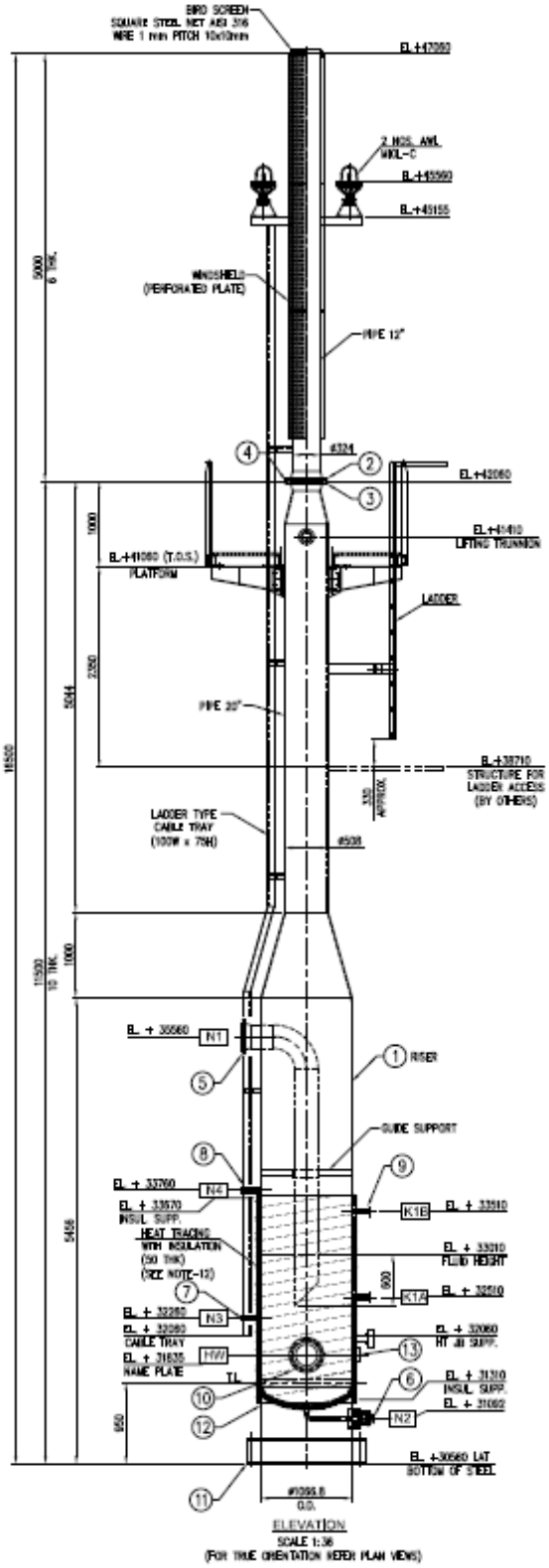
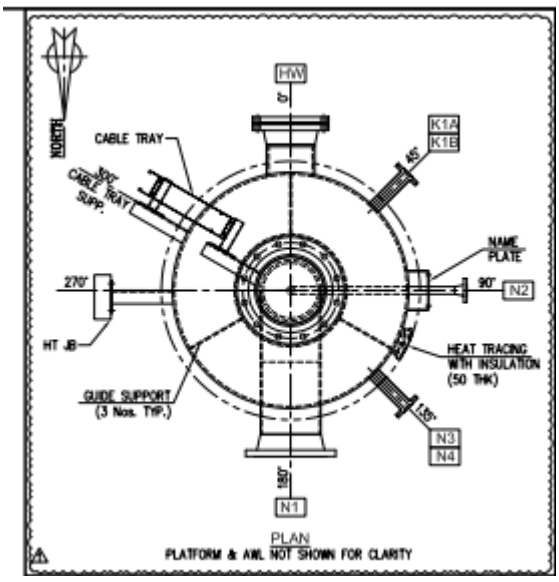


Figure 4 Elevation of the vent stack

The geometry of the vent stack is depicted in the document 1724000887-MAC-DA-00003 and shown hereafter for a quick reference.





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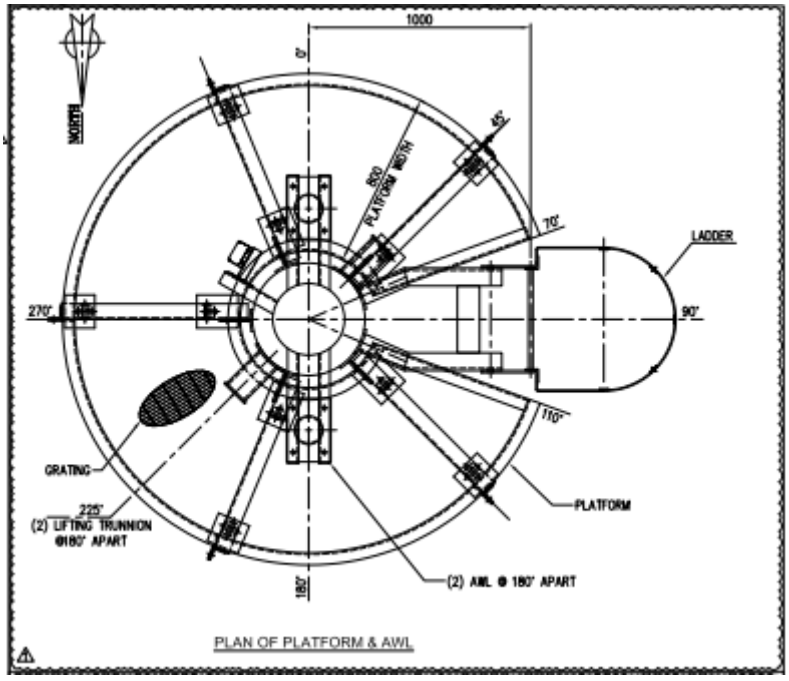


Figure 5 General Arrangment

The structure has a vortex disrupter device at the top, which is covered by a perforated shield to prevent the occurrence of vibrations caused by vortices.

4. LOADS

4.1 DEAD LOADS

The dead loads of the structural element are calculated according to the specific weight of the materials and the involved volumes.

The dead loads which is not parts of the resisting system has been inputted manually in the calculation.

4.2 DEAD LOAD OF EQUIPMENT CONTENT WEIGHT

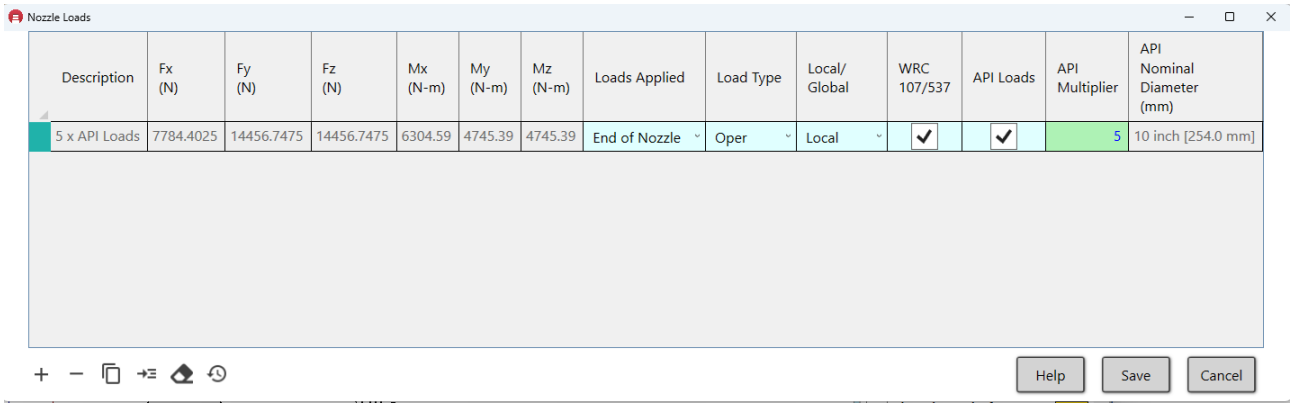
The dead load of the equipment content weight is coming from a water level up to 2.45 m inside of the stack from the elliptical bottom head.

4.3 LOADS ON PLATFORM

Not applicable

4.4 NOZZLE LOADS

Nozzle 1N's loads have been calculated with a factor of 5 times the value from API 537.



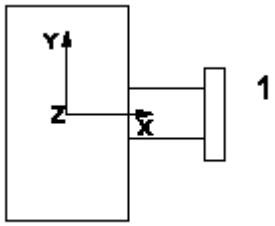


Figure 6 Nozzle 1N loads

4.5 WIND LOADS

For the pourpose of the calculation the desing wind load is considered according to 100 -years period of return (extreme environmental condition) according to the data K559-2254-PM-PLN-003 - Basic Design Engineering Package_rev2 §6.1.3.

6.1.3 Wind Speed Data

Omni-Directional wind data is to be used as shown in Table 6.6

Table 6.6 - Omni-Directional Extreme Values at 125 m MSL

Averaging Time	Return period (years)						
	1	2	5	10	50	100	1,000
1hr	31.8	33.4	35.1	36.4	39.1	40.1	43.4
10min	33.7	35.5	37.4	38.8	41.7	42.9	46.5
3s	39.4	41.6	44.1	45.9	49.7	51.1	56.0

Figure 6.6 Omni direction Extreme value of wind loads at 125 MSL

As the calculation is performed using the Eurocode the input shall be the design wind loads at 10 m and 10 min average. At the same time the structural verification following Eurocode procedure are performed consider 3s gust in conformity with the requirement of ISO 19901-3 (2014) .

A 10 min average wind speed of 42.9 m/s at 125 msl for a category II terrain is derived from a basic wind speed of 28 m/s. The latter is used for the calculations.

The following image is showing the detail of the porous shroud.

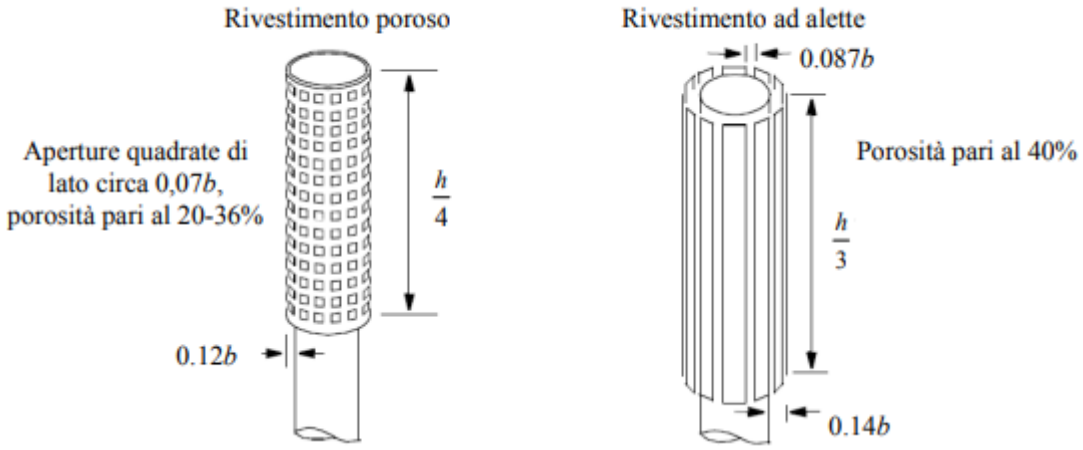


Figure 7 Porous shroud information

4.6 WAVE AND CURRENT LOADS

According to the structural design basis the table below reported applied to the case to evaluate the inertia forces.

Case	Location	Elevation (LAT) [m]	Sea State	Max acceleration [m/s2]
Operational	Topsides CoG	28	Normal	0.67
Extreme	Topsides CoG	28	Extreme	1.61

Figure 8 Topsides acceleration to evaluate inertia forces

According to the table an horizontal and vertical acceleration of $\frac{1.61}{9.806} g = 0.164$ is applied on the structure.

4.7 SEISMIC LOADS

Not applied

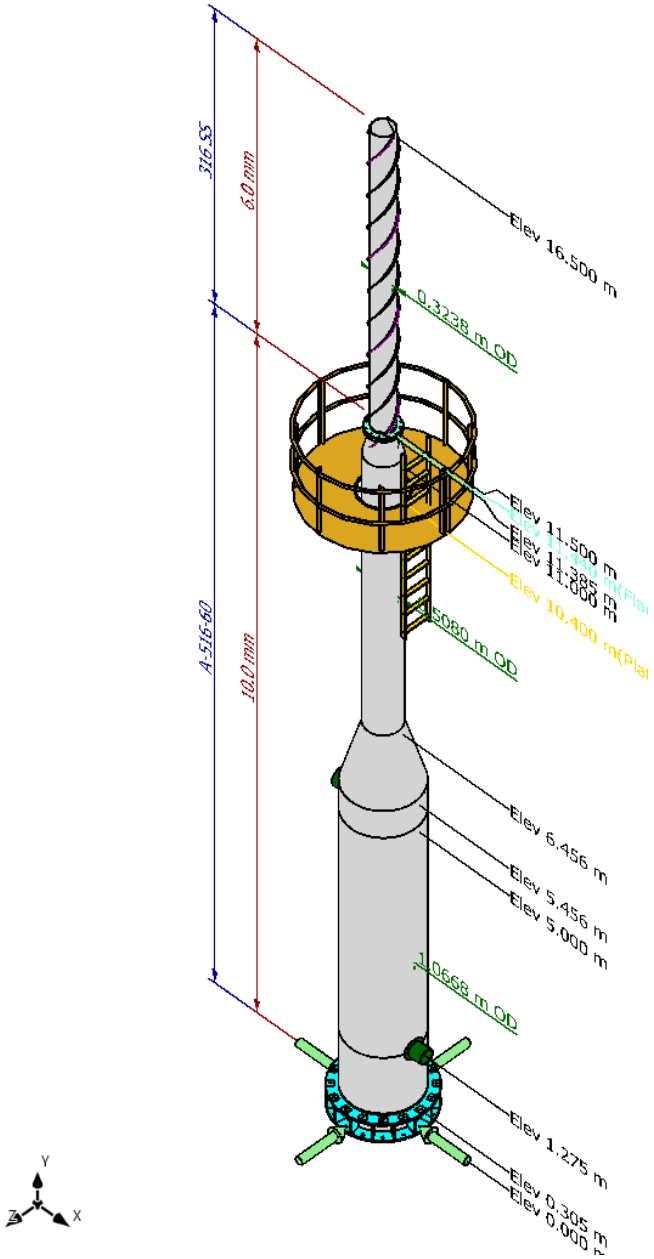
Transportation Loads

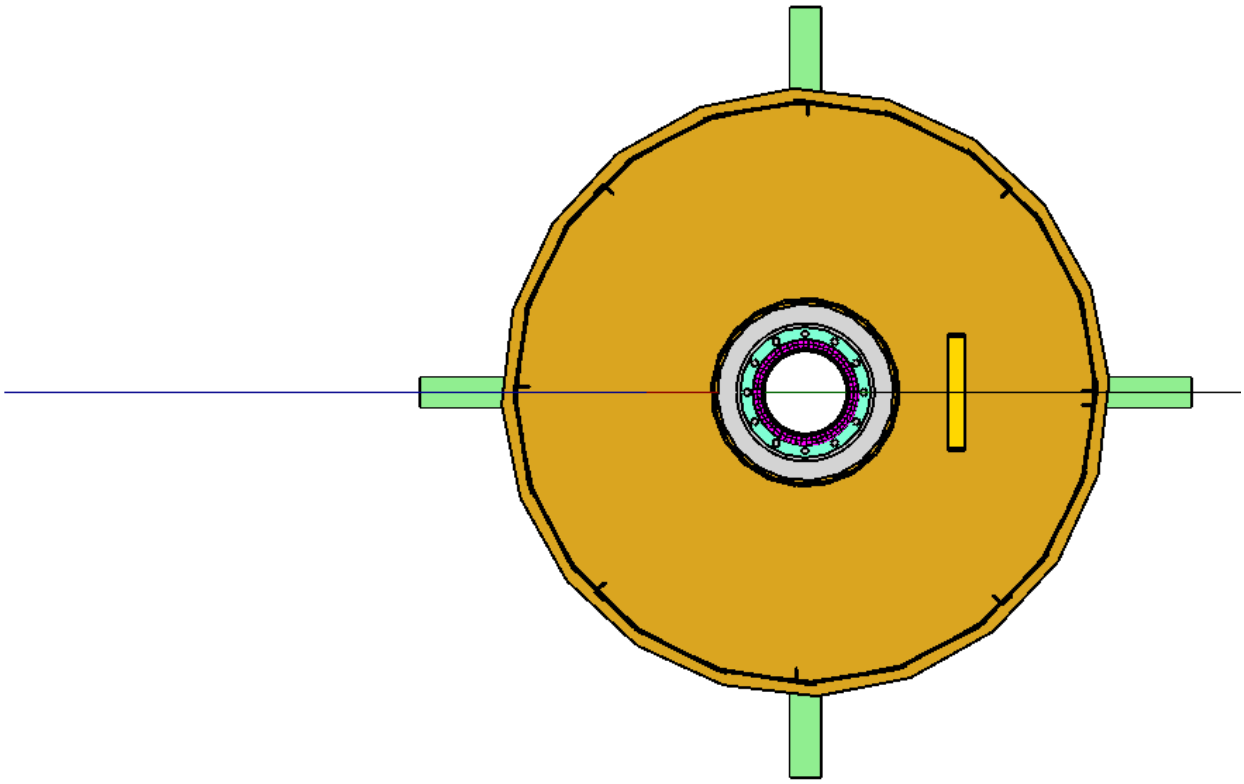
An horizontal load of 0.7 g us applied at the vent center of gravity to cater for the acceleration during the transportation

5 STRUCTURAL CALCULATIONS

The calculation is performed using Mecastack one of the most reliable software in this field.

The Mecastack software is a specialized tool for the design and analysis of steel piles subjected to axial, transverse and moment loads. The software allows to check the strength, stability and deformability of the stacks according to international standards. In particular the calculation has been performed according to Eurocode standards.







Note:

1- We use helical strakes in the calculation instead of the porous shroud. The results are not affected because we only need to consider a large wind area. We size the porous shroud based on reliable literature and previous experience.

2- A dummy high damping ratio of 10% has been added to the calculation to make the software ignore the vortex shedding (which is not important because of the shroud).

3- The loads case named "seismic" are referring to the maximum between transportation loads and case "wave and current loads" as shown above in this document. This is required because the software can handle only one seismic loads during the analysis.

MecaStack v5630

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Calculations Prepared by:
Date: Dec 04, 2024

File Location: W:\1.COMMESSE\DB-ENCORE-C16-23-0193-Rosetti Marino Cross Wind\4.Calcoli\MECASTACK\23-0193-Vent Cross wind-20241204-00.stk

INPUT PARAMETERS:
* Linear Static Analysis
* Stress analysis based upon Allowable Stress Design

Total Stack Height = 16.50 m Top of Stack Elevation = 47.06 m
Grade Elevation = 0.00 m Bottom of Stack = 30.56 m

All elevations are entered based upon the bottom of the structure being at Elevation 30.56 m

Stack Geometry:

Elevation m	Outer Diameter m	Elevation m	Thickness mm	Elevation m	Corrosion Allow mm
47.06	0.3238	47.06	6.0	47.06	0.0
41.945	0.3238	42.06	10.0	42.06	3.0
41.56	0.5080			30.865	0.0
37.016	0.5080				
36.016	1.0668				

Materials:

Elev m	Material	Temp Deg C	Fyld MPa	Elas Mod MPa	Alpha mm/mm/C	Allow Strs MPa	Density Kg/m^3	Tensile MPa
47.06	316 SS	200.00	148.65	182352	1.71E-05	99.37	8000	496.28
		-10.00	206.84	195121	1.53E-05	137.89	8000	517.11
42.06	A-516-60	80.00	204.66	199333	1.20E-05	117.90	7849	413.68
		-10.00	220.63	202705	1.15E-05	117.90	7849	413.68
31.006	S275J0	80.00	239.00	207692	1.20E-05	101.79	7849	356.33

```
                -10.00 275.00    210000 1.20E-05     117.14     7849   410.03
```

Platforms:

```
Plat Elev      Start Ang      End Ang      Width       Stack OD      Weight
    m            Deg           Deg          m            m            kg
---------      ---------      -------      ------      --------      ------
   40.960           0.0        360.0      0.7500        0.5080       319.3
```

Ladders:

```
Top Elev  Bot Elev   Orientation   Type of Ladder   Weight   Wind Area
    m         m          Deg                        kg/m      m^2/m
--------  --------   -----------   --------------   ------   ---------
  42.060    38.960           0.0      Ladder Only    22.32       0.152
```

General Attachment Uniform

```
    Description          Top Elev      Bot Elev       Area       Lin Wt      Type
                            m             m            m          kg/m
-------------------      --------      --------      ------      ------      ----
Water                      33.010        31.510      0.0000      758.00      Oper
External insulation        33.660        30.910      0.0000       30.00      Dead
```

General Attachment Concentrated

```
Description                Elev            Area            Weight            Type
                             m             sq m              kg
---------------            ------          -----           ------            ----
Elliptical head            31.510          0.000           200.0             Dead
```

Nozzles:

```
Num Description Elevation       Nominal      Schedule   Outer  Thickness Tilt Orien-
Proj-
                                Diameter                Diameter                tation
ection
                      m                                   mm        mm     Deg    Deg     mm
--- ----------- --------- ------------------ -------- -------- --------- ---- ------ ----
--
 1  1N             35.560 10 inch [254.0 mm]   Std       273.1       9.3  0.0  180.0
200.0
 2  HW             31.835  8 inch [203.2 mm]   Std       219.1       8.2  0.0    0.0
200.0


Num Description Repad   Repad          Flange           Flange      Flange    Nozzle
                Width Thickness         Spec          Radial Width Thickness   Loads
                  mm      mm                              mm          mm
--- ----------- ----- --------- ---------------------- ------------ --------- ---------
 1  1N          100.0       8.0 ANSI B16.5 150# Flange         66.7      30.2 Loads = 1
 2  HW           50.0       8.0 ANSI B16.5 150# Flange         61.9      28.6 Loads = 0
```

Nozzle # 1 Nozzle Load Cases

```
Load  Description   Fx    Fy    Fz    Mx    My    Mz  Local/     Load       Load   Check
Num                                                   Global    Applied    Type  WRC 107
```

			KN	KN	KN	KN-m	KN-m	KN-m				
1	5 x API Loads		7.78	14.46	14.46	6.30	4.75	4.75	Local	End of Nozzle	Oper	Yes

Nozzle # 1 Load Summary of Transformed Loads
Transformation of Loads to Global Coordiantes and at Stack Centerline

Load Num	Description	Load Type	FxC KN	FyC KN	FzC KN	MxC KN-m	MyC KN-m	MzC KN-m		Ver KN	Shear KN	Mom KN-m	Mbase KN-m
1	5 x API Loads	Oper	7.78	14.46	14.46	6.30	4.75	4.75	|	14.46	16.42	7.89	89.99

Equivalent Nozzle Loads Applied on Stack:
Ver = Stack Vertical Load considered at Nozzle Elev: Fy
Shear = Stack Shear Load considered at Nozzle Elev: [Fx^2+Fz^2]^0.5
Mom = Stack Moment Load considered at Nozzle Elev: [Mx^2+Mz^2]^0.5
Mbase = Est Mom at base if no Support: Mom + Shear*Elev
Provided only to evaluate the impact of the load on overall stack

Helical Strakes: (3 Vanes 120 deg apart assumed)

ElTop	= Top Strake Elevation	= 47.06 m
ElBot	= Bottom Strake Elevation	= 41.56 m
Pitch	= Strake Pitch (One complete wrap)	= 1.6190 m
Width	= Strake Width	= 32.4 mm
Thick	= Strake Thickness	= 3.2 mm
OD	= Outer Diameter of Stack and Insulation (If Applicable)	= 323.8 mm
ShapeFac	= Strake Shape Factor (Applied to bare stack shell)	= 1.40
SO	= Stand-off from OD of shell to strake	= 0.0 mm
Len	= Pitch Length: [(PI*(OD+2*SO+2*Width))^2+(Pitch^2)]^0.5	= 32.588 m
Area	= Total Painted Area (3 vanes): (2*Width*Len*3*Wraps)	= 92.932 sq cm
Wraps	= Total Number of Wraps (Top elev - Bot elev)/ Pitch	= 3.40
WtUni	= Estimated Linear Weight of Strakes and Clips: Wt/(ElTop-ElBot)	= 4.54 kg/m
Wt	= Estimated total Wt of Strakes and Clips: 1.5*(Area/2)*Thick*Dens	= 25.0 kg

Type	= Type of Baseplate	= Chair Continuous Plate
SupType	= Type of Support	= Rigid Steel Base
Friction	= Coefficient of Friction for Support	= 0.300
BasisBolt	= Basis for Bolt Design	= Brownell & Young
Nbolt	= Number of Bolts	= 16
Dbolt	= Nominal Bolt Diameter	= 27.0 mm
Dbh	= Bolt Hole Diameter	= 36.0 mm
CAbolt	= Corrosion Allowance on Bolt	= 3.0 mm
CAplt	= Corrosion Allowance on Plates	= 0.0 mm
ID	= Inside Diameter of Baseplate	= 820.0 mm
BCD	= Bolt Circle Diameter of Baseplate	= 1270.0 mm
OD	= Outer Diameter of Baseplate	= 1385.0 mm
Tb	= Thickness of Bottom Plate	= 25.0 mm
Tt	= Thickness of Top Plate	= 25.0 mm
Fw	= Fillet Weld Size	= 5.0 mm

```
Fwu       = Weld Ultimate Tensile Strength                          = 482632.1
KPa
Ngus      = Number of Gussets per Bolt                              = 1
Hg        = Height of Anchor Chair                                  = 305.0 mm
Tg        = Thickness of Gusset                                     = 12.0 mm
Material: (Properties looked up from database)
Spec      = Material Specification                                  = S275J0
Dens      = Material Density                                        = 7849 Kg/m^3
Temp      = Design Temperature                                      = 21.11 Deg C
Fy        = Minimum Yield Stress                                    = 274996.9
KPa
Fu        = Ultimate Tensile Stress                                 = 410030.5
KPa
Sa        = Allowable Tensile Stress                                = 117141.7
KPa
E         = Modulus of Elasticity                                   = 209957162.5
KPa
A         = Coefficient of Thermal Expansion                        = 1.20E-05
mm/mm/C


Bolt Material:
Override  = Manually Specify Material                               = False
Matl      = Bolt Material Specification                             = Gr. 8.8
Fu        = Ultimate Tensile Stress                                 = 800548.8
KPa
Fy        = Yield Stress                                            = 640440.4
KPa
Fproof    = Proof Stress                                            = 544374.4
KPa
Eb        = Modulus of Elasticity                                   = 202705497.9
KPa
Anchor Bolt Pretension:
Pretension= Pretension for Bolt as % of Ultimate Tensile            = 60.00 %
Fult      = Bolt Ultimate Tensile Stress                            = 800.55 MPa
PreStress = Pretension Stress on Bolt                               = 480.33 MPa

Plate Washer:
Ptype     = The Type of Plate Washer                                = Rectangular
Pt        = Plate Washer Thickness                                  = 15.0 mm
Pw        = Width of Washer Perpendicular to Shell                  = 90.0 mm
Pl        = Length of Washer Parallel to Shell                      = 100.0 mm
Pdh       = Bolt Hole Diameter                                      = 30.0 mm
Structural Flange(s):
Structural Flange:  FLANGE #1 - 42.0 m
Flange Standard: None
Ds        = Outer Diameter of Shell                                 = 323.8 mm
Do        = Outside Diameter of Flange                              = 482.6 mm
Rod       = Radial Dist from Bolt Circle to OD of Flange            = 25.4 mm
Dbc       = Bolt Circle Diameter                                    = 431.8 mm
Rbc       = Radial Dist from OD of Shell to Bolt Circle             = 54.0 mm
Tf        = Thickness of Flange                                     = 31.8 mm
Tw        = Fillet Weld Size                                        = 6.0 mm
Gus       = Gussets                                                 = False
Db        = Nominal Bolt Diameter                                   = 22.2 mm
Nb        = Number of Bolts                                         = 12
BMatl     = Bolt Material                                           = Gr 8 (US)
```

```
Fu        = Ultimate Bolt Tensile Stress                                  = 1034.21 MPa
Eb        = Modulus of Elasticity for Bolt                                = 202705.50
MPa
Fp        = Pre-Load % of Allowable Bolt                                  = 60.00 %
Fw        = Tensile Stress of Weld                                        = 413.68 MPa
FMatl     = Flange Material                                               = A-36
Fyf       = Yield Stress of Flange                                        = 215.81 MPa
Ef        = Modulus of Elasticity of Flange                               = 193742.33
MPa
```

Design Codes

Comprehensive Design Standard:

Stress Criteria: Eurocde 3 - Design of Steel structures: Part 3-2: Towers, masts and chimneys

```
Class     = Fabrication Quality Class (A=Excellent, B=High, C=Normal)     = C
Bspace    = Flange Max Bolt spacing in terms of # of bolt diameters       = 10.00
Incl_Ecc  = Include Eccentric Moment when Centroid is Offset              = False
```

Wind Criteria: Eurocode: EN 1991-1-4:2005 'Actions on Structures'

```
Vbo       = Basic Wind Velocity (10 minute mean)                          = 28.00 m/s
Cdir      = Directional Factor per Para 4.2                               = 1.000
Cseason   = Season factor per Para 4.2                                    = 1.000
Ki        = Turbulence Factor per Para 4.3.2                              = 1.000
K         = Equivalent Surface Roughness per Table 7.13                   = 0.0200 mm
Terrain   = Terrain Category Per Table 4.1                                = 0
Alt       = Altitude of the site above sea level                          = 0.0000 m
```

Vortex Criteria: Eurocode: EN 1991-1-4:2005 'Actions on Structures'

```
Arrange   = Stack Arrangement                                             = Single
Simplified= Use the simplified method found in Para E.1.5.3 'Approach 2'  = False
Modes     = Number of Modes to consider in Vortex Shedding Analysis       = 1
```

Fatigue Criteria: Eurocde 3 - Design of Steel structures: Part 3-2: Towers, masts and chimneys

```
Life      = Fatigue Life Of Stack In Years                                = 50.0 Years
GMf       = Partial Safety Factor for Fatigue Strength                    = 1.35
GFf       = Partial Safety Factor for Equiv Const Amplitude Stress Range  = 1.00
```

Fatigue Categories: Euro

Elev m	Cat
47.060	69

Seismic Criteria: Manually Specify Seismic Loading

```
Spec      = What is the basis for the loads being entered                 =
Ft        = Load applied at the top of the stack (0 if none)              = 0 N
RatioShear= Ratio of Base Shear to Dead Weight (g-force)                  = 0.700
RatioVer  = Ratio of Base Vertical Load to Dead Weight (g-force)          = 0.700
Method    = Method used to apply the loads to the structure               = ASCE 7-10
Fac_Live  = Factor to apply to Live loads to be treated as Mass           = 0.000
```

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Fac_Oper = Factor to apply to operating loads to be treated as Masses = 1.000

Deflection Criteria:

Deflection Criteria for Static Loading:
MaxDefl = Limitation based upon Stack Ht: Stack_Ht / 133 = 124.1 mm

Deflection Criteria for Vortex Loading:
DeflLimit = Limitation based upon a % of Top OD: Stack_Top_OD x 0.05 = 16.2 mm

Damping Criteria:

Structural Damping Criteria:
Criteria: ASME STS-1-2021
Stack Type: UnLined
Support: ELASTIC

Mode	Bs Struc Damping	Ds Log Decrement Damping
1	0.1000	0.6283
2	0.0040	0.0251
3	0.0040	0.0251

Log Decrement Damping = 2 * PI * Bs

Aerodynamic Damping Criteria:
(Only used in Along wind analysis, Not considered for vortex shedding)

Criteria: EN 1994-1-4

Weight Summary (Live)

Component	Elev COG m	Weight kg	Weight N
Platforms (Live, Fac = 1)	40.960	1360.1	13338
Total	40.960	1360.1	13338

Platforms (Live Load)

Platform Elevation m	Platform Total Angle Deg	Platform Width m	Platform Area sq m	Live Load Pressure kPa	Live Load Force kg
40.960	360.0	0.7500	2.964	4.500	1360.1
Total	0.0	0.0000	0.000	0.000	1360.1

Weight Summary (Oper)

Component	Elev COG	Weight	Weight

	m	kg	N
General Attachment Uniform (Oper, Fac = 1)	32.260	1137.0	11150
Nozzle(s)	35.560	-1474.2	-14457
Total	46.688	-337.2	-3307

General Attach Uniform Wt (Oper, Factor = 1): (Wt = 1137.0 kg, El COG = 32.260 m)

Description	El Top m	El Bot m	El COG m	Lin Wt kg/m	Tot Wt kg
Water	33.010	31.510	32.260	758.00	1137.0
Total	30.560	30.560	32.260		1137.0

Nozzle Wt (Oper): (Wt = -1474.2 kg, El COG = 35.560 m)

Num	Elev m	OD mm	Removed Shell kg	Pipe kg	Repad kg	Flange kg	Noz Loads kg	Elev COG m	Weight kg
1	35.560	273.1	0.00	0.00	0.00	0.00	-1474.18	35.560	-1474.18
Total			0.0	0.00	0.00	0.00	-1474.18	35.560	-1474.18

Weight Summary (Dead)

Component	Elev COG m	Weight kg	Weight N
Stack (Corroded Wt = 1822.5 kg)	36.164	2458.5	24110
Ladders	40.510	69.2	679
Platforms	40.960	319.3	3132
Helical Strakes	44.310	25.0	245
Baseplate	30.687	389.0	3815
Structural Flange(s)	42.000	58.0	569
Nozzle(s)	34.097	53.2	521
General Attachment Uniform)	32.285	82.5	809
General Attachment Concentrated	31.510	200.0	1961
Total	35.859	3654.7	35841

Cylindrical Shells Wt: (Wt = 2458.5 kg, El COG = 36.164 m)

Elev Top m	Elev Bot m	Elev COG m	OD m	Thk mm	Density Kg/m^3	Wt Corroded kg	Lin Wt UnCorroded kg/m	Wt UnCorroded kg
47.060	42.060	44.560	0.3238	6.0	8000	239.6	47.92	239.6
42.060	41.945	42.003	0.3238	10.0	7849	6.3	77.38	8.9
41.945	41.560	41.753	0.4159	10.0	7849	27.2	100.09	38.5
41.560	37.016	39.288	0.5080	10.0	7849	393.0	122.80	558.0
37.016	36.016	36.516	0.7874	10.0	7849	134.7	191.69	191.7
36.016	31.006	33.511	1.0668	10.0	7849	916.5	260.59	1305.6
31.006	30.865	30.936	1.0668	10.0	7849	25.8	260.59	36.7
30.865	30.560	30.713	1.0668	10.0	7849	79.5	260.59	79.5

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Total	36.164					1822.5		2458.5

Note: Conical Sections show equivalent Diameter that gives same uncorroded weight

Ladders Wt: (Wt = 69.2 kg, El COG = 40.510 m)

Description	Elev Top m	Elev Bot m	Elev COG m	Lin Wt kg/m	Weight kg
Ladder Only	42.060	38.960	40.510	22.32	69.2
Total			40.510		69.2

Platforms Wt: (Wt = 319.3 kg, El COG = 40.960 m)

Plat Elev m	Start Ang Deg	End Ang Deg	Width m	Stack OD m	Elev COG m	Weight kg
40.960	0.0	360.0	0.7500	0.5080	40.960	319.3
Total					40.960	319.3

Helical Strakes Wt: (Wt = 25.0 kg, El COG = 44.310 m)

El Top m	El Bot m	El COG m	Lin Wt kg/m	TOt Wt kg
47.060	41.560	44.310	4.54	25.0
Total		44.310		25.0

Baseplate Wt: (Wt = 389.0 kg, El COG = 30.687 m)

Description	Elevation COG m	Weight kg
Bottom Plate	30.573	192.0
Top Plate	30.853	120.2
Gussets	30.713	61.1
Washers	30.713	15.6
Total	30.687	389.0

Structural Flanges Wt: (Wt = 58.0 kg, El COG = 42.000 m)

Elev m	Flg OD mm	Flg Thk mm	Gus Ht mm	Gus Thk mm	Wt Gus kg	Wt Flg kg	Wt Bolts kg	Elev COG m	Qty	Weight kg
42.000	482.6	31.8	0.0	0.0	0.0	25.1	7.9	42.000	2	58.0
Total					0.0	25.1	7.9	42.000		58.0

1. Weight = (Wt_Flg + Wt_Gus)*Qty

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Nozzle Wt (Dead): (Wt = 53.2 kg, El COG = 34.097 m)

Num	Elev m	OD mm	Removed Shell kg	Pipe kg	Repad kg	Flange kg	Noz Loads kg	Elev COG m	Weight kg
1	35.560	273.1	-3.99	12.06	7.36	16.85	0.00	35.560	32.27
2	31.835	219.1	-2.53	8.51	2.65	12.26	0.00	31.835	20.89
Total		0.0	-6.53	20.57	10.01	29.11	0.00	34.097	53.16

General Attach Uniform Wt (Dead, Factor = 1): (Wt = 82.5 kg, El COG = 32.285 m)

Description	El Top m	El Bot m	El COG m	Lin Wt kg/m	Tot Wt kg
External insula	33.660	30.910	32.285	30.00	82.5
Total	30.560	30.560	32.285		82.5

General Attach Concentrated Wt (Dead): (Wt = 200.0 kg, El COG = 31.510 m)

Description	Elev m	Area sq m	Weight kg
Elliptical head	31.510	0.000	200.0
Total	31.510		200.0

Weights of Each Lifting Section
Assumes each section with a flange or field weld is a lifting section

Lift Section Number	Elev Bottom m	Elev Top m	Section Length m	Elev Center of Gravity m	Weight kg
1	30.560	42.000	11.4400	35.099	3357.1
2	42.000	47.060	5.0600	44.257	297.6
Total	30.560	47.060	16.5000	35.845	3654.7

Lifting Weight Detailed Breakdown

Component	Lift # 1 kg	Lift # 2 kg	Total kg
Stack	2214.3	244.2	2458.5
Ladder(s)	67.9	1.3	69.2
Platform(s)	319.3	0.0	319.3
Helical Strakes	2.0	23.0	25.0
Baseplate	389.0	0.0	389.0
Structural Flange(s)	29.0	29.0	58.0
Nozzle(s)	53.2	0.0	53.2
Gen Attach Uniform	82.5	0.0	82.5
Gen Attach Concentrated	200.0	0.0	200.0
Total	3357.1	297.6	3654.7

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Wind Area Summary

Elev m	Shape Fac Riser	Riser Area m^2/m	Ladder Area m^2/m	Platform Area m^2/m	Piping Area m^2/m	Attach Area m^2/m	Tot Uni Area m^2/m	Total Area sq m
47.060	1.400	0.453	0.000	0.000	0.000	0.000	0.453	1.360
44.060	1.400	0.453	0.000	0.000	0.000	0.000	0.453	0.907
42.060	1.400	0.453	0.305	0.000	0.000	0.000	0.758	0.025
42.027	1.400	0.453	0.305	1.824	0.000	0.000	2.582	0.211
41.945	1.400	0.453	0.305	1.824	0.000	0.000	2.582	0.331
41.817	1.400	0.539	0.305	1.885	0.000	0.000	2.729	0.350
41.688	1.400	0.625	0.305	1.947	0.000	0.000	2.877	0.369
41.560	0.512	0.260	0.305	2.008	0.000	0.000	2.573	1.544
40.960	0.511	0.260	0.305	0.000	0.000	0.000	0.565	1.129
38.960	0.510	0.259	0.000	0.000	0.000	0.000	0.259	0.504
37.016	0.508	0.258	0.000	0.000	0.000	0.000	0.258	0.086
36.683	0.509	0.353	0.000	0.000	0.000	0.000	0.353	0.118
36.349	0.507	0.446	0.000	0.000	0.000	0.000	0.446	0.149
36.016	0.504	0.538	0.000	0.000	0.000	0.000	0.538	0.172
35.697	0.504	0.537	0.000	0.000	0.000	0.000	0.537	0.073
35.560	0.504	0.537	0.000	0.000	0.000	0.000	0.537	0.073
35.423	0.503	0.537	0.000	0.000	0.000	0.000	0.537	0.947
33.660	0.501	0.534	0.000	0.000	0.000	0.000	0.534	0.347
33.010	0.499	0.533	0.000	0.000	0.000	0.000	0.533	0.567
31.945	0.495	0.528	0.000	0.000	0.000	0.000	0.528	0.058
31.835	0.495	0.528	0.000	0.000	0.000	0.000	0.528	0.058
31.725	0.494	0.527	0.000	0.000	0.000	0.000	0.527	0.114
31.510	0.493	0.526	0.000	0.000	0.000	0.000	0.526	0.265
31.006	0.493	0.526	0.000	0.000	0.000	0.000	0.526	0.050
30.910	0.493	0.526	0.000	0.000	0.000	0.000	0.526	0.024
30.865	0.493	0.526	0.000	0.000	0.000	2.244	2.770	0.845
Total (m^2/m)								10.676

1. Total Riser Wind Area = 6.967 sq m (65.26 % of Total Area)
2. Total Ladder Wind Area = 0.945 sq m (8.85 % of Total Area)
3. Total Platform Wind Area = 2.080 sq m (19.48 % of Total Area)
4. Total Piping Wind Area = 0.000 sq m (0.00 % of Total Area)
5. Total Attachment Wind Area = 0.684 sq m (6.41 % of Total Area)

Wind Area: Ladders

Elev Bot m	Elev Top m	Shape Factor	Overlap	Wind Area m^2/m
42.027	42.060	2.000	No	0.305
41.945	42.027	2.000	No	0.305
41.817	41.945	2.000	No	0.305
41.688	41.817	2.000	No	0.305
41.560	41.688	2.000	No	0.305
40.960	41.560	2.000	No	0.305
38.960	40.960	2.000	No	0.305

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Overlap : When 2 ladders overlap only 25% of one ladder is considered due to shielding.

Wind Area: Platforms

Elev Top m	Elev Bot m	Shape Factor	Wind Area m^2/m	Tot Wind Area sq m
42.027	40.960	2.000	2.008	2.142

Wind Area: General Attachment (Uniform)

Elev Top m	Elev Bot m	Wind Area m^2/m
33.010	31.510	0.000
33.660	30.910	0.000

Wind Area: General Attachment (Concentrated)
Shape factor is accounted for manually by the user in the wind areas entered

Wind Area: General Attachment (Concentrated)

Elev Top m	Elev Bot m	Wind Area m^2/m
31.725	31.510	0.000

Wind Area: Baseplate

OD = Outer diameter of baseplate = 1.3850 m
StackOD = Outer Diameter of Stack = 1.0668 m
Cf_Riser = Wind Shape Factor for Riser = 0.493
Cf_LandP = Wind Shape Factor for Ladders & Platforms = 2.000
Wind Area = OD * Cf_LandP - StackOD * Cf_Riser = 2.244 m^2/m
The Baseplate wind area is included in the 'Attachment' category.

Section Properties
Properties calculated based upon Corroded stack

Top Elev m	Bot Elev m	Outer Diameter mm	Thick mm	Rad of Gyration mm	Area sq cm	Plastic Sec Mod cm^3	Elastic Sec Mod cm^3	Mom of Inertia cm^4	Section Props
47.060	44.060	323.8	6.0	112.4	59.904	606.1	467.3	7565.33	Ideal
44.060	42.060	323.8	6.0	112.4	59.904	606.1	467.3	7565.33	Ideal
42.060	42.027	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
42.027	41.945	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
41.945	41.817	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
41.817	41.688	385.2	7.0	133.7	83.171	1001.4	772.4	14875.49	Ideal
41.688	41.560	446.6	7.0	155.4	96.673	1352.9	1046.0	23358.29	Ideal
41.560	40.960	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
40.960	38.960	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal

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38.960	37.016	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
37.016	36.683	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
36.683	36.349	694.3	7.0	243.0	151.138	3306.5	2570.9	89243.50	Ideal
36.349	36.016	880.5	7.0	308.8	192.100	5341.5	4162.0	183240.21	Ideal
36.016	35.697	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
35.697	35.560	1066.8	7.0	356.8	258.745	7914.0	6175.1	329389.19	1
35.560	35.423	1066.8	7.0	370.4	230.396	7596.5	5927.3	316171.94	2
35.423	33.660	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
33.660	33.010	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
33.010	31.945	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
31.945	31.835	1066.8	7.0	363.4	248.063	7872.5	6142.6	327659.06	3
31.835	31.725	1066.8	7.0	368.4	226.134	7372.8	5752.7	306862.01	4
31.725	31.510	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
31.510	31.006	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
31.006	30.910	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
30.910	30.865	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
30.865	30.560	1066.8	10.0	404.0	637.478	19311.7	15026.1	1040594.63	5

Section Props - If a number is shown, then the section contains something unusual (Breach, nozzle, stiffeners, etc..) and so the properties were calculated using numerical methods.
- 'Ideal' indicates the properties calculated using ideal equations

Section Properties calculated using Numerical Methods
These sections contains unusual geometry (Nozzles, Breach, stiffeners, etc..)

Section Props	Principal Axis Deg	Centroid Xc mm	Centroid Yc mm	Area sq cm	Minimum Mom of Iner cm^4	Maximum Mom of Iner cm^4	Min Elas Sec Mod cm^3	Minimum Rad of Gyr mm
1	0.0	-52.6	0.0	258.745	329389.19	392083.97	6175.1	356.8
2	0.0	7.6	0.0	230.396	316171.94	331995.89	5927.3	370.4
3	0.0	32.3	0.0	248.063	327659.06	367515.76	6142.6	363.4
4	0.0	-16.4	0.0	226.134	306862.01	328213.14	5752.7	368.4
5	67.0	0.0	0.0	637.478	1040594.63	1040594.63	15026.1	404.0

Thermal Expansion of Stack
+ values are in the +Y (up) direction and - values are in the -Y (Down)

Elev m	Installation Temperature Deg C	Hot Temperature Deg C	Hot Expansion mm	Cold Temperature Deg C	Cold Expansion mm
47.060	21.11	200.00	23.4	-10.00	-6.5
44.060	21.11	200.00	14.2	-10.00	-5.1
42.060	21.11	80.00	8.1	-10.00	-4.1
42.027	21.11	80.00	8.1	-10.00	-4.1
41.945	21.11	80.00	8.0	-10.00	-4.1
41.817	21.11	80.00	7.9	-10.00	-4.0
41.688	21.11	80.00	7.8	-10.00	-4.0
41.560	21.11	80.00	7.8	-10.00	-3.9
40.960	21.11	80.00	7.3	-10.00	-3.7
38.960	21.11	80.00	5.9	-10.00	-3.0
37.016	21.11	80.00	4.6	-10.00	-2.3
36.683	21.11	80.00	4.3	-10.00	-2.2
36.349	21.11	80.00	4.1	-10.00	-2.1

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36.016	21.11	80.00	3.8	-10.00	-2.0
35.697	21.11	80.00	3.6	-10.00	-1.8
35.560	21.11	80.00	3.5	-10.00	-1.8
35.423	21.11	80.00	3.4	-10.00	-1.7
33.660	21.11	80.00	2.2	-10.00	-1.1
33.010	21.11	80.00	1.7	-10.00	-0.9
31.945	21.11	80.00	1.0	-10.00	-0.5
31.835	21.11	80.00	0.9	-10.00	-0.5
31.725	21.11	80.00	0.8	-10.00	-0.4
31.510	21.11	80.00	0.7	-10.00	-0.3
31.006	21.11	80.00	0.3	-10.00	-0.2
30.910	21.11	80.00	0.2	-10.00	-0.1
30.865	21.11	80.00	0.2	-10.00	-0.1
30.560	21.11	80.00	0.0	-10.00	0.0

1. Elevation for Y restraint = 30.56 m

Frequency Summary

Description	Direction Deg	Mode # 1 Hz	Mode # 2 Hz	Mode # 3 Hz
Hot & Corroded	0.0	3.822	11.290	26.499
Hot & UnCorroded	0.0	4.472	12.368	29.949
Cold & Corroded	0.0	3.860	11.502	26.899
Cold & Uncorroded	0.0	4.518	12.625	30.382

Mode Shape (Hot & Corroded)

Elevation m	Mode # 1 (3.822 Hz) Normalized	Mode # 2 (11.290 Hz) Normalized	Mode # 3 (26.499 Hz) Normalized
47.060	1.000	1.000	1.000
44.060	0.620	0.111	-0.430
42.060	0.404	-0.224	-0.487
42.027	0.401	-0.226	-0.479
41.945	0.394	-0.231	-0.460
41.817	0.383	-0.237	-0.426
41.688	0.372	-0.242	-0.391
41.560	0.361	-0.247	-0.354
40.960	0.312	-0.260	-0.175
38.960	0.168	-0.240	0.370
37.016	0.077	-0.161	0.535
36.683	0.068	-0.147	0.514
36.349	0.061	-0.134	0.483
36.016	0.054	-0.121	0.448
35.697	0.049	-0.109	0.414
35.560	0.046	-0.105	0.399
35.423	0.044	-0.100	0.384
33.660	0.018	-0.044	0.186
33.010	0.011	-0.027	0.121
31.945	0.003	-0.008	0.037

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31.835	0.003	-0.007	0.031
31.725	0.002	-0.005	0.025
31.510	0.001	-0.003	0.016
31.006	0.000	0.000	0.002
30.910	0.000	0.000	0.001
30.865	0.000	0.000	0.001

Mode Shape (Hot & UnCorroded)

Elevation m	Mode # 1 (4.472 Hz) Normalized	Mode # 2 (12.368 Hz) Normalized	Mode # 3 (29.949 Hz) Normalized
47.060	1.000	1.000	1.000
44.060	0.597	0.073	-0.510
42.060	0.380	-0.245	-0.485
42.027	0.377	-0.246	-0.476
41.945	0.370	-0.249	-0.452
41.817	0.360	-0.252	-0.414
41.688	0.350	-0.255	-0.375
41.560	0.339	-0.257	-0.334
40.960	0.293	-0.260	-0.143
38.960	0.158	-0.221	0.403
37.016	0.072	-0.143	0.547
36.683	0.064	-0.130	0.524
36.349	0.057	-0.118	0.492
36.016	0.051	-0.107	0.456
35.697	0.046	-0.097	0.421
35.560	0.044	-0.092	0.405
35.423	0.041	-0.088	0.390
33.660	0.017	-0.039	0.189
33.010	0.011	-0.024	0.124
31.945	0.003	-0.007	0.039
31.835	0.003	-0.006	0.033
31.725	0.002	-0.005	0.027
31.510	0.001	-0.003	0.017
31.006	0.000	-0.001	0.003
30.910	0.000	0.000	0.002
30.865	0.000	0.000	0.001

Mode Shape (Cold & Corroded)

Elevation m	Mode # 1 (3.860 Hz) Normalized	Mode # 2 (11.502 Hz) Normalized	Mode # 3 (26.899 Hz) Normalized
47.060	1.000	1.000	1.000
44.060	0.623	0.117	-0.418
42.060	0.408	-0.221	-0.487
42.027	0.405	-0.223	-0.480
41.945	0.397	-0.228	-0.461
41.817	0.386	-0.235	-0.428
41.688	0.375	-0.240	-0.393
41.560	0.364	-0.245	-0.357
40.960	0.314	-0.260	-0.180

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38.960	0.169	-0.243	0.364
37.016	0.078	-0.164	0.533
36.683	0.069	-0.150	0.512
36.349	0.061	-0.137	0.482
36.016	0.055	-0.124	0.447
35.697	0.049	-0.112	0.413
35.560	0.047	-0.107	0.398
35.423	0.044	-0.102	0.383
33.660	0.018	-0.044	0.186
33.010	0.011	-0.028	0.121
31.945	0.003	-0.008	0.038
31.835	0.003	-0.007	0.031
31.725	0.002	-0.006	0.026
31.510	0.001	-0.003	0.016
31.006	0.000	0.000	0.002
30.910	0.000	0.000	0.001
30.865	0.000	0.000	0.001

Mode Shape (Cold & Uncorroded)

Elevation m	Mode # 1 (4.518 Hz) Normalized	Mode # 2 (12.625 Hz) Normalized	Mode # 3 (30.382 Hz) Normalized
47.060	1.000	1.000	1.000
44.060	0.601	0.078	-0.497
42.060	0.384	-0.241	-0.486
42.027	0.381	-0.243	-0.477
41.945	0.374	-0.246	-0.454
41.817	0.364	-0.250	-0.416
41.688	0.353	-0.253	-0.377
41.560	0.343	-0.255	-0.338
40.960	0.296	-0.260	-0.148
38.960	0.160	-0.224	0.397
37.016	0.073	-0.145	0.545
36.683	0.065	-0.132	0.522
36.349	0.058	-0.121	0.490
36.016	0.052	-0.109	0.455
35.697	0.046	-0.099	0.420
35.560	0.044	-0.094	0.404
35.423	0.042	-0.090	0.389
33.660	0.017	-0.039	0.189
33.010	0.011	-0.025	0.124
31.945	0.003	-0.008	0.039
31.835	0.003	-0.006	0.033
31.725	0.002	-0.005	0.027
31.510	0.001	-0.003	0.017
31.006	0.000	-0.001	0.003
30.910	0.000	0.000	0.002
30.865	0.000	0.000	0.001

Wind Loads per Eurocode - EN 1991-1-4:2005(E)

Wind Criteria: Eurocode: EN 1991-1-4:2005 'Actions on Structures'
Vbo = Basic Wind Velocity (10 minute mean) = 28.00 m/s
Cdir = Directional Factor per Para 4.2 = 1.000

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Cseason   = Season factor per Para 4.2                                  = 1.000
Ki        = Turbulence Factor per Para 4.3.2                           = 1.000
K         = Equivalent Surface Roughness per Table 7.13                = 0.0200 mm
Terrain   = Terrain Category Per Table 4.1                             = 0
Alt       = Altitude of the site above sea level                       = 0.0000 m
```

Orography Factors {Ref Para 4.3.1}

Elev m	Co
47.060	1.000

```
H         = Distance from Bottom of Stack to Top of Stack              = 16.5000 m
zbase     = Distance from Grade to Bottom of Stack                     = 30.5600 m
b         = Average Wind OD for entire Stack                           = 0.6441 m
Zs        = 0.6*H + zbase  {Fig 6.1}                                   = 40.4600 m
Calt      = 1 + 0.001 * Alt * (10/Zs)^0.2   {Since z > 10 m NA.2b}     = 1.000
Vb        = Basic Wind Velocity: Vbo * Cdir * Calt * Cseason {Eqn 4.1} = 28.00 m/s
Zo        = Terrain Categories and parameters (Table 4.1)              = 0.0030 m
Zmin      = Terrain Categories and parameters (Table 4.1)              = 1.0000 m
Kr        = 0.19 * (Zo / 0.05)^0.07   {Eqn 4.5}                        = 0.156
Sy        = Wind Turbulence: Kr * Vb * Ki {Eqn 4.6}                    = 4.37

Zs        = 0.6*H + zbase  {Fig 6.1}                                   = 40.4600 m
Zt        = Reference height provided in Annex B.1                     = 200.00
Lt        = Reference length scale provided in Annex B.1               = 300.00
Alpha     = 0.67 + 0.05 * Ln(Zo)  {Eqn B.1}                            = 0.380
Lzs       = Lt * (Zs / Zt)^Alpha   {Eqn B.1}                           = 163.575
Cr(Zs)    = Roughness Factor: Kr * ln(Zs/Zo)   {Eqn 4.4}               = 1.484
Co        = Orography factor based upon user entered data @ Elev = 71.020 m = 1.00
Vm(Zs)    = Cr(Zs) * Co(Zs) * Vb  {Eqn 4.3}                            = 41.55 m/s
n         = Natural Frequency                                          = 3.822 Hz
Fl(Zs)    = n * L(Zs) / Vm(Zs)  {Eqn B.2}                              = 15.049
Sl(Zs)    = Spectral - 6.8*Fl(Zs) / (1+10.2*fl(Zs))^(5/3)  {Eqn B.2}   = 0.023

d         = Diameter used for Reynolds Number Calculation              = 0.6441 m
V         = V used for Reynolds Number Calculation                     = 54.74 m/s
Re        = Reynolds Number: d * V / 0.000015  {Eqn 7.15}               = 2.35E+06
Cfo       = Force Coeff for Cylinder without Free End flow per Fig 7.28 = 0.650
Lambda    = Effective Slenderness Ratio per Table 7.16                 = 25.288
Pl        = Lookup value based upon Lambda from Fig 7.16               = 0.801
me        = Equivalent mass per unit length   {F.14}                   = 74.71 kg/m
Ba        = Aero Log Decrement Damping:  Cf*Rho*b*Vm(Zs)/(2*n*me)  [F.18] = 0.0299
Bs        = Structural Log Damping                                     = 0.6283
Bt        = Total Logarithmic Damping: (Bs+Ba)*2*PI  {Eqn B.6}         = 0.658
B2        = Background: 1/(1+0.9*((b+h)/L(Zs))^0.63)  {Eqn B.3}        = 0.821
Nh        = 4.6 * h * fl(Zs) / L(Zs)  {Eqn B.8}                        = 6.983
Nh        = 4.6 * b * fl(Zs) / L(Zs)  {Eqn B.8}                        = 0.273
Rh        = 1/Nh - (1-e^(-2*Nh))/(2*Nh^2)  {Eqn B.7}                   = 0.133
Rb        = 1/Nb - (1-e^(-2*Nb))/(2*Nb^2)  {Eqn B.8}                   = 0.841
Rt        = ((PI^2) / (2*Del)) * Sl * Rh * Rb   {Eqn B.6}              = 0.019
v         = n * (R2 / (B2 + R2))^0.5   {Eqn B.5}                       = 0.579
kp        = (2 * ln(v * 600))^0.5 + 0.6 / (2 * ln(v*600))^0.5  {Eqn B4} = 3.596
Iv(Zs)    = Sv / Vm(Zs)    {Eqn B.7}                                   = 0.105
CsCd      = (1 + 2*kp*Iv(Zs) * (B2+R2)^0.5) / (1 + 7*Iv(Zs))  {Eqn 6.1} = 0.975
Cs        = (1 + 7 * Iv(Zs) * B2^0.5) / (1 + 7 * Iv(Zs))  {Eqn 6.2}    = 0.960
```

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```
Cd        = (1 + 2*kp*Iv(Zs)*((B2+R2)^0.5))/(1+7*Iv(Zs)*B2^0.5)    {Eqn 6.3} = 1.016
Rho       = Air Density                                                       = 1.225
Kg/m^3
qb        = 0.5 * Rho * Vb^2  {Eqn 4.10}                                      = 480.357 kPa
```

Calculate Riser Shape Factors

Z m	D m	V m/s	Re	Lambda	Pl	Cfo	Cf
47.060	0.32	56.06	1.21E+06	50.302	0.88	0.589	0.515
44.060	0.32	55.15	1.19E+06	50.302	0.88	0.587	0.514
42.060	0.32	54.43	1.17E+06	50.302	0.88	0.586	0.513
42.027	0.32	54.41	1.17E+06	50.302	0.88	0.586	0.513
41.945	0.32	54.38	1.17E+06	50.302	0.88	0.586	0.513
41.817	0.39	54.33	1.40E+06	42.284	0.86	0.603	0.517
41.688	0.45	54.28	1.62E+06	36.471	0.84	0.617	0.519
41.560	0.51	54.22	1.84E+06	32.063	0.83	0.629	0.520
40.960	0.51	53.97	1.83E+06	32.063	0.83	0.628	0.519
38.960	0.51	53.00	1.79E+06	32.063	0.83	0.627	0.518
37.016	0.51	51.80	1.75E+06	32.063	0.83	0.625	0.516
36.683	0.69	51.56	2.39E+06	23.460	0.79	0.651	0.516
36.349	0.88	51.30	3.01E+06	18.498	0.77	0.670	0.514
36.016	1.07	51.03	3.63E+06	15.268	0.75	0.684	0.510
35.697	1.07	50.76	3.61E+06	15.268	0.75	0.684	0.510
35.560	1.07	50.64	3.60E+06	15.268	0.75	0.684	0.510
35.423	1.07	50.51	3.59E+06	15.268	0.75	0.683	0.510
33.660	1.07	48.45	3.45E+06	15.268	0.75	0.680	0.507
33.010	1.07	47.37	3.37E+06	15.268	0.75	0.679	0.506
31.945	1.07	44.74	3.18E+06	15.268	0.75	0.674	0.503
31.835	1.07	44.36	3.16E+06	15.268	0.75	0.674	0.502
31.725	1.07	43.95	3.13E+06	15.268	0.75	0.673	0.502
31.510	1.07	43.00	3.06E+06	15.268	0.75	0.671	0.501
31.006	1.07	39.48	2.81E+06	15.268	0.75	0.665	0.496
30.910	1.07	38.34	2.73E+06	15.268	0.75	0.662	0.494
30.865	1.07	37.69	2.68E+06	15.268	0.75	0.661	0.493

```
   Re     = Reynolds Num: D*V / v {Eqn 7.15}          | v  = Air Viscosity: 15*10^-6 m^2/s
   Lambda = Eff Slenderness Ratio {Table 7.16}        | Pl = End Effect Factor {Fig 7.36}
   Cfo    = Force coeff w/o Free-end Flow {Fig 7.28} | Cf = Force coefficient {Eqn 7.19}
```

Wind Pressures and Forces

Z m	Z ft	Cr	Co	Vm m/s	Iv	Ce	Linear Area m^2/m	Total Area sq m	qp kPa	Fw lb	Fw N
47.060	154.396	1.507	1.000	42.21	0.104	3.919	0.453	1.360	1.882	561	2497
44.060	144.553	1.497	1.000	41.92	0.104	3.877	0.453	0.907	1.862	370	1647
42.060	137.992	1.490	1.000	41.72	0.105	3.847	0.758	0.025	1.848	10	45
42.027	137.883	1.490	1.000	41.71	0.105	3.847	2.582	0.211	1.848	86	381
41.945	137.614	1.489	1.000	41.70	0.105	3.845	2.582	0.331	1.847	134	597
41.817	137.193	1.489	1.000	41.69	0.105	3.843	2.729	0.350	1.846	142	631
41.688	136.772	1.488	1.000	41.68	0.105	3.841	2.877	0.369	1.845	149	664
41.560	136.351	1.488	1.000	41.66	0.105	3.839	2.573	1.544	1.844	624	2777
40.960	134.383	1.486	1.000	41.60	0.105	3.830	0.565	1.129	1.840	456	2027

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38.960	127.821	1.478	1.000	41.38	0.106	3.799	0.259	0.504	1.825	201	896
37.016	121.443	1.470	1.000	41.16	0.106	3.766	0.258	0.086	1.809	34	152
36.683	120.350	1.469	1.000	41.12	0.106	3.761	0.353	0.118	1.806	47	208
36.349	119.256	1.467	1.000	41.08	0.106	3.755	0.446	0.149	1.804	59	262
36.016	118.162	1.466	1.000	41.04	0.106	3.749	0.538	0.172	1.801	68	302
35.697	117.114	1.464	1.000	41.00	0.107	3.743	0.537	0.073	1.798	29	129
35.560	116.666	1.464	1.000	40.98	0.107	3.741	0.537	0.073	1.797	29	129
35.423	116.218	1.463	1.000	40.97	0.107	3.739	0.537	0.947	1.796	373	1659
33.660	110.433	1.455	1.000	40.74	0.107	3.707	0.534	0.347	1.781	136	603
33.010	108.300	1.452	1.000	40.66	0.107	3.694	0.533	0.567	1.775	221	982
31.945	104.805	1.447	1.000	40.51	0.108	3.674	0.528	0.058	1.765	22	100
31.835	104.445	1.446	1.000	40.50	0.108	3.672	0.528	0.058	1.764	22	99
31.725	104.086	1.446	1.000	40.48	0.108	3.670	0.527	0.114	1.763	44	195
31.510	103.379	1.445	1.000	40.45	0.108	3.666	0.526	0.265	1.761	102	455
31.006	101.725	1.442	1.000	40.38	0.108	3.656	0.526	0.050	1.756	19	86
30.910	101.410	1.442	1.000	40.37	0.108	3.654	0.526	0.024	1.755	9	41
30.865	101.263	1.442	1.000	40.36	0.108	3.653	2.770	0.845	1.755	325	1446
Total								10.676		4273	19009

Cr = Roughness: kr * ln(z/zo) {Eqn 4.4} | Co = Orography factor {Sec 4.3.1}
Vm = Mean Velocity: Cr(z)*Co(z)*Vb {Eqn 4.3} | Iv = Turbulence: Sv/Vm(z) {Eqn 4.7}
Ce = Exposure: qp(z) / qb {Eqn 4.9} | qp = Peak Vel Press: Ce(z)*qb {Eqn 4.8}
Fw = Force: qp*CsCd*(Total Area) {Eqn 5.3}

Wind Loads Applied to the Model

Top Elev m	Bot Elev m	Uniform Load N/m	Total Load N
47.060	44.060	832.4	2497
44.060	42.060	823.4	1647
42.060	42.027	1366.5	45
42.027	41.945	4653.4	381
41.945	41.817	4651.9	597
41.817	41.688	4914.9	631
41.688	41.560	5177.7	664
41.560	40.960	4628.5	2777
40.960	38.960	1013.3	2027
38.960	37.016	461.0	896
37.016	36.683	455.3	152
36.683	36.349	622.5	208
36.349	36.016	785.5	262
36.016	35.697	944.6	302
35.697	35.560	942.5	129
35.560	35.423	941.6	129
35.423	33.660	940.7	1659
33.660	33.010	927.7	603
33.010	31.945	921.9	982
31.945	31.835	909.7	100
31.835	31.725	908.1	99
31.725	31.510	906.4	195
31.510	31.006	903.3	455

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31.006	30.910	900.8	86
30.910	30.865	900.4	41
30.865	30.560	4740.9	1446
Total			19009

Weight Summary (Seismic)

Component	Elev COG m	Weight kg	Weight N
Stack (Corroded Wt = 1822.5 kg)	36.164	2458.5	24110
Ladders	40.510	69.2	679
Platforms	40.960	319.3	3132
Helical Strakes	44.310	25.0	245
Baseplate	30.687	389.0	3815
Structural Flange(s)	42.000	58.0	569
Nozzle(s)	34.097	53.2	521
General Attachment Uniform)	32.285	82.5	809
General Attachment Uniform (Oper, Fac = 1)	32.260	1137.0	11150
General Attachment Concentrated	31.510	200.0	1961
Nozzle(s)	35.560	-1474.2	-14457
Platforms (Live, Fac = 0)	30.560	0.0	0
Total	34.758	3317.6	32534

Seismic Loads Entered by User are Based upon

Seismic Criteria: Manually Specify Seismic Loading

Spec	= What is the basis for the loads being entered	=
Ft	= Load applied at the top of the stack (0 if none)	= 0 N
RatioShear	= Ratio of Base Shear to Dead Weight (g-force)	= 0.700
RatioVer	= Ratio of Base Vertical Load to Dead Weight (g-force)	= 0.700
Method	= Method used to apply the loads to the structure	= ASCE 7-10
Fac_Live	= Factor to apply to Live loads to be treated as Mass	= 0.000
Fac_Oper	= Factor to apply to operating loads to be treated as Masses	= 1.000
T	= Period of Structure	= 0.221 s
Wt	= Weight of stack	= 3317.6 kg
Wt	= Weight of stack	= 32534 N
Base_Shear	= Seismic Base Shear (RatioShear * Wt)	= 22774 N
Base_Ver	= Seismic Base Vertical Load (RatioVer * Wt)	= 22774 N
Kfac	= Exponent based upon Period per ASCE 7-10 Eqn 12.8-12	= 1.000

Elev m	hx m	wx N	wx*hx^k	Cvx	Shear N	Ver N
45.560	15.0000	1544	23161.8	0.171	3893	1080
43.060	12.5000	1029	12867.7	0.095	2163	720
42.043	11.4834	319	3659.2	0.027	615	223
41.986	11.4259	368	4208.9	0.031	707	258
41.881	11.3208	160	1809.5	0.013	304	112
41.753	11.1925	160	1789.0	0.013	301	112
41.624	11.0642	160	1768.5	0.013	297	112
41.260	10.7000	2420	25900.7	0.191	4353	1694

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39.960	9.4000	4412	41490.0	0.306	6973	3088
37.988	7.4280	2341	17396.3	0.128	2924	1639
36.849	6.2893	627	3942.6	0.029	663	439
36.516	5.9560	627	3733.7	0.028	628	439
36.183	5.6227	627	3524.7	0.026	592	439
35.856	5.2963	816	4325.7	0.032	727	571
35.628	5.0683	-6721	-34078.4	-0.252	-5728	-4705
35.492	4.9317	-6721	-33160.4	-0.245	-5573	-4705
34.542	3.9817	4507	17951.1	0.132	3017	3155
33.335	2.7750	1852	5142.2	0.038	864	1297
32.477	1.9173	10956	21014.5	0.155	3532	7669
31.890	1.3298	1229	1634.7	0.012	275	860
31.780	1.2202	1229	1500.0	0.011	252	860
31.618	1.0577	3196	3382.2	0.025	568	2237
31.258	0.6980	2417	1687.7	0.012	284	1692
30.958	0.3980	274	108.9	0.001	18	192
30.888	0.3275	115	37.7	0.000	6	80
30.713	0.1525	4594	700.9	0.005	118	3216
Total	0.0000	32534	135499.2	1.000	22774	22774

hx = Distance from Bottom of Stack
Elev = Elevation above grade
Denom = Summation(wx*hx^k) = 135499
Cvx = % of Total Base Shear: wx*hx^k / Denom
Ver = RatioVer * wx

Seismic Loads Applied to Model

Top Elev m	Bot Elev m	Uniform Load N/m	Total Load N
47.060	44.060	1297.6	3893
44.060	42.060	1081.4	2163
42.060	42.027	18526.7	615
42.027	41.945	8647.6	707
41.945	41.817	2369.8	304
41.817	41.688	2343.0	301
41.688	41.560	2316.1	297
41.560	40.960	7255.4	4353
40.960	38.960	3486.7	6973
38.960	37.016	1504.0	2924
37.016	36.683	1988.0	663
36.683	36.349	1882.6	628
36.349	36.016	1777.2	592
36.016	35.697	2275.7	727
35.697	35.560	-41953.3	-5728
35.560	35.423	-40823.2	-5573
35.423	33.660	1710.9	3017
33.660	33.010	1329.6	864
33.010	31.945	3315.0	3532
31.945	31.835	2508.2	275
31.835	31.725	2301.6	252
31.725	31.510	2638.3	568
31.510	31.006	562.8	284

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31.006	30.910	190.7	18
30.910	30.865	140.7	6
30.865	30.560	386.2	118
------	------	--------	-----
Total			22774

Vortex Shedding Summary

Mode Num	Configuration	Frequency Hz	Crit Wind Speed m/s	Reduced Mass kg	Defl Max m	Defl Limit m	Defl Ratio	Comment
1	Hot & Corroded	3.822	6.88	208	0.0007	0.0162	0.041	PASS
1	Hot & UnCorroded	4.472	8.05	194	0.0007	0.0162	0.043	PASS
1	Cold & Corroded	3.860	6.95	210	0.0007	0.0162	0.041	PASS
1	Cold & Uncorroded	4.518	8.13	196	0.0007	0.0162	0.043	PASS

1. Defl Ratio = Defl Max / Defl Limit

Vortex Shedding Analysis per Eurocode: EN 1991-1-4:2005+A1:2010
Ref Para E.1.5.2 Approach 1 for calculation of cross wind amplitudes

Zcr	= (5/6) * Stack Ht + Dist from Grade To Base Of Stack	= 74.870 m
Co	= Orography factor based upon user entered data @ Elev = 74.870 m	= 1.00
Vm	= Mean Wind Velocity: Cr * Co * Vb {Eqn 4.3}	= 41.94 m/s
Bs	= Structural Log Decrement Damping	= 0.6283
St	= Strouhal number for a single stack	= 0.180
Vc	= Critical Wind Speed: b * n / S	= 8.13 m/s
b	= Diameter at Turbulence Zone (Mode # 1)	= 0.3238 m
n	= Natural Frequency of Mode # 1	= 4.518 Hz
me	= Equivalent mass per unit length	= 73.40 kg/m
Nodes	= Number of Nodes	= 1
AntiNodes	= Number of AntiNodes	= 1

Summary of Nodes and Antinodes

Num	Node Elevation m	Anti-Node Elevation m
---	---------	---------
1	30.560	47.060

Nodes are where the lateral deflection is zero
Anti-Nodes are the points between nodes where the deflection is maximum

Correlation Length # 1:		
b1	= Average Diameter for Correction Length # 1	= 0.3238 m
yf/b1	= Ratio of yf / b1	= 0.00
L1	= Since Yf/b < 0.1: 6 * b	= 1.9428 m
L1_Top	= Top Elevation for Correlation Length # 1	= 47.060 m
L1_Bot	= Bot Elevation for Correlation Length # 1	= 45.117 m
Clat Calculation for Correlation Length # 1:		
b1	= Average diameter for correlation length # 1	= 0.3238 m

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```
Vm1       = Mean wind speed for Correlation Length # 1 {Eqn 4.3}            = 37.63 m/s
Vcrit1    = Critical Wind Speed:  b1 * n / St  {Eqn E.2}                    = 8.13 m/s
Re1       = Reynolds Number:  b1 * Vcrit1 / (15*10^-6 m^2/2)   {Eqn E.5}    = 1.75E+05
Ratio1    = Ratio:  Vcrit1 / Vm1  {Ref Table E.3}                           = 0.216
Clat01    = Basic lateral force coeffic for circular cylinders {Fig E.2}    = 0.700
Clat1     = Since Ratio <= 0.83: Clat0 {Table E.3}                          = 0.700

Clat      = Maximum value of Clat from all considered correlation lengths   = 0.700

Check to Determine if Strakes Adequate to Meet EN 1993-3-2:2006 Sec B.2(3):
b         = Average Wind OD in Strake Region                                = 0.3281 m
h         = Stack Height                                                    = 16.5000 m
P         = Strake Pitch                                                    = 1.6190 m
Pmin      = Minimum Acceptable Pitch: 4.5*b                                 = 1.4764 m
Pmax      = Maximum Acceptable Pitch: 5*b                                   = 1.6405 m
Chk1      = Pitch in Acceptable Range:  Pmin <= P <= Pmax                   = True

T         = Strake Depth                                                    = 32.4 mm
Tmin      = Minimum Acceptable Strake Depth: 0.1*b                          = 32.8 mm
Tmax      = Maximum Acceptable Strake Depth: 0.12*b                         = 39.4 mm
Chk2      = Depth in Acceptable Range:  Tmin <= T <= Tmax                   = False

Ls        = Length of Straked Region                                        = 5.5000 m
Lmin      = Minimum Req'd Strake Length: 0.3*h                              = 4.9500 m
Lmax      = Maximum Req'd Strake Length: 0.5*h                              = 8.2500 m
Chk3      = Length in Acceptable Range:  Lmin <= L <= Lmax                  = True

Lu        = Length of Unstraked Portion at top of Stack                     = 0.0000 m
Lu_Max    = Max Allowed Unstraked Length: b                                 = 0.3281 m
Chk4      = Unstraked Length @ Top Acceptable: Lu <= Lu_max                 = True

Sc        = Scruton Number: 2 * me * Bs / (Rho * D1^2)                      = 699.25
Chk5      = Scruton Number is Larger than 8                                 = True

Straked?  = Are all strake criteria from EN 1993-3-2 Section B.2(3) Met?    = False

Kw        = Effective Correlation length Factor Kw {Eqn E.8}                = 0.522
K         = Mode shape factor K                                             = 0.137

Calculate yf for Correlation Length # 1:
b1        = Average Outer Diameter at correlation length # 1                = 0.3238 m
St        = Strouhal number for a single stack                              = 0.180
Sc        = Scruton Number: 2 * me * Bs / (Rho * D1^2)                      = 717.94
yf1       = (1/St^2) * (1/Sc) * K * Kw * clat * b     {Eqn E.7}             = 0.0007 m

yf        = Maximum yf from all correlation lengths considered  {Eqn E.7}   = 0.0007 m

Eo        = Bandwidth factor:  0.3    {Eqn E.10}                            = 0.300
Number of cycles calculations based upon EN 1991-1-4 Section E.1.5.2.6:
Vcrit     = Critical Wind Speed corresponding to Clat calculation           = 8.13 m/s
Vm        = Mean Wind Speed corresponding to Clat calculation               = 41.94 m/s
Vo        = Weibull probability distribution * (2)^0.5: 0.2*Vm  {Eqn E.10}  = 8.39 m/s
Tyrs      = Life of Structure in Years                                      = 50.0 Years
T         = Life of Structure in Seconds: 3.2*10^7 * T                      = 1.60E+09
N         = Num Cycles: 2*T*n*Eo*(Vcrit/Vo)^2*Exp(-(Vcrit/Vo)^2) {Eqn E.10} = 1.593E+09

 Elev      Elev     mtot         m        Phi       Ht        Fw         Fw       Fw
```

m	ft	kg	kg/m		m	Uniform N/m	Total lb	Total N
77.620	254.658	157.4	52.46	1.000	3.0000	29.5	20	88
74.620	244.815	104.9	52.46	0.601	2.0000	17.7	8	35
72.620	238.254	3.5	104.24	0.384	0.0332	22.5	0	1
72.587	238.145	37.5	459.00	0.381	0.0818	98.3	2	8
72.505	237.877	16.3	126.96	0.374	0.1283	26.7	1	3
72.377	237.455	16.3	126.96	0.364	0.1283	25.9	1	3
72.248	237.034	16.3	126.96	0.353	0.1283	25.2	1	3
72.120	236.613	246.7	411.23	0.343	0.6000	79.2	11	48
71.520	234.645	449.9	224.95	0.296	2.0000	37.4	17	75
69.520	228.083	238.7	122.80	0.160	1.9440	11.0	5	21
67.576	221.705	63.9	191.69	0.073	0.3333	7.9	1	3
67.243	220.612	63.9	191.69	0.065	0.3333	7.0	1	2
66.909	219.518	63.9	191.69	0.058	0.3333	6.3	0	2
66.576	218.424	83.3	260.59	0.052	0.3195	7.6	1	2
66.257	217.376	-685.4	-5020.12	0.046	0.1365	-130.8	-4	-18
66.120	216.928	-685.4	-5020.12	0.044	0.1365	-124.3	-4	-17
65.983	216.481	459.5	260.59	0.042	1.7635	6.1	2	11
64.220	210.695	188.9	290.59	0.017	0.6500	2.8	0	2
63.570	208.562	1117.2	1048.59	0.011	1.0655	6.3	2	7
62.505	205.067	125.3	1143.92	0.003	0.1095	2.0	0	0
62.395	204.707	125.3	1143.92	0.003	0.1095	1.7	0	0
62.285	204.348	325.9	1512.71	0.002	0.2155	1.8	0	0
62.070	203.641	246.5	489.00	0.001	0.5040	0.4	0	0
61.566	201.988	27.9	290.59	0.000	0.0960	0.0	0	0
61.470	201.673	11.7	260.59	0.000	0.0450	0.0	0	0
61.425	201.525	468.5	1536.00	0.000	0.3050	0.1	0	0
Total		3288.5					63	281

Fw = m * (2*PI*n)^2 * Phi * yf {Eqn E.6} m = Uniform mass

Vortex Shedding Loads Applied to Model

Top Elev m	Bot Elev m	Uniform Load N/m	Total Load N
47.060	44.060	29.5	88
44.060	42.060	17.7	35
42.060	42.027	22.5	1
42.027	41.945	98.3	8
41.945	41.817	26.7	3
41.817	41.688	25.9	3
41.688	41.560	25.2	3
41.560	40.960	79.2	48
40.960	38.960	37.4	75
38.960	37.016	11.0	21
37.016	36.683	7.9	3
36.683	36.349	7.0	2
36.349	36.016	6.3	2
36.016	35.697	7.6	2
35.697	35.560	-130.8	-18
35.560	35.423	-124.3	-17

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35.423	33.660	6.1	11
33.660	33.010	2.8	2
33.010	31.945	6.3	7
31.945	31.835	2.0	0
31.835	31.725	1.7	0
31.725	31.510	1.8	0
31.510	31.006	0.4	0
31.006	30.910	0.0	0
30.910	30.865	0.0	0
30.865	30.560	0.1	0
Total			281

Primary Loads
Abbreviations are used in Load Combinations

Number	Description	Abbreviation
1	Dead	D
2	Live	L
3	Operating	O
4	Thermal Hot	TH
5	Wind	W
6	Seismic Hor	Eh
7	Seismic Ver	Ev
8	Vortex Across	V

Load Combinations
Column Abbreviations can be found in the Primary Load Table

Num	Description	S	D	FS	Dir Deg	D	L	O	TH	W	Eh	Ev	V
9	A: 0.9*D 0 Deg	X		1.100	0	0.9							
10	A: 1.1*D+1.5*W+0.9*L+0.9*O 0 D	X		1.100	0	1.1	0.9	0.9		1.5			
11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0	X		1.100	0	1.35	0.9	0.9		1.5			
12	B: 1.0*D 0 Deg	X		1.100	0	1.0							
13	C: 1.0*D+1.3*W+0.78*L+0.78*O 0	X		1.100	0	1.0	0.78	0.78		1.3			
14	Serviceability: 1.0*D+1.0*W 0		X	1.100	0	1.0				1.0			
15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	X		1.100	0	1.0	1.0	1.0			1.0		
16	1.0*D+1.0*S 0 Deg	X		1.100	0	1.0					1.0		
17	Serviceability: 1.0*D+1.0*S 0		X	1.100	0	1.0					1.0		
18	D+O+P 0 Deg	X		1.000	0	1.0		1.0					

FS: Factor of Safety used in Conjunction with the Stress Code which has been selected.
Dir: Direction of Lateral Loads (Wind/Seismic/Vortex), 0 Deg = X Axis, 90 Deg = Z Axis
P: Internal Pressure (Doesn't produce support loads only used for stack tensile stress)
S: Include in Stress Analysis D: Calculate Deflections
Load Combinations were Automatically generated
Stress Criteria: EN 1993-3-2 (Limit States)
Wind Criteria: EN 1991-1-4 (Ultimate)
Seismic Criteria: MANUAL (N/A)
Wind Combinations:
Service wind loads specified, use combos per EN 1990 Appendix A

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Seismic Combinations:
Seismic code is based upon ultimate loads, and so are the EN 1990 Table A1.3 combinations,
so we use the factors from that table

Boundary Conditions Specified for System
'F' is translational restraint and 'M' is rotational restraint

Joint #	Description	X m	Y m	Z m	Fx	Fy	Fz	Mx	My	Mz
27	Fixed	0.0000	0.0000	0.0000	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed

Riser Stiffening Ring Property Summary
All stiffening rings as well as other components that behave as stiffening rings

ID	Country	Shape	Size	Config	Material	Inside Stack?

The material properties for the shell/ring section are based upon the shell.
Software does not evaluate any problems that could arise if the riser is a different material than the stiffening rings.

Ring Num	Elev m	Stiff Ring	Eff Shell Width mm	Shell Thickness mm	Ls m	Area sq cm	Mom of Inertia cm^4	Section Modulus cm^3	Xc mm
1	42.000	Flange	65.6	7.0	10.6275	55.014	343.67	79.4	36.1
2	30.865	Baseplate Top	493.3	10.0	5.7200	89.110	2417.41	191.3	32.7
3	30.560	Baseplate Bot	493.3	10.0	0.1525	119.960	10913.54	541.9	81.1

Properties are for the combined stiffener and effective shell (Corroded)
Ls = Ring spacing, 1/2 of shell on each side of ring.
Xc = Centroid of combined section from OD of stack shell
Effective Shell Width Each Side of Stiff = 0.975*(0.5*D*Shell_Thk)^0.4 [EN 1993-1-6 Sec B3.1]

Stiffening Ring: [1] Flange
El 42.0 m

Description	Dx mm	Dy mm	Xc mm	Yc mm	Area sq cm	Iy_Loc cm^4	Iy_Tot cm^4
Flat_Bar	79.4	63.5	39.7	0.0	50.419	264.88	271.45
Shell Above	7.0	32.8	-3.5	16.4	2.298	0.09	36.11
Shell Below	7.0	32.8	-3.5	-16.4	2.298	0.09	36.11
Total			36.1	0.0	55.014		343.67

X & Y axis are local used for this calculation & may not correspond to global X & Y.

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Dx = Dimension of the rectangle in X Dir, Dy = Dimension of Rectangle in Y Dir.
Xc = Centroid of Rect in X Dir, Yc = Centroid of Rect in Y Dir
Ix_Tot = Ix_Loc + Area*(Yc-Yc_Tot)^2, Iy_Tot = Iy_Loc + Area*(Xc-Xc_Tot)^2
Sy_Tot = 79.4 cm^3

Stiffening Ring: [2] Baseplate Top
El 30.865 m

Description	Dx mm	Dy mm	Xc mm	Yc mm	Area sq cm	Iy_Loc cm^4	Iy_Tot cm^4
Flat_Bar	159.1	25.0	79.6	0.0	39.775	839.04	1710.61
Shell Above	10.0	246.7	-5.0	123.3	24.667	2.06	353.40
Shell Below	10.0	246.7	-5.0	-123.3	24.667	2.06	353.40
Total			32.7	0.0	89.110		2417.41

X & Y axis are local used for this calculation & may not correspond to global X & Y.
Dx = Dimension of the rectangle in X Dir, Dy = Dimension of Rectangle in Y Dir.
Xc = Centroid of Rect in X Dir, Yc = Centroid of Rect in Y Dir
Ix_Tot = Ix_Loc + Area*(Yc-Yc_Tot)^2, Iy_Tot = Iy_Loc + Area*(Xc-Xc_Tot)^2
Sy_Tot = 191.3 cm^3

Stiffening Ring: [3] Baseplate Bot
El 30.56 m

Description	Dx mm	Dy mm	Xc mm	Yc mm	Area sq cm	Iy_Loc cm^4	Iy_Tot cm^4
Flat_Bar	282.5	25.0	141.3	0.0	70.625	4696.93	7251.88
Shell Above	10.0	246.7	-5.0	123.3	24.667	2.06	1830.83
Shell Below	10.0	246.7	-5.0	-123.3	24.667	2.06	1830.83
Total			81.1	0.0	119.960		10913.54

X & Y axis are local used for this calculation & may not correspond to global X & Y.
Dx = Dimension of the rectangle in X Dir, Dy = Dimension of Rectangle in Y Dir.
Xc = Centroid of Rect in X Dir, Yc = Centroid of Rect in Y Dir
Ix_Tot = Ix_Loc + Area*(Yc-Yc_Tot)^2, Iy_Tot = Iy_Loc + Area*(Xc-Xc_Tot)^2
Sy_Tot = 541.9 cm^3

Summary of Stiffening Ring Check for Static Ovalling
Are Stiff Rings are Adequate to consider riser 'Stiffened'

Ring Num	Elev m	d m	t mm	rm m	we kPa	Ls m	My N-m	Sact cm^3	Sreqd cm^3	Unity Sreqd/Sact
1	72.560	0.3238	7.0	0.1584	1.848	10.6275	246.3	79.4	1.3	0.017
2	61.425	1.0668	10.0	0.5284	1.755	5.7200	1401.1	191.3	6.4	0.034
3	61.120	1.0668	10.0	0.5284	1.755	0.1525	37.4	541.9	0.2	0.000

d = Outer Diameter of Stack
Ls = 1/2 of dist each side of stiff
My = Moment: 0.5*rm^2*we*Ls
t = Corroded Thickness of shell
Sact = Act Sec Modulus of Ring+Shell
we = Wind Press at Elevation

```
Sreqd = My / (Fy / 1.1)
```

Verify that Beam Theory can be Used per EN 1993-3-2 [5.1]

Since the Chimney is considered to be Stiffend then Beam Theory can be used.

Fatigue Analysis Vortex Shedding per Eurocode
Ref EN 1993-2 Sect 9.2 and EN 1993-1-9

Fatigue Criteria: Eurocde 3 - Design of Steel structures: Part 3-2: Towers, masts and chimneys

```
Life      = Fatigue Life Of Stack In Years                                  = 50.0 Years
GMf       = Partial Safety Factor for Fatigue Strength                      = 1.35
GFf       = Partial Safety Factor for Equiv Const Amplitude Stress Range    = 1.00
```

Fatigue Categories: Euro

Elev m	Cat
47.060	69

```
Number of cycles calculations based upon EN 1991-1-4 Section E.1.5.2.6:
Vcrit     = Critical Wind Speed corresponding to Clat calculation           = 8.13 m/s
Vm        = Mean Wind Speed corresponding to Clat calculation               = 41.94 m/s
Vo        = Weibull probability distribution * (2)^0.5: 0.2*Vm  {Eqn E.10}  = 8.39 m/s
Tyrs      = Life of Structure in Years                                      = 50.0 Years
T         = Life of Structure in Seconds: 3.2*10^7 * T                      = 1.60E+09
N         = Num Cycles: 2*T*n*Eo*(Vcrit/Vo)^2*Exp(-(Vcrit/Vo)^2) {Eqn E.10} = 1.593E+09
m         = Slope of S-N curve per EN 1993-1-9 Figure 7.1                   = 0.000
            Since N > 1E08 then the S-N curve Is flat And m = 0

Lambda    = Equivalence Factor  (N / 2E6)^(1/m) [EN 1993-3-2 9.2]           = 2.187
          Since N > 1E8 then use N = 1e8 And m = 5 for Lamda calculation
```

Fatigue Analysis Vortex Shedding for Load # 8 - Vortex Across
Fatigue Analysis per Eurocode EN 1993-1-9

Top El m	Bot El m	Moment KN-m	DSE MPa	DSE2 MPa	DSc MPa	Ratio
47.060	44.060	0.13	0.57	1.24	69.00	0.024
44.060	42.060	0.34	1.48	3.23	69.00	0.063
42.060	42.027	0.35	1.29	2.83	69.00	0.055
42.027	41.945	0.36	1.33	2.91	69.00	0.057
41.945	41.817	0.38	1.39	3.05	69.00	0.060
41.817	41.688	0.39	1.02	2.23	69.00	0.044
41.688	41.560	0.41	0.79	1.72	69.00	0.034
41.560	40.960	0.51	0.75	1.65	69.00	0.032
40.960	38.960	0.97	1.42	3.11	69.00	0.061
38.960	37.016	1.50	2.21	4.83	69.00	0.094
37.016	36.683	1.60	2.35	5.14	69.00	0.101
36.683	36.349	1.70	1.32	2.88	69.00	0.056
36.349	36.016	1.79	0.86	1.88	69.00	0.037
36.016	35.697	1.89	0.62	1.35	69.00	0.026

35.697	35.560	1.93	0.62	1.36	69.00	0.027
35.560	35.423	1.96	0.66	1.45	69.00	0.028
35.423	33.660	2.43	0.79	1.73	69.00	0.034
33.660	33.010	2.61	0.85	1.86	69.00	0.036
33.010	31.945	2.91	0.95	2.07	69.00	0.041
31.945	31.835	2.94	0.96	2.09	69.00	0.041
31.835	31.725	2.97	1.03	2.26	69.00	0.044
31.725	31.510	3.03	0.99	2.16	69.00	0.042
31.510	31.006	3.17	1.03	2.26	69.00	0.044
31.006	30.910	3.20	1.04	2.28	69.00	0.045
30.910	30.865	3.21	1.05	2.29	69.00	0.045
30.865	30.560	3.29	0.44	0.96	69.00	0.019

DSE = 2 x Bending Stress
DSc = Fatigue Strength Category
DSE2 = DSE * Lambda [EN 1993-3-2 9.1]
Ratio: GFf*DSE2 / (DSc / GMf) [EN 1993-1-9 8.2]

Fatigue Analysis Along Wind per Eurocode
Ref EN 1993-2 Sect 9.2.1, EN 1993-3-1 9.2.1 and EN 1993-1-9

Fatigue Criteria: Eurocde 3 - Design of Steel structures: Part 3-2: Towers, masts and chimneys

Life	= Fatigue Life Of Stack In Years	= 50.0 Years
GMf	= Partial Safety Factor for Fatigue Strength	= 1.35
GFf	= Partial Safety Factor for Equiv Const Amplitude Stress Range	= 1.00

Fatigue Categories: Euro

Elev m	Cat
47.060	69

N	= Number of cycles: EN 1993-3-1 Eqn 9.1: 10^5*Tyrs/50	= 1.000E+05
m	= Slope of S-N curve per EN 1993-1-9 Figure 7.1	= 3.000
Lambda	= Equivalence Factor [EN 1993-3-2 9.2]	= 0.368
qp	= (1 + 7 * Iv(Z) * 0.5 * Rho * Vm(Z) {Eqn 4.10}	= 1572.585 kPa
Rho	= Air Density	= 1.225 Kg/m^3
qb	= 0.5 * Rho * Vb^2 {Eqn 4.10}	= 480.357 kPa
Ce	= qp(Z) / qb {Eqn 4.9}	= 3.274
G	= Gust Response Factor: ce*cs*cd-1 {EN 1993-3-1 Eqn 9.1}	= 2.193

Fatigue Analysis Along Wind for Load # 5 - Wind
Fatigue Analysis per Eurocode EN 1993-1-9

Top El m	Bot El m	Moment KN-m	SR MPa	DSE MPa	DSE2 MPa	DSc MPa	Ratio
47.060	44.060	3.75	16.03	7.96	2.93	69.00	0.057
44.060	42.060	10.39	44.45	22.09	8.14	69.00	0.159
42.060	42.027	10.52	38.97	19.36	7.13	69.00	0.140
42.027	41.945	10.88	40.30	20.02	7.38	69.00	0.144
41.945	41.817	11.51	42.61	21.17	7.80	69.00	0.153
41.817	41.688	12.21	31.62	15.71	5.79	69.00	0.113

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41.688	41.560	13.00	24.85	12.35	4.55	69.00	0.089
41.560	40.960	17.71	26.02	12.93	4.76	69.00	0.093
40.960	38.960	38.21	56.15	27.89	10.28	69.00	0.201
38.960	37.016	60.99	89.60	44.52	16.40	69.00	0.321
37.016	36.683	65.06	95.60	47.50	17.50	69.00	0.342
36.683	36.349	69.20	53.84	26.75	9.85	69.00	0.193
36.349	36.016	73.42	35.28	17.53	6.46	69.00	0.126
36.016	35.697	77.55	25.28	12.56	4.63	69.00	0.091
35.697	35.560	79.35	25.70	12.77	4.70	69.00	0.092
35.560	35.423	81.16	27.39	13.61	5.01	69.00	0.098
35.423	33.660	106.15	34.61	17.19	6.33	69.00	0.124
33.660	33.010	116.10	37.85	18.80	6.93	69.00	0.136
33.010	31.945	133.25	43.44	21.58	7.95	69.00	0.156
31.945	31.835	135.07	43.98	21.85	8.05	69.00	0.157
31.835	31.725	136.90	47.60	23.65	8.71	69.00	0.170
31.725	31.510	140.54	45.82	22.76	8.39	69.00	0.164
31.510	31.006	149.21	48.65	24.17	8.90	69.00	0.174
31.006	30.910	150.89	49.19	24.44	9.00	69.00	0.176
30.910	30.865	151.68	49.45	24.57	9.05	69.00	0.177
30.865	30.560	157.26	20.93	10.40	3.83	69.00	0.075

Moment = Moment due to 1.0 x Wind Loads (10 minute mean wind speed)
SR = Full Stress Range due to 10 minute Mean wind speed: Moment / Sec Mod
DSE = 1.1*(SR-(G/r)*SR) [EN 1993-3-1 9.1] DSE2 = DSE * Lambda [EN 1993-3-2 9.1]
DSc = Fatigue Strength Category Ratio: GFf*DSE2 / (DSc / GMf) [EN 1993-1-9 8.2]

Stack Stress Worst Case Summary
Summary of the load and highest stress ratios for each stack element

Top El m	Bot El m	Load #	Load Case	Controlling Case	Ratio	Result
47.060	44.060	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.097	PASS
44.060	42.060	16	1.0*D+1.0*S 0 Deg	Buckling	0.261	PASS
42.060	42.027	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.168	PASS
42.027	41.945	16	1.0*D+1.0*S 0 Deg	Buckling	0.174	PASS
41.945	41.817	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.184	PASS
41.817	41.688	16	1.0*D+1.0*S 0 Deg	Buckling	0.139	PASS
41.688	41.560	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.111	PASS
41.560	40.960	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.118	PASS
40.960	38.960	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.263	PASS
38.960	37.016	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.442	PASS
37.016	36.683	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.476	PASS
36.683	36.349	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.249	PASS
36.349	36.016	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.171	PASS
36.016	35.697	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.129	PASS
35.697	35.560	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.131	PASS
35.560	35.423	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.145	PASS
35.423	33.660	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.193	PASS
33.660	33.010	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.214	PASS
33.010	31.945	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.252	PASS
31.945	31.835	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.257	PASS
31.835	31.725	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.279	PASS
31.725	31.510	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.271	PASS

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31.510	31.006	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg Buckling	0.291	PASS
31.006	30.910	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg Buckling	0.258	PASS
30.910	30.865	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg Buckling	0.260	PASS
30.865	30.560	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg Buckling	0.103	PASS

STACK COMPRESSIVE STRESSES PER EN 1991-1-6, Worst Case
Highest Unity ratios for each member and the load case that produces it.

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio	Load Case
44.060	5.84	0.77	0.13	12.50	12.63	0.03	130.79	31.32	1.976	1.424	0.097	0.010	0.097	15
42.060	15.79	2.06	0.34	33.79	34.13	0.03	130.79	31.32	1.976	1.424	0.261	0.070	0.261	16
42.027	16.00	2.59	0.37	29.62	29.99	0.03	178.95	46.59	1.971	1.438	0.168	0.030	0.168	15
41.945	16.57	3.22	0.46	30.69	31.15	0.03	178.95	46.59	1.971	1.438	0.174	0.032	0.174	16
41.817	17.54	3.34	0.48	32.47	32.95	0.03	178.95	46.59	1.971	1.438	0.184	0.036	0.184	15
41.688	18.55	3.50	0.42	24.01	24.43	0.03	175.79	32.93	1.959	1.383	0.139	0.021	0.139	16
41.560	19.50	4.94	0.51	18.64	19.15	0.04	172.76	24.52	1.946	1.349	0.111	0.014	0.111	11
40.960	26.56	5.62	0.51	19.51	20.02	0.04	169.82	18.98	1.935	1.327	0.118	0.016	0.118	11
38.960	58.10	22.49	2.04	42.68	44.73	0.04	169.82	18.98	1.935	1.327	0.263	0.076	0.263	15
37.016	99.06	25.08	2.28	72.77	75.05	0.04	169.82	18.98	1.935	1.327	0.442	0.206	0.442	15
36.683	106.68	26.56	2.41	78.37	80.78	0.04	169.82	18.98	1.935	1.327	0.476	0.238	0.476	15
36.349	114.52	27.19	1.80	44.54	46.34	0.06	186.06	10.34	2.000	1.292	0.249	0.063	0.249	15
36.016	122.56	27.82	1.45	29.45	30.89	0.07	180.23	6.85	1.977	1.278	0.171	0.034	0.171	15
35.697	130.47	28.54	1.22	21.27	22.49	0.09	173.90	5.47	1.951	1.272	0.129	0.024	0.129	15
35.560	133.51	29.12	1.13	21.62	22.75	0.09	174.04	5.47	1.952	1.272	0.131	0.024	0.131	15
35.423	145.91	15.33	0.67	24.62	25.28	0.09	174.71	5.47	1.954	1.272	0.145	0.028	0.145	15
33.660	201.93	17.76	0.76	32.92	33.68	0.09	174.82	5.47	1.955	1.272	0.193	0.045	0.193	15
33.010	223.84	20.94	0.90	36.49	37.39	0.09	174.78	5.47	1.955	1.272	0.214	0.054	0.214	15
31.945	260.40	35.63	1.53	42.45	43.98	0.09	174.47	5.47	1.953	1.272	0.252	0.073	0.252	11
31.835	264.75	41.82	1.69	43.10	44.79	0.09	174.38	5.47	1.953	1.272	0.257	0.075	0.257	11

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```
31.725 269.12 43.25  1.91 46.78 48.69  0.09 174.34   5.47 1.953 1.272 0.279 0.088 0.279
11
31.510 277.76 44.96  1.93 45.28 47.21  0.09 174.29   5.47 1.953 1.272 0.271 0.083 0.271
11
31.006 298.22 49.72  2.13 48.61 50.74  0.09 174.26   5.47 1.952 1.272 0.291 0.095 0.291
11
30.910 302.15 50.87  2.18 49.25 51.44  0.09 199.09   5.70 1.937 1.270 0.258 0.078 0.258
11
30.865 304.00 51.13  2.19 49.55 51.75  0.09 199.09   5.70 1.937 1.270 0.260 0.078 0.260
11
30.560 316.88 57.41  0.90 21.09 21.99  0.08 212.95 217.27 1.985 2.000 0.103 0.011 0.103
11

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]   [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Buckling Summary Per EN 1993-1-6:2007, Load # 9
Load Combination #9 A: 0.9*D 0 Deg (Corroded), FS = 1.1

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	0.00	0.69	0.12	0.00	0.12	0.03	130.79	31.32	1.976	1.424	0.001	0.000	0.001
42.060	0.00	1.85	0.31	0.00	0.31	0.03	130.79	31.32	1.976	1.424	0.002	0.000	0.002
42.027	0.00	2.33	0.33	0.00	0.33	0.03	178.95	46.59	1.971	1.438	0.002	0.000	0.002
41.945	0.00	2.90	0.42	0.00	0.42	0.03	178.95	46.59	1.971	1.438	0.002	0.000	0.002
41.817	0.00	3.01	0.43	0.00	0.43	0.03	178.95	46.59	1.971	1.438	0.002	0.000	0.002
41.688	0.00	3.15	0.38	0.00	0.38	0.03	175.79	32.93	1.959	1.383	0.002	0.000	0.002
41.560	0.00	3.29	0.34	0.00	0.34	0.04	172.76	24.52	1.946	1.349	0.002	0.000	0.002
40.960	0.00	3.75	0.34	0.00	0.34	0.04	169.82	18.98	1.935	1.327	0.002	0.000	0.002
38.960	0.00	8.23	0.75	0.00	0.75	0.04	169.82	18.98	1.935	1.327	0.004	0.000	0.004
37.016	0.00	10.57	0.96	0.00	0.96	0.04	169.82	18.98	1.935	1.327	0.006	0.000	0.006
36.683	0.00	11.90	1.08	0.00	1.08	0.04	169.82	18.98	1.935	1.327	0.006	0.000	0.006
36.349	0.00	12.47	0.82	0.00	0.82	0.06	161.35	10.34	1.900	1.292	0.006	0.001	0.006
36.016	0.00	13.03	0.68	0.00	0.68	0.07	153.32	6.85	1.868	1.278	0.011	0.003	0.011
35.697	0.00	13.68	0.59	0.00	0.59	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
35.560	0.00	14.20	0.55	0.00	0.55	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
35.423	0.00	14.80	0.64	0.00	0.64	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
33.660	0.00	16.99	0.73	0.00	0.73	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
33.010	0.00	19.85	0.85	0.00	0.85	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
31.945	0.00	22.05	0.95	0.00	0.95	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
31.835	0.00	23.56	0.95	0.00	0.95	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
31.725	0.00	24.02	1.06	0.00	1.06	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
31.510	0.00	24.44	1.05	0.00	1.05	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
31.006	0.00	27.13	1.16	0.00	1.16	0.09	145.56	5.47	1.837	1.272	0.016	0.005	0.016
30.910	0.00	27.90	1.20	0.00	1.20	0.09	165.11	5.70	1.820	1.270	0.015	0.005	0.015
30.865	0.00	28.07	1.20	0.00	1.20	0.09	165.11	5.70	1.820	1.270	0.015	0.005	0.015

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30.560 0.00 32.26 0.51 0.00 0.51 0.08 197.44 217.27 1.932 2.000 0.003 0.000 0.003

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Load # 9
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 32.26 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 150172.90 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 9
Load Combination #9 A: 0.9*D 0 Deg (Corroded), FS = 1.1

Bot Elev m	w m	l	Cxb	Cx	Dwk mm	ax	Fyk MPa	Lxo	Lpx	Lx	Xx	s_xRcr MPa	s_xRk MPa	s_xRd MPa
44.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	130.79
42.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	130.79
42.027	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.945	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.817	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.688	289.4	10.6275	1.0	0.60	2.3	0.448	204.66	0.200	1.059	0.279	0.945	2629.83	193.37	175.79
41.560	268.8	10.6275	1.0	0.60	2.5	0.435	204.66	0.200	1.042	0.300	0.929	2268.27	190.03	172.76
40.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
38.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
37.016	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
36.683	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
36.349	215.6	10.6275	1.0	0.60	3.1	0.391	204.66	0.200	0.989	0.375	0.867	1459.11	177.49	161.35

```
36.016 191.4 10.6275 1.0 0.60 3.5 0.366 204.66 0.200 0.956 0.422 0.824 1150.45 168.65
153.32
35.697 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
35.560 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
35.423 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
33.660 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
33.010 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.945 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.835 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.725 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.510 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.006 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
30.910 173.9 10.6275 1.0 0.60 3.8 0.345 239.00 0.200 0.928 0.491 0.760  989.40 181.62
165.11
30.865 173.9 10.6275 1.0 0.60 3.8 0.345 239.00 0.200 0.928 0.491 0.760  989.40 181.62
165.11
30.560   2.1  0.1525 1.0 1.00 4.6 0.383 239.00 0.200 0.979 0.319 0.909 2355.72 217.18
197.44

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 9
Load Combination #9 A: 0.9*D 0 Deg (Corroded), FS = 1.1

Bot Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	31.32
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	31.32
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	46.59
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	32.93
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	24.52
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	18.98
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	18.98

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37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	18.98
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	18.98
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	10.34
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	6.85
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	5.47
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	5.47
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	5.47
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	5.47
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	5.47
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	5.47
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	5.47
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	5.47
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	5.47
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	5.47
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	5.70
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	5.70
30.560	1.00	2.11	0.500	0.257	1.118	0.818	1.755	1.435	1.0000	0.08	3620.51	239.00	217.27

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 10
Load Combination #10 A: 1.1*D+1.5*W+0.9*L+0.9*O 0 Deg (Corroded), FS = 1.1

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	5.62	0.85	0.14	12.02	12.17	0.03	130.79	31.32	1.976	1.424	0.093	0.009	0.093
42.060	15.58	2.26	0.38	33.34	33.72	0.03	130.79	31.32	1.976	1.424	0.258	0.069	0.258
42.027	15.79	2.85	0.41	29.23	29.64	0.03	178.95	46.59	1.971	1.438	0.166	0.029	0.166
41.945	16.32	3.54	0.51	30.22	30.73	0.03	178.95	46.59	1.971	1.438	0.172	0.031	0.172
41.817	17.26	3.67	0.53	31.96	32.49	0.03	178.95	46.59	1.971	1.438	0.182	0.035	0.182
41.688	18.32	3.85	0.46	23.72	24.18	0.03	175.79	32.93	1.959	1.383	0.138	0.021	0.138
41.560	19.50	4.02	0.42	18.64	19.06	0.04	172.76	24.52	1.946	1.349	0.110	0.014	0.110
40.960	26.56	4.58	0.42	19.51	19.93	0.04	169.82	18.98	1.935	1.327	0.117	0.016	0.117
38.960	57.32	22.07	2.00	42.11	44.11	0.04	169.82	18.98	1.935	1.327	0.260	0.074	0.260
37.016	91.48	24.92	2.26	67.20	69.46	0.04	169.82	18.98	1.935	1.327	0.409	0.178	0.409
36.683	97.60	26.55	2.41	71.70	74.11	0.04	169.82	18.98	1.935	1.327	0.436	0.201	0.436
36.349	103.81	27.24	1.80	40.38	42.18	0.06	186.06	10.34	2.000	1.292	0.227	0.053	0.227
36.016	110.13	27.93	1.45	26.46	27.91	0.07	180.09	6.85	1.976	1.278	0.155	0.028	0.155
35.697	116.33	28.72	1.23	18.96	20.19	0.09	173.71	5.47	1.950	1.272	0.116	0.020	0.116
35.560	119.02	29.36	1.13	19.27	20.41	0.09	173.87	5.47	1.951	1.272	0.117	0.021	0.117
35.423	130.86	17.09	0.74	22.08	22.82	0.09	174.53	5.47	1.954	1.272	0.131	0.024	0.131
33.660	194.41	19.76	0.85	31.69	32.54	0.09	174.72	5.47	1.954	1.272	0.186	0.043	0.186
33.010	218.93	23.25	1.00	35.69	36.68	0.09	174.68	5.47	1.954	1.272	0.210	0.053	0.210
31.945	260.40	29.51	1.27	42.45	43.71	0.09	174.63	5.47	1.954	1.272	0.250	0.072	0.250
31.835	264.75	35.28	1.42	43.10	44.52	0.09	174.55	5.47	1.954	1.272	0.255	0.075	0.255

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```
31.725 269.12 36.58  1.62 46.78 48.40  0.09 174.51   5.47 1.953 1.272 0.277 0.087 0.277
31.510 277.76 38.18  1.64 45.28 46.91  0.09 174.46   5.47 1.953 1.272 0.269 0.082 0.269
31.006 298.22 42.18  1.81 48.61 50.42  0.09 174.43   5.47 1.953 1.272 0.289 0.094 0.289
30.910 302.15 43.12  1.85 49.25 51.10  0.09 199.30   5.70 1.938 1.270 0.256 0.076 0.256
30.865 304.00 43.34  1.86 49.55 51.41  0.09 199.31   5.70 1.938 1.270 0.258 0.077 0.258
30.560 316.88 48.45  0.76 21.09 21.85  0.08 213.07 217.27 1.985 2.000 0.103 0.011 0.103

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Load # 10
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]              = 48.45 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]     = 150172.90
KN
Nratio   = Nb / Ncrit   [5.5]                                             = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 10
Load Combination #10 A: 1.1*D+1.5*W+0.9*L+0.9*O 0 Deg (Corroded), FS = 1.1

```
  Bot     w       l     Cxb  Cx  Dwk   ax     Fyk    Lxo    Lpx    Lx     Xx  s_xRcr  s_xRk
s_xRd
 Elev
  m              m              mm           MPa                            MPa     MPa
MPa
------ ------ -------- --- ---- --- ----- ------ ----- ----- ----- ----- ------- ------ ---
---
44.060 341.0 10.6275 1.0 0.60 1.9 0.450 148.65 0.200 1.061 0.246 0.968 2453.13 143.87
130.79
42.060 341.0 10.6275 1.0 0.60 1.9 0.450 148.65 0.200 1.061 0.246 0.968 2453.13 143.87
130.79
42.027 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.945 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.817 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.688 289.4 10.6275 1.0 0.60 2.3 0.448 204.66 0.200 1.059 0.279 0.945 2629.83 193.37
175.79
41.560 268.8 10.6275 1.0 0.60 2.5 0.435 204.66 0.200 1.042 0.300 0.929 2268.27 190.03
172.76
40.960 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
38.960 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
```

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37.016 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.683 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.349 215.6 10.6275 1.0 0.98 3.1 0.391 204.66 0.296 0.989 0.293 1.000 2390.29 204.66
186.06
36.016 191.4 10.6275 1.0 0.98 3.5 0.366 204.66 0.295 0.956 0.330 0.968 1877.48 198.10
180.09
35.697 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.294 0.928 0.364 0.934 1544.00 191.08
173.71
35.560 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.294 0.928 0.364 0.934 1547.44 191.25
173.87
35.423 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1562.06 191.99
174.53
33.660 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.361 0.939 1566.14 192.19
174.72
33.010 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.939 1565.42 192.15
174.68
31.945 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.939 1564.30 192.10
174.63
31.835 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1562.42 192.00
174.55
31.725 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1561.48 191.96
174.51
31.510 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1560.53 191.91
174.46
31.006 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.296 0.928 0.362 0.938 1559.91 191.88
174.43
30.910 173.9 10.6275 1.0 0.99 3.8 0.345 239.00 0.296 0.928 0.383 0.917 1625.12 219.23
199.30
30.865 173.9 10.6275 1.0 0.99 3.8 0.345 239.00 0.296 0.928 0.383 0.917 1625.15 219.24
199.31
30.560   2.1  0.1525 1.0 1.00 4.6 0.383 239.00 0.297 0.979 0.319 0.981 2355.72 234.38
213.07

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 10
Load Combination #10 A: 1.1*D+1.5*W+0.9*L+0.9*O 0 Deg (Corroded), FS = 1.1

Bot Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd	s_qRcr MPa	s_qRk MPa	s_qRd MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	31.32
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	31.32
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59

41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	46.59
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	32.93
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	24.52
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	18.98
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	18.98
37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	18.98
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	18.98
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	10.34
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	6.85
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	5.47
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	5.47
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	5.47
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	5.47
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	5.47
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	5.47
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	5.47
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	5.47
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	5.47
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	5.47
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	5.70
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	5.70
30.560	1.00	2.11	0.500	0.257	1.118	0.818	1.755	1.435	1.0000	0.08	3620.51	239.00	217.27

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 11
Load Combination #11 B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg (Corroded), FS = 1.1

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	5.62	1.04	0.17	12.02	12.20	0.03	130.79	31.32	1.976	1.424	0.093	0.009	0.093
42.060	15.58	2.78	0.46	33.34	33.80	0.03	130.79	31.32	1.976	1.424	0.258	0.069	0.258
42.027	15.79	3.50	0.50	29.23	29.73	0.03	178.95	46.59	1.971	1.438	0.166	0.029	0.166
41.945	16.32	4.34	0.62	30.22	30.85	0.03	178.95	46.59	1.971	1.438	0.172	0.031	0.172
41.817	17.26	4.51	0.65	31.96	32.61	0.03	178.95	46.59	1.971	1.438	0.182	0.035	0.182
41.688	18.32	4.72	0.57	23.72	24.28	0.03	175.79	32.93	1.959	1.383	0.138	0.021	0.138
41.560	19.50	4.94	0.51	18.64	19.15	0.04	172.76	24.52	1.946	1.349	0.111	0.014	0.111
40.960	26.56	5.62	0.51	19.51	20.02	0.04	169.82	18.98	1.935	1.327	0.118	0.016	0.118
38.960	57.32	24.35	2.21	42.11	44.32	0.04	169.82	18.98	1.935	1.327	0.261	0.075	0.261
37.016	91.48	27.85	2.53	67.20	69.73	0.04	169.82	18.98	1.935	1.327	0.411	0.179	0.411
36.683	97.60	29.86	2.71	71.70	74.41	0.04	169.82	18.98	1.935	1.327	0.438	0.203	0.438
36.349	103.81	30.70	2.03	40.38	42.41	0.06	186.06	10.34	2.000	1.292	0.228	0.053	0.228
36.016	110.13	31.55	1.64	26.46	28.10	0.07	179.91	6.85	1.975	1.278	0.156	0.029	0.156
35.697	116.33	32.52	1.40	18.96	20.36	0.09	173.49	5.47	1.949	1.272	0.117	0.021	0.117

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35.560 119.02 33.31  1.29 19.27 20.56  0.09 173.66   5.47 1.950 1.272 0.118 0.021 0.118
35.423 130.86 21.20  0.92 22.08 23.00  0.09 174.32   5.47 1.953 1.272 0.132 0.024 0.132
33.660 194.41 24.48  1.05 31.69 32.74  0.09 174.54   5.47 1.954 1.272 0.188 0.043 0.188
33.010 218.93 28.77  1.23 35.69 36.92  0.09 174.51   5.47 1.953 1.272 0.212 0.053 0.212
31.945 260.40 35.63  1.53 42.45 43.98  0.09 174.47   5.47 1.953 1.272 0.252 0.073 0.252
31.835 264.75 41.82  1.69 43.10 44.79  0.09 174.38   5.47 1.953 1.272 0.257 0.075 0.257
31.725 269.12 43.25  1.91 46.78 48.69  0.09 174.34   5.47 1.953 1.272 0.279 0.088 0.279
31.510 277.76 44.96  1.93 45.28 47.21  0.09 174.29   5.47 1.953 1.272 0.271 0.083 0.271
31.006 298.22 49.72  2.13 48.61 50.74  0.09 174.26   5.47 1.952 1.272 0.291 0.095 0.291
30.910 302.15 50.87  2.18 49.25 51.44  0.09 199.09   5.70 1.937 1.270 0.258 0.078 0.258
30.865 304.00 51.13  2.19 49.55 51.75  0.09 199.09   5.70 1.937 1.270 0.260 0.078 0.260
30.560 316.88 57.41  0.90 21.09 21.99  0.08 212.95 217.27 1.985 2.000 0.103 0.011 0.103

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Load # 11
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 57.41 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 150172.90
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 11
Load Combination #11 B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg (Corroded), FS = 1.1

```
  Bot     w       l     Cxb  Cx  Dwk    ax     Fyk    Lxo    Lpx     Lx     Xx  s_xRcr  s_xRk
s_xRd
 Elev
  m              m              mm           MPa                              MPa     MPa
MPa
------ ----- -------- --- ---- --- ----- ------ ----- ----- ----- ----- ------- ------ ---
---
44.060 341.0 10.6275 1.0 0.60 1.9 0.450 148.65 0.200 1.061 0.246 0.968 2453.13 143.87
130.79
42.060 341.0 10.6275 1.0 0.60 1.9 0.450 148.65 0.200 1.061 0.246 0.968 2453.13 143.87
130.79
42.027 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.945 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.817 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.688 289.4 10.6275 1.0 0.60 2.3 0.448 204.66 0.200 1.059 0.279 0.945 2629.83 193.37
175.79
```

```
41.560 268.8 10.6275 1.0 0.60 2.5 0.435 204.66 0.200 1.042 0.300 0.929 2268.27 190.03
172.76
40.960 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
38.960 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
37.016 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.683 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.349 215.6 10.6275 1.0 0.98 3.1 0.391 204.66 0.295 0.989 0.293 1.000 2385.26 204.66
186.06
36.016 191.4 10.6275 1.0 0.98 3.5 0.366 204.66 0.294 0.956 0.331 0.967 1872.60 197.90
179.91
35.697 173.9 10.6275 1.0 0.97 3.8 0.345 204.66 0.293 0.928 0.365 0.932 1539.24 190.84
173.49
35.560 173.9 10.6275 1.0 0.97 3.8 0.345 204.66 0.294 0.928 0.364 0.933 1543.00 191.03
173.66
35.423 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.296 0.928 0.363 0.937 1557.31 191.75
174.32
33.660 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1562.33 192.00
174.54
33.010 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1561.47 191.96
174.51
31.945 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1560.63 191.91
174.47
31.835 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.296 0.928 0.362 0.937 1558.81 191.82
174.38
31.725 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.296 0.928 0.362 0.937 1557.77 191.77
174.34
31.510 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.296 0.928 0.363 0.937 1556.76 191.72
174.29
31.006 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.296 0.928 0.363 0.937 1556.02 191.68
174.26
30.910 173.9 10.6275 1.0 0.98 3.8 0.345 239.00 0.296 0.928 0.384 0.916 1621.01 219.00
199.09
30.865 173.9 10.6275 1.0 0.98 3.8 0.345 239.00 0.296 0.928 0.384 0.916 1621.04 219.00
199.09
30.560   2.1  0.1525 1.0 1.00 4.6 0.383 239.00 0.296 0.979 0.319 0.980 2355.72 234.25
212.95

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 11
Load Combination #11 B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg (Corroded), FS = 1.1

Bot	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max	qeq	Xq	f_qEd	s_qRcr	s_qRk	s_qRd

Elev m							kPa	kPa		MPa	MPa	MPa	MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	31.32
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	31.32
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	46.59
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	32.93
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	24.52
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	18.98
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	18.98
37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	18.98
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	18.98
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	10.34
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	6.85
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	5.47
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	5.47
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	5.47
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	5.47
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	5.47
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	5.47
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	5.47
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	5.47
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	5.47
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	5.47
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	5.70
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	5.70
30.560	1.00	2.11	0.500	0.257	1.118	0.818	1.755	1.435	1.0000	0.08	3620.51	239.00	217.27

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 12
Load Combination #12 B: 1.0*D 0 Deg (Corroded), FS = 1.1

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	0.00	0.77	0.13	0.00	0.13	0.03	130.79	31.32	1.976	1.424	0.001	0.000	0.001
42.060	0.00	2.06	0.34	0.00	0.34	0.03	130.79	31.32	1.976	1.424	0.003	0.000	0.003
42.027	0.00	2.59	0.37	0.00	0.37	0.03	178.95	46.59	1.971	1.438	0.002	0.000	0.002
41.945	0.00	3.22	0.46	0.00	0.46	0.03	178.95	46.59	1.971	1.438	0.003	0.000	0.003
41.817	0.00	3.34	0.48	0.00	0.48	0.03	178.95	46.59	1.971	1.438	0.003	0.000	0.003
41.688	0.00	3.50	0.42	0.00	0.42	0.03	175.79	32.93	1.959	1.383	0.002	0.000	0.002
41.560	0.00	3.66	0.38	0.00	0.38	0.04	172.76	24.52	1.946	1.349	0.002	0.000	0.002
40.960	0.00	4.17	0.38	0.00	0.38	0.04	169.82	18.98	1.935	1.327	0.002	0.000	0.002

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38.960   0.00  9.15  0.83  0.00  0.83  0.04 169.82  18.98 1.935 1.327 0.005 0.000 0.005
37.016   0.00 11.74  1.07  0.00  1.07  0.04 169.82  18.98 1.935 1.327 0.006 0.000 0.006
36.683   0.00 13.22  1.20  0.00  1.20  0.04 169.82  18.98 1.935 1.327 0.007 0.000 0.007
36.349   0.00 13.85  0.92  0.00  0.92  0.06 161.35  10.34 1.900 1.292 0.006 0.001 0.006
36.016   0.00 14.48  0.75  0.00  0.75  0.07 153.32   6.85 1.868 1.278 0.011 0.003 0.011
35.697   0.00 15.20  0.65  0.00  0.65  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
35.560   0.00 15.78  0.61  0.00  0.61  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
35.423   0.00 16.45  0.71  0.00  0.71  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
33.660   0.00 18.88  0.81  0.00  0.81  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
33.010   0.00 22.05  0.95  0.00  0.95  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
31.945   0.00 24.50  1.05  0.00  1.05  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
31.835   0.00 26.17  1.06  0.00  1.06  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
31.725   0.00 26.69  1.18  0.00  1.18  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
31.510   0.00 27.15  1.17  0.00  1.17  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
31.006   0.00 30.14  1.29  0.00  1.29  0.09 145.56   5.47 1.837 1.272 0.016 0.005 0.016
30.910   0.00 30.99  1.33  0.00  1.33  0.09 165.11   5.70 1.820 1.270 0.015 0.005 0.015
30.865   0.00 31.19  1.34  0.00  1.34  0.09 165.11   5.70 1.820 1.270 0.015 0.005 0.015
30.560   0.00 35.84  0.56  0.00  0.56  0.08 197.44 217.27 1.932 2.000 0.003 0.000 0.003

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]   [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Load # 12
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 35.84 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 150172.90
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 12
Load Combination #12 B: 1.0*D 0 Deg (Corroded), FS = 1.1

```
  Bot     w       l     Cxb  Cx  Dwk    ax     Fyk    Lxo    Lpx     Lx     Xx  s_xRcr  s_xRk
s_xRd
 Elev
  m              m              mm           MPa                              MPa     MPa
MPa
------ ----- -------- --- ---- --- ----- ------ ----- ----- ----- ----- ------- ------ ---
---
44.060 341.0 10.6275 1.0 0.60 1.9 0.450 148.65 0.200 1.061 0.246 0.968 2453.13 143.87
130.79
42.060 341.0 10.6275 1.0 0.60 1.9 0.450 148.65 0.200 1.061 0.246 0.968 2453.13 143.87
130.79
42.027 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
```

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41.945 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.817 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.688 289.4 10.6275 1.0 0.60 2.3 0.448 204.66 0.200 1.059 0.279 0.945 2629.83 193.37
175.79
41.560 268.8 10.6275 1.0 0.60 2.5 0.435 204.66 0.200 1.042 0.300 0.929 2268.27 190.03
172.76
40.960 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
38.960 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
37.016 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.683 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.349 215.6 10.6275 1.0 0.60 3.1 0.391 204.66 0.200 0.989 0.375 0.867 1459.11 177.49
161.35
36.016 191.4 10.6275 1.0 0.60 3.5 0.366 204.66 0.200 0.956 0.422 0.824 1150.45 168.65
153.32
35.697 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
35.560 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
35.423 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
33.660 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
33.010 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.945 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.835 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.725 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.510 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
31.006 173.9 10.6275 1.0 0.60 3.8 0.345 204.66 0.200 0.928 0.464 0.782  949.58 160.12
145.56
30.910 173.9 10.6275 1.0 0.60 3.8 0.345 239.00 0.200 0.928 0.491 0.760  989.40 181.62
165.11
30.865 173.9 10.6275 1.0 0.60 3.8 0.345 239.00 0.200 0.928 0.491 0.760  989.40 181.62
165.11
30.560   2.1  0.1525 1.0 1.00 4.6 0.383 239.00 0.200 0.979 0.319 0.909 2355.72 217.18
197.44

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

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Circumferential Buckling Per EN 1993-1-6:2007, Load # 12
Load Combination #12 B: 1.0*D 0 Deg (Corroded), FS = 1.1

Bot Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	31.32
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	31.32
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	46.59
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	32.93
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	24.52
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	18.98
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	18.98
37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	18.98
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	18.98
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	10.34
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	6.85
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	5.47
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	5.47
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	5.47
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	5.47
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	5.47
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	5.47
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	5.47
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	5.47
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	5.47
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	5.47
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	5.70
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	5.70
30.560	1.00	2.11	0.500	0.257	1.118	0.818	1.755	1.435	1.0000	0.08	3620.51	239.00	217.27

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 13
Load Combination #13 C: 1.0*D+1.3*W+0.78*L+0.78*O 0 Deg (Corroded), FS = 1.1

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	4.87	0.77	0.13	10.42	10.55	0.03	130.79	31.32	1.976	1.424	0.081	0.007	0.081

```
42.060  13.50  2.06  0.34 28.90 29.24  0.03 130.79  31.32 1.976 1.424 0.224 0.052 0.224
42.027  13.68  2.59  0.37 25.33 25.70  0.03 178.95  46.59 1.971 1.438 0.144 0.022 0.144
41.945  14.15  3.22  0.46 26.19 26.66  0.03 178.95  46.59 1.971 1.438 0.149 0.023 0.149
41.817  14.96  3.34  0.48 27.70 28.18  0.03 178.95  46.59 1.971 1.438 0.157 0.026 0.157
41.688  15.87  3.50  0.42 20.55 20.97  0.03 175.79  32.93 1.959 1.383 0.119 0.016 0.119
41.560  16.90  3.66  0.38 16.15 16.53  0.04 172.76  24.52 1.946 1.349 0.096 0.011 0.096
40.960  23.02  4.17  0.38 16.91 17.29  0.04 169.82  18.98 1.935 1.327 0.102 0.012 0.102
38.960  49.68 19.55  1.77 36.50 38.27  0.04 169.82  18.98 1.935 1.327 0.225 0.056 0.225
37.016  79.28 22.14  2.01 58.24 60.25  0.04 169.82  18.98 1.935 1.327 0.355 0.135 0.355
36.683  84.58 23.63  2.14 62.14 64.28  0.04 169.82  18.98 1.935 1.327 0.379 0.153 0.379
36.349  89.96 24.26  1.60 34.99 36.60  0.06 186.06  10.34 2.000 1.292 0.197 0.040 0.197
36.016  95.45 24.88  1.30 22.93 24.23  0.07 180.05   6.85 1.976 1.278 0.135 0.022 0.135
35.697 100.82 25.60  1.10 16.43 17.53  0.09 173.66   5.47 1.950 1.272 0.101 0.017 0.101
35.560 103.15 26.19  1.01 16.70 17.72  0.09 173.82   5.47 1.951 1.272 0.102 0.017 0.102
35.423 113.41 15.58  0.68 19.13 19.81  0.09 174.49   5.47 1.953 1.272 0.114 0.020 0.114
33.660 168.49 18.00  0.77 27.46 28.24  0.09 174.68   5.47 1.954 1.272 0.162 0.034 0.162
33.010 189.74 21.18  0.91 30.93 31.84  0.09 174.65   5.47 1.954 1.272 0.182 0.041 0.182
31.945 225.68 26.72  1.15 36.79 37.93  0.09 174.60   5.47 1.954 1.272 0.217 0.056 0.217
31.835 229.45 31.80  1.28 37.35 38.64  0.09 174.51   5.47 1.953 1.272 0.221 0.058 0.221
31.725 233.24 32.95  1.46 40.54 42.00  0.09 174.47   5.47 1.953 1.272 0.241 0.067 0.241
31.510 240.73 34.35  1.47 39.24 40.71  0.09 174.43   5.47 1.953 1.272 0.233 0.064 0.233
31.006 258.46 37.96  1.63 42.13 43.76  0.09 174.40   5.47 1.953 1.272 0.251 0.072 0.251
30.910 261.87 38.82  1.67 42.69 44.35  0.09 199.26   5.70 1.938 1.270 0.223 0.059 0.223
30.865 263.47 39.01  1.67 42.95 44.62  0.09 199.26   5.70 1.938 1.270 0.224 0.060 0.224
30.560 274.63 43.67  0.68 18.28 18.96  0.08 213.04 217.27 1.985 2.000 0.089 0.008 0.089

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Load # 13
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 43.67 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 150172.90
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 13
Load Combination #13 C: 1.0*D+1.3*W+0.78*L+0.78*O 0 Deg (Corroded), FS = 1.1

```
  Bot     w       l     Cxb  Cx  Dwk    ax     Fyk    Lxo    Lpx     Lx     Xx  s_xRcr  s_xRk
s_xRd
 Elev
  m              m              mm           MPa                              MPa     MPa
MPa
------ ----- ------- --- ---- --- ----- ------ ----- ----- ----- ----- ------- ------ ---
---
```

```
44.060 341.0 10.6275 1.0 0.60 1.9 0.450 148.65 0.200 1.061 0.246 0.968 2453.13 143.87
130.79
42.060 341.0 10.6275 1.0 0.60 1.9 0.450 148.65 0.200 1.061 0.246 0.968 2453.13 143.87
130.79
42.027 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.945 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.817 315.7 10.6275 1.0 0.60 2.1 0.463 204.66 0.200 1.076 0.256 0.962 3128.51 196.85
178.95
41.688 289.4 10.6275 1.0 0.60 2.3 0.448 204.66 0.200 1.059 0.279 0.945 2629.83 193.37
175.79
41.560 268.8 10.6275 1.0 0.60 2.5 0.435 204.66 0.200 1.042 0.300 0.929 2268.27 190.03
172.76
40.960 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
38.960 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
37.016 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.683 252.0 10.6275 1.0 0.60 2.6 0.422 204.66 0.200 1.028 0.320 0.913 1994.12 186.80
169.82
36.349 215.6 10.6275 1.0 0.98 3.1 0.391 204.66 0.296 0.989 0.293 1.000 2389.20 204.66
186.06
36.016 191.4 10.6275 1.0 0.98 3.5 0.366 204.66 0.295 0.956 0.330 0.968 1876.42 198.05
180.05
35.697 173.9 10.6275 1.0 0.97 3.8 0.345 204.66 0.294 0.928 0.364 0.933 1542.97 191.03
173.66
35.560 173.9 10.6275 1.0 0.98 3.8 0.345 204.66 0.294 0.928 0.364 0.934 1546.47 191.21
173.82
35.423 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1561.03 191.93
174.49
33.660 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.939 1565.32 192.15
174.68
33.010 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.939 1564.57 192.11
174.65
31.945 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1563.51 192.06
174.60
31.835 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1561.63 191.96
174.51
31.725 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.297 0.928 0.362 0.938 1560.68 191.92
174.47
31.510 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.296 0.928 0.362 0.937 1559.72 191.87
174.43
31.006 173.9 10.6275 1.0 0.99 3.8 0.345 204.66 0.296 0.928 0.362 0.937 1559.07 191.84
174.40
30.910 173.9 10.6275 1.0 0.98 3.8 0.345 239.00 0.296 0.928 0.384 0.917 1624.23 219.18
199.26
30.865 173.9 10.6275 1.0 0.98 3.8 0.345 239.00 0.296 0.928 0.384 0.917 1624.26 219.19
199.26
30.560   2.1  0.1525 1.0 1.00 4.6 0.383 239.00 0.296 0.979 0.319 0.981 2355.72 234.35
213.04

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
```

```
   Lpx   = (ax / (1-B))^0.5  [8.16]          Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17] s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                  s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]    fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 13
Load Combination #13 C: 1.0*D+1.3*W+0.78*L+0.78*O 0 Deg (Corroded), FS = 1.1

Bot Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	31.32
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	31.32
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	46.59
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	32.93
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	24.52
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	18.98
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	18.98
37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	18.98
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	18.98
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	10.34
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	6.85
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	5.47
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	5.47
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	5.47
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	5.47
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	5.47
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	5.47
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	5.47
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	5.47
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	5.47
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	5.47
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	5.70
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	5.70
30.560	1.00	2.11	0.500	0.257	1.118	0.818	1.755	1.435	1.0000	0.08	3620.51	239.00	217.27

```
   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 15
Load Combination #15 1.0*D+1.0*S+1.0*L+1.0*O 0 Deg (Corroded), FS = 1.1

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Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	5.84	0.77	0.13	12.50	12.63	0.03	130.79	31.32	1.976	1.424	0.097	0.010	0.097
42.060	15.79	2.06	0.34	33.79	34.13	0.03	130.79	31.32	1.976	1.424	0.261	0.070	0.261
42.027	16.00	2.59	0.37	29.62	29.99	0.03	178.95	46.59	1.971	1.438	0.168	0.030	0.168
41.945	16.57	3.22	0.46	30.69	31.15	0.03	178.95	46.59	1.971	1.438	0.174	0.032	0.174
41.817	17.54	3.34	0.48	32.47	32.95	0.03	178.95	46.59	1.971	1.438	0.184	0.036	0.184
41.688	18.55	3.50	0.42	24.01	24.43	0.03	175.79	32.93	1.959	1.383	0.139	0.021	0.139
41.560	19.59	3.66	0.38	18.73	19.10	0.04	172.76	24.52	1.946	1.349	0.111	0.014	0.111
40.960	25.86	4.17	0.38	19.00	19.38	0.04	169.82	18.98	1.935	1.327	0.114	0.015	0.114
38.960	58.10	22.49	2.04	42.68	44.73	0.04	169.82	18.98	1.935	1.327	0.263	0.076	0.263
37.016	99.06	25.08	2.28	72.77	75.05	0.04	169.82	18.98	1.935	1.327	0.442	0.206	0.442
36.683	106.68	26.56	2.41	78.37	80.78	0.04	169.82	18.98	1.935	1.327	0.476	0.238	0.476
36.349	114.52	27.19	1.80	44.54	46.34	0.06	186.06	10.34	2.000	1.292	0.249	0.063	0.249
36.016	122.56	27.82	1.45	29.45	30.89	0.07	180.23	6.85	1.977	1.278	0.171	0.034	0.171
35.697	130.47	28.54	1.22	21.27	22.49	0.09	173.90	5.47	1.951	1.272	0.129	0.024	0.129
35.560	133.51	29.12	1.13	21.62	22.75	0.09	174.04	5.47	1.952	1.272	0.131	0.024	0.131
35.423	145.91	15.33	0.67	24.62	25.28	0.09	174.71	5.47	1.954	1.272	0.145	0.028	0.145
33.660	201.93	17.76	0.76	32.92	33.68	0.09	174.82	5.47	1.955	1.272	0.193	0.045	0.193
33.010	223.84	20.94	0.90	36.49	37.39	0.09	174.78	5.47	1.955	1.272	0.214	0.054	0.214
31.945	262.10	27.34	1.17	42.72	43.90	0.09	174.70	5.47	1.954	1.272	0.251	0.072	0.251
31.835	266.24	33.38	1.35	43.34	44.69	0.09	174.60	5.47	1.954	1.272	0.256	0.075	0.256
31.725	270.41	34.71	1.54	47.01	48.54	0.09	174.56	5.47	1.954	1.272	0.278	0.087	0.278
31.510	278.70	36.38	1.56	45.43	46.99	0.09	174.51	5.47	1.953	1.272	0.269	0.082	0.269
31.006	298.31	40.17	1.72	48.63	50.35	0.09	174.48	5.47	1.953	1.272	0.289	0.093	0.289
30.910	302.06	41.03	1.76	49.24	51.00	0.09	199.36	5.70	1.938	1.270	0.256	0.076	0.256
30.865	303.82	41.22	1.77	49.52	51.29	0.09	199.36	5.70	1.938	1.270	0.257	0.077	0.257
30.560	315.76	45.87	0.72	21.01	21.73	0.08	213.10	217.27	1.986	2.000	0.102	0.011	0.102

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Load # 15
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 45.87 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 150172.90 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 15
Load Combination #15 1.0*D+1.0*S+1.0*L+1.0*O 0 Deg (Corroded), FS = 1.1

Bot	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd

Elev m	m	mm	MPa					MPa	MPa	MPa
44.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	130.79
42.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	130.79
42.027	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.945	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.817	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.688	289.4	10.6275	1.0	0.60	2.3	0.448	204.66	0.200	1.059	0.279	0.945	2629.83	193.37	175.79
41.560	268.8	10.6275	1.0	0.60	2.5	0.435	204.66	0.200	1.042	0.300	0.929	2268.27	190.03	172.76
40.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
38.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
37.016	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
36.683	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
36.349	215.6	10.6275	1.0	0.98	3.1	0.391	204.66	0.296	0.989	0.292	1.000	2394.09	204.66	186.06
36.016	191.4	10.6275	1.0	0.98	3.5	0.366	204.66	0.295	0.956	0.330	0.969	1881.48	198.25	180.23
35.697	173.9	10.6275	1.0	0.98	3.8	0.345	204.66	0.295	0.928	0.364	0.935	1548.17	191.29	173.90
35.560	173.9	10.6275	1.0	0.98	3.8	0.345	204.66	0.295	0.928	0.363	0.935	1551.31	191.45	174.04
35.423	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.939	1565.98	192.18	174.71
33.660	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.298	0.928	0.361	0.940	1568.32	192.30	174.82
33.010	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.298	0.928	0.361	0.939	1567.43	192.25	174.78
31.945	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.939	1565.72	192.17	174.70
31.835	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1563.57	192.06	174.60
31.725	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1562.62	192.01	174.56
31.510	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1561.61	191.96	174.51
31.006	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1560.97	191.93	174.48
30.910	173.9	10.6275	1.0	0.99	3.8	0.345	239.00	0.297	0.928	0.383	0.918	1626.24	219.30	199.36
30.865	173.9	10.6275	1.0	0.99	3.8	0.345	239.00	0.297	0.928	0.383	0.918	1626.26	219.30	199.36
30.560	2.1	0.1525	1.0	1.00	4.6	0.383	239.00	0.297	0.979	0.319	0.981	2355.72	234.41	213.10

```
   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 15
Load Combination #15 1.0*D+1.0*S+1.0*L+1.0*O 0 Deg (Corroded), FS = 1.1

Bot Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	31.32
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	31.32
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	46.59
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	32.93
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	24.52
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	18.98
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	18.98
37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	18.98
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	18.98
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	10.34
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	6.85
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	5.47
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	5.47
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	5.47
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	5.47
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	5.47
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	5.47
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	5.47
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	5.47
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	5.47
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	5.47
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	5.70
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	5.70
30.560	1.00	2.11	0.500	0.257	1.118	0.818	1.755	1.435	1.0000	0.08	3620.51	239.00	217.27

```
   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 16
Load Combination #16 1.0*D+1.0*S 0 Deg (Corroded), FS = 1.1

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	5.84	0.77	0.13	12.50	12.63	0.03	130.79	31.32	1.976	1.424	0.097	0.010	0.097
42.060	15.79	2.06	0.34	33.79	34.13	0.03	130.79	31.32	1.976	1.424	0.261	0.070	0.261
42.027	16.00	2.59	0.37	29.62	29.99	0.03	178.95	46.59	1.971	1.438	0.168	0.030	0.168
41.945	16.57	3.22	0.46	30.69	31.15	0.03	178.95	46.59	1.971	1.438	0.174	0.032	0.174
41.817	17.54	3.34	0.48	32.47	32.95	0.03	178.95	46.59	1.971	1.438	0.184	0.036	0.184
41.688	18.55	3.50	0.42	24.01	24.43	0.03	175.79	32.93	1.959	1.383	0.139	0.021	0.139
41.560	19.59	3.66	0.38	18.73	19.10	0.04	172.76	24.52	1.946	1.349	0.111	0.014	0.111
40.960	25.86	4.17	0.38	19.00	19.38	0.04	169.82	18.98	1.935	1.327	0.114	0.015	0.114
38.960	58.10	9.15	0.83	42.68	43.51	0.04	169.82	18.98	1.935	1.327	0.256	0.072	0.256
37.016	99.06	11.74	1.07	72.77	73.84	0.04	169.82	18.98	1.935	1.327	0.435	0.200	0.435
36.683	106.68	13.22	1.20	78.37	79.57	0.04	169.82	18.98	1.935	1.327	0.469	0.231	0.469
36.349	114.52	13.85	0.92	44.54	45.46	0.06	186.06	10.34	2.000	1.292	0.244	0.061	0.244
36.016	122.56	14.48	0.75	29.45	30.20	0.07	180.83	6.85	1.979	1.278	0.167	0.032	0.167
35.697	130.47	15.20	0.65	21.27	21.92	0.09	174.61	5.47	1.954	1.272	0.126	0.023	0.126
35.560	133.51	15.78	0.61	21.62	22.23	0.09	174.68	5.47	1.954	1.272	0.127	0.023	0.127
35.423	135.78	16.45	0.71	22.91	23.62	0.09	174.60	5.47	1.954	1.272	0.135	0.025	0.135
33.660	162.85	18.88	0.81	26.55	27.35	0.09	174.62	5.47	1.954	1.272	0.157	0.032	0.157
33.010	174.08	22.05	0.95	28.38	29.32	0.09	174.54	5.47	1.954	1.272	0.168	0.036	0.168
31.945	194.85	24.50	1.05	31.76	32.81	0.09	174.55	5.47	1.954	1.272	0.188	0.043	0.188
31.835	197.19	26.17	1.06	32.10	33.16	0.09	174.55	5.47	1.954	1.272	0.190	0.044	0.190
31.725	199.56	26.69	1.18	34.69	35.87	0.09	174.52	5.47	1.953	1.272	0.206	0.051	0.206
31.510	204.32	27.15	1.17	33.30	34.47	0.09	174.49	5.47	1.953	1.272	0.198	0.047	0.198
31.006	215.65	30.14	1.29	35.15	36.45	0.09	174.45	5.47	1.953	1.272	0.209	0.052	0.209
30.910	217.82	30.99	1.33	35.51	36.84	0.09	199.31	5.70	1.938	1.270	0.185	0.043	0.185
30.865	218.84	31.19	1.34	35.67	37.01	0.09	199.31	5.70	1.938	1.270	0.186	0.043	0.186
30.560	225.77	35.84	0.56	15.03	15.59	0.08	213.05	217.27	1.985	2.000	0.073	0.006	0.073

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Load # 16
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 35.84 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 150172.90 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 16
Load Combination #16 1.0*D+1.0*S 0 Deg (Corroded), FS = 1.1

Bot Elev m	w m	l	Cxb	Cx	Dwk mm	ax	Fyk MPa	Lxo	Lpx	Lx	Xx	s_xRcr MPa	s_xRk MPa	s_xRd MPa
44.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	130.79
42.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	130.79
42.027	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.945	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.817	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	178.95
41.688	289.4	10.6275	1.0	0.60	2.3	0.448	204.66	0.200	1.059	0.279	0.945	2629.83	193.37	175.79
41.560	268.8	10.6275	1.0	0.60	2.5	0.435	204.66	0.200	1.042	0.300	0.929	2268.27	190.03	172.76
40.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
38.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
37.016	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
36.683	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	169.82
36.349	215.6	10.6275	1.0	0.99	3.1	0.391	204.66	0.298	0.989	0.291	1.000	2412.24	204.66	186.06
36.016	191.4	10.6275	1.0	0.99	3.5	0.366	204.66	0.298	0.956	0.328	0.972	1898.28	198.91	180.83
35.697	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1563.80	192.07	174.61
35.560	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.939	1565.27	192.15	174.68
35.423	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1563.51	192.06	174.60
33.660	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1563.89	192.08	174.62
33.010	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1562.21	191.99	174.54
31.945	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1562.36	192.00	174.55
31.835	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1562.49	192.01	174.55
31.725	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1561.81	191.97	174.52
31.510	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.938	1561.24	191.94	174.49
31.006	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.296	0.928	0.362	0.938	1560.17	191.89	174.45

```
30.910 173.9 10.6275 1.0 0.99 3.8 0.345 239.00 0.296 0.928 0.383 0.917 1625.19 219.24
199.31
30.865 173.9 10.6275 1.0 0.99 3.8 0.345 239.00 0.296 0.928 0.383 0.917 1625.15 219.24
199.31
30.560   2.1  0.1525 1.0 1.00 4.6 0.383 239.00 0.296 0.979 0.319 0.981 2355.72 234.35
213.05

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 16
Load Combination #16 1.0*D+1.0*S 0 Deg (Corroded), FS = 1.1

Bot Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	31.32
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	31.32
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	46.59
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	46.59
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	32.93
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	24.52
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	18.98
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	18.98
37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	18.98
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	18.98
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	10.34
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	6.85
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	5.47
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	5.47
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	5.47
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	5.47
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	5.47
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	5.47
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	5.47
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	5.47
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	5.47
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	5.47
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	5.70
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	5.70
30.560	1.00	2.11	0.500	0.257	1.118	0.818	1.755	1.435	1.0000	0.08	3620.51	239.00	217.27

```
   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
```

```
   s_qRk = Xq * fyk  [8.12]                          f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 18
Load Combination #18 D+O+P 0 Deg (Corroded), FS = 1

Bot Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
44.060	0.00	0.77	0.13	0.00	0.13	0.03	143.87	34.45	1.976	1.424	0.001	0.000	0.001
42.060	0.00	2.06	0.34	0.00	0.34	0.03	143.87	34.45	1.976	1.424	0.002	0.000	0.002
42.027	0.00	2.59	0.37	0.00	0.37	0.03	196.85	51.25	1.971	1.438	0.002	0.000	0.002
41.945	0.00	3.22	0.46	0.00	0.46	0.03	196.85	51.25	1.971	1.438	0.002	0.000	0.002
41.817	0.00	3.34	0.48	0.00	0.48	0.03	196.85	51.25	1.971	1.438	0.002	0.000	0.002
41.688	0.00	3.50	0.42	0.00	0.42	0.03	193.37	36.23	1.959	1.383	0.002	0.000	0.002
41.560	0.00	3.66	0.38	0.00	0.38	0.04	190.03	26.97	1.946	1.349	0.002	0.000	0.002
40.960	0.00	4.17	0.38	0.00	0.38	0.04	186.80	20.88	1.935	1.327	0.002	0.000	0.002
38.960	0.00	9.15	0.83	0.00	0.83	0.04	186.80	20.88	1.935	1.327	0.004	0.000	0.004
37.016	0.00	11.74	1.07	0.00	1.07	0.04	186.80	20.88	1.935	1.327	0.006	0.000	0.006
36.683	0.00	13.22	1.20	0.00	1.20	0.04	186.80	20.88	1.935	1.327	0.006	0.000	0.006
36.349	0.00	13.85	0.92	0.00	0.92	0.06	177.49	11.38	1.900	1.292	0.005	0.001	0.005
36.016	0.00	14.48	0.75	0.00	0.75	0.07	168.65	7.53	1.868	1.278	0.010	0.003	0.010
35.697	0.00	15.20	0.65	0.00	0.65	0.09	160.12	6.02	1.837	1.272	0.015	0.005	0.015
35.560	0.00	15.78	0.61	0.00	0.61	0.09	160.12	6.02	1.837	1.272	0.015	0.005	0.015
35.423	10.13	1.99	0.09	1.71	1.80	0.09	191.49	6.02	1.952	1.272	0.015	0.005	0.015
33.660	39.09	4.42	0.19	6.37	6.56	0.09	192.10	6.02	1.954	1.272	0.034	0.006	0.034
33.010	49.76	7.60	0.33	8.11	8.44	0.09	191.79	6.02	1.953	1.272	0.044	0.007	0.044
31.945	67.25	14.00	0.60	10.96	11.56	0.09	191.37	6.02	1.951	1.272	0.060	0.009	0.060
31.835	69.05	20.04	0.81	11.24	12.05	0.09	190.89	6.02	1.950	1.272	0.063	0.009	0.063
31.725	70.85	21.37	0.95	12.32	13.26	0.09	190.76	6.02	1.949	1.272	0.070	0.010	0.070
31.510	74.39	23.05	0.99	12.13	13.11	0.09	190.63	6.02	1.949	1.272	0.069	0.010	0.069
31.006	82.66	26.83	1.15	13.47	14.63	0.09	190.52	6.02	1.948	1.272	0.077	0.011	0.077
30.910	84.24	27.69	1.19	13.73	14.92	0.09	217.62	6.27	1.933	1.270	0.069	0.010	0.069
30.865	84.98	27.88	1.20	13.85	15.05	0.09	217.62	6.27	1.933	1.270	0.069	0.010	0.069
30.560	89.99	32.53	0.51	5.99	6.50	0.08	233.49	239.00	1.983	2.000	0.028	0.001	0.028

```
   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]   [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Load # 18
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]              = 32.53 KN
```

Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 150172.90 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 18
Load Combination #18 D+O+P 0 Deg (Corroded), FS = 1

Bot Elev m	w m	l	Cxb	Cx	Dwk mm	ax	Fyk MPa	Lxo	Lpx	Lx	Xx	s_xRcr MPa	s_xRk MPa	s_xRd MPa
44.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	143.87
42.060	341.0	10.6275	1.0	0.60	1.9	0.450	148.65	0.200	1.061	0.246	0.968	2453.13	143.87	143.87
42.027	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	196.85
41.945	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	196.85
41.817	315.7	10.6275	1.0	0.60	2.1	0.463	204.66	0.200	1.076	0.256	0.962	3128.51	196.85	196.85
41.688	289.4	10.6275	1.0	0.60	2.3	0.448	204.66	0.200	1.059	0.279	0.945	2629.83	193.37	193.37
41.560	268.8	10.6275	1.0	0.60	2.5	0.435	204.66	0.200	1.042	0.300	0.929	2268.27	190.03	190.03
40.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	186.80
38.960	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	186.80
37.016	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	186.80
36.683	252.0	10.6275	1.0	0.60	2.6	0.422	204.66	0.200	1.028	0.320	0.913	1994.12	186.80	186.80
36.349	215.6	10.6275	1.0	0.60	3.1	0.391	204.66	0.200	0.989	0.375	0.867	1459.11	177.49	177.49
36.016	191.4	10.6275	1.0	0.60	3.5	0.366	204.66	0.200	0.956	0.422	0.824	1150.45	168.65	168.65
35.697	173.9	10.6275	1.0	0.60	3.8	0.345	204.66	0.200	0.928	0.464	0.782	949.58	160.12	160.12
35.560	173.9	10.6275	1.0	0.60	3.8	0.345	204.66	0.200	0.928	0.464	0.782	949.58	160.12	160.12
35.423	173.9	10.6275	1.0	0.98	3.8	0.345	204.66	0.295	0.928	0.363	0.936	1552.18	191.49	191.49
33.660	173.9	10.6275	1.0	0.99	3.8	0.345	204.66	0.297	0.928	0.362	0.939	1564.34	192.10	192.10
33.010	173.9	10.6275	1.0	0.98	3.8	0.345	204.66	0.296	0.928	0.362	0.937	1558.18	191.79	191.79
31.945	173.9	10.6275	1.0	0.98	3.8	0.345	204.66	0.295	0.928	0.363	0.935	1549.75	191.37	191.37
31.835	173.9	10.6275	1.0	0.97	3.8	0.345	204.66	0.293	0.928	0.365	0.933	1540.19	190.89	190.89

```
31.725 173.9 10.6275 1.0 0.97 3.8 0.345 204.66 0.293 0.928 0.365 0.932 1537.51 190.76
190.76
31.510 173.9 10.6275 1.0 0.97 3.8 0.345 204.66 0.292 0.928 0.365 0.931 1534.91 190.63
190.63
31.006 173.9 10.6275 1.0 0.97 3.8 0.345 204.66 0.292 0.928 0.365 0.931 1532.80 190.52
190.52
30.910 173.9 10.6275 1.0 0.97 3.8 0.345 239.00 0.292 0.928 0.387 0.911 1596.48 217.62
217.62
30.865 173.9 10.6275 1.0 0.97 3.8 0.345 239.00 0.292 0.928 0.387 0.911 1596.57 217.62
217.62
30.560   2.1  0.1525 1.0 1.00 4.6 0.383 239.00 0.292 0.979 0.319 0.977 2355.72 233.49
233.49

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 18
Load Combination #18 D+O+P 0 Deg (Corroded), FS = 1

Bot Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
44.060	1.00	1.00	0.500	1.469	1.118	0.650	1.882	1.224	0.2317	0.03	68.89	34.45	34.45
42.060	1.00	1.00	0.500	1.469	1.118	0.650	1.862	1.210	0.2317	0.03	68.89	34.45	34.45
42.027	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	51.25
41.945	1.00	1.00	0.500	1.413	1.118	0.650	1.848	1.201	0.2504	0.03	102.50	51.25	51.25
41.817	1.00	1.00	0.500	1.413	1.118	0.650	1.847	1.201	0.2504	0.03	102.50	51.25	51.25
41.688	1.00	1.00	0.500	1.681	1.118	0.650	1.846	1.200	0.1770	0.03	72.45	36.23	36.23
41.560	1.00	1.00	0.500	1.948	1.118	0.650	1.845	1.199	0.1318	0.04	53.95	26.97	26.97
40.960	1.00	1.00	0.500	2.214	1.118	0.650	1.844	1.199	0.1020	0.04	41.77	20.88	20.88
38.960	1.00	1.00	0.500	2.214	1.118	0.650	1.840	1.196	0.1020	0.04	41.77	20.88	20.88
37.016	1.00	1.00	0.500	2.214	1.118	0.650	1.825	1.186	0.1020	0.04	41.77	20.88	20.88
36.683	1.00	1.00	0.500	2.214	1.118	0.650	1.809	1.176	0.1020	0.04	41.77	20.88	20.88
36.349	1.00	1.00	0.500	2.999	1.118	0.650	1.806	1.174	0.0556	0.06	22.75	11.38	11.38
36.016	1.00	1.00	0.500	3.686	1.118	0.650	1.804	1.172	0.0368	0.07	15.06	7.53	7.53
35.697	1.00	1.00	0.500	4.123	1.118	0.650	1.801	1.171	0.0294	0.09	12.04	6.02	6.02
35.560	1.00	1.00	0.500	4.123	1.118	0.650	1.798	1.169	0.0294	0.09	12.04	6.02	6.02
35.423	1.00	1.00	0.500	4.123	1.118	0.650	1.797	1.168	0.0294	0.09	12.04	6.02	6.02
33.660	1.00	1.00	0.500	4.123	1.118	0.650	1.796	1.167	0.0294	0.09	12.04	6.02	6.02
33.010	1.00	1.00	0.500	4.123	1.118	0.650	1.781	1.157	0.0294	0.09	12.04	6.02	6.02
31.945	1.00	1.00	0.500	4.123	1.118	0.650	1.775	1.154	0.0294	0.09	12.04	6.02	6.02
31.835	1.00	1.00	0.500	4.123	1.118	0.650	1.765	1.147	0.0294	0.09	12.04	6.02	6.02
31.725	1.00	1.00	0.500	4.123	1.118	0.650	1.764	1.146	0.0294	0.09	12.04	6.02	6.02
31.510	1.00	1.00	0.500	4.123	1.118	0.650	1.763	1.146	0.0294	0.09	12.04	6.02	6.02
31.006	1.00	1.00	0.500	4.123	1.118	0.650	1.761	1.145	0.0294	0.09	12.04	6.02	6.02
30.910	1.00	1.00	0.500	4.365	1.118	0.650	1.756	1.141	0.0262	0.09	12.54	6.27	6.27
30.865	1.00	1.00	0.500	4.365	1.118	0.650	1.755	1.141	0.0262	0.09	12.54	6.27	6.27

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30.560 1.00 2.11 0.500 0.257 1.118 0.818 1.755 1.435 1.0000 0.08 3620.51 239.00 239.00

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Summary of Maximum Stack Deflection
A summary of the worst lateral deflections for the stack and the load case the produced them.

Elev m	Load #	Load Case	Defl Max mm	Defl Limit mm	Unity	Result
47.060	17	Serviceability: 1.0*D+1.0*S 0 Deg	67.4	124.1	0.543	Pass
44.060	17	Serviceability: 1.0*D+1.0*S 0 Deg	42.9	101.5	0.422	Pass
42.060	17	Serviceability: 1.0*D+1.0*S 0 Deg	28.7	86.5	0.332	Pass
42.027	17	Serviceability: 1.0*D+1.0*S 0 Deg	28.5	86.2	0.331	Pass
41.945	17	Serviceability: 1.0*D+1.0*S 0 Deg	28.0	85.6	0.327	Pass
41.817	17	Serviceability: 1.0*D+1.0*S 0 Deg	27.2	84.6	0.322	Pass
41.688	17	Serviceability: 1.0*D+1.0*S 0 Deg	26.5	83.7	0.316	Pass
41.560	17	Serviceability: 1.0*D+1.0*S 0 Deg	25.7	82.7	0.311	Pass
40.960	17	Serviceability: 1.0*D+1.0*S 0 Deg	22.3	78.2	0.285	Pass
38.960	17	Serviceability: 1.0*D+1.0*S 0 Deg	12.1	63.2	0.192	Pass
37.016	17	Serviceability: 1.0*D+1.0*S 0 Deg	5.6	48.5	0.114	Pass
36.683	17	Serviceability: 1.0*D+1.0*S 0 Deg	4.9	46.0	0.107	Pass
36.349	17	Serviceability: 1.0*D+1.0*S 0 Deg	4.4	43.5	0.101	Pass
36.016	17	Serviceability: 1.0*D+1.0*S 0 Deg	3.9	41.0	0.095	Pass
35.697	17	Serviceability: 1.0*D+1.0*S 0 Deg	3.5	38.6	0.090	Pass
35.560	17	Serviceability: 1.0*D+1.0*S 0 Deg	3.3	37.6	0.088	Pass
35.423	17	Serviceability: 1.0*D+1.0*S 0 Deg	3.1	36.6	0.086	Pass
33.660	17	Serviceability: 1.0*D+1.0*S 0 Deg	1.3	23.3	0.055	Pass
33.010	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.8	18.4	0.043	Pass
31.945	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.2	10.4	0.022	Pass
31.835	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.2	9.6	0.019	Pass
31.725	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.2	8.8	0.017	Pass
31.510	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.1	7.1	0.013	Pass
31.006	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.0	3.4	0.004	Pass
30.910	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.0	2.6	0.002	Pass
30.865	17	Serviceability: 1.0*D+1.0*S 0 Deg	0.0	2.3	0.002	Pass
30.865	14	Serviceability: 1.0*D+1.0*W 0 Deg	0.0	NaN	0.000	Pass

Ratio = Defl Max / Defl Limit

Stack Deflection Load # 14
Load Combination Serviceability: 1.0*D+1.0*W 0 Deg

Elev	Dx	Dy	Dz	Dres	Limit	Ratio	Rresult

m	mm	mm	mm	mm	mm		
47.060	43.4	-0.1	0.0	43.4	124.1	0.350	Pass
44.060	27.6	-0.1	0.0	27.6	101.5	0.272	Pass
42.060	18.5	-0.1	0.0	18.5	86.5	0.214	Pass
42.027	18.3	-0.1	0.0	18.3	86.2	0.213	Pass
41.945	18.0	-0.1	0.0	18.0	85.6	0.211	Pass
41.817	17.5	-0.1	0.0	17.5	84.6	0.207	Pass
41.688	17.0	-0.1	0.0	17.0	83.7	0.204	Pass
41.560	16.6	0.0	0.0	16.6	82.7	0.200	Pass
40.960	14.4	0.0	0.0	14.4	78.2	0.184	Pass
38.960	7.9	0.0	0.0	7.9	63.2	0.125	Pass
37.016	3.7	0.0	0.0	3.7	48.5	0.076	Pass
36.683	3.3	0.0	0.0	3.3	46.0	0.071	Pass
36.349	2.9	0.0	0.0	2.9	43.5	0.068	Pass
36.016	2.6	0.0	0.0	2.6	41.0	0.064	Pass
35.697	2.3	0.0	0.0	2.3	38.6	0.061	Pass
35.560	2.2	0.0	0.0	2.2	37.6	0.059	Pass
35.423	2.1	0.0	0.0	2.1	36.6	0.058	Pass
33.660	0.9	0.0	0.0	0.9	23.3	0.038	Pass
33.010	0.5	0.0	0.0	0.5	18.4	0.029	Pass
31.945	0.2	0.0	0.0	0.2	10.4	0.015	Pass
31.835	0.1	0.0	0.0	0.1	9.6	0.013	Pass
31.725	0.1	0.0	0.0	0.1	8.8	0.012	Pass
31.510	0.1	0.0	0.0	0.1	7.1	0.009	Pass
31.006	0.0	0.0	0.0	0.0	3.4	0.003	Pass
30.910	0.0	0.0	0.0	0.0	2.6	0.002	Pass
30.865	0.0	0.0	0.0	0.0	2.3	0.001	Pass
30.560	0.0	0.0	0.0	0.0	NaN	0.000	Pass

Dres = Max Lateral Displacement: (Dx^2 + Dz^2)
Ratio = Dres / Limit

Stack Deflection Load # 17
Load Combination Serviceability: 1.0*D+1.0*S 0 Deg

Elev m	Dx mm	Dy mm	Dz mm	Dres mm	Limit mm	Ratio	Rresult
47.060	67.4	-0.1	0.0	67.4	124.1	0.543	Pass
44.060	42.9	-0.1	0.0	42.9	101.5	0.422	Pass
42.060	28.7	-0.1	0.0	28.7	86.5	0.332	Pass
42.027	28.5	-0.1	0.0	28.5	86.2	0.331	Pass
41.945	28.0	-0.1	0.0	28.0	85.6	0.327	Pass
41.817	27.2	-0.1	0.0	27.2	84.6	0.322	Pass
41.688	26.5	-0.1	0.0	26.5	83.7	0.316	Pass
41.560	25.7	0.0	0.0	25.7	82.7	0.311	Pass
40.960	22.3	0.0	0.0	22.3	78.2	0.285	Pass
38.960	12.1	0.0	0.0	12.1	63.2	0.192	Pass
37.016	5.6	0.0	0.0	5.6	48.5	0.114	Pass
36.683	4.9	0.0	0.0	4.9	46.0	0.107	Pass
36.349	4.4	0.0	0.0	4.4	43.5	0.101	Pass
36.016	3.9	0.0	0.0	3.9	41.0	0.095	Pass
35.697	3.5	0.0	0.0	3.5	38.6	0.090	Pass
35.560	3.3	0.0	0.0	3.3	37.6	0.088	Pass

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35.423	3.1	0.0	0.0	3.1	36.6	0.086	Pass
33.660	1.3	0.0	0.0	1.3	23.3	0.055	Pass
33.010	0.8	0.0	0.0	0.8	18.4	0.043	Pass
31.945	0.2	0.0	0.0	0.2	10.4	0.022	Pass
31.835	0.2	0.0	0.0	0.2	9.6	0.019	Pass
31.725	0.2	0.0	0.0	0.2	8.8	0.017	Pass
31.510	0.1	0.0	0.0	0.1	7.1	0.013	Pass
31.006	0.0	0.0	0.0	0.0	3.4	0.004	Pass
30.910	0.0	0.0	0.0	0.0	2.6	0.002	Pass
30.865	0.0	0.0	0.0	0.0	2.3	0.002	Pass
30.560	0.0	0.0	0.0	0.0	NaN	0.000	Pass

Dres = Max Lateral Displacement: (Dx^2 + Dz^2)
Ratio = Dres / Limit

Conical Transition Analysis

Cone Analysis per API RP 2A-WSD: Elev 41.945 m to 41.560 m
Load Combination # 10, A: 1.1*D+1.5*W+0.9*L+0.9*O 0 Deg

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	7.0	7.0	7.0
Fys:	Yield Stress (MPa)	204.66	204.66	204.66
E:	Modulus of Elasticity (MPa)	199333.14	199333.14	199333.14
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	618.98	618.98	618.98
M:	Overturning Moment (KN-m)	16.32	0.00	19.50
V:	Vertical Axial Loading (KN)	3.54	0.00	4.02
Sx:	Section Modulus (cm^3)	540.1	540.1	1361.2
Ax:	Cross Sectional Area (sq cm)	69.668	69.668	110.176
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.51	0.52	0.37
fb:	Bending Strss - M/Sx (MPa)	30.22	31.08	14.32
fb':	Localized Bending Stress (MPa)	42.43	42.43	25.40
fh':	Hoop Stress (MPa)	22.50	0.00	13.47

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Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1723.70	1723.70	1098.69
Fhc:	Hoop Comp - Fys (MPa)	307.00	307.00	300.96
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	153.50	153.50	150.48
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2585.54	2585.54	1648.03
Fxc:	Crit Lcl Bklng (MPa)	204.66	204.66	198.26
Stot:	Total Stress Check 1: fa + fb (MPa)	30.73	31.60	14.69
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	73.16	74.03	40.09
Fb:	Allow Bend (LRFD): .9*Fxc (MPa)	184.20	184.20	178.43
Fh:	Min(Fb, 0.5*Fhc) (MPa)	153.50	153.50	150.48

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.167	PASS	0.172	PASS	0.082	PASS
Check 2: Stot1 / Ft	0.118	PASS	0.120	PASS	0.065	PASS
Check 3: fh' < Fh	0.147	PASS	0.000	PASS	0.090	PASS
Stiff Ring Req'd?	0.167	Not Req'd	0.172	Cone OK	0.090	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 37.016 m to 36.016 m
Load Combination # 15, 1.0*D+1.0*S+1.0*L+1.0*O 0 Deg

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	7.0	7.0	7.0
Fys:	Yield Stress (MPa)	204.66	204.66	204.66
E:	Modulus of Elasticity (MPa)	199333.14	199333.14	199333.14
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	618.98	618.98	618.98
M:	Overturning Moment (KN-m)	99.06	0.00	122.56
V:	Vertical Axial Loading (KN)	25.08	0.00	27.82
Sx:	Section Modulus (cm^3)	1361.2	1361.2	6134.7

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```
Ax:    Cross Sectional Area (sq cm)                    110.176     110.176
233.061

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                         2.28        2.36
1.19
fb:    Bending Strss - M/Sx (MPa)                       72.77       75.56
19.98
fb':   Localized Bending Stress (MPa)                  151.57      151.57
61.96
fh':   Hoop Stress (MPa)                                80.38        0.00
32.86
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                   1098.69     1098.69
523.19
Fhc:   Hoop Comp - Fys (MPa)                           300.96      300.96
260.94
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                    150.48      150.48
130.47
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                   1648.03     1648.03
784.78
Fxc:   Crit Lcl Bklng  (MPa)                           198.26      199.54
170.26
Stot:  Total Stress Check 1: fa + fb (MPa)              75.05       77.92
21.17
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)       226.62      229.50
83.13
Fb:    Allow Bend (LRFD): .9*Fxc (MPa)                 178.43      179.59
153.23
Fh:    Min(Fb, 0.5*Fhc) (MPa)                          150.48      150.48
130.47
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.421	PASS	0.434	PASS	0.138	PASS
Check 2: Stot1 / Ft	0.366	PASS	0.371	PASS	0.134	PASS
Check 3: fh' < Fh	0.534	PASS	0.000	PASS	0.252	PASS
Stiff Ring Req'd?	0.534	Not Req'd	0.434	Cone OK	0.252	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Structural Flange Analysis

Structural Flange # 1: Elev 42.000 m, Load # 9
Load Combination # 9, A: 0.9*D 0 Deg
Controlling: Max Bolt Spacing

```
M      = Moment on Flange                                          = 0.0 N-m
V      = Vertical Load on Flange (- is compression, + is tension)  = -2331 N
S      = Shear Load on Flange                                      = 0 N

Ds     = Outer Diameter of Shell                                   = 323.8 mm
Do     = Outside Diameter of Flange                                = 482.6 mm
Dbc    = Bolt Circle Diameter                                      = 431.8 mm
Tf     = Thickness of Flange                                       = 31.8 mm
Tw     = Fillet Weld Size                                          = 6.0 mm
```

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```
Db        = Nominal Bolt Diameter                                    = 22.2 mm
Nb        = Number of Bolts                                          = 12
Fu        = Ultimate Bolt Tensile Stress                             = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (LRFD) 0.56*Fu            = 579.16 MPa
Fv        = Allowable Bolt Tensile Stress: (LRFD) 0.34*Fy            = 351.63 MPa
Fp        = Pre-Load % of Allowable Bolt                             = 60.00 %
Eb        = Modulus of Elasticity for Bolt                           = 202705.50
MPa

Fys       = Yield Stress of Shell                                    = 215.81 MPa
Fw        = Tensile Stress of Weld                                   = 413.68 MPa
Fyc       = Yield Stress of Flange                                   = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (LRFD) 1.35*Fy             = 291.34 MPa
E         = Modulus of Elasticity of Flange                          = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt           = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters         = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                          = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                     = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N  = 0 N
Ab        = Nominal Area of Bolt                                     = 3.879 sq cm
Km        = Stiffness of Material                                    = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                        = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)   = 0.173
Fby       = Bolt Yield Stress                                        = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                             = 761869.3
KPa
Aroot     = Bolt Root Area                                           = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}         = 123659 N
K         = Coefficient of Thread Friction                           = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                  = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                 = 0 N
Fact      = Actual force on bolt                                     = 134811 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi     = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)               = 224684 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)               = 144440 N
Ratio     = Fb / Fbcomb                                              = 0.856

Sh        = Shear on Bolt                                            = 0 N
Sallow    = Allowable Shear on Bolt                                  = 136415 N
Ratio     = Sh / Sallow                                              = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                       = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                         = 22621.48
cm^4
```

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```
Aw        = Area of Weld                                                = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                          = 270.0 KPa
Sw        = Allowable Fillet Weld Stress: (LRFD) 0.45*Fuw               = 186.16 MPa
Ratio     = Fba / Sw                                                    = 0.001

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                = 87.6 mm
Lg        = Gross Flange area for each bolt                             = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                  = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                   = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                            = 54.0 mm
A         = Distance from Bolt CL to Flange OD                          = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                  = 42.9 mm
Rho       = Calculated Parameter                                        = 3.377
Beta      = Calulcated Parameter                                        = 0
Alpha'    = Alpha where treq'd is minimum                               = 0
Tc        = Required thickness to develop load w/no prying              = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                            = 0
Q         = Prying Force per bolt                                       = 0 N
Treq'd    = Required Flange Thickness                                   = 0.0 mm
Ratio     = Treqd / Tf                                                  = 0.000
```

Structural Flange # 1: Elev 42.000 m, Load # 15
Load Combination # 15, 1.0*D+1.0*S+1.0*L+1.0*O 0 Deg

Controlling: Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                            = 15999.1 N-m
V         = Vertical Load on Flange (- is compression, + is tension)    = -2589 N
S         = Shear Load on Flange                                        = 6363 N

Ds        = Outer Diameter of Shell                                     = 323.8 mm
Do        = Outside Diameter of Flange                                  = 482.6 mm
Dbc       = Bolt Circle Diameter                                        = 431.8 mm
Tf        = Thickness of Flange                                         = 31.8 mm
Tw        = Fillet Weld Size                                            = 6.0 mm

Db        = Nominal Bolt Diameter                                       = 22.2 mm
Nb        = Number of Bolts                                             = 12
Fu        = Ultimate Bolt Tensile Stress                                = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (LRFD) 0.56*Fu               = 579.16 MPa
Fv        = Allowable Bolt Tensile Stress: (LRFD) 0.34*Fy               = 351.63 MPa
Fp        = Pre-Load % of Allowable Bolt                                = 60.00 %
Eb        = Modulus of Elasticity for Bolt                              = 202705.50
MPa

Fys       = Yield Stress of Shell                                       = 215.81 MPa
Fw        = Tensile Stress of Weld                                      = 413.68 MPa
Fyc       = Yield Stress of Flange                                      = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (LRFD) 1.35*Fy                = 291.34 MPa
E         = Modulus of Elasticity of Flange                             = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt              = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters            = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                             = 222.3 mm
```

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```
Sp_UR      = Unity Ratio for Spacing:  Sp / SpMax                          = 0.509

BOLT LOADING:
P          = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N       = 12135 N
Ab         = Nominal Area of Bolt                                          = 3.879 sq cm
Km         = Stiffness of Material                                         = 5922221.21
N/mm
Kb         = Stiffness of Bolt                                             = 1238416.78
N/mm
CC         = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)        = 0.173
Fby        = Bolt Yield Stress                                             = 896316.8
KPa
Fproof     = Bolt Proof Stress (0.85*Fby)                                  = 761869.3
KPa
Aroot      = Bolt Root Area                                                = 2.705 sq cm
Fi         = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}              = 123659 N
K          = Coefficient of Thread Friction                                = 0.000
Tb         = Bolt Torque to Produce Preload: K*Fi*Db                       = 0.00 N-m
Fmin       = Min. Force to keep Flange in Compression                      = 11040 N
Fact       = Actual force on bolt                                          = 134811 N
Ratio      = Enough Pre-load to keep Joint in Compression:  Fmin / Fact    = 0.082

Fb         = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi          = 125757 N
Fballow    = Allowable Bolt Tensile Load (Pure Tension)                    = 224684 N
Fbcomb     = Allowable Bolt Tensile Load (Tens & Shear)                    = 144436 N
Ratio      = Fb / Fbcomb                                                   = 0.871

Sh         = Shear on Bolt                                                 = 530 N
Sallow     = Allowable Shear on Bolt                                       = 136415 N
Ratio      = Sh / Sallow                                                   = 0.004

Check Welding
Iw         = Bending Moment of Inertia for Weld                            = 11310.74
cm^4
Jw         = Polar Moment of Inertia for Weld                              = 22621.48
cm^4
Aw         = Area of Weld                                                  = 86.303 sq
cm
Fba        = Weld Stress due to Axial & Bending                            = 23200.7 KPa
Sw         = Allowable Fillet Weld Stress: (LRFD) 0.45*Fuw                 = 186.16 MPa
Ratio      = Fba / Sw                                                      = 0.125

Design Flange: NO GUSSETS
Ln         = Net Flange area at each bolt                                  = 87.6 mm
Lg         = Gross Flange area for each bolt                               = 113.0 mm
Delta      = Ratio of net area(@bolt line) & gross area                    = 0.7753
A'         = Distance from Flange OD to Bolt Hole Edge                     = 12.7 mm
B          = Distance from Bolt CL to Pipe OD                              = 54.0 mm
A          = Distance from Bolt CL to Flange OD                            = 25.4 mm
B'         = Distance from Pipe OD to edge of Bolt Hole                    = 42.9 mm
Rho        = Calculated Parameter                                          = 3.377
Beta       = Calulcated Parameter                                          = 5.1868
Alpha'     = Alpha where treq'd is minimum                                 = 1
Tc         = Required thickness to develop load w/no prying                = 13.1 mm
Alpha      = Ratio mom@ BL to Mom @ stem line                              = 0
Q          = Prying Force per bolt                                         = 0 N
Treq'd     = Required Flange Thickness                                     = 8.4 mm
```

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Ratio = Treqd / Tf = 0.266

Breach # 1: Elev 35.560 m, Load # 15
Load Combination # 15, 1.0*D+1.0*S+1.0*L+1.0*O 0 Deg
Controlling: Shell Buckling Capacity w/ Breach

Breach Analysis based upon 'Tubular Steel Structures' by M.S. Troitsky
Analysis assumes that this is the only breach and doesn't consider interaction with other openings.

This breach opening is due to a nozzle and was automatically generated by the MecaStack.

Elev = Elevation Where Breach Ctr Line Intersects Stack Ctr Line = 35.56 m

ElTop = Elevation at Top of Breach = 35.697 m
ElBot = Elevation at Bottom of Breach = 35.423 m
Wid = Width of Ducting = 273.1 mm
Ht = Height of Ducting = 273.1 mm
Ht1 = Vertical Height of Breach Opening at Shell = 273.1 mm
Tilt = Tilt of Duct relative to grade (0 is Horizontal) = 0.0 Deg
OD = Outer Diameter at Elevation = 1066.8 mm
ThkUnc = Uncorroded Thickness of Stack = 10.0 mm
ThkCor = Corroded Thickness of Stack = 7.0 mm

Loads Acting @ Breach (Take worst of loads at Top, Mid and Bot of Breach):
Moment is for a perfect cylinder and won't match stress summary if eccentric moments are included.
V = Vertical Load = 15.33 KN
M = Moment due to Lateral Loads = 145.91 KN-m

Yc = Distance from Centerline to Elastic Neutral Axis = 60.2 mm
r = Radius to Outside of Stack = 533.4 mm
r1 = Radius to Inside of Stack = 20.7 mm
Dm = Mean Diameter: 2*(r+r1)/2 = 41.7 mm
Alpha = Half Angle of Opening: ArcSin(Wid/OD) = 0.2588 rads
Beta = Angle to Neutral Axis: ArcSin(Yc/r) = 0.1132 rads
Gamma1 = (PI/2 - Alpha + Beta)/2 = 0.7126 rads
Gamma2 = (PI/2 - Alpha - Beta)/2 = 0.5994 rads
Sc = Statical Moment Under Compression = 3536.6 cm^3
St = Statical Moment Under Tension = 198.6 cm^3
Ic = Moment of Inertia of Wall Under Compression = 3597.78 cm^4
It = Moment of Inertia of Wall Under Tension = 2892.11 cm^4
Phi = (Mom + Ver*Yc) / (Ic + It) = 200.2527
N = Phi * (Sc-St) = 3.45 KN

Breach # 1 Ld 15 Cylinder Buckling Capacity:
This checks the reduced buckling capacity for the cylinder considering that it is weakened by the breach cutout. Reduction is based upon Troitsky Fig 5-24 for Effect of Rect Cutout on Cylindrical Buckling Capacity.

fclassic = Classic Buckling Stress for Cylinder: 0.6*E*ThkCor/r = 1569.56 MPa
FS = Factor of Safety for Compression = 0.900
rbar = Non-dimensional parameter: (Wid+Ht) / (4*((OD/2)*ThkCor)^0.5) = 2.234
P/Pcl = Actual / Classical Buckling Capacity {Fig 5-23}; Max=0.2 = 0.200

```
fmax      = Max Comp Stress: (Phi/2)*(2*Yc+(r+r1)*COS(Alpha))              = 4.51 MPa
fallow    = Allowable Reduced Buckling Stress: (P/Pcl)*fclassic*FS          = 282.52 MPa
UR_sb     = Shell Buckling Unity Ratio: fmax/fallow                         = 0.110
```

Breach # 2: Elev 31.835 m, Load # 11
Load Combination # 11, B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg
Controlling: Shell Buckling Capacity w/ Breach

Breach Analysis based upon 'Tubular Steel Structures' by M.S. Troitsky
Analysis assumes that this is the only breach and doesn't consider interaction with other openings.

This breach opening is due to a nozzle and was automatically generated by the MecaStack.

```
Elev      = Elevation Where Breach Ctr Line Intersects Stack Ctr Line       = 31.835 m

ElTop     = Elevation at Top of Breach                                      = 31.945 m
ElBot     = Elevation at Bottom of Breach                                   = 31.725 m
Wid       = Width of Ducting                                                = 219.1 mm
Ht        = Height of Ducting                                               = 219.1 mm
Ht1       = Vertical Height of Breach Opening at Shell                      = 219.1 mm
Tilt      = Tilt of Duct relative to grade (0 is Horizontal)                = 0.0 Deg
OD        = Outer Diameter at Elevation                                     = 1066.8 mm
ThkUnc    = Uncorroded Thickness of Stack                                   = 10.0 mm
ThkCor    = Corroded Thickness of Stack                                     = 7.0 mm

Loads Acting @ Breach (Take worst of loads at Top, Mid and Bot of Breach):
Moment is for a perfect cylinder and won't match stress summary if eccentric moments are
included.
V         = Vertical Load                                                   = 43.25 KN
M         = Moment due to Lateral Loads                                     = 269.12 KN-m

Yc        = Distance from Centerline to Elastic Neutral Axis                = 57.8 mm
r         = Radius to Outside of Stack                                      = 533.4 mm
r1        = Radius to Inside of Stack                                       = 20.7 mm
Dm        = Mean Diameter: 2*(r+r1)/2                                       = 41.7 mm
Alpha     = Half Angle of Opening:  ArcSin(Wid/OD)                          = 0.2068 rads
Beta      = Angle to Neutral Axis:  ArcSin(Yc/r)                            = 0.1085 rads
Gamma1    = (PI/2 - Alpha + Beta)/2                                         = 0.7362 rads
Gamma2    = (PI/2 - Alpha - Beta)/2                                         = 0.6277 rads
Sc        = Statical Moment Under Compression                               = 3731.6 cm^3
St        = Statical Moment Under Tension                                   = 200.2 cm^3
Ic        = Moment of Inertia of Wall Under Compression                     = 3860.45
cm^4
It        = Moment of Inertia of Wall Under Tension                         = 2931.06
cm^4
Phi       = (Mom + Ver*Yc) / (Ic + It)                                      = 353.9735
N         = Phi * (Sc-St)                                                   = 9.72 KN
```

Breach # 2 Ld 11 Cylinder Buckling Capacity:
This checks the reduced buckling capacity for the cylinder considering that it is weakened by
the breach cutout. Reduction is based upon Troitsky Fig 5-24 for Effect of Rect Cutout on Cylindrical Buckling Capacity.

```
fclassic  = Classic Buckling Stress for Cylinder: 0.6*E*ThkCor/r            = 1569.56 MPa
FS        = Factor of Safety for Compression                                = 0.900
```

```
rbar      = Non-dimensional parameter: (Wid+Ht) / (4*((OD/2)*ThkCor)^0.5)    = 1.793
P/Pcl     = Actual / Classical Buckling Capacity {Fig 5-23}; Max=0.2         = 0.200
fmax      = Max Comp Stress: (Phi/2)*(2*Yc+(r+r1)*COS(Alpha))                = 8.03 MPa
fallow    = Allowable Reduced Buckling Stress: (P/Pcl)*fclassic*FS           = 282.52 MPa
UR_sb     = Shell Buckling Unity Ratio: fmax/fallow                          = 0.196
```

Nozle # 1: Check Nozzle Loads Per WRC 107/537
Description: 1N

```
Elev      = Elev of Ctr of Nozzle to Ctr of Stack Intersection               = 35.56 m
OD        = Outer Diameter of Nozzle                                         = 273.1 mm
Thk       = Thickness of Nozzle                                              = 9.3 mm
Proj      = Radial Projection from OD of Stack to end of Nozzle/Flange       = 200.0 mm
RW        = Radial Width of Repad from OD of Nozzle ot OD of Repad           = 100.0 mm
RT        = Repad Thickness                                                  = 8.0 mm
Tilt      = Tilt Relative to Horizonal (0 is Horizzontal, + is down)         = 0.0 Deg
Orien     = Orientation of Nozzle in the Plan View                           = 180.0 Deg
FW        = Flange Width                                                     = 66.7 mm
FT        = Flange Thickness                                                 = 30.2 mm
```

Nozzle # 1 Nozzle WRC Load Summary

Load Num	Description	Fx KN	Fy KN	Fz KN	Mx KN-m	My KN-m	Mz KN-m	Local/ Global	Load Applied	Load Type	Max Ratio	Worst Case
1	5 x API Loads	7.78	14.46	14.46	6.30	4.75	4.75	Local	End of Nozzle	Oper	0.475	*

* is the worst case loading

Nozzle # 1 WRC Load Summary of Transformed Loads
Transformation of Loads to Global Coordinates and at Nozzle to Shell Intersection

Load Num	Description	Fxt [P] KN	Fyt [Vl] KN	Fzt [Vc] KN	Mxt [Mt] KN-m	Myt [Mc] KN-m	Mzt [Ml] KN-m	Load Type	Max Ratio	Worst Case
1	5 x API Loads	7.78	14.46	14.46	6.30	4.75	4.75	Oper	0.475	*

* WRC 107 Analysis is based upon loads being at the Nozzle to Shell Interface
* Values in [] represent those values that are used in WRC 537 stress analysis

Nozzle # 1 Nozzle Load Detailed Calculations for Load Producing Highest Stress Ratio:
Load #'s Refer to the Load # for the Nozzle Loads Only

```
Ds        = Outer Diameter of Stack @ Nozzle                                 = 1066.8 mm
Ts        = Corroded thickness of Stack @ Nozzle                             = 7.0 mm
Rw        = Repad Width                                                      = 3.9 mm
Rt        = Repad Thickness                                                  = 0.3 mm
Teff      = Effective Thickness: (Ts^2+Rt^2)^0.5                             = 0.4 mm
Rcyl      = Mean Cylinder Radius: [(Ds+2*Rt) + (Ds-2*Ts)]/4                  = 21.0 mm
Sallow    = Allowable Local Stress: 2 * Fy                                   = 409.33 MPa
```

Nozzle # 1 Local Stress per WRC 537: Cylinder to Repad

```
P         = Radial Force                                                     = 7.78 KN
```

```
Mc        = Circumferential Moment                                    = 474.54 KN-
cm
Ml        = Longitudinal Moment                                       = 474.54 KN-
cm
Mt        = Torsional Moment                                          = 630.46 KN-
cm
Vc        = Shear in Circumferential Direction                        = 14.46 KN
Vl        = Shear in Longitudinal Direction                           = 14.46 KN
```

Parameter	Cylinder	Cylinder mm	Round Attachment	Round Attachment mm
Outer Diameter	Do	1082.8	do	273.1
Mean Diameter	Dm	1067.8	dm	263.8
Inside Diameter	Di	1052.8	di	254.5
Mean Radius	Rm	533.9	rm	131.9
Thickness	T	15.0	t	9.3

Parameter	Expected Range	Actual Value	Status
Gamma = Rm/T	5 <= Gamma <= 300	35.593	OK
Beta = 0.875*ro/Rm	Beta <= 0.5	0.224	OK
di/Di	di/Di <= 0.6	0.242	OK
t/T	t/T >= 1	0.618	Warning
Lambda = (dm/Dm)*(Dm/T)^0.5	Lambda <= 2.8	2.084	OK

One ore more criteria was not met so please use the results with caution.
It is recommended to verify the local stress using Finite Element Analysis
When checking FEA it is recommended to use the Loads x Nd to apply the appropriate safety factor

Local Stress per WRC 537: Nozzle # 1 Cylinder to Repad - Circumferential Stress

Loading	Stress Type	Beta	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa
P	Membrane	0.224	-4.77	-4.77	-4.77	-4.77	-2.91	-2.91	-2.91	-2.91
P	Bending	0.224	-6.43	6.43	-6.43	6.43	-12.52	12.52	-12.52	12.52
Mc	Membrane	0.224	0.00	0.00	0.00	0.00	-7.55	-7.55	7.55	7.55
Mc	Bending	0.224	0.00	0.00	0.00	0.00	-81.97	81.97	81.97	-81.97
Ml	Membrane	0.224	-17.88	-17.88	17.88	17.88	0.00	0.00	0.00	0.00

Ml	Bending	0.224	-25.19	25.19	25.19	-25.19	0.00	0.00	0.00	0.00
TOTAL	Circumferential		-54.27	8.96	31.87	-5.65	-104.96	84.03	74.09	-64.81

Local Stress per WRC 537: Nozzle # 1 Cylinder to Repad - Longitudinal Stress

Loading	Stress Type	Beta	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa
P	Membrane	0.224	-2.91	-2.91	-2.91	-2.91	-4.77	-4.77	-4.77	-4.77
P	Bending	0.224	-12.75	12.75	-12.75	12.75	-6.40	6.40	-6.40	6.40
Mc	Membrane	0.224	0.00	0.00	0.00	0.00	-14.64	-14.64	14.64	14.64
Mc	Bending	0.224	0.00	0.00	0.00	0.00	-38.06	38.06	38.06	-38.06
Ml	Membrane	0.224	-7.50	-7.50	7.50	7.50	0.00	0.00	0.00	0.00
Ml	Bending	0.224	-42.63	42.63	42.63	-42.63	0.00	0.00	0.00	0.00
TOTAL	Longitudinal		-65.79	44.96	34.48	-25.30	-63.87	25.05	41.53	-21.80

Local Stress per WRC 537: Nozzle # 1 Cylinder to Repad - Shear Stress

Loading	Stress Type	Beta	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa
Vc	Shear	0.000	2.25	2.25	-2.25	-2.25	0.00	0.00	0.00	0.00
Vl	Shear	0.000	0.00	0.00	0.00	0.00	-2.25	-2.25	2.25	2.25
Mt	Shear	0.000	3.59	3.59	3.59	3.59	3.59	3.59	3.59	3.59
TOTAL	Shear		5.84	5.84	1.34	1.34	1.34	1.34	5.84	5.84

Local Stress per WRC 537: Nozzle # 1 Cylinder to Repad - Combined Stress Intensity

Description	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa
Total Circumferential (Sc)	-54.27	8.96	31.87	-5.65	-104.96	84.03	74.09	-64.81
Total Longitudinal (Sl)	-65.79	44.96	34.48	-25.30	-63.87	25.05	41.53	-21.80

Total Shear (Ss)	5.84	5.84	1.34	1.34	1.34	1.34	5.84	5.84
Combined Intensity	16.40	45.88	35.04	19.83	41.18	84.06	75.11	44.57

When Sc & Sl have like signs: S = 0.5*(Sc+Sl +/- [(Sc-Sl)^2 + 4*Ss^2]^0.5
or S = [(Sc-Sl)^2+4*Ss^2]^0.5
When Ss=0: S = Max of [Abs(Sc), Abs(Sl) or Abs(Sc-Sl)]
When Sc & Sl have unlike Signs: S = [(Sc-Sl)^2+4*Ss^2]^0.5

SI_Max = Maximum Combined Stress Intensity = 84.06 MPa
Sallow = Allowable Local Stress: 2 * Fy = 409.33 MPa
UR = Unity Stress Ratio: SI_Max / Allow = 0.205

Nozzle # 1 Local Stress per WRC 537: Repad to Shell

P = Radial Force = 7.78 KN
Mc = Circumferential Moment = 474.54 KN-cm
Ml = Longitudinal Moment = 474.54 KN-cm
Mt = Torsional Moment = 630.46 KN-cm
Vc = Shear in Circumferential Direction = 14.46 KN
Vl = Shear in Longitudinal Direction = 14.46 KN

Parameter	Cylinder	Cylinder	Round Attachment	Round Attachment
		mm		mm
Outer Diameter	Do	1066.8	do	487.1
Mean Diameter	Dm	1059.8	dm	480.1
Inside Diameter	Di	1052.8	di	473.1
Mean Radius	Rm	529.9	rm	240.0
Thickness	T	7.0	t	7.0

Parameter	Expected Range	Actual Value	Status
Gamma = Rm/T	5 <= Gamma <= 300	75.700	OK
Beta = 0.875*ro/Rm	Beta <= 0.5	0.402	OK
di/Di	di/Di <= 0.6	0.449	OK
t/T	t/T >= 1	1.000	OK
Lambda = (dm/Dm)*(Dm/T)^0.5	Lambda <= 2.8	5.573	Warning

One ore more criteria was not met so please use the results with caution.
It is recommended to verify the local stress using Finite Element Analysis

When checking FEA it is recommended to use the Loads x Nd to apply the appropriate safety factor

Local Stress per WRC 537: Nozzle # 1 Repad to Shell - Circumferential Stress

Loading	Stress Type	Beta	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa
P	Membrane	0.391	-10.78	-10.78	-10.78	-10.78	-3.51	-3.51	-3.51	-3.51
P	Bending	0.391	-4.73	4.73	-4.73	4.73	-47.66	47.66	-47.66	47.66
Mc	Membrane	0.391	0.00	0.00	0.00	0.00	-9.40	-9.40	9.40	9.40
Mc	Bending	0.391	0.00	0.00	0.00	0.00	-159.53	159.53	159.53	-159.53
Ml	Membrane	0.391	-17.68	-17.68	17.68	17.68	0.00	0.00	0.00	0.00
Ml	Bending	0.391	-19.14	19.14	19.14	-19.14	0.00	0.00	0.00	0.00
TOTAL	Circumferential		-52.34	-4.59	21.31	-7.51	-220.09	194.28	117.76	-105.98

Local Stress per WRC 537: Nozzle # 1 Repad to Shell - Longitudinal Stress

Loading	Stress Type	Beta	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa
P	Membrane	0.391	-3.51	-3.51	-3.51	-3.51	-10.78	-10.78	-10.78	-10.78
P	Bending	0.391	-13.32	13.32	-13.32	13.32	-19.06	19.06	-19.06	19.06
Mc	Membrane	0.391	0.00	0.00	0.00	0.00	-40.97	-40.97	40.97	40.97
Mc	Bending	0.391	0.00	0.00	0.00	0.00	-60.13	60.13	60.13	-60.13
Ml	Membrane	0.391	-9.74	-9.74	9.74	9.74	0.00	0.00	0.00	0.00
Ml	Bending	0.391	-40.79	40.79	40.79	-40.79	0.00	0.00	0.00	0.00
TOTAL	Longitudinal		-67.36	40.86	33.71	-21.24	-130.96	27.44	71.26	-10.88

Local Stress per WRC 537: Nozzle # 1 Repad to Shell - Shear Stress

Loading	Stress Type	Beta	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa

Vc	Shear	0.000	2.78	2.78	-2.78	-2.78	0.00	0.00	0.00	0.00
Vl	Shear	0.000	0.00	0.00	0.00	0.00	-2.78	-2.78	2.78	2.78
Mt	Shear	0.000	2.56	2.56	2.56	2.56	2.56	2.56	2.56	2.56
TOTAL	Shear		5.34	5.34	-0.22	-0.22	-0.22	-0.22	5.34	5.34

Local Stress per WRC 537: Nozzle # 1 Repad to Shell - Combined Stress Intensity

Description	Au MPa	Al MPa	Bu MPa	Bl MPa	Cu MPa	Cl MPa	Du MPa	Dl MPa
Total Circumferential (Sc)	-52.34	-4.59	21.31	-7.51	-220.09	194.28	117.76	-105.98
Total Longitudinal (Sl)	-67.36	40.86	33.71	-21.24	-130.96	27.44	71.26	-10.88
Total Shear (Ss)	5.34	5.34	-0.22	-0.22	-0.22	-0.22	5.34	5.34
Combined Intensity	18.43	46.69	33.72	13.73	89.14	194.28	118.36	95.70

When Sc & Sl have like signs: S = 0.5*(Sc+Sl +/- [(Sc-Sl)^2 + 4*Ss^2]^0.5
or S = [(Sc-Sl)^2+4*Ss^2]^0.5
When Ss=0: S = Max of [Abs(Sc), Abs(Sl) or Abs(Sc-Sl)]
When Sc & Sl have unlike Signs: S = [(Sc-Sl)^2+4*Ss^2]^0.5

SI_Max	= Maximum Combined Stress Intensity	= 194.28 MPa
Sallow	= Allowable Local Stress: 2 * Fy	= 409.33 MPa
UR	= Unity Stress Ratio: SI_Max / Allow	= 0.475

Baseplate Analysis, Worst Case Load # 10 - A: 1.1*D+1.5*W+0.9*L+0.9*O 0 Deg
Based Upon 'Process Equipment Design' by Brownell & Young

The following components are Controlled by this Load Case:
Bolt Tension, Top Plate, Gussets, Local, Weld

M	= Moment on Baseplate	= 316.88 KN-m
V	= Vertical Load on Baseplate (+ is compression / - is tension)	= 48.45 KN
S	= Shear Load on Baseplate	= 43.29 KN
Ds	= Outer Diameter of Stack at Base	= 1066.8 mm
Type	= Type of Baseplate	= Chair Continuous Plate
SupType	= Type of Support	= Rigid Steel Base
Friction	= Coefficient of Friction for Support	= 0.300
BasisBolt	= Basis for Bolt Design	= Brownell & Young

```
Nbolt     = Number of Bolts                                    = 16
Dbolt     = Nominal Bolt Diameter                              = 27.0 mm
Dbh       = Bolt Hole Diameter                                 = 36.0 mm
CAbolt    = Corrosion Allowance on Bolt                        = 3.0 mm
CAplt     = Corrosion Allowance on Plates                      = 0.0 mm
ID        = Inside Diameter of Baseplate                       = 820.0 mm
BCD       = Bolt Circle Diameter of Baseplate                  = 1270.0 mm
OD        = Outer Diameter of Baseplate                        = 1385.0 mm
Tb        = Thickness of Bottom Plate                          = 25.0 mm
Tt        = Thickness of Top Plate                             = 25.0 mm
Fw        = Fillet Weld Size                                   = 5.0 mm
Fwu       = Weld Ultimate Tensile Strength                     = 482632.1
KPa
Ngus      = Number of Gussets per Bolt                         = 1
Hg        = Height of Anchor Chair                             = 305.0 mm
Tg        = Thickness of Gusset                                = 12.0 mm
Material: (Properties looked up from database)
Spec      = Material Specification                             = S275J0
Dens      = Material Density                                   = 7849 Kg/m^3
Temp      = Design Temperature                                 = 21.11 Deg C
Fy        = Minimum Yield Stress                               = 274996.9
KPa
Fu        = Ultimate Tensile Stress                            = 410030.5
KPa
Sa        = Allowable Tensile Stress                           = 117141.7
KPa
E         = Modulus of Elasticity                              = 209957162.5
KPa
A         = Coefficient of Thermal Expansion                   = 1.20E-05
mm/mm/C


Bolt Material:
Override  = Manually Specify Material                          = False
Matl      = Bolt Material Specification                        = Gr. 8.8
Fu        = Ultimate Tensile Stress                            = 800548.8
KPa
Fy        = Yield Stress                                       = 640440.4
KPa
Fproof    = Proof Stress                                       = 544374.4
KPa
Eb        = Modulus of Elasticity                              = 202705497.9
KPa
Anchor Bolt Pretension:
Pretension= Pretension for Bolt as % of Ultimate Tensile       = 60.00 %
Fult      = Bolt Ultimate Tensile Stress                       = 800.55 MPa
PreStress = Pretension Stress on Bolt                          = 480.33 MPa

Plate Washer:
Ptype     = The Type of Plate Washer                           = Rectangular
Pt        = Plate Washer Thickness                             = 15.0 mm
Pw        = Width of Washer Perpendicular to Shell             = 90.0 mm
Pl        = Length of Washer Parallel to Shell                 = 100.0 mm
Pdh       = Bolt Hole Diameter                                 = 30.0 mm
Bolt Properties:
P         = Thread Pitch                                       = 3.6 mm
Dminor    = Minor Diameter:  Dboltc - 1.299038*P               = 19.3 mm
```

```
Aroot     = Bolt Minor Area:  (PI/4)*Dminor^2                                  = 2.921 sq cm

Bolt Tensile Strength per 'Process Equipment Design' by Brownell and Young:
Fu        = Bolt Ultimate Tensile Stress                                       = 800.55 MPa
Dbolt     = Diameter of Bolt                                                   = 27.0 mm
Cor Allow = Bolt Corrosion Allowance                                           = 3.0 mm
Dboltc    = Bolt Diameter Corroded:  Dbolt - Cor Allow                         = 24.0 mm
P         = Thread Pitch                                                       = 3.6 mm
Dminor    = Minor Diameter:  Dboltc - 1.299038*P                               = 19.3 mm
Abolt     = Bolt Minor Area:  (PI/4)*Dminor^2                                  = 2.921 sq cm
Phi       = Factor for LRFD:   0.33*1.5                                        = 0.50
Pallow    = Bolt Tensile Strength: Phi*Fu*Abolt                                = 116.94 KN

Stack Shell Properties: (Uses Stack Hot Properties at the Baseplate Location)
Fys       = Yield Stress of Shell Material                                     = 239.00 MPa
Fb_shell  = Allowable Plate Weak Bending: (LRFD) 1.35*Fy                       = 322.65 MPa

Baseplate Stress Limits: (Uses Baseplate Material Properties)
Fb        = Allowable Plate Weak Bending: (LRFD) 1.35*Fy                       = 371.25 MPa
Fbs       = Allowable Plate Strong Bending: (LRFD) 0.9*Fy                      = 247.50 MPa

BASEPLATE COMPRESSIVE STRESS:
fcmax     = [4*M/(PI*Ds^2) + V/(PI*Ds)] / [(OD-ID)*0.5]                        = 1306.1 KPa

BOLT LOADING:
Pbolt     = Max Bolt Load: 4*M/(N*Dbc) - V / N                                 = 59349 N
Pallow    = Allowable Bolt Tensile Load                                        = 116936 N
Ratio     = Unity Ratio: Pbolt / Pallow                                        = 0.508


Bottom (Bearing) Plate: ('Pressure Vessel Design Manual' 3rd Edition by Dennis Moss)
Tension Case Between Gussets where gussets attempt to Lift up Bottom Plate
b         = Gusset Inside Spacing Between Gussets: (BCD*PI/Nbolt)-Tg           = 237.4 mm
bs        = Gusset Inside Spacing Outside Gussets: b                           = 237.4 mm
Mo        = Moment due to Tension: Pbolt*b/8                                   = 107456.3
KPa
w         = Radial Width of Bottom Plate: 0.5*(OD-ID)                          = 282.5 mm
tbt       = Thickness Req'd for Tension: (6*Mo/((w-Dbh)*Fb)^0.5+CAplt          = 10.7 mm
Compression Case where concrete bearing is applied to Bottom Plate
bmax      = Controlling Inside Gusset Spacing: Max(b, bs)                      = 237.4 mm
l         = Radial bending width of baseplate: 0.5*(OD-Ds)                     = 159.1 mm
l/bmax    = Ratio used for Moment Calculation: l/b                             = 0.670
cc1       = Moment coefficient taken from Table 3-36 using l/b                 = 0.0563
cc2       = Moment coefficient taken from Table 3-36 using l/b                 = 0.2256
Mx        = Moment in x dir: cc1 * fcmax * b^2 {Units Force*Length/Length}     = 4.15 KN
My        = Moment in y dir: cc2 * fcmax * L^2 {Units Force*Length/Length}     = 7.46 KN
Mmax      = Maximum Moment: Max(Mx, My) {Units Force*Length/Length}            = 7.46 KN
tbc       = Thickness req'd for Compression: (6*Mmax/Fb)^.5+CAplt              = 11.0 mm
tb_reqd   = Thickness req'd for Bottom Plate: Max(tbc, tbt)                    = 11.0 mm
Ratio     = Unity Ratio: tb_reqd / Tb                                          = 0.439

TOP PLATE: ('Process Equipment Design' by Brownell & Young)
bt        = Gusset Inside Spacing Between Gussets: (BCD*PI/Nbolt)-Tg           = 237.4 mm
Lt        = Radial distance:  (Do-Dbc)/2                                       = 159.1 mm
bl        = bt / Lt                                                            = 1.492
ly        = Distance in x direction: lt                                        = 159.1 mm
at        = (Dbc - Ds) / 2                                                     = 101.6 mm
```

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G1        = Gamma1 Value from Table 10.6                                    = 0.171
G2        = Gamma 1 Value from Table 10.6                                   = 0.072
e         = 1/2 Distance across flats of Bolting Nut                        = 21.8 mm
Term1     = Pbolt / (4*PI)                                                  = 1061.7268
Term2     = [2*ly*Sin(PI*at1/ly)]/(PI*e)                                    = 4.2055
Mx        = Term1 * ((1 + U) * Log(Term2) + 1) - (1 - U - G2t) [Eqn 10.39]  = 0.27 KN-m
My        = Term1 * ((1 + U) * Log(Term2) + 1) - (G1t * Term1) [Eqn 10.38]  = 0.32 KN-m
tt_reqd   = Req'd Thickness: (6*Mmax / Fb)^0.5 + CAplt                      = 14.3 mm
Ratio     = Unity Ratio tt_reqd / Tt                                        = 0.574


GUSSET: (AISC 15th Edition for Column Buckling)
Gusset: Nominal Compressive Strength per AISC 360-16 Sec E3:
Lc        = Effective Length of Member                                      = 255.0 mm
r         = Minimum of Radius of gyration:  Min(rx, ry)                     = 3.5 mm
Lc/r      = Slenderness Ratio                                               = 73.612
Limit     = Limit used for Lc/r:  4.71*(E/Fy)^0.5                           = 130.143
Fe        = Elastic Buckling Stress:  PI^2*E / (Lc/r)^2   {E3-4}            = 382.41 MPa
Limit     = Limit used for Lc/r:  4.71*(E/Fy)^0.5                           = 130.143
Fcr       = Critical Stress: [0.658^(Fy/Fe)]*Fy   {E3-2}                    = 203.52 MPa
Ag        = Gross Cross Sectional Area of Member                            = 19.092 sq
cm
Pn        = Flexural Buckling Strength:  Fcr*Ag {E3-1}                      = 388.57 KN
Pc        = Design Compressive Strength: Pn*0.9 (LRFD)                      = 349.71 KN
Pg        = Bolt load per gusset:  Pbolt / Ngus                             = 59.35 KN
Ratio     = Unity Ratio: Pg / Pc                                            = 0.170

SHELL LOCAL STRESS: ('Process Equipment Design' by Brownell & Young)
a         = Radial Dist to Bolts:  (BCD-Ds)/2                               = 101.6 mm
m         = PI * BCD / Nbolt                                                = 249.4 mm
Fb_shell  = Allowable bending stress of shell                               = 322.65 MPa
ts        = 1.76*(Pbolt*a/(m*hg*Fb_shell))^0.6667 * [Ds/2]^0.333 [Eqn 10.59]= 5.6 mm
Ratio     = Unity Ratio ts / Ts                                             = 0.560

WELD STRESS: (Per AISC 15th ed)
m         = PI * Ds / Nbolt                                                 = 209.5 mm
Aw        = Weld Area per Bolt: Lw*Fw/1.414                                 = 14.814 sq
cm
Lw        = Weld Length per Bolt: 2*m                                       = 418.9 mm
Abm       = Area of Base Metal (Assumes Ts is thinnest): Ts*Lw              = 41.893 sq
cm
Fnw       = Nominal Stress of Weld Material:  0.6*Fwu {Table J2.5}          = 289579.3
KPa
Rnw       = Design Weld Strength (LRFD): Fnw*Aw*0.75 {Eqn J2-2}             = 321731 N
Rnpy      = Design Base Metal Strength (LRFD): 0.6*Fy*Abm {Eqn J4-3}        = 600743 N
Rnpr      = Allowable Base Rupture (ASD):  0.6*Fu*Abm*0.75 {Eqn J4-5}       = 671758 N
Pnw       = Minimum of Rnw, Rnpy, and Rnpr                                  = 321731 N
Ratio     = Unity Ratio:  Pbolt / Pnw                                       = 0.184
```

Baseplate Analysis, Worst Case Load # 11 - B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg
Based Upon 'Process Equipment Design' by Brownell & Young

```
The following components are Controlled by this Load Case:
Bottom Plate

M         = Moment on Baseplate                                             = 316.88 KN-m
V         = Vertical Load on Baseplate (+ is compression / - is tension)    = 57.41 KN
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```
S          = Shear Load on Baseplate                                    = 43.29 KN
Ds         = Outer Diameter of Stack at Base                            = 1066.8 mm
Type       = Type of Baseplate                                          = Chair
                                                                          Continuous

Plate
SupType    = Type of Support                                            = Rigid Steel
Base
Friction   = Coefficient of Friction for Support                        = 0.300
BasisBolt  = Basis for Bolt Design                                      = Brownell &
Young
Nbolt      = Number of Bolts                                            = 16
Dbolt      = Nominal Bolt Diameter                                      = 27.0 mm
Dbh        = Bolt Hole Diameter                                         = 36.0 mm
CAbolt     = Corrosion Allowance on Bolt                                = 3.0 mm
CAplt      = Corrosion Allowance on Plates                              = 0.0 mm
ID         = Inside Diameter of Baseplate                               = 820.0 mm
BCD        = Bolt Circle Diameter of Baseplate                          = 1270.0 mm
OD         = Outer Diameter of Baseplate                                = 1385.0 mm
Tb         = Thickness of Bottom Plate                                  = 25.0 mm
Tt         = Thickness of Top Plate                                     = 25.0 mm
Fw         = Fillet Weld Size                                           = 5.0 mm
Fwu        = Weld Ultimate Tensile Strength                             = 482632.1
KPa
Ngus       = Number of Gussets per Bolt                                 = 1
Hg         = Height of Anchor Chair                                     = 305.0 mm
Tg         = Thickness of Gusset                                        = 12.0 mm
Material: (Properties looked up from database)
Spec       = Material Specification                                     = S275J0
Dens       = Material Density                                           = 7849 Kg/m^3
Temp       = Design Temperature                                         = 21.11 Deg C
Fy         = Minimum Yield Stress                                       = 274996.9
KPa
Fu         = Ultimate Tensile Stress                                    = 410030.5
KPa
Sa         = Allowable Tensile Stress                                   = 117141.7
KPa
E          = Modulus of Elasticity                                      = 209957162.5
KPa
A          = Coefficient of Thermal Expansion                           = 1.20E-05
mm/mm/C


Bolt Material:
Override   = Manually Specify Material                                  = False
Matl       = Bolt Material Specification                                = Gr. 8.8
Fu         = Ultimate Tensile Stress                                    = 800548.8
KPa
Fy         = Yield Stress                                               = 640440.4
KPa
Fproof     = Proof Stress                                               = 544374.4
KPa
Eb         = Modulus of Elasticity                                      = 202705497.9
KPa
Anchor Bolt Pretension:
Pretension= Pretension for Bolt as % of Ultimate Tensile                = 60.00 %
Fult       = Bolt Ultimate Tensile Stress                               = 800.55 MPa
PreStress  = Pretension Stress on Bolt                                  = 480.33 MPa
```

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```
Plate Washer:
Ptype     = The Type of Plate Washer                                    = Rectangular
Pt        = Plate Washer Thickness                                      = 15.0 mm
Pw        = Width of Washer Perpendicular to Shell                      = 90.0 mm
Pl        = Length of Washer Parallel to Shell                          = 100.0 mm
Pdh       = Bolt Hole Diameter                                          = 30.0 mm
Bolt Properties:
P         = Thread Pitch                                                = 3.6 mm
Dminor    = Minor Diameter:  Dboltc - 1.299038*P                        = 19.3 mm
Aroot     = Bolt Minor Area:  (PI/4)*Dminor^2                           = 2.921 sq cm

Bolt Tensile Strength per 'Process Equipment Design' by Brownell and Young:
Fu        = Bolt Ultimate Tensile Stress                                = 800.55 MPa
Dbolt     = Diameter of Bolt                                            = 27.0 mm
Cor Allow = Bolt Corrosion Allowance                                    = 3.0 mm
Dboltc    = Bolt Diameter Corroded:  Dbolt - Cor Allow                  = 24.0 mm
P         = Thread Pitch                                                = 3.6 mm
Dminor    = Minor Diameter:  Dboltc - 1.299038*P                        = 19.3 mm
Abolt     = Bolt Minor Area:  (PI/4)*Dminor^2                           = 2.921 sq cm
Phi       = Factor for LRFD:   0.33*1.5                                 = 0.50
Pallow    = Bolt Tensile Strength: Phi*Fu*Abolt                         = 116.94 KN

Stack Shell Properties: (Uses Stack Hot Properties at the Baseplate Location)
Fys       = Yield Stress of Shell Material                              = 239.00 MPa
Fb_shell  = Allowable Plate Weak Bending: (LRFD) 1.35*Fy                = 322.65 MPa

Baseplate Stress Limits: (Uses Baseplate Material Properties)
Fb        = Allowable Plate Weak Bending: (LRFD) 1.35*Fy                = 371.25 MPa
Fbs       = Allowable Plate Strong Bending: (LRFD) 0.9*Fy               = 247.50 MPa

BASEPLATE COMPRESSIVE STRESS:
fcmax     = [4*M/(PI*Ds^2) + V/(PI*Ds)] / [(OD-ID)*0.5]                 = 1315.6 KPa

BOLT LOADING:
Pbolt     = Max Bolt Load: 4*M/(N*Dbc) - V / N                          = 58789 N
Pallow    = Allowable Bolt Tensile Load                                 = 116936 N
Ratio     = Unity Ratio: Pbolt / Pallow                                 = 0.503


Bottom (Bearing) Plate: ('Pressure Vessel Design Manual' 3rd Edition by Dennis Moss)
Tension Case Between Gussets where gussets attempt to Lift up Bottom Plate
b         = Gusset Inside Spacing Between Gussets: (BCD*PI/Nbolt)-Tg     = 237.4 mm
bs        = Gusset Inside Spacing Outside Gussets: b                    = 237.4 mm
Mo        = Moment due to Tension: Pbolt*b/8                            = 106442.3
KPa
w         = Radial Width of Bottom Plate: 0.5*(OD-ID)                   = 282.5 mm
tbt       = Thickness Req'd for Tension: (6*Mo/((w-Dbh)*Fb)^0.5+CAplt   = 10.7 mm
Compression Case where concrete bearing is applied to Bottom Plate
bmax      = Controlling Inside Gusset Spacing: Max(b, bs)               = 237.4 mm
l         = Radial bending width of baseplate: 0.5*(OD-Ds)              = 159.1 mm
l/bmax    = Ratio used for Moment Calculation: l/b                      = 0.670
cc1       = Moment coefficient taken from Table 3-36 using l/b          = 0.0563
cc2       = Moment coefficient taken from Table 3-36 using l/b          = 0.2256
Mx        = Moment in x dir: cc1 * fcmax * b^2 {Units Force*Length/Length}  = 4.18 KN
My        = Moment in y dir: cc2 * fcmax * L^2 {Units Force*Length/Length}  = 7.51 KN
Mmax      = Maximum Moment: Max(Mx, My) {Units Force*Length/Length}     = 7.51 KN
```

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tbc       = Thickness req'd for Compression: (6*Mmax/Fb)^.5+CAplt          = 11.0 mm
tb_reqd   = Thickness req'd for Bottom Plate: Max(tbc, tbt)                = 11.0 mm
Ratio     = Unity Ratio: tb_reqd / Tb                                      = 0.441

TOP PLATE: ('Process Equipment Design' by Brownell & Young)
bt        = Gusset Inside Spacing Between Gussets: (BCD*PI/Nbolt)-Tg       = 237.4 mm
Lt        = Radial distance:  (Do-Dbc)/2                                   = 159.1 mm
bl        = bt / Lt                                                        = 1.492
ly        = Distance in x direction: lt                                    = 159.1 mm
at        = (Dbc - Ds) / 2                                                 = 101.6 mm
G1        = Gamma1 Value from Table 10.6                                   = 0.171
G2        = Gamma 1 Value from Table 10.6                                  = 0.072
e         = 1/2 Distance across flats of Bolting Nut                       = 21.8 mm
Term1     = Pbolt / (4*PI)                                                 = 1051.7084
Term2     = [2*ly*Sin(PI*at1/ly)]/(PI*e)                                   = 4.2055
Mx        = Term1 * ((1 + U) * Log(Term2) + 1) - (1 - U - G2t) [Eqn 10.39] = 0.27 KN-m
My        = Term1 * ((1 + U) * Log(Term2) + 1) - (G1t * Term1) [Eqn 10.38] = 0.32 KN-m
tt_reqd   = Req'd Thickness: (6*Mmax / Fb)^0.5 + CAplt                     = 14.3 mm
Ratio     = Unity Ratio tt_reqd / Tt                                       = 0.571


GUSSET: (AISC 15th Edition for Column Buckling)
Gusset: Nominal Compressive Strength per AISC 360-16 Sec E3:
Lc        = Effective Length of Member                                     = 255.0 mm
r         = Minimum of Radius of gyration:  Min(rx, ry)                    = 3.5 mm
Lc/r      = Slenderness Ratio                                              = 73.612
Limit     = Limit used for Lc/r:  4.71*(E/Fy)^0.5                          = 130.143
Fe        = Elastic Buckling Stress:  PI^2*E / (Lc/r)^2   {E3-4}           = 382.41 MPa
Limit     = Limit used for Lc/r:  4.71*(E/Fy)^0.5                          = 130.143
Fcr       = Critical Stress: [0.658^(Fy/Fe)]*Fy   {E3-2}                   = 203.52 MPa
Ag        = Gross Cross Sectional Area of Member                           = 19.092 sq
cm
Pn        = Flexural Buckling Strength:  Fcr*Ag {E3-1}                     = 388.57 KN
Pc        = Design Compressive Strength: Pn*0.9 (LRFD)                     = 349.71 KN
Pg        = Bolt load per gusset:  Pbolt / Ngus                            = 58.79 KN
Ratio     = Unity Ratio: Pg / Pc                                           = 0.168

SHELL LOCAL STRESS: ('Process Equipment Design' by Brownell & Young)
a         = Radial Dist to Bolts:  (BCD-Ds)/2                              = 101.6 mm
m         = PI * BCD / Nbolt                                               = 249.4 mm
Fb_shell  = Allowable bending stress of shell                              = 322.65 MPa
ts        = 1.76*(Pbolt*a/(m*hg*Fb_shell))^0.6667 * [Ds/2]^0.333 [Eqn 10.59]= 5.6 mm
Ratio     = Unity Ratio ts / Ts                                            = 0.556

WELD STRESS: (Per AISC 15th ed)
m         = PI * Ds / Nbolt                                                = 209.5 mm
Aw        = Weld Area per Bolt: Lw*Fw/1.414                                = 14.814 sq
cm
Lw        = Weld Length per Bolt: 2*m                                      = 418.9 mm
Abm       = Area of Base Metal (Assumes Ts is thinnest): Ts*Lw             = 41.893 sq
cm
Fnw       = Nominal Stress of Weld Material:  0.6*Fwu {Table J2.5}         = 289579.3
KPa
Rnw       = Design Weld Strength (LRFD): Fnw*Aw*0.75 {Eqn J2-2}            = 321731 N
Rnpy      = Design Base Metal Strength (LRFD): 0.6*Fy*Abm {Eqn J4-3}       = 600743 N
Rnpr      = Allowable Base Rupture (ASD):  0.6*Fu*Abm*0.75 {Eqn J4-5}      = 671758 N
Pnw       = Minimum of Rnw, Rnpy, and Rnpr                                 = 321731 N
```

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Ratio = Unity Ratio: Pbolt / Pnw = 0.183

Static Summation of Forces
Total sum of all loads acting on system, Shear = (Fx^2+Fz^2)^0.5

Ld	Load Case (P)=Primary, (C)=Combination	Dir	Fx	Fy	Fz	Shear
		Deg	KN	KN	KN	KN
1	(P)Dead	0	0.00	-35.84	0.00	0.00
2	(P)Live	0	0.00	-13.34	0.00	0.00
3	(P)Operating	0	16.42	3.31	0.00	16.42
4	(P)Thermal Hot	0	0.00	0.00	0.00	0.00
5	(P)Wind	0	19.01	0.00	0.00	19.01
6	(P)Seismic Hor	0	22.77	0.00	0.00	22.77
7	(P)Seismic Ver	0	0.00	-22.77	0.00	0.00
8	(P)Vortex Across	0	0.00	0.00	0.28	0.28
9	(C)A: 0.9*D 0 Deg	0	0.00	-32.26	0.00	0.00
10	(C)A: 1.1*D+1.5*W+0.9*L+0.9*O	0	43.29	-48.45	0.00	43.29
11	(C)B: 1.35*D+1.5*W+0.9*L+0.9*O	0	43.29	-57.41	0.00	43.29
12	(C)B: 1.0*D 0 Deg	0	0.00	-35.84	0.00	0.00
13	(C)C: 1.0*D+1.3*W+0.78*L+0.78*	0	37.52	-43.67	0.00	37.52
14	(C)Serviceability: 1.0*D+1.0*W	0	19.01	-35.84	0.00	19.01
15	(C)1.0*D+1.0*S+1.0*L+1.0*O 0 D	0	39.19	-45.87	0.00	39.19
16	(C)1.0*D+1.0*S 0 Deg	0	22.77	-35.84	0.00	22.77
17	(C)Serviceability: 1.0*D+1.0*S	0	22.77	-35.84	0.00	22.77
18	(C)D+O+P 0 Deg	0	16.42	-32.53	0.00	16.42

Support Loading Notes
These notes apply to the support loading data which follows

1) Joint = Joint Number, Load = Load Number, Type = P(Primary) Or C(Combination)
2) Dir= Direction Of Lateral Loads (Wind/Seismic/Vortex), 0 Deg=+X axis, 90 Deg=+Z Axis
3) Fx/Fy/Fz = Forces In X/Y/Z directions, Mx/My/Mz = Moments about X/Y/Z Axis
4) Y Is the vertical direction, And + loads are acting up, And - Is acting down.

Detailed Support Loads: Fixed @ El 30.56 m
Loads acting on the support points (+Y is Vertical and Upward)

Load	Load Case (P)=Primary,(C)=Combo	Dir	Fx	Fy	Fz	Mx	My	Mz
		Deg	KN	KN	KN	KN-m	KN-m	KN-m
1	(P)Dead	0	0.00	-35.84	0.00	0.00	0.00	0.00
2	(P)Live	0	0.00	-13.34	0.00	0.00	0.00	0.00
3	(P)Operating	0	16.42	3.31	0.00	0.00	0.00	-89.99
4	(P)Thermal Hot	0	0.00	0.00	0.00	0.00	0.00	0.00
5	(P)Wind	0	19.01	0.00	0.00	0.00	0.00	-157.26
6	(P)Seismic Hor	0	22.77	0.00	0.00	0.00	0.00	-225.77
7	(P)Seismic Ver	0	0.00	-22.77	0.00	0.00	0.00	0.00
8	(P)Vortex Across	0	0.00	0.00	0.28	3.29	0.00	0.00
9	(C)A: 0.9*D 0 Deg	0	0.00	-32.26	0.00	0.00	0.00	0.00
10	(C)A: 1.1*D+1.5*W+0.9*L+0.9*O 0 Deg	0	43.29	-48.45	0.00	0.00	0.00	-316.88
11	(C)B: 1.35*D+1.5*W+0.9*L+0.9*O 0 De	0	43.29	-57.41	0.00	0.00	0.00	-316.88

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12	(C)B: 1.0*D 0 Deg	0	0.00	-35.84	0.00	0.00	0.00	0.00
13	(C)C: 1.0*D+1.3*W+0.78*L+0.78*O 0 D	0	37.52	-43.67	0.00	0.00	0.00	-274.63
14	(C)Serviceability: 1.0*D+1.0*W 0 De	0	19.01	-35.84	0.00	0.00	0.00	-157.26
15	(C)1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	0	39.19	-45.87	0.00	0.00	0.00	-315.76
16	(C)1.0*D+1.0*S 0 Deg	0	22.77	-35.84	0.00	0.00	0.00	-225.77
17	(C)Serviceability: 1.0*D+1.0*S 0 De	0	22.77	-35.84	0.00	0.00	0.00	-225.77
18	(C)D+O+P 0 Deg	0	16.42	-32.53	0.00	0.00	0.00	-89.99

Load	Load Case (P)=Primary,(C)=Combo	Vertical KN	Shear KN	Moment KN-m
1	(P)Dead	-35.84	0.00	0.00
2	(P)Live	-13.34	0.00	0.00
3	(P)Operating	3.31	16.42	89.99
4	(P)Thermal Hot	0.00	0.00	0.00
5	(P)Wind	0.00	19.01	157.26
6	(P)Seismic Hor	0.00	22.77	225.77
7	(P)Seismic Ver	-22.77	0.00	0.00
8	(P)Vortex Across	0.00	0.28	3.29
9	(C)A: 0.9*D 0 Deg	-32.26	0.00	0.00
10	(C)A: 1.1*D+1.5*W+0.9*L+0.9*O 0 Deg	-48.45	43.29	316.88
11	(C)B: 1.35*D+1.5*W+0.9*L+0.9*O 0 De	-57.41	43.29	316.88
12	(C)B: 1.0*D 0 Deg	-35.84	0.00	0.00
13	(C)C: 1.0*D+1.3*W+0.78*L+0.78*O 0 D	-43.67	37.52	274.63
14	(C)Serviceability: 1.0*D+1.0*W 0 De	-35.84	19.01	157.26
15	(C)1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	-45.87	39.19	315.76
16	(C)1.0*D+1.0*S 0 Deg	-35.84	22.77	225.77
17	(C)Serviceability: 1.0*D+1.0*S 0 De	-35.84	22.77	225.77
18	(C)D+O+P 0 Deg	-32.53	16.42	89.99

These are the resultant forces and the shear and moment can occur in any direction
Shear = Resultant Shear: (Fx^2 + Fz^2)^0.5
Moment = Resultant Mom: (Mx^2 + Mz^2)^0.5
Vertical load is the Fy force.

Maximum Support Loads for All Load Combinations
Maximum loading for each restraint, but loads may not necessarily occur at the same time

Restraint Description	Vertical KN	Uplift KN	Shear KN	Moment KN-m	Torsion KN-m
Fixed	-57.41	0.00	43.29	316.88	0.00

Vertical = Max downward acting Fy (Largest negative Fy value)
Uplift = Max upward acting Fy (Largest postive Fy value)
Shear = Resultant Shear: (Fx^2 + Fz^2)^0.5
Moment = Resultant Overturning Moment: (Mx^2 + Mz^2)^0.5
Torsion = Maximum magnitude of My

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6. MAIN RESULTS

Stack Stress Worst Case Summary

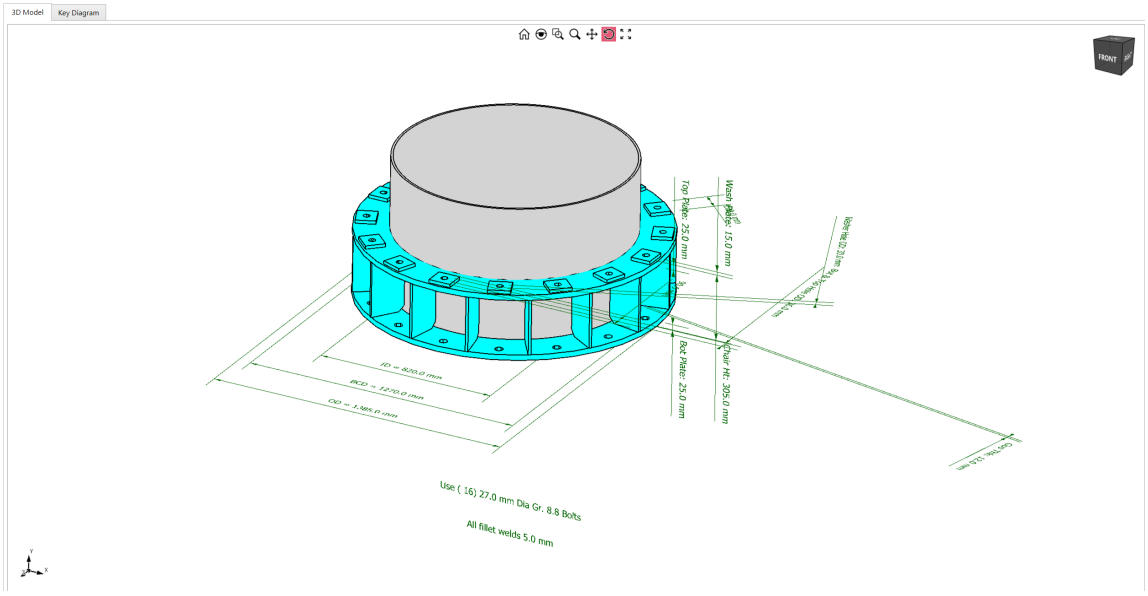
Summary of the load and highest stress ratios for each stack element

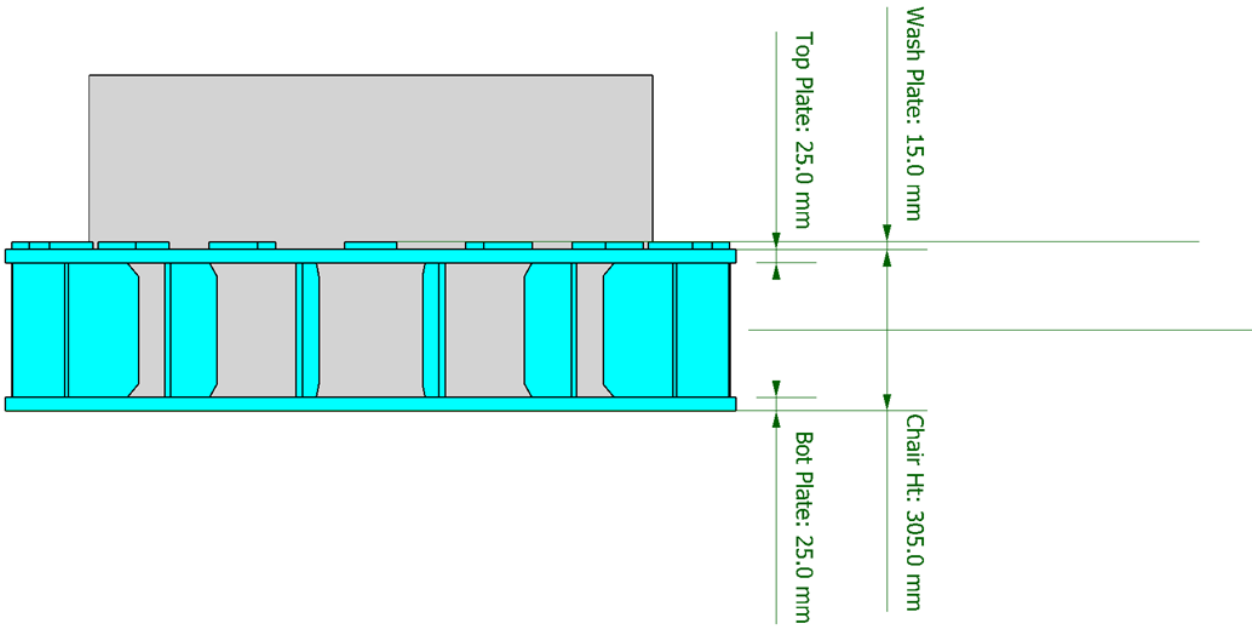
Top El m	Bot El m	Load #	Load Case	Controlling Case	Ratio	Result
16.500	13.500	16	1.0*D+1.0*S 0 Deg	Buckling	0.097	PASS
13.500	11.500	16	1.0*D+1.0*S 0 Deg	Buckling	0.263	PASS
11.500	11.467	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.174	PASS
11.467	11.385	16	1.0*D+1.0*S 0 Deg	Buckling	0.181	PASS
11.385	11.257	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.191	PASS
11.257	11.128	16	1.0*D+1.0*S 0 Deg	Buckling	0.144	PASS
11.128	11.000	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.115	PASS
11.000	10.400	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.121	PASS
10.400	8.400	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.273	PASS
8.400	6.456	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.458	PASS
6.456	6.123	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.493	PASS
6.123	5.789	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.259	PASS
5.789	5.456	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.178	PASS
5.456	5.137	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.134	PASS
5.137	5.000	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.135	PASS
5.000	4.863	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.150	PASS
4.863	3.100	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.199	PASS
3.100	2.450	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.221	PASS
2.450	1.385	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.260	PASS
1.385	1.275	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.265	PASS
1.275	1.165	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.287	PASS
1.165	0.950	15	1.0*D+1.0*S+1.0*L+1.0*O 0 Deg	Buckling	0.278	PASS
0.950	0.350	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.302	PASS
0.350	0.305	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.304	PASS
0.305	0.000	11	B: 1.35*D+1.5*W+0.9*L+0.9*O 0 Deg	Buckling	0.122	PASS

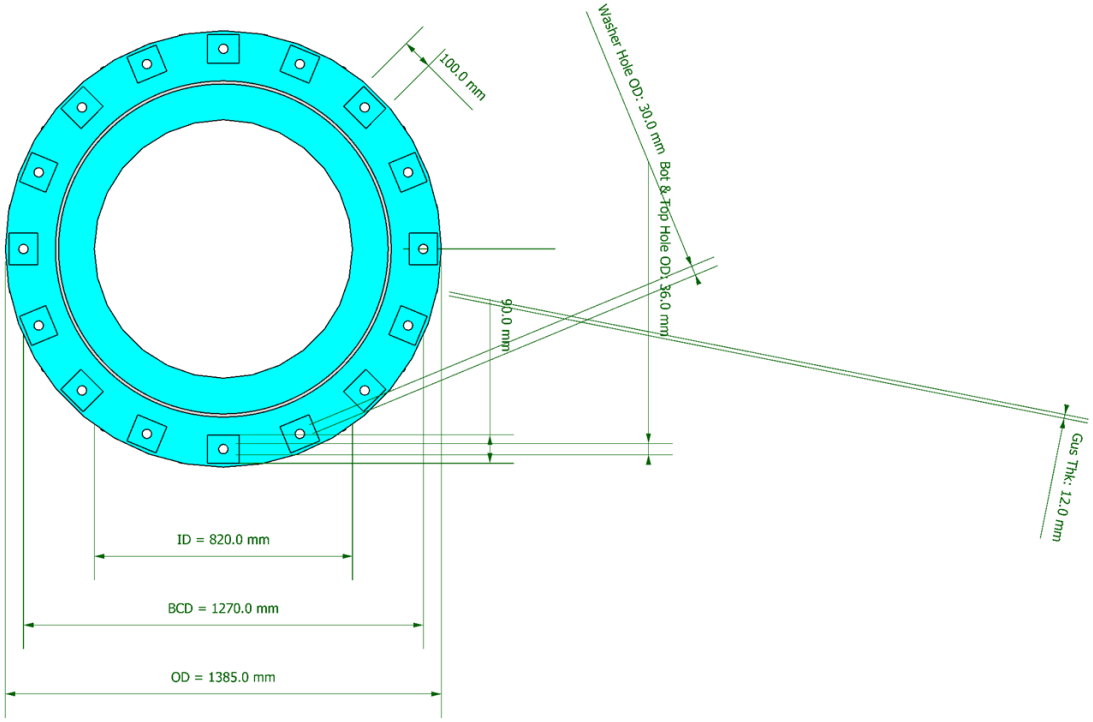
The maximum ratio of demand/capacity for the shell is lower than 1 showing a good structural behavior of the structure which has enough safety margin. All the verification are passed.

7. LOADS AT THE BASE

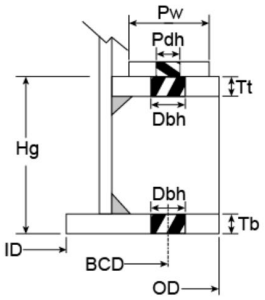
7.2 BASE PLATE

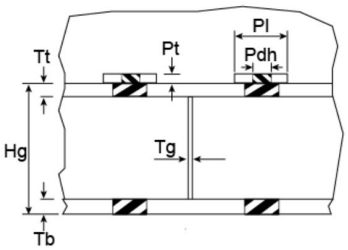





100.0 mm
Washer Hole OD: 30.0 mm Bot & Top Hole OD: 36.0 mm
90.0 mm
Gus Thk: 12.0 mm
ID = 820.0 mm
BCD = 1270.0 mm
OD = 1385.0 mm

Parameters	Description	Value	Units
Type	Type of Baseplate	Chair Continuous Plate	
Standard	Populate with Standard Dimensions	Get Standard Dimensions	
SupType	Type of Support	Rigid Steel Base	
Friction	Coefficient of Friction for Support	0.3	
Bolt	Bolt Material	Gr. 8.8	
BasisBolt	Basis for Bolt Design	Brownell & Young	
Pretension	Anchor Bolt Pretension	60.00 % of Ult / 480.33 MPa	
Nbolt	Number of Bolts	16	
Dbolt	Nominal Bolt Diameter	27	mm
Dbh	Bolt Hole Diameter	36	mm
CAbolt	Corrosion Allowance on Bolt	3	mm
Matl	Baseplate Material	S275J0	
CAplt	Corrosion Allowance on Plates	0	mm
ID	Inside Diameter of Baseplate	820	mm
BCD	Bolt Circle Diameter of Baseplate	1270	mm
OD	Outer Diameter of Baseplate	1385	mm
Tb	Thickness of Bottom Plate	25	mm
Tt	Thickness of Top Plate	25	mm
Fw	Fillet Weld Size	5	mm
Fwu	Weld Ultimate Tensile Strength	482632.1	KPa
Ngus	Number of Gussets per Bolt	1	
Hg	Height of Anchor Chair	305	mm
Tg	Thickness of Gusset	12	mm
Washer	Plate Washer	100.0 x 90.0 x 15.0 mm	





7.3Resultant Actions

The Case 6 below is representing the Transportation loads which provides the highest reactions effect among the horizontal acceleration applied with the load cases "transportation Loads" and " Wave and current Loads"

Detailed Support Loads: Fixed @ El 0.0 m

Loads acting on the support points (+Y is Vertical and Upward)

Load	Load Case (P)=Primary, (C)=Combo	Dir	Fx	Fy	Fz	Mx	My	Mz
		Deg	KN	KN	KN	KN-m	KN-m	KN-m
1	(P)Dead	0	0.00	-35.84	0.00	0.00	0.00	0.00
2	(P)Live	0	0.00	-13.34	0.00	0.00	0.00	0.00
3	(P)Operating	0	16.42	3.31	0.00	0.00	0.00	-89.99
4	(P)Thermal Hot	0	0.00	0.00	0.00	0.00	0.00	0.00
5	(P)Wind	0	18.99	0.00	0.00	0.00	0.00	-157.10
6	(P)Seismic Hor	0	22.77	0.00	0.00	0.00	0.00	-227.63
7	(P)Seismic Ver	0	0.00	-22.77	0.00	0.00	0.00	0.00
8	(P)Vortex Across	0	0.00	0.00	0.28	3.29	0.00	0.00

9	(C)A: 0.9*D 0 Deg	0	0.00	-32.26	0.00	0.00	0.00

Load	Load Case (P)=Primary,(C)=Combo	Vertical KN	Shear KN	Moment KN-m
1	(P)Dead	-35.84	0.00	0.00
2	(P)Live	-13.34	0.00	0.00
3	(P)Operating	3.31	16.42	89.99
4	(P)Thermal Hot	0.00	0.00	0.00
5	(P)Wind	0.00	18.99	157.10
6	(P)Seismic Hor	0.00	22.77	227.63
7	(P)Seismic Ver	-22.77	0.00	0.00
8	(P)Vortex Across	0.00	0.28	3.29

These are the resultant forces and the shear and moment can occur in any direction
Shear = Resultant Shear: (Fx^2 + Fz^2)^0.5
Moment = Resultant Mom: (Mx^2 + Mz^2)^0.5
Vertical load is the Fy force.

Maximum Support Loads for All Load Combinations

Maximum loading for each restraint, but loads may not necessarily occur at the same time

Restraint Description	Vertical KN	Uplift KN	Shear KN	Moment KN-m	Torsion KN-m
Fixed	-57.41	0.00	43.26	317.61	0.00

Vertical = Max downward acting Fy (Largest negative Fy value)
Uplift = Max upward acting Fy (Largest postive Fy value)
Shear = Resultant Shear: (Fx^2 + Fz^2)^0.5
Moment = Resultant Overturning Moment: (Mx^2 + Mz^2)^0.5
Torsion = Maximum magnitude of My

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8. LIST OF ATTACHMENT

A- ASME VIII PRESSURE CALCULATION OF BOTTOM KOD

B- LIFTING ANALYSIS CONFIGURATION WITHOUT TIP

C- LIFTING ANALYSIS CONFIGURATION WITH TIP

D- LIFTING LUG CALCULATION

E- MISCELLANUES CALCULATION

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9. CONCLUSIONS

Based on the results of the analysis, the following conclusions can be drawn:

- All the load cases have been considered and checked for the stability of the structure.
- The resultant stresses are within the allowable limits for all the load cases.
- The structure is stable and safe under the applied loads.

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A – PRESSURE CALCULATION ACCORDING TO ASME VIII div.1

The calculation is performed using PV ELITE one of the most reliable software in this field.

PV Elite is a comprehensive software tool used for the design and analysis of pressure vessels and heat exchangers. It offers capabilities such as finite element analysis, wind and seismic analysis, and the ability to model various types of vessel components.

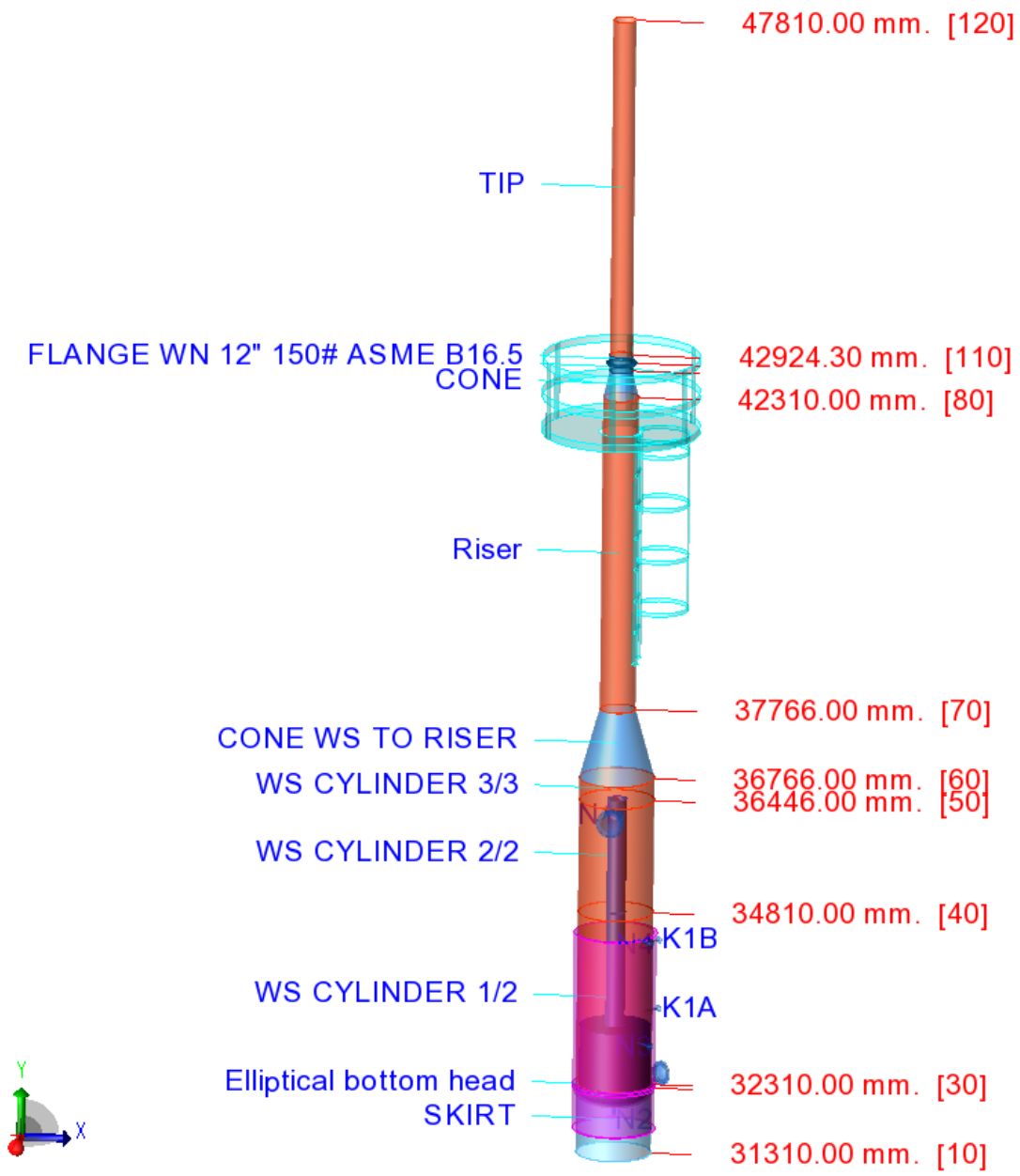
Note:

1- Base Plate analysis is not included. For details refers to the structural calculation in this document.

2- The loads case named "seismic" are referring to the maximum between transportation loads and case "wave and current loads" as shown above in this document. This is required because the software can handle only one seismic loads during the analysis.

3- The skirt is modeled with a dummy material of SA516-60 but for its verification , as it is not an element under pressure, please refer to the structural analysis where S75J0 has been used.

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47810.00 mm. [120]
TIP
FLANGE WN 12" 150# ASME B16.5
CONE
42924.30 mm. [110]
42310.00 mm. [80]
Riser
37766.00 mm. [70]
CONE WS TO RISER
WS CYLINDER 3/3
36766.00 mm. [60]
36446.00 mm. [50]
WS CYLINDER 2/2
34810.00 mm. [40]
K1B
WS CYLINDER 1/2
K1A
Elliptical bottom head
SKIRT
32310.00 mm. [30]
31310.00 mm. [10]
Y
X

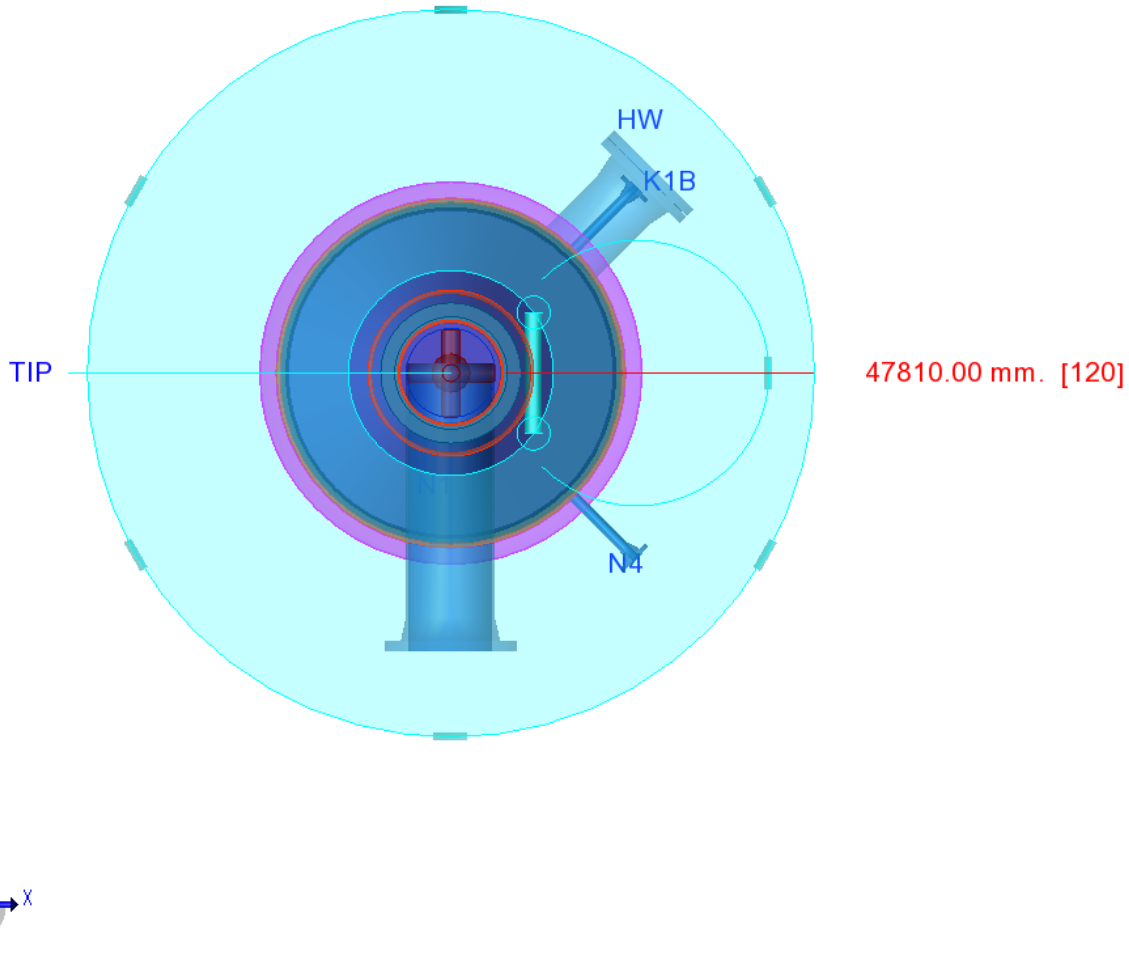

HW
K1B
TIP
47810.00 mm. [120]
N4
Y
X
Z

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DESIGN CALCULATION

In Accordance with ASME Section VIII Division 1

ASME Code Version : 2023

Analysis Performed by : Ing.Diego Bruciafreddo

Job File : W:\1.COMMESSE\DB-ENCORE-C16-23-0193-ROSETTI MARI

Date of Analysis : Dec 4,2024 9:40pm

Note:
PV Elite performs all calculations internally in Imperial Units
to remain compliant with the ASME Code and any built in assumptions
in the ASME Code formulas. The finalized results are reflected to show
the user's set of selected units.

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PV Elite Vessel Analysis Program: Input Data

Design Internal Pressure (for Hydrotest)	350	kPa
Design Internal Temperature	80.0	°C
Type of Hydrotest	1.43 * MAWP (PED)	
Hydrotest Position	Vertical	
Projection of Nozzle from Vessel Top	0	mm
Projection of Nozzle from Vessel Bottom	0	mm
Minimum Design Metal Temperature	-10.0	°C
Type of Construction	Welded	
Special Service	None	
Degree of Radiography	RT-2	
Use Higher Longitudinal Stresses (Flag)	Y	
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	EN 1991-1-4:2005+A1:2010	
Fundamental Wind Velocity [Vb,0]	100.8	Km/hr
Direction Factor [Cdir]	1.0	
Seasonal Factor [CSeason]	1.0	
Force Coefficient [Cf]	0.69999999	
Structural Factor [CsCd]	1.0	
Terrain Category	0 - Sea or Costal Area	
Seismic Design Code	G Loading	
Seismic Importance Factor	1.000	
G Loading Coefficient Gx	0.700	
G Loading Coefficient Gz	0.700	
G Loading Coefficient Gy	0.700	
Percent Seismic for Hydrotest	0.000	
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	1997	

Configuration Directives:

Do not use Nozzle MDMT Interpretation VIII-1 01-37	No
Use Table G instead of exact equation for "A"	No
Shell Head Joints are Tapered	No
Compute "K" in corroded condition	No
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	Skirt Sup.	
Description	SKIRT	
Distance "FROM" to "TO"	950	mm

Skirt Outside Diameter		1066.8	mm
Diameter of Skirt at Base		1066.8	mm
Skirt Thickness		10	mm
Internal Corrosion Allowance		3	mm
Nominal Thickness		0	mm
External Corrosion Allowance		0	mm
Design Temperature Internal Pressure		80	°C
Design Temperature External Pressure		80	°C
Effective Diameter Multiplier		1.2	
Material Name		SA/EN 10028-2	
Allowable Stress, Ambient		134.5	N/mm^2
Allowable Stress, Operating		134.5	N/mm^2
Allowable Stress, Hydrotest		174.8	N/mm^2
Material Density		0.00775	kg/cm^3
P Number Thickness		30.988	mm
Yield Stress, Operating		266.6	N/mm^2
UCS-66 Chart Curve Designation		B	
External Pressure Chart Name		CS-2	
UNS Number			
Class / Thickness / Grade	P355GH:: 6	< t <= 10	
Product Form		Plate	
Efficiency, Longitudinal Seam		0.85	
Efficiency, Head-to-Skirt or Circ. Seam		0.85	
Weld is pre-Heated		No	
Element From Node		10	
Detail Type		Insulation	
Detail ID		Insulation ext	
Dist. from "FROM" Node / Offset dist		350	mm
Height/Length of Insulation		600	mm
Thickness of Insulation		50	mm
Density		0.00016	kg/cm^3

Element From Node		20	
Element To Node		30	
Element Type		Elliptical	
Description	Elliptical bottom head		
Distance "FROM" to "TO"		50	mm
Element Outside Diameter		1066.8	mm
Element Thickness		6.35	mm
Internal Corrosion Allowance		3	mm
Nominal Thickness		0	mm
External Corrosion Allowance		0	mm
Design Internal Pressure		350	kPa
Design Temperature Internal Pressure		80	°C
Design External Pressure		0	kPa
Design Temperature External Pressure		80	°C
Effective Diameter Multiplier		1.2	
Material Name		SA-516 60	
Allowable Stress, Ambient		117.9	N/mm^2
Allowable Stress, Operating		117.9	N/mm^2
Allowable Stress, Hydrotest		153.3	N/mm^2
Material Density		0.00775	kg/cm^3
P Number Thickness		30.988	mm
Yield Stress, Operating		204.7	N/mm^2

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UCS-66 Chart Curve Designation	C	
External Pressure Chart Name	CS-2	
UNS Number	K02100	
Product Form	Plate	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Elliptical Head Factor	2.0	
Weld is pre-Heated	No	
Element From Node	20	
Detail Type	Liquid	
Detail ID	WS LIQUID 1/2	
Dist. from "FROM" Node / Offset dist	-263.52	mm
Height/Length of Liquid	313.52	mm
Liquid Density	0.0009996	kg/cm^3
Element From Node	20	
Detail Type	Insulation	
Detail ID	Insulation ext	
Dist. from "FROM" Node / Offset dist	-266.7	mm
Height/Length of Insulation	316.7	mm
Thickness of Insulation	50	mm
Density	0.00016	kg/cm^3
Element From Node	20	
Detail Type	Nozzle	
Detail ID	N2	
Dist. from "FROM" Node / Offset dist	0	mm
Nozzle Diameter	2	in.
Nozzle Schedule	XS	
Nozzle Class	150	
Layout Angle	0.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	5.3838	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	

Element From Node	30	
Element To Node	40	
Element Type	Cylinder	
Description	WS CYLINDER 1/2	
Distance "FROM" to "TO"	2500	mm
Element Outside Diameter	1066.8	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 60	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	

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Weld is pre-Heated	No	
Element From Node	30	
Detail Type	Liquid	
Detail ID	WS Liquid 2/2	
Dist. from "FROM" Node / Offset dist	0	mm
Height/Length of Liquid	850	mm
Liquid Density	0.0009996	kg/cm^3
Element From Node	30	
Detail Type	Insulation	
Detail ID	Insulation ext	
Dist. from "FROM" Node / Offset dist	0	mm
Height/Length of Insulation	2200	mm
Thickness of Insulation	50	mm
Density	0.00016	kg/cm^3
Element From Node	30	
Detail Type	Nozzle	
Detail ID	N3	
Dist. from "FROM" Node / Offset dist	700	mm
Nozzle Diameter	1	in.
Nozzle Schedule	XS	
Nozzle Class	150	
Layout Angle	135.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2.1591	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	
Element From Node	30	
Detail Type	Nozzle	
Detail ID	N4	
Dist. from "FROM" Node / Offset dist	2200	mm
Nozzle Diameter	1	in.
Nozzle Schedule	XS	
Nozzle Class	150	
Layout Angle	135.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2.1591	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	
Element From Node	30	
Detail Type	Nozzle	
Detail ID	K1A	
Dist. from "FROM" Node / Offset dist	950	mm
Nozzle Diameter	1	in.
Nozzle Schedule	XS	
Nozzle Class	150	
Layout Angle	45.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2.1591	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	
Element From Node	30	

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Detail Type	Nozzle	
Detail ID	K1B	
Dist. from "FROM" Node / Offset dist	1950	mm
Nozzle Diameter	1	in.
Nozzle Schedule	XS	
Nozzle Class	150	
Layout Angle	45.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2.1591	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	

Element From Node	30	
Detail Type	Nozzle	
Detail ID	HW	
Dist. from "FROM" Node / Offset dist	0	mm
Nozzle Diameter	8	in.
Nozzle Schedule	STD	
Nozzle Class	150	
Layout Angle	45.0	
Blind Flange (Y/N)	Y	
Weight of Nozzle (Used if > 0)	49.044	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	

Element From Node	30	
Detail Type	Weight	
Detail ID	WGHT:[1 OF 1]	
Dist. from "FROM" Node / Offset dist	850	mm
Miscellaneous Weight	87.271	kgf
Offset from Element Centerline	0	mm

Element From Node	40	
Element To Node	50	
Element Type	Cylinder	
Description	WS CYLINDER 2/2	
Distance "FROM" to "TO"	1636	mm
Element Outside Diameter	1066.8	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 60	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Weld is pre-Heated	No	

Element From Node	40	
Detail Type	Nozzle	
Detail ID	N1	

Dist. from "FROM" Node / Offset dist	1500	mm
Nozzle Diameter	10	in.
Nozzle Schedule	STD	
Nozzle Class	150	
Layout Angle	180.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	71.383	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	

Element From Node	40	
Detail Type	Weight	
Detail ID	N1-INNER1OF2	
Dist. from "FROM" Node / Offset dist	0	mm
Miscellaneous Weight	103.46	kgf
Offset from Element Centerline	0	mm

Element From Node	40	
Detail Type	For./Mom.	
Detail ID	N10 Nozle Laod	
Dist. from "FROM" Node / Offset dist	1500	mm
Force in X Direction	1445	kgf
Force in Y Direction	1445	kgf
Force in Z Direction	-778	kgf
Moment about X Axis	474	kgf-m
Moment about Y Axis	0	kgf-m
Moment about Z Axis	631	kgf-m
Force/Moment Combination Method	SRSS	

Element From Node	50	
Element To Node	60	
Element Type	Cylinder	
Description	WS CYLINDER 3/3	
Distance "FROM" to "TO"	320	mm
Element Outside Diameter	1066.8	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 60	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Weld is pre-Heated	No	

Element From Node	60	
Element To Node	70	
Element Type	Conical	
Description	CONE WS TO RISER	

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Distance "FROM" to "TO"	1000	mm
Element Outside Diameter	1066.8	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 60	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Cone Diameter at "To" End	508	mm
Design Length of Cone	1000	mm
Half Apex Angle of Cone	15.61036	degrees
Toriconical (Y/N)	N	
Weld is pre-Heated	No	

Element From Node	70	
Element To Node	80	
Element Type	Cylinder	
Description	Riser	
Distance "FROM" to "TO"	4544	mm
Element Outside Diameter	508	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 60	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Weld is pre-Heated	No	

Element From Node	70	
Detail Type	Platform	
Detail ID	PLT 1	
Dist. from "FROM" Node / Offset dist	4044	mm
Platform Start Angle (degrees)	0.0	
Platform End Angle (degrees)	360.0	
Platform Wind Area	14080	cm^2
Platform Weight	181.4	kgf
Platform Railing Weight	0.03	kgf/mm
Platform Grating Weight	0.003026	kg/cm^2
Platform Width	800	mm
Platform Height	1100	mm
Platform Clearance or End Offset	60	mm
Platform Force Coefficient	1.6	
Ladder Layout Angle	90.0	

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Ladder Start Elevation	39865	mm
Ladder End Elevation	43200	mm
Unit Weight of Ladder	0.04	kgf/mm
Platform Length (top head platform)	0	mm

Element From Node	80	
Element To Node	90	
Element Type	Conical	
Description	CONE	
Distance "FROM" to "TO"	385.7	mm
Element Outside Diameter	508	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 60	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Cone Diameter at "To" End	323.9	mm
Design Length of Cone	385.7	mm
Half Apex Angle of Cone	13.422951	degrees
Toriconical (Y/N)	N	
Weld is pre-Heated	No	

Element From Node	90	
Element To Node	100	
Element Type	Flange	
Description	FLANGE WN 12" 150# ASME B16.5	
Distance "FROM" to "TO"	114.3	mm
Flange Inside Diameter	323.9	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-350 LF2 [Impact Tested]	
Allowable Stress, Ambient	137.9	N/mm^2
Allowable Stress, Operating	137.9	N/mm^2
Allowable Stress, Hydrotest	179.3	N/mm^2
Material Density	0.00775	kg/cm^3
P Number Thickness	30.988	mm
Yield Stress, Operating	230.2	N/mm^2
UCS-66 Chart Curve Designation	Impact Tested	
External Pressure Chart Name	CS-2	

UNS Number	K03011	
Class / Thickness / Grade 1::		
Product Form	Forgings	
Perform Flange Stress Calculation (Y/N)	N	
Weight of ANSI B16.5/B16.47 Flange	0	kgf
Class of ANSI B16.5/B16.47 Flange	150	
Grade of ANSI B16.5/B16.47 Flange	GR 1.1	
Weld is pre-Heated	No	

Element From Node	100	
Element To Node	110	
Element Type	Flange	
Description	FLANGE WN 12" 150# ASME B16.5	
Distance "FROM" to "TO"	114.3	mm
Flange Inside Diameter	323.9	mm
Element Thickness	10	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-182 F316L	
Allowable Stress, Ambient	115.1	N/mm^2
Allowable Stress, Operating	115.1	N/mm^2
Allowable Stress, Hydrotest	149.7	N/mm^2
Material Density	0.008027	kg/cm^3
P Number Thickness	0	mm
Yield Stress, Operating	151.5	N/mm^2
External Pressure Chart Name	HA-4	
UNS Number	S31603	
Class / Thickness / Grade :: > 5		
Product Form	Forgings	
Perform Flange Stress Calculation (Y/N)	N	
Weight of ANSI B16.5/B16.47 Flange	0	kgf
Class of ANSI B16.5/B16.47 Flange	150	
Grade of ANSI B16.5/B16.47 Flange	GR 1.1	
Weld is pre-Heated	No	

Element From Node	110	
Element To Node	120	
Element Type	Cylinder	
Description	TIP	
Distance "FROM" to "TO"	4885.7	mm
Element Outside Diameter	323.9	mm
Element Thickness	6	mm
Internal Corrosion Allowance	0	mm
Nominal Thickness	0	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	350	kPa
Design Temperature Internal Pressure	80	°C

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Design External Pressure	0	kPa
Design Temperature External Pressure	80	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-213 TP316	
Allowable Stress, Ambient	137.9	N/mm^2
Allowable Stress, Operating	123.8	N/mm^2
Allowable Stress, Hydrotest	179.3	N/mm^2
Material Density	0.008027	kg/cm^3
P Number Thickness	0	mm
Yield Stress, Operating	183.5	N/mm^2
External Pressure Chart Name	HA-2	
UNS Number	S31600	
Product Form	Smls. tube	
Efficiency, Longitudinal Seam	1.0	
Efficiency, Circumferential Seam	1.0	
Weld is pre-Heated	No	

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XY Coordinate Calculations:

From	To	X (Horiz.) mm	Y (Vert.) mm	DX (Horiz.) mm	DY (Vert.) mm
	SKIRT	...	950	...	950
Elliptical bott		...	1000	...	50
WS CYLINDER 1/2		...	3500	...	2500
WS CYLINDER 2/2		...	5136	...	1636
WS CYLINDER 3/3		...	5456	...	320
CONE WS TO RISE		...	6456	...	1000
	Riser	...	11000	...	4544
	CONE	...	11385.7	...	385.7
FLANGE WN 12" 1		...	11500	...	114.3
FLANGE WN 12" 1		...	11623.8	...	114.3
	TIP	...	16509.5	...	4885.7

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Element Thickness, Pressure, Diameter and Allowable Stress :

From	To	Int. Press + Liq. Hd kPa	Nominal Thickness mm	Total Corr Allowance mm	Element Diameter mm	Allowable Stress(SE) N/mm^2
	SKIRT	...	...	3	1066.8	...
Elliptical botto		361.4	...	3	1066.8	100.22
WS CYLINDER 1/2		358.33	...	3	1066.8	100.22
WS CYLINDER 2/2		350	...	3	1066.8	100.22
WS CYLINDER 3/3		350	...	3	1066.8	100.22
CONE WS TO RISER		350	...	3	1066.8	100.22
	Riser	350	...	3	508	100.22
	CONE	350	...	3	508	100.22
FLANGE WN 12" 15		350	...	3	323.9	137.9
FLANGE WN 12" 15		350	...	3	323.9	115.1
	TIP	350	...	...	323.9	123.8

Element Required Thickness and MAWP :

From	To	Design Pressure kPa	M.A.W.P. Corroded kPa	M.A.P. New & Cold kPa	Minimum Thickness mm	Required Thickness mm
SKIRT	...	No Calc	No Calc	10	No Calc
Elliptical botto	350	621.533	1205.89	6.35	4.91749
WS CYLINDER 1/2	350	1313.69	1892.88	10	4.90463
WS CYLINDER 2/2	350	1322.02	1892.88	10	4.8604
WS CYLINDER 3/3	350	1322.02	1892.88	10	4.8604
CONE WS TO RISER	350	1273.01	1822.55	10	4.93166
Riser	350	2792.45	4008.37	10	4.5875
CONE	350	2715.34	3897.17	10	4.5875
FLANGE WN 12" 15	350	1833.99	1964.96	10	No Calc
FLANGE WN 12" 15	350	1833.99	1964.96	10	No Calc
TIP	350	4655.32	5185.53	6	1.5875
Minimum		621.533	1205.880		

MAWP: 621.533 kPa, limited by: Elliptical bottom head.

Internal Pressure Calculation Results :

ASME Code, Section VIII Division 1, 2023

Elliptical Head From 20 To 30 SA-516 60 , UCS-66 Crv. C at 80 °C

Elliptical bottom head

Material UNS Number: K02100

Required Thickness due to Internal Pressure [tr]:
= (P*Do*K)/(2*S*E+2*P*(K-0.1)) per Appendix 1-4 (c)
= (361.4*1067*1)/(2*117.9*0.85+2*361.4*(1-0.1))
= 1.9175 + 3.0000 = 4.9175 mm

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 11.405 kPa
= (2*S*E*t)/(K*Do-2*t*(K-0.1)) per Appendix 1-4 (c)
= (2*117.9*0.85*3.35)/(1*1067-2*3.35*(1-0.1))
= 632.938 - 11.405 = 621.533 kPa

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (2*S*E*t)/(K*Do-2*t*(K-0.1)) per Appendix 1-4 (c)
= (2*117.9*0.85*6.35)/(1*1067-2*6.35*(1-0.1))
= 1205.887 kPa

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(K*Do-2*t*(K-0.1)))/(2*E*t)
= (361.4*(1*1067-2*3.35*(1-0.1)))/(2*0.85*3.35)
= 67.320 N/mm^2

Straight Flange Required Thickness:

```
= (P*Ro)/(S*E+0.4*P) + ca   per Appendix 1-1 (a)(1)
= (361.4*533.4)/(117.9*0.85+0.4*361.4)+3
= 4.921 mm
```

Straight Flange Maximum Allowable Working Pressure:
Less Operating Hydrostatic Head Pressure of 8.822 kPa

```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9 * 0.85 * 3.35 )/(533.4 - 0.4 * 3.35 )
= 630.945 - 8.822 = 622.123  kPa
```

Percent Elong. per UCS-79, VIII-1-01-57 (75*tnom/Rf)*(1-Rf/Ro) 2.611 %

MDMT Calculations in the Knuckle Portion:

Govrn. thk, tg = 6.35, tr = 1.917, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.487, Temp. Reduction = 34 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C              -48 °C
```

MDMT Calculations in the Head Straight Flange:

Govrn. thk, tg = 6.35, tr = 1.921, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.487, Temp. Reduction = 34 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C              -48 °C
```

Cylindrical Shell From 30 To 40 SA-516 60 , UCS-66 Crv. C at 80 °C

WS CYLINDER 1/2

Material UNS Number: K02100

Required Thickness due to Internal Pressure [tr]:

```
= (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (358.3*533.4)/(117.9*0.85+0.4*358.3)
= 1.9046 + 3.0000 = 4.9046 mm
```

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 8.332 kPa

```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*7)/(533.4-0.4*7)
= 1322.021 - 8.332 = 1313.689  kPa
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*10)/(533.4-0.4*10)
= 1892.882 kPa
```

Actual stress at given pressure and thickness, corroded [Sact]:

```
= (P*(Ro-0.4*t))/(E*t)
= (358.3*((533.4-0.4*7))/(0.85*7)
= 31.957 N/mm^2
```

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 0.946 %

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Minimum Design Metal Temperature Results:

Govrn. thk, tg = 10, tr = 4.012, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.487, Temp. Reduction = 34 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C          -44 °C
Min Metal Temp. at Required thickness (UCS 66.1)        -48 °C
```

Cylindrical Shell From 40 To 50 SA-516 60 , UCS-66 Crv. C at 80 °C

WS CYLINDER 2/2

Material UNS Number: K02100

Required Thickness due to Internal Pressure [tr]:
```
= (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (350*533.4)/(117.9*0.85+0.4*350)
= 1.8604 + 3.0000 = 4.8604 mm
```

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*7)/(533.4-0.4*7)
= 1322.021 kPa
```

Maximum Allowable Pressure, New and Cold [MAPNC]:
```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*10)/(533.4-0.4*10)
= 1892.882 kPa
```

Actual stress at given pressure and thickness, corroded [Sact]:
```
= (P*(Ro-0.4*t))/(E*t)
= (350*((533.4-0.4*7))/(0.85*7)
= 31.214 N/mm^2
```

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 0.946 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 10, tr = 2.574, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.313, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C          -44 °C
Min Metal Temp. at Required thickness (UCS 66.1)       -104 °C
```

Cylindrical Shell From 50 To 60 SA-516 60 , UCS-66 Crv. C at 80 °C

WS CYLINDER 3/3

Material UNS Number: K02100

Required Thickness due to Internal Pressure [tr]:
```
= (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (350*533.4)/(117.9*0.85+0.4*350)
= 1.8604 + 3.0000 = 4.8604 mm
```

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*7)/(533.4-0.4*7)
= 1322.021 kPa

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*10)/(533.4-0.4*10)
= 1892.882 kPa

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Ro-0.4*t))/(E*t)
= (350*((533.4-0.4*7))/(0.85*7)
= 31.214 N/mm^2

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 0.946 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 10, tr = 1.86, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.226, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve C	-44 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Conical Section From 60 To 70 SA-516 60 , UCS-66 Crv. C at 80 °C

CONE WS TO RISER

Material UNS Number: K02100

Required Thickness due to Internal Pressure [tr]:
= (P*Do)/(2*cos(a)*(S*E+0.4*P)) per Appendix 1-4 (e)
= (350*1067)/(2*0.963*(117.9*0.85+0.4*350))
= 1.9317 + 3.0000 = 4.9317 mm

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
= (2*S*E*t*cos(a))/(D-0.8*t*cos(a)) per Appendix 1-4 (e)(5)
= (2*117.9*0.85*(7)*0.963)/(1067-0.8*(7)*0.963)
= 1273.009 kPa

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (2*S*E*t*cos(a))/(D-0.8*t*cos(a)) per Appendix 1-4(e)
= (2*117.9*0.85*10*0.963)/(1067-0.8*10*0.963)
= 1822.553 kPa

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(D-0.8*t*cos(a)))/(2*E*t*cos(a))
= (350*(1067-0.8*(7)*0.963))/(2*0.85*(7)*0.963)
= 32.415 N/mm^2

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 2.010 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 10, tr = 1.932, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.235, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C          -44 °C
Min Metal Temp. at Required thickness (UCS 66.1)       -104 °C
```

Cylindrical Shell From 70 To 80 SA-516 60 , UCS-66 Crv. C at 80 °C

Riser

Material UNS Number: K02100

Required Thickness due to Internal Pressure [tr]:
```
= (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (350*254)/(117.9*0.85+0.4*350)
= 0.8859 + 3.0000 = 3.8859 mm
```

Note: The thickness required was less than the Code Minimum, therefore the Code Minimum value of 1.5875 mm per UG-16 will be used.

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*7)/(254-0.4*7)
= 2792.454 kPa
```

Maximum Allowable Pressure, New and Cold [MAPNC]:
```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*10)/(254-0.4*10)
= 4008.367 kPa
```

Actual stress at given pressure and thickness, corroded [Sact]:
```
= (P*(Ro-0.4*t))/(E*t)
= (350*((254-0.4*7))/(0.85*7)
= 14.777 N/mm^2
```

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 2.008 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 10, tr = 2.643, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.321, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C          -44 °C
Min Metal Temp. at Required thickness (UCS 66.1)       -104 °C
```

Conical Section From 80 To 90 SA-516 60 , UCS-66 Crv. C at 80 °C

CONE

Material UNS Number: K02100

Required Thickness due to Internal Pressure [tr]:
```
= (P*Do)/(2*cos(a)*(S*E+0.4*P)) per Appendix 1-4 (e)
```

```
= (350*508)/(2*0.973*(117.9*0.85+0.4*350))
= 0.9108 + 3.0000 = 3.9108 mm
```

Note: The thickness required was less than the Code Minimum, therefore the Code Minimum value of 1.5875 mm per UG-16 will be used.

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:

```
= (2*S*E*t*cos(a))/(D-0.8*t*cos(a)) per Appendix 1-4 (e)(5)
= (2*117.9*0.85*(7)*0.973)/(508-0.8*(7)*0.973)
= 2715.345 kPa
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
= (2*S*E*t*cos(a))/(D-0.8*t*cos(a)) per Appendix 1-4(e)
= (2*117.9*0.85*10*0.973)/(508-0.8*10*0.973)
= 3897.167 kPa
```

Actual stress at given pressure and thickness, corroded [Sact]:

```
= (P*(D-0.8*t*cos(a)))/(2*E*t*cos(a))
= (350*(508-0.8*(7)*0.973))/(2*0.85*(7)*0.973)
= 15.197 N/mm^2
```

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 3.189 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 10, tr = 1.587, c = 3 mm, E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.193, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C          -44 °C
Min Metal Temp. at Required thickness (UCS 66.1)       -104 °C
```

Cylindrical Shell From 110 To 120 SA-213 TP316 at 80 °C

TIP

Material UNS Number: S31600

Required Thickness due to Internal Pressure [tr]:

```
= (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (350*161.9)/(123.8*1+0.4*350)
= 0.4574 + 0.0000 = 0.4574 mm
```

Note: The thickness required was less than the Code Minimum, therefore the Code Minimum value of 1.5875 mm per UG-16 will be used.

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:

```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (123.8*1*6)/(161.9-0.4*6)
= 4655.324 kPa
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (137.9*1*6)/(161.9-0.4*6)
= 5185.534 kPa
```

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Actual stress at given pressure and thickness, corroded [Sact]:

```
= (P*(Ro-0.4*t))/(E*t)
= (350*((161.9-0.4*6))/(1*6)
= 9.308 N/mm^2
```

SA-213 TP316, Min Metal Temp without impact per UHA-51: -196 °C

Note: Heads and Shells Exempted to -20F (-29C) by paragraph UG-20F

Hydrostatic Test Pressure Results:

```
Pressure per UG99b      = 1.30 * M.A.W.P. * Sa/S        807.993  kPa
Pressure per UG99b[36] = 1.30 * Design Pres * Sa/S      455.000  kPa
Pressure per UG99c      = 1.30 * M.A.P. - Head(Hyd)    1412.639  kPa
Pressure per UG100      = 1.10 * M.A.W.P. * Sa/S        683.686  kPa
Pressure per PED        = max(1.43*DP, 1.25*DP*ratio)   500.500  kPa
Pressure per App 27-4   = M.A.W.P.                      621.533  kPa
```

Pressure per the PED:
= max(1.43 * Design Pressure, 1.25 * Design Pressure * Stress ratio)
= max(1.43 * 350, 1.25 * 350 * 1)
= max(500.5, 437.5)
= 500.500 kPa

Vertical Test performed per: PED

Please note that Nozzle, Shell, Head, Flange, etc MAWPs are all considered when determining the hydrotest pressure for those test types that are based on the MAWP of the vessel.

Stresses on Elements due to Test Pressure (N/mm^2 & kPa):

From To	Stress	Allowable	Ratio	Pressure
Elliptical bottom he	64.1	153.3	0.418	655.50
WS CYLINDER 1/2	40.6	153.3	0.265	652.43
WS CYLINDER 2/2	39.1	153.3	0.255	627.93
WS CYLINDER 3/3	38.1	153.3	0.249	611.89
CONE WS TO RISER	39.4	153.3	0.257	608.75
Riser	17.6	153.3	0.115	598.95
CONE	16.8	153.3	0.109	554.41
TIP	14.6	179.3	0.081	548.39

Stress ratios for Nozzle and Pad Materials (N/mm^2):

Description	Pad/Nozzle	Ambient	Operating	Ratio
N2	Nozzle	117.90	117.90	1.000
N2	Pad	117.90	117.90	1.000
N3	Nozzle	117.90	117.90	1.000
N4	Nozzle	117.90	117.90	1.000
K1A	Nozzle	117.90	117.90	1.000
K1B	Nozzle	117.90	117.90	1.000
HW	Nozzle	117.90	117.90	1.000
HW	Pad	137.90	137.90	1.000

N1	Nozzle	117.90	117.90	1.000
N1	Pad	117.90	117.90	1.000
Minimum				1.000

Stress ratios for Pressurized Vessel Elements (N/mm^2):

Description	Ambient	Operating	Ratio
Elliptical bottom he	117.90	117.90	1.000
WS CYLINDER 1/2	117.90	117.90	1.000
WS CYLINDER 2/2	117.90	117.90	1.000
WS CYLINDER 3/3	117.90	117.90	1.000
CONE WS TO RISER	117.90	117.90	1.000
Riser	117.90	117.90	1.000
CONE	117.90	117.90	1.000
FLANGE WN 12" 150# A	137.90	137.90	1.000
FLANGE WN 12" 150# A	115.10	115.10	1.000
TIP	137.90	123.80	1.114
Minimum			1.000

Hoop Stress in Nozzle Wall during Pressure Test (N/mm^2):

Description	Ambient	Operating	Ratio
N2	3.31	153.28	0.022
N3	2.11	153.28	0.014
N4	2.07	153.28	0.013
K1A	2.11	153.28	0.014
K1B	2.07	153.28	0.014
HW	8.48	153.28	0.055
N1	8.79	153.28	0.057

Elements Suitable for Internal Pressure.

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External Pressure Calculation Results :

External Pressure Calculations:

From	To	Section Length mm	Outside Diameter mm	Corroded Thickness mm	Factor A	Factor B N/mm^2
10	20	950	...	...	No Calc	No Calc
20	30	No Calc	1066.8	3.35	0.00043614	43.6045
30	40	4593.84	1066.8	7	0.00016183	16.1796
40	50	4593.84	1066.8	7	0.00016183	16.1796
50	60	4593.84	1066.8	7	0.00016183	16.1796
60	70	737.907	1066.8	7	0.00099569	85.1672
70	80	4544	508	7	0.00023648	23.6426
80	90	315.734	508	7	0.0035425	114.682
90	100	No Calc	...	7	No Calc	No Calc
100	110	No Calc	...	7	No Calc	No Calc

110	120	4885.7	323.9	6	0.00037746	35.7443

External Pressure Calculations:

From	To	External Actual T. mm	External Required T. mm	External Design Pressure kPa	External M.A.W.P. kPa
10	20	...	No Calc	...	No Calc
20	30	6.35	4.5875	...	152.134
30	40	10	No Calc	...	141.545
40	50	10	No Calc	...	141.545
50	60	10	No Calc	...	141.545
60	70	10	No Calc	...	717.594
70	80	10	No Calc	...	434.353
80	90	10	No Calc	...	2049.35
90	100	10	7	...	No Calc
100	110	10	7	...	No Calc
110	120	6	No Calc	...	882.795
Minimum					141.545

External Pressure Calculations:

From	To	Actual Length Bet. Stiffeners mm	Allowable Length Bet. Stiffeners mm	Ring Inertia Required cm**4	Ring Inertia Available cm**4
10	20	950	No Calc	No Calc	No Calc
20	30	No Calc	No Calc	No Calc	No Calc
30	40	4593.84	No Calc	No Calc	No Calc
40	50	4593.84	No Calc	No Calc	No Calc
50	60	4593.84	No Calc	No Calc	No Calc
60	70	737.907	737.907	No Calc	No Calc
70	80	4544	No Calc	No Calc	No Calc
80	90	315.734	315.734	No Calc	No Calc
90	100	No Calc	No Calc	No Calc	No Calc
100	110	No Calc	No Calc	No Calc	No Calc
110	120	4885.7	No Calc	No Calc	No Calc

Elements Suitable for External Pressure.

ASME Code, Section VIII Division 1, 2023

Elliptical Head From 20 to 30 Ext. Chart: CS-2 at 80 °C

Elliptical bottom head

Elastic Modulus from Chart: CS-2 at 80 °C : 0.200E+09 kPa

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	D/t	Factor A	B
3.350	1066.80	318.45	0.0004361	43.60

EMAP = B/(K0*D/t) = 43.6/(0.9 *318.4) = 152.1 kPa

*Check the requirements of UG-33(a)(1) using P = 1.67 * External Design pressure for this head.*

Material UNS Number: K02100

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:

```
  = ((2*S*E*t)/(K*D+0.2*t))/1.67 per Appendix 1-4 (c)
  = ((2*117.9*1*3.35)/(1*1060+0.2*3.35))/1.67
  = 445.888 kPa
```

Maximum Allowable External Pressure [MAEP]:

```
  = min( MAEP, MAWP )
  = min( 152.1, 445.9 )
  = 152.134 kPa
```

Cylindrical Shell From 30 to 40 Ext. Chart: CS-2 at 80 °C

WS CYLINDER 1/2

Elastic Modulus from Chart: CS-2 at 80 °C : 0.200E+09 kPa

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	1066.80	4593.84	152.40	4.3062	0.0001618	16.18

EMAP = (4*B)/(3*(D/t)) = (4*16.18)/(3*152.4) = 141.5 kPa

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	1066.80	4593.84	152.40	4.3062	0.0001618	16.18

EMAP = (4*B)/(3*(D/t)) = (4*16.18)/(3*152.4) = 141.5 kPa

Cylindrical Shell From 40 to 50 Ext. Chart: CS-2 at 80 °C

WS CYLINDER 2/2

Elastic Modulus from Chart: CS-2 at 80 °C : 0.200E+09 kPa

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	1066.80	4593.84	152.40	4.3062	0.0001618	16.18

EMAP = (4*B)/(3*(D/t)) = (4*16.18)/(3*152.4) = 141.5 kPa

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	1066.80	4593.84	152.40	4.3062	0.0001618	16.18

EMAP = (4*B)/(3*(D/t)) = (4*16.18)/(3*152.4) = 141.5 kPa

Cylindrical Shell From 50 to 60 Ext. Chart: CS-2 at 80 °C

WS CYLINDER 3/3

Elastic Modulus from Chart: CS-2 at 80 °C : 0.200E+09 kPa

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Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	1066.80	4593.84	152.40	4.3062	0.0001618	16.18

EMAP = (4*B)/(3*(D/t)) = (4*16.18)/(3*152.4) = 141.5 kPa

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	1066.80	4593.84	152.40	4.3062	0.0001618	16.18

EMAP = (4*B)/(3*(D/t)) = (4*16.18)/(3*152.4) = 141.5 kPa

Cone From 60 to 70 Ext. Chart: CS-2 at 80 °C

CONE WS TO RISER

Elastic Modulus from Chart: CS-2 at 80 °C : 0.200E+09 kPa

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
6.742	1066.80	737.91	158.24	0.6917	0.0009957	85.17

EMAP = (4*B)/(3*(D/t)) = (4*85.17)/(3*158.2) = 717.6 kPa

Note: The cone thickness used in the calculation has been modified per UG-33(f), te = t * cos(alpha).

Cylindrical Shell From 70 to 80 Ext. Chart: CS-2 at 80 °C

Riser

Elastic Modulus from Chart: CS-2 at 80 °C : 0.200E+09 kPa

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	508.00	4544.00	72.57	8.9449	0.0002365	23.64

EMAP = (4*B)/(3*(D/t)) = (4*23.64)/(3*72.57) = 434.4 kPa

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
7.000	508.00	4544.00	72.57	8.9449	0.0002365	23.64

EMAP = (4*B)/(3*(D/t)) = (4*23.64)/(3*72.57) = 434.4 kPa

Cone **From 80 to 90 Ext. Chart: CS-2 at 80 °C**

CONE

Elastic Modulus from Chart: CS-2 at 80 °C : 0.200E+09 kPa

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
6.809	508.00	315.73	74.61	0.6215	0.0035425	114.68

EMAP = (4*B)/(3*(D/t)) = (4*114.7)/(3*74.61) = 2049 kPa

Note: The cone thickness used in the calculation has been modified per UG-33(f), te = t * cos(alpha).

Cylindrical Shell From 110 to 120 Ext. Chart: HA-2 at 80 °C

TIP

Elastic Modulus from Chart: HA-2 at 80 °C : 0.189E+09 kPa

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
6.000	323.90	4885.70	53.98	15.0840	0.0003775	35.74

EMAP = (4*B)/(3*(D/t)) = (4*35.74)/(3*53.98) = 882.8 kPa

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
6.000	323.90	4885.70	53.98	15.0840	0.0003775	35.74

EMAP = (4*B)/(3*(D/t)) = (4*35.74)/(3*53.98) = 882.8 kPa

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Element and Detail Weights:

From	To	Element Metal Wgt. kgm	Element ID Volume cm3	Corroded Metal Wgt. kgm	Corroded ID Volume cm3	Extra due Misc % kgm
10	20	244.454	...	208.063	...	...
20	30	74.4388	196948	39.2708	200079	...
30	40	643.301	2151570	451.589	2176305	...
40	50	420.976	1407987	295.519	1424174	...
50	60	82.3426	275401	57.8033	278567	...
60	70	196.441	482036	138.06	489568	...
70	80	550.994	849897	388.019	870924	...
80	90	39.1679	48212.7	27.626	49701.9	...
90	100	...	9417.95	...	9770.1	...
100	110	...	9417.95	...	9770.1	...
110	120	235.011	373289	235.011	373289	...
Total		2487	5823012.50	1840	5901690.50	0

Weight of Details:

From	Type	Weight of Detail kgm	X Offset, Dtl. Cent. mm	Y Offset, Dtl. Cent. mm	Description
10	Insl	16.8396	...	650	Insulation ext
20	Liqd	196.864	...	-131.762	WS LIQUID 1/2
20	Insl	12.742	...	-108.35	Insulation ext
20	Nozl	5.38381	...	-388.531	N2
30	Liqd	731.221	...	425	WS Liquid 2/2
30	Insl	61.7452	...	1100	Insulation ext
30	Nozl	2.15915	535.554	700	N3
30	Nozl	2.15915	535.554	2200	N4
30	Nozl	2.15915	535.554	950	K1A
30	Nozl	2.15915	535.554	1950	K1B
30	Nozl	49.0437	624.759	...	HW
30	Wght	87.2711	...	850	WGHT:[1 OF 1]
40	Nozl	71.383	659.925	1500	N1
40	Wght	103.456	...	...	N1-INNER1OF2
40	Forc	...	...	1500	N10 Nozle Laod

```
    70|Plat|      181.4 |0.14523E-04 |      4044 |   PLT 1
 ------------------------------------------------
```

Total Weight of Each Detail Type:

```
 Platforms                          181.4
 Liquid                             928.1
 Insulation                          91.3
 Nozzles                            134.4
 Weights                            190.7
 ----------------------------------------
 Sum of the Detail Weights        1526.0 kgm
```

Weight Summation Results: (kgm)

```
                | Fabricated |  Shop Test |   Shipping |    Erected |      Empty |
Operating |
 ------------------------------------------------------------------------------------
-----
 Main Elements |     2487.1 |     2487.1 |     2487.1 |     2487.1 |     2487.1 |
2487.1 |
       Nozzles |      134.4 |      134.4 |      134.4 |      134.4 |      134.4 |
134.4 |
   Wld Weights |      190.7 |      190.7 |      190.7 |      190.7 |      190.7 |
190.7 |
     Platforms |        ... |        ... |      181.4 |      181.4 |      181.4 |
181.4 |
    Insulation |        ... |        ... |       91.3 |       91.3 |       91.3 |
91.3 |
   Ope. Liquid |        ... |        ... |        ... |        ... |        ... |
928.1 |
   Test Liquid |        ... |     5820.5 |        ... |        ... |        ... |
... |
 ------------------------------------------------------------------------------------
-----
        Totals |     2812.3 |     8632.8 |     3085.0 |     3085.0 |     3085.0 |
4013.1 |
```

Field Installation Options:

Weight Summary:

```
 Fabricated Wt.  - Bare Weight without Removable Internals              2812.3 kgm
 Shop Test Wt.   - Fabricated Weight + Water ( Full )                   8632.8 kgm
 Shipping Wt.    - Fab. Weight + removable Intls.+ Shipping App.        3085.0 kgm
 Erected  Wt.    - Fab. Wt + or - loose items (trays,platforms etc.)    3085.0 kgm
 Ope. Wt. no Liq - Fab. Weight + Internals. + Details + Weights         3085.0 kgm
 Operating Wt.   - Empty Weight + Operating Liq. Uncorroded             4013.1 kgm
 Field Test Wt.  - Empty Weight + Water (Full)                          8905.6 kgm
 Mass of the Upper 1/3 of the Vertical Vessel                            262.2 kgm
```

Outside Surface Areas of Elements:

```
      |    |        Surface |
  From| To |           Area |
      |    |           cm^2 |
 ----------------------------
```

10	20	31838.8
20	30	14012.2
30	40	83786.3
40	50	54829.7
50	60	10724.6
60	70	25684.3
70	80	72519
80	90	5181.67
90	100	823.971
100	110	823.971
110	120	49715
Total		349939.500 cm^2

Element and Detail Weights:

From	To	Total Ele. Empty Wgt. kgm	Total. Ele. Oper. Wgt. kgm	Total. Ele. Hydro. Wgt. kgm	Total Dtl. Offset Mom. kgf-m	Oper. Wgt. No Liquid kgm
10	20	261.293	261.293	261.293	...	261.293
20	30	92.5645	289.428	289.428	...	92.5645
30	40	849.998	1581.22	3000.65	35.2665	849.998
40	50	595.815	595.815	2003.2	47.1083	595.815
50	60	82.3426	82.3426	357.626	...	82.3426
60	70	196.441	196.441	678.271	...	196.441
70	80	732.394	732.394	1581.93	0.26346E-05	732.394
80	90	39.1679	39.1679	87.36	...	39.1679
90	100	...	...	9.41392	...	...
100	110	...	...	9.41392	...	...
110	120	235.011	235.011	608.141	...	235.011

Empty Support Force + the Sum of the Y forces	1640.03	kgf
Operating Support Force + the Sum of the Y forces	2568.11	kgf
Hydro Support Force + the Sum of the Y forces	7441.72	kgf

Cumulative Vessel Weight

From	To	Cumulative Ope Wgt. No Liquid kgm	Cumulative Oper. Wgt. kgm	Cumulative Hydro. Wgt. kgm
10	20	3085.03	4013.11	8886.72
20	30	2823.73	3751.82	8625.43
30	40	2731.17	3462.39	8336
40	50	1881.17	1881.17	5335.35
50	60	1285.36	1285.36	3332.15
60	70	1203.01	1203.01	2974.53
70	80	1006.57	1006.57	2296.26
80	90	274.179	274.179	714.329
90	100	235.011	235.011	626.969
100	110	235.011	235.011	617.555
110	120	235.011	235.011	608.141

Note: The cumulative operating weights no liquid in the column above

are the cumulative operating weights minus the operating liquid weight minus any weights absent in the empty condition.

Cumulative Vessel Moment

From	To	Cumulative Empty Mom. kgf-m	Cumulative Oper. Mom. kgf-m	Cumulative Hydro. Mom. kgf-m
10	20	82.3749	82.3749	82.3749
20	30	82.3749	82.3749	82.3749
30	40	82.3749	82.3749	82.3749
40	50	47.1084	47.1084	47.1084
50	60	0.26346E-05	0.26346E-05	0.26346E-05
60	70	0.26346E-05	0.26346E-05	0.26346E-05
70	80	0.26346E-05	0.26346E-05	0.26346E-05
80	90	...	...	...
90	100	...	...	...
100	110	...	...	...
110	120	...	...	...

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Nozzle Flange MAWP Results:

Nozzle Description	Flange Rating Ope. kPa	Ambient kPa	Design Temp °C	Class	Grade/ Group	Equiv. Press	Max Pressure PVP	50% DNV kPa
N2	1834.0	1965.0	80	150	GR 1.1	...	...	... ...
N3	1834.0	1965.0	80	150	GR 1.1	...	...	... ...
N4	1834.0	1965.0	80	150	GR 1.1	...	...	... ...
K1A	1834.0	1965.0	80	150	GR 1.1	...	...	... ...
K1B	1834.0	1965.0	80	150	GR 1.1	...	...	... ...
HW	1834.0	1965.0	80	150	GR 1.1	...	...	... ...
N1	1834.0	1965.0	80	150	GR 1.1	...	...	... ...
Min Rating	833.988	1964.961 kPa [for Core Elements]				0.000	0.000	0.000

Selected Method for Derating ANSI B16.5 Flange MAWP: None Selected

ANSI Ratings are per ANSI/ASME B16.5 2013 Edition

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Natural Frequency for the Operating Case (No Liquid), Freese Method

Natural Frequency Calculation:

From	To	Element Total Wgt. kgm	Centroid Deflection mm	Elem. End Deflection mm	Elem. Ang. Rotation	Element Empty Wgt. kgm
10	20	261.293	0.022501	0.08735	0.00017837	261.293
20	30	92.5645	0.091942	0.096799	0.00019959	92.5645
30	40	849.998	0.49252	1.13349	0.00059364	849.998
40	50	595.815	1.6555	2.24123	0.00074995	595.815
50	60	82.3426	2.3622	2.48507	0.00077371	82.3426
60	70	196.441	2.89338	3.34107	0.00093134	196.441
70	80	732.394	6.53869	11.0859	0.0021636	732.394
80	90	39.1679	11.5066	11.934	0.0022323	39.1679
90	100	...	12.062	12.191	0.0022652	...
100	110	...	12.3209	12.4518	0.002298	...
110	120	235.011	18.8898	26.0078	0.0029332	235.011

The Natural Frequency for the Vessel (Empty.) is 4.86808 Hz.

Natural Frequency for the Operating Case, Freese Method

Natural Frequency Calculation:

From	To	Element Total Wgt. kgm	Centroid Deflection mm	Elem. End Deflection mm	Elem. Ang. Rotation	Element Empty Wgt. kgm
10	20	261.293	0.024872	0.096009	0.00019486	261.293
20	30	289.428	0.10102	0.10632	0.00021753	92.5645
30	40	1581.22	0.53207	1.20936	0.00062304	849.998
40	50	595.815	1.75541	2.36519	0.00077934	595.815
50	60	82.3426	2.49086	2.61843	0.00080311	82.3426
60	70	196.441	3.04145	3.50383	0.00096074	196.441
70	80	732.394	6.76824	11.3822	0.002193	732.394
80	90	39.1679	11.8086	12.2416	0.0022617	39.1679
90	100	...	12.3714	12.502	0.0022945	...
100	110	...	12.6337	12.7662	0.0023274	...
110	120	235.011	19.276	26.4658	0.0029626	235.011

The Natural Frequency for the Vessel (Ope...) is 4.90294 Hz.

Natural Frequency for the Filled Case, Freese Method

The Natural Frequency for the Vessel (Filled) is 3.64821 Hz.

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Forces/Moments Applied to Vessel (Combined w/Wind Loads)

From	To	X and Z Dir Force Res. kgf	X,Z Moment and For Res kgf-m
10	20	...	...
20	30	...	...
30	40	...	...
40	50	1641.13	3250.94
50	60	...	...
60	70	...	...
70	80	...	...
80	90	...	...
90	100	...	...
100	110	...	...
110	120	...	...

Forces/Moments Applied to Vessel (Combined w/Seismic Loads)

From	To	X and Z Dir Force Res. kgf	X,Z Moment and For Res kgf-m
10	20	...	...
20	30	...	...
30	40	...	...
40	50	1641.13	3250.94
50	60	...	...
60	70	...	...
70	80	...	...
80	90	...	...
90	100	...	...
100	110	...	...
110	120	...	...

User Input Forces and Moments:

From Node	Distance From	Forces Fx	Fy	Fz	Moments Mx	My	Mz
40	1500.00	1445.	1445.	-778.	474.		631.

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Wind Load results per EN 1991-1-4:2005+A1:2010

Input Data:

Fundamental Wind Velocity	Vb	100.800 Km/hr
Air Density per Section 4.5	Rho	1.250 kg/m³
Wind Direction Factor	Cdir	1.000
Season Factor	CSeason	1.000
Structural Factor	CsCd	1.000
Wind Force Coefficient	Cf	0.700
Vessel Base Height (site)	Hb	31310.000 mm
Terrain Category		0

Note: The Wind Load Results below are in Metric Units.

Category 2 Basic Wind Velocity [Vb]:

$= Cdir * CSeason * Vb,0$
$= 1 * 1 * 28$
$= 28.001\ m/s$

Terrain Factor dependant on Roughness Length [kr]:

$= 0.19 * (Zo / Z0,ii) ^ 0.07$
$= 0.19 * (0.003/0.05)^{0.07}$
$= 0.156$

Sample Calculation for the first Element:

Determine the Roughness factor as a function of Elevation [Cr(z)]:

$= kr * ln(z / zo)$
$= 0.156 * ln(31.78/0.003)$
$= 1.446$

Mean Velocity at Height z [Vm(z)]:

$= cr(z) * 1.0 * Vb$
$= 1.446 * 1.0 * 28$
$= 40.493\ m/s$

Turbulence Intensity at Height z [Vm(z)]:

$= 1.0 / (1.0 * ln(z / zo))$
$= 1.0/(1.0 * ln(31.78/0.003))$
$= 0.108$

Peak Velocity Pressure at Height z [qp(z)]:

$= [1.0 + 7.0 * Iv(z)] * 1/2 * 1.25 * Vm(z)^2$
$= [1.0 + 7.0 * 0.108] * 1/2 * 1.25 * 40.49^2$
$= 1798.849\ N/m^2$

Force on the First Element at Height z [Fw(z)]:

$= qp(z) * CsCd * Aref * Cf$
$= 1799 * 1 * 1.288 * 0.7$
$= 1622.039\ Newtons$

Note: The orography factor co(z) and the turbulence factor ki(z) are taken to be 1.0.

Wind Vibration Calculations

This evaluation is based on work by Kanti Mahajan and Ed Zorilla

Nomenclature

Cf - Correction factor for natural frequency
D - Average internal diameter of vessel mm
Df - Damping Factor < 0.75 Unstable, > 0.95 Stable
Dr - Average internal diameter of top half of vessel mm
f - Natural frequency of vibration (Hertz)
f1 - Natural frequency of bare vessel based on a unit value of $(D/L^2)(10^4)$
L - Total height of structure mm
Lc - Total length of conical section(s) of vessel mm

```
tb  - Uncorroded plate thickness at bottom of vessel mm
V30 - Design Wind Speed provided by user Km/hr
Vc  - Critical wind velocity Km/hr
Vw  - Maximum wind speed at top of structure Km/hr
W   - Total corroded weight of structure kgf
Ws  - Cor. vessel weight excl. weight of parts which do not effect stiff. kgf
 Z  - Maximum amplitude of vibration at top of vessel mm
Dl  - Logarithmic decrement ( taken as 0.03 for Welded Structures )
Vp  - Vib. Chance, <= 0.32037E-06 (High); 0.32037E-06 < 0.40047E-06 (Probable)
P30 - wind pressure 30 feet above the base
```

Check other Conditions and Basic Assumptions:

```
#1 - Total Cone Length / Total Length < 0.5
     1386/16510 = 0.0839

#2 - ( D / L² ) * 10⁴ < 8.0 (English Units)
   - ( 2.189/54.17² ) * 10⁴ = 7.462
```

Compute the vibration possibility. If Vp > 0.40047E-06 no chance. [Vp]:

```
  = W / ( L * Dr²)
  = 3367/( 16510 * 377.2² )
  = 0.14333E-05
```

Since Vp is > 0.40047E-06 no further vibration analysis is required !

Platform Load Calculations

ID	Wind Area cm^2	Elevation mm	Pressure kg/m^2	Force kgf	Cf
PLT 1	14080.00	41810.00	192.03	270.38	1.60

Wind Loads on Masses/Equipment/Piping

ID	Wind Area cm^2	Elevation mm	Pressure kg/m^2	Force kgf
WGHT:[1 OF 1]	3153.73	33985.00	185.51	58.51
N1-INNER1OF2	3738.60	35628.00	187.00	69.91

The Natural Frequency for the Vessel (Ope...) is 4.90294 Hz.

Wind Load Calculation:

From	To	Wind Height mm	Wind Diameter mm	Wind Area cm^2	Wind Pressure kg/m^2	Element Wind Load kgf
10	20	31785	1355.95	12881.5	183.435	165.4
20	30	32285	1400.16	700.08	183.921	9.01285
30	40	33560	1385.76	34644	185.127	508.18
40	50	35628	1280.16	20943.4	186.997	344.047
50	60	36606	1280.16	4096.51	187.847	53.8645
60	70	37205.3	943.961	9439.61	188.357	124.457
70	80	40038	609.6	27700.2	190.672	652.054

80	90	42487.9	498.466	1922.58	192.554	25.9133
90	100	42752.8	388.68	444.261	192.752	5.99407
100	110	42876.7	388.68	444.261	192.844	5.99693
110	120	45376.7	388.68	18989.7	194.65	258.736

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Input Values for G Loading:

Horizontal Acceleration factor	(GX)	0.700
Horizontal Acceleration factor	(GZ)	0.700
Vertical Acceleration factor	(GY)	0.700

Computed Results:

The Natural Frequency for the Vessel (Ope...) is 4.90294 Hz.

Earthquake Load Calculation:

From	To	Earthquake Height mm	Earthquake Weight kgf	Element Ope Load kgf	Element Emp Load kgf
10	20	475	261.293	258.667	258.667
20	30	975	289.428	286.519	91.6342
30	40	2250	1581.22	1565.33	841.455
40	50	4318	595.815	589.827	589.827
50	60	5296	82.3426	81.515	81.515
60	70	5956	196.441	194.467	194.467
70	80	8728	732.394	725.033	725.033
80	90	11192.8	39.1679	38.7742	38.7742
90	100	11442.8	...	...	...
100	110	11566.7	...	...	...
110	120	14066.7	235.011	232.649	232.649

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Bending Moments due to user defined forces and moments.

User Force/Moment Shear and Bending

From	To	Distance to Support mm	Cumulative Shr Wind Cas kgf	Cumulative Shr Eqk Cas kgf	Wind Bending kgf-m	Earthquake Bending kgf-m
10	20	475	1641.13	1641.13	8986.89	8986.89
20	30	975	1641.13	1641.13	7427.95	7427.95
30	40	2250	1641.13	1641.13	7345.9	7345.9
40	50	4318	1641.13	1641.13	3244.19	3244.19
50	60	5296	...	...	...	...
60	70	5956	...	...	...	...
70	80	8728	...	...	...	...
80	90	11192.8	...	...	...	...
90	100	11442.8	...	...	...	...
100	110	11566.7	...	...	...	...

110	120	14066.7	...	...	...	...

Note:
The Wind Shears/Moments and the Earthquake Shears/Moments calculated and printed in the Wind/Earthquake Shear and Bending report have been factored by the input Scalar/Load reductions factors of;
Wind: 1.000; Earthquake: 1.000.

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The following table is for the Operating Case.

Wind/Earthquake Shear, Bending:

From	To	Distance to Support mm	Cumulative Wind Shear kgf	Earthquake Shear kgf	Wind Bending kgf-m	Earthquake Bending kgf-m
10	20	475	2153.66	3972.78	13501.8	18096.1
20	30	975	1988.26	3714.11	11534.4	14444.7
30	40	2250	1979.24	3427.59	11435.2	14266.2
40	50	4318	1471.06	1862.26	7122.23	7653.73
50	60	5296	1127.02	1272.44	4996.96	5089.49
60	70	5956	1073.15	1190.92	4644.93	4695.34
70	80	8728	948.694	996.456	3633.98	3601.63
80	90	11192.8	296.641	271.423	804.526	720.951
90	100	11442.8	270.727	232.649	695.107	623.739
100	110	11566.7	264.733	232.649	661.983	594.93
110	120	14066.7	258.736	232.649	632.066	568.338

Note:
The Wind Shears/Moments and the Earthquake Shears/Moments calculated and printed in the Wind/Earthquake Shear and Bending report have been factored by the input Scalar/Load reductions factors of;
Wind: 1.000; Earthquake: 1.000.

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Wind Deflection Calculations:

The following table is for the Applied Forces Case.

Wind Deflection:

From	To	Cumulative Wind Shear kgf	Centroid Deflection mm	Elem. End Deflection mm	Elem. Ang. Rotation
10	20	1641.13	0.012094	0.046937	0.95783E-04
20	30	1641.13	0.049403	0.052011	0.00010713
30	40	1641.13	0.26325	0.59739	0.00030378
40	50	1641.13	0.85061	1.10773	0.00031466
50	60	...	1.15807	1.20842	0.00031466
60	70	...	1.36575	1.52308	0.00031466

70	80	...	2.23798	2.95288	0.00031466
80	90	...	3.01356	3.07424	0.00031466
90	100	...	3.09222	3.1102	0.00031466
100	110	...	3.12819	3.14617	0.00031466
110	120	...	3.91483	4.68349	0.00031466

Allowable deflection at the Tower Top (For)(6.000"/100ft. Criteria)
Allowable deflection : 82.548 Actual deflection : 4.683 mm

The following table is for the Operating Case.

Wind Deflection:

From	To	Cumulative Wind Shear kgf	Centroid Deflection mm	Elem. End Deflection mm	Elem. Ang. Rotation
10	20	2153.66	0.018465	0.072	0.00014771
20	30	1988.26	0.075805	0.079833	0.00016556
30	40	1979.24	0.41172	0.95847	0.00051032
40	50	1471.06	1.40978	1.92146	0.00065821
50	60	1127.02	2.02772	2.13584	0.0006814
60	70	1073.15	2.49763	2.89838	0.00083732
70	80	948.694	5.89415	10.2938	0.0021126
80	90	296.641	10.7051	11.1236	0.0021884
90	100	270.727	11.2492	11.3758	0.0022247
100	110	264.733	11.5035	11.6322	0.0022608
110	120	258.736	18.0626	25.2416	0.0029601

Critical Wind Velocity for Tower Vibration:

From	To	1st Crit. Wind Speed Km/hr	2nd Crit. Wind Speed Km/hr
10	20	119.344	745.901
20	30	123.235	770.221
30	40	121.968	762.3
40	50	112.674	704.21
50	60	112.674	704.21
60	70	83.0829	519.268
70	80	53.6541	335.338
80	90	43.8726	274.204
90	100	34.2098	213.811
100	110	34.2098	213.811
110	120	34.2098	213.811

Allowable deflection at the Tower Top (Ope)(6.000"/100ft. Criteria)
Allowable deflection : 82.548 Actual deflection : 25.242 mm

Total Deflection in the Operating Condition + Applied Forces :
Allowable deflection : 82.548 Actual deflection : 29.925 mm

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Longitudinal Stress Constants:

From	To	Metal Area New cm^2	Metal Area Corroded cm^2	Section Modulus New mm³	Section Modulus Corroded mm³
10	20	332.004	233.063	8690112	6134741
20	30	211.55	111.92	5575274	2966227
30	40	332.004	233.062	8690095	6134733
40	50	332.004	233.062	8690095	6134733
50	60	332.004	233.062	8690095	6134733
60	70	344.594	241.927	9013156	6364886
70	80	156.451	110.175	1910244	1361197
80	90	160.754	113.225	1960618	1397796
90	100	160.754	114.532	1960618	1413453
100	110	59.9227	30.2441	467580	240407
110	120	59.9227	59.9227	467580	467580

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Longitudinal Allowable Stresses:

From	To	Tensile N/mm^2	Hydrotest Tensile N/mm^2	Compressive N/mm^2	Hydrotest Compressive N/mm^2
10	20	137.19	178.296	-118.874	-128.609
20	30	120.258	156.366	-93.0141	-115.899
30	40	120.258	156.366	-118.874	-128.609
40	50	120.258	156.366	-118.874	-128.609
50	60	120.258	156.366	-118.874	-128.609
60	70	120.258	156.366	-119.985	-129.529
70	80	120.258	156.366	-137.086	-143.047
80	90	120.258	156.366	-137.614	-143.434
90	100	165.48	215.16	-137.833	-143.434
100	110	138.12	179.64	-84.5316	-103.301
110	120	148.56	215.16	-107.249	-110.081

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Longitudinal Stress Report

Note: Longitudinal Operating and Empty Stresses are computed in the corroded condition. Stresses due to loads in the hydrostatic test cases have been computed in the new and cold condition.

Longitudinal Pressure Stresses due to:

From	To	Longitudinal Stress Internal Pressure N/mm^2	Longitudinal Stress External Pressure N/mm^2	Longitudinal Stress Hydrotest Pressure N/mm^2
10	20	...	...	...

20	30	27.6208	...	20.6718
30	40	13.0908	...	12.9987
40	50	13.0908	...	12.9987
50	60	13.0908	...	12.9987
60	70	13.0814	...	12.9853
70	80	6.10535	...	6.00635
80	90	6.09847	...	5.99651
90	100	...	...	...
100	110	...	...	...
110	120	4.4788	...	6.40469

Longitudinal Stresses due to Weight Loads for these Conditions:

From	To	Wght. Str. Empty N/mm^2	Wght. Str. Operating N/mm^2	Wght. Str. Hydrotest N/mm^2	Wght. Str. Emp. Mom. N/mm^2	Wght. Str. Opr. Mom. N/mm^2
10	20	-1.29812	-1.68864	-2.62499	0.13168	0.13168
20	30	-2.47425	-2.47425	-1.309	0.27234	0.27234
30	40	-1.14923	-1.14923	-0.80674	0.13168	0.13168
40	50	-0.79156	-0.79156	-0.55567	0.075305	0.075305
50	60	-0.54086	-0.54086	-0.37967	0.42114E-08	0.42114E-08
60	70	-0.48766	-0.48766	-0.34237	0.40592E-08	0.40592E-08
70	80	-0.89596	-0.89596	-0.63095	0.18980E-07	0.18980E-07
80	90	-0.23748	-0.23748	-0.16726	...	...
90	100	-0.20123	-0.20123	-0.14337	...	...
100	110	-0.76204	-0.76204	-0.38461	...	...
110	120	-0.38461	-0.38461	-0.38461	...	...

Longitudinal Stresses due to Weight Loads and Bending for these Conditions:

From	To	Wght. Str. Hyd. Mom. N/mm^2	Bend. Str. Oper. Wind N/mm^2	Bend. Str. Oper. Equ. N/mm^2	Bend. Str. Hyd. Wind N/mm^2	Bend. Str. Hyd. Equ. N/mm^2
10	20	0.092959	21.5832	28.9273	5.02807	...
20	30	0.14489	38.1338	47.7557	6.69518	...
30	40	0.092959	18.2797	22.8051	4.25847	...
40	50	0.053161	11.3852	12.2348	2.65232	...
50	60	0.29731E-08	7.98786	8.13577	1.86087	...
60	70	0.28665E-08	7.15662	7.2343	1.66777	...
70	80	0.13525E-07	26.1807	25.9477	6.15642	...
80	90	...	5.64438	5.05803	1.32795	...
90	100	...	4.8227	4.32754	1.14734	...
100	110	...	27.0035	24.2683	4.58168	...
110	120	...	13.2564	11.9198	4.37462	...

Longitudinal Stresses due to these Conditions:

From	To	Vortex Shedding Operating Case N/mm^2	Vortex Shedding Empty Case N/mm^2	Vortex Shedding Test Case N/mm^2	Earthquake Empty Case N/mm^2
10	20	...	...	...	26.0199

20	30	...	...	...	44.6283
30	40	...	...	...	21.3586
40	50	...	...	...	12.2348
50	60	...	...	...	8.13577
60	70	...	...	...	7.2343
70	80	...	...	...	25.9477
80	90	...	...	...	5.05803
90	100	...	...	...	4.32754
100	110	...	...	...	24.2683
110	120	...	...	...	11.9198

Longitudinal Stresses due to Applied Axial Forces:

From	To	Longitudinal Stress Y Forces Wind N/mm^2	Longitudinal Stress Y Forces Seismic N/mm^2
10	20	0.60803	1.79008
20	30	1.26616	3.56738
30	40	0.60803	1.62787
40	50	0.60803	1.16212
50	60	...	0.3786
60	70	...	0.34136
70	80	...	0.62717
80	90	...	0.16623
90	100	...	0.14086
100	110	...	0.53343
110	120	...	0.26923

Longitudinal Stresses due to User Forces and Moments:

From	To	Wind For/Mom Corroded N/mm^2	Earthquake For/Mom Corroded N/mm^2	Wind For/Mom No Corrosion N/mm^2	Earthquake For/Mom No Corrosion N/mm^2
10	20	14.3659	14.3659	10.1415	10.1415
20	30	24.5575	24.5575	13.0654	13.0654
30	40	11.7427	11.7427	8.28973	8.28973
40	50	5.18599	5.18599	3.66102	3.66102
50	60	...	...	...	...
60	70	...	...	...	...
70	80	...	...	...	...
80	90	...	...	...	...
90	100	...	...	...	...
100	110	...	...	...	...
110	120	...	...	...	...

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Stress Combination Load Cases for Vertical Vessels:

Load Case Definition Key

IP = Longitudinal Stress due to Internal Pressure

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 EP = Longitudinal Stress due to External  Pressure
 HP = Longitudinal Stress due to Hydrotest Pressure
 NP = No Pressure
 EW = Longitudinal Stress due to Weight (No Liquid)
 OW = Longitudinal Stress due to Weight (Operating)
 HW = Longitudinal Stress due to Weight (Hydrotest)
 WI = Bending Stress due to Wind Moment (Operating)
 EQ = Bending Stress due to Earthquake Moment (Operating)
 EE = Bending Stress due to Earthquake Moment (Empty)
 HI = Bending Stress due to Wind Moment (Hydrotest)
 HE = Bending Stress due to Earthquake Moment (Hydrotest)
 WE = Bending Stress due to Wind Moment (Empty) (no CA)
 WF = Bending Stress due to Wind Moment (Filled) (no CA)
 CW = Longitudinal Stress due to Weight (Empty) (no CA)
 VO = Bending Stress due to Vortex Shedding Loads ( Ope )
 VE = Bending Stress due to Vortex Shedding Loads ( Emp )
 VF = Bending Stress due to Vortex Shedding Loads ( Test No CA. )
 FW = Axial Stress due to Vertical Forces for the Wind Case
 FS = Axial Stress due to Vertical Forces for the Seismic Case
 BW = Bending Stress due to Lat. Forces for the Wind Case, Corroded
 BS = Bending Stress due to Lat. Forces for the Seismic Case, Corroded
 BN = Bending Stress due to Lat. Forces for the Wind Case, UnCorroded
 BU = Bending Stress due to Lat. Forces for the Seismic Case, UnCorroded
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General Notes:

Case types HI and HE are in the Un-Corroded condition.

Case types WE, WF, and CW are in the Un-Corroded condition.

A blank stress and stress ratio indicates that the corresponding stress comprising those components that did not contribute to that type of stress.

An asterisk (*) in the final column denotes overstress.

Analysis of Load Case 1 : NP+EW+WI+FW+BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	35.39	137.19	-36.77	118.87	0.2580	0.3093
20	61.76	120.26	-64.17	93.01	0.5135	0.6899
30	29.61	120.26	-30.70	118.87	0.2462	0.2582
40	16.46	120.26	-16.83	118.87	0.1369	0.1416
50	7.45	120.26	-8.53	118.87	0.0619	0.0717
60	6.67	120.26	-7.64	119.99	0.0555	0.0637
70	25.28	120.26	-27.08	137.09	0.2103	0.1975
80	5.41	120.26	-5.88	137.61	0.0450	0.0427
110	12.87	148.56	-13.64	107.25	0.0866	0.1272

Analysis of Load Case 2 : NP+EW+EE+FS+BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	41.01	137.19	-40.03	118.87	0.2989	0.3367
20	70.55	120.26	-68.37	93.01	0.5867	0.7350
30	33.71	120.26	-32.75	118.87	0.2803	0.2755
40	17.87	120.26	-17.13	118.87	0.1486	0.1441
50	7.97	120.26	-8.30	118.87	0.0663	0.0698

60	7.09	120.26	-7.38	119.99	0.0589	0.0615
70	25.68	120.26	-26.22	137.09	0.2135	0.1912
80	4.99	120.26	-5.13	137.61	0.0415	0.0373
110	11.80	148.56	-12.04	107.25	0.0795	0.1122

Analysis of Load Case 3 : NP+OW+WI+FW+BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	35.00	137.19	-37.16	118.87	0.2551	0.3126
20	61.76	120.26	-64.17	93.01	0.5135	0.6899
30	29.61	120.26	-30.70	118.87	0.2462	0.2582
40	16.46	120.26	-16.83	118.87	0.1369	0.1416
50	7.45	120.26	-8.53	118.87	0.0619	0.0717
60	6.67	120.26	-7.64	119.99	0.0555	0.0637
70	25.28	120.26	-27.08	137.09	0.2103	0.1975
80	5.41	120.26	-5.88	137.61	0.0450	0.0427
110	12.87	148.56	-13.64	107.25	0.0866	0.1272

Analysis of Load Case 4 : NP+OW+EQ+FS+BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	43.53	137.19	-43.32	118.87	0.3173	0.3644
20	73.68	120.26	-71.49	93.01	0.6127	0.7686
30	35.16	120.26	-34.20	118.87	0.2924	0.2877
40	17.87	120.26	-17.13	118.87	0.1486	0.1441
50	7.97	120.26	-8.30	118.87	0.0663	0.0698
60	7.09	120.26	-7.38	119.99	0.0589	0.0615
70	25.68	120.26	-26.22	137.09	0.2135	0.1912
80	4.99	120.26	-5.13	137.61	0.0415	0.0373
110	11.80	148.56	-12.04	107.25	0.0795	0.1122

Analysis of Load Case 5 : NP+HW+HI

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	2.50	178.30	-7.75	128.61	0.0140	0.0602
20	5.53	156.37	-8.15	115.90	0.0354	0.0703
30	3.54	156.37	-5.16	128.61	0.0227	0.0401
40	2.15	156.37	-3.26	128.61	0.0137	0.0254
50	1.48	156.37	-2.24	128.61	0.0095	0.0174
60	1.33	156.37	-2.01	129.53	0.0085	0.0155
70	5.53	156.37	-6.79	143.05	0.0353	0.0474
80	1.16	156.37	-1.50	143.43	0.0074	0.0104
110	3.99	215.16	-4.76	110.08	0.0185	0.0432

Analysis of Load Case 6 : NP+HW+HE

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		178.30	-2.72	128.61		0.0211
20		156.37	-1.45	115.90		0.0125
30		156.37	-0.90	128.61		0.0070
40		156.37	-0.61	128.61		0.0047
50		156.37	-0.38	128.61		0.0030
60		156.37	-0.34	129.53		0.0026
70		156.37	-0.63	143.05		0.0044
80		156.37	-0.17	143.43		0.0012
110		215.16	-0.38	110.08		0.0035

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Analysis of Load Case 7 : IP+OW+WI+FW+BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	35.00	137.19	-37.16	118.87	0.2551	0.3126
20	89.38	120.26	-36.55	93.01	0.7432	0.3930
30	42.70	120.26	-17.60	118.87	0.3551	0.1481
40	29.55	120.26	-3.74	118.87	0.2458	0.0315
50	20.54	120.26		118.87	0.1708	
60	19.75	120.26		119.99	0.1642	
70	31.39	120.26	-20.97	137.09	0.2610	0.1530
80	11.51	120.26		137.61	0.0957	
110	17.35	148.56	-9.16	107.25	0.1168	0.0854

Analysis of Load Case 8 : IP+OW+EQ+FS+BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	43.53	137.19	-43.32	118.87	0.3173	0.3644
20	101.30	120.26	-43.87	93.01	0.8424	0.4717
30	48.25	120.26	-21.11	118.87	0.4012	0.1776
40	30.96	120.26	-4.03	118.87	0.2574	0.0339
50	21.06	120.26		118.87	0.1752	
60	20.17	120.26		119.99	0.1677	
70	31.78	120.26	-20.11	137.09	0.2643	0.1467
80	11.09	120.26		137.61	0.0922	
110	16.28	148.56	-7.56	107.25	0.1096	0.0705

Analysis of Load Case 9 : EP+OW+WI+FW+BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	35.00	137.19	-37.16	118.87	0.2551	0.3126
20	61.76	120.26	-64.17	93.01	0.5135	0.6899
30	29.61	120.26	-30.70	118.87	0.2462	0.2582
40	16.46	120.26	-16.83	118.87	0.1369	0.1416
50	7.45	120.26	-8.53	118.87	0.0619	0.0717
60	6.67	120.26	-7.64	119.99	0.0555	0.0637
70	25.28	120.26	-27.08	137.09	0.2103	0.1975
80	5.41	120.26	-5.88	137.61	0.0450	0.0427
110	12.87	148.56	-13.64	107.25	0.0866	0.1272

Analysis of Load Case 10 : EP+OW+EQ+FS+BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	43.53	137.19	-43.32	118.87	0.3173	0.3644
20	73.68	120.26	-71.49	93.01	0.6127	0.7686
30	35.16	120.26	-34.20	118.87	0.2924	0.2877
40	17.87	120.26	-17.13	118.87	0.1486	0.1441
50	7.97	120.26	-8.30	118.87	0.0663	0.0698
60	7.09	120.26	-7.38	119.99	0.0589	0.0615
70	25.68	120.26	-26.22	137.09	0.2135	0.1912
80	4.99	120.26	-5.13	137.61	0.0415	0.0373
110	11.80	148.56	-12.04	107.25	0.0795	0.1122

Analysis of Load Case 11 : HP+HW+HI

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	2.50	178.30	-7.75	128.61	0.0140	0.0602
20	26.20	156.37		115.90	0.1676	

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30	16.54	156.37		128.61	0.1058	
40	15.15	156.37		128.61	0.0969	
50	14.48	156.37		128.61	0.0926	
60	14.31	156.37		129.53	0.0915	
70	11.53	156.37	-0.78	143.05	0.0737	0.0055
80	7.16	156.37		143.43	0.0458	
110	10.39	215.16		110.08	0.0483	

Analysis of Load Case 12 : HP+HW+HE

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		178.30	-2.72	128.61		0.0211
20	19.51	156.37		115.90	0.1248	
30	12.28	156.37		128.61	0.0786	
40	12.50	156.37		128.61	0.0799	
50	12.62	156.37		128.61	0.0807	
60	12.64	156.37		129.53	0.0809	
70	5.38	156.37		143.05	0.0344	
80	5.83	156.37		143.43	0.0373	
110	6.02	215.16		110.08	0.0280	

Analysis of Load Case 13 : IP+WE+EW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		137.19	-1.43	118.87		0.0120
20	25.42	120.26		93.01	0.2114	
30	12.07	120.26		118.87	0.1004	
40	12.37	120.26		118.87	0.1029	
50	12.55	120.26		118.87	0.1044	
60	12.59	120.26		119.99	0.1047	
70	5.21	120.26		137.09	0.0433	
80	5.86	120.26		137.61	0.0487	
110	4.09	148.56		107.25	0.0276	

Analysis of Load Case 14 : IP+WF+CW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		137.19	-1.19	118.87		0.0100
20	26.31	120.26		93.01	0.2188	
30	12.28	120.26		118.87	0.1021	
40	12.54	120.26		118.87	0.1042	
50	12.71	120.26		118.87	0.1057	
60	12.74	120.26		119.99	0.1059	
70	5.47	120.26		137.09	0.0455	
80	5.93	120.26		137.61	0.0493	
110	4.09	148.56		107.25	0.0276	

Analysis of Load Case 15 : IP+VO+OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		137.19	-1.82	118.87		0.0153
20	25.42	120.26		93.01	0.2114	
30	12.07	120.26		118.87	0.1004	
40	12.37	120.26		118.87	0.1029	
50	12.55	120.26		118.87	0.1044	
60	12.59	120.26		119.99	0.1047	
70	5.21	120.26		137.09	0.0433	

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80	5.86	120.26		137.61	0.0487
110	4.09	148.56		107.25	0.0276

Analysis of Load Case 16 : IP+VE+EW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		137.19	-1.43	118.87		0.0120
20	25.42	120.26		93.01	0.2114	
30	12.07	120.26		118.87	0.1004	
40	12.37	120.26		118.87	0.1029	
50	12.55	120.26		118.87	0.1044	
60	12.59	120.26		119.99	0.1047	
70	5.21	120.26		137.09	0.0433	
80	5.86	120.26		137.61	0.0487	
110	4.09	148.56		107.25	0.0276	

Analysis of Load Case 17 : NP+VO+OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10		137.19	-1.82	118.87		0.0153
20		120.26	-2.75	93.01		0.0295
30		120.26	-1.28	118.87		0.0108
40		120.26	-0.87	118.87		0.0073
50		120.26	-0.54	118.87		0.0045
60		120.26	-0.49	119.99		0.0041
70		120.26	-0.90	137.09		0.0065
80		120.26	-0.24	137.61		0.0017
110		148.56	-0.38	107.25		0.0036

Analysis of Load Case 18 : FS+BS+IP+OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	14.60	137.19	-14.40	118.87	0.1064	0.1211
20	53.54	120.26		93.01	0.4452	
30	25.44	120.26		118.87	0.2116	
40	18.72	120.26		118.87	0.1557	
50	12.93	120.26		118.87	0.1075	
60	12.94	120.26		119.99	0.1076	
70	5.84	120.26		137.09	0.0485	
80	6.03	120.26		137.61	0.0501	
110	4.36	148.56		107.25	0.0294	

Analysis of Load Case 19 : FS+BS+EP+OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	14.60	137.19	-14.40	118.87	0.1064	0.1211
20	25.92	120.26	-23.74	93.01	0.2156	0.2552
30	12.35	120.26	-11.40	118.87	0.1027	0.0959
40	5.63	120.26	-4.89	118.87	0.0468	0.0411
50		120.26	-0.16	118.87		0.0014
60		120.26	-0.15	119.99		0.0012
70		120.26	-0.27	137.09		0.0020
80		120.26	-0.07	137.61		0.0005
110		148.56	-0.12	107.25		0.0011

Absolute Maximum of the all of the Stress Ratio's 0.8424

Governing Element: Elliptical bottom head
Governing Load Case 8 : IP+OW+EQ+FS+BS

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Shop/Field Installation Options :

Platform(s) installed in the Shop.
Insulation is installed in the Shop.

Note : The CG is computed from the first Element From Node

Center of Gravity of Platforms	10500.001 mm
Center of Gravity of Liquid	1296.295 mm
Center of Gravity of Insulation	1657.071 mm
Center of Gravity of Nozzles	3199.334 mm
Center of Gravity of Added Weights (Operating)	2745.008 mm
Center of Gravity of Added Weights (Empty)	2745.008 mm
Center of Gravity of Bare Shell New and Cold	5464.207 mm
Center of Gravity of Bare Shell Corroded	5727.950 mm
Vessel CG in the Operating Condition	4383.118 mm
Vessel CG in the Fabricated (Shop/Empty) Condition	5380.793 mm
Vessel CG in the Test Condition	5108.408 mm

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Conical Reinforcement Calculations, ASME VIII Div. 1, App. 1

Conical Section From 60 To 70 SA-516 60

CONE WS TO RISER

Elastic Modulus Data from ASME Section II Part D at 80 °C

Elastic Modulus of Cone Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Small Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large End Reinforcement	0.199E+09 kPa at 80 °C
Elastic Modulus of Small End Reinforcement	0.199E+09 kPa at 80 °C

Elastic Modulus Data from ASME Section II Part D at 80 °C

Elastic Modulus of Cone Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Small Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large End Reinforcement	0.199E+09 kPa at 80 °C
Elastic Modulus of Small End Reinforcement	0.199E+09 kPa at 80 °C

Axial Force on Small End of Cone	301.97	kgf
Axial Force on Large End of Cone	360.90	kgf
Moment on Small End of Cone	3633.98	kgf-m
Moment on Large End of Cone	4695.34	kgf-m

Note: Both ends of the Cone are Lines of Support

Maximum Centroid Reinforcement Distance Large End	15.2762	mm

```
Maximum Centroid Reinforcement Distance Small End    10.5416  mm
```

Note: No ring was found close enough to the large end to be considered.

Note: No ring was found close enough to the small end to be considered.

Reinforcement Calculations for Cone / Large Cylinder:

Required Area of Reinforcement for Large End Under Internal Pressure

```
Large end ratio of pressure to allowable stress      0.00349
Large end max. half apex angle w/o reinforcement      19.478  degrees
Large end actual half apex angle                      15.610  degrees
```

Reinforcement Calculations for Cone / Small Cylinder:

Required Area of Reinforcement for Small End under Internal Pressure

```
Small end ratio of pressure to allowable stress      0.00349
Small end max. half apex angle w/o reinforcement      4.995  degrees
Small end actual half apex angle                     15.610  degrees
```

Intermediate Value [k]:

```
= max( Y / ( Sr * Ers ), 1 )
= max( 23.50E+09/( 117.9 * 199328640 ), 1 )
= 1.0000
```

where [Y] is:

```
= Small End All. Stress * Small End Elastic Modulus (Int. temp.)
= 117.9 * 199328640
= 23500847104.0 N/mm^2^2
```

Decay Length, Cone Small End:

```
= 1.4 * sqrt( Rs( ts - ca ) )
= 1.4 * sqrt( 247 ( 10 - 3 ) )
= 58.214 mm
```

Required Area of Reinforcement, Small End, Internal [Ars]:

```
= k*QS*Rs/(Ss*E1)*(1-delta/alpha)*tan(alpha)
= 1 * 22.43 * 247/( 117.9 * 0.85 ) *
  ( 1 - 4.995/15.61 )0.279
= 1.03 cm^2
```

Force per Length, Cone Small End [QS]:

```
= P( Rs/2 ) - Faxial/(pi(Ds + Ts)) + Moment/(pi(Rs + Ts/2)(Rs + Ts/2))
= 350 ( 247/2 ) - 302/(pi(494 + 10 )) +
  3634/(pi(247 + 10/2)(247 + 10/2))
= 22.430 kgf/mm
```

Area of Reinforcement Available in Small End Shell [Aes]:

```
= 0.78(Rs*Ts)½*((Ts-t)+(Tc-Tr)/cos(alpha) ))
= 0.78(247 *7 )½*(( 7 -0.865 )+( 7 -0.898 )/0.963 )
= 4.0450 cm^2
```

Summary of Reinforcement Area, Small End, Internal Pressure:

```
Area of reinforcement required per App. 1-5(3)       1.0300  cm^2
Area of reinforcement in shell per App. 1-5(4)       4.0450  cm^2
Area of reinforcement in stiffening ring             0.0000  cm^2
```

Note: The following calculations are only required per 1-5(g)(1) and do include external loads due to wind or seismic. These discontinuity stresses are computed at the shell/cone junction and do not include effects of local stiffening from a junction ring.

Results for Discontinuity Stresses per Bednar p. 236 2nd Edition

Stress Type	Stress	Allowable	Location
Tensile Stress	93.31	353.70	Small Cyl. Long.
Compres. Stress	-58.16	-353.70	Small Cyl. Long.
Membrane Stress	46.37	176.85	Small End Tang.
Tensile Stress	94.53	353.70	Cone Longitudinal
Compres. Stress	-58.92	-353.70	Cone Longitudinal
Tensile Stress	46.85	176.85	Cone Tangential
Tensile Stress	78.33	353.70	Large Cyl. Long.
Compres. Stress	-37.22	-353.70	Large Cyl. Long.
Membrane Stress	17.77	-176.85	Large End Tang.
Tensile Stress	79.11	353.70	Cone Longitudinal
Compres. Stress	-36.43	-353.70	Cone Longitudinal
Compres Stress	18.79	-176.85	Cone Tangential

Note: An asterisk (*) denotes that this stress was not applicable for this combination of loads.

Maximum Allowable Pressure Calculations for Cone to Shell Junction:

Pressure Case	Pressure kPa	Reason for Failure at this Pressure
MAWP	1274.481	Thickness due to internal pressure, Cone Large End
MAPnc	1825.126	Thickness due to internal pressure, Cone Large End

These pressures were determined by iteration.

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Conical Reinforcement Calculations, ASME VIII Div. 1, App. 1

Conical Section From 80 To 90 SA-516 60

CONE

Elastic Modulus Data from ASME Section II Part D at 80 °C

Elastic Modulus of Cone Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Small Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large End Reinforcement	0.199E+09 kPa at 80 °C
Elastic Modulus of Small End Reinforcement	0.199E+09 kPa at 80 °C

Elastic Modulus Data from ASME Section II Part D at 80 °C

Elastic Modulus of Cone Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Small Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large Cylinder Material	0.199E+09 kPa at 80 °C
Elastic Modulus of Large End Reinforcement	0.199E+09 kPa at 80 °C

```
Elastic Modulus of Small End Reinforcement       0.199E+09 kPa at 80 °C

Axial Force on Small End of Cone                      70.50  kgf
Axial Force on Large End of Cone                      82.25  kgf
Moment on Small End of Cone                            0.00  kgf-m
Moment on Large End of Cone                          804.53  kgf-m
```

Note: Both ends of the Cone are Lines of Support

```
Maximum Centroid Reinforcement Distance Large End    10.5416  mm
Maximum Centroid Reinforcement Distance Small End     8.4101  mm
```

Note: No ring was found close enough to the large end to be considered.

Note: No ring was found close enough to the small end to be considered.

Reinforcement Calculations for Cone / Large Cylinder:

Required Area of Reinforcement for Large End Under Internal Pressure

```
Large end ratio of pressure to allowable stress      0.00349
Large end max. half apex angle w/o reinforcement      19.478  degrees
Large end actual half apex angle                      13.423  degrees
```

Reinforcement Calculations for Cone / Small Cylinder:

Required Area of Reinforcement for Small End under Internal Pressure

```
Small end ratio of pressure to allowable stress      0.00349
Small end max. half apex angle w/o reinforcement       4.995  degrees
Small end actual half apex angle                      13.423  degrees
```

Intermediate Value [k]:

```
= max( Y / ( Sr * Ers ), 1 )
= max( 23.50E+09/( 117.9 * 199328640 ), 1 )
= 1.0000
```

where [Y] is:

```
= Small End All. Stress * Small End Elastic Modulus (Int. temp.)
= 117.9 * 199328640
= 23500847104.0 N/mm^2^2
```

Decay Length, Cone Small End:

```
= 1.4 * sqrt( Rs( ts - ca ) )
= 1.4 * sqrt( 154.7 ( 10 - 3 ) )
= 46.066 mm
```

Required Area of Reinforcement, Small End, Internal [Ars]:

```
= k*QS*Rs/(Sc*E2)*tan(alpha)
= 1 * 2.689 * 154.7/( 117.9 * 0.85 ) * 0.239
= 0.0971 cm^2
```

Force per Length, Cone Small End [QS]:

```
= P( Rs/2 ) - Faxial/(pi(Ds + Ts)) + Moment/(pi(Rs + Ts/2)(Rs + Ts/2))
= 350 ( 154.7/2 ) - 70.5/(pi(309.3 + 10 )) +
  0/(pi(154.7 + 10/2)(154.7 + 10/2))
= 2.689 kgf/mm
```

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Area of Reinforcement Available in Small End Shell [Aes]:

```
  = ( tc - tr ) * sqrt( Rs*tc/cos(alpha) )
  = ( 7 - 0.557 ) * sqrt( 154.7 * 7/0.973 )
  = 2.1497 cm^2
```

Summary of Reinforcement Area, Small End, Internal Pressure:

```
 Area of reinforcement required per App. 1-5(3)        0.0971  cm^2
 Area of reinforcement in shell per App. 1-5(4)        2.1497  cm^2
 Area of reinforcement in stiffening ring              0.0000  cm^2
```

Note: The following calculations are only required per 1-5(g)(1) and do include external loads due to wind or seismic. These discontinuity stresses are computed at the shell/cone junction and do not include effects of local stiffening from a junction ring.

Results for Discontinuity Stresses per Bednar p. 236 2nd Edition

Stress Type	Stress	Allowable	Location
Tensile Stress	8.92	353.70	Small Cyl. Long.
Compres. Stress	-1.21	-353.70	Small Cyl. Long.
Membrane Stress	10.70	-176.85	Small End Tang.
Tensile Stress	9.03	353.70	Cone Longitudinal
Compres. Stress	-1.11	-353.70	Cone Longitudinal
Compres Stress	10.92	-176.85	Cone Tangential
Tensile Stress	31.61	353.70	Large Cyl. Long.
Compres. Stress	-7.80	-353.70	Large Cyl. Long.
Membrane Stress	12.10	-176.85	Large End Tang.
Tensile Stress	31.95	353.70	Cone Longitudinal
Compres. Stress	-7.46	-353.70	Cone Longitudinal
Compres Stress	12.45	-176.85	Cone Tangential

Note: An asterisk (*) denotes that this stress was not applicable for this combination of loads.

Maximum Allowable Pressure Calculations for Cone to Shell Junction:

Pressure Case	Pressure kPa	Reason for Failure at this Pressure
MAWP	2720.389	Thickness due to internal pressure, Cone Large End
MAPnc	3905.757	Thickness due to internal pressure, Cone Large End

These pressures were determined by iteration.

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Nozzle Calculation Summary:

Description	MAWP kPa	Ext	MAPNC kPa	UG-45	[tr] mm	Weld Path	Areas or Stresses
N2	621.53	...	...	OK	4.42	OK	No Calc[*]

```
 N3                |           |    ...  |        ...  |    OK  |  3.95  |     OK   | No
Calc[*] |
 N4                |           |    ...  |        ...  |    OK  |  3.95  |     OK   | No
Calc[*] |
 K1A               |           |    ...  |        ...  |    OK  |  3.95  |     OK   | No
Calc[*] |
 K1B               |           |    ...  |        ...  |    OK  |  3.95  |     OK   | No
Calc[*] |
 HW                |           |    ...  |        ...  |   ...  |        |     OK   | No
Calc[*] |
 N1                |           |    ...  |        ...  |    OK  |  4.59  |     OK   | No
Calc[*] |
 ------------------------------------------------------------------------------------------
------
```

MAWP Summary:

```
 Minimum MAWP Nozzles         :         621.533 Nozzle  : N2
 Minimum MAWP Shells/Flanges  :         621.533 Element : Elliptical bottom he
 Minimum MAPnc Shells/Flanges :        1205.880 Element : Elliptical bottom he
 ------------------------------------------------------------------------
 Computed Vessel M.A.W.P.     :         621.533 kPa
```

[*] - This was a small opening and the areas were not computed or the MAWP of this connection could not be computed because the longitudinal bending stress was greater than the hoop stress.

Note: MAWPs (Internal Case) shown above are at the High Point.

Check the Spatial Relationship between the Nozzles

From Node	Nozzle Description	Y Coordinate mm	Layout Angle deg	Dia. Limit mm
20	N2	0.000	0.000	102.501
30	N3	750.000	135.000	52.616
30	N4	2250.000	135.000	52.616
30	K1A	1000.000	45.000	52.616
30	K1B	2000.000	45.000	52.616
30	HW	50.000	45.000	417.435
40	N1	4049.999	180.000	521.016

The nozzle spacing is computed by the following:
= Sqrt(ll^2 + lc^2) where
ll - Arc length along the inside vessel surface in the long. direction.
lc - Arc length along the inside vessel surface in the circ. direction

If any interferences/violations are found, they will be noted below.
No interference violations have been detected !

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Input, Nozzle Desc: N2 From: 20

```
 Pressure for Reinforcement Calculations        P     361.405  kPa
 Temperature for Internal Pressure           Temp          80  °C
```

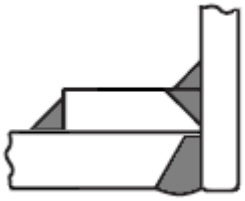
Shell Material		SA-516 60	
Shell Allowable Stress at Temperature	Sv	117.90	N/mm^2
Shell Allowable Stress At Ambient	Sva	117.90	N/mm^2
Inside Diameter of Elliptical Head	D	1054.10	mm
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	6.3500	mm
Head Internal Corrosion Allowance	c	3.0000	mm
Head External Corrosion Allowance	co	0.0000	mm
Distance from Head Centerline	L1	0.0000	mm
User Entered Minimum Design Metal Temperature		-10.00	°C

Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		OD	
Layout Angle		0.00	deg
Diameter		2.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness	tn	XS	
Flange Material		SA-105	
Flange Type		None	
Corrosion Allowance	can	1.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	6.3500	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Pad Material		SA-516 60	
Pad Allowable Stress at Temperature	Sp	117.90	N/mm^2
Pad Allowable Stress At Ambient	Spa	117.90	N/mm^2
Diameter of Pad along vessel surface	Dp	150.0000	mm
Thickness of Pad	te	8.0000	mm
Weld leg size between Pad and Shell	Wp	6.0000	mm
Groove weld depth between Pad and Nozzle	Wgpn	8.0000	mm
Reinforcing Pad Width		44.8375	mm
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Insert/Set-in Nozzle With Pad, no Inside projection

Reinforcement CALCULATION, Description: N2

ASME Code, Section VIII, Div. 1, 2023, UG-37 to UG-45

```
Actual Outside Diameter Used in Calculation            2.375  in.
Actual Thickness Used in Calculation                   0.218  in.
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Elliptical Head, Tr [Int. Press]
```
= (P*K1*D))/(2*Sv*E-0.2*P) per UG-37(a)(3)
= (361.4*0.9*1060)/(2 *117.9*1-0.2*361.4)
= 1.4628 mm
```

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]
```
= (P*Ro)/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
= (361.4*30.16)/(117.9*1+0.4*361.4)
= 0.0923 mm
```

UG-40, Limits of Reinforcement : [Internal Pressure]
```
Parallel to Vessel Wall (Diameter Limit)              Dl   102.5012  mm
Parallel to Vessel Wall, opening length                d    51.2506  mm
Normal to Vessel Wall (Thickness Limit), pad side Tlwp      8.3750  mm
```

Note: The Pad diameter is greater than the Diameter Limit. The excess will not be considered.

Note:

Taking a UG-36(c)(3)(a) exemption for nozzle: N2.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
```
Wall Thickness for Internal/External pressures      ta = 1.0923 mm
Wall Thickness per UG16(b),                      tr16b = 4.5875 mm
Wall Thickness, shell/head, internal pressure     trb1 = 4.6254 mm
Wall Thickness                tb1 = max(trb1, tr16b) = 4.6254 mm
Wall Thickness                tb2 = max(trb2, tr16b) = 4.5875 mm
```

```
Wall Thickness per table UG-45                      tb3 = 4.4200 mm
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 4.42, max( 4.625, 4.588 ) ]
  = 4.4200 mm
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

```
  = max( ta, tb )
  = max( 1.092, 4.42 )
  = 4.4200 mm
```

Available Nozzle Neck Thickness = 0.875 * 5.537 = 4.845 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Pad Weld for the Nozzle (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
Impact Test Temperature provided per Specification         -46 °C

Calculated Minimum Design Metal Temperature               -104 °C
```

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: C

Govrn. thk, tg = 4.845, tr = 0.0923, c = 1 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.024, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C             -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C
```

Shell to Pad Weld Junction at Pad OD, Curve: C

Govrn. thk, tg = 6.35, tr = 1.463, c = 3 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.437, Temp. Reduction = 42 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C             -48 °C
```

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: C

Govrn. thk, tg = 4.845, tr = 0.0923, c = 1 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.024, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C             -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C

Governing MDMT of the Nozzle                          :   -104 °C
Governing MDMT of the Reinforcement Pad               :    -48 °C
Governing MDMT of all the sub-joints of this Junction :    -48 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification       -17 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)          -104 °C
```

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Where the Stress Reduction Ratio per UCS-66(i)(2) is :
Design Pressure/Ambient Rating = 361.40/1964.96 = 0.184

Weld Size Calculations, Description: N2

Intermediate Calc. for nozzle/shell Welds	Tmin	4.5372	mm
Intermediate Calc. for pad/shell Welds	TminPad	3.3500	mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	3.1760 = 0.7 * tmin.	7.0700 = 0.7 * Wo mm
Pad Weld	1.6750 = 0.5*TminPad	4.2420 = 0.7 * Wp mm

Skipping the nozzle attachment weld strength calculations.
Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a)
(small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case		632.938	kPa

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 0.4770 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 156.8270 mm

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Input, Nozzle Desc: N3 From: 30

Pressure for Reinforcement Calculations	P	351.470	kPa
Temperature for Internal Pressure	Temp	80	°C
Shell Material		SA-516 60	
Shell Allowable Stress at Temperature	Sv	117.90	N/mm^2
Shell Allowable Stress At Ambient	Sva	117.90	N/mm^2
Inside Diameter of Cylindrical Shell	D	1046.80	mm
Shell Finished (Minimum) Thickness	t	10.0000	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		750.00	mm
User Entered Minimum Design Metal Temperature		-10.00	°C

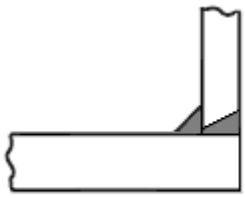
Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		ID	
Layout Angle		135.00	deg
Diameter		1.0000	in.

Size and Thickness Basis		Nominal	
Nominal Thickness	tn	XS	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	1.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	216.6000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	5.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	4.5466	mm
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: N3

ASME Code, Section VIII, Div. 1, 2023, UG-37 to UG-45

Actual Inside Diameter Used in Calculation	0.957	in.
Actual Thickness Used in Calculation	0.179	in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
= (351.5*526.4)/(117.9*1-0.6*351.5)
= 1.5721 mm

The Longitudinal Stress Governs over the Hoop Stress on the shell course where this nozzle is located. The Maximum stress ratio times the Shell thickness will be used in the calculation of the Area required.

The Stress Ratio is 0.4012 and the shell thk. is 10.0000 mm

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]
= (P*R)/(Sn*E-0.6*P) per UG-27 (c)(1)

```
  = (351.5*13.15)/(117.9*1-0.6*351.5)
  = 0.0393 mm
```

UG-40, Limits of Reinforcement : [Internal Pressure]

```
 Parallel to Vessel Wall (Diameter Limit)              Dl     52.6156  mm
 Parallel to Vessel Wall, opening length                d     26.3078  mm
 Normal to Vessel Wall (Thickness Limit), no pad     Tlnp      8.8665  mm
```

Note:

Taking a UG-36(c)(3)(a) exemption for nozzle: N3.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

```
 Wall Thickness for Internal/External pressures       ta = 1.0393 mm
 Wall Thickness per UG16(b),                       tr16b = 4.5875 mm
 Wall Thickness, shell/head, internal pressure      trb1 = 4.5721 mm
 Wall Thickness                  tb1 = max(trb1, tr16b) = 4.5875 mm
 Wall Thickness                  tb2 = max(trb2, tr16b) = 4.5875 mm
 Wall Thickness per table UG-45                     tb3 = 3.9464 mm
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 3.946, max( 4.588, 4.588 ) ]
  = 3.9464 mm
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

```
  = max( ta, tb )
  = max( 1.039, 3.946 )
  = 3.9464 mm
```

Available Nozzle Neck Thickness = 0.875 * 4.547 = 3.978 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
 Impact Test Temperature provided per Specification        -46 °C

 Calculated Minimum Design Metal Temperature              -104 °C
```

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: C

Govrn. thk, tg = 3.978, tr = 0.0393, c = 1 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0132, Temp. Reduction = 78 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve C            -48 °C
 Min Metal Temp. at Required thickness (UCS 66.1)         -104 °C
```

```
Governing MDMT of all the sub-joints of this Junction  :  -104 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification       -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)          -104 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)          -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :

```
Design Pressure/Ambient Rating = 351.47/1964.96 = 0.179
```

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: N3

```
Intermediate Calc. for nozzle/shell Welds   Tmin      3.5466  mm
```

Results Per UW-16.1:

```
                      Required Thickness    Actual Thickness
Nozzle Weld         2.4826 = 0.7 * tmin.  3.5350 = 0.7 * Wo mm
```

Skipping the nozzle attachment weld strength calculations.
Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a)
(small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:

```
Converged Max. Allow. Pressure in Operating case     1315.159  kPa
```

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 0.2665 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 226.8665 mm

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Input, Nozzle Desc: N4 From: 30

```
Pressure for Reinforcement Calculations        P     350.000  kPa
Temperature for Internal Pressure           Temp          80  °C

Shell Material                                      SA-516 60
Shell Allowable Stress at Temperature          Sv     117.90  N/mm^2
Shell Allowable Stress At Ambient             Sva     117.90  N/mm^2

Inside Diameter of Cylindrical Shell            D    1046.80  mm
Shell Finished (Minimum) Thickness              t    10.0000  mm
Shell Internal Corrosion Allowance              c     3.0000  mm
Shell External Corrosion Allowance             co     0.0000  mm

Distance from Bottom/Left Tangent                    2250.00  mm

User Entered Minimum Design Metal Temperature         -10.00  °C
```

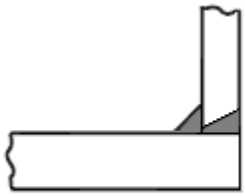
Type of Element Connected to the Shell : Nozzle

```
Material        [Impact Tested]                      SA-333 6
```

Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		ID	
Layout Angle		135.00	deg
Diameter		1.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness	tn	XS	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	1.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	216.6000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	5.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	4.5466	mm
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: N4

ASME Code, Section VIII, Div. 1, 2023, UG-37 to UG-45

Actual Inside Diameter Used in Calculation	0.957	in.
Actual Thickness Used in Calculation	0.179	in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]

```
  = (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
  = (350*526.4)/(117.9*1-0.6*350)
  = 1.5656 mm
```

The Longitudinal Stress Governs over the Hoop Stress on the shell course where this nozzle is located. The Maximum stress ratio times the Shell thickness will be used in the calculation of the Area required.

The Stress Ratio is 0.4012 and the shell thk. is 10.0000 mm

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

```
  = (P*R)/(Sn*E-0.6*P) per UG-27 (c)(1)
  = (350*13.15)/(117.9*1-0.6*350)
  = 0.0391 mm
```

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	Dl	52.6156	mm
Parallel to Vessel Wall, opening length	d	26.3078	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	8.8665	mm

Note:

Taking a UG-36(c)(3)(a) exemption for nozzle: N4.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

```
Wall Thickness for Internal/External pressures      ta = 1.0391 mm
Wall Thickness per UG16(b),                      tr16b = 4.5875 mm
Wall Thickness, shell/head, internal pressure     trb1 = 4.5656 mm
Wall Thickness                 tb1 = max(trb1, tr16b) = 4.5875 mm
Wall Thickness                 tb2 = max(trb2, tr16b) = 4.5875 mm
Wall Thickness per table UG-45                    tb3 = 3.9464 mm
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 3.946, max( 4.588, 4.588 ) ]
  = 3.9464 mm
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

```
  = max( ta, tb )
  = max( 1.039, 3.946 )
  = 3.9464 mm
```

Available Nozzle Neck Thickness = 0.875 * 4.547 = 3.978 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
Impact Test Temperature provided per Specification      -46 °C

Calculated Minimum Design Metal Temperature            -104 °C
```

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: C

Govrn. thk, tg = 3.978, tr = 0.0391, c = 1 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0131, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve C		-48 °C
Min Metal Temp. at Required thickness (UCS 66.1)		-104 °C
Governing MDMT of all the sub-joints of this Junction	:	-104 °C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

MDMT of ANSI B16.5/47 flange per Matl. Specification	-46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)	-104 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)	-104 °C

Where the Stress Reduction Ratio per UCS-66(i)(2) is :
Design Pressure/Ambient Rating = 350.00/1964.96 = 0.178

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: N4

Intermediate Calc. for nozzle/shell Welds	Tmin	3.5466	mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	2.4826 = 0.7 * tmin.	3.5350 = 0.7 * Wo mm

Skipping the nozzle attachment weld strength calculations.
Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a)
(small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case	1313.689	kPa

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 0.2665 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 226.8665 mm

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Input, Nozzle Desc: K1A From: 30

Pressure for Reinforcement Calculations	P	350.000	kPa
Temperature for Internal Pressure	Temp	80	°C
Shell Material		SA-516 60	
Shell Allowable Stress at Temperature	Sv	117.90	N/mm^2
Shell Allowable Stress At Ambient	Sva	117.90	N/mm^2
Inside Diameter of Cylindrical Shell	D	1046.80	mm
Shell Finished (Minimum) Thickness	t	10.0000	mm
Shell Internal Corrosion Allowance	c	3.0000	mm

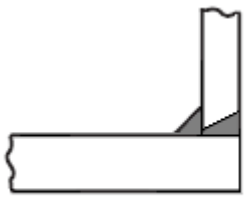
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		1000.00	mm
User Entered Minimum Design Metal Temperature		-10.00	°C

Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		ID	
Layout Angle		45.00	deg
Diameter		1.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness	tn	XS	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	1.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	216.6000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	5.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	4.5466	mm
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: K1A

ASME Code, Section VIII, Div. 1, 2023, UG-37 to UG-45

```
Actual Inside Diameter Used in Calculation              0.957  in.
Actual Thickness Used in Calculation                    0.179  in.
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]

```
  = (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
  = (350*526.4)/(117.9*1-0.6*350)
  = 1.5656 mm
```

The Longitudinal Stress Governs over the Hoop Stress on the shell course where this nozzle is located. The Maximum stress ratio times the Shell thickness will be used in the calculation of the Area required.

The Stress Ratio is 0.4012 and the shell thk. is 10.0000 mm

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

```
  = (P*R)/(Sn*E-0.6*P) per UG-27 (c)(1)
  = (350*13.15)/(117.9*1-0.6*350)
  = 0.0391 mm
```

UG-40, Limits of Reinforcement : [Internal Pressure]

```
Parallel to Vessel Wall (Diameter Limit)            Dl     52.6156  mm
Parallel to Vessel Wall, opening length              d     26.3078  mm
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp      8.8665  mm
```

Note:

Taking a UG-36(c)(3)(a) exemption for nozzle: K1A.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

```
Wall Thickness for Internal/External pressures      ta = 1.0391 mm
Wall Thickness per UG16(b),                      tr16b = 4.5875 mm
Wall Thickness, shell/head, internal pressure     trb1 = 4.5656 mm
Wall Thickness                 tb1 = max(trb1, tr16b) = 4.5875 mm
Wall Thickness                 tb2 = max(trb2, tr16b) = 4.5875 mm
Wall Thickness per table UG-45                    tb3 = 3.9464 mm
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 3.946, max( 4.588, 4.588 ) ]
  = 3.9464 mm
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

```
  = max( ta, tb )
  = max( 1.039, 3.946 )
  = 3.9464 mm
```

Available Nozzle Neck Thickness = 0.875 * 4.547 = 3.978 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
Impact Test Temperature provided per Specification          -46 °C

Calculated Minimum Design Metal Temperature                -104 °C
```

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: C

Govrn. thk, tg = 3.978, tr = 0.0391, c = 1 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0131, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C              -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)           -104 °C

Governing MDMT of all the sub-joints of this Junction  :   -104 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification        -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)           -104 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)           -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :

```
Design Pressure/Ambient Rating = 350.00/1964.96 = 0.178
```

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: K1A

```
Intermediate Calc. for nozzle/shell Welds   Tmin      3.5466  mm
```

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	2.4826 = 0.7 * tmin.	3.5350 = 0.7 * Wo mm

Skipping the nozzle attachment weld strength calculations.
Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a)
(small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:

```
Converged Max. Allow. Pressure in Operating case     1313.689  kPa
```

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 0.2665 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 226.8665 mm

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Input, Nozzle Desc: K1B From: 30

```
Pressure for Reinforcement Calculations        P     350.000  kPa
```

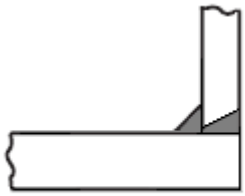
Temperature for Internal Pressure	Temp	80	°C
Shell Material		SA-516 60	
Shell Allowable Stress at Temperature	Sv	117.90	N/mm^2
Shell Allowable Stress At Ambient	Sva	117.90	N/mm^2
Inside Diameter of Cylindrical Shell	D	1046.80	mm
Shell Finished (Minimum) Thickness	t	10.0000	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		2000.00	mm
User Entered Minimum Design Metal Temperature		-10.00	°C

Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		ID	
Layout Angle		45.00	deg
Diameter		1.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness	tn	XS	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	1.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	216.6000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	5.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	4.5466	mm
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: K1B

ASME Code, Section VIII, Div. 1, 2023, UG-37 to UG-45

```
Actual Inside Diameter Used in Calculation              0.957  in.
Actual Thickness Used in Calculation                    0.179  in.
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]

```
  = (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
  = (350*526.4)/(117.9*1-0.6*350)
  = 1.5656 mm
```

The Longitudinal Stress Governs over the Hoop Stress on the shell course where this nozzle is located. The Maximum stress ratio times the Shell thickness will be used in the calculation of the Area required.

The Stress Ratio is 0.4012 and the shell thk. is 10.0000 mm

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

```
  = (P*R)/(Sn*E-0.6*P) per UG-27 (c)(1)
  = (350*13.15)/(117.9*1-0.6*350)
  = 0.0391 mm
```

UG-40, Limits of Reinforcement : [Internal Pressure]

```
Parallel to Vessel Wall (Diameter Limit)            Dl    52.6156  mm
Parallel to Vessel Wall, opening length              d    26.3078  mm
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp     8.8665  mm
```

Note:

Taking a UG-36(c)(3)(a) exemption for nozzle: K1B.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation or force the Appendix 1-10 computation in Nozzle Design Options.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

```
Wall Thickness for Internal/External pressures      ta = 1.0391 mm
Wall Thickness per UG16(b),                      tr16b = 4.5875 mm
```

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```
Wall Thickness, shell/head, internal pressure     trb1 = 4.5656 mm
Wall Thickness                  tb1 = max(trb1, tr16b) = 4.5875 mm
Wall Thickness                  tb2 = max(trb2, tr16b) = 4.5875 mm
Wall Thickness per table UG-45                   tb3 = 3.9464 mm
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 3.946, max( 4.588, 4.588 ) ]
  = 3.9464 mm
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

```
  = max( ta, tb )
  = max( 1.039, 3.946 )
  = 3.9464 mm
```

Available Nozzle Neck Thickness = 0.875 * 4.547 = 3.978 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
Impact Test Temperature provided per Specification        -46 °C

Calculated Minimum Design Metal Temperature              -104 °C
```

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: C

Govrn. thk, tg = 3.978, tr = 0.0391, c = 1 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0131, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C            -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)         -104 °C

Governing MDMT of all the sub-joints of this Junction  :  -104 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification      -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)         -104 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)         -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :

```
Design Pressure/Ambient Rating = 350.00/1964.96 = 0.178
```

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: K1B

```
Intermediate Calc. for nozzle/shell Welds   Tmin      3.5466  mm
```

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	2.4826 = 0.7 * tmin.	3.5350 = 0.7 * Wo mm

Skipping the nozzle attachment weld strength calculations.
Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a)
(small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case		1313.689	kPa

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 0.2665 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 226.8665 mm

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Input, Nozzle Desc: HW **From: 30**

Pressure for Reinforcement Calculations	P	358.332	kPa
Temperature for Internal Pressure	Temp	80	°C
Shell Material		SA-516 60	
Shell Allowable Stress at Temperature	Sv	117.90	N/mm^2
Shell Allowable Stress At Ambient	Sva	117.90	N/mm^2
Inside Diameter of Cylindrical Shell	D	1046.80	mm
Shell Finished (Minimum) Thickness	t	10.0000	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		50.00	mm
User Entered Minimum Design Metal Temperature		-10.00	°C

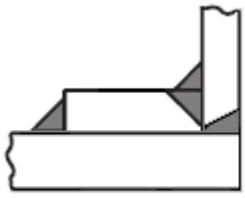
Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		ID	
Layout Angle		45.00	deg
Diameter		8.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness	tn	STD	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	216.6000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	6.0000	mm

Groove weld depth between Nozzle and Vessel	Wgnv	8.1788	mm
Pad Material		SA-516 70	
Pad Allowable Stress at Temperature	Sp	137.90	N/mm^2
Pad Allowable Stress At Ambient	Spa	137.90	N/mm^2
Diameter of Pad along vessel surface	Dp	319.0750	mm
Thickness of Pad	te	8.0000	mm
Weld leg size between Pad and Shell	Wp	8.0000	mm
Groove weld depth between Pad and Nozzle	Wgpn	8.0000	mm
Reinforcing Pad Width		50.0000	mm
This is a Manway or Access Opening.			
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle With Pad

Reinforcement CALCULATION, Description: HW

ASME Code, Section VIII, Div. 1, 2023, UG-37 to UG-45

Actual Inside Diameter Used in Calculation	7.981	in.
Actual Thickness Used in Calculation	0.322	in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
= (358.3*526.4)/(117.9*1-0.6*358.3)
= 1.6029 mm

The Longitudinal Stress Governs over the Hoop Stress on the shell course where this nozzle is located. The Maximum stress ratio times the Shell thickness will be used in the calculation of the Area required.

The Stress Ratio is 0.4012 and the shell thk. is 10.0000 mm

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]
= (P*R)/(Sn*E-0.6*P) per UG-27 (c)(1)
= (358.3*104.4)/(117.9*1-0.6*358.3)
= 0.3178 mm

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UG-40, Limits of Reinforcement : [Internal Pressure]

```
Parallel to Vessel Wall (Diameter Limit)              Dl    417.4348  mm
Parallel to Vessel Wall, opening length                d    208.7174  mm
Normal to Vessel Wall (Thickness Limit), pad side Tlwp     17.5000  mm
```

Weld Strength Reduction Factor [fr1]:

```
= 1.000
```

Weld Strength Reduction Factor [fr2]:

```
= min( 1, Sn/Sv )
= min( 1, 117.9/117.9 )
= 1.000
```

Weld Strength Reduction Factor [fr4]:

```
= min( 1, Sp/Sv )
= min( 1, 137.9/117.9 )
= 1.000
```

Weld Strength Reduction Factor [fr3]:

```
= min( fr2, fr4 )
= min( 1, 1 )
= 1.000
```

Results of Nozzle Reinforcement Area Calculations: (cm^2)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	5.862	NA	NA
Area in Shell	A1	8.748	NA	NA
Area in Nozzle Wall	A2	1.701	NA	NA
Area in Inward Nozzle	A3	0.000	NA	NA
Area in Welds	A41+A42+A43	1.000	NA	NA
Area in Element	A5	8.000	NA	NA
TOTAL AREA AVAILABLE	Atot	19.450	NA	NA

The Internal Pressure Case Governs the Analysis.

```
Nozzle Angle Used in Area Calculations                 90.00  Degs.
```

The area available without a pad is Sufficient.
The area available with the given pad is Sufficient.

Area Required [A]:

```
= ( d * tr*F + 2 * tn * tr*F * (1-fr1) ) UG-37(c)
= (208.7*2.808*1+2*5.179*2.808*1*(1-1))
= 5.862 cm^2
```

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

```
= d( E1*t - F*tr ) - 2 * tn( E1*t - F*tr ) * ( 1 - fr1 )
= 208.7 ( 1 * 7 - 1 * 2.808 ) - 2 * 5.179
  ( 1 * 7 - 1 * 2.808 ) * ( 1 - 1 )
= 8.748 cm^2
```

Area Available in Nozzle Wall Projecting Outward [A2]:

```
  = ( 2 * Tlwp ) * ( tn - trn ) * fr2
  = ( 2 * 17.5 ) * ( 5.179 - 0.318 ) * 1
  = 1.701 cm^2
```

Area Available in Welds [A41 + A42 + A43]:

```
  = Wo² * fr3 + (Wi-can/0.707)² * fr2 + Wp² * fr4
  = 6² * 1 + (0 )² * 1 + 8² * 1
  = 1.000 cm^2
```

Area Available in Element [A5]:

```
  = (min(Dp,DL)-(Nozzle OD))*(min(tp,Tlwp,te)) * fr4
  = ( 319.1 - 219.1 ) * 8 * 1
  = 8.000 cm^2
```

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
 Impact Test Temperature provided per Specification         -46 °C

 Calculated Minimum Design Metal Temperature               -104 °C
```

Nozzle Neck to Pad Weld for the Nozzle (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
 Impact Test Temperature provided per Specification         -46 °C

 Calculated Minimum Design Metal Temperature               -104 °C
```

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: B

Govrn. thk, tg = 7.156, tr = 0.318, c = 3 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0765, Temp. Reduction = 78 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve B             -29 °C
 Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C
```

Shell to Pad Weld Junction at Pad OD, min(Curve:B, Curve:C)

Govrn. thk, tg = 8, c = 3 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.229, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

```
 Min Metal Temp. w/o impact per UCS-66, Curve B             -29 °C
 Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C
```

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: C

Govrn. thk, tg = 7.156, tr = 0.318, c = 3 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0765, Temp. Reduction = 78 °C

```
 Min Metal Temp. w/o impact per UCS-66, Curve C             -48 °C
```

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```
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C

Governing MDMT of the Nozzle                          :   -104 °C
Governing MDMT of the Reinforcement Pad               :   -104 °C
Governing MDMT of all the sub-joints of this Junction :   -104 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification       -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)          -104 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)          -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :

```
Design Pressure/Ambient Rating = 358.33/1964.96 = 0.182
```

Note:
Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: HW

```
Intermediate Calc. for nozzle/shell Welds   Tmin      5.1788  mm
Intermediate Calc. for pad/shell Welds    TminPad     7.0000  mm
```

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	3.6252 = 0.7 * tmin.	4.2420 = 0.7 * Wo mm
Pad Weld	3.5000 = 0.5*TminPad	5.6560 = 0.7 * Wp mm

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)

Weld Load [W]:

```
= ( Ar - A1 )* Sv
= ( 5.862 - 8.748 ) * 117.9
= 0.00 kgf
```

Note: F is always set to 1.0 throughout the calculation.

Weld Load [W1]:

```
= (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
= ( 1.701 + 8 + 1 - 0 * 1 ) * 117.9
= 12865.43 kgf
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
= (pi/2) * Dlo * Wo * 0.49 * Snw
= ( 3.142/2.0 ) * 219.1 * 6 * 0.49 * 117.9
= 12164. kgf
```

Shear, Pad Element Weld [Spew]:

```
= (pi/2) * DP * WP * 0.49 * SEW
= ( 3.142/2.0 ) * 319.1 * 8 * 0.49 * 117.9
= 23620. kgf
```

Tension, Pad Groove Weld [Tpgw]:

```
= ( pi/2) * Dlo * Wgpn * 0.74 * Seg
```

```
=  (3.142/2 ) * 219.1 * 8 * 0.74 * 137.9
= 28646. kgf
```

Shear, Nozzle Groove Weld [Sngw]:

```
= (pi/2) * (Dlr+Wgnva) * (Wgnva-Can) * 0.60 * Sng
= (3.142/2)*(208.7 +8.179 )*(8.179 -3 )*0.6*117.9
= 12728. kgf
```

Strength of Failure Paths:

```
PATH11 = ( SPEW + SNGW ) = ( 23620 + 12728 ) = 36348 kgf
```

Summary of Failure Path Calculations:

```
Path 1-1 = 36348 kgf, must exceed W = 0 kgf or W1 = 12865 kgf
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
Converged Max. Allow. Pressure in Operating case     1322.021  kPa
```

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 11.5904 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 238.1904 mm

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Input, Nozzle Desc: N1 From: 40

Pressure for Reinforcement Calculations	P	350.000	kPa
Temperature for Internal Pressure	Temp	80	°C
Shell Material		SA-516 60	
Shell Allowable Stress at Temperature	Sv	117.90	N/mm^2
Shell Allowable Stress At Ambient	Sva	117.90	N/mm^2
Inside Diameter of Cylindrical Shell	D	1046.80	mm
Shell Finished (Minimum) Thickness	t	10.0000	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		4050.00	mm
User Entered Minimum Design Metal Temperature		-10.00	°C

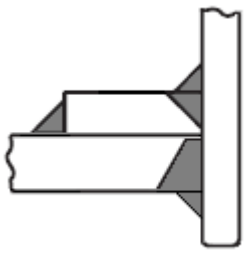
Type of Element Connected to the Shell : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		OD	
Layout Angle		180.00	deg
Diameter		10.0000	in.
Size and Thickness Basis		Nominal	

Nominal Thickness	tn	STD	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	216.6000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	10.0000	mm
Inside Projection	h	533.4000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Pad Material		SA-516 60	
Pad Allowable Stress at Temperature	Sp	117.90	N/mm^2
Pad Allowable Stress At Ambient	Spa	117.90	N/mm^2
Diameter of Pad along vessel surface	Dp	473.0500	mm
Thickness of Pad	te	8.0000	mm
Weld leg size between Pad and Shell	Wp	8.0000	mm
Groove weld depth between Pad and Nozzle	Wgpn	8.0000	mm
Reinforcing Pad Width		100.0000	mm
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Insert/Set-in Nozzle With Pad, with Inside projection

Reinforcement CALCULATION, Description: N1

ASME Code, Section VIII, Div. 1, 2023, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	10.750	in.
Actual Thickness Used in Calculation	0.365	in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]
= (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
= (350*526.4)/(117.9*1-0.6*350)

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= 1.5656 mm

The Longitudinal Stress Governs over the Hoop Stress on the shell course where this nozzle is located. The Maximum stress ratio times the Shell thickness will be used in the calculation of the Area required.

The Stress Ratio is 0.2574 and the shell thk. is 10.0000 mm

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]
= (P*Ro)/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
= (350*136.5)/(117.9*1+0.4*350)
= 0.4048 mm

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	Dl	521.0160	mm
Parallel to Vessel Wall, opening length	d	260.5080	mm
Normal to Vessel Wall (Thickness Limit), pad side	Tlwp	17.5000	mm
Normal to Vessel Wall, Inward		8.1775	mm

Weld Strength Reduction Factor [fr1]:
= min(1, Sn/Sv)
= min(1, 117.9/117.9)
= 1.000

Weld Strength Reduction Factor [fr2]:
= min(1, Sn/Sv)
= min(1, 117.9/117.9)
= 1.000

Weld Strength Reduction Factor [fr4]:
= min(1, Sp/Sv)
= min(1, 117.9/117.9)
= 1.000

Weld Strength Reduction Factor [fr3]:
= min(fr2, fr4)
= min(1, 1)
= 1.000

Results of Nozzle Reinforcement Area Calculations: (cm^2)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	4.694	NA	NA
Area in Shell	A1	13.541	NA	NA
Area in Nozzle Wall	A2	2.053	NA	NA
Area in Inward Nozzle	A3	0.535	NA	NA
Area in Welds	A41+A42+A43	1.637	NA	NA
Area in Element	A5	16.000	NA	NA
TOTAL AREA AVAILABLE	Atot	33.767	NA	NA

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.
The area available with the given pad is Sufficient.

Area Required [A]:
```
= ( d * tr*F + 2 * tn * tr*F * (1-fr1) ) UG-37(c)
= (260.5*1.802*1+2*6.271*1.802*1*(1-1))
= 4.694 cm^2
```

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:
```
= d( E1*t - F*tr ) - 2 * tn( E1*t - F*tr ) * ( 1 - fr1 )
= 260.5 ( 1 * 7 - 1 * 1.802 ) - 2 * 6.271
  ( 1 * 7 - 1 * 1.802 ) * ( 1 - 1 )
= 13.541 cm^2
```

Area Available in Nozzle Wall Projecting Outward [A2]:
```
= ( 2 * Tlwp ) * ( tn - trn ) * fr2
= ( 2 * 17.5 ) * ( 6.271 - 0.405 ) * 1
= 2.053 cm^2
```

Area Available in Inward Nozzle [A3]:
```
= 2 * ti * min( h, Tl, 2.5 * ti) * fr2
= 2 * 3.271 * ( 8.177 ) * 1
= 0.535 cm^2
```

Area Available in Welds [A41 + A42 + A43]:
```
= (Wo² - Ar Lost)*Fr3+((Wi-can/0.707)² - Ar Lost)*fr2 + Wp²*fr4
= (0.997 ) * 1 + (0 ) * 1 + 203.2² * 1
= 1.637 cm^2
```

Area Available in Element [A5]:
```
= (min(Dp,DL)-(Nozzle OD))*(min(tp,Tlwp,te)) * fr4
= ( 473 - 273 ) * 8 * 1
= 16.000 cm^2
```

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
```
Wall Thickness for Internal/External pressures      ta = 3.4048 mm
Wall Thickness per UG16(b),                      tr16b = 4.5875 mm
Wall Thickness, shell/head, internal pressure     trb1 = 4.5656 mm
Wall Thickness                 tb1 = max(trb1, tr16b) = 4.5875 mm
Wall Thickness                 tb2 = max(trb2, tr16b) = 4.5875 mm
Wall Thickness per table UG-45                    tb3 = 11.1026 mm
```

Determine Nozzle Thickness candidate [tb]:
```
= min[ tb3, max( tb1,tb2) ]
= min[ 11.1, max( 4.588, 4.588 ) ]
= 4.5875 mm
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
```
= max( ta, tb )
= max( 3.405, 4.588 )
= 4.5875 mm
```

Available Nozzle Neck Thickness = 0.875 * 9.271 = 8.112 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
Impact Test Temperature provided per Specification         -46 °C

Calculated Minimum Design Metal Temperature               -104 °C
```

Nozzle Neck to Pad Weld for the Nozzle (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
Impact Test Temperature provided per Specification         -46 °C

Calculated Minimum Design Metal Temperature               -104 °C
```

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: C

Govrn. thk, tg = 8, c = 3 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.224, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

```
Min Metal Temp. w/o impact per UCS-66, Curve C             -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C
```

Shell to Pad Weld Junction at Pad OD, Curve: C

Govrn. thk, tg = 8, c = 3 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.224, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

```
Min Metal Temp. w/o impact per UCS-66, Curve C             -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C
```

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: C

Govrn. thk, tg = 8.112, tr = 0.405, c = 3 mm, E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0792, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve C             -48 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C

Governing MDMT of the Nozzle                          :   -104 °C
Governing MDMT of the Reinforcement Pad               :   -104 °C
Governing MDMT of all the sub-joints of this Junction :   -104 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
MDMT of ANSI B16.5/47 flange per Matl. Specification       -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2)          -104 °C
Flange MDMT with Temp reduction per UCS-66(i)(3)          -104 °C
```

Where the Stress Reduction Ratio per UCS-66(i)(2) is :

```
Design Pressure/Ambient Rating = 350.00/1964.96 = 0.178
```

Note:

Using the min value from (i)(2) and (i)(3) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: N1

```
Intermediate Calc. for nozzle/shell Welds    Tmin      6.2710  mm
Intermediate Calc. for pad/shell Welds    TminPad      7.0000  mm
```

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.3897 = 0.7 * tmin.	7.0700 = 0.7 * Wo mm
Pad Weld	3.5000 = 0.5*TminPad	5.6560 = 0.7 * Wp mm

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)

Weld Load [W]:

```
= max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
= max( 0, (4.694 - 13.54 + 2 * 6.271 * 1 *
  (1 * 7 - 1.802 ) )117.9 )
= max( 0, -9852.27) kgf
```

Note: F is always set to 1.0 throughout the calculation.

Weld Load [W1]:

```
= (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
= ( 2.053 + 16 + 1.637 - 0 * 1 ) * 117.9
= 23672.58 kgf
```

Weld Load [W2]:

```
= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
= ( 2.053 + 0.535 + 1 + ( 0.878 ) ) * 117.9
= 5369.22 kgf
```

Weld Load [W3]:

```
= (A2+A3+A4+A5+(2*tn*t*fr1))*S
= ( 2.053 + 0.535 + 1.637 + 16 + ( 0.878 ) ) * 117.9
= 25371.21 kgf
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
= (pi/2) * Dlo * Wo * 0.49 * Snw
= ( 3.142/2.0 ) * 273 * 10 * 0.49 * 117.9
= 25267. kgf
```

Shear, Pad Element Weld [Spew]:

```
= (pi/2) * DP * WP * 0.49 * SEW
= ( 3.142/2.0 ) * 473 * 8 * 0.49 * 117.9
= 35019. kgf
```

Shear, Nozzle Wall [Snw]:

```
= (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
= (3.142 * 133.4 ) * ( 9.271 - 3 ) * 0.7 * 117.9
= 22116. kgf
```

Tension, Pad Groove Weld [Tpgw]:

```
= ( pi/2) * Dlo * Wgpn * 0.74 * Seg
=  (3.142/2 ) * 273 * 8 * 0.74 * 117.9
```

```
  = 30527. kgf
```

Tension, Shell Groove Weld [Tngw]:

```
  = (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.142/2.0 ) * 273 * ( 10 - 3 ) * 0.74 * 117.9
  = 26711. kgf
```

Strength of Failure Paths:

```
  PATH11 = ( SPEW + SNW ) = ( 35019 + 22116 ) = 57135 kgf
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 25267 + 30527 + 26711 + 0 ) = 82506 kgf
  PATH33 = ( Spew + Tngw + Sinw )
         = ( 35019 + 26711 + 0 ) = 61730 kgf
```

Summary of Failure Path Calculations:

```
 Path 1-1 = 57134 kgf, must exceed W = 0 kgf or W1 = 23672 kgf
 Path 2-2 = 82505 kgf, must exceed W = 0 kgf or W2 = 5369 kgf
 Path 3-3 = 61729 kgf, must exceed W = 0 kgf or W3 = 25371 kgf
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
 Converged Max. Allow. Pressure in Operating case     1136.355  kPa
```

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 18.1194 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 760.0001 mm

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Nozzle Schedule:

Description	Nominal or Actual Size	Schd or FVC Type	Flg Type	Nozzle O/Dia in	Wall Thk mm	Reinforcing Pad Diameter mm	Reinforcing Pad Thk mm	Cut Length mm	Flg Class
HW	8.000 in	STD	WNF	8.625	8.179	319.08	8.00	238.19	150
K1A	1.000 in	XS	WNF	1.315	4.547	...	...	226.87	150
K1B	1.000 in	XS	WNF	1.315	4.547	...	...	226.87	150
N1	10.000 in	STD	WNF	10.750	9.271	473.05	8.00	760.00	150
N2	2.000 in	XS	None	2.375	5.537	150.00	8.00	156.83	150
N3	1.000 in	XS	WNF	1.315	4.547	...	...	226.87	150
N4	1.000 in	XS	WNF	1.315	4.547	...	...	226.87	150

General Notes for the above table:

The Cut Length is the Outside Projection + Inside Projection + Drop + In Plane Shell Thickness. This value does not include weld gaps, nor does it account for shrinkage.

In the case of Oblique Nozzles, the Outside Diameter must be increased. The Re-Pad WIDTH around the nozzle is calculated as follows: Width of Pad = (Pad Outside Dia. (per above) - Nozzle Outside Dia.)/2

For hub nozzles, the thickness and diameter shown are those of the smaller and thinner section.

Nozzle Material and Weld Fillet Leg Size Details (mm):

Description	Material	Shl Grve Weld	Noz Shl/Pad Weld	Pad OD Weld	Pad Grve Weld	Inside Weld
HW	SA-333 6	8.179	6.000	8.000	8.000	...
K1A	SA-333 6	4.547	5.000	...	...	...
K1B	SA-333 6	4.547	5.000	...	...	...
N1	SA-333 6	10.000	10.000	8.000	8.000	...
N2	SA-333 6	6.350	10.000	6.000	8.000	...
N3	SA-333 6	4.547	5.000	...	...	...
N4	SA-333 6	4.547	5.000	...	...	...

Note: The Outside projections below do not include the flange thickness.

Nozzle Miscellaneous Data:

Description	Elev/Distance From Datum mm	Layout Angle deg	Proj Outside mm	Proj Inside mm	Installed in Component
HW	1000.000	45.0	216.60	0.00	WS CYLINDER 1/2
K1A	1950.000	45.0	216.60	0.00	WS CYLINDER 1/2
K1B	2950.000	45.0	216.60	0.00	WS CYLINDER 1/2
N1	4999.999	180.0	216.60	533.40	WS CYLINDER 2/2
N2	...	0.0	150.00	0.00	Elliptical botto

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```
  N3              |        1700.000 |    135.0 |      216.60 |    0.00 |     WS CYLINDER
1/2 |
  N4              |        3200.000 |    135.0 |      216.60 |    0.00 |     WS CYLINDER
1/2 |
```

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Minimum Design Metal Temperature Results Summary :

Description	Notes	Curve	Basic MDMT °C	Reduced MDMT °C	UG-20(f) MDMT °C	Thickness ratio	Gov Thk mm	E*	PWHT reqd
Elliptical bo	[10]	C	-48	-48	-29	0.487	6.350	0.85	No
Elliptical bot	[7]	C	-48	-48	-29	0.487	6.350	0.85	No
WS CYLINDER 1	[20]	C	-44	-48	-29	0.487	10.000	0.85	No
WS CYLINDER 2	[20]	C	-44	-104	-29	0.313	10.000	0.85	No
WS CYLINDER 3/	[8]	C	-44	-104	-29	0.226	10.000	0.85	No
CONE WS TO RIS	[8]	C	-44	-104	-29	0.235	10.000	0.85	No
Riser	[20]	C	-44	-104	-29	0.321	10.000	0.85	No
CONE	[8]	C	-44	-104	-29	0.193	10.000	0.85	No
TIP	[16]		-196						
N2	[1]	C	-48	-48	-29	0.437	6.350	1.00	No
Nozzle Flg	[5]	!	-17	-104					
N3	[1]	C	-46	-104		0.013	3.978	1.00	No
Nozzle Flg	[4]	!	-46	-104					
N4	[1]	C	-46	-104		0.013	3.978	1.00	No
Nozzle Flg	[4]	!	-46	-104					
K1A	[1]	C	-46	-104		0.013	3.978	1.00	No
Nozzle Flg	[4]	!	-46	-104					
K1B	[1]	C	-46	-104		0.013	3.978	1.00	No
Nozzle Flg	[4]	!	-46	-104					
HW	[1]	B	-46	-104		0.076	7.156	1.00	No
Nozzle Flg	[4]	!	-46	-104					
N1	[1]	C	-46	-104		0.079	8.112	1.00	No
Nozzle Flg	[4]	!	-46	-104					
Warmest MDMT:			-17	-48					

Required Minimum Design Metal Temperature -10.0 °C
Warmest Computed Minimum Design Metal Temperature -48.0 °C

Notes:
[!] - This was an impact tested material.
[1] - Governing Nozzle Weld.
[4] - ANSI Flange MDMT Calcs; Thickness ratio per UCS-66(b)(1)(-c).
[5] - ANSI Flange MDMT Calcs; Thickness ratio per UCS-66(b)(1)(-b).
[6] - MDMT Calculations at the Shell/Head Joint.
[7] - MDMT Calculations for the Straight Flange.
[8] - Cylinder/Cone/Flange Junction MDMT.
[9] - Calculations in the Spherical Portion of the Head.
[10] - Calculations in the Knuckle Portion of the Head.
[11] - Calculated (Body Flange) Flange MDMT.
[12] - Calculated Flat Head MDMT per UCS-66.3
[13] - Tubesheet MDMT, shell side, if applicable
[14] - Tubesheet MDMT, tube side, if applicable
[15] - Nozzle Material

[16] - Shell or Head Material
[17] - Impact Testing required
[18] - Impact Testing not required, see UCS-66(b)(3)
[20] - Cylinder/Cone Junction MDMT based on Longitudinal Stress considerations
[21] - Bolting Material

UG-84(b)(2) was not considered.
UCS-66(g) was not considered.
UCS-66(i) was not considered.

Notes:
Impact test temps were not entered in and not considered in the analysis.
UCS-66(i) applies to impact tested materials not by specification and
UCS-66(g) applies to materials impact tested per UG-84.1 General Note (c).
The Basic MDMT includes the (30F) PWHT credit if applicable.

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ASME Code, Section VIII Division 1, 2023

Diameter Spec : 1066.800 x 508.000 x 323.900 mm OD		
Vessel Design Length, Tangent to Tangent	15559.52	mm
Distance of Bottom Tangent above Grade	32260.00	mm
Distance of Base above Grade	31310.00	mm
Specified Datum Line Distance	0.00	mm
Internal Design Temperature	80	°C
Internal Design Pressure	350.000	kPa
External Design Temperature	80	°C
Maximum Allowable Working Pressure	621.533	kPa
Hydrostatic Test Pressure	500.500	kPa
Required Minimum Design Metal Temperature	-10.0	°C
Warmest Computed Minimum Design Metal Temperature	-48.0	°C
Wind Design Code	EN-2010	
Earthquake Design Code	G-Loading	

Materials of Construction:

Component Type	Material	Class	Thickness	UNS #	Normalized	Impact Tested
Shell	SA-516 60	...	...	K02100	No	No
Shell	SA-213 TP316	...	...	S31600	No	No
Head	SA-516 60	...	...	K02100	No	No
Cone	SA-516 60	...	...	K02100	No	No

Flange	SA-350 LF2	1	...	K03011	No	Yes
Flange	SA-182 F316L	...	> 5	S31603	No	No
Skirt	SA/EN 10028-2	P355GH	6 < t <= 10		No	No
Nozzle	SA-333 6	...	...	K03006	No	Yes
Re-Pad	SA-516 60	...	...	K02100	No	No
Re-Pad	SA-516 70	...	...	K02700	No	No
Nozzle Flg	SA-105	...	...	K03504	No	Yes
Nozzle Flg	SA-350 LF2	1	...	K03011	No	Yes

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 (kPa & mm):

Element Description or Type	Design Pressure + Stat. head	Ext. Press.	Element M.A.W.P	Corrosion Allowance	Str. Flg. Gov.	In Creep Range
Elliptical bottom head	361.405	0.00	621.533	3.0000	No	No
WS CYLINDER 1/2	358.332	0.00	1313.689	3.0000	N/A	No
WS CYLINDER 2/2	350.000	0.00	1322.021	3.0000	N/A	No
WS CYLINDER 3/3	350.000	0.00	1322.021	3.0000	N/A	No
CONE WS TO RISER	350.000	0.00	1273.009	3.0000	N/A	No
Riser	350.000	0.00	2792.454	3.0000	N/A	No
CONE	350.000	0.00	2715.345	3.0000	N/A	No
FLANGE WN 12" 150# ASME	350.000	0.00	1833.988	3.0000	N/A	No
FLANGE WN 12" 150# ASME	350.000	0.00	1833.988	3.0000	N/A	?
TIP	350.000	0.00	4655.324	0.0000	N/A	No

Liquid Level: 1163.53 mm Dens.: 0.001 kg/cm^3 Sp. Gr.: 1.000

Element Types and Properties:

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Element Type	"To" Elev mm	Element Length mm	Nominal Thickness mm	Finished Thickness mm	Reqd Thk Internal mm	Reqd Thk External mm	Long Eff	Circ Eff
Skirt	950.0	950.0	...	10.0	...	...	0.85	0.85
Ellipse	1000.0	50.0	...	6.3	4.9	4.6	0.85	0.85
Cylinder	3500.0	2500.0	...	10.0	4.9	...	0.85	0.85
Cylinder	5136.0	1636.0	...	10.0	4.9	...	0.85	0.85
Cylinder	5456.0	320.0	...	10.0	4.9	...	0.85	0.85
Conical	6456.0	1000.0	...	10.0	4.9	...	0.85	0.85
Cylinder	11000.0	4544.0	...	10.0	4.6	...	0.85	0.85
Conical	11385.7	385.7	...	10.0	4.6	...	0.85	0.85
Body Flg	11500.0	114.3	...	10.0	...	7.0	1.00	1.00
Body Flg	11623.8	114.3	...	10.0	...	7.0	1.00	1.00
Cylinder	16509.5	4885.7	...	6.0	1.6	...	1.00	1.00

Wind/Earthquake Shear, Bending:

From	To	Distance to Support mm	Cumulative Wind Shear kgf	Earthquake Shear kgf	Wind Bending kgf-m	Earthquake Bending kgf-m
10	20	475	2153.66	3972.78	13501.8	18096.1
20	30	975	1988.26	3714.11	11534.4	14444.7
30	40	2250	1979.24	3427.59	11435.2	14266.2
40	50	4318	1471.06	1862.26	7122.23	7653.73
50	60	5296	1127.02	1272.44	4996.96	5089.49
60	70	5956	1073.15	1190.92	4644.93	4695.34
70	80	8728	948.694	996.456	3633.98	3601.63
80	90	11192.8	296.641	271.423	804.526	720.951
90	100	11442.8	270.727	232.649	695.107	623.739
100	110	11566.7	264.733	232.649	661.983	594.93
110	120	14066.7	258.736	232.649	632.066	568.338

Abs Max of the all of the Stress Ratio's : 0.8424

Total Wind Shear on Support 3795. kgf
Total Earthquake Shear on Support 5614. kgf

Note: The Wind and Seismic loads were not load factored in this analysis.

Note:
Wind and Earthquake moments include the effects of user defined forces and moments if any exist in the job and were specified to act (compute loads and stresses) during these cases. Also included are moment effects due to eccentric weights if any are present in the input.

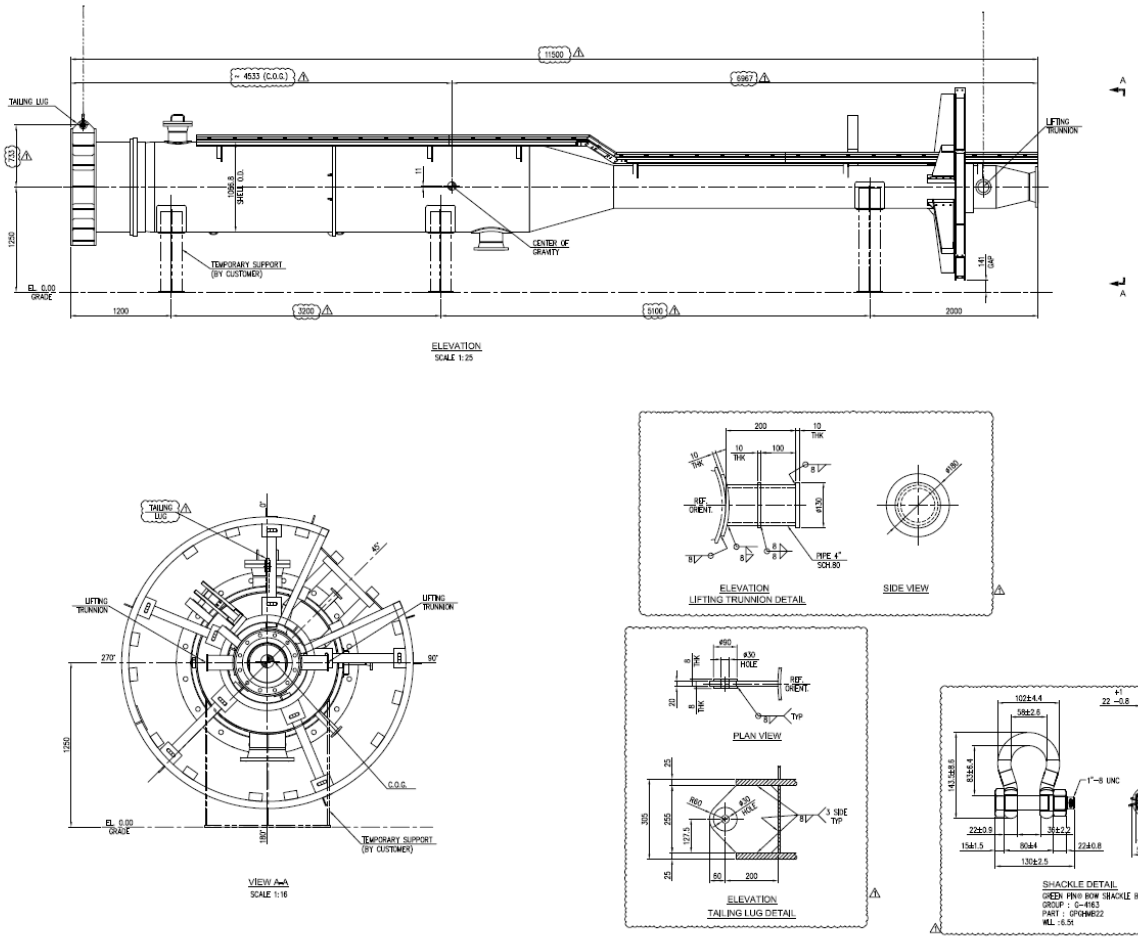
Weights:

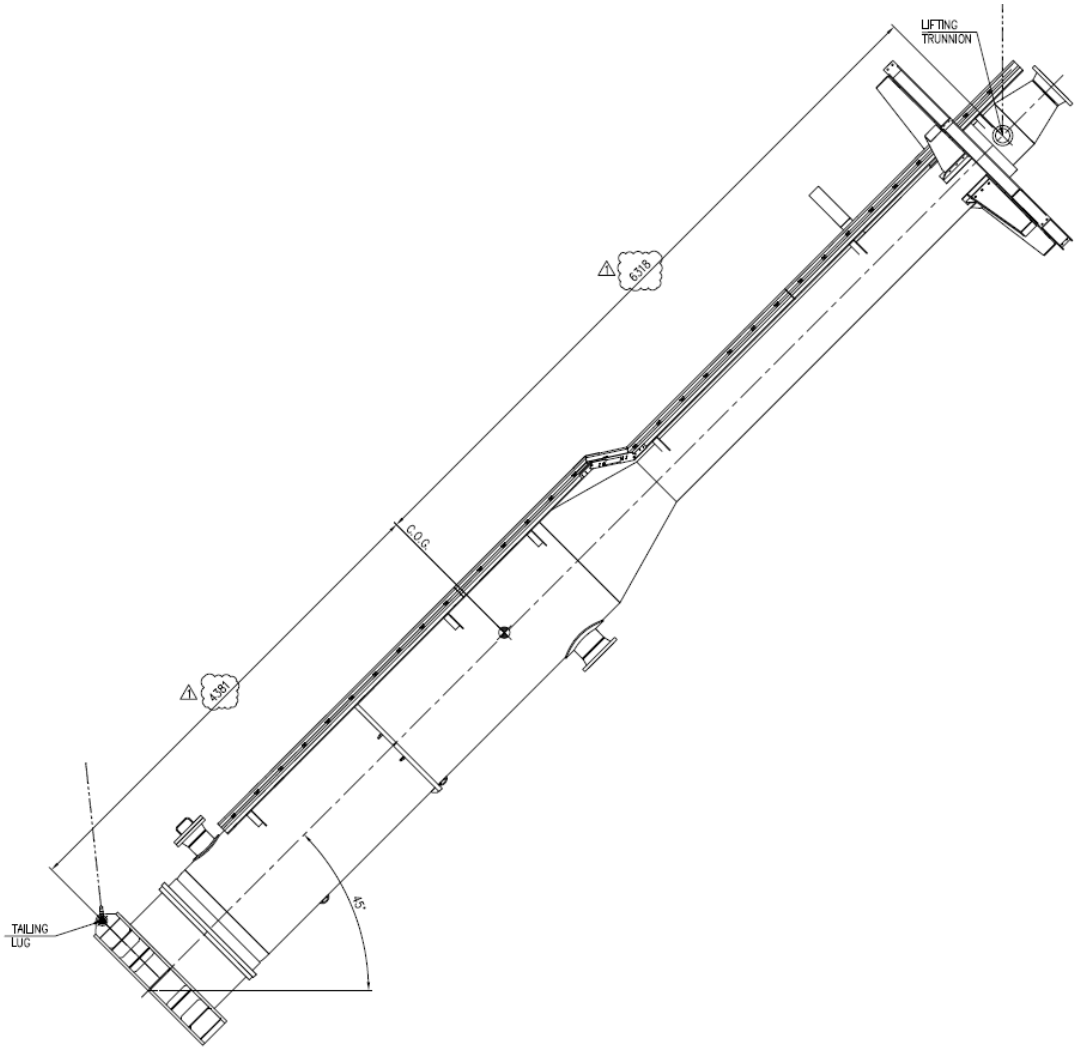
Fabricated	- Bare W/O Removable Internals	2812.3	kgm
Shop Test	- Fabricated + Water (Full)	8632.8	kgm
Shipping	- Fab. + Rem. Intls.+ Shipping App.	3085.0	kgm
Erected	- Fab. + Rem. Intls.+ Insul. (etc)	3085.0	kgm
Empty	- Fab. + Intls. + Details + Wghts.	3085.0	kgm
Operating	- Empty + Operating Liquid (No CA)	4013.1	kgm
Field Test	- Empty Weight + Water (Full)	8905.6	kgm

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B - LIFTING ANALYSIS CONFIGURATION WITHOUT TIP INSTALLED

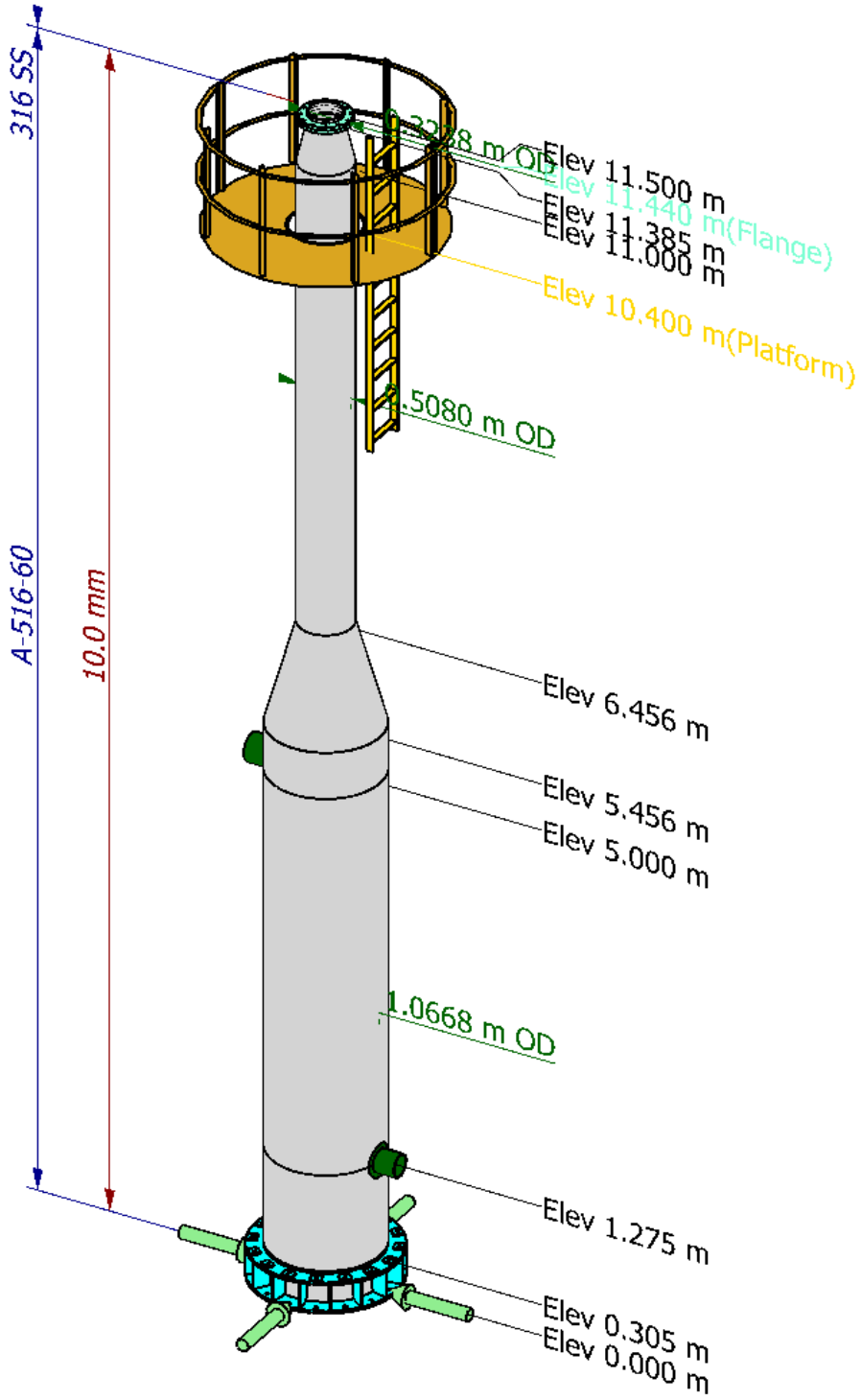
The configuration for the lifting is shown here after.



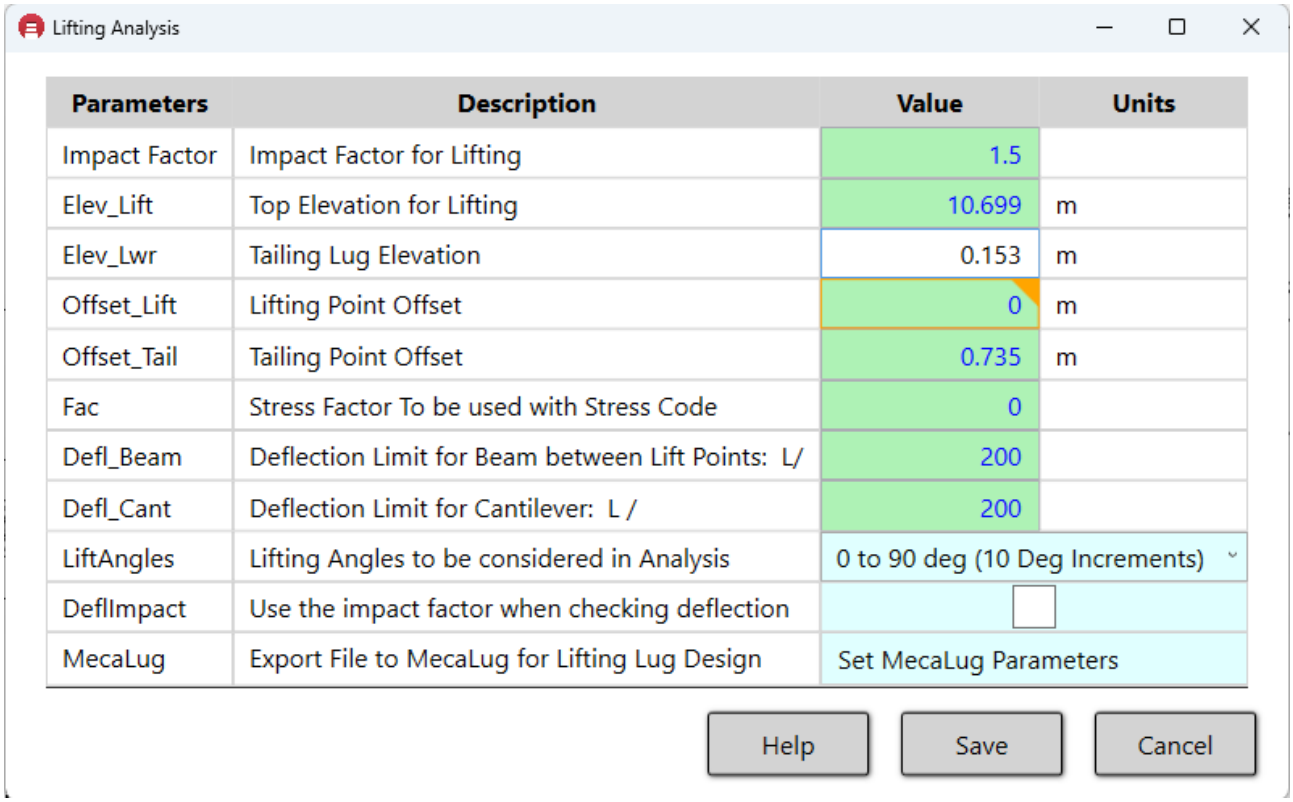


The tip will be installed after the precise vertical alignment of the bottom part.

A specialized model has been developed to analyze the lifting phases. For safety, the top platform is assumed to be fully assembled during the lift. In practice, some components will be added later to avoid potential conflicts with the lifting hardware.



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MecaStack v5630

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Calculations Prepared by:
Date: Oct 17, 2024

File Location: W:\1.COMMESSE\DB-ENCORE-C16-23-0193-Rosetti Marino Cross Wind\4.Calcoli\MECASTACK\23-0193-Lifting analysis-20240920-01.stk

INPUT PARAMETERS:
* Linear Static Analysis
* Stress analysis based upon Allowable Stress Design

Total Stack Height = 11.50 m Top of Stack Elevation = 11.5 m
Grade Elevation = 0.00 m Bottom of Stack = 0.0 m

All elevations are based upon the bottom of stack being at 0 m

Stack Geometry:

Elevation m	Outer Diameter m	Elevation m	Thickness mm	Elevation m	Corrosion Allow mm
11.5	0.3238	11.5	10.0	11.5	3.0
11.385	0.3238			0.305	0.0
11.0	0.5080				
6.456	0.5080				
5.456	1.0668				

Materials:

Elev m	Material	Temp Deg C	Fyld MPa	Elas Mod MPa	Alpha mm/mm/C	Allow Strs MPa	Density Kg/m^3	Tensile MPa
11.5	316 SS	200.00	148.65	182352	1.71E-05	99.37	8000	496.28
		21.11	206.84	195121	1.53E-05	137.89	8000	517.11
11.5	A-516-60	120.00	198.71	196914	1.22E-05	117.90	7849	413.68
		21.11	220.63	202705	1.15E-05	117.90	7849	413.68

Platforms:

Plat Elev m	Start Ang Deg	End Ang Deg	Width m	Stack OD m	Weight kg
10.400	0.0	360.0	0.7500	0.5080	319.3

Ladders:

Top Elev m	Bot Elev m	Orientation Deg	Type of Ladder	Weight kg/m	Wind Area m^2/m
11.500	8.400	0.0	Ladder Only	22.32	0.152

General Attachment Uniform

Description	Top Elev m	Bot Elev m	Area m	Lin Wt kg/m	Type
Water	2.450	0.950	0.0000	758.00	Oper
External insulation	3.100	0.350	0.0000	30.00	Dead

General Attachment Concentrated

Description	Elev m	Area sq m	Weight kg	Type
Elliptical head	0.305	0.000	200.0	Dead

Nozzles:

Num	Description	Elevation m	Nominal Diameter	Schedule	Outer Diameter mm	Thickness mm	Tilt Deg	Orien-tation Deg	Proj-ection mm

```
 1  1N              5.000 10 inch [254.0 mm]    Std       273.1        9.3  0.0  180.0
200.0
 2  HW              1.275  8 inch [203.2 mm]    Std       219.1        8.2  0.0    0.0
200.0
```

Num	Description	Repad Width mm	Repad Thickness mm	Flange Spec	Flange Radial Width mm	Flange Thickness mm	Nozzle Loads
1	1N	100.0	8.0	ANSI B16.5 150# Flange	66.7	30.2	Loads = 1
2	HW	50.0	8.0	ANSI B16.5 150# Flange	61.9	28.6	Loads = 0

Nozzle # 1 Nozzle Load Cases

Load Num	Description	Fx KN	Fy KN	Fz KN	Mx KN-m	My KN-m	Mz KN-m	Local/ Global	Load Applied	Load Type	Check WRC 107
1	5 x API Loads	7.78	14.46	14.46	6.30	4.75	4.75	Local	End of Nozzle	Oper	Yes

Nozzle # 1 Load Summary of Transformed Loads
Transformation of Loads to Global Coordiantes and at Stack Centerline

Load Num	Description	Load Type	FxC KN	FyC KN	FzC KN	MxC KN-m	MyC KN-m	MzC KN-m	Ver KN	Shear KN	Mom KN-m	Mbase KN-m
1	5 x API Loads	Oper	7.78	14.46	14.46	6.30	4.75	4.75	14.46	16.42	7.89	89.99

```
   Equivalent Nozzle Loads Applied on Stack:
   Ver   = Stack Vertical Load considered at Nozzle Elev: Fy
   Shear = Stack Shear Load considered at Nozzle Elev:  [Fx^2+Fz^2]^0.5
   Mom   = Stack Moment Load considered at Nozzle Elev: [Mx^2+Mz^2]^0.5
   Mbase = Est Mom at base if no Support:  Mom + Shear*Elev
           Provided only to evaluate the impact of the load on overall stack
```

```
Type      = Type of Baseplate                                          = Chair
                                                                         Continuous
Plate
SupType   = Type of Support                                            = Rigid Steel
Base
Friction  = Coefficient of Friction for Support                        = 0.300
BasisBolt = Basis for Bolt Design                                      = Brownell &
Young
Nbolt     = Number of Bolts                                            = 16
Dbolt     = Nominal Bolt Diameter                                      = 27.0 mm
Dbh       = Bolt Hole Diameter                                         = 36.0 mm
CAbolt    = Corrosion Allowance on Bolt                                = 3.0 mm
CAplt     = Corrosion Allowance on Plates                              = 0.0 mm
ID        = Inside Diameter of Baseplate                               = 820.0 mm
BCD       = Bolt Circle Diameter of Baseplate                          = 1270.0 mm
OD        = Outer Diameter of Baseplate                                = 1385.0 mm
Tb        = Thickness of Bottom Plate                                  = 25.0 mm
Tt        = Thickness of Top Plate                                     = 25.0 mm
Fw        = Fillet Weld Size                                           = 5.0 mm
```

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```
Fwu       = Weld Ultimate Tensile Strength                          = 482632.1
KPa
Ngus      = Number of Gussets per Bolt                              = 1
Hg        = Height of Anchor Chair                                  = 305.0 mm
Tg        = Thickness of Gusset                                     = 12.0 mm
Material: (Properties looked up from database)
Spec      = Material Specification                                  = S275J0
Dens      = Material Density                                        = 7849 Kg/m^3
Temp      = Design Temperature                                      = 21.11 Deg C
Fy        = Minimum Yield Stress                                    = 274996.9
KPa
Fu        = Ultimate Tensile Stress                                 = 410030.5
KPa
Sa        = Allowable Tensile Stress                                = 117141.7
KPa
E         = Modulus of Elasticity                                   = 209957162.5
KPa
A         = Coefficient of Thermal Expansion                        = 1.20E-05
mm/mm/C


Bolt Material:
Override  = Manually Specify Material                               = False
Matl      = Bolt Material Specification                             = Gr. 8.8
Fu        = Ultimate Tensile Stress                                 = 800548.8
KPa
Fy        = Yield Stress                                            = 640440.4
KPa
Fproof    = Proof Stress                                            = 544374.4
KPa
Eb        = Modulus of Elasticity                                   = 202705497.9
KPa
Anchor Bolt Pretension:
Pretension= Pretension for Bolt as % of Ultimate Tensile            = 60.00 %
Fult      = Bolt Ultimate Tensile Stress                            = 800.55 MPa
PreStress = Pretension Stress on Bolt                               = 480.33 MPa

Plate Washer:
Ptype     = The Type of Plate Washer                                = Rectangular
Pt        = Plate Washer Thickness                                  = 15.0 mm
Pw        = Width of Washer Perpendicular to Shell                  = 90.0 mm
Pl        = Length of Washer Parallel to Shell                      = 100.0 mm
Pdh       = Bolt Hole Diameter                                      = 30.0 mm
Structural Flange(s):
Structural Flange:  FLANGE #1 - 11.44 m
Flange Standard: None
Ds        = Outer Diameter of Shell                                 = 323.8 mm
Do        = Outside Diameter of Flange                              = 482.6 mm
Rod       = Radial Dist from Bolt Circle to OD of Flange            = 25.4 mm
Dbc       = Bolt Circle Diameter                                    = 431.8 mm
Rbc       = Radial Dist from OD of Shell to Bolt Circle             = 54.0 mm
Tf        = Thickness of Flange                                     = 31.8 mm
Tw        = Fillet Weld Size                                        = 6.0 mm
Gus       = Gussets                                                 = False
Db        = Nominal Bolt Diameter                                   = 22.2 mm
Nb        = Number of Bolts                                         = 12
BMatl     = Bolt Material                                           = Gr 8 (US)
```

```
Fu        = Ultimate Bolt Tensile Stress                                  = 1034.21 MPa
Eb        = Modulus of Elasticity for Bolt                                = 202705.50
MPa
Fp        = Pre-Load % of Allowable Bolt                                  = 60.00 %
Fw        = Tensile Stress of Weld                                        = 413.68 MPa
FMatl     = Flange Material                                               = A-36
Fyf       = Yield Stress of Flange                                        = 215.81 MPa
Ef        = Modulus of Elasticity of Flange                               = 193742.33
MPa
```

Design Codes

```
Stress Criteria:  Eurocde 3 - Design of Steel structures:  Part 3-2: Towers, masts and
chimneys
Class     = Fabrication Quality Class (A=Excellent, B=High, C=Normal)     = C
Bspace    = Flange Max Bolt spacing in terms of # of bolt diameters       = 10.00
Incl_Ecc  = Include Eccentric Moment when Centroid is Offset              = False

Lifting Criteria:

Impact    = Impact Factor                                                 = 1.50
Lift_El   = Elevation of Lifting Point                                    = 10.699 m
UprOff    = Longitudinal Offset for Lifting Lug point from Lift Elev to Lift Eye= 0.0000
m
Tail_El   = Elevation of Tailing Point                                    = 0.153 m
LwrOff    = Radial Offset for Tailing Lug point from Ctr Line to Tail Pt  = 0.7350 m
SF        = Stress Factor of Safety                                       = 0.000
Defl_Beam = Deflection Limit between Lifting Points:  L /                 = 200.0
Defl_Cant = Deflection Limit for Cantilevers:         L /                 = 200.0
Defl_Impact= Consider Impact loading for deflection check?                 = False
Check Stack for 0 to 90 Deg in 10 Deg increments
```

Damping Criteria:

```
Structural Damping Criteria:
     Criteria:      ASME STS-1-2021
     Stack Type:    UnLined
     Support:       ELASTIC
```

Mode	Bs Struc Damping	Ds Log Decrement Damping
1	0.1000	0.6283
2	0.0040	0.0251
3	0.0040	0.0251

```
   Log Decrement Damping = 2 * PI * Bs

Aerodynamic Damping Criteria:
     (Only used in Along wind analysis, Not considered for vortex shedding)
```

Criteria: EN 1994-1-4

Section Properties
Properties calculated based upon Corroded stack

Top Elev m	Bot Elev m	Outer Diameter mm	Thick mm	Rad of Gyration mm	Area sq cm	Plastic Sec Mod cm^3	Elastic Sec Mod cm^3	Mom of Inertia cm^4	Section Props
11.500	11.467	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
11.467	11.385	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
11.385	11.257	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
11.257	11.128	385.2	7.0	133.7	83.171	1001.4	772.4	14875.49	Ideal
11.128	11.000	446.6	7.0	155.4	96.673	1352.9	1046.0	23358.29	Ideal
11.000	10.699	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
10.699	10.400	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
10.400	8.400	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
8.400	7.667	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
7.667	6.456	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
6.456	6.123	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
6.123	5.789	694.3	7.0	243.0	151.138	3306.5	2570.9	89243.50	Ideal
5.789	5.456	880.5	7.0	308.8	192.100	5341.5	4162.0	183240.21	Ideal
5.456	5.137	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
5.137	5.000	1066.8	7.0	356.8	258.745	7914.0	6175.1	329389.19	1
5.000	4.863	1066.8	7.0	370.4	230.396	7596.5	5927.3	316171.94	2
4.863	3.100	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
3.100	2.450	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
2.450	1.385	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
1.385	1.275	1066.8	7.0	363.4	248.063	7872.5	6142.6	327659.06	3
1.275	1.165	1066.8	7.0	368.4	226.134	7372.8	5752.7	306862.01	4
1.165	0.950	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
0.950	0.350	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
0.350	0.305	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
0.305	0.153	1066.8	10.0	404.0	637.478	19311.7	15026.1	1040594.63	5
0.153	0.000	1066.8	10.0	404.0	637.478	19311.7	15026.1	1040594.63	6

Section Props - If a number is shown, then the section contains something unusual (Breach, nozzle, stiffeners, etc..) and so the properties were calculated using numerical methods.
- 'Ideal' indicates the properties calculated using ideal equations

Section Properties calculated using Numerical Methods
These sections contains unusual geometry (Nozzles, Breach, stiffeners, etc..)

Section Props	Principal Axis Deg	Centroid Xc mm	Centroid Yc mm	Area sq cm	Minimum Mom of Iner cm^4	Maximum Mom of Iner cm^4	Min Elas Sec Mod cm^3	Minimum Rad of Gyr mm
1	0.0	-52.6	0.0	258.745	329389.19	392083.97	6175.1	356.8
2	0.0	7.6	0.0	230.396	316171.94	331995.89	5927.3	370.4
3	0.0	32.3	0.0	248.063	327659.06	367515.76	6142.6	363.4
4	0.0	-16.4	0.0	226.134	306862.01	328213.14	5752.7	368.4
5	67.0	0.0	0.0	637.478	1040594.63	1040594.63	15026.1	404.0
6	67.0	0.0	0.0	637.478	1040594.63	1040594.63	15026.1	404.0

Weight Summary (Lifting)

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Component	Elev COG m	Weight kg	Weight N
Stack (Corroded Wt = 1583.0 kg)	4.698	2219.1	21762
Ladders	9.950	69.2	679
Platforms	10.400	319.3	3132
Baseplate	0.127	389.0	3815
Structural Flange(s)	11.440	58.0	569
Nozzle(s)	3.537	53.2	521
General Attachment Uniform)	1.725	82.5	809
General Attachment Concentrated	0.305	200.0	1961
Total	4.584	3390.3	33248

Cylindrical Shells Wt: (Wt = 2219.1 kg, El COG = 4.698 m)

Elev Top m	Elev Bot m	Elev COG m	OD m	Thk mm	Density Kg/m^3	Wt Corroded kg	Lin Wt UnCorroded kg/m	Wt UnCorroded kg
11.500	11.385	11.443	0.3238	10.0	8000	6.4	78.86	9.1
11.385	11.000	11.193	0.4159	10.0	7849	27.2	100.09	38.5
11.000	6.456	8.728	0.5080	10.0	7849	393.0	122.80	558.0
6.456	5.456	5.956	0.7874	10.0	7849	134.7	191.69	191.7
5.456	0.305	2.881	1.0668	10.0	7849	942.3	260.59	1342.3
0.305	0.000	0.153	1.0668	10.0	7849	79.5	260.59	79.5
Total		4.698				1583.0		2219.1

Note: Conical Sections show equivalent Diameter that gives same uncorroded weight

Ladders Wt: (Wt = 69.2 kg, El COG = 9.950 m)

Description	Elev Top m	Elev Bot m	Elev COG m	Lin Wt kg/m	Weight kg
Ladder Only	11.500	8.400	9.950	22.32	69.2
Total			9.950		69.2

Platforms Wt: (Wt = 319.3 kg, El COG = 10.400 m)

Plat Elev m	Start Ang Deg	End Ang Deg	Width m	Stack OD m	Elev COG m	Weight kg
10.400	0.0	360.0	0.7500	0.5080	10.400	319.3
Total					10.400	319.3

Baseplate Wt: (Wt = 389.0 kg, El COG = 0.127 m)

Description	Elevation COG m	Weight kg

Bottom Plate	0.013	192.0
Top Plate	0.293	120.2
Gussets	0.153	61.1
Washers	0.153	15.6
Total	0.127	389.0

Structural Flanges Wt: (Wt = 58.0 kg, El COG = 11.440 m)

Elev m	Flg OD mm	Flg Thk mm	Gus Ht mm	Gus Thk mm	Wt Gus kg	Wt Flg kg	Wt Bolts kg	Elev COG m	Qty	Weight kg
11.440	482.6	31.8	0.0	0.0	0.0	25.1	7.9	11.440	2	58.0
Total					0.0	25.1	7.9	11.440		58.0

1. Weight = (Wt_Flg + Wt_Gus)*Qty

Nozzle Wt (Dead): (Wt = 53.2 kg, El COG = 3.537 m)

Num	Elev m	OD mm	Removed Shell kg	Pipe kg	Repad kg	Flange kg	Noz Loads kg	Elev COG m	Weight kg
1	5.000	273.1	-3.99	12.06	7.36	16.85	0.00	5.000	32.27
2	1.275	219.1	-2.53	8.51	2.65	12.26	0.00	1.275	20.89
Total	0.0		-6.53	20.57	10.01	29.11	0.00	3.537	53.16

General Attach Uniform Wt (Dead, Factor = 1): (Wt = 82.5 kg, El COG = 1.725 m)

Description	El Top m	El Bot m	El COG m	Lin Wt kg/m	Tot Wt kg
External insula	3.100	0.350	1.725	30.00	82.5
Total	0.000	0.000	1.725		82.5

General Attach Concentrated Wt (Dead): (Wt = 200.0 kg, El COG = 0.305 m)

Description	Elev m	Area sq m	Weight kg
Elliptical head	0.305	0.000	200.0
Total	0.305		200.0

Primary Loads
Abbreviations are used in Load Combinations

Number	Description	Abbreviation
1	Dead	D
2	Impact Load	I

Load Combinations
Column Abbreviations can be found in the Primary Load Table

Num	Description	S	D	FS	Dir Deg	D	I
3	Dead Weight		X	0.000	0	1.0	
4	Dead Weight + Impact	X		0.000	0	1.0	1.0

FS: Factor of Safety used in Conjunction with the Stress Code which has been selected.
Dir: Direction of Lateral Loads (Wind/Seismic/Vortex), 0 Deg = X Axis, 90 Deg = Z Axis
P: Internal Pressure (Doesn't produce support loads only used for stack tensile stress)
S: Include in Stress Analysis D: Calculate Deflections
Load Combinations were Automatically generated

Boundary Conditions Specified for System
'F' is translational restraint and 'M' is rotational restraint

Joint #	Description	X m	Y m	Z m	Fx	Fy	Fz	Mx	My	Mz
7	Upper Lift Point	10.6990	0.0000	0.0000	Fixed	Fixed	Fixed	Fixed	Free	Free
28	Lower Lift Point	0.1530	0.7350	0.0000	Free	Fixed	Free	Free	Free	Free

Stack Stress Worst Case Summary
Summary of the load and highest stress ratios for each stack element

Top El m	Bot El m	Load #	Load Case	Controlling Case	Ratio	Result
11.500	11.467	4	Dead Weight + Impact	Buckling	0.000	PASS
11.467	11.385	4	Dead Weight + Impact	Buckling	0.000	PASS
11.385	11.257	4	Dead Weight + Impact	Buckling	0.001	PASS
11.257	11.128	4	Dead Weight + Impact	Buckling	0.001	PASS
11.128	11.000	4	Dead Weight + Impact	Buckling	0.002	PASS
11.000	10.699	4	Dead Weight + Impact	Buckling	0.002	PASS
10.699	10.400	4	Dead Weight + Impact	Buckling	0.023	PASS
10.400	8.400	4	Dead Weight + Impact	Buckling	0.018	PASS
8.400	7.667	4	Dead Weight + Impact	Buckling	0.096	PASS
7.667	6.456	4	Dead Weight + Impact	Buckling	0.118	PASS
6.456	6.123	4	Dead Weight + Impact	Buckling	0.147	PASS
6.123	5.789	4	Dead Weight + Impact	Buckling	0.081	PASS
5.789	5.456	4	Dead Weight + Impact	Buckling	0.051	PASS
5.456	5.137	4	Dead Weight + Impact	Buckling	0.036	PASS
5.137	5.000	4	Dead Weight + Impact	Buckling	0.036	PASS
5.000	4.863	4	Dead Weight + Impact	Buckling	0.039	PASS
4.863	3.100	4	Dead Weight + Impact	Buckling	0.036	PASS
3.100	2.450	4	Dead Weight + Impact	Buckling	0.032	PASS
2.450	1.385	4	Dead Weight + Impact	Buckling	0.028	PASS
1.385	1.275	4	Dead Weight + Impact	Buckling	0.020	PASS
1.275	1.165	4	Dead Weight + Impact	Buckling	0.020	PASS
1.165	0.950	4	Dead Weight + Impact	Buckling	0.018	PASS
0.950	0.350	4	Dead Weight + Impact	Buckling	0.016	PASS

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0.350	0.305	4	Dead Weight + Impact	Buckling	0.011 PASS
0.305	0.153	4	Dead Weight + Impact	Buckling	0.006 PASS
0.153	0.000	4	Dead Weight + Impact	Buckling	0.001 PASS
0.000	0.000	0			0.000 PASS

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 0 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	0.00	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	0.00	0.00	0.00	0.00	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.08	0.00	0.00	0.11	0.11	0.00	145.11	71.15	1.990	1.613	0.001	0.000	0.001
11.257	0.23	0.00	0.00	0.21	0.21	0.00	143.11	50.28	1.980	1.506	0.001	0.000	0.001
11.128	0.40	0.00	0.00	0.27	0.27	0.00	147.09	37.61	2.000	1.442	0.002	0.000	0.002
11.000	0.61	0.00	0.00	0.32	0.32	0.00	147.09	29.38	2.000	1.400	0.002	0.000	0.002
10.699	1.22	0.00	0.00	0.64	0.64	0.00	147.09	29.38	2.000	1.400	0.004	0.000	0.004
10.400	4.22	0.00	0.00	2.21	2.21	0.00	147.09	29.38	2.000	1.400	0.015	0.000	0.015
8.400	26.33	0.00	0.00	13.78	13.78	0.00	147.09	29.38	2.000	1.400	0.094	0.009	0.094
7.667	32.39	0.00	0.00	16.95	16.95	0.00	147.09	29.38	2.000	1.400	0.115	0.013	0.115
6.456	40.26	0.00	0.00	21.07	21.07	0.00	147.09	29.38	2.000	1.400	0.143	0.021	0.143
6.123	41.90	0.00	0.00	11.56	11.56	0.00	147.09	17.46	2.000	1.339	0.079	0.006	0.079
5.789	43.24	0.00	0.00	7.35	7.35	0.00	147.09	14.88	2.000	1.326	0.050	0.002	0.050
5.456	44.25	0.00	0.00	5.09	5.09	0.00	145.82	15.12	1.994	1.327	0.035	0.001	0.035
5.137	44.89	0.00	0.00	5.14	5.14	0.00	145.82	15.12	1.994	1.327	0.035	0.001	0.035
5.000	45.04	0.00	0.00	5.60	5.60	0.00	145.82	15.12	1.994	1.327	0.038	0.002	0.038
4.863	45.05	0.00	0.00	5.18	5.18	0.00	145.82	15.12	1.994	1.327	0.036	0.001	0.036
3.100	38.81	0.00	0.00	4.47	4.47	0.00	145.82	15.12	1.994	1.327	0.031	0.001	0.031
2.450	33.41	0.00	0.00	3.84	3.84	0.00	145.82	15.12	1.994	1.327	0.026	0.001	0.026
1.385	20.65	0.00	0.00	2.37	2.37	0.00	145.82	15.12	1.994	1.327	0.016	0.000	0.016
1.275	19.07	0.00	0.00	2.40	2.40	0.00	145.82	15.12	1.994	1.327	0.016	0.000	0.016
1.165	17.40	0.00	0.00	2.00	2.00	0.00	145.82	15.12	1.994	1.327	0.014	0.000	0.014
0.950	13.96	0.00	0.00	1.61	1.61	0.00	145.82	15.12	1.994	1.327	0.011	0.000	0.011
0.350	3.34	0.00	0.00	0.38	0.38	0.00	145.82	15.12	1.994	1.327	0.003	0.000	0.003
0.305	2.48	0.00	0.00	0.17	0.17	0.00	145.82	147.09	1.994	2.000	0.001	0.000	0.001
0.153	0.92	0.00	0.00	0.06	0.06	0.00	145.82	147.09	1.994	2.000	0.000	0.000	0.000

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 0 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 0.00 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 146567.34 KN

Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 0 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	1.00	3.0	0.466	220.63	0.300	1.080	0.200	1.000	5492.02	220.63	147.09
11.000	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4828.22	220.63	147.09
10.699	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4828.22	220.63	147.09
10.400	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4828.22	220.63	147.09
8.400	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4828.22	220.63	147.09
7.667	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4828.22	220.63	147.09
6.456	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4828.22	220.63	147.09
6.123	95.5	5.6275	1.0	1.00	3.7	0.427	220.63	0.300	1.033	0.250	1.000	3532.85	220.63	147.09
5.789	84.8	5.6275	1.0	1.00	4.1	0.403	220.63	0.300	1.004	0.281	1.000	2785.52	220.63	147.09
5.456	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
5.137	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
5.000	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
4.863	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
3.100	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
2.450	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
1.385	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
1.275	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82
1.165	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2299.16	218.73	145.82

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```
 0.950  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 0.350  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 0 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

```
   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
```

```
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 10 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	0.00	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.17	-0.02	0.00	-0.02	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.08	-0.20	-0.02	0.10	0.08	0.00	145.11	71.15	1.990	1.613	0.001	0.000	0.001
11.257	0.22	-0.24	-0.02	0.21	0.19	0.00	143.11	50.28	1.980	1.506	0.001	0.000	0.001
11.128	0.40	-0.28	-0.02	0.27	0.25	0.00	147.09	37.61	2.000	1.442	0.002	0.000	0.002
11.000	0.60	-0.35	-0.02	0.31	0.29	0.00	147.09	29.38	2.000	1.400	0.002	0.000	0.002
10.699	1.20	3.22	0.21	0.63	0.84	0.00	147.09	29.38	2.000	1.400	0.006	0.000	0.006
10.400	4.26	1.98	0.13	2.23	2.36	0.00	147.09	29.38	2.000	1.400	0.016	0.000	0.016
8.400	26.73	1.49	0.10	13.99	14.09	0.00	147.09	29.38	2.000	1.400	0.096	0.009	0.096
7.667	32.94	1.19	0.08	17.25	17.32	0.00	147.09	29.38	2.000	1.400	0.118	0.014	0.118
6.456	41.12	0.92	0.06	21.52	21.58	0.00	147.09	29.38	2.000	1.400	0.147	0.022	0.147
6.123	42.85	0.76	0.04	11.82	11.86	0.00	147.09	17.46	2.000	1.339	0.081	0.006	0.081
5.789	44.28	0.59	0.02	7.52	7.55	0.00	147.09	14.88	2.000	1.326	0.051	0.003	0.051
5.456	45.40	0.40	0.01	5.22	5.24	0.00	145.77	15.12	1.993	1.327	0.036	0.001	0.036
5.137	46.13	0.25	0.01	5.28	5.29	0.00	145.79	15.12	1.993	1.327	0.036	0.001	0.036
5.000	46.33	0.08	0.00	5.76	5.76	0.00	145.81	15.12	1.993	1.327	0.039	0.002	0.039
4.863	46.39	-0.55	-0.02	5.34	5.32	0.00	145.88	15.12	1.994	1.327	0.036	0.001	0.036
3.100	40.86	-1.38	-0.04	4.70	4.66	0.00	146.00	15.12	1.994	1.327	0.032	0.001	0.032
2.450	35.76	-2.02	-0.06	4.12	4.05	0.00	146.13	15.12	1.995	1.327	0.028	0.001	0.028
1.385	23.57	-2.45	-0.07	2.71	2.64	0.00	146.38	15.12	1.996	1.327	0.018	0.000	0.018
1.275	22.04	-2.59	-0.08	2.77	2.69	0.00	146.45	15.12	1.997	1.327	0.018	0.000	0.018
1.165	20.44	-2.71	-0.08	2.35	2.27	0.00	146.57	15.12	1.997	1.327	0.015	0.000	0.015
0.950	17.13	-3.01	-0.09	1.97	1.88	0.00	146.83	15.12	1.999	1.327	0.013	0.000	0.013
0.350	6.88	-3.25	-0.10	0.79	0.69	0.00	147.09	15.12	2.000	1.327	0.005	0.000	0.005
0.305	6.05	-3.83	-0.06	0.40	0.34	0.00	147.09	147.09	2.000	2.000	0.002	0.000	0.002
0.153	0.91	1.04	0.02	0.06	0.08	0.00	143.16	147.09	1.980	2.000	0.001	0.000	0.001

```
   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 10 Deg
Per EN 1993-3-2: Para 5.2.3

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Nb        = Design Value of Total Vertical Load at Base [5.5]              = 1.04 KN
Ncrit     = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]     = 146567.34
KN
Nratio    = Nb / Ncrit   [5.5]                                             = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 10 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	1.03	3.0	0.466	220.63	0.308	1.080	0.197	1.000	5670.24	220.63	147.09
11.000	111.7	5.6275	1.0	1.03	3.1	0.455	220.63	0.308	1.067	0.211	1.000	4978.62	220.63	147.09
10.699	111.7	5.6275	1.0	0.90	3.1	0.455	220.63	0.275	1.067	0.225	1.000	4352.26	220.63	147.09
10.400	111.7	5.6275	1.0	0.98	3.1	0.455	220.63	0.295	1.067	0.216	1.000	4724.50	220.63	147.09
8.400	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.299	1.067	0.214	1.000	4815.12	220.63	147.09
7.667	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4819.74	220.63	147.09
6.456	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.300	1.067	0.214	1.000	4822.97	220.63	147.09
6.123	95.5	5.6275	1.0	1.00	3.7	0.427	220.63	0.300	1.033	0.250	1.000	3528.66	220.63	147.09
5.789	84.8	5.6275	1.0	1.00	4.1	0.403	220.63	0.300	1.004	0.282	1.000	2782.32	220.63	147.09
5.456	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2297.02	218.65	145.77
5.137	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2297.93	218.68	145.79
5.000	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2298.77	218.71	145.81
4.863	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.992	2302.04	218.82	145.88
3.100	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.301	0.979	0.309	0.993	2307.37	219.01	146.00
2.450	77.1	5.6275	1.0	1.01	4.6	0.383	220.63	0.301	0.979	0.309	0.993	2312.95	219.19	146.13
1.385	77.1	5.6275	1.0	1.01	4.6	0.383	220.63	0.303	0.979	0.308	0.995	2323.81	219.56	146.38

```
 1.275  77.1 5.6275 1.0 1.01 4.6 0.383 220.63 0.303 0.979 0.308 0.996 2326.95 219.67
146.45
 1.165  77.1 5.6275 1.0 1.01 4.6 0.383 220.63 0.304 0.979 0.308 0.996 2332.22 219.85
146.57
 0.950  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.305 0.979 0.307 0.998 2343.54 220.24
146.83
 0.350  77.1 5.6275 1.0 1.06 4.6 0.383 220.63 0.314 0.979 0.301 1.000 2428.99 220.63
147.09
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.318 0.979 0.310 1.000 2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.279 0.979 0.310 0.973 2299.16 214.75
143.16

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 10 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

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```
   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 20 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.01	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.33	-0.03	0.00	-0.03	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.07	-0.39	-0.04	0.10	0.06	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.21	-0.47	-0.04	0.20	0.16	0.00	143.11	50.28	1.980	1.506	0.001	0.000	0.001
11.128	0.38	-0.55	-0.04	0.26	0.22	0.00	147.09	37.61	2.000	1.442	0.001	0.000	0.001
11.000	0.57	-0.70	-0.04	0.30	0.25	0.00	147.09	29.38	2.000	1.400	0.002	0.000	0.002
10.699	1.15	6.47	0.41	0.60	1.01	0.00	147.09	29.38	2.000	1.400	0.007	0.000	0.007
10.400	4.17	4.03	0.26	2.18	2.44	0.00	147.09	29.38	2.000	1.400	0.017	0.000	0.017
8.400	26.29	3.07	0.20	13.76	13.96	0.00	147.09	29.38	2.000	1.400	0.095	0.009	0.095
7.667	32.48	2.47	0.16	17.00	17.16	0.00	147.09	29.38	2.000	1.400	0.117	0.014	0.117
6.456	40.69	1.93	0.12	21.30	21.42	0.00	147.09	29.38	2.000	1.400	0.146	0.021	0.146
6.123	42.46	1.61	0.08	11.71	11.79	0.00	147.09	17.46	2.000	1.339	0.080	0.006	0.080
5.789	43.94	1.29	0.05	7.47	7.51	0.00	147.09	14.88	2.000	1.326	0.051	0.003	0.051
5.456	45.12	0.92	0.03	5.19	5.22	0.00	145.71	15.12	1.993	1.327	0.036	0.001	0.036
5.137	45.93	0.62	0.02	5.26	5.28	0.00	145.75	15.12	1.993	1.327	0.036	0.001	0.036
5.000	46.16	0.28	0.01	5.74	5.74	0.00	145.79	15.12	1.993	1.327	0.039	0.002	0.039
4.863	46.27	-0.96	-0.03	5.32	5.29	0.00	145.93	15.12	1.994	1.327	0.036	0.001	0.036
3.100	41.59	-2.60	-0.08	4.79	4.71	0.00	146.16	15.12	1.995	1.327	0.032	0.001	0.032
2.450	36.96	-3.85	-0.12	4.25	4.14	0.00	146.40	15.12	1.997	1.327	0.028	0.001	0.028
1.385	25.69	-4.71	-0.14	2.95	2.82	0.00	146.82	15.12	1.999	1.327	0.019	0.000	0.019
1.275	24.27	-4.97	-0.16	3.05	2.90	0.00	146.94	15.12	1.999	1.327	0.020	0.000	0.020
1.165	22.77	-5.21	-0.16	2.62	2.46	0.00	147.09	15.12	2.000	1.327	0.017	0.000	0.017
0.950	19.69	-5.81	-0.17	2.27	2.09	0.00	147.09	15.12	2.000	1.327	0.014	0.000	0.014
0.350	10.11	-6.28	-0.19	1.16	0.97	0.00	147.09	15.12	2.000	1.327	0.007	0.000	0.007
0.305	9.34	-7.41	-0.12	0.62	0.51	0.00	147.09	147.09	2.000	2.000	0.003	0.000	0.003
0.153	0.86	2.06	0.03	0.06	0.09	0.00	141.45	147.09	1.971	2.000	0.001	0.000	0.001

```
   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]   [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
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Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 20 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 2.06 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 146567.34 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 20 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	1.07	3.0	0.466	220.63	0.318	1.080	0.193	1.000	5894.65	220.63	147.09
11.000	111.7	5.6275	1.0	1.07	3.1	0.455	220.63	0.318	1.067	0.207	1.000	5166.73	220.63	147.09
10.699	111.7	5.6275	1.0	0.84	3.1	0.455	220.63	0.259	1.067	0.234	1.000	4040.81	220.63	147.09
10.400	111.7	5.6275	1.0	0.96	3.1	0.455	220.63	0.289	1.067	0.218	1.000	4624.50	220.63	147.09
8.400	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.299	1.067	0.214	1.000	4801.08	220.63	147.09
7.667	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.299	1.067	0.214	1.000	4810.46	220.63	147.09
6.456	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.299	1.067	0.214	1.000	4817.08	220.63	147.09
6.123	95.5	5.6275	1.0	1.00	3.7	0.427	220.63	0.299	1.033	0.250	1.000	3523.86	220.63	147.09
5.789	84.8	5.6275	1.0	1.00	4.1	0.403	220.63	0.299	1.004	0.282	1.000	2778.52	220.63	147.09
5.456	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.299	0.979	0.310	0.991	2294.27	218.56	145.71
5.137	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2296.13	218.62	145.75
5.000	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2297.76	218.68	145.79
4.863	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.301	0.979	0.309	0.992	2304.21	218.90	145.93
3.100	77.1	5.6275	1.0	1.01	4.6	0.383	220.63	0.302	0.979	0.309	0.994	2314.43	219.25	146.16
2.450	77.1	5.6275	1.0	1.01	4.6	0.383	220.63	0.303	0.979	0.308	0.995	2324.94	219.60	146.40

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 1.385  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.305 0.979 0.307 0.998 2343.45 220.24
146.82
 1.275  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.305 0.979 0.306 0.999 2348.77 220.42
146.94
 1.165  77.1 5.6275 1.0 1.03 4.6 0.383 220.63 0.306 0.979 0.306 1.000 2357.76 220.63
147.09
 0.950  77.1 5.6275 1.0 1.03 4.6 0.383 220.63 0.308 0.979 0.305 1.000 2376.12 220.63
147.09
 0.350  77.1 5.6275 1.0 1.08 4.6 0.383 220.63 0.319 0.979 0.298 1.000 2477.53 220.63
147.09
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.323 0.979 0.310 1.000 2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.264 0.979 0.310 0.962 2299.16 212.17
141.45

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 20 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12

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 0.305 1.00 2.11 0.500 0.250 1.118 0.818  0.000 0.000 1.0000  0.00 3533.59 220.63 147.09
 0.153 1.00 2.11 0.500 0.250 1.118 0.818  0.000 0.000 1.0000  0.00 3533.59 220.63 147.09

   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 30 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.01	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.48	-0.05	0.00	-0.05	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.07	-0.57	-0.06	0.09	0.03	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.20	-0.69	-0.06	0.18	0.12	0.00	143.11	50.28	1.980	1.506	0.001	0.000	0.001
11.128	0.35	-0.80	-0.06	0.24	0.18	0.00	147.09	37.61	2.000	1.442	0.001	0.000	0.001
11.000	0.53	-1.02	-0.07	0.28	0.21	0.00	147.09	29.38	2.000	1.400	0.001	0.000	0.001
10.699	1.06	9.66	0.62	0.55	1.17	0.00	147.09	29.38	2.000	1.400	0.008	0.000	0.008
10.400	3.95	6.09	0.39	2.07	2.46	0.00	147.09	29.38	2.000	1.400	0.017	0.000	0.017
8.400	25.04	4.69	0.30	13.11	13.41	0.00	147.09	29.38	2.000	1.400	0.091	0.008	0.091
7.667	30.99	3.81	0.24	16.22	16.47	0.00	147.09	29.38	2.000	1.400	0.112	0.013	0.112
6.456	38.98	3.03	0.19	20.41	20.60	0.00	147.09	29.38	2.000	1.400	0.140	0.020	0.140
6.123	40.73	2.56	0.12	11.24	11.35	0.00	147.09	17.46	2.000	1.339	0.077	0.006	0.077
5.789	42.21	2.09	0.08	7.17	7.25	0.00	147.09	14.88	2.000	1.326	0.049	0.002	0.049
5.456	43.42	1.55	0.05	5.00	5.04	0.00	145.62	15.12	1.993	1.327	0.035	0.001	0.035
5.137	44.27	1.11	0.03	5.07	5.10	0.00	145.69	15.12	1.993	1.327	0.035	0.001	0.035
5.000	44.54	0.61	0.02	5.53	5.55	0.00	145.75	15.12	1.993	1.327	0.038	0.001	0.038
4.863	44.68	-1.21	-0.04	5.14	5.11	0.00	145.97	15.12	1.994	1.327	0.035	0.001	0.035
3.100	40.99	-3.59	-0.11	4.72	4.61	0.00	146.31	15.12	1.996	1.327	0.032	0.001	0.032
2.450	36.95	-5.43	-0.16	4.25	4.09	0.00	146.65	15.12	1.998	1.327	0.028	0.001	0.028
1.385	26.93	-6.68	-0.19	3.10	2.90	0.00	147.09	15.12	2.000	1.327	0.020	0.000	0.020
1.275	25.66	-7.07	-0.22	3.23	3.00	0.00	147.09	15.12	2.000	1.327	0.020	0.000	0.020
1.165	24.32	-7.42	-0.22	2.80	2.58	0.00	147.09	15.12	2.000	1.327	0.018	0.000	0.018
0.950	21.56	-8.29	-0.25	2.48	2.23	0.00	147.09	15.12	2.000	1.327	0.015	0.000	0.015
0.350	12.94	-8.97	-0.27	1.49	1.22	0.00	147.09	15.12	2.000	1.327	0.008	0.000	0.008
0.305	12.24	-10.63	-0.17	0.81	0.65	0.00	147.09	147.09	2.000	2.000	0.004	0.000	0.004
0.153	0.80	3.01	0.05	0.05	0.10	0.00	140.18	147.09	1.965	2.000	0.001	0.000	0.001

```
   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]   [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
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   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 30 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]              = 3.01 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]     = 146567.34
KN
Nratio   = Nb / Ncrit   [5.5]                                             = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 30 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	1.13	3.0	0.466	220.63	0.333	1.080	0.189	1.000	6207.59	220.63	147.09
11.000	111.7	5.6275	1.0	1.12	3.1	0.455	220.63	0.331	1.067	0.202	1.000	5426.67	220.63	147.09
10.699	111.7	5.6275	1.0	0.79	3.1	0.455	220.63	0.247	1.067	0.241	1.000	3809.96	220.63	147.09
10.400	111.7	5.6275	1.0	0.94	3.1	0.455	220.63	0.284	1.067	0.221	1.000	4522.13	220.63	147.09
8.400	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.298	1.067	0.215	1.000	4785.04	220.63	147.09
7.667	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.299	1.067	0.214	1.000	4799.65	220.63	147.09
6.456	111.7	5.6275	1.0	1.00	3.1	0.455	220.63	0.299	1.067	0.214	1.000	4810.07	220.63	147.09
6.123	95.5	5.6275	1.0	1.00	3.7	0.427	220.63	0.299	1.033	0.250	1.000	3518.03	220.63	147.09
5.789	84.8	5.6275	1.0	1.00	4.1	0.403	220.63	0.299	1.004	0.282	1.000	2773.78	220.63	147.09
5.456	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.299	0.979	0.310	0.990	2290.65	218.44	145.62
5.137	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.299	0.979	0.310	0.990	2293.56	218.53	145.69
5.000	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2296.00	218.62	145.75
4.863	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.301	0.979	0.309	0.992	2305.72	218.95	145.97

```
 3.100  77.1 5.6275 1.0 1.01 4.6 0.383 220.63 0.302 0.979 0.308 0.995 2320.76 219.46
146.31
 2.450  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.304 0.979 0.307 0.997 2335.93 219.98
146.65
 1.385  77.1 5.6275 1.0 1.03 4.6 0.383 220.63 0.307 0.979 0.306 1.000 2360.14 220.63
147.09
 1.275  77.1 5.6275 1.0 1.03 4.6 0.383 220.63 0.307 0.979 0.305 1.000 2367.10 220.63
147.09
 1.165  77.1 5.6275 1.0 1.03 4.6 0.383 220.63 0.309 0.979 0.305 1.000 2378.93 220.63
147.09
 0.950  77.1 5.6275 1.0 1.04 4.6 0.383 220.63 0.311 0.979 0.303 1.000 2402.08 220.63
147.09
 0.350  77.1 5.6275 1.0 1.09 4.6 0.383 220.63 0.322 0.979 0.297 1.000 2503.05 220.63
147.09
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.326 0.979 0.310 1.000 2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.253 0.979 0.310 0.953 2299.16 210.27
140.18

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 30 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12

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1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 40 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.02	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.62	-0.06	0.00	-0.06	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.06	-0.73	-0.07	0.08	0.01	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.17	-0.88	-0.07	0.16	0.09	0.00	143.11	50.28	1.980	1.506	0.001	0.000	0.001
11.128	0.31	-1.03	-0.08	0.21	0.14	0.00	147.09	37.61	2.000	1.442	0.001	0.000	0.001
11.000	0.47	-1.31	-0.08	0.24	0.16	0.00	147.09	29.38	2.000	1.400	0.001	0.000	0.001
10.699	0.94	12.73	0.81	0.49	1.30	0.00	146.11	29.38	1.995	1.400	0.009	0.000	0.009
10.400	3.60	8.13	0.52	1.89	2.40	0.00	147.09	29.38	2.000	1.400	0.016	0.000	0.016
8.400	22.99	6.34	0.41	12.04	12.44	0.00	147.09	29.38	2.000	1.400	0.085	0.007	0.085
7.667	28.53	5.21	0.33	14.93	15.27	0.00	147.09	29.38	2.000	1.400	0.104	0.011	0.104
6.456	36.04	4.20	0.27	18.87	19.14	0.00	147.09	29.38	2.000	1.400	0.130	0.017	0.130
6.123	37.71	3.60	0.17	10.40	10.57	0.00	147.09	17.46	2.000	1.339	0.072	0.005	0.072
5.789	39.14	3.00	0.11	6.65	6.76	0.00	147.09	14.88	2.000	1.326	0.046	0.002	0.046
5.456	40.33	2.30	0.07	4.64	4.71	0.00	145.51	15.12	1.992	1.327	0.032	0.001	0.032
5.137	41.21	1.74	0.05	4.72	4.77	0.00	145.60	15.12	1.992	1.327	0.033	0.001	0.033
5.000	41.49	1.10	0.03	5.16	5.19	0.00	145.68	15.12	1.993	1.327	0.036	0.001	0.036
4.863	41.67	-1.24	-0.04	4.80	4.76	0.00	145.98	15.12	1.994	1.327	0.033	0.001	0.033
3.100	39.05	-4.31	-0.13	4.49	4.36	0.00	146.44	15.12	1.997	1.327	0.030	0.001	0.030
2.450	35.71	-6.67	-0.20	4.11	3.91	0.00	146.89	15.12	1.999	1.327	0.027	0.001	0.027
1.385	27.25	-8.28	-0.24	3.13	2.89	0.00	147.09	15.12	2.000	1.327	0.020	0.000	0.020
1.275	26.17	-8.78	-0.28	3.29	3.01	0.00	147.09	15.12	2.000	1.327	0.020	0.000	0.020
1.165	25.02	-9.23	-0.28	2.88	2.60	0.00	147.09	15.12	2.000	1.327	0.018	0.000	0.018
0.950	22.65	-10.35	-0.31	2.61	2.30	0.00	147.09	15.12	2.000	1.327	0.016	0.000	0.016
0.350	15.25	-11.23	-0.34	1.76	1.42	0.00	147.09	15.12	2.000	1.327	0.010	0.000	0.010
0.305	14.65	-13.36	-0.21	0.98	0.77	0.00	147.09	147.09	2.000	2.000	0.005	0.000	0.005
0.153	0.71	3.87	0.06	0.05	0.11	0.00	139.15	147.09	1.960	2.000	0.001	0.000	0.001

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]

```
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]        kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]   [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 40 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]              = 3.87 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]     = 146567.34
KN
Nratio   = Nb / Ncrit   [5.5]                                             = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 40 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	1.22	3.0	0.466	220.63	0.356	1.080	0.181	1.000	6712.18	220.63	147.09
11.000	111.7	5.6275	1.0	1.21	3.1	0.455	220.63	0.352	1.067	0.194	1.000	5840.15	220.63	147.09
10.699	111.7	5.6275	1.0	0.75	3.1	0.455	220.63	0.238	1.067	0.247	0.993	3622.67	219.16	146.11
10.400	111.7	5.6275	1.0	0.91	3.1	0.455	220.63	0.278	1.067	0.224	1.000	4410.67	220.63	147.09
8.400	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.297	1.067	0.215	1.000	4765.34	220.63	147.09
7.667	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.298	1.067	0.215	1.000	4786.11	220.63	147.09
6.456	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.299	1.067	0.214	1.000	4801.11	220.63	147.09
6.123	95.5	5.6275	1.0	0.99	3.7	0.427	220.63	0.298	1.033	0.251	1.000	3510.47	220.63	147.09
5.789	84.8	5.6275	1.0	0.99	4.1	0.403	220.63	0.298	1.004	0.282	1.000	2767.47	220.63	147.09
5.456	77.1	5.6275	1.0	0.99	4.6	0.383	220.63	0.299	0.979	0.311	0.989	2285.64	218.27	145.51
5.137	77.1	5.6275	1.0	1.00	4.6	0.383	220.63	0.299	0.979	0.310	0.990	2289.79	218.41	145.60

```
 5.000  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.299 0.979 0.310 0.990 2293.11 218.52
145.68
 4.863  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.301 0.979 0.309 0.992 2306.41 218.97
145.98
 3.100  77.1 5.6275 1.0 1.01 4.6 0.383 220.63 0.303 0.979 0.308 0.996 2326.52 219.66
146.44
 2.450  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.305 0.979 0.307 0.999 2346.40 220.34
146.89
 1.385  77.1 5.6275 1.0 1.03 4.6 0.383 220.63 0.308 0.979 0.305 1.000 2374.99 220.63
147.09
 1.275  77.1 5.6275 1.0 1.04 4.6 0.383 220.63 0.309 0.979 0.304 1.000 2383.26 220.63
147.09
 1.165  77.1 5.6275 1.0 1.04 4.6 0.383 220.63 0.311 0.979 0.303 1.000 2397.40 220.63
147.09
 0.950  77.1 5.6275 1.0 1.05 4.6 0.383 220.63 0.314 0.979 0.302 1.000 2424.03 220.63
147.09
 0.350  77.1 5.6275 1.0 1.10 4.6 0.383 220.63 0.324 0.979 0.296 1.000 2518.57 220.63
147.09
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.327 0.979 0.310 1.000 2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.244 0.979 0.310 0.946 2299.16 208.72
139.15

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 40 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12

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4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 50 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.02	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.74	-0.07	0.00	-0.07	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.05	-0.87	-0.09	0.07	-0.02	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.15	-1.05	-0.09	0.13	0.05	0.00	143.11	50.28	1.980	1.506	0.000	0.000	0.000
11.128	0.26	-1.23	-0.09	0.18	0.09	0.00	147.09	37.61	2.000	1.442	0.001	0.000	0.001
11.000	0.39	-1.56	-0.10	0.20	0.10	0.00	147.09	29.38	2.000	1.400	0.001	0.000	0.001
10.699	0.79	15.65	1.00	0.41	1.41	0.00	144.62	29.38	1.987	1.400	0.010	0.000	0.010
10.400	3.14	10.17	0.65	1.64	2.29	0.00	147.09	29.38	2.000	1.400	0.016	0.000	0.016
8.400	20.21	8.03	0.51	10.58	11.09	0.00	147.09	29.38	2.000	1.400	0.075	0.006	0.075
7.667	25.15	6.68	0.43	13.17	13.59	0.00	147.09	29.38	2.000	1.400	0.092	0.009	0.092
6.456	31.94	5.49	0.35	16.72	17.07	0.00	147.09	29.38	2.000	1.400	0.116	0.013	0.116
6.123	33.47	4.77	0.22	9.23	9.46	0.00	147.09	17.46	2.000	1.339	0.064	0.004	0.064
5.789	34.81	4.05	0.15	5.91	6.06	0.00	147.09	14.88	2.000	1.326	0.041	0.002	0.041
5.456	35.94	3.22	0.10	4.14	4.23	0.00	145.34	15.12	1.991	1.327	0.029	0.001	0.029
5.137	36.80	2.55	0.07	4.22	4.29	0.00	145.47	15.12	1.992	1.327	0.029	0.001	0.029
5.000	37.09	1.78	0.06	4.61	4.66	0.00	145.57	15.12	1.992	1.327	0.032	0.001	0.032
4.863	37.30	-1.01	-0.03	4.29	4.26	0.00	145.97	15.12	1.994	1.327	0.029	0.001	0.029
3.100	35.81	-4.66	-0.14	4.12	3.98	0.00	146.55	15.12	1.997	1.327	0.027	0.001	0.027
2.450	33.26	-7.47	-0.22	3.83	3.60	0.00	147.09	15.12	2.000	1.327	0.024	0.001	0.024
1.385	26.59	-9.39	-0.27	3.06	2.79	0.00	147.09	15.12	2.000	1.327	0.019	0.000	0.019
1.275	25.72	-9.99	-0.31	3.23	2.92	0.00	147.09	15.12	2.000	1.327	0.020	0.000	0.020
1.165	24.80	-10.52	-0.32	2.85	2.54	0.00	147.09	15.12	2.000	1.327	0.017	0.000	0.017
0.950	22.90	-11.85	-0.36	2.64	2.28	0.00	147.09	15.12	2.000	1.327	0.015	0.000	0.015
0.350	16.93	-12.90	-0.39	1.95	1.56	0.00	147.09	15.12	2.000	1.327	0.011	0.000	0.011
0.305	16.45	-15.45	-0.24	1.09	0.85	0.00	147.09	147.09	2.000	2.000	0.006	0.000	0.006
0.153	0.59	4.61	0.07	0.04	0.11	0.00	138.24	147.09	1.955	2.000	0.001	0.000	0.001

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   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 50 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 4.61 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 146567.34
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 50 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	1.41	3.0	0.466	220.63	0.403	1.080	0.169	1.000	7752.70	220.63	147.09
11.000	111.7	5.6275	1.0	1.38	3.1	0.455	220.63	0.395	1.067	0.182	1.000	6671.30	220.63	147.09
10.699	111.7	5.6275	1.0	0.72	3.1	0.455	220.63	0.229	1.067	0.253	0.983	3459.45	216.93	144.62
10.400	111.7	5.6275	1.0	0.89	3.1	0.455	220.63	0.272	1.067	0.227	1.000	4281.00	220.63	147.09
8.400	111.7	5.6275	1.0	0.98	3.1	0.455	220.63	0.295	1.067	0.216	1.000	4738.88	220.63	147.09
7.667	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.297	1.067	0.215	1.000	4767.53	220.63	147.09
6.456	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.298	1.067	0.215	1.000	4788.55	220.63	147.09
6.123	95.5	5.6275	1.0	0.99	3.7	0.427	220.63	0.298	1.033	0.251	1.000	3499.72	220.63	147.09
5.789	84.8	5.6275	1.0	0.99	4.1	0.403	220.63	0.298	1.004	0.283	1.000	2758.33	220.63	147.09

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 5.456  77.1 5.6275 1.0 0.99 4.6 0.383 220.63 0.298 0.979 0.311 0.988 2278.11 218.01
145.34
 5.137  77.1 5.6275 1.0 0.99 4.6 0.383 220.63 0.298 0.979 0.311 0.989 2283.88 218.21
145.47
 5.000  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.299 0.979 0.311 0.990 2288.22 218.35
145.57
 4.863  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.301 0.979 0.309 0.992 2305.71 218.95
145.97
 3.100  77.1 5.6275 1.0 1.01 4.6 0.383 220.63 0.304 0.979 0.308 0.996 2331.60 219.83
146.55
 2.450  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.306 0.979 0.306 1.000 2356.59 220.63
147.09
 1.385  77.1 5.6275 1.0 1.04 4.6 0.383 220.63 0.310 0.979 0.304 1.000 2388.52 220.63
147.09
 1.275  77.1 5.6275 1.0 1.04 4.6 0.383 220.63 0.311 0.979 0.303 1.000 2397.91 220.63
147.09
 1.165  77.1 5.6275 1.0 1.05 4.6 0.383 220.63 0.312 0.979 0.302 1.000 2413.99 220.63
147.09
 0.950  77.1 5.6275 1.0 1.06 4.6 0.383 220.63 0.316 0.979 0.301 1.000 2443.28 220.63
147.09
 0.350  77.1 5.6275 1.0 1.10 4.6 0.383 220.63 0.325 0.979 0.295 1.000 2528.26 220.63
147.09
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.328 0.979 0.310 1.000 2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.235 0.979 0.310 0.940 2299.16 207.37
138.24

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 50 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46

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5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 60 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.02	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.83	-0.08	0.00	-0.08	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.04	-0.99	-0.10	0.05	-0.05	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.11	-1.19	-0.10	0.10	0.00	0.00	143.11	50.28	1.980	1.506	0.000	0.000	0.000
11.128	0.20	-1.39	-0.10	0.14	0.04	0.00	147.09	37.61	2.000	1.442	0.000	0.000	0.000
11.000	0.30	-1.77	-0.11	0.16	0.05	0.00	147.09	29.38	2.000	1.400	0.000	0.000	0.000
10.699	0.61	18.47	1.18	0.32	1.50	0.00	143.23	29.38	1.980	1.400	0.010	0.000	0.010
10.400	2.58	12.28	0.78	1.35	2.13	0.00	147.09	29.38	2.000	1.400	0.015	0.000	0.015
8.400	16.75	9.85	0.63	8.77	9.40	0.00	147.09	29.38	2.000	1.400	0.064	0.004	0.064
7.667	20.93	8.33	0.53	10.95	11.49	0.00	147.09	29.38	2.000	1.400	0.078	0.006	0.078
6.456	26.75	6.98	0.45	14.00	14.45	0.00	147.09	29.38	2.000	1.400	0.098	0.010	0.098
6.123	28.10	6.17	0.29	7.75	8.04	0.00	147.09	17.46	2.000	1.339	0.055	0.003	0.055
5.789	29.28	5.35	0.20	4.98	5.17	0.00	147.09	14.88	2.000	1.326	0.035	0.001	0.035
5.456	30.31	4.41	0.13	3.49	3.62	0.00	145.05	15.12	1.990	1.327	0.025	0.001	0.025
5.137	31.13	3.66	0.10	3.57	3.67	0.00	145.24	15.12	1.991	1.327	0.025	0.001	0.025
5.000	31.41	2.79	0.09	3.90	3.99	0.00	145.36	15.12	1.991	1.327	0.027	0.001	0.027
4.863	31.63	-0.36	-0.01	3.64	3.63	0.00	145.88	15.12	1.994	1.327	0.025	0.001	0.025
3.100	31.27	-4.49	-0.14	3.60	3.46	0.00	146.63	15.12	1.998	1.327	0.024	0.001	0.024
2.450	29.58	-7.67	-0.23	3.40	3.17	0.00	147.09	15.12	2.000	1.327	0.022	0.000	0.022
1.385	24.87	-9.84	-0.28	2.86	2.58	0.00	147.09	15.12	2.000	1.327	0.018	0.000	0.018
1.275	24.25	-10.51	-0.33	3.05	2.72	0.00	147.09	15.12	2.000	1.327	0.018	0.000	0.018
1.165	23.58	-11.11	-0.33	2.71	2.38	0.00	147.09	15.12	2.000	1.327	0.016	0.000	0.016
0.950	22.20	-12.62	-0.38	2.55	2.17	0.00	147.09	15.12	2.000	1.327	0.015	0.000	0.015

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 0.350  17.83 -13.81 -0.42  2.05  1.64  0.00 147.09  15.12 2.000 1.327 0.011 0.000 0.011
 0.305  17.47 -16.68 -0.26  1.16  0.90  0.00 147.09 147.09 2.000 2.000 0.006 0.000 0.006
 0.153   0.46   5.21  0.08  0.03  0.11  0.00 137.40 147.09 1.951 2.000 0.001 0.000 0.001

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 60 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 5.21 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 146567.34
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 60 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	2.12	3.0	0.466	220.63	0.580	1.080	0.138	1.000	11650.99	220.63	147.09
11.000	111.7	5.6275	1.0	1.98	3.1	0.455	220.63	0.544	1.067	0.152	1.000	9549.63	220.63	147.09
10.699	111.7	5.6275	1.0	0.69	3.1	0.455	220.63	0.221	1.067	0.258	0.974	3308.53	214.85	143.23
10.400	111.7	5.6275	1.0	0.85	3.1	0.455	220.63	0.263	1.067	0.231	1.000	4118.08	220.63	147.09
8.400	111.7	5.6275	1.0	0.97	3.1	0.455	220.63	0.293	1.067	0.217	1.000	4698.81	220.63	147.09
7.667	111.7	5.6275	1.0	0.98	3.1	0.455	220.63	0.295	1.067	0.216	1.000	4738.66	220.63	147.09
6.456	111.7	5.6275	1.0	0.99	3.1	0.455	220.63	0.297	1.067	0.215	1.000	4768.59	220.63	147.09

```
 6.123  95.5 5.6275 1.0 0.99 3.7 0.427 220.63 0.296 1.033 0.252 1.000  3482.41 220.63
147.09
 5.789  84.8 5.6275 1.0 0.98 4.1 0.403 220.63 0.296 1.004 0.284 1.000  2743.35 220.63
147.09
 5.456  77.1 5.6275 1.0 0.99 4.6 0.383 220.63 0.296 0.979 0.312 0.986  2265.39 217.58
145.05
 5.137  77.1 5.6275 1.0 0.99 4.6 0.383 220.63 0.297 0.979 0.312 0.987  2273.52 217.85
145.24
 5.000  77.1 5.6275 1.0 0.99 4.6 0.383 220.63 0.298 0.979 0.311 0.988  2279.11 218.04
145.36
 4.863  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.992  2301.91 218.82
145.88
 3.100  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.304 0.979 0.307 0.997  2335.08 219.95
146.63
 2.450  77.1 5.6275 1.0 1.03 4.6 0.383 220.63 0.307 0.979 0.305 1.000  2366.07 220.63
147.09
 1.385  77.1 5.6275 1.0 1.04 4.6 0.383 220.63 0.311 0.979 0.303 1.000  2400.42 220.63
147.09
 1.275  77.1 5.6275 1.0 1.05 4.6 0.383 220.63 0.312 0.979 0.303 1.000  2410.83 220.63
147.09
 1.165  77.1 5.6275 1.0 1.06 4.6 0.383 220.63 0.314 0.979 0.301 1.000  2428.57 220.63
147.09
 0.950  77.1 5.6275 1.0 1.07 4.6 0.383 220.63 0.317 0.979 0.299 1.000  2459.98 220.63
147.09
 0.350  77.1 5.6275 1.0 1.10 4.6 0.383 220.63 0.325 0.979 0.295 1.000  2533.05 220.63
147.09
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.329 0.979 0.310 1.000  2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.227 0.979 0.310 0.934  2299.16 206.10
137.40

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 60 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38

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8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 70 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.02	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.91	-0.09	0.00	-0.09	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.03	-1.07	-0.11	0.04	-0.07	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.08	-1.29	-0.11	0.07	-0.04	0.00	143.11	50.28	1.980	1.506	0.000	0.000	0.000
11.128	0.14	-1.51	-0.11	0.09	-0.02	0.00	NaN	37.61	NaN	1.442	0.000	0.000	0.000
11.000	0.21	-1.92	-0.12	0.11	-0.01	0.00	NaN	29.38	NaN	1.400	0.000	0.000	0.000
10.699	0.42	21.48	1.37	0.22	1.59	0.00	141.87	29.38	1.973	1.400	0.011	0.000	0.011
10.400	1.92	14.77	0.94	1.01	1.95	0.00	147.09	29.38	2.000	1.400	0.013	0.000	0.013
8.400	12.67	12.14	0.78	6.63	7.41	0.00	147.09	29.38	2.000	1.400	0.050	0.003	0.050
7.667	15.91	10.49	0.67	8.33	9.00	0.00	147.09	29.38	2.000	1.400	0.061	0.004	0.061
6.456	20.53	9.02	0.58	10.75	11.32	0.00	147.09	29.38	2.000	1.400	0.077	0.006	0.077
6.123	21.62	8.13	0.38	5.96	6.34	0.00	147.09	17.46	2.000	1.339	0.043	0.002	0.043
5.789	22.61	7.25	0.27	3.84	4.11	0.00	147.09	14.88	2.000	1.326	0.028	0.001	0.028
5.456	23.49	6.23	0.19	2.70	2.89	0.00	144.46	15.12	1.987	1.327	0.020	0.000	0.020
5.137	24.21	5.41	0.15	2.77	2.92	0.00	144.74	15.12	1.988	1.327	0.020	0.000	0.020
5.000	24.48	4.47	0.14	3.04	3.18	0.00	144.90	15.12	1.989	1.327	0.022	0.001	0.022
4.863	24.71	1.05	0.03	2.84	2.87	0.00	145.59	15.12	1.992	1.327	0.020	0.000	0.020
3.100	25.38	-3.43	-0.10	2.92	2.82	0.00	146.58	15.12	1.997	1.327	0.019	0.000	0.019
2.450	24.57	-6.87	-0.21	2.83	2.62	0.00	147.09	15.12	2.000	1.327	0.018	0.000	0.018

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1.385	21.90	-9.23	-0.27	2.52	2.25	0.00	147.09	15.12	2.000	1.327	0.015	0.000	0.015
1.275	21.54	-9.96	-0.31	2.71	2.40	0.00	147.09	15.12	2.000	1.327	0.016	0.000	0.016
1.165	21.14	-10.62	-0.32	2.43	2.11	0.00	147.09	15.12	2.000	1.327	0.014	0.000	0.014
0.950	20.31	-12.25	-0.37	2.34	1.97	0.00	147.09	15.12	2.000	1.327	0.013	0.000	0.013
0.350	17.63	-13.54	-0.41	2.03	1.62	0.00	147.09	15.12	2.000	1.327	0.011	0.000	0.011
0.305	17.41	-16.66	-0.26	1.16	0.90	0.00	147.09	147.09	2.000	2.000	0.006	0.000	0.006
0.153	0.31	5.65	0.09	0.02	0.11	0.00	136.56	147.09	1.946	2.000	0.001	0.000	0.001

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 70 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 5.65 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 146567.34 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 70 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	-1.76	3.0	0.466	220.63	-0.391	1.080	NaN	NaN	-9686.24	NaN	NaN
11.000	111.7	5.6275	1.0	-2.58	3.1	0.455	220.63	-0.595	1.067	NaN	NaN	-12459.55	NaN	NaN
10.699	111.7	5.6275	1.0	0.65	3.1	0.455	220.63	0.214	1.067	0.264	0.965	3162.27	212.81	141.87
10.400	111.7	5.6275	1.0	0.81	3.1	0.455	220.63	0.252	1.067	0.238	1.000	3893.06	220.63	147.09
8.400	111.7	5.6275	1.0	0.96	3.1	0.455	220.63	0.290	1.067	0.218	1.000	4625.97	220.63	147.09

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 7.667 111.7 5.6275 1.0  0.97 3.1 0.455 220.63  0.293 1.067 0.217 1.000   4684.35 220.63
147.09
 6.456 111.7 5.6275 1.0  0.98 3.1 0.455 220.63  0.295 1.067 0.216 1.000   4729.91 220.63
147.09
 6.123  95.5 5.6275 1.0  0.98 3.7 0.427 220.63  0.294 1.033 0.253 1.000   3448.55 220.63
147.09
 5.789  84.8 5.6275 1.0  0.97 4.1 0.403 220.63  0.294 1.004 0.285 1.000   2713.59 220.63
147.09
 5.456  77.1 5.6275 1.0  0.97 4.6 0.383 220.63  0.294 0.979 0.314 0.982   2239.42 216.70
144.46
 5.137  77.1 5.6275 1.0  0.98 4.6 0.383 220.63  0.295 0.979 0.313 0.984   2251.58 217.11
144.74
 5.000  77.1 5.6275 1.0  0.98 4.6 0.383 220.63  0.296 0.979 0.313 0.985   2258.88 217.36
144.90
 4.863  77.1 5.6275 1.0  1.00 4.6 0.383 220.63  0.299 0.979 0.310 0.990   2289.01 218.38
145.59
 3.100  77.1 5.6275 1.0  1.01 4.6 0.383 220.63  0.304 0.979 0.308 0.997   2332.87 219.87
146.58
 2.450  77.1 5.6275 1.0  1.03 4.6 0.383 220.63  0.308 0.979 0.305 1.000   2371.83 220.63
147.09
 1.385  77.1 5.6275 1.0  1.05 4.6 0.383 220.63  0.312 0.979 0.303 1.000   2407.81 220.63
147.09
 1.275  77.1 5.6275 1.0  1.05 4.6 0.383 220.63  0.313 0.979 0.302 1.000   2419.28 220.63
147.09
 1.165  77.1 5.6275 1.0  1.06 4.6 0.383 220.63  0.315 0.979 0.301 1.000   2438.33 220.63
147.09
 0.950  77.1 5.6275 1.0  1.08 4.6 0.383 220.63  0.319 0.979 0.299 1.000   2471.65 220.63
147.09
 0.350  77.1 5.6275 1.0  1.10 4.6 0.383 220.63  0.325 0.979 0.295 1.000   2530.51 220.63
147.09
 0.305   2.1 0.1525 1.0  1.00 4.6 0.383 220.63  0.329 0.979 0.310 1.000   2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0  1.00 4.6 0.383 220.63  0.219 0.979 0.310 0.928   2299.16 204.84
136.56

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 70 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28

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11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 80 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.02	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.95	-0.10	0.00	-0.10	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.01	-1.12	-0.11	0.02	-0.10	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.04	-1.35	-0.11	0.04	-0.08	0.00	143.11	50.28	1.980	1.506	0.000	0.000	0.000
11.128	0.07	-1.58	-0.12	0.05	-0.07	0.00	126.03	37.61	1.893	1.442	0.000	0.000	0.000
11.000	0.11	-2.01	-0.13	0.06	-0.07	0.00	122.06	29.38	1.872	1.400	0.000	0.000	0.000
10.699	0.21	26.02	1.66	0.11	1.77	0.00	140.51	29.38	1.966	1.400	0.013	0.000	0.013
10.400	1.16	18.97	1.21	0.61	1.82	0.00	145.37	29.38	1.991	1.400	0.013	0.000	0.013
8.400	7.85	16.22	1.04	4.11	5.15	0.00	147.09	29.38	2.000	1.400	0.035	0.001	0.035
7.667	9.95	14.49	0.93	5.21	6.13	0.00	147.09	29.38	2.000	1.400	0.042	0.002	0.042
6.456	13.04	12.95	0.83	6.83	7.65	0.00	147.09	29.38	2.000	1.400	0.052	0.003	0.052
6.123	13.80	12.02	0.56	3.81	4.37	0.00	147.09	17.46	2.000	1.339	0.030	0.001	0.030
5.789	14.51	11.10	0.41	2.47	2.87	0.00	146.61	14.88	1.998	1.326	0.020	0.000	0.020
5.456	15.16	10.03	0.30	1.74	2.05	0.00	142.75	15.12	1.978	1.327	0.014	0.000	0.014
5.137	15.73	9.17	0.26	1.80	2.06	0.00	143.23	15.12	1.980	1.327	0.014	0.000	0.014

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5.000	15.95	8.19	0.26	1.98	2.24	0.00	143.45	15.12	1.981	1.327	0.016	0.000	0.016
4.863	16.14	4.60	0.14	1.86	2.00	0.00	144.37	15.12	1.986	1.327	0.014	0.000	0.014
3.100	17.57	-0.09	0.00	2.02	2.02	0.00	145.85	15.12	1.994	1.327	0.014	0.000	0.014
2.450	17.56	-3.70	-0.11	2.02	1.91	0.00	147.04	15.12	2.000	1.327	0.013	0.000	0.013
1.385	16.87	-6.18	-0.18	1.94	1.76	0.00	147.09	15.12	2.000	1.327	0.012	0.000	0.012
1.275	16.75	-6.94	-0.22	2.11	1.89	0.00	147.09	15.12	2.000	1.327	0.013	0.000	0.013
1.165	16.61	-7.63	-0.23	1.91	1.68	0.00	147.09	15.12	2.000	1.327	0.011	0.000	0.011
0.950	16.32	-9.34	-0.28	1.88	1.60	0.00	147.09	15.12	2.000	1.327	0.011	0.000	0.011
0.350	15.34	-10.69	-0.32	1.76	1.44	0.00	147.09	15.12	2.000	1.327	0.010	0.000	0.010
0.305	15.25	-13.96	-0.22	1.02	0.80	0.00	147.09	147.09	2.000	2.000	0.005	0.000	0.005
0.153	0.16	5.92	0.09	0.01	0.10	0.00	135.66	147.09	1.942	2.000	0.001	0.000	0.001

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 80 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 5.92 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 146567.34 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 80 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	0.32	3.0	0.466	220.63	0.129	1.080	0.356	0.857	1741.04	189.05	126.03
11.000	111.7	5.6275	1.0	0.30	3.1	0.455	220.63	0.124	1.067	0.392	0.830	1438.01	183.09	122.06
10.699	111.7	5.6275	1.0	0.63	3.1	0.455	220.63	0.206	1.067	0.270	0.955	3017.84	210.77	140.51

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10.400 111.7 5.6275 1.0 0.73 3.1 0.455 220.63 0.233 1.067 0.250 0.988 3541.13 218.05
145.37
 8.400 111.7 5.6275 1.0 0.92 3.1 0.455 220.63 0.280 1.067 0.223 1.000 4439.19 220.63
147.09
 7.667 111.7 5.6275 1.0 0.94 3.1 0.455 220.63 0.285 1.067 0.221 1.000 4536.61 220.63
147.09
 6.456 111.7 5.6275 1.0 0.96 3.1 0.455 220.63 0.289 1.067 0.219 1.000 4619.38 220.63
147.09
 6.123  95.5 5.6275 1.0 0.95 3.7 0.427 220.63 0.287 1.033 0.257 1.000 3351.83 220.63
147.09
 5.789  84.8 5.6275 1.0 0.94 4.1 0.403 220.63 0.286 1.004 0.290 0.997 2628.03 219.92
146.61
 5.456  77.1 5.6275 1.0 0.94 4.6 0.383 220.63 0.285 0.979 0.319 0.970 2163.39 214.12
142.75
 5.137  77.1 5.6275 1.0 0.95 4.6 0.383 220.63 0.288 0.979 0.318 0.974 2184.56 214.84
143.23
 5.000  77.1 5.6275 1.0 0.95 4.6 0.383 220.63 0.289 0.979 0.317 0.975 2194.30 215.17
143.45
 4.863  77.1 5.6275 1.0 0.97 4.6 0.383 220.63 0.293 0.979 0.314 0.982 2235.30 216.56
144.37
 3.100  77.1 5.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.992 2300.45 218.77
145.85
 2.450  77.1 5.6275 1.0 1.02 4.6 0.383 220.63 0.306 0.979 0.306 1.000 2352.91 220.56
147.04
 1.385  77.1 5.6275 1.0 1.04 4.6 0.383 220.63 0.310 0.979 0.304 1.000 2392.12 220.63
147.09
 1.275  77.1 5.6275 1.0 1.05 4.6 0.383 220.63 0.312 0.979 0.303 1.000 2405.34 220.63
147.09
 1.165  77.1 5.6275 1.0 1.05 4.6 0.383 220.63 0.314 0.979 0.302 1.000 2424.73 220.63
147.09
 0.950  77.1 5.6275 1.0 1.07 4.6 0.383 220.63 0.318 0.979 0.299 1.000 2461.19 220.63
147.09
 0.350  77.1 5.6275 1.0 1.09 4.6 0.383 220.63 0.322 0.979 0.297 1.000 2504.40 220.63
147.09
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.328 0.979 0.310 1.000 2299.16 220.63
147.09
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.210 0.979 0.310 0.922 2299.16 203.49
135.66

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
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Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 80 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa

11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 90 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
11.500	0.00	-0.02	0.00	0.00	0.00	0.00	136.31	68.24	1.991	1.621	0.000	0.000	0.000
11.467	0.00	-0.96	-0.10	0.00	-0.10	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.385	0.00	-1.14	-0.12	0.00	-0.12	0.00	145.11	71.15	1.990	1.613	0.000	0.000	0.000
11.257	0.00	-1.37	-0.12	0.00	-0.12	0.00	143.11	50.28	1.980	1.506	0.000	0.000	0.000
11.128	0.00	-1.60	-0.12	0.00	-0.12	0.00	141.19	37.61	1.970	1.442	0.000	0.000	0.000
11.000	0.00	-2.04	-0.13	0.00	-0.13	0.00	139.35	29.38	1.961	1.400	0.000	0.000	0.000
10.699	0.00	49.87	3.19	0.00	3.19	0.00	139.35	29.38	1.961	1.400	0.023	0.001	0.023
10.400	0.00	40.04	2.56	0.00	2.56	0.00	139.35	29.38	1.961	1.400	0.018	0.000	0.018
8.400	0.00	37.24	2.38	0.00	2.38	0.00	139.35	29.38	1.961	1.400	0.017	0.000	0.017
7.667	0.00	35.49	2.27	0.00	2.27	0.00	139.35	29.38	1.961	1.400	0.016	0.000	0.016
6.456	0.00	33.92	2.17	0.00	2.17	0.00	139.35	29.38	1.961	1.400	0.016	0.000	0.016

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6.123	0.00	32.98	1.53	0.00	1.53	0.00	134.09	17.46	1.934	1.339	0.011	0.000	0.011
5.789	0.00	32.04	1.17	0.00	1.17	0.00	129.16	14.88	1.909	1.326	0.009	0.000	0.009
5.456	0.00	30.96	0.93	0.00	0.93	0.00	124.44	15.12	1.885	1.327	0.007	0.000	0.007
5.137	0.00	30.09	0.84	0.00	0.84	0.00	124.44	15.12	1.885	1.327	0.007	0.000	0.007
5.000	0.00	29.09	0.91	0.00	0.91	0.00	124.44	15.12	1.885	1.327	0.007	0.000	0.007
4.863	0.00	25.45	0.77	0.00	0.77	0.00	124.44	15.12	1.885	1.327	0.006	0.000	0.006
3.100	0.00	20.68	0.62	0.00	0.62	0.00	124.44	15.12	1.885	1.327	0.005	0.000	0.005
2.450	0.00	17.01	0.51	0.00	0.51	0.00	124.44	15.12	1.885	1.327	0.004	0.000	0.004
1.385	0.00	14.50	0.42	0.00	0.42	0.00	124.44	15.12	1.885	1.327	0.003	0.000	0.003
1.275	0.00	13.73	0.43	0.00	0.43	0.00	124.44	15.12	1.885	1.327	0.003	0.000	0.003
1.165	0.00	13.03	0.39	0.00	0.39	0.00	124.44	15.12	1.885	1.327	0.003	0.000	0.003
0.950	0.00	11.29	0.34	0.00	0.34	0.00	124.44	15.12	1.885	1.327	0.003	0.000	0.003
0.350	0.00	9.92	0.30	0.00	0.30	0.00	124.44	15.12	1.885	1.327	0.002	0.000	0.002
0.305	0.00	6.60	0.10	0.00	0.10	0.00	134.65	147.09	1.937	2.000	0.001	0.000	0.001
0.153	0.00	6.02	0.09	0.00	0.09	0.00	134.65	147.09	1.937	2.000	0.001	0.000	0.001

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 90 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 6.02 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 146567.34 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 90 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
11.500	139.9	5.6275	1.0	0.60	2.5	0.491	206.84	0.200	1.108	0.217	0.988	4374.86	204.46	136.31
11.467	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	139.9	5.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	128.2	5.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	119.1	5.6275	1.0	0.60	3.0	0.466	220.63	0.200	1.080	0.259	0.960	3295.21	211.79	141.19

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11.000 111.7 5.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.699 111.7 5.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.400 111.7 5.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 8.400 111.7 5.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 7.667 111.7 5.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.456 111.7 5.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.123  95.5 5.6275 1.0 0.60 3.7 0.427 220.63 0.200 1.033 0.323 0.912 2119.71 201.14
134.09
 5.789  84.8 5.6275 1.0 0.60 4.1 0.403 220.63 0.200 1.004 0.363 0.878 1671.31 193.74
129.16
 5.456  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 5.137  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 5.000  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 4.863  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 3.100  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 2.450  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 1.385  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 1.275  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 1.165  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 0.950  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 0.350  77.1 5.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 0.305   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.200 0.979 0.310 0.915 2299.16 201.98
134.65
 0.153   2.1 0.1525 1.0 1.00 4.6 0.383 220.63 0.200 0.979 0.310 0.915 2299.16 201.98
134.65

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
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Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 90 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

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Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
11.500	1.00	1.00	0.500	1.005	1.118	0.650	0.000	0.000	0.4949	0.00	204.99	102.36	68.24
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4837	0.00	212.96	106.72	71.15
11.257	1.00	1.00	0.500	1.209	1.118	0.650	0.000	0.000	0.3419	0.00	150.85	75.42	50.28
11.128	1.00	1.00	0.500	1.398	1.118	0.650	0.000	0.000	0.2557	0.00	112.83	56.42	37.61
11.000	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.699	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
10.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
8.400	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
7.667	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.456	1.00	1.01	0.500	1.582	1.118	0.650	0.000	0.000	0.1998	0.00	88.15	44.07	29.38
6.123	1.00	1.01	0.500	2.053	1.118	0.650	0.000	0.000	0.1187	0.00	52.37	26.19	17.46
5.789	1.00	1.01	0.500	2.223	1.118	0.650	0.000	0.000	0.1012	0.00	44.64	22.32	14.88
5.456	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.137	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
5.000	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
4.863	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
3.100	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
2.450	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.385	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.275	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
1.165	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.950	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.350	1.00	1.01	0.500	2.205	1.118	0.650	0.000	0.000	0.1028	0.00	45.37	22.69	15.12
0.305	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09
0.153	1.00	2.11	0.500	0.250	1.118	0.818	0.000	0.000	1.0000	0.00	3533.59	220.63	147.09

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Structural Flange Analysis, Angle = 0 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 0 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

M	= Moment on Flange	= 0.8 N-m
V	= Vertical Load on Flange (- is compression, + is tension)	= 0 N
S	= Shear Load on Flange	= 25 N
Ds	= Outer Diameter of Shell	= 323.8 mm
Do	= Outside Diameter of Flange	= 482.6 mm
Dbc	= Bolt Circle Diameter	= 431.8 mm
Tf	= Thickness of Flange	= 31.8 mm

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Tw        = Fillet Weld Size                                              = 6.0 mm

Db        = Nominal Bolt Diameter                                         = 22.2 mm
Nb        = Number of Bolts                                               = 12
Fu        = Ultimate Bolt Tensile Stress                                  = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu                  = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                    = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                                  = 60.00 %
Eb        = Modulus of Elasticity for Bolt                                = 202705.50
MPa

Fys       = Yield Stress of Shell                                         = 215.81 MPa
Fw        = Tensile Stress of Weld                                        = 413.68 MPa
Fyc       = Yield Stress of Flange                                        = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                    = 194.22 MPa
E         = Modulus of Elasticity of Flange                               = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt                 = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters              = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                               = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                          = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N       = 1 N
Ab        = Nominal Area of Bolt                                          = 3.879 sq cm
Km        = Stiffness of Material                                         = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                             = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)        = 0.173
Fby       = Bolt Yield Stress                                             = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                                  = 761869.3
KPa
Aroot     = Bolt Root Area                                                = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}              = 123659 N
K         = Coefficient of Thread Friction                                = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                       = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                      = 1 N
Fact      = Actual force on bolt                                          = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact    = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi          = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                    = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                    = 144440 N
Ratio     = Fb / Fbcomb                                                   = 0.856

Sh        = Shear on Bolt                                                 = 2 N
Sallow    = Allowable Shear on Bolt                                       = 92281 N
Ratio     = Sh / Sallow                                                   = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                            = 11310.74
cm^4
```

```
Jw        = Polar Moment of Inertia for Weld                          = 22621.48
cm^4
Aw        = Area of Weld                                              = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                        = 1.2 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw               = 124.11 MPa
Ratio     = Fba / Sw                                                  = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                              = 87.6 mm
Lg        = Gross Flange area for each bolt                           = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                 = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                          = 54.0 mm
A         = Distance from Bolt CL to Flange OD                        = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                = 42.9 mm
Rho       = Calculated Parameter                                      = 3.377
Beta      = Calulcated Parameter                                      = 70918.0591
Alpha'    = Alpha where treq'd is minimum                             = 1
Tc        = Required thickness to develop load w/no prying            = 0.1 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                          = 0
Q         = Prying Force per bolt                                     = 0 N
Treq'd    = Required Flange Thickness                                 = 0.1 mm
Ratio     = Treqd / Tf                                                = 0.002
```

Structural Flange Analysis, Angle = 10 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 10 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                          = 0.8 N-m
V         = Vertical Load on Flange (- is compression, + is tension)  = -4 N
S         = Shear Load on Flange                                      = 24 N

Ds        = Outer Diameter of Shell                                   = 323.8 mm
Do        = Outside Diameter of Flange                                = 482.6 mm
Dbc       = Bolt Circle Diameter                                      = 431.8 mm
Tf        = Thickness of Flange                                       = 31.8 mm
Tw        = Fillet Weld Size                                          = 6.0 mm

Db        = Nominal Bolt Diameter                                     = 22.2 mm
Nb        = Number of Bolts                                           = 12
Fu        = Ultimate Bolt Tensile Stress                              = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu              = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                              = 60.00 %
Eb        = Modulus of Elasticity for Bolt                            = 202705.50
MPa

Fys       = Yield Stress of Shell                                     = 215.81 MPa
Fw        = Tensile Stress of Weld                                    = 413.68 MPa
Fyc       = Yield Stress of Flange                                    = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                = 194.22 MPa
E         = Modulus of Elasticity of Flange                           = 193742.33
MPa
```

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```
Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt                  = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters               = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                                = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                           = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N        = 0 N
Ab        = Nominal Area of Bolt                                           = 3.879 sq cm
Km        = Stiffness of Material                                          = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                              = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)         = 0.173
Fby       = Bolt Yield Stress                                              = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                                   = 761869.3
KPa
Aroot     = Bolt Root Area                                                 = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}               = 123659 N
K         = Coefficient of Thread Friction                                 = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                        = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                       = 0 N
Fact      = Actual force on bolt                                           = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact     = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi           = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                     = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                     = 144440 N
Ratio     = Fb / Fbcomb                                                    = 0.856

Sh        = Shear on Bolt                                                  = 2 N
Sallow    = Allowable Shear on Bolt                                        = 92281 N
Ratio     = Sh / Sallow                                                    = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                             = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                               = 22621.48
cm^4
Aw        = Area of Weld                                                   = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                             = 1.7 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                    = 124.11 MPa
Ratio     = Fba / Sw                                                       = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                   = 87.6 mm
Lg        = Gross Flange area for each bolt                                = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                     = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                      = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                               = 54.0 mm
A         = Distance from Bolt CL to Flange OD                             = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                     = 42.9 mm
Rho       = Calculated Parameter                                           = 3.377
Beta      = Calulcated Parameter                                           = 169521.3588
```

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```
Alpha'    = Alpha where treq'd is minimum                          = 1
Tc        = Required thickness to develop load w/no prying         = 0.1 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                       = 0
Q         = Prying Force per bolt                                  = 0 N
Treq'd    = Required Flange Thickness                              = 0.0 mm
Ratio     = Treqd / Tf                                             = 0.002
```

Structural Flange Analysis, Angle = 20 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 20 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                       = 0.8 N-m
V         = Vertical Load on Flange (- is compression, + is tension)  = -8 N
S         = Shear Load on Flange                                   = 23 N

Ds        = Outer Diameter of Shell                                = 323.8 mm
Do        = Outside Diameter of Flange                             = 482.6 mm
Dbc       = Bolt Circle Diameter                                   = 431.8 mm
Tf        = Thickness of Flange                                    = 31.8 mm
Tw        = Fillet Weld Size                                       = 6.0 mm

Db        = Nominal Bolt Diameter                                  = 22.2 mm
Nb        = Number of Bolts                                        = 12
Fu        = Ultimate Bolt Tensile Stress                           = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu           = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy             = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                           = 60.00 %
Eb        = Modulus of Elasticity for Bolt                         = 202705.50
MPa

Fys       = Yield Stress of Shell                                  = 215.81 MPa
Fw        = Tensile Stress of Weld                                 = 413.68 MPa
Fyc       = Yield Stress of Flange                                 = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy             = 194.22 MPa
E         = Modulus of Elasticity of Flange                        = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt         = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters       = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                        = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                   = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N  = 0 N
Ab        = Nominal Area of Bolt                                   = 3.879 sq cm
Km        = Stiffness of Material                                  = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                      = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)  = 0.173
Fby       = Bolt Yield Stress                                      = 896316.8
KPa
```

```
Fproof     = Bolt Proof Stress (0.85*Fby)                                  = 761869.3
KPa
Aroot      = Bolt Root Area                                                = 2.705 sq cm
Fi         = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}              = 123659 N
K          = Coefficient of Thread Friction                                = 0.000
Tb         = Bolt Torque to Produce Preload: K*Fi*Db                       = 0.00 N-m
Fmin       = Min. Force to keep Flange in Compression                      = 0 N
Fact       = Actual force on bolt                                          = 91479 N
Ratio      = Enough Pre-load to keep Joint in Compression:  Fmin / Fact    = 0.000

Fb         = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi          = 123659 N
Fballow    = Allowable Bolt Tensile Load (Pure Tension)                    = 152464 N
Fbcomb     = Allowable Bolt Tensile Load (Tens & Shear)                    = 144440 N
Ratio      = Fb / Fbcomb                                                   = 0.856

Sh         = Shear on Bolt                                                 = 2 N
Sallow     = Allowable Shear on Bolt                                       = 92281 N
Ratio      = Sh / Sallow                                                   = 0.000

Check Welding
Iw         = Bending Moment of Inertia for Weld                            = 11310.74
cm^4
Jw         = Polar Moment of Inertia for Weld                              = 22621.48
cm^4
Aw         = Area of Weld                                                  = 86.303 sq
cm
Fba        = Weld Stress due to Axial & Bending                            = 2.1 KPa
Sw         = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                   = 124.11 MPa
Ratio      = Fba / Sw                                                      = 0.000

Design Flange: NO GUSSETS
Ln         = Net Flange area at each bolt                                  = 87.6 mm
Lg         = Gross Flange area for each bolt                               = 113.0 mm
Delta      = Ratio of net area(@bolt line) & gross area                    = 0.7753
A'         = Distance from Flange OD to Bolt Hole Edge                     = 12.7 mm
B          = Distance from Bolt CL to Pipe OD                              = 54.0 mm
A          = Distance from Bolt CL to Flange OD                            = 25.4 mm
B'         = Distance from Pipe OD to edge of Bolt Hole                    = 42.9 mm
Rho        = Calculated Parameter                                          = 3.377
Beta       = Calulcated Parameter                                          = 0
Alpha'     = Alpha where treq'd is minimum                                 = 0
Tc         = Required thickness to develop load w/no prying                = 0.0 mm
Alpha      = Ratio mom@ BL to Mom @ stem line                              = 0
Q          = Prying Force per bolt                                         = 0 N
Treq'd     = Required Flange Thickness                                     = 0.0 mm
Ratio      = Treqd / Tf                                                    = 0.000
```

Structural Flange Analysis, Angle = 30 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 30 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M          = Moment on Flange                                              = 0.7 N-m
V          = Vertical Load on Flange (- is compression, + is tension)      = -12 N
S          = Shear Load on Flange                                          = 22 N
```

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```
Ds          = Outer Diameter of Shell                                   = 323.8 mm
Do          = Outside Diameter of Flange                                = 482.6 mm
Dbc         = Bolt Circle Diameter                                      = 431.8 mm
Tf          = Thickness of Flange                                       = 31.8 mm
Tw          = Fillet Weld Size                                          = 6.0 mm

Db          = Nominal Bolt Diameter                                     = 22.2 mm
Nb          = Number of Bolts                                           = 12
Fu          = Ultimate Bolt Tensile Stress                              = 1034.21 MPa
Ft          = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu              = 393.00 MPa
Fv          = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                = 237.87 MPa
Fp          = Pre-Load % of Allowable Bolt                              = 60.00 %
Eb          = Modulus of Elasticity for Bolt                            = 202705.50
MPa

Fys         = Yield Stress of Shell                                     = 215.81 MPa
Fw          = Tensile Stress of Weld                                    = 413.68 MPa
Fyc         = Yield Stress of Flange                                    = 215.81 MPa
Fbwp        = Allowable Plate Weak Bending: (ASD) 0.9*Fy                = 194.22 MPa
E           = Modulus of Elasticity of Flange                           = 193742.33
MPa

Check Bolt Spacing:
Sp          = Center to Center Bolt Spacing:  Dbc*PI / Nbolt            = 113.0 mm
Bspace      = Max bolt spacing in terms of # of bolt diameters          = 10.00
Spmax       = Maximum bolt spacing: Bspace*Db                           = 222.3 mm
Sp_UR       = Unity Ratio for Spacing:  Sp / SpMax                      = 0.509

BOLT LOADING:
P           = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N   = 0 N
Ab          = Nominal Area of Bolt                                      = 3.879 sq cm
Km          = Stiffness of Material                                     = 5922221.21
N/mm
Kb          = Stiffness of Bolt                                         = 1238416.78
N/mm
CC          = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)    = 0.173
Fby         = Bolt Yield Stress                                         = 896316.8
KPa
Fproof      = Bolt Proof Stress (0.85*Fby)                              = 761869.3
KPa
Aroot       = Bolt Root Area                                            = 2.705 sq cm
Fi          = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}          = 123659 N
K           = Coefficient of Thread Friction                            = 0.000
Tb          = Bolt Torque to Produce Preload: K*Fi*Db                   = 0.00 N-m
Fmin        = Min. Force to keep Flange in Compression                  = 0 N
Fact        = Actual force on bolt                                      = 91479 N
Ratio       = Enough Pre-load to keep Joint in Compression:  Fmin / Fact = 0.000

Fb          = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi      = 123659 N
Fballow     = Allowable Bolt Tensile Load (Pure Tension)                = 152464 N
Fbcomb      = Allowable Bolt Tensile Load (Tens & Shear)                = 144440 N
Ratio       = Fb / Fbcomb                                               = 0.856

Sh          = Shear on Bolt                                             = 2 N
Sallow      = Allowable Shear on Bolt                                   = 92281 N
Ratio       = Sh / Sallow                                               = 0.000
```

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```
Check Welding
Iw        = Bending Moment of Inertia for Weld                          = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                            = 22621.48
cm^4
Aw        = Area of Weld                                                = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                          = 2.5 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                 = 124.11 MPa
Ratio     = Fba / Sw                                                    = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                = 87.6 mm
Lg        = Gross Flange area for each bolt                             = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                  = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                   = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                            = 54.0 mm
A         = Distance from Bolt CL to Flange OD                          = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                  = 42.9 mm
Rho       = Calculated Parameter                                        = 3.377
Beta      = Calulcated Parameter                                        = 0
Alpha'    = Alpha where treq'd is minimum                               = 0
Tc        = Required thickness to develop load w/no prying              = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                            = 0
Q         = Prying Force per bolt                                       = 0 N
Treq'd    = Required Flange Thickness                                   = 0.0 mm
Ratio     = Treqd / Tf                                                  = 0.000
```

Structural Flange Analysis, Angle = 40 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 40 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                            = 0.6 N-m
V         = Vertical Load on Flange (- is compression, + is tension)    = -16 N
S         = Shear Load on Flange                                        = 19 N

Ds        = Outer Diameter of Shell                                     = 323.8 mm
Do        = Outside Diameter of Flange                                  = 482.6 mm
Dbc       = Bolt Circle Diameter                                        = 431.8 mm
Tf        = Thickness of Flange                                         = 31.8 mm
Tw        = Fillet Weld Size                                            = 6.0 mm

Db        = Nominal Bolt Diameter                                       = 22.2 mm
Nb        = Number of Bolts                                             = 12
Fu        = Ultimate Bolt Tensile Stress                                = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu                = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                  = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                                = 60.00 %
Eb        = Modulus of Elasticity for Bolt                              = 202705.50
MPa

Fys       = Yield Stress of Shell                                       = 215.81 MPa
Fw        = Tensile Stress of Weld                                      = 413.68 MPa
```

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```
Fyc       = Yield Stress of Flange                                    = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                = 194.22 MPa
E         = Modulus of Elasticity of Flange                           = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt            = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters          = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                           = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                      = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N   = 0 N
Ab        = Nominal Area of Bolt                                      = 3.879 sq cm
Km        = Stiffness of Material                                     = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                         = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)    = 0.173
Fby       = Bolt Yield Stress                                         = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                              = 761869.3
KPa
Aroot     = Bolt Root Area                                            = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}          = 123659 N
K         = Coefficient of Thread Friction                            = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                   = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                  = 0 N
Fact      = Actual force on bolt                                      = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi      = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                = 144440 N
Ratio     = Fb / Fbcomb                                               = 0.856

Sh        = Shear on Bolt                                             = 2 N
Sallow    = Allowable Shear on Bolt                                   = 92281 N
Ratio     = Sh / Sallow                                               = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                        = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                          = 22621.48
cm^4
Aw        = Area of Weld                                              = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                        = 2.7 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw               = 124.11 MPa
Ratio     = Fba / Sw                                                  = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                              = 87.6 mm
Lg        = Gross Flange area for each bolt                           = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                 = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                          = 54.0 mm
```

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A	=	Distance from Bolt CL to Flange OD	= 25.4 mm
B'	=	Distance from Pipe OD to edge of Bolt Hole	= 42.9 mm
Rho	=	Calculated Parameter	= 3.377
Beta	=	Calulcated Parameter	= 0
Alpha'	=	Alpha where treq'd is minimum	= 0
Tc	=	Required thickness to develop load w/no prying	= 0.0 mm
Alpha	=	Ratio mom@ BL to Mom @ stem line	= 0
Q	=	Prying Force per bolt	= 0 N
Treq'd	=	Required Flange Thickness	= 0.0 mm
Ratio	=	Treqd / Tf	= 0.000

Structural Flange Analysis, Angle = 50 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 50 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

M	=	Moment on Flange	= 0.5 N-m
V	=	Vertical Load on Flange (- is compression, + is tension)	= -19 N
S	=	Shear Load on Flange	= 16 N
Ds	=	Outer Diameter of Shell	= 323.8 mm
Do	=	Outside Diameter of Flange	= 482.6 mm
Dbc	=	Bolt Circle Diameter	= 431.8 mm
Tf	=	Thickness of Flange	= 31.8 mm
Tw	=	Fillet Weld Size	= 6.0 mm
Db	=	Nominal Bolt Diameter	= 22.2 mm
Nb	=	Number of Bolts	= 12
Fu	=	Ultimate Bolt Tensile Stress	= 1034.21 MPa
Ft	=	Allowable Bolt Tensile Stress: (ASD) 0.38*Fu	= 393.00 MPa
Fv	=	Allowable Bolt Shear Stress: (ASD) 0.23*Fy	= 237.87 MPa
Fp	=	Pre-Load % of Allowable Bolt	= 60.00 %
Eb	=	Modulus of Elasticity for Bolt	= 202705.50 MPa
Fys	=	Yield Stress of Shell	= 215.81 MPa
Fw	=	Tensile Stress of Weld	= 413.68 MPa
Fyc	=	Yield Stress of Flange	= 215.81 MPa
Fbwp	=	Allowable Plate Weak Bending: (ASD) 0.9*Fy	= 194.22 MPa
E	=	Modulus of Elasticity of Flange	= 193742.33 MPa

Check Bolt Spacing:

Sp	=	Center to Center Bolt Spacing: Dbc*PI / Nbolt	= 113.0 mm
Bspace	=	Max bolt spacing in terms of # of bolt diameters	= 10.00
Spmax	=	Maximum bolt spacing: Bspace*Db	= 222.3 mm
Sp_UR	=	Unity Ratio for Spacing: Sp / SpMax	= 0.509

BOLT LOADING:

P	=	Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N	= 0 N
Ab	=	Nominal Area of Bolt	= 3.879 sq cm
Km	=	Stiffness of Material	= 5922221.21 N/mm
Kb	=	Stiffness of Bolt	= 1238416.78 N/mm

```
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)          = 0.173
Fby       = Bolt Yield Stress                                               = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                                    = 761869.3
KPa
Aroot     = Bolt Root Area                                                  = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}                = 123659 N
K         = Coefficient of Thread Friction                                  = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                         = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                        = 0 N
Fact      = Actual force on bolt                                            = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact      = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi            = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                      = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                      = 144440 N
Ratio     = Fb / Fbcomb                                                     = 0.856

Sh        = Shear on Bolt                                                   = 1 N
Sallow    = Allowable Shear on Bolt                                         = 92281 N
Ratio     = Sh / Sallow                                                     = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                              = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                                = 22621.48
cm^4
Aw        = Area of Weld                                                    = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                              = 3.0 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                     = 124.11 MPa
Ratio     = Fba / Sw                                                        = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                    = 87.6 mm
Lg        = Gross Flange area for each bolt                                 = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                      = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                       = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                                = 54.0 mm
A         = Distance from Bolt CL to Flange OD                              = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                      = 42.9 mm
Rho       = Calculated Parameter                                            = 3.377
Beta      = Calulcated Parameter                                            = 0
Alpha'    = Alpha where treq'd is minimum                                   = 0
Tc        = Required thickness to develop load w/no prying                  = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                                = 0
Q         = Prying Force per bolt                                           = 0 N
Treq'd    = Required Flange Thickness                                       = 0.0 mm
Ratio     = Treqd / Tf                                                      = 0.000
```

Structural Flange Analysis, Angle = 60 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 60 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

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```
M          = Moment on Flange                                              = 0.4 N-m
V          = Vertical Load on Flange (- is compression, + is tension)      = -21 N
S          = Shear Load on Flange                                          = 12 N

Ds         = Outer Diameter of Shell                                       = 323.8 mm
Do         = Outside Diameter of Flange                                    = 482.6 mm
Dbc        = Bolt Circle Diameter                                          = 431.8 mm
Tf         = Thickness of Flange                                           = 31.8 mm
Tw         = Fillet Weld Size                                              = 6.0 mm

Db         = Nominal Bolt Diameter                                         = 22.2 mm
Nb         = Number of Bolts                                               = 12
Fu         = Ultimate Bolt Tensile Stress                                  = 1034.21 MPa
Ft         = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu                  = 393.00 MPa
Fv         = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                    = 237.87 MPa
Fp         = Pre-Load % of Allowable Bolt                                  = 60.00 %
Eb         = Modulus of Elasticity for Bolt                                = 202705.50
MPa

Fys        = Yield Stress of Shell                                         = 215.81 MPa
Fw         = Tensile Stress of Weld                                        = 413.68 MPa
Fyc        = Yield Stress of Flange                                        = 215.81 MPa
Fbwp       = Allowable Plate Weak Bending: (ASD) 0.9*Fy                    = 194.22 MPa
E          = Modulus of Elasticity of Flange                               = 193742.33
MPa

Check Bolt Spacing:
Sp         = Center to Center Bolt Spacing:  Dbc*PI / Nbolt                 = 113.0 mm
Bspace     = Max bolt spacing in terms of # of bolt diameters              = 10.00
Spmax      = Maximum bolt spacing: Bspace*Db                               = 222.3 mm
Sp_UR      = Unity Ratio for Spacing:  Sp / SpMax                          = 0.509

BOLT LOADING:
P          = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N       = 0 N
Ab         = Nominal Area of Bolt                                          = 3.879 sq cm
Km         = Stiffness of Material                                         = 5922221.21
N/mm
Kb         = Stiffness of Bolt                                             = 1238416.78
N/mm
CC         = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)        = 0.173
Fby        = Bolt Yield Stress                                             = 896316.8
KPa
Fproof     = Bolt Proof Stress (0.85*Fby)                                  = 761869.3
KPa
Aroot      = Bolt Root Area                                                = 2.705 sq cm
Fi         = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}              = 123659 N
K          = Coefficient of Thread Friction                                = 0.000
Tb         = Bolt Torque to Produce Preload: K*Fi*Db                       = 0.00 N-m
Fmin       = Min. Force to keep Flange in Compression                      = 0 N
Fact       = Actual force on bolt                                          = 91479 N
Ratio      = Enough Pre-load to keep Joint in Compression:  Fmin / Fact    = 0.000

Fb         = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi          = 123659 N
Fballow    = Allowable Bolt Tensile Load (Pure Tension)                    = 152464 N
Fbcomb     = Allowable Bolt Tensile Load (Tens & Shear)                    = 144440 N
Ratio      = Fb / Fbcomb                                                   = 0.856
```

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```
Sh        = Shear on Bolt                                          = 1 N
Sallow    = Allowable Shear on Bolt                                = 92281 N
Ratio     = Sh / Sallow                                            = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                     = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                       = 22621.48
cm^4
Aw        = Area of Weld                                           = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                     = 3.1 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw            = 124.11 MPa
Ratio     = Fba / Sw                                               = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                           = 87.6 mm
Lg        = Gross Flange area for each bolt                        = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area             = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge              = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                       = 54.0 mm
A         = Distance from Bolt CL to Flange OD                     = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole             = 42.9 mm
Rho       = Calculated Parameter                                   = 3.377
Beta      = Calulcated Parameter                                   = 0
Alpha'    = Alpha where treq'd is minimum                          = 0
Tc        = Required thickness to develop load w/no prying         = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                       = 0
Q         = Prying Force per bolt                                  = 0 N
Treq'd    = Required Flange Thickness                              = 0.0 mm
Ratio     = Treqd / Tf                                             = 0.000
```

Structural Flange Analysis, Angle = 70 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 70 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                       = 0.3 N-m
V         = Vertical Load on Flange (- is compression, + is tension) = -23 N
S         = Shear Load on Flange                                   = 8 N

Ds        = Outer Diameter of Shell                                = 323.8 mm
Do        = Outside Diameter of Flange                             = 482.6 mm
Dbc       = Bolt Circle Diameter                                   = 431.8 mm
Tf        = Thickness of Flange                                    = 31.8 mm
Tw        = Fillet Weld Size                                       = 6.0 mm

Db        = Nominal Bolt Diameter                                  = 22.2 mm
Nb        = Number of Bolts                                        = 12
Fu        = Ultimate Bolt Tensile Stress                           = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu           = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy             = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                           = 60.00 %
Eb        = Modulus of Elasticity for Bolt                         = 202705.50
MPa
```

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```
Fys       = Yield Stress of Shell                                        = 215.81 MPa
Fw        = Tensile Stress of Weld                                       = 413.68 MPa
Fyc       = Yield Stress of Flange                                       = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                   = 194.22 MPa
E         = Modulus of Elasticity of Flange                              = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt               = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters             = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                              = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                         = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N      = 0 N
Ab        = Nominal Area of Bolt                                         = 3.879 sq cm
Km        = Stiffness of Material                                        = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                            = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)       = 0.173
Fby       = Bolt Yield Stress                                            = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                                 = 761869.3
KPa
Aroot     = Bolt Root Area                                               = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}             = 123659 N
K         = Coefficient of Thread Friction                               = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                      = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                     = 0 N
Fact      = Actual force on bolt                                         = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact   = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi         = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                   = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                   = 144440 N
Ratio     = Fb / Fbcomb                                                  = 0.856

Sh        = Shear on Bolt                                                = 1 N
Sallow    = Allowable Shear on Bolt                                      = 92281 N
Ratio     = Sh / Sallow                                                  = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                           = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                             = 22621.48
cm^4
Aw        = Area of Weld                                                 = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                           = 3.1 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                  = 124.11 MPa
Ratio     = Fba / Sw                                                     = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                 = 87.6 mm
Lg        = Gross Flange area for each bolt                              = 113.0 mm
```

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```
Delta     = Ratio of net area(@bolt line) & gross area                  = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                   = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                            = 54.0 mm
A         = Distance from Bolt CL to Flange OD                          = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                  = 42.9 mm
Rho       = Calculated Parameter                                        = 3.377
Beta      = Calulcated Parameter                                        = 0
Alpha'    = Alpha where treq'd is minimum                               = 0
Tc        = Required thickness to develop load w/no prying              = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                            = 0
Q         = Prying Force per bolt                                       = 0 N
Treq'd    = Required Flange Thickness                                   = 0.0 mm
Ratio     = Treqd / Tf                                                  = 0.000
```

Structural Flange Analysis, Angle = 80 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 80 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                            = 0.1 N-m
V         = Vertical Load on Flange (- is compression, + is tension)    = -24 N
S         = Shear Load on Flange                                        = 4 N

Ds        = Outer Diameter of Shell                                     = 323.8 mm
Do        = Outside Diameter of Flange                                  = 482.6 mm
Dbc       = Bolt Circle Diameter                                        = 431.8 mm
Tf        = Thickness of Flange                                         = 31.8 mm
Tw        = Fillet Weld Size                                            = 6.0 mm

Db        = Nominal Bolt Diameter                                       = 22.2 mm
Nb        = Number of Bolts                                             = 12
Fu        = Ultimate Bolt Tensile Stress                                = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu                = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                  = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                                = 60.00 %
Eb        = Modulus of Elasticity for Bolt                              = 202705.50
MPa

Fys       = Yield Stress of Shell                                       = 215.81 MPa
Fw        = Tensile Stress of Weld                                      = 413.68 MPa
Fyc       = Yield Stress of Flange                                      = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                  = 194.22 MPa
E         = Modulus of Elasticity of Flange                             = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt              = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters            = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                             = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                        = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N     = 0 N
Ab        = Nominal Area of Bolt                                        = 3.879 sq cm
```

```
Km          = Stiffness of Material                                    = 5922221.21
N/mm
Kb          = Stiffness of Bolt                                        = 1238416.78
N/mm
CC          = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)   = 0.173
Fby         = Bolt Yield Stress                                        = 896316.8
KPa
Fproof      = Bolt Proof Stress (0.85*Fby)                             = 761869.3
KPa
Aroot       = Bolt Root Area                                           = 2.705 sq cm
Fi          = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}         = 123659 N
K           = Coefficient of Thread Friction                           = 0.000
Tb          = Bolt Torque to Produce Preload: K*Fi*Db                  = 0.00 N-m
Fmin        = Min. Force to keep Flange in Compression                 = 0 N
Fact        = Actual force on bolt                                     = 91479 N
Ratio       = Enough Pre-load to keep Joint in Compression:  Fmin / Fact = 0.000

Fb          = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi     = 123659 N
Fballow     = Allowable Bolt Tensile Load (Pure Tension)               = 152464 N
Fbcomb      = Allowable Bolt Tensile Load (Tens & Shear)               = 144440 N
Ratio       = Fb / Fbcomb                                              = 0.856

Sh          = Shear on Bolt                                            = 0 N
Sallow      = Allowable Shear on Bolt                                  = 92281 N
Ratio       = Sh / Sallow                                              = 0.000

Check Welding
Iw          = Bending Moment of Inertia for Weld                       = 11310.74
cm^4
Jw          = Polar Moment of Inertia for Weld                         = 22621.48
cm^4
Aw          = Area of Weld                                             = 86.303 sq
cm
Fba         = Weld Stress due to Axial & Bending                       = 3.0 KPa
Sw          = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw              = 124.11 MPa
Ratio       = Fba / Sw                                                 = 0.000

Design Flange: NO GUSSETS
Ln          = Net Flange area at each bolt                             = 87.6 mm
Lg          = Gross Flange area for each bolt                          = 113.0 mm
Delta       = Ratio of net area(@bolt line) & gross area               = 0.7753
A'          = Distance from Flange OD to Bolt Hole Edge                = 12.7 mm
B           = Distance from Bolt CL to Pipe OD                         = 54.0 mm
A           = Distance from Bolt CL to Flange OD                       = 25.4 mm
B'          = Distance from Pipe OD to edge of Bolt Hole               = 42.9 mm
Rho         = Calculated Parameter                                     = 3.377
Beta        = Calulcated Parameter                                     = 0
Alpha'      = Alpha where treq'd is minimum                            = 0
Tc          = Required thickness to develop load w/no prying           = 0.0 mm
Alpha       = Ratio mom@ BL to Mom @ stem line                         = 0
Q           = Prying Force per bolt                                    = 0 N
Treq'd      = Required Flange Thickness                                = 0.0 mm
Ratio       = Treqd / Tf                                               = 0.000
```

Structural Flange Analysis, Angle = 90 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 90 Deg , Load # 4

Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

M	= Moment on Flange	= 0.0 N-m
V	= Vertical Load on Flange (- is compression, + is tension)	= -25 N
S	= Shear Load on Flange	= 0 N
Ds	= Outer Diameter of Shell	= 323.8 mm
Do	= Outside Diameter of Flange	= 482.6 mm
Dbc	= Bolt Circle Diameter	= 431.8 mm
Tf	= Thickness of Flange	= 31.8 mm
Tw	= Fillet Weld Size	= 6.0 mm
Db	= Nominal Bolt Diameter	= 22.2 mm
Nb	= Number of Bolts	= 12
Fu	= Ultimate Bolt Tensile Stress	= 1034.21 MPa
Ft	= Allowable Bolt Tensile Stress: (ASD) 0.38*Fu	= 393.00 MPa
Fv	= Allowable Bolt Shear Stress: (ASD) 0.23*Fy	= 237.87 MPa
Fp	= Pre-Load % of Allowable Bolt	= 60.00 %
Eb	= Modulus of Elasticity for Bolt	= 202705.50 MPa
Fys	= Yield Stress of Shell	= 215.81 MPa
Fw	= Tensile Stress of Weld	= 413.68 MPa
Fyc	= Yield Stress of Flange	= 215.81 MPa
Fbwp	= Allowable Plate Weak Bending: (ASD) 0.9*Fy	= 194.22 MPa
E	= Modulus of Elasticity of Flange	= 193742.33 MPa
Check Bolt Spacing:		
Sp	= Center to Center Bolt Spacing: Dbc*PI / Nbolt	= 113.0 mm
Bspace	= Max bolt spacing in terms of # of bolt diameters	= 10.00
Spmax	= Maximum bolt spacing: Bspace*Db	= 222.3 mm
Sp_UR	= Unity Ratio for Spacing: Sp / SpMax	= 0.509
BOLT LOADING:		
P	= Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N	= 0 N
Ab	= Nominal Area of Bolt	= 3.879 sq cm
Km	= Stiffness of Material	= 5922221.21 N/mm
Kb	= Stiffness of Bolt	= 1238416.78 N/mm
CC	= Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)	= 0.173
Fby	= Bolt Yield Stress	= 896316.8 KPa
Fproof	= Bolt Proof Stress (0.85*Fby)	= 761869.3 KPa
Aroot	= Bolt Root Area	= 2.705 sq cm
Fi	= Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}	= 123659 N
K	= Coefficient of Thread Friction	= 0.000
Tb	= Bolt Torque to Produce Preload: K*Fi*Db	= 0.00 N-m
Fmin	= Min. Force to keep Flange in Compression	= 0 N
Fact	= Actual force on bolt	= 91479 N
Ratio	= Enough Pre-load to keep Joint in Compression: Fmin / Fact	= 0.000
Fb	= Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi	= 123659 N

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```
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                = 144440 N
Ratio     = Fb / Fbcomb                                               = 0.856

Sh        = Shear on Bolt                                             = 0 N
Sallow    = Allowable Shear on Bolt                                   = 92281 N
Ratio     = Sh / Sallow                                               = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                        = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                          = 22621.48
cm^4
Aw        = Area of Weld                                              = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                        = 2.9 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw               = 124.11 MPa
Ratio     = Fba / Sw                                                  = 0.000

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                              = 87.6 mm
Lg        = Gross Flange area for each bolt                           = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                 = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                          = 54.0 mm
A         = Distance from Bolt CL to Flange OD                        = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                = 42.9 mm
Rho       = Calculated Parameter                                      = 3.377
Beta      = Calulcated Parameter                                      = 0
Alpha'    = Alpha where treq'd is minimum                             = 0
Tc        = Required thickness to develop load w/no prying            = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                          = 0
Q         = Prying Force per bolt                                     = 0 N
Treq'd    = Required Flange Thickness                                 = 0.0 mm
Ratio     = Treqd / Tf                                                = 0.000
```

Conical Transition Analysis, Angle = 0 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 0 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65

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```
M:     Overturning Moment (KN-m)                          0.08        0.00
0.61
V:     Vertical Axial Loading (KN)                        0.00        0.00
0.00
Sx:    Section Modulus (cm^3)                            750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                      98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                          0.00        0.00
0.00
fb:    Bending Strss - M/Sx (MPa)                         0.11        0.11
0.32
fb':   Localized Bending Stress (MPa)                     0.12        0.12
0.46
fh':   Hoop Stress (MPa)                                  0.07        0.00
0.24
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)                0.11        0.11
0.32
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)          0.23        0.23
0.78
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.002	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.002	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.002	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.002	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 0 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0      1000.0
0.0
```

```
OD:     Outer Diameter (mm)                          508.0         0.0
1066.8
T:      Thickness (mm)                                10.0        10.0
10.0
Fys:    Yield Stress (MPa)                           220.63      220.63
220.63
E:      Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:     Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:     Tensile Stress (MPa)                         412.65      412.65
412.65

M:      Overturning Moment (KN-m)                     40.26        0.00
44.25
V:      Vertical Axial Loading (KN)                    0.00        0.00
0.00
Sx:     Section Modulus (cm^3)                       1910.2      1910.2
8690.0
Ax:     Cross Sectional Area (sq cm)                156.451     156.451
332.002

CALCULATE STRESSES:
fa:     Axial Stress - V/Ax (MPa)                      0.00        0.00
0.00
fb:     Bending Strss - M/Sx (MPa)                    21.07       21.88
5.09
fb':    Localized Bending Stress (MPa)                35.61       35.61
12.47
fh':    Hoop Stress (MPa)                             18.88        0.00
6.61
Fhe:    Elas Hoop - 0.4*E*T/OD (MPa)                1596.11     1596.11
760.05
Fhc:    Hoop Comp - Fys (MPa)                        220.63      220.63
200.67
FhcA:   Allow Hoop Comp-Fhc*.5 (MPa)                 110.32      110.32
100.34
Fxe:    Crit Elas-2*0.3*E*T/OD (MPa)                2394.16     2394.16
1140.08
Fxc:    Crit Lcl Bklng  (MPa)                        220.63      220.63
198.75
Stot:   Total Stress Check 1: fa + fb (MPa)           21.07       21.88
5.09
Stot1:  Total Stress Check 2: fa + fb + fbp (MPa)     56.68       57.49
17.56
Fb:     Allow Bend (ASD): .6*Fxc (MPa)               132.38      132.38
119.25
Fh:     Min(Fb, 0.5*Fhc) (MPa)                       110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.159	PASS	0.165	PASS	0.043	PASS
Check 2: Stot1 / Ft	0.137	PASS	0.139	PASS	0.043	PASS
Check 3: fh' < Fh	0.171	PASS	0.000	PASS	0.066	PASS

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Stiff Ring Req'd? 0.171 Not Req'd 0.165 Cone OK 0.066 Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 10 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 10 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	0.08	0.00	0.60
V:	Vertical Axial Loading (KN)	0.17	0.00	0.28
Sx:	Section Modulus (cm^3)	750.3	750.3	1910.2
Ax:	Cross Sectional Area (sq cm)	98.583	98.583	156.451
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.02	0.02	0.02
fb:	Bending Strss - M/Sx (MPa)	0.10	0.11	0.31
fb':	Localized Bending Stress (MPa)	0.14	0.14	0.48
fh':	Hoop Stress (MPa)	0.07	0.00	0.25
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08	1596.11
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	220.63
Stot:	Total Stress Check 1: fa + fb (MPa)	0.12	0.13	0.33

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```
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)              0.26        0.27
0.81
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                       132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                               110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.003	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.002	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.002	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.003	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 10 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0      1000.0
0.0
OD:    Outer Diameter (mm)                            508.0         0.0
1066.8
T:     Thickness (mm)                                  10.0        10.0
10.0
Fys:   Yield Stress (MPa)                             220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                 202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                   117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                           412.65      412.65
412.65

M:     Overturning Moment (KN-m)                       41.12        0.00
45.40
V:     Vertical Axial Loading (KN)                      1.19        0.00
0.59
Sx:    Section Modulus (cm^3)                         1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                  156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                        0.08        0.08
0.02
fb:    Bending Strss - M/Sx (MPa)                      21.52       22.35
5.22
fb':   Localized Bending Stress (MPa)                  36.50       36.50
12.84
fh':   Hoop Stress (MPa)                               19.36        0.00
6.81
```

```
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)               21.60       22.43
5.24
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)         58.10       58.92
18.08
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.163	PASS	0.169	PASS	0.044	PASS
Check 2: Stot1 / Ft	0.141	PASS	0.143	PASS	0.044	PASS
Check 3: fh' < Fh	0.175	PASS	0.000	PASS	0.068	PASS
Stiff Ring Req'd?	0.175	Not Req'd	0.169	Cone OK	0.068	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 20 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 20 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0       385.0
0.0
OD:    Outer Diameter (mm)                          323.8         0.0
508.0
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                      0.07        0.00
0.57
V:     Vertical Axial Loading (KN)                    0.33        0.00
0.55
```

```
Sx:    Section Modulus (cm^3)                          750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                    98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                         0.03        0.03
0.04
fb:    Bending Strss - M/Sx (MPa)                        0.10        0.10
0.30
fb':   Localized Bending Stress (MPa)                    0.15        0.15
0.48
fh':   Hoop Stress (MPa)                                 0.08        0.00
0.26
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                   2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                           220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                    110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                   3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                           220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)               0.13        0.14
0.33
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)         0.29        0.29
0.82
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                  132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                          110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.003	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.002	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.002	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.003	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 20 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0      1000.0
0.0
OD:    Outer Diameter (mm)                            508.0         0.0
1066.8
T:     Thickness (mm)                                  10.0        10.0
10.0
Fys:   Yield Stress (MPa)                             220.63      220.63
220.63
```

```
E:     Modulus of Elasticity (MPa)                    202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                      117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                              412.65      412.65
412.65

M:     Overturning Moment (KN-m)                          40.69        0.00
45.12
V:     Vertical Axial Loading (KN)                         2.47        0.00
1.29
Sx:    Section Modulus (cm^3)                           1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                     156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                           0.16        0.16
0.04
fb:    Bending Strss - M/Sx (MPa)                         21.30       22.12
5.19
fb':   Localized Bending Stress (MPa)                     36.26       36.26
12.81
fh':   Hoop Stress (MPa)                                  19.23        0.00
6.79
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                             220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                      110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                             220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)                21.46       22.28
5.23
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)          57.72       58.54
18.04
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                     132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                             110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.162	PASS	0.168	PASS	0.044	PASS
Check 2: Stot1 / Ft	0.140	PASS	0.142	PASS	0.044	PASS
Check 3: fh' < Fh	0.174	PASS	0.000	PASS	0.068	PASS
Stiff Ring Req'd?	0.174	Not Req'd	0.168	Cone OK	0.068	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 30 Deg

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Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 30 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	0.07	0.00	0.53
V:	Vertical Axial Loading (KN)	0.48	0.00	0.80
Sx:	Section Modulus (cm^3)	750.3	750.3	1910.2
Ax:	Cross Sectional Area (sq cm)	98.583	98.583	156.451
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.05	0.05	0.05
fb:	Bending Strss - M/Sx (MPa)	0.09	0.09	0.28
fb':	Localized Bending Stress (MPa)	0.16	0.16	0.47
fh':	Hoop Stress (MPa)	0.09	0.00	0.25
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08	1596.11
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	220.63
Stot:	Total Stress Check 1: fa + fb (MPa)	0.14	0.14	0.33
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	0.30	0.31	0.80
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	132.38
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	110.32

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Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.002	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.002	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.002	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.002	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 30 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	38.98	0.00	43.42
V:	Vertical Axial Loading (KN)	3.81	0.00	2.09
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.24	0.25	0.06
fb:	Bending Strss - M/Sx (MPa)	20.41	21.19	5.00
fb':	Localized Bending Stress (MPa)	34.90	34.90	12.39
fh':	Hoop Stress (MPa)	18.51	0.00	6.57
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08

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```
Fxc:   Crit Lcl Bklng  (MPa)                          220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)             20.65       21.44
5.06
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)       55.55       56.34
17.45
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                 132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                         110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.156	PASS	0.162	PASS	0.042	PASS
Check 2: Stot1 / Ft	0.135	PASS	0.137	PASS	0.042	PASS
Check 3: fh' < Fh	0.168	PASS	0.000	PASS	0.065	PASS
Stiff Ring Req'd?	0.168	Not Req'd	0.162	Cone OK	0.065	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 40 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 40 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0       385.0
0.0
OD:    Outer Diameter (mm)                          323.8         0.0
508.0
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                      0.06        0.00
0.47
V:     Vertical Axial Loading (KN)                    0.62        0.00
1.03
Sx:    Section Modulus (cm^3)                       750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                 98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                      0.06        0.06
0.07
```

fb:	Bending Strss - M/Sx (MPa)	0.08	0.08
0.24			
fb':	Localized Bending Stress (MPa)	0.17	0.17
0.45			
fh':	Hoop Stress (MPa)	0.09	0.00
0.24			
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08
1596.11			
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63
220.63			
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32
110.32			
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12
2394.16			
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63
220.63			
Stot:	Total Stress Check 1: fa + fb (MPa)	0.14	0.15
0.31			
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	0.31	0.31
0.76			
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38
132.38			
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32
110.32			

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.002	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.002	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.002	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.002	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 40 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	
0.0				
OD:	Outer Diameter (mm)	508.0	0.0	
1066.8				
T:	Thickness (mm)	10.0	10.0	
10.0				
Fys:	Yield Stress (MPa)	220.63	220.63	
220.63				
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	
202705.50				
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	
117.90				
Ft:	Tensile Stress (MPa)	412.65	412.65	
412.65				

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```
M:     Overturning Moment (KN-m)                          36.04        0.00
40.33
V:     Vertical Axial Loading (KN)                         5.21        0.00
3.00
Sx:    Section Modulus (cm^3)                           1910.2       1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                     156.451      156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                           0.33        0.35
0.09
fb:    Bending Strss - M/Sx (MPa)                         18.87       19.59
4.64
fb':   Localized Bending Stress (MPa)                     32.45       32.45
11.59
fh':   Hoop Stress (MPa)                                  17.21        0.00
6.14
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    1596.11      1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                            220.63       220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32       110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    2394.16      2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                            220.63       220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)               19.20        19.94
4.73
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)         51.65        52.38
16.32
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                    132.38       132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                            110.32       110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.145	PASS	0.151	PASS	0.040	PASS
Check 2: Stot1 / Ft	0.125	PASS	0.127	PASS	0.040	PASS
Check 3: fh' < Fh	0.156	PASS	0.000	PASS	0.061	PASS
Stiff Ring Req'd?	0.156	Not Req'd	0.151	Cone OK	0.061	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 50 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 50 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                        Small        Cone       Large
Ht:    Height of Cone (mm)                                0.0       385.0
0.0
```

OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	0.05	0.00	0.39
V:	Vertical Axial Loading (KN)	0.74	0.00	1.23
Sx:	Section Modulus (cm^3)	750.3	750.3	1910.2
Ax:	Cross Sectional Area (sq cm)	98.583	98.583	156.451
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.07	0.08	0.08
fb:	Bending Strss - M/Sx (MPa)	0.07	0.07	0.20
fb':	Localized Bending Stress (MPa)	0.17	0.17	0.41
fh':	Hoop Stress (MPa)	0.09	0.00	0.22
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08	1596.11
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	220.63
Stot:	Total Stress Check 1: fa + fb (MPa)	0.14	0.15	0.28
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	0.31	0.31	0.69
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	132.38
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	110.32

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.002	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.002	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.002	PASS

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Stiff Ring Req'd? 0.001 Not Req'd 0.001 Cone OK 0.002 Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 50 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	31.94	0.00	35.94
V:	Vertical Axial Loading (KN)	6.68	0.00	4.05
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.43	0.44	0.12
fb:	Bending Strss - M/Sx (MPa)	16.72	17.36	4.14
fb':	Localized Bending Stress (MPa)	28.97	28.97	10.42
fh':	Hoop Stress (MPa)	15.37	0.00	5.53
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	198.75
Stot:	Total Stress Check 1: fa + fb (MPa)	17.15	17.80	4.26
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	46.12	46.78	14.68

```
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                    132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                            110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.130	PASS	0.134	PASS	0.036	PASS
Check 2: Stot1 / Ft	0.112	PASS	0.113	PASS	0.036	PASS
Check 3: fh' < Fh	0.139	PASS	0.000	PASS	0.055	PASS
Stiff Ring Req'd?	0.139	Not Req'd	0.134	Cone OK	0.055	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 60 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 60 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0       385.0
0.0
OD:    Outer Diameter (mm)                            323.8         0.0
508.0
T:     Thickness (mm)                                  10.0        10.0
10.0
Fys:   Yield Stress (MPa)                             220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                 202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                   117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                           412.65      412.65
412.65

M:     Overturning Moment (KN-m)                        0.04        0.00
0.30
V:     Vertical Axial Loading (KN)                      0.83        0.00
1.39
Sx:    Section Modulus (cm^3)                         750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                    98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                        0.08        0.09
0.09
fb:    Bending Strss - M/Sx (MPa)                       0.05        0.05
0.16
fb':   Localized Bending Stress (MPa)                   0.16        0.16
0.36
fh':   Hoop Stress (MPa)                                0.08        0.00
0.19
```

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```
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)                0.14        0.14
0.25
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)          0.30        0.30
0.61
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.002	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.001	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.002	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.002	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 60 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone        Large
Ht:    Height of Cone (mm)                            0.0      1000.0
0.0
OD:    Outer Diameter (mm)                          508.0         0.0
1066.8
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                     26.75        0.00
30.31
V:     Vertical Axial Loading (KN)                    8.33        0.00
5.35
Sx:    Section Modulus (cm^3)                       1910.2      1910.2
8690.0
```

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```
Ax:    Cross Sectional Area (sq cm)                    156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                         0.53        0.55
0.16
fb:    Bending Strss - M/Sx (MPa)                       14.00       14.54
3.49
fb':   Localized Bending Stress (MPa)                   24.56       24.56
8.94
fh':   Hoop Stress (MPa)                                13.03        0.00
4.74
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                   1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                           220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                    110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                   2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                           220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)              14.54       15.09
3.65
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)        39.10       39.66
12.59
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                  132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                          110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.110	PASS	0.114	PASS	0.031	PASS
Check 2: Stot1 / Ft	0.095	PASS	0.096	PASS	0.030	PASS
Check 3: fh' < Fh	0.118	PASS	0.000	PASS	0.047	PASS
Stiff Ring Req'd?	0.118	Not Req'd	0.114	Cone OK	0.047	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 70 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 70 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0       385.0
0.0
OD:    Outer Diameter (mm)                            323.8         0.0
508.0
T:     Thickness (mm)                                  10.0        10.0
10.0
Fys:   Yield Stress (MPa)                             220.63      220.63
220.63
```

```
E:     Modulus of Elasticity (MPa)                    202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                      117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                              412.65      412.65
412.65

M:     Overturning Moment (KN-m)                           0.03        0.00
0.21
V:     Vertical Axial Loading (KN)                         0.91        0.00
1.51
Sx:    Section Modulus (cm^3)                             750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                       98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                           0.09        0.09
0.10
fb:    Bending Strss - M/Sx (MPa)                          0.04        0.04
0.11
fb':   Localized Bending Stress (MPa)                      0.15        0.15
0.30
fh':   Hoop Stress (MPa)                                   0.08        0.00
0.16
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                     2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                             220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                      110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                     3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                             220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)                 0.13        0.13
0.21
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)           0.28        0.28
0.50
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                    132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                            110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.002	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.001	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.001	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.002	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 70 Deg

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Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	20.53	0.00	23.49
V:	Vertical Axial Loading (KN)	10.49	0.00	7.25
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.67	0.70	0.22
fb:	Bending Strss - M/Sx (MPa)	10.75	11.16	2.70
fb':	Localized Bending Stress (MPa)	19.29	19.29	7.15
fh':	Hoop Stress (MPa)	10.23	0.00	3.79
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	198.75
Stot:	Total Stress Check 1: fa + fb (MPa)	11.42	11.85	2.92
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	30.71	31.15	10.08
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	119.25
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	100.34

Check	Small	Small	Cone	Cone	Large	Large

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	Ratio	Result	Ratio	Result	Ratio	Result
Check 1: Stot / Fb	0.086	PASS	0.090	PASS	0.024	PASS
Check 2: Stot1 / Ft	0.074	PASS	0.075	PASS	0.024	PASS
Check 3: fh' < Fh	0.093	PASS	0.000	PASS	0.038	PASS
Stiff Ring Req'd?	0.093	Not Req'd	0.090	Cone OK	0.038	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 80 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 80 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	0.01	0.00	0.11
V:	Vertical Axial Loading (KN)	0.95	0.00	1.58
Sx:	Section Modulus (cm^3)	750.3	750.3	1910.2
Ax:	Cross Sectional Area (sq cm)	98.583	98.583	156.451
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.10	0.10	0.10
fb:	Bending Strss - M/Sx (MPa)	0.02	0.02	0.06
fb':	Localized Bending Stress (MPa)	0.13	0.13	0.23
fh':	Hoop Stress (MPa)	0.07	0.00	0.12
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08	1596.11
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16

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```
Fxc:   Crit Lcl Bklng  (MPa)                          220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)              0.11        0.12
0.16
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)        0.25        0.25
0.38
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                 132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                         110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.001	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.001	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.001	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.001	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 80 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0      1000.0
0.0
OD:    Outer Diameter (mm)                          508.0         0.0
1066.8
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                     13.04        0.00
15.16
V:     Vertical Axial Loading (KN)                   14.49        0.00
11.10
Sx:    Section Modulus (cm^3)                       1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                     0.93        0.96
0.33
fb:    Bending Strss - M/Sx (MPa)                    6.83        7.09
1.74
```

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```
fb':   Localized Bending Stress (MPa)                    13.10       13.10
5.09
fh':   Hoop Stress (MPa)                                  6.95        0.00
2.70
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)                7.75        8.05
2.08
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)          20.85       21.15
7.17
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.059	PASS	0.061	PASS	0.017	PASS
Check 2: Stot1 / Ft	0.051	PASS	0.051	PASS	0.017	PASS
Check 3: fh' < Fh	0.063	PASS	0.000	PASS	0.027	PASS
Stiff Ring Req'd?	0.063	Not Req'd	0.061	Cone OK	0.027	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 90 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 90 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0       385.0
0.0
OD:    Outer Diameter (mm)                          323.8         0.0
508.0
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65
```

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```
M:     Overturning Moment (KN-m)                          0.00         0.00
0.00
V:     Vertical Axial Loading (KN)                        0.96         0.00
1.60
Sx:    Section Modulus (cm^3)                            750.3        750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                     98.583       98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                          0.10         0.10
0.10
fb:    Bending Strss - M/Sx (MPa)                         0.00         0.00
0.00
fb':   Localized Bending Stress (MPa)                     0.11         0.11
0.15
fh':   Hoop Stress (MPa)                                  0.06         0.00
0.08
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    2504.08      2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                            220.63       220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32       110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    3756.12      3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                            220.63       220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)                0.10         0.10
0.10
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)          0.21         0.21
0.25
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38       132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32       110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.001	PASS	0.001	PASS	0.001	PASS
Check 2: Stot1 / Ft	0.001	PASS	0.001	PASS	0.001	PASS
Check 3: fh' < Fh	0.001	PASS	0.000	PASS	0.001	PASS
Stiff Ring Req'd?	0.001	Not Req'd	0.001	Cone OK	0.001	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 90 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0      1000.0
0.0
OD:    Outer Diameter (mm)                            508.0         0.0
1066.8
```

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T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	0.00	0.00	0.00
V:	Vertical Axial Loading (KN)	35.49	0.00	32.04
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	2.27	2.36	0.97
fb:	Bending Strss - M/Sx (MPa)	0.00	0.00	0.00
fb':	Localized Bending Stress (MPa)	3.83	3.83	2.36
fh':	Hoop Stress (MPa)	2.03	0.00	1.25
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	198.75
Stot:	Total Stress Check 1: fa + fb (MPa)	2.27	2.36	0.97
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	6.10	6.19	3.33
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	119.25
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	100.34

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.017	PASS	0.018	PASS	0.008	PASS
Check 2: Stot1 / Ft	0.015	PASS	0.015	PASS	0.008	PASS
Check 3: fh' < Fh	0.018	PASS	0.000	PASS	0.012	PASS
Stiff Ring Req'd?	0.018	Not Req'd	0.018	Cone OK	0.012	Not Req'd

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All cone analysis checks Passed And the cone design Is Acceptable

Stack Deflection Lift Angle = 0 Deg
Load Combination Dead Weight

Elev m	Dx mm	Dy mm	Dz mm	Dres mm	Limit mm	Ratio	Rresult
11.500	0.0	0.5	0.0	0.5	4.0	0.120	Pass
11.467	0.0	0.5	0.0	0.5	3.8	0.120	Pass
11.385	0.0	0.4	0.0	0.4	3.4	0.120	Pass
11.257	0.0	0.3	0.0	0.3	2.8	0.120	Pass
11.128	0.0	0.3	0.0	0.3	2.1	0.121	Pass
11.000	0.0	0.2	0.0	0.2	1.5	0.121	Pass
10.699	0.0	0.0	0.0	0.0	52.7	0.000	Pass
10.400	0.0	-0.2	0.0	0.2	52.7	0.003	Pass
8.400	0.0	-1.2	0.0	1.2	52.7	0.023	Pass
7.667	0.0	-1.5	0.0	1.5	52.7	0.028	Pass
6.456	0.0	-1.6	0.0	1.6	52.7	0.030	Pass
6.123	0.0	-1.6	0.0	1.6	52.7	0.030	Pass
5.789	0.0	-1.5	0.0	1.5	52.7	0.028	Pass
5.456	0.0	-1.4	0.0	1.4	52.7	0.027	Pass
5.137	0.0	-1.4	0.0	1.4	52.7	0.026	Pass
5.000	0.0	-1.3	0.0	1.3	52.7	0.026	Pass
4.863	0.0	-1.3	0.0	1.3	52.7	0.025	Pass
3.100	0.0	-0.9	0.0	0.9	52.7	0.017	Pass
2.450	0.0	-0.7	0.0	0.7	52.7	0.013	Pass
1.385	0.0	-0.4	0.0	0.4	52.7	0.007	Pass
1.275	0.0	-0.4	0.0	0.4	52.7	0.007	Pass
1.165	0.0	-0.3	0.0	0.3	52.7	0.006	Pass
0.950	0.0	-0.3	0.0	0.3	52.7	0.005	Pass
0.350	0.0	-0.1	0.0	0.1	52.7	0.001	Pass
0.305	0.0	0.0	0.0	0.0	52.7	0.001	Pass
0.153	0.0	0.0	0.0	0.0	52.7	0.000	Pass
0.000	0.0	0.0	0.0	0.0	0.8	0.063	Pass

Dres = Max Lateral Displacement: (Dx^2 + Dy^2 + Dz^2)
Ratio = Dres / Limit

Lifting Reactions Summary - Dead Load
*** Angle of Lift relative to grade. 0 Deg is Horizontal and 90 Deg is vertical**

Lift Angle Deg	Lifting Load N	Tailing Load N
0.0	13924	19324
10.0	14158	19089
20.0	14402	18846
30.0	14671	18576
40.0	14991	18256
50.0	15406	17842
60.0	16005	17243
70.0	17029	16218
80.0	19398	13850
90.0	33248	0

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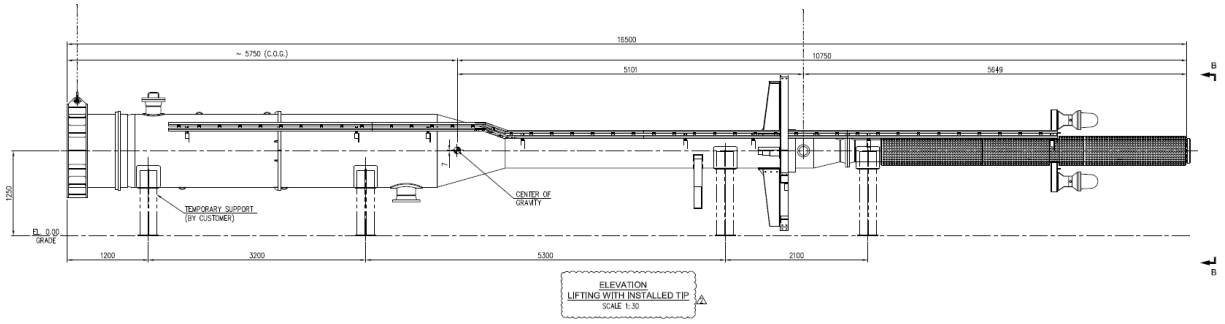
Lifting Reactions Summary - Dead + Impact Load
*** Angle of Lift relative to grade. 0 Deg is Horizontal and 90 Deg is vertical**

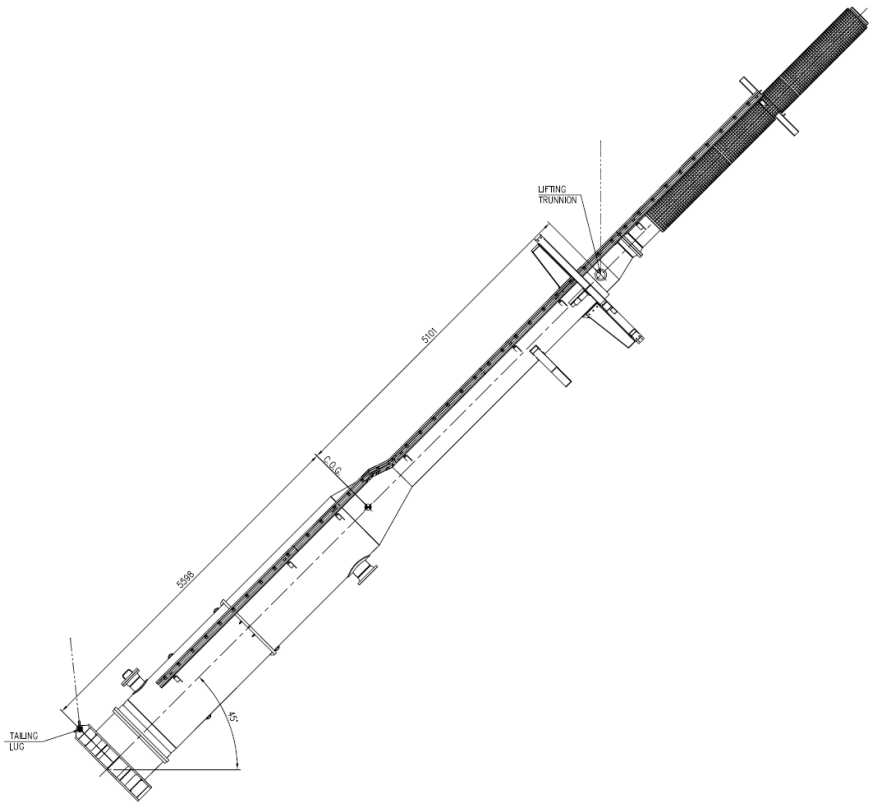
Lift Angle Deg	Lifting Load N	Tailing Load N
0.0	20885	28986
10.0	21237	28634
20.0	21602	28269
30.0	22007	27865
40.0	22487	27384
50.0	23108	26763
60.0	24008	25864
70.0	25544	24328
80.0	29097	20775
90.0	49871	0

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C- LIFTING ANALYSIS CONFIGURATION WITH INSTALLED TIP

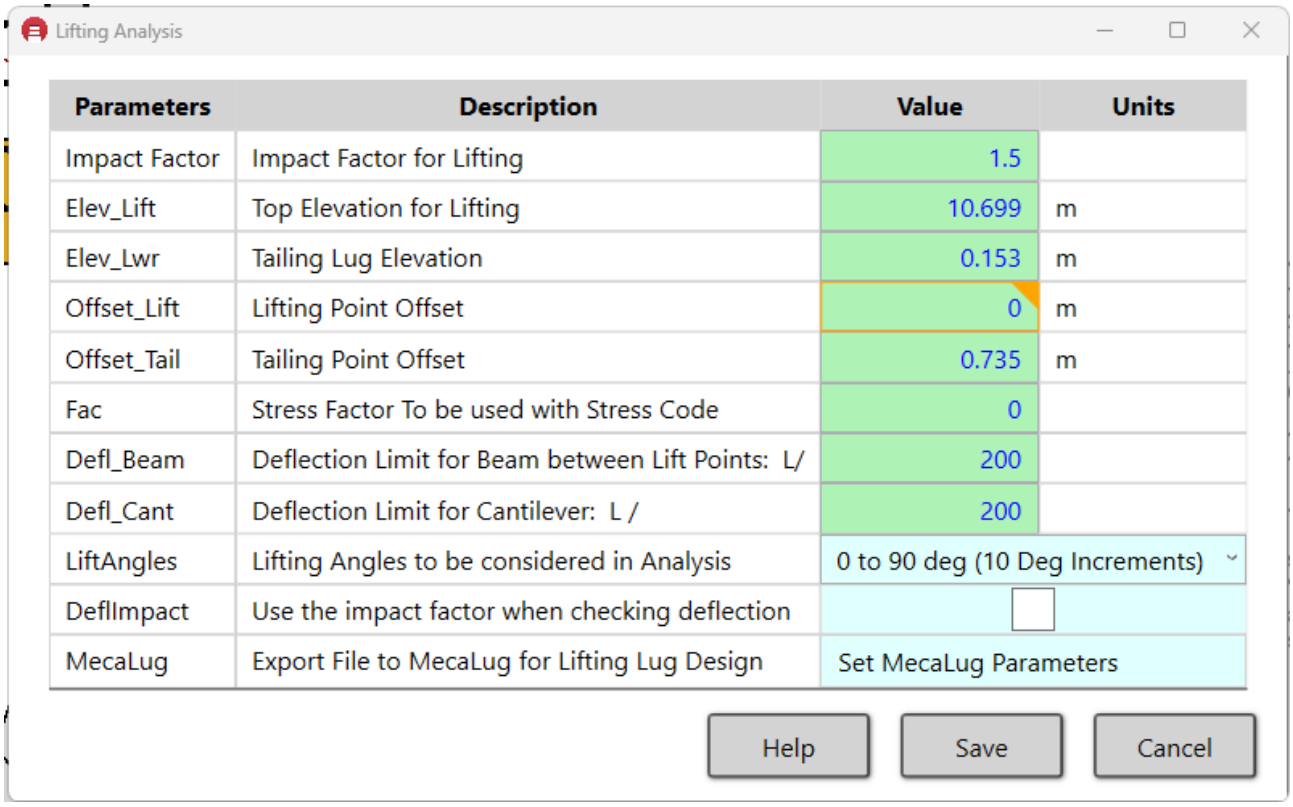
The configuration for the lifting is shown here after.





Differently than what analyzed in the annex D, here the tip will be installed before lifting.

A specialized model has been developed to analyze the lifting phases. For safety, the top platform is assumed to be fully assembled during the lift. In practice, some components will be added later to avoid potential conflicts with the lifting hardware.



Parameters	Description	Value	Units
Impact Factor	Impact Factor for Lifting	1.5	
Elev_Lift	Top Elevation for Lifting	10.699	m
Elev_Lwr	Tailing Lug Elevation	0.153	m
Offset_Lift	Lifting Point Offset	0	m
Offset_Tail	Tailing Point Offset	0.735	m
Fac	Stress Factor To be used with Stress Code	0	
Defl_Beam	Deflection Limit for Beam between Lift Points: L/	200	
Defl_Cant	Deflection Limit for Cantilever: L /	200	
LiftAngles	Lifting Angles to be considered in Analysis	0 to 90 deg (10 Deg Increments)	
DeflImpact	Use the impact factor when checking deflection	☐	
MecaLug	Export File to MecaLug for Lifting Lug Design	Set MecaLug Parameters	

MecaStack v5630

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Calculations Prepared by:
Date: Dec 04, 2024

File Location: W:\1.COMMESSE\DB-ENCORE-C16-23-0193-Rosetti Marino Cross Wind\4.Calcoli\MECASTACK\23-0193-Vent Cross wind-20241204-00.stk

INPUT PARAMETERS:
* Linear Static Analysis
* Stress analysis based upon Allowable Stress Design

Total Stack Height = 16.50 m Top of Stack Elevation = 16.5 m

Grade Elevation = 0.00 m Bottom of Stack = 0.0 m

All elevations are based upon the bottom of stack being at 0 m

Stack Geometry:

Elevation m	Outer Diameter m	Elevation m	Thickness mm	Elevation m	Corrosion Allow mm
16.5	0.3238	16.5	6.0	16.5	0.0
11.385	0.3238	11.5	10.0	11.5	3.0
11.0	0.5080			0.305	0.0
6.456	0.5080				
5.456	1.0668				

Materials:

Elev m	Material	Temp Deg C	Fyld MPa	Elas Mod MPa	Alpha mm/mm/C	Allow Strs MPa	Density Kg/m^3	Tensile MPa
16.5	316 SS	200.00	148.65	182352	1.71E-05	99.37	8000	496.28
		-10.00	206.84	195121	1.53E-05	137.89	8000	517.11
11.5	A-516-60	80.00	204.66	199333	1.20E-05	117.90	7849	413.68
		-10.00	220.63	202705	1.15E-05	117.90	7849	413.68
0.446	S275J0	80.00	239.00	207692	1.20E-05	101.79	7849	356.33
		-10.00	275.00	210000	1.20E-05	117.14	7849	410.03

Platforms:

Plat Elev m	Start Ang Deg	End Ang Deg	Width m	Stack OD m	Weight kg
10.400	0.0	360.0	0.7500	0.5080	319.3

Ladders:

Top Elev m	Bot Elev m	Orientation Deg	Type of Ladder	Weight kg/m	Wind Area m^2/m
11.500	8.400	0.0	Ladder Only	22.32	0.152

General Attachment Uniform

Description	Top Elev m	Bot Elev m	Area m	Lin Wt kg/m	Type
Water	2.450	0.950	0.0000	758.00	Oper
External insulation	3.100	0.350	0.0000	30.00	Dead

General Attachment Concentrated

Description	Elev m	Area sq m	Weight kg	Type
Elliptical head	0.950	0.000	200.0	Dead

Nozzles:

Num	Description	Elevation	Nominal Diameter	Schedule	Outer Diameter	Thickness	Tilt	Orientation	Projection
		m			mm	mm	Deg	Deg	mm
1	1N	5.000	10 inch [254.0 mm]	Std	273.1	9.3	0.0	180.0	200.0
2	HW	1.275	8 inch [203.2 mm]	Std	219.1	8.2	0.0	0.0	200.0

Num	Description	Repad Width	Repad Thickness	Flange Spec	Flange Radial Width	Flange Thickness	Nozzle Loads
		mm	mm		mm	mm	
1	1N	100.0	8.0	ANSI B16.5 150# Flange	66.7	30.2	Loads = 1
2	HW	50.0	8.0	ANSI B16.5 150# Flange	61.9	28.6	Loads = 0

Nozzle # 1 Nozzle Load Cases

Load Num	Description	Fx	Fy	Fz	Mx	My	Mz	Local/ Global	Load Applied	Load Type	Check WRC 107
		KN	KN	KN	KN-m	KN-m	KN-m				
1	5 x API Loads	7.78	14.46	14.46	6.30	4.75	4.75	Local	End of Nozzle	Oper	Yes

Nozzle # 1 Load Summary of Transformed Loads
Transformation of Loads to Global Coordiantes and at Stack Centerline

Load Num	Description	Load Type	FxC	FyC	FzC	MxC	MyC	MzC	Ver	Shear	Mom	Mbase
			KN	KN	KN	KN-m	KN-m	KN-m	KN	KN	KN-m	KN-m
1	5 x API Loads	Oper	7.78	14.46	14.46	6.30	4.75	4.75	14.46	16.42	7.89	89.99

Equivalent Nozzle Loads Applied on Stack:
Ver = Stack Vertical Load considered at Nozzle Elev: Fy
Shear = Stack Shear Load considered at Nozzle Elev: [Fx^2+Fz^2]^0.5
Mom = Stack Moment Load considered at Nozzle Elev: [Mx^2+Mz^2]^0.5
Mbase = Est Mom at base if no Support: Mom + Shear*Elev
Provided only to evaluate the impact of the load on overall stack

Helical Strakes: (3 Vanes 120 deg apart assumed)

ElTop	= Top Strake Elevation	= 16.5 m
ElBot	= Bottom Strake Elevation	= 11.0 m
Pitch	= Strake Pitch (One complete wrap)	= 1.6190 m
Width	= Strake Width	= 32.4 mm
Thick	= Strake Thickness	= 3.2 mm
OD	= Outer Diameter of Stack and Insulation (If Applicable)	= 323.8 mm
ShapeFac	= Strake Shape Factor (Applied to bare stack shell)	= 1.40
SO	= Stand-off from OD of shell to strake	= 0.0 mm
Len	= Pitch Length: [(PI*(OD+2*SO+2*Width))^2+(Pitch^2)]^0.5	= 2.028 m

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Area      = Total Painted Area (3 vanes): (2*Width*Len*3*Wraps)            = 92.932 sq
cm
Wraps     = Total Number of Wraps (Top elev - Bot elev)/ Pitch             = 3.40
WtUni     = Estimated Linear Weight of Strakes and Clips: Wt/(ElTop-ElBot) = 4.54 kg/m
Wt        = Estimated total Wt of Strakes and Clips: 1.5*(Area/2)*Thick*Dens= 25.0 kg

Type      = Type of Baseplate                                              = Chair
                                                                             Continuous
Plate
SupType   = Type of Support                                                = Rigid Steel
Base
Friction  = Coefficient of Friction for Support                            = 0.300
BasisBolt = Basis for Bolt Design                                          = Brownell &
Young
Nbolt     = Number of Bolts                                                = 16
Dbolt     = Nominal Bolt Diameter                                          = 27.0 mm
Dbh       = Bolt Hole Diameter                                             = 36.0 mm
CAbolt    = Corrosion Allowance on Bolt                                    = 3.0 mm
CAplt     = Corrosion Allowance on Plates                                  = 0.0 mm
ID        = Inside Diameter of Baseplate                                   = 820.0 mm
BCD       = Bolt Circle Diameter of Baseplate                              = 1270.0 mm
OD        = Outer Diameter of Baseplate                                    = 1385.0 mm
Tb        = Thickness of Bottom Plate                                      = 25.0 mm
Tt        = Thickness of Top Plate                                         = 25.0 mm
Fw        = Fillet Weld Size                                               = 5.0 mm
Fwu       = Weld Ultimate Tensile Strength                                 = 482632.1
KPa
Ngus      = Number of Gussets per Bolt                                     = 1
Hg        = Height of Anchor Chair                                         = 305.0 mm
Tg        = Thickness of Gusset                                            = 12.0 mm
Material: (Properties looked up from database)
Spec      = Material Specification                                         = S275J0
Dens      = Material Density                                               = 7849 Kg/m^3
Temp      = Design Temperature                                             = 21.11 Deg C
Fy        = Minimum Yield Stress                                           = 274996.9
KPa
Fu        = Ultimate Tensile Stress                                        = 410030.5
KPa
Sa        = Allowable Tensile Stress                                       = 117141.7
KPa
E         = Modulus of Elasticity                                          = 209957162.5
KPa
A         = Coefficient of Thermal Expansion                               = 1.20E-05
mm/mm/C


Bolt Material:
Override  = Manually Specify Material                                      = False
Matl      = Bolt Material Specification                                    = Gr. 8.8
Fu        = Ultimate Tensile Stress                                        = 800548.8
KPa
Fy        = Yield Stress                                                   = 640440.4
KPa
Fproof    = Proof Stress                                                   = 544374.4
KPa
Eb        = Modulus of Elasticity                                          = 202705497.9
KPa
```

```
Anchor Bolt Pretension:
Pretension= Pretension for Bolt as % of Ultimate Tensile                    = 60.00 %
Fult      = Bolt Ultimate Tensile Stress                                    = 800.55 MPa
PreStress = Pretension Stress on Bolt                                       = 480.33 MPa

Plate Washer:
Ptype     = The Type of Plate Washer                                        = Rectangular
Pt        = Plate Washer Thickness                                          = 15.0 mm
Pw        = Width of Washer Perpendicular to Shell                          = 90.0 mm
Pl        = Length of Washer Parallel to Shell                              = 100.0 mm
Pdh       = Bolt Hole Diameter                                              = 30.0 mm
Structural Flange(s):
Structural Flange:  FLANGE #1 - 11.44 m
Flange Standard: None
Ds        = Outer Diameter of Shell                                         = 323.8 mm
Do        = Outside Diameter of Flange                                      = 482.6 mm
Rod       = Radial Dist from Bolt Circle to OD of Flange                    = 25.4 mm
Dbc       = Bolt Circle Diameter                                            = 431.8 mm
Rbc       = Radial Dist from OD of Shell to Bolt Circle                     = 54.0 mm
Tf        = Thickness of Flange                                             = 31.8 mm
Tw        = Fillet Weld Size                                                = 6.0 mm
Gus       = Gussets                                                         = False
Db        = Nominal Bolt Diameter                                           = 22.2 mm
Nb        = Number of Bolts                                                 = 12
BMatl     = Bolt Material                                                   = Gr 8 (US)
Fu        = Ultimate Bolt Tensile Stress                                    = 1034.21 MPa
Eb        = Modulus of Elasticity for Bolt                                  = 202705.50
MPa
Fp        = Pre-Load % of Allowable Bolt                                    = 60.00 %
Fw        = Tensile Stress of Weld                                          = 413.68 MPa
FMatl     = Flange Material                                                 = A-36
Fyf       = Yield Stress of Flange                                          = 215.81 MPa
Ef        = Modulus of Elasticity of Flange                                 = 193742.33
MPa
```

Design Codes

```
Stress Criteria:  Eurocde 3 - Design of Steel structures:  Part 3-2: Towers, masts and
chimneys
Class     = Fabrication Quality Class (A=Excellent, B=High, C=Normal)       = C
Bspace    = Flange Max Bolt spacing in terms of # of bolt diameters         = 10.00
Incl_Ecc  = Include Eccentric Moment when Centroid is Offset                = False

Lifting Criteria:

Impact    = Impact Factor                                                   = 1.50
Lift_El   = Elevation of Lifting Point                                      = 10.699 m
UprOff    = Longitudinal Offset for Lifting Lug point from Lift Elev to Lift Eye= 0.0000
m
Tail_El   = Elevation of Tailing Point                                      = 0.153 m
LwrOff    = Radial Offset for Tailing Lug point from Ctr Line to Tail Pt    = 0.7350 m
SF        = Stress Factor of Safety                                         = 0.000
Defl_Beam = Deflection Limit between Lifting Points:  L /                   = 200.0
Defl_Cant = Deflection Limit for Cantilevers:         L /                   = 200.0
Defl_Impact= Consider Impact loading for deflection check?                   = False
```

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Check Stack for 0 to 90 Deg in 10 Deg increments

Damping Criteria:

Structural Damping Criteria:
Criteria: ASME STS-1-2021
Stack Type: UnLined
Support: ELASTIC

Mode	Bs Struc Damping	Ds Log Decrement Damping
1	0.1000	0.6283
2	0.0040	0.0251
3	0.0040	0.0251

Log Decrement Damping = 2 * PI * Bs

Aerodynamic Damping Criteria:
(Only used in Along wind analysis, Not considered for vortex shedding)

Criteria: EN 1994-1-4

Section Properties
Properties calculated based upon Corroded stack

Top Elev m	Bot Elev m	Outer Diameter mm	Thick mm	Rad of Gyration mm	Area sq cm	Plastic Sec Mod cm^3	Elastic Sec Mod cm^3	Mom of Inertia cm^4	Section Props
16.500	13.452	323.8	6.0	112.4	59.904	606.1	467.3	7565.33	Ideal
13.452	11.500	323.8	6.0	112.4	59.904	606.1	467.3	7565.33	Ideal
11.500	11.467	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
11.467	11.385	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
11.385	11.257	323.8	7.0	112.0	69.668	702.7	540.1	8744.31	Ideal
11.257	11.128	385.2	7.0	133.7	83.171	1001.4	772.4	14875.49	Ideal
11.128	11.000	446.6	7.0	155.4	96.673	1352.9	1046.0	23358.29	Ideal
11.000	10.699	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
10.699	10.400	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
10.400	8.400	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
8.400	6.456	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
6.456	6.123	508.0	7.0	177.1	110.176	1757.1	1361.2	34574.50	Ideal
6.123	5.789	694.3	7.0	243.0	151.138	3306.5	2570.9	89243.50	Ideal
5.789	5.456	880.5	7.0	308.8	192.100	5341.5	4162.0	183240.21	Ideal
5.456	5.137	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
5.137	5.000	1066.8	7.0	356.8	258.745	7914.0	6175.1	329389.19	1
5.000	4.863	1066.8	7.0	370.4	230.396	7596.5	5927.3	316171.94	2
4.863	3.100	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
3.100	2.450	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
2.450	1.385	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
1.385	1.275	1066.8	7.0	363.4	248.063	7872.5	6142.6	327659.06	3
1.275	1.165	1066.8	7.0	368.4	226.134	7372.8	5752.7	306862.01	4
1.165	0.950	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal

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0.950	0.446	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
0.446	0.350	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
0.350	0.305	1066.8	7.0	374.7	233.061	7862.3	6134.7	327223.37	Ideal
0.305	0.153	1066.8	10.0	404.0	637.478	19311.7	15026.1	1040594.63	5
0.153	0.000	1066.8	10.0	404.0	637.478	19311.7	15026.1	1040594.63	6

Section Props - If a number is shown, then the section contains something unusual (Breach, nozzle, stiffeners, etc..) and so the properties were calculated using numerical methods.
- 'Ideal' indicates the properties calculated using ideal equations

Section Properties calculated using Numerical Methods
These sections contains unusual geometry (Nozzles, Breach, stiffeners, etc..)

Section Props	Principal Axis Deg	Centroid Xc mm	Centroid Yc mm	Area sq cm	Minimum Mom of Iner cm^4	Maximum Mom of Iner cm^4	Min Elas Sec Mod cm^3	Minimum Rad of Gyr mm
1	0.0	-52.6	0.0	258.745	329389.19	392083.97	6175.1	356.8
2	0.0	7.6	0.0	230.396	316171.94	331995.89	5927.3	370.4
3	0.0	32.3	0.0	248.063	327659.06	367515.76	6142.6	363.4
4	0.0	-16.4	0.0	226.134	306862.01	328213.14	5752.7	368.4
5	67.0	0.0	0.0	637.478	1040594.63	1040594.63	15026.1	404.0
6	67.0	0.0	0.0	637.478	1040594.63	1040594.63	15026.1	404.0

Weight Summary (Lifting)

Component	Elev COG m	Weight kg	Weight N
Stack (Corroded Wt = 1822.5 kg)	5.604	2458.5	24110
Ladders	9.950	69.2	679
Platforms	10.400	319.3	3132
Helical Strakes	13.750	25.0	245
Baseplate	0.127	389.0	3815
Structural Flange(s)	11.440	58.0	569
Nozzle(s)	3.537	53.2	521
General Attachment Uniform)	1.725	82.5	809
General Attachment Concentrated	0.950	200.0	1961
Total	5.299	3654.7	35841

Cylindrical Shells Wt: (Wt = 2458.5 kg, El COG = 5.604 m)

Elev Top m	Elev Bot m	Elev COG m	OD m	Thk mm	Density Kg/m^3	Wt Corroded kg	Lin Wt UnCorroded kg/m	Wt UnCorroded kg
16.500	11.500	14.000	0.3238	6.0	8000	239.6	47.92	239.6
11.500	11.385	11.443	0.3238	10.0	7849	6.3	77.38	8.9
11.385	11.000	11.193	0.4159	10.0	7849	27.2	100.09	38.5
11.000	6.456	8.728	0.5080	10.0	7849	393.0	122.80	558.0
6.456	5.456	5.956	0.7874	10.0	7849	134.7	191.69	191.7
5.456	0.446	2.951	1.0668	10.0	7849	916.5	260.59	1305.6
0.446	0.305	0.376	1.0668	10.0	7849	25.8	260.59	36.7
0.305	0.000	0.153	1.0668	10.0	7849	79.5	260.59	79.5

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Total	5.604					1822.5		2458.5

Note: Conical Sections show equivalent Diameter that gives same uncorroded weight

Ladders Wt: (Wt = 69.2 kg, El COG = 9.950 m)

Description	Elev Top m	Elev Bot m	Elev COG m	Lin Wt kg/m	Weight kg
Ladder Only	11.500	8.400	9.950	22.32	69.2
Total			9.950		69.2

Platforms Wt: (Wt = 319.3 kg, El COG = 10.400 m)

Plat Elev m	Start Ang Deg	End Ang Deg	Width m	Stack OD m	Elev COG m	Weight kg
10.400	0.0	360.0	0.7500	0.5080	10.400	319.3
Total					10.400	319.3

Helical Strakes Wt: (Wt = 25.0 kg, El COG = 13.750 m)

El Top m	El Bot m	El COG m	Lin Wt kg/m	TOt Wt kg
16.500	11.000	13.750	4.54	25.0
Total		13.750		25.0

Baseplate Wt: (Wt = 389.0 kg, El COG = 0.127 m)

Description	Elevation COG m	Weight kg
Bottom Plate	0.013	192.0
Top Plate	0.293	120.2
Gussets	0.153	61.1
Washers	0.153	15.6
Total	0.127	389.0

Structural Flanges Wt: (Wt = 58.0 kg, El COG = 11.440 m)

Elev m	Flg OD mm	Flg Thk mm	Gus Ht mm	Gus Thk mm	Wt Gus kg	Wt Flg kg	Wt Bolts kg	Elev COG m	Qty	Weight kg
11.440	482.6	31.8	0.0	0.0	0.0	25.1	7.9	11.440	2	58.0
Total					0.0	25.1	7.9	11.440		58.0

1. Weight = (Wt_Flg + Wt_Gus)*Qty

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Nozzle Wt (Dead): (Wt = 53.2 kg, El COG = 3.537 m)

Num	Elev m	OD mm	Removed Shell kg	Pipe kg	Repad kg	Flange kg	Noz Loads kg	Elev COG m	Weight kg
1	5.000	273.1	-3.99	12.06	7.36	16.85	0.00	5.000	32.27
2	1.275	219.1	-2.53	8.51	2.65	12.26	0.00	1.275	20.89
Total		0.0	-6.53	20.57	10.01	29.11	0.00	3.537	53.16

General Attach Uniform Wt (Dead, Factor = 1): (Wt = 82.5 kg, El COG = 1.725 m)

Description	El Top m	El Bot m	El COG m	Lin Wt kg/m	Tot Wt kg
External insula	3.100	0.350	1.725	30.00	82.5
Total	0.000	0.000	1.725		82.5

General Attach Concentrated Wt (Dead): (Wt = 200.0 kg, El COG = 0.950 m)

Description	Elev m	Area sq m	Weight kg
Elliptical head	0.950	0.000	200.0
Total	0.950		200.0

Primary Loads
Abbreviations are used in Load Combinations

Number	Description	Abbreviation
1	Dead	D
2	Impact Load	I

Load Combinations
Column Abbreviations can be found in the Primary Load Table

Num	Description	S	D	FS	Dir Deg	D	I
3	Dead Weight		X	0.000	0	1.0	
4	Dead Weight + Impact	X		0.000	0	1.0	1.0

FS: Factor of Safety used in Conjunction with the Stress Code which has been selected.
Dir: Direction of Lateral Loads (Wind/Seismic/Vortex), 0 Deg = X Axis, 90 Deg = Z Axis
P: Internal Pressure (Doesn't produce support loads only used for stack tensile stress)
S: Include in Stress Analysis D: Calculate Deflections
Load Combinations were Automatically generated

Boundary Conditions Specified for System
'F' is translational restraint and 'M' is rotational restraint

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Joint #	Description	X m	Y m	Z m	Fx	Fy	Fz	Mx	My	Mz
9	Upper Lift Point	10.6990	0.0000	0.0000	Fixed	Fixed	Fixed	Fixed	Free	Free
30	Lower Lift Point	0.1530	0.7350	0.0000	Free	Fixed	Free	Free	Free	Free

Stack Stress Worst Case Summary
Summary of the load and highest stress ratios for each stack element

Top El m	Bot El m	Load #	Load Case	Controlling Case	Ratio	Result
16.500	13.452	4	Dead Weight + Impact	Buckling	0.000	PASS
13.452	11.500	4	Dead Weight + Impact	Buckling	0.059	PASS
11.500	11.467	4	Dead Weight + Impact	Buckling	0.089	PASS
11.467	11.385	4	Dead Weight + Impact	Buckling	0.090	PASS
11.385	11.257	4	Dead Weight + Impact	Buckling	0.093	PASS
11.257	11.128	4	Dead Weight + Impact	Buckling	0.070	PASS
11.128	11.000	4	Dead Weight + Impact	Buckling	0.056	PASS
11.000	10.699	4	Dead Weight + Impact	Buckling	0.046	PASS
10.699	10.400	4	Dead Weight + Impact	Buckling	0.053	PASS
10.400	8.400	4	Dead Weight + Impact	Buckling	0.031	PASS
8.400	6.456	4	Dead Weight + Impact	Buckling	0.066	PASS
6.456	6.123	4	Dead Weight + Impact	Buckling	0.129	PASS
6.123	5.789	4	Dead Weight + Impact	Buckling	0.069	PASS
5.789	5.456	4	Dead Weight + Impact	Buckling	0.045	PASS
5.456	5.137	4	Dead Weight + Impact	Buckling	0.032	PASS
5.137	5.000	4	Dead Weight + Impact	Buckling	0.032	PASS
5.000	4.863	4	Dead Weight + Impact	Buckling	0.035	PASS
4.863	3.100	4	Dead Weight + Impact	Buckling	0.033	PASS
3.100	2.450	4	Dead Weight + Impact	Buckling	0.030	PASS
2.450	1.385	4	Dead Weight + Impact	Buckling	0.027	PASS
1.385	1.275	4	Dead Weight + Impact	Buckling	0.020	PASS
1.275	1.165	4	Dead Weight + Impact	Buckling	0.020	PASS
1.165	0.950	4	Dead Weight + Impact	Buckling	0.018	PASS
0.950	0.446	4	Dead Weight + Impact	Buckling	0.015	PASS
0.446	0.350	4	Dead Weight + Impact	Buckling	0.009	PASS
0.350	0.305	4	Dead Weight + Impact	Buckling	0.008	PASS
0.305	0.153	4	Dead Weight + Impact	Buckling	0.005	PASS
0.153	0.000	4	Dead Weight + Impact	Buckling	0.001	PASS
0.000	0.000	0			0.000	PASS

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 0 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
16.500	0.00	0.00	0.00	0.00	0.00	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	3.58	0.00	0.00	7.67	7.67	0.00	130.14	24.57	1.958	1.384	0.059	0.004	0.059
11.500	9.65	0.00	0.00	12.86	12.86	0.00	145.11	71.07	1.990	1.612	0.089	0.008	0.089
11.467	9.78	0.00	0.00	13.03	13.03	0.00	145.11	71.07	1.990	1.612	0.090	0.008	0.090
11.385	10.17	0.00	0.00	13.56	13.56	0.00	145.11	71.07	1.990	1.612	0.093	0.009	0.093

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11.257	10.81	0.00	0.00	10.03	10.03	0.00	143.11	50.11	1.980	1.505	0.070	0.005	0.070
11.128	11.49	0.00	0.00	7.84	7.84	0.00	141.19	37.29	1.970	1.440	0.056	0.003	0.056
11.000	12.19	0.00	0.00	6.38	6.38	0.00	139.35	28.85	1.961	1.397	0.046	0.002	0.046
10.699	13.98	0.00	0.00	7.32	7.32	0.00	139.35	28.85	1.961	1.397	0.053	0.003	0.053
10.400	8.12	0.00	0.00	4.25	4.25	0.00	139.35	28.85	1.961	1.397	0.030	0.001	0.030
8.400	16.77	0.00	0.00	8.78	8.78	0.00	139.35	28.85	1.961	1.397	0.063	0.004	0.063
6.456	33.40	0.00	0.00	17.48	17.48	0.00	139.35	28.85	1.961	1.397	0.125	0.017	0.125
6.123	35.51	0.00	0.00	9.79	9.79	0.00	147.09	15.58	2.000	1.329	0.067	0.004	0.067
5.789	37.30	0.00	0.00	6.34	6.34	0.00	147.09	10.00	2.000	1.301	0.043	0.002	0.043
5.456	38.78	0.00	0.00	4.46	4.46	0.00	145.82	7.41	1.994	1.288	0.031	0.001	0.031
5.137	39.86	0.00	0.00	4.57	4.57	0.00	145.82	7.41	1.994	1.288	0.031	0.001	0.031
5.000	40.20	0.00	0.00	5.00	5.00	0.00	145.82	7.41	1.994	1.288	0.034	0.001	0.034
4.863	40.40	0.00	0.00	4.65	4.65	0.00	145.82	7.41	1.994	1.288	0.032	0.001	0.032
3.100	36.61	0.00	0.00	4.21	4.21	0.00	145.82	7.41	1.994	1.288	0.029	0.001	0.029
2.450	32.12	0.00	0.00	3.70	3.70	0.00	145.82	7.41	1.994	1.288	0.025	0.001	0.025
1.385	20.84	0.00	0.00	2.40	2.40	0.00	145.82	7.41	1.994	1.288	0.016	0.000	0.016
1.275	19.41	0.00	0.00	2.44	2.44	0.00	145.82	7.41	1.994	1.288	0.017	0.000	0.017
1.165	17.89	0.00	0.00	2.06	2.06	0.00	145.82	7.41	1.994	1.288	0.014	0.000	0.014
0.950	14.75	0.00	0.00	1.70	1.70	0.00	145.82	7.41	1.994	1.288	0.012	0.000	0.012
0.446	5.15	0.00	0.00	0.59	0.59	0.00	176.89	7.68	1.974	1.281	0.003	0.000	0.003
0.350	3.20	0.00	0.00	0.37	0.37	0.00	176.89	7.68	1.974	1.281	0.002	0.000	0.002
0.305	2.27	0.00	0.00	0.15	0.15	0.00	176.89	183.33	1.974	2.000	0.001	0.000	0.001
0.153	0.92	0.00	0.00	0.06	0.06	0.00	176.89	183.33	1.974	2.000	0.000	0.000	0.000

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 0 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 0.00 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 151841.57 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 0 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
16.500	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14

```
13.452 341.0 10.6275 1.0 0.60 1.9 0.450 206.84 0.200 1.061 0.281 0.944 2624.92 195.20
130.14
11.500 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.467 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.385 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.257 242.2 10.6275 1.0 0.60 2.7 0.478 220.63 0.200 1.093 0.240 0.973 3820.46 214.66
143.11
11.128 224.9 10.6275 1.0 0.60 3.0 0.466 220.63 0.200 1.080 0.259 0.960 3295.21 211.79
141.19
11.000 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.699 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 8.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.456 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.123 180.4 10.6275 1.0 1.00 3.7 0.427 220.63 0.300 1.033 0.250 1.000 3532.85 220.63
147.09
 5.789 160.2 10.6275 1.0 1.00 4.1 0.403 220.63 0.300 1.004 0.281 1.000 2785.52 220.63
147.09
 5.456 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 5.137 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 5.000 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 4.863 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 3.100 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 2.450 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 1.385 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 1.275 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 1.165 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 0.950 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.16 218.73
145.82
 0.446 145.5 10.6275 1.0 1.00 4.6 0.383 275.00 0.300 0.979 0.340 0.965 2381.90 265.33
176.89
 0.350 145.5 10.6275 1.0 1.00 4.6 0.383 275.00 0.300 0.979 0.340 0.965 2381.90 265.33
176.89
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.300 0.979 0.340 0.965 2381.90 265.33
176.89
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.300 0.979 0.340 0.965 2381.90 265.33
176.89

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
```

```
   w     = Length Param:  l/(r*t)^0.5  [D.1]     Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]       Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]              Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]     s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                      s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]        fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 0 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

```
   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 10 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-0.20	-0.03	0.00	-0.03	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	3.53	-0.54	-0.09	7.56	7.47	0.00	130.14	24.57	1.958	1.384	0.057	0.004	0.057
11.500	9.50	-0.67	-0.07	12.66	12.59	0.00	145.11	71.07	1.990	1.612	0.087	0.008	0.087
11.467	9.63	-0.84	-0.09	12.83	12.75	0.00	145.11	71.07	1.990	1.612	0.088	0.008	0.088
11.385	10.02	-0.87	-0.09	13.35	13.26	0.00	145.11	71.07	1.990	1.612	0.091	0.009	0.091
11.257	10.65	-0.91	-0.08	9.88	9.80	0.00	143.11	50.11	1.980	1.505	0.069	0.005	0.069
11.128	11.31	-0.95	-0.07	7.73	7.66	0.00	141.19	37.29	1.970	1.440	0.054	0.003	0.054
11.000	12.01	-1.03	-0.07	6.29	6.22	0.00	139.35	28.85	1.961	1.397	0.045	0.002	0.045
10.699	13.76	3.46	0.22	7.21	7.43	0.00	139.35	28.85	1.961	1.397	0.053	0.003	0.053
10.400	7.90	2.22	0.14	4.13	4.27	0.00	139.35	28.85	1.961	1.397	0.031	0.001	0.031
8.400	17.27	1.54	0.10	9.04	9.14	0.00	139.35	28.85	1.961	1.397	0.066	0.005	0.066
6.456	34.29	1.16	0.07	17.95	18.02	0.00	139.35	28.85	1.961	1.397	0.129	0.018	0.129
6.123	36.48	0.99	0.05	10.06	10.11	0.00	147.09	15.58	2.000	1.329	0.069	0.005	0.069
5.789	38.36	0.83	0.03	6.52	6.55	0.00	147.09	10.00	2.000	1.301	0.045	0.002	0.045
5.456	39.93	0.64	0.02	4.59	4.61	0.00	145.73	7.41	1.993	1.288	0.032	0.001	0.032
5.137	41.09	0.49	0.01	4.71	4.72	0.00	145.76	7.41	1.993	1.288	0.032	0.001	0.032
5.000	41.47	0.32	0.01	5.15	5.16	0.00	145.78	7.41	1.993	1.288	0.035	0.001	0.035
4.863	41.72	-0.31	-0.01	4.80	4.79	0.00	145.86	7.41	1.994	1.288	0.033	0.001	0.033
3.100	38.57	-1.14	-0.03	4.44	4.40	0.00	145.98	7.41	1.994	1.288	0.030	0.001	0.030
2.450	34.35	-1.78	-0.05	3.95	3.90	0.00	146.10	7.41	1.995	1.288	0.027	0.001	0.027
1.385	23.60	-2.22	-0.06	2.71	2.65	0.00	146.32	7.41	1.996	1.288	0.018	0.000	0.018
1.275	22.22	-2.35	-0.07	2.79	2.72	0.00	146.38	7.41	1.996	1.288	0.019	0.000	0.019
1.165	20.76	-2.47	-0.07	2.39	2.31	0.00	146.49	7.41	1.997	1.288	0.016	0.000	0.016
0.950	17.74	-3.25	-0.10	2.04	1.94	0.00	146.87	7.41	1.999	1.288	0.013	0.000	0.013
0.446	8.45	-3.47	-0.10	0.97	0.87	0.00	180.06	7.68	1.987	1.281	0.005	0.000	0.005
0.350	6.56	-3.52	-0.11	0.76	0.65	0.00	181.20	7.68	1.991	1.281	0.004	0.000	0.004
0.305	5.67	-3.59	-0.06	0.38	0.32	0.00	179.63	183.33	1.985	2.000	0.002	0.000	0.002
0.153	0.91	1.04	0.02	0.06	0.08	0.00	173.73	183.33	1.961	2.000	0.000	0.000	0.000

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 10 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 1.04 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 151841.57 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

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Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 10 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
16.500	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
13.452	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
11.500	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.467	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	242.2	10.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	224.9	10.6275	1.0	0.60	3.0	0.466	220.63	0.200	1.080	0.259	0.960	3295.21	211.79	141.19
11.000	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.699	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
8.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.456	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.123	180.4	10.6275	1.0	1.00	3.7	0.427	220.63	0.300	1.033	0.250	1.000	3526.39	220.63	147.09
5.789	160.2	10.6275	1.0	1.00	4.1	0.403	220.63	0.300	1.004	0.282	1.000	2780.35	220.63	147.09
5.456	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2295.30	218.59	145.73
5.137	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2296.49	218.63	145.76
5.000	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2297.40	218.67	145.78
4.863	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.992	2300.98	218.79	145.86
3.100	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.301	0.979	0.309	0.992	2306.35	218.97	145.98
2.450	145.5	10.6275	1.0	1.01	4.6	0.383	220.63	0.301	0.979	0.309	0.993	2311.80	219.16	146.10
1.385	145.5	10.6275	1.0	1.01	4.6	0.383	220.63	0.302	0.979	0.308	0.995	2321.33	219.48	146.32
1.275	145.5	10.6275	1.0	1.01	4.6	0.383	220.63	0.303	0.979	0.308	0.995	2324.11	219.58	146.38
1.165	145.5	10.6275	1.0	1.01	4.6	0.383	220.63	0.303	0.979	0.308	0.996	2328.73	219.73	146.49
0.950	145.5	10.6275	1.0	1.02	4.6	0.383	220.63	0.305	0.979	0.307	0.999	2345.46	220.30	146.87

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 0.446 145.5 10.6275 1.0 1.05 4.6 0.383 275.00 0.312 0.979 0.332 0.982 2496.62 270.09
180.06
 0.350 145.5 10.6275 1.0 1.07 4.6 0.383 275.00 0.316 0.979 0.329 0.988 2537.56 271.79
181.20
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.318 0.979 0.340 0.980 2381.90 269.45
179.63
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.279 0.979 0.340 0.948 2381.90 260.59
173.73

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 10 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

```
   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 20 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-0.40	-0.07	0.00	-0.07	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	3.37	-1.06	-0.18	7.21	7.03	0.00	130.14	24.57	1.958	1.384	0.054	0.003	0.054
11.500	9.07	-1.33	-0.13	12.08	11.95	0.00	145.11	71.07	1.990	1.612	0.082	0.007	0.082
11.467	9.19	-1.65	-0.17	12.24	12.08	0.00	145.11	71.07	1.990	1.612	0.083	0.007	0.083
11.385	9.56	-1.71	-0.17	12.74	12.56	0.00	145.11	71.07	1.990	1.612	0.087	0.008	0.087
11.257	10.16	-1.80	-0.15	9.43	9.28	0.00	143.11	50.11	1.980	1.505	0.065	0.004	0.065
11.128	10.79	-1.88	-0.14	7.37	7.23	0.00	141.19	37.29	1.970	1.440	0.051	0.003	0.051
11.000	11.46	-2.03	-0.13	6.00	5.87	0.00	139.35	28.85	1.961	1.397	0.042	0.002	0.042
10.699	13.13	6.94	0.44	6.88	7.32	0.00	139.35	28.85	1.961	1.397	0.053	0.003	0.053
10.400	7.44	4.49	0.29	3.89	4.18	0.00	139.35	28.85	1.961	1.397	0.030	0.001	0.030
8.400	17.23	3.16	0.20	9.02	9.22	0.00	139.35	28.85	1.961	1.397	0.066	0.005	0.066
6.456	34.11	2.40	0.15	17.85	18.01	0.00	139.35	28.85	1.961	1.397	0.129	0.018	0.129
6.123	36.30	2.08	0.10	10.01	10.11	0.00	147.09	15.58	2.000	1.329	0.069	0.005	0.069
5.789	38.20	1.75	0.06	6.49	6.56	0.00	147.09	10.00	2.000	1.301	0.045	0.002	0.045
5.456	39.81	1.38	0.04	4.58	4.62	0.00	145.63	7.41	1.993	1.288	0.032	0.001	0.032
5.137	41.02	1.09	0.03	4.70	4.73	0.00	145.68	7.41	1.993	1.288	0.032	0.001	0.032
5.000	41.43	0.74	0.02	5.15	5.17	0.00	145.72	7.41	1.993	1.288	0.035	0.001	0.035
4.863	41.71	-0.50	-0.02	4.80	4.78	0.00	145.88	7.41	1.994	1.288	0.033	0.001	0.033
3.100	39.28	-2.13	-0.06	4.52	4.46	0.00	146.12	7.41	1.995	1.288	0.030	0.001	0.030
2.450	35.47	-3.39	-0.10	4.08	3.98	0.00	146.35	7.41	1.996	1.288	0.027	0.001	0.027
1.385	25.56	-4.25	-0.12	2.94	2.82	0.00	146.72	7.41	1.998	1.288	0.019	0.000	0.019
1.275	24.28	-4.51	-0.14	3.05	2.91	0.00	146.83	7.41	1.999	1.288	0.020	0.000	0.020
1.165	22.92	-4.75	-0.14	2.64	2.50	0.00	147.02	7.41	2.000	1.288	0.017	0.000	0.017
0.950	20.11	-6.28	-0.19	2.31	2.13	0.00	147.09	7.41	2.000	1.288	0.014	0.000	0.014
0.446	11.42	-6.72	-0.20	1.31	1.11	0.00	181.69	7.68	1.993	1.281	0.006	0.000	0.006
0.350	9.65	-6.82	-0.21	1.11	0.90	0.00	182.89	7.68	1.998	1.281	0.005	0.000	0.005
0.305	8.80	-6.95	-0.11	0.59	0.48	0.00	180.49	183.33	1.988	2.000	0.003	0.000	0.003
0.153	0.86	2.06	0.03	0.06	0.09	0.00	171.68	183.33	1.952	2.000	0.001	0.000	0.001

```
   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]   [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
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Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 20 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb      = Design Value of Total Vertical Load at Base [5.5]              = 2.06 KN
Ncrit   = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]     = 151841.57
KN
Nratio  = Nb / Ncrit   [5.5]                                             = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 20 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
16.500	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
13.452	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
11.500	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.467	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	242.2	10.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	224.9	10.6275	1.0	0.60	3.0	0.466	220.63	0.200	1.080	0.259	0.960	3295.21	211.79	141.19
11.000	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.699	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
8.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.456	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.123	180.4	10.6275	1.0	1.00	3.7	0.427	220.63	0.299	1.033	0.250	1.000	3519.35	220.63	147.09
5.789	160.2	10.6275	1.0	1.00	4.1	0.403	220.63	0.299	1.004	0.282	1.000	2774.62	220.63	147.09
5.456	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.299	0.979	0.310	0.990	2290.86	218.44	145.63
5.137	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.299	0.979	0.310	0.990	2293.26	218.52	145.68
5.000	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.991	2295.04	218.59	145.72
4.863	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.300	0.979	0.310	0.992	2302.06	218.82	145.88

```
 3.100 145.5 10.6275 1.0 1.01 4.6 0.383 220.63 0.301 0.979 0.309 0.993 2312.42 219.18
146.12
 2.450 145.5 10.6275 1.0 1.01 4.6 0.383 220.63 0.303 0.979 0.308 0.995 2322.73 219.53
146.35
 1.385 145.5 10.6275 1.0 1.02 4.6 0.383 220.63 0.304 0.979 0.307 0.998 2339.11 220.09
146.72
 1.275 145.5 10.6275 1.0 1.02 4.6 0.383 220.63 0.305 0.979 0.307 0.998 2343.90 220.25
146.83
 1.165 145.5 10.6275 1.0 1.02 4.6 0.383 220.63 0.306 0.979 0.306 1.000 2351.88 220.52
147.02
 0.950 145.5 10.6275 1.0 1.04 4.6 0.383 220.63 0.309 0.979 0.304 1.000 2381.01 220.63
147.09
 0.446 145.5 10.6275 1.0 1.07 4.6 0.383 275.00 0.318 0.979 0.328 0.991 2555.37 272.54
181.69
 0.350 145.5 10.6275 1.0 1.09 4.6 0.383 275.00 0.323 0.979 0.325 0.998 2598.22 274.34
182.89
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.323 0.979 0.340 0.985 2381.90 270.74
180.49
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.264 0.979 0.340 0.936 2381.90 257.52
171.68

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 20 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41

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3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 30 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-0.59	-0.10	0.00	-0.10	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	3.10	-1.55	-0.26	6.64	6.38	0.00	130.14	24.57	1.958	1.384	0.049	0.003	0.049
11.500	8.35	-1.94	-0.20	11.14	10.94	0.00	145.11	71.07	1.990	1.612	0.075	0.006	0.075
11.467	8.47	-2.41	-0.24	11.28	11.04	0.00	145.11	71.07	1.990	1.612	0.076	0.006	0.076
11.385	8.81	-2.50	-0.25	11.74	11.49	0.00	145.11	71.07	1.990	1.612	0.079	0.006	0.079
11.257	9.36	-2.62	-0.22	8.69	8.47	0.00	143.11	50.11	1.980	1.505	0.059	0.004	0.059
11.128	9.95	-2.74	-0.20	6.79	6.59	0.00	141.19	37.29	1.970	1.440	0.047	0.002	0.047
11.000	10.56	-2.96	-0.19	5.53	5.34	0.00	139.35	28.85	1.961	1.397	0.038	0.002	0.038
10.699	12.10	10.33	0.66	6.34	7.00	0.00	139.35	28.85	1.961	1.397	0.050	0.003	0.050
10.400	6.75	6.76	0.43	3.54	3.97	0.00	139.35	28.85	1.961	1.397	0.028	0.001	0.028
8.400	16.65	4.81	0.31	8.72	9.02	0.00	139.35	28.85	1.961	1.397	0.065	0.005	0.065
6.456	32.85	3.70	0.24	17.19	17.43	0.00	139.35	28.85	1.961	1.397	0.125	0.017	0.125
6.123	34.98	3.23	0.15	9.65	9.80	0.00	147.09	15.58	2.000	1.329	0.067	0.004	0.067
5.789	36.84	2.76	0.10	6.26	6.36	0.00	147.09	10.00	2.000	1.301	0.043	0.002	0.043
5.456	38.44	2.22	0.07	4.42	4.49	0.00	145.51	7.41	1.992	1.288	0.031	0.001	0.031
5.137	39.66	1.78	0.05	4.54	4.59	0.00	145.59	7.41	1.992	1.288	0.032	0.001	0.032
5.000	40.08	1.28	0.04	4.98	5.02	0.00	145.65	7.41	1.993	1.288	0.034	0.001	0.034
4.863	40.39	-0.54	-0.02	4.65	4.63	0.00	145.89	7.41	1.994	1.288	0.032	0.001	0.032
3.100	38.73	-2.93	-0.09	4.46	4.37	0.00	146.24	7.41	1.996	1.288	0.030	0.001	0.030
2.450	35.44	-4.76	-0.14	4.08	3.94	0.00	146.58	7.41	1.997	1.288	0.027	0.001	0.027
1.385	26.66	-6.01	-0.17	3.07	2.89	0.00	147.07	7.41	2.000	1.288	0.020	0.000	0.020
1.275	25.52	-6.40	-0.20	3.21	3.01	0.00	147.09	7.41	2.000	1.288	0.020	0.000	0.020
1.165	24.30	-6.75	-0.20	2.80	2.59	0.00	147.09	7.41	2.000	1.288	0.018	0.000	0.018
0.950	21.79	-8.99	-0.27	2.51	2.24	0.00	147.09	7.41	2.000	1.288	0.015	0.000	0.015
0.446	13.94	-9.63	-0.29	1.60	1.31	0.00	182.72	7.68	1.998	1.281	0.007	0.000	0.007
0.350	12.34	-9.78	-0.29	1.42	1.13	0.00	183.33	7.68	2.000	1.281	0.006	0.000	0.006
0.305	11.58	-9.96	-0.16	0.77	0.61	0.00	180.92	183.33	1.990	2.000	0.003	0.000	0.003

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0.153 0.80 3.01 0.05 0.05 0.10 0.00 170.17 183.33 1.946 2.000 0.001 0.000 0.001

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 30 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 3.01 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 151841.57 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 30 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
16.500	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
13.452	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
11.500	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.467	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	242.2	10.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	224.9	10.6275	1.0	0.60	3.0	0.466	220.63	0.200	1.080	0.259	0.960	3295.21	211.79	141.19
11.000	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.699	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
8.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.456	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35

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 6.123 180.4 10.6275 1.0 0.99 3.7 0.427 220.63 0.298 1.033 0.251 1.000 3511.20 220.63
147.09
 5.789 160.2 10.6275 1.0 0.99 4.1 0.403 220.63 0.298 1.004 0.282 1.000 2767.86 220.63
147.09
 5.456 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.299 0.979 0.311 0.989 2285.49 218.26
145.51
 5.137 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.299 0.979 0.310 0.990 2289.20 218.39
145.59
 5.000 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.299 0.979 0.310 0.990 2291.86 218.48
145.65
 4.863 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.992 2302.39 218.84
145.89
 3.100 145.5 10.6275 1.0 1.01 4.6 0.383 220.63 0.302 0.979 0.309 0.994 2317.71 219.36
146.24
 2.450 145.5 10.6275 1.0 1.01 4.6 0.383 220.63 0.304 0.979 0.308 0.997 2332.66 219.87
146.58
 1.385 145.5 10.6275 1.0 1.02 4.6 0.383 220.63 0.306 0.979 0.306 1.000 2354.28 220.60
147.07
 1.275 145.5 10.6275 1.0 1.03 4.6 0.383 220.63 0.307 0.979 0.306 1.000 2360.63 220.63
147.09
 1.165 145.5 10.6275 1.0 1.03 4.6 0.383 220.63 0.308 0.979 0.305 1.000 2371.24 220.63
147.09
 0.950 145.5 10.6275 1.0 1.05 4.6 0.383 220.63 0.312 0.979 0.303 1.000 2410.51 220.63
147.09
 0.446 145.5 10.6275 1.0 1.09 4.6 0.383 275.00 0.322 0.979 0.326 0.997 2592.22 274.08
182.72
 0.350 145.5 10.6275 1.0 1.10 4.6 0.383 275.00 0.326 0.979 0.323 1.000 2631.20 275.00
183.33
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.325 0.979 0.340 0.987 2381.90 271.38
180.92
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.253 0.979 0.340 0.928 2381.90 255.26
170.17

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
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Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 30 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11

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11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 40 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-0.76	-0.13	0.00	-0.13	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	2.75	-2.00	-0.33	5.88	5.54	0.00	130.14	24.57	1.958	1.384	0.043	0.002	0.043
11.500	7.39	-2.50	-0.25	9.85	9.60	0.00	145.11	71.07	1.990	1.612	0.066	0.004	0.066
11.467	7.49	-3.10	-0.31	9.98	9.67	0.00	145.11	71.07	1.990	1.612	0.067	0.005	0.067
11.385	7.79	-3.22	-0.33	10.38	10.06	0.00	145.11	71.07	1.990	1.612	0.069	0.005	0.069
11.257	8.28	-3.37	-0.29	7.69	7.40	0.00	143.11	50.11	1.980	1.505	0.052	0.003	0.052
11.128	8.80	-3.53	-0.26	6.01	5.75	0.00	141.19	37.29	1.970	1.440	0.041	0.002	0.041
11.000	9.34	-3.81	-0.24	4.89	4.65	0.00	139.35	28.85	1.961	1.397	0.033	0.001	0.033
10.699	10.71	13.58	0.87	5.60	6.47	0.00	139.35	28.85	1.961	1.397	0.046	0.002	0.046
10.400	5.87	8.98	0.57	3.07	3.65	0.00	139.35	28.85	1.961	1.397	0.026	0.001	0.026
8.400	15.53	6.48	0.41	8.13	8.54	0.00	139.35	28.85	1.961	1.397	0.061	0.004	0.061
6.456	30.54	5.05	0.32	15.99	16.31	0.00	139.35	28.85	1.961	1.397	0.117	0.015	0.117
6.123	32.54	4.44	0.21	8.98	9.18	0.00	147.09	15.58	2.000	1.329	0.062	0.004	0.062
5.789	34.31	3.84	0.14	5.83	5.97	0.00	147.09	10.00	2.000	1.301	0.041	0.002	0.041
5.456	35.83	3.14	0.09	4.12	4.22	0.00	145.35	7.41	1.991	1.288	0.029	0.001	0.029

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 5.137  37.03   2.58  0.07  4.24  4.31  0.00 145.47   7.41 1.992 1.288 0.030 0.001 0.030
 5.000  37.45   1.94  0.06  4.65  4.71  0.00 145.55   7.41 1.992 1.288 0.032 0.001 0.032
 4.863  37.77  -0.40 -0.01  4.35  4.33  0.00 145.88   7.41 1.994 1.288 0.030 0.001 0.030
 3.100  36.92  -3.47 -0.10  4.25  4.14  0.00 146.34   7.41 1.996 1.288 0.028 0.001 0.028
 2.450  34.24  -5.82 -0.18  3.94  3.76  0.00 146.79   7.41 1.998 1.288 0.026 0.001 0.026
 1.385  26.84  -7.44 -0.21  3.09  2.87  0.00 147.09   7.41 2.000 1.288 0.020 0.000 0.020
 1.275  25.87  -7.94 -0.25  3.25  3.00  0.00 147.09   7.41 2.000 1.288 0.020 0.000 0.020
 1.165  24.84  -8.38 -0.25  2.86  2.61  0.00 147.09   7.41 2.000 1.288 0.018 0.000 0.018
 0.950  22.69 -11.26 -0.34  2.61  2.27  0.00 147.09   7.41 2.000 1.288 0.015 0.000 0.015
 0.446  15.92 -12.09 -0.36  1.83  1.47  0.00 183.33   7.68 2.000 1.281 0.008 0.000 0.008
 0.350  14.54 -12.27 -0.37  1.67  1.30  0.00 183.33   7.68 2.000 1.281 0.007 0.000 0.007
 0.305  13.88 -12.52 -0.20  0.92  0.73  0.00 181.17 183.33 1.991 2.000 0.004 0.000 0.004
 0.153   0.71   3.87  0.06  0.05  0.11  0.00 168.95 183.33 1.941 2.000 0.001 0.000 0.001

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 40 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 3.87 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 151841.57
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 40 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

```
 Elev     w       l     Cxb  Cx  Dwk   ax     Fyk    Lxo    Lpx     Lx     Xx  s_xRcr  s_xRk
s_xRd
  m               m              mm           MPa                              MPa     MPa
MPa
------ ----- -------- --- ---- --- ----- ------ ----- ----- ----- ----- ------- ------ ---
---
16.500 341.0 10.6275 1.0 0.60 1.9 0.450 206.84 0.200 1.061 0.281 0.944 2624.92 195.20
130.14
13.452 341.0 10.6275 1.0 0.60 1.9 0.450 206.84 0.200 1.061 0.281 0.944 2624.92 195.20
130.14
11.500 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.467 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.385 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.257 242.2 10.6275 1.0 0.60 2.7 0.478 220.63 0.200 1.093 0.240 0.973 3820.46 214.66
143.11
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11.128 224.9 10.6275 1.0 0.60 3.0 0.466 220.63 0.200 1.080 0.259 0.960 3295.21 211.79
141.19
11.000 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.699 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 8.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.456 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.123 180.4 10.6275 1.0 0.99 3.7 0.427 220.63 0.298 1.033 0.251 1.000 3501.05 220.63
147.09
 5.789 160.2 10.6275 1.0 0.99 4.1 0.403 220.63 0.298 1.004 0.283 1.000 2759.32 220.63
147.09
 5.456 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.298 0.979 0.311 0.988 2278.52 218.02
145.35
 5.137 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.298 0.979 0.311 0.989 2283.78 218.20
145.47
 5.000 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.299 0.979 0.311 0.990 2287.38 218.32
145.55
 4.863 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.992 2301.72 218.81
145.88
 3.100 145.5 10.6275 1.0 1.01 4.6 0.383 220.63 0.303 0.979 0.308 0.995 2322.33 219.51
146.34
 2.450 145.5 10.6275 1.0 1.02 4.6 0.383 220.63 0.305 0.979 0.307 0.998 2342.01 220.19
146.79
 1.385 145.5 10.6275 1.0 1.03 4.6 0.383 220.63 0.307 0.979 0.305 1.000 2367.79 220.63
147.09
 1.275 145.5 10.6275 1.0 1.03 4.6 0.383 220.63 0.308 0.979 0.305 1.000 2375.45 220.63
147.09
 1.165 145.5 10.6275 1.0 1.04 4.6 0.383 220.63 0.310 0.979 0.304 1.000 2388.27 220.63
147.09
 0.950 145.5 10.6275 1.0 1.06 4.6 0.383 220.63 0.315 0.979 0.301 1.000 2436.51 220.63
147.09
 0.446 145.5 10.6275 1.0 1.10 4.6 0.383 275.00 0.325 0.979 0.324 1.000 2618.16 275.00
183.33
 0.350 145.5 10.6275 1.0 1.11 4.6 0.383 275.00 0.328 0.979 0.322 1.000 2652.15 275.00
183.33
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.327 0.979 0.340 0.988 2381.90 271.76
181.17
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.244 0.979 0.340 0.922 2381.90 253.42
168.95

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 40 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 50 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Moment KN-m	Vert KN	f_xEN MPa	f_xEM MPa	f_xEd MPa	f_qEd MPa	s_xRd MPa	s_qRd MPa	kx	kq	UR1	UR2	Unity Ratio
16.500	0.00	-0.90	-0.15	0.00	-0.15	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	2.30	-2.38	-0.40	4.93	4.53	0.00	130.14	24.57	1.958	1.384	0.035	0.001	0.035
11.500	6.20	-2.98	-0.30	8.26	7.96	0.00	145.11	71.07	1.990	1.612	0.055	0.003	0.055

11.467	6.28	-3.70	-0.38	8.38	8.00	0.00	145.11	71.07	1.990	1.612	0.055	0.003	0.055
11.385	6.54	-3.84	-0.39	8.71	8.32	0.00	145.11	71.07	1.990	1.612	0.057	0.003	0.057
11.257	6.95	-4.02	-0.34	6.45	6.11	0.00	143.11	50.11	1.980	1.505	0.043	0.002	0.043
11.128	7.38	-4.20	-0.31	5.04	4.74	0.00	141.19	37.29	1.970	1.440	0.034	0.001	0.034
11.000	7.84	-4.54	-0.29	4.10	3.81	0.00	139.35	28.85	1.961	1.397	0.027	0.001	0.027
10.699	8.98	16.63	1.06	4.70	5.77	0.00	139.35	28.85	1.961	1.397	0.041	0.002	0.041
10.400	4.81	11.15	0.71	2.52	3.23	0.00	139.35	28.85	1.961	1.397	0.023	0.001	0.023
8.400	13.91	8.17	0.52	7.28	7.80	0.00	139.35	28.85	1.961	1.397	0.056	0.004	0.056
6.456	27.24	6.47	0.41	14.26	14.67	0.00	139.35	28.85	1.961	1.397	0.105	0.012	0.105
6.123	29.05	5.75	0.27	8.01	8.28	0.00	147.09	15.58	2.000	1.329	0.056	0.003	0.056
5.789	30.66	5.03	0.18	5.21	5.39	0.00	147.09	10.00	2.000	1.301	0.037	0.001	0.037
5.456	32.06	4.20	0.13	3.69	3.82	0.00	145.13	7.41	1.990	1.288	0.026	0.001	0.026
5.137	33.19	3.53	0.10	3.80	3.90	0.00	145.29	7.41	1.991	1.288	0.027	0.001	0.027
5.000	33.59	2.76	0.09	4.17	4.26	0.00	145.40	7.41	1.991	1.288	0.029	0.001	0.029
4.863	33.91	-0.02	0.00	3.90	3.90	0.00	145.82	7.41	1.994	1.288	0.027	0.001	0.027
3.100	33.87	-3.68	-0.11	3.90	3.79	0.00	146.43	7.41	1.997	1.288	0.026	0.001	0.026
2.450	31.87	-6.49	-0.20	3.67	3.47	0.00	146.99	7.41	2.000	1.288	0.024	0.001	0.024
1.385	26.07	-8.41	-0.24	3.00	2.75	0.00	147.09	7.41	2.000	1.288	0.019	0.000	0.019
1.275	25.29	-9.00	-0.28	3.18	2.90	0.00	147.09	7.41	2.000	1.288	0.020	0.000	0.020
1.165	24.47	-9.54	-0.29	2.82	2.53	0.00	147.09	7.41	2.000	1.288	0.017	0.000	0.017
0.950	22.74	-12.97	-0.39	2.62	2.23	0.00	147.09	7.41	2.000	1.288	0.015	0.000	0.015
0.446	17.26	-13.95	-0.42	1.99	1.57	0.00	183.33	7.68	2.000	1.281	0.009	0.000	0.009
0.350	16.13	-14.17	-0.43	1.86	1.43	0.00	183.33	7.68	2.000	1.281	0.008	0.000	0.008
0.305	15.60	-14.46	-0.23	1.04	0.81	0.00	181.33	183.33	1.992	2.000	0.004	0.000	0.004
0.153	0.59	4.61	0.07	0.04	0.11	0.00	167.87	183.33	1.937	2.000	0.001	0.000	0.001

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 50 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 4.61 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 151841.57 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 50 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
------	-----	-------	---	----	---	-----	------	-----	-----	-----	-----	-------	------	---

```
16.500 341.0 10.6275 1.0 0.60 1.9 0.450 206.84 0.200 1.061 0.281 0.944 2624.92 195.20
130.14
13.452 341.0 10.6275 1.0 0.60 1.9 0.450 206.84 0.200 1.061 0.281 0.944 2624.92 195.20
130.14
11.500 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.467 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.385 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.257 242.2 10.6275 1.0 0.60 2.7 0.478 220.63 0.200 1.093 0.240 0.973 3820.46 214.66
143.11
11.128 224.9 10.6275 1.0 0.60 3.0 0.466 220.63 0.200 1.080 0.259 0.960 3295.21 211.79
141.19
11.000 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.699 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 8.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.456 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.123 180.4 10.6275 1.0 0.99 3.7 0.427 220.63 0.297 1.033 0.252 1.000 3487.22 220.63
147.09
 5.789 160.2 10.6275 1.0 0.99 4.1 0.403 220.63 0.297 1.004 0.283 1.000 2747.53 220.63
147.09
 5.456 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.297 0.979 0.312 0.987 2268.68 217.69
145.13
 5.137 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.297 0.979 0.311 0.988 2275.89 217.93
145.29
 5.000 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.298 0.979 0.311 0.988 2280.57 218.09
145.40
 4.863 145.5 10.6275 1.0 1.00 4.6 0.383 220.63 0.300 0.979 0.310 0.991 2299.34 218.73
145.82
 3.100 145.5 10.6275 1.0 1.01 4.6 0.383 220.63 0.303 0.979 0.308 0.996 2326.06 219.64
146.43
 2.450 145.5 10.6275 1.0 1.02 4.6 0.383 220.63 0.306 0.979 0.306 0.999 2350.92 220.49
146.99
 1.385 145.5 10.6275 1.0 1.04 4.6 0.383 220.63 0.309 0.979 0.304 1.000 2380.08 220.63
147.09
 1.275 145.5 10.6275 1.0 1.04 4.6 0.383 220.63 0.310 0.979 0.304 1.000 2388.90 220.63
147.09
 1.165 145.5 10.6275 1.0 1.05 4.6 0.383 220.63 0.311 0.979 0.303 1.000 2403.65 220.63
147.09
 0.950 145.5 10.6275 1.0 1.07 4.6 0.383 220.63 0.318 0.979 0.299 1.000 2460.50 220.63
147.09
 0.446 145.5 10.6275 1.0 1.11 4.6 0.383 275.00 0.327 0.979 0.323 1.000 2637.58 275.00
183.33
 0.350 145.5 10.6275 1.0 1.12 4.6 0.383 275.00 0.330 0.979 0.321 1.000 2666.38 275.00
183.33
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.328 0.979 0.340 0.989 2381.90 272.00
181.33
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.235 0.979 0.340 0.916 2381.90 251.81
167.87
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```
   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 50 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

```
   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 60 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-1.02	-0.17	0.00	-0.17	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	1.79	-2.69	-0.45	3.84	3.39	0.00	130.14	24.57	1.958	1.384	0.026	0.001	0.026
11.500	4.82	-3.36	-0.34	6.43	6.09	0.00	145.11	71.07	1.990	1.612	0.042	0.002	0.042
11.467	4.89	-4.18	-0.42	6.51	6.09	0.00	145.11	71.07	1.990	1.612	0.042	0.002	0.042
11.385	5.09	-4.34	-0.44	6.78	6.34	0.00	145.11	71.07	1.990	1.612	0.044	0.002	0.044
11.257	5.41	-4.55	-0.39	5.02	4.63	0.00	143.11	50.11	1.980	1.505	0.032	0.001	0.032
11.128	5.74	-4.75	-0.35	3.92	3.58	0.00	141.19	37.29	1.970	1.440	0.025	0.001	0.025
11.000	6.10	-5.13	-0.33	3.19	2.86	0.00	139.35	28.85	1.961	1.397	0.021	0.000	0.021
10.699	6.99	19.54	1.25	3.66	4.91	0.00	139.35	28.85	1.961	1.397	0.035	0.001	0.035
10.400	3.61	13.35	0.85	1.89	2.75	0.00	139.35	28.85	1.961	1.397	0.020	0.000	0.020
8.400	11.80	9.98	0.64	6.18	6.82	0.00	139.35	28.85	1.961	1.397	0.049	0.003	0.049
6.456	23.00	8.05	0.51	12.04	12.56	0.00	139.35	28.85	1.961	1.397	0.090	0.009	0.090
6.123	24.55	7.24	0.34	6.77	7.11	0.00	147.09	15.58	2.000	1.329	0.048	0.002	0.048
5.789	25.95	6.43	0.23	4.41	4.64	0.00	147.09	10.00	2.000	1.301	0.032	0.001	0.032
5.456	27.18	5.49	0.17	3.13	3.29	0.00	144.77	7.41	1.988	1.288	0.023	0.001	0.023
5.137	28.20	4.73	0.13	3.23	3.36	0.00	145.00	7.41	1.989	1.288	0.023	0.001	0.023
5.000	28.57	3.87	0.12	3.55	3.67	0.00	145.13	7.41	1.990	1.288	0.025	0.001	0.025
4.863	28.87	0.71	0.02	3.32	3.34	0.00	145.68	7.41	1.993	1.288	0.023	0.001	0.023
3.100	29.60	-3.42	-0.10	3.41	3.30	0.00	146.47	7.41	1.997	1.288	0.023	0.001	0.023
2.450	28.32	-6.59	-0.20	3.26	3.06	0.00	147.09	7.41	2.000	1.288	0.021	0.000	0.021
1.385	24.26	-8.77	-0.25	2.79	2.54	0.00	147.09	7.41	2.000	1.288	0.017	0.000	0.017
1.275	23.71	-9.44	-0.30	2.98	2.68	0.00	147.09	7.41	2.000	1.288	0.018	0.000	0.018
1.165	23.11	-10.04	-0.30	2.66	2.36	0.00	147.09	7.41	2.000	1.288	0.016	0.000	0.016
0.950	21.86	-13.92	-0.42	2.52	2.10	0.00	147.09	7.41	2.000	1.288	0.014	0.000	0.014
0.446	17.81	-15.03	-0.45	2.05	1.60	0.00	183.33	7.68	2.000	1.281	0.009	0.000	0.009
0.350	16.98	-15.28	-0.46	1.95	1.49	0.00	183.33	7.68	2.000	1.281	0.008	0.000	0.008
0.305	16.58	-15.61	-0.24	1.10	0.86	0.00	181.43	183.33	1.992	2.000	0.005	0.000	0.005
0.153	0.46	5.21	0.08	0.03	0.11	0.00	166.86	183.33	1.933	2.000	0.001	0.000	0.001

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 60 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 5.21 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 151841.57 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 60 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
16.500	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
13.452	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
11.500	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.467	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	242.2	10.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	224.9	10.6275	1.0	0.60	3.0	0.466	220.63	0.200	1.080	0.259	0.960	3295.21	211.79	141.19
11.000	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.699	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
8.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.456	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.123	180.4	10.6275	1.0	0.98	3.7	0.427	220.63	0.295	1.033	0.252	1.000	3465.91	220.63	147.09
5.789	160.2	10.6275	1.0	0.98	4.1	0.403	220.63	0.295	1.004	0.284	1.000	2729.15	220.63	147.09
5.456	145.5	10.6275	1.0	0.98	4.6	0.383	220.63	0.295	0.979	0.313	0.984	2253.00	217.16	144.77
5.137	145.5	10.6275	1.0	0.98	4.6	0.383	220.63	0.296	0.979	0.312	0.986	2262.98	217.50	145.00
5.000	145.5	10.6275	1.0	0.99	4.6	0.383	220.63	0.297	0.979	0.312	0.987	2268.98	217.70	145.13
4.863	145.5	10.6275	1.0	1.00	4.6	0.383	220.63	0.299	0.979	0.310	0.990	2293.25	218.52	145.68
3.100	145.5	10.6275	1.0	1.01	4.6	0.383	220.63	0.303	0.979	0.308	0.996	2327.81	219.70	146.47
2.450	145.5	10.6275	1.0	1.03	4.6	0.383	220.63	0.306	0.979	0.306	1.000	2358.83	220.63	147.09
1.385	145.5	10.6275	1.0	1.04	4.6	0.383	220.63	0.310	0.979	0.304	1.000	2390.74	220.63	147.09
1.275	145.5	10.6275	1.0	1.04	4.6	0.383	220.63	0.311	0.979	0.303	1.000	2400.68	220.63	147.09

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 1.165 145.5 10.6275 1.0 1.05 4.6 0.383 220.63 0.313 0.979 0.302 1.000 2417.14 220.63
147.09
 0.950 145.5 10.6275 1.0 1.08 4.6 0.383 220.63 0.320 0.979 0.298 1.000 2483.05 220.63
147.09
 0.446 145.5 10.6275 1.0 1.11 4.6 0.383 275.00 0.328 0.979 0.322 1.000 2651.95 275.00
183.33
 0.350 145.5 10.6275 1.0 1.12 4.6 0.383 275.00 0.331 0.979 0.321 1.000 2675.50 275.00
183.33
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.329 0.979 0.340 0.990 2381.90 272.14
181.43
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.227 0.979 0.340 0.910 2381.90 250.30
166.86

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 60 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68

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 0.305 1.00 2.11 0.500 0.274 1.118 0.818  0.000 0.000 1.0000  0.00 3660.74 275.00 183.33
 0.153 1.00 2.11 0.500 0.274 1.118 0.818  0.000 0.000 1.0000  0.00 3660.74 275.00 183.33

   Cq    = Ext Buckling Fac Short Cyl [Table D.3]  Cqs   = Ext Bcklng Fac Med Cyl [Table
D.4]
   aq    = Param based on Fab Quality [Table D.5]  Lq    = (fyk/s_qRcr)^0.5  [8.17]
   Lpq   = (aq / (1-B))^0.5  [8.16]                Lqo   = 0.4  [D.26]
   s_qRk = Xq * fyk  [8.12]                        f_qEd = Circ Stress: (qeq+qs)*(r/t)
[D.30]
   s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1]  s_qRd = s_qRk / SF  [8.11]
   qeq   = Kw*qw_max  [D.28]                       qs    = Internal vacum: 0 [D.30]
   Kw    = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29]     qw_max= Max Wind Pressure [D.28]
```

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 70 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-1.11	-0.18	0.00	-0.18	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	1.23	-2.92	-0.49	2.62	2.14	0.00	130.14	24.57	1.958	1.384	0.016	0.000	0.016
11.500	3.30	-3.65	-0.37	4.40	4.03	0.00	145.11	71.07	1.990	1.612	0.028	0.001	0.028
11.467	3.34	-4.54	-0.46	4.46	4.00	0.00	145.11	71.07	1.990	1.612	0.028	0.001	0.028
11.385	3.48	-4.71	-0.48	4.64	4.16	0.00	145.11	71.07	1.990	1.612	0.029	0.001	0.029
11.257	3.70	-4.93	-0.42	3.43	3.01	0.00	143.11	50.11	1.980	1.505	0.021	0.000	0.021
11.128	3.93	-5.16	-0.38	2.68	2.31	0.00	141.19	37.29	1.970	1.440	0.016	0.000	0.016
11.000	4.17	-5.57	-0.36	2.18	1.83	0.00	139.35	28.85	1.961	1.397	0.013	0.000	0.013
10.699	4.78	22.58	1.44	2.50	3.95	0.00	139.35	28.85	1.961	1.397	0.028	0.001	0.028
10.400	2.32	15.86	1.01	1.22	2.23	0.00	139.35	28.85	1.961	1.397	0.016	0.000	0.016
8.400	9.22	12.20	0.78	4.83	5.61	0.00	139.35	28.85	1.961	1.397	0.040	0.002	0.040
6.456	17.86	10.11	0.65	9.35	10.00	0.00	139.35	28.85	1.961	1.397	0.072	0.006	0.072
6.123	19.09	9.23	0.43	5.26	5.69	0.00	147.09	15.58	2.000	1.329	0.039	0.001	0.039
5.789	20.21	8.35	0.31	3.43	3.74	0.00	147.09	10.00	2.000	1.301	0.025	0.001	0.025
5.456	21.22	7.33	0.22	2.44	2.66	0.00	144.09	7.41	1.985	1.288	0.018	0.000	0.018
5.137	22.07	6.51	0.18	2.53	2.71	0.00	144.42	7.41	1.986	1.288	0.019	0.000	0.019
5.000	22.39	5.57	0.17	2.78	2.96	0.00	144.59	7.41	1.987	1.288	0.020	0.000	0.020
4.863	22.67	2.15	0.06	2.61	2.67	0.00	145.31	7.41	1.991	1.288	0.018	0.000	0.018
3.100	24.05	-2.33	-0.07	2.77	2.70	0.00	146.36	7.41	1.996	1.288	0.018	0.000	0.018
2.450	23.50	-5.78	-0.17	2.70	2.53	0.00	147.09	7.41	2.000	1.288	0.017	0.000	0.017
1.385	21.26	-8.14	-0.23	2.44	2.21	0.00	147.09	7.41	2.000	1.288	0.015	0.000	0.015
1.275	20.93	-8.87	-0.28	2.63	2.35	0.00	147.09	7.41	2.000	1.288	0.016	0.000	0.016
1.165	20.58	-9.52	-0.29	2.37	2.08	0.00	147.09	7.41	2.000	1.288	0.014	0.000	0.014
0.950	19.83	-13.73	-0.41	2.28	1.87	0.00	147.09	7.41	2.000	1.288	0.013	0.000	0.013
0.446	17.31	-14.93	-0.45	1.99	1.54	0.00	183.33	7.68	2.000	1.281	0.008	0.000	0.008
0.350	16.79	-15.21	-0.46	1.93	1.47	0.00	183.33	7.68	2.000	1.281	0.008	0.000	0.008
0.305	16.54	-15.56	-0.24	1.10	0.86	0.00	181.42	183.33	1.992	2.000	0.005	0.000	0.005
0.153	0.31	5.65	0.09	0.02	0.11	0.00	165.86	183.33	1.929	2.000	0.001	0.000	0.001

```
   f_xEN = Axial Stress: V/A [D.12]             f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]     f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]        kq     = Buckling Param: 1+Xq^2 [8.21]
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   UR1    = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2    = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq   [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 70 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]                = 5.65 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]       = 151841.57
KN
Nratio   = Nb / Ncrit   [5.5]                                               = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 70 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
16.500	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
13.452	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
11.500	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.467	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	242.2	10.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	224.9	10.6275	1.0	0.60	3.0	0.466	220.63	0.200	1.080	0.259	0.960	3295.21	211.79	141.19
11.000	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.699	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
8.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.456	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
6.123	180.4	10.6275	1.0	0.97	3.7	0.427	220.63	0.292	1.033	0.254	1.000	3426.29	220.63	147.09
5.789	160.2	10.6275	1.0	0.97	4.1	0.403	220.63	0.292	1.004	0.286	1.000	2694.56	220.63	147.09
5.456	145.5	10.6275	1.0	0.97	4.6	0.383	220.63	0.292	0.979	0.315	0.980	2222.90	216.14	144.09
5.137	145.5	10.6275	1.0	0.97	4.6	0.383	220.63	0.293	0.979	0.314	0.982	2237.41	216.63	144.42

```
 5.000 145.5 10.6275 1.0 0.98 4.6 0.383 220.63 0.294 0.979 0.313 0.983 2245.19 216.89
144.59
 4.863 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.298 0.979 0.311 0.988 2276.90 217.97
145.31
 3.100 145.5 10.6275 1.0 1.01 4.6 0.383 220.63 0.303 0.979 0.308 0.995 2323.12 219.54
146.36
 2.450 145.5 10.6275 1.0 1.03 4.6 0.383 220.63 0.307 0.979 0.306 1.000 2362.43 220.63
147.09
 1.385 145.5 10.6275 1.0 1.04 4.6 0.383 220.63 0.311 0.979 0.303 1.000 2396.78 220.63
147.09
 1.275 145.5 10.6275 1.0 1.05 4.6 0.383 220.63 0.312 0.979 0.303 1.000 2407.95 220.63
147.09
 1.165 145.5 10.6275 1.0 1.06 4.6 0.383 220.63 0.314 0.979 0.302 1.000 2425.85 220.63
147.09
 0.950 145.5 10.6275 1.0 1.09 4.6 0.383 220.63 0.322 0.979 0.297 1.000 2502.67 220.63
147.09
 0.446 145.5 10.6275 1.0 1.12 4.6 0.383 275.00 0.329 0.979 0.322 1.000 2659.72 275.00
183.33
 0.350 145.5 10.6275 1.0 1.12 4.6 0.383 275.00 0.331 0.979 0.320 1.000 2677.92 275.00
183.33
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.328 0.979 0.340 0.990 2381.90 272.13
181.42
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.219 0.979 0.340 0.905 2381.90 248.79
165.86

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 70 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00

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5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 80 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-1.16	-0.19	0.00	-0.19	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	0.62	-3.06	-0.51	1.33	0.82	0.00	130.14	24.57	1.958	1.384	0.006	0.000	0.006
11.500	1.68	-3.83	-0.39	2.23	1.84	0.00	145.11	71.07	1.990	1.612	0.013	0.000	0.013
11.467	1.70	-4.75	-0.48	2.26	1.78	0.00	145.11	71.07	1.990	1.612	0.012	0.000	0.012
11.385	1.77	-4.93	-0.50	2.35	1.85	0.00	145.11	71.07	1.990	1.612	0.013	0.000	0.013
11.257	1.88	-5.17	-0.44	1.74	1.30	0.00	143.11	50.11	1.980	1.505	0.009	0.000	0.009
11.128	1.99	-5.40	-0.39	1.36	0.97	0.00	141.19	37.29	1.970	1.440	0.007	0.000	0.007
11.000	2.12	-5.84	-0.37	1.11	0.74	0.00	139.35	28.85	1.961	1.397	0.005	0.000	0.005
10.699	2.43	27.00	1.73	1.27	3.00	0.00	139.35	28.85	1.961	1.397	0.021	0.001	0.021
10.400	1.00	19.95	1.28	0.53	1.80	0.00	139.35	28.85	1.961	1.397	0.013	0.000	0.013
8.400	6.03	16.12	1.03	3.16	4.19	0.00	139.35	28.85	1.961	1.397	0.030	0.001	0.030
6.456	11.56	13.93	0.89	6.05	6.94	0.00	139.35	28.85	1.961	1.397	0.050	0.003	0.050
6.123	12.38	13.00	0.60	3.41	4.02	0.00	147.09	15.58	2.000	1.329	0.027	0.001	0.027
5.789	13.14	12.08	0.44	2.23	2.67	0.00	146.14	10.00	1.995	1.301	0.018	0.000	0.018
5.456	13.85	11.01	0.33	1.59	1.93	0.00	142.24	7.41	1.975	1.288	0.014	0.000	0.014
5.137	14.47	10.15	0.28	1.66	1.94	0.00	142.78	7.41	1.978	1.288	0.014	0.000	0.014
5.000	14.72	9.17	0.29	1.83	2.11	0.00	143.01	7.41	1.979	1.288	0.015	0.000	0.015
4.863	14.94	5.58	0.17	1.72	1.89	0.00	143.96	7.41	1.984	1.288	0.013	0.000	0.013
3.100	16.67	0.89	0.03	1.92	1.95	0.00	145.53	7.41	1.992	1.288	0.013	0.000	0.013
2.450	16.78	-2.72	-0.08	1.93	1.85	0.00	146.74	7.41	1.998	1.288	0.013	0.000	0.013
1.385	16.26	-5.20	-0.15	1.87	1.72	0.00	147.09	7.41	2.000	1.288	0.012	0.000	0.012
1.275	16.16	-5.96	-0.19	2.03	1.85	0.00	147.09	7.41	2.000	1.288	0.013	0.000	0.013
1.165	16.05	-6.65	-0.20	1.85	1.65	0.00	147.09	7.41	2.000	1.288	0.011	0.000	0.011

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 0.950  15.80 -11.06 -0.33  1.82  1.48  0.00 147.09   7.41 2.000 1.288 0.010 0.000 0.010
 0.446  14.81 -12.32 -0.37  1.70  1.33  0.00 183.33   7.68 2.000 1.281 0.007 0.000 0.007
 0.350  14.60 -12.61 -0.38  1.68  1.30  0.00 183.33   7.68 2.000 1.281 0.007 0.000 0.007
 0.305  14.50 -12.98 -0.20  0.97  0.76  0.00 181.13 183.33 1.991 2.000 0.004 0.000 0.004
 0.153   0.16   5.92  0.09  0.01  0.10  0.00 164.80 183.33 1.924 2.000 0.001 0.000 0.001

   f_xEN = Axial Stress: V/A [D.12]              f_xEM  = Bending Stress:  M / S [D.12]
   f_xEd = Total Stress: f_xEN+f_xEM [D.12]      f_qEd  = Circum Stress: (qeq+qs)*(r/t)
[D.30]
   s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd  = Buckling Resistance: s_qRk/SF
[8.11]
   kx    = Buckling Param: 1+Xx^2 [8.20]         kq     = Buckling Param: 1+Xq^2 [8.21]
   UR1   = Max[ (f_xEd/s_xRd), (f_qEd/s_q_Rd)]    [8.18]
   UR2   = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq  [8.19]
   Unity = Max(UR1, UR2)
```

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 80 Deg
Per EN 1993-3-2: Para 5.2.3

```
Nb       = Design Value of Total Vertical Load at Base [5.5]              = 5.92 KN
Ncrit    = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5]     = 151841.57
KN
Nratio   = Nb / Ncrit   [5.5]                                             = 0.000
```

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 80 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
16.500	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
13.452	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
11.500	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.467	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.385	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.257	242.2	10.6275	1.0	0.60	2.7	0.478	220.63	0.200	1.093	0.240	0.973	3820.46	214.66	143.11
11.128	224.9	10.6275	1.0	0.60	3.0	0.466	220.63	0.200	1.080	0.259	0.960	3295.21	211.79	141.19
11.000	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.699	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35
10.400	210.9	10.6275	1.0	0.60	3.1	0.455	220.63	0.200	1.067	0.276	0.947	2896.93	209.03	139.35

```
 8.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.456 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.123 180.4 10.6275 1.0 0.94 3.7 0.427 220.63 0.285 1.033 0.258 1.000 3320.16 220.63
147.09
 5.789 160.2 10.6275 1.0 0.93 4.1 0.403 220.63 0.283 1.004 0.291 0.994 2601.54 219.21
146.14
 5.456 145.5 10.6275 1.0 0.93 4.6 0.383 220.63 0.283 0.979 0.321 0.967 2140.75 213.36
142.24
 5.137 145.5 10.6275 1.0 0.94 4.6 0.383 220.63 0.285 0.979 0.319 0.971 2164.72 214.17
142.78
 5.000 145.5 10.6275 1.0 0.95 4.6 0.383 220.63 0.286 0.979 0.318 0.972 2174.95 214.51
143.01
 4.863 145.5 10.6275 1.0 0.96 4.6 0.383 220.63 0.291 0.979 0.315 0.979 2217.21 215.94
143.96
 3.100 145.5 10.6275 1.0 0.99 4.6 0.383 220.63 0.299 0.979 0.311 0.989 2286.54 218.30
145.53
 2.450 145.5 10.6275 1.0 1.02 4.6 0.383 220.63 0.304 0.979 0.307 0.998 2339.99 220.12
146.74
 1.385 145.5 10.6275 1.0 1.03 4.6 0.383 220.63 0.309 0.979 0.305 1.000 2379.24 220.63
147.09
 1.275 145.5 10.6275 1.0 1.04 4.6 0.383 220.63 0.310 0.979 0.304 1.000 2392.46 220.63
147.09
 1.165 145.5 10.6275 1.0 1.05 4.6 0.383 220.63 0.312 0.979 0.303 1.000 2410.95 220.63
147.09
 0.950 145.5 10.6275 1.0 1.09 4.6 0.383 220.63 0.322 0.979 0.297 1.000 2505.46 220.63
147.09
 0.446 145.5 10.6275 1.0 1.11 4.6 0.383 275.00 0.328 0.979 0.322 1.000 2647.01 275.00
183.33
 0.350 145.5 10.6275 1.0 1.12 4.6 0.383 275.00 0.329 0.979 0.322 1.000 2660.00 275.00
183.33
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.327 0.979 0.340 0.988 2381.90 271.69
181.13
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.210 0.979 0.340 0.899 2381.90 247.20
164.80

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
   l     = Distance between stiffeners
```

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 80 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57

11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Buckling Summary Per EN 1993-1-6:2007, Load # 4, Lift Angle = 90 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	Moment	Vert	f_xEN	f_xEM	f_xEd	f_qEd	s_xRd	s_qRd	kx	kq	UR1	UR2	Unity Ratio
m	KN-m	KN	MPa	MPa	MPa	MPa	MPa	MPa					
16.500	0.00	-1.18	-0.20	0.00	-0.20	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
13.452	0.00	-3.11	-0.52	0.00	-0.52	0.00	130.14	24.57	1.958	1.384	0.000	0.000	0.000
11.500	0.00	-3.88	-0.39	0.00	-0.39	0.00	145.11	71.07	1.990	1.612	0.000	0.000	0.000
11.467	0.00	-4.83	-0.49	0.00	-0.49	0.00	145.11	71.07	1.990	1.612	0.000	0.000	0.000
11.385	0.00	-5.01	-0.51	0.00	-0.51	0.00	145.11	71.07	1.990	1.612	0.000	0.000	0.000
11.257	0.00	-5.25	-0.45	0.00	-0.45	0.00	143.11	50.11	1.980	1.505	0.000	0.000	0.000
11.128	0.00	-5.49	-0.40	0.00	-0.40	0.00	141.19	37.29	1.970	1.440	0.000	0.000	0.000
11.000	0.00	-5.93	-0.38	0.00	-0.38	0.00	139.35	28.85	1.961	1.397	0.000	0.000	0.000
10.699	0.00	53.76	3.44	0.00	3.44	0.00	139.35	28.85	1.961	1.397	0.025	0.001	0.025
10.400	0.00	40.04	2.56	0.00	2.56	0.00	139.35	28.85	1.961	1.397	0.018	0.000	0.018
8.400	0.00	36.15	2.31	0.00	2.31	0.00	139.35	28.85	1.961	1.397	0.017	0.000	0.017

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6.456	0.00	33.92	2.17	0.00	2.17	0.00	139.35	28.85	1.961	1.397	0.016	0.000	0.016
6.123	0.00	32.98	1.53	0.00	1.53	0.00	134.09	15.58	1.934	1.329	0.011	0.000	0.011
5.789	0.00	32.04	1.17	0.00	1.17	0.00	129.16	10.00	1.909	1.301	0.009	0.000	0.009
5.456	0.00	30.96	0.93	0.00	0.93	0.00	124.44	7.41	1.885	1.288	0.007	0.000	0.007
5.137	0.00	30.09	0.84	0.00	0.84	0.00	124.44	7.41	1.885	1.288	0.007	0.000	0.007
5.000	0.00	29.09	0.91	0.00	0.91	0.00	124.44	7.41	1.885	1.288	0.007	0.000	0.007
4.863	0.00	25.45	0.77	0.00	0.77	0.00	124.44	7.41	1.885	1.288	0.006	0.000	0.006
3.100	0.00	20.68	0.62	0.00	0.62	0.00	124.44	7.41	1.885	1.288	0.005	0.000	0.005
2.450	0.00	17.01	0.51	0.00	0.51	0.00	124.44	7.41	1.885	1.288	0.004	0.000	0.004
1.385	0.00	14.50	0.42	0.00	0.42	0.00	124.44	7.41	1.885	1.288	0.003	0.000	0.003
1.275	0.00	13.73	0.43	0.00	0.43	0.00	124.44	7.41	1.885	1.288	0.003	0.000	0.003
1.165	0.00	13.03	0.39	0.00	0.39	0.00	124.44	7.41	1.885	1.288	0.003	0.000	0.003
0.950	0.00	8.55	0.26	0.00	0.26	0.00	124.44	7.41	1.885	1.288	0.002	0.000	0.002
0.446	0.00	7.27	0.22	0.00	0.22	0.00	149.63	7.68	1.862	1.281	0.001	0.000	0.001
0.350	0.00	6.98	0.21	0.00	0.21	0.00	149.63	7.68	1.862	1.281	0.001	0.000	0.001
0.305	0.00	6.60	0.10	0.00	0.10	0.00	163.59	183.33	1.919	2.000	0.001	0.000	0.001
0.153	0.00	6.02	0.09	0.00	0.09	0.00	163.59	183.33	1.919	2.000	0.001	0.000	0.001

f_xEN = Axial Stress: V/A [D.12] f_xEM = Bending Stress: M / S [D.12]
f_xEd = Total Stress: f_xEN+f_xEM [D.12] f_qEd = Circum Stress: (qeq+qs)*(r/t) [D.30]
s_xRd = Buckling Resistance: s_xRk/SF [8.11] s_qRd = Buckling Resistance: s_qRk/SF [8.11]
kx = Buckling Param: 1+Xx^2 [8.20] kq = Buckling Param: 1+Xq^2 [8.21]
UR1 = Max[(f_xEd/s_xRd), (f_qEd/s_q_Rd)] [8.18]
UR2 = (f_xEd/s_xRd)^kx - ki(f_xEd/s_xRd)*(f_qEd/s_q_Rd)+(r_qEd/s_qRd)^kq [8.19]
Unity = Max(UR1, UR2)

Check to see if Secondary Moments need to be Considered, Ld # 4, Angle = 90 Deg
Per EN 1993-3-2: Para 5.2.3

Nb = Design Value of Total Vertical Load at Base [5.5] = 6.02 KN
Ncrit = Elastic Critical Value for Failure at Base: s_xRcr*A [5.5] = 151841.57 KN
Nratio = Nb / Ncrit [5.5] = 0.000

Since Nratio <= 0.1 then Secondary Moments need not be considered.

Meridional Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 90 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev	w	l	Cxb	Cx	Dwk	ax	Fyk	Lxo	Lpx	Lx	Xx	s_xRcr	s_xRk	s_xRd
m		m			mm		MPa					MPa	MPa	MPa
16.500	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
13.452	341.0	10.6275	1.0	0.60	1.9	0.450	206.84	0.200	1.061	0.281	0.944	2624.92	195.20	130.14
11.500	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11
11.467	264.1	10.6275	1.0	0.60	2.5	0.491	220.63	0.200	1.108	0.220	0.987	4544.91	217.67	145.11

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11.385 264.1 10.6275 1.0 0.60 2.5 0.491 220.63 0.200 1.108 0.220 0.987 4544.91 217.67
145.11
11.257 242.2 10.6275 1.0 0.60 2.7 0.478 220.63 0.200 1.093 0.240 0.973 3820.46 214.66
143.11
11.128 224.9 10.6275 1.0 0.60 3.0 0.466 220.63 0.200 1.080 0.259 0.960 3295.21 211.79
141.19
11.000 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.699 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
10.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 8.400 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.456 210.9 10.6275 1.0 0.60 3.1 0.455 220.63 0.200 1.067 0.276 0.947 2896.93 209.03
139.35
 6.123 180.4 10.6275 1.0 0.60 3.7 0.427 220.63 0.200 1.033 0.323 0.912 2119.71 201.14
134.09
 5.789 160.2 10.6275 1.0 0.60 4.1 0.403 220.63 0.200 1.004 0.363 0.878 1671.31 193.74
129.16
 5.456 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 5.137 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 5.000 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 4.863 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 3.100 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 2.450 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 1.385 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 1.275 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 1.165 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 0.950 145.5 10.6275 1.0 0.60 4.6 0.383 220.63 0.200 0.979 0.400 0.846 1379.50 186.66
124.44
 0.446 145.5 10.6275 1.0 0.60 4.6 0.383 275.00 0.200 0.979 0.439 0.816 1429.14 224.44
149.63
 0.350 145.5 10.6275 1.0 0.60 4.6 0.383 275.00 0.200 0.979 0.439 0.816 1429.14 224.44
149.63
 0.305   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.200 0.979 0.340 0.892 2381.90 245.39
163.59
 0.153   2.1  0.1525 1.0 1.00 4.6 0.383 275.00 0.200 0.979 0.340 0.892 2381.90 245.39
163.59

   ax    = 0.62 / (1+1.91*(Dwk/t)^1.44) [D.14]  Q   = Quality Parameter:  16 [Table D.2]
   w     = Length Param:  l/(r*t)^0.5  [D.1]    Dwk = Imperfect Amp: (1/Q)*(r/t)^0.5*t
[D.15]
   Cx    = Meridional Param: [D.2 to D.13]      Cxb = Meridional Param  [Table D.1]
   Lpx   = (ax / (1-B))^0.5  [8.16]             Lx  = (fyk / s_xRcr)^0.5  [8.17]
   Lxo   = 0.2 + 0.1*(s_xEM / s_xEd)  [D.17]    s_xRcr = 0.605*E*Cx*(t/r)  [D.2]
   s_xRk = Xx * fyk  [8.12]                     s_xRd  = s_xRk / SF  [8.11]
   Xx    = Buckling Red Fac's [8.13-8.15]       fyk = Yield stress
```

l = Distance between stiffeners

Circumferential Buckling Per EN 1993-1-6:2007, Load # 4, Lift Angle = 90 Deg
Load Combination #4 Dead Weight + Impact (UnCorroded), FS = 0

Elev m	Cq	Cqs	aq	Lq	Lpq	Kw	qw_max kPa	qeq kPa	Xq	f_qEd MPa	s_qRcr MPa	s_qRk MPa	s_qRd MPa
16.500	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
13.452	1.00	1.00	0.500	1.675	1.118	0.650	0.000	0.000	0.1782	0.00	73.72	36.86	24.57
11.500	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.467	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.385	1.00	1.00	0.500	1.018	1.118	0.650	0.000	0.000	0.4832	0.00	212.69	106.60	71.07
11.257	1.00	1.00	0.500	1.212	1.118	0.650	0.000	0.000	0.3407	0.00	150.32	75.16	50.11
11.128	1.00	1.00	0.500	1.404	1.118	0.650	0.000	0.000	0.2535	0.00	111.88	55.94	37.29
11.000	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.699	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
10.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
8.400	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.456	1.00	1.00	0.500	1.597	1.118	0.650	0.000	0.000	0.1961	0.00	86.54	43.27	28.85
6.123	1.00	1.00	0.500	2.173	1.118	0.650	0.000	0.000	0.1059	0.00	46.73	23.37	15.58
5.789	1.00	1.00	0.500	2.713	1.118	0.650	0.000	0.000	0.0680	0.00	29.99	14.99	10.00
5.456	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.137	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
5.000	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
4.863	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
3.100	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
2.450	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.385	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.275	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
1.165	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.950	1.00	1.00	0.500	3.150	1.118	0.650	0.000	0.000	0.0504	0.00	22.24	11.12	7.41
0.446	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.350	1.00	1.00	0.500	3.455	1.118	0.650	0.000	0.000	0.0419	0.00	23.04	11.52	7.68
0.305	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33
0.153	1.00	2.11	0.500	0.274	1.118	0.818	0.000	0.000	1.0000	0.00	3660.74	275.00	183.33

Cq = Ext Buckling Fac Short Cyl [Table D.3] Cqs = Ext Bcklng Fac Med Cyl [Table D.4]
aq = Param based on Fab Quality [Table D.5] Lq = (fyk/s_qRcr)^0.5 [8.17]
Lpq = (aq / (1-B))^0.5 [8.16] Lqo = 0.4 [D.26]
s_qRk = Xq * fyk [8.12] f_qEd = Circ Stress: (qeq+qs)*(r/t) [D.30]
s_qRcr= Elas Crit Circ Bcklng Stress [D.1.3.1] s_qRd = s_qRk / SF [8.11]
qeq = Kw*qw_max [D.28] qs = Internal vacum: 0 [D.30]
Kw = 0.46*(1+0.1*(Cq*r/(w*t))^0.5 [D.29] qw_max= Max Wind Pressure [D.28]

Structural Flange Analysis, Angle = 0 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 0 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact
Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M          = Moment on Flange                                              = 9775.9 N-m
V          = Vertical Load on Flange (- is compression, + is tension)      = 0 N
S          = Shear Load on Flange                                          = 3887 N

Ds         = Outer Diameter of Shell                                       = 323.8 mm
Do         = Outside Diameter of Flange                                    = 482.6 mm
Dbc        = Bolt Circle Diameter                                          = 431.8 mm
Tf         = Thickness of Flange                                           = 31.8 mm
Tw         = Fillet Weld Size                                              = 6.0 mm

Db         = Nominal Bolt Diameter                                         = 22.2 mm
Nb         = Number of Bolts                                               = 12
Fu         = Ultimate Bolt Tensile Stress                                  = 1034.21 MPa
Ft         = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu                  = 393.00 MPa
Fv         = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                    = 237.87 MPa
Fp         = Pre-Load % of Allowable Bolt                                  = 60.00 %
Eb         = Modulus of Elasticity for Bolt                                = 202705.50
MPa

Fys        = Yield Stress of Shell                                         = 215.81 MPa
Fw         = Tensile Stress of Weld                                        = 413.68 MPa
Fyc        = Yield Stress of Flange                                        = 215.81 MPa
Fbwp       = Allowable Plate Weak Bending: (ASD) 0.9*Fy                    = 194.22 MPa
E          = Modulus of Elasticity of Flange                               = 193742.33
MPa

Check Bolt Spacing:
Sp         = Center to Center Bolt Spacing:  Dbc*PI / Nbolt                 = 113.0 mm
Bspace     = Max bolt spacing in terms of # of bolt diameters              = 10.00
Spmax      = Maximum bolt spacing: Bspace*Db                               = 222.3 mm
Sp_UR      = Unity Ratio for Spacing:  Sp / SpMax                          = 0.509

BOLT LOADING:
P          = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N       = 7547 N
Ab         = Nominal Area of Bolt                                          = 3.879 sq cm
Km         = Stiffness of Material                                         = 5922221.21
N/mm
Kb         = Stiffness of Bolt                                             = 1238416.78
N/mm
CC         = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)        = 0.173
Fby        = Bolt Yield Stress                                             = 896316.8
KPa
Fproof     = Bolt Proof Stress (0.85*Fby)                                  = 761869.3
KPa
Aroot      = Bolt Root Area                                                = 2.705 sq cm
Fi         = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}              = 123659 N
K          = Coefficient of Thread Friction                                = 0.000
Tb         = Bolt Torque to Produce Preload: K*Fi*Db                       = 0.00 N-m
Fmin       = Min. Force to keep Flange in Compression                      = 6866 N
Fact       = Actual force on bolt                                          = 91479 N
Ratio      = Enough Pre-load to keep Joint in Compression:  Fmin / Fact    = 0.075

Fb         = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi          = 124964 N
Fballow    = Allowable Bolt Tensile Load (Pure Tension)                    = 152464 N
Fbcomb     = Allowable Bolt Tensile Load (Tens & Shear)                    = 144438 N
Ratio      = Fb / Fbcomb                                                   = 0.865
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Sh        = Shear on Bolt                                          = 324 N
Sallow    = Allowable Shear on Bolt                                = 92281 N
Ratio     = Sh / Sallow                                            = 0.004

Check Welding
Iw        = Bending Moment of Inertia for Weld                     = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                       = 22621.48
cm^4
Aw        = Area of Weld                                           = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                     = 13993.0 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw            = 124.11 MPa
Ratio     = Fba / Sw                                               = 0.113

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                           = 87.6 mm
Lg        = Gross Flange area for each bolt                        = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area             = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge              = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                       = 54.0 mm
A         = Distance from Bolt CL to Flange OD                     = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole             = 42.9 mm
Rho       = Calculated Parameter                                   = 3.377
Beta      = Calulcated Parameter                                   = 5.6865
Alpha'    = Alpha where treq'd is minimum                          = 1
Tc        = Required thickness to develop load w/no prying         = 10.3 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                       = 0
Q         = Prying Force per bolt                                  = 0 N
Treq'd    = Required Flange Thickness                              = 8.2 mm
Ratio     = Treqd / Tf                                             = 0.257
```

Structural Flange Analysis, Angle = 10 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 10 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                       = 9627.4 N-m
V         = Vertical Load on Flange (- is compression, + is tension)  = -674 N
S         = Shear Load on Flange                                   = 3826 N

Ds        = Outer Diameter of Shell                                = 323.8 mm
Do        = Outside Diameter of Flange                             = 482.6 mm
Dbc       = Bolt Circle Diameter                                   = 431.8 mm
Tf        = Thickness of Flange                                    = 31.8 mm
Tw        = Fillet Weld Size                                       = 6.0 mm

Db        = Nominal Bolt Diameter                                  = 22.2 mm
Nb        = Number of Bolts                                        = 12
Fu        = Ultimate Bolt Tensile Stress                           = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu           = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy             = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                           = 60.00 %
Eb        = Modulus of Elasticity for Bolt                         = 202705.50
MPa
```

```
Fys       = Yield Stress of Shell                                    = 215.81 MPa
Fw        = Tensile Stress of Weld                                   = 413.68 MPa
Fyc       = Yield Stress of Flange                                   = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy               = 194.22 MPa
E         = Modulus of Elasticity of Flange                          = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt           = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters         = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                          = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                     = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N  = 7376 N
Ab        = Nominal Area of Bolt                                     = 3.879 sq cm
Km        = Stiffness of Material                                    = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                        = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)   = 0.173
Fby       = Bolt Yield Stress                                        = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                             = 761869.3
KPa
Aroot     = Bolt Root Area                                           = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}         = 123659 N
K         = Coefficient of Thread Friction                           = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                  = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                 = 6710 N
Fact      = Actual force on bolt                                     = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact = 0.073

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi     = 124934 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)               = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)               = 144439 N
Ratio     = Fb / Fbcomb                                              = 0.865

Sh        = Shear on Bolt                                            = 319 N
Sallow    = Allowable Shear on Bolt                                  = 92281 N
Ratio     = Sh / Sallow                                              = 0.003

Check Welding
Iw        = Bending Moment of Inertia for Weld                       = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                         = 22621.48
cm^4
Aw        = Area of Weld                                             = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                       = 13858.5 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw              = 124.11 MPa
Ratio     = Fba / Sw                                                 = 0.112

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                             = 87.6 mm
Lg        = Gross Flange area for each bolt                          = 113.0 mm
```

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```
Delta     = Ratio of net area(@bolt line) & gross area                  = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                   = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                            = 54.0 mm
A         = Distance from Bolt CL to Flange OD                          = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                  = 42.9 mm
Rho       = Calculated Parameter                                        = 3.377
Beta      = Calulcated Parameter                                        = 5.8251
Alpha'    = Alpha where treq'd is minimum                               = 1
Tc        = Required thickness to develop load w/no prying              = 10.2 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                            = 0
Q         = Prying Force per bolt                                       = 0 N
Treq'd    = Required Flange Thickness                                   = 8.1 mm
Ratio     = Treqd / Tf                                                  = 0.254
```

Structural Flange Analysis, Angle = 20 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 20 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                            = 9186.3 N-m
V         = Vertical Load on Flange (- is compression, + is tension)    = -1328 N
S         = Shear Load on Flange                                        = 3651 N

Ds        = Outer Diameter of Shell                                     = 323.8 mm
Do        = Outside Diameter of Flange                                  = 482.6 mm
Dbc       = Bolt Circle Diameter                                        = 431.8 mm
Tf        = Thickness of Flange                                         = 31.8 mm
Tw        = Fillet Weld Size                                            = 6.0 mm

Db        = Nominal Bolt Diameter                                       = 22.2 mm
Nb        = Number of Bolts                                             = 12
Fu        = Ultimate Bolt Tensile Stress                                = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu                = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                  = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                                = 60.00 %
Eb        = Modulus of Elasticity for Bolt                              = 202705.50
MPa

Fys       = Yield Stress of Shell                                       = 215.81 MPa
Fw        = Tensile Stress of Weld                                      = 413.68 MPa
Fyc       = Yield Stress of Flange                                      = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                  = 194.22 MPa
E         = Modulus of Elasticity of Flange                             = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt              = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters            = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                             = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                        = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N     = 6981 N
Ab        = Nominal Area of Bolt                                        = 3.879 sq cm
```

```
Km        = Stiffness of Material                                        = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                            = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)       = 0.173
Fby       = Bolt Yield Stress                                            = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                                 = 761869.3
KPa
Aroot     = Bolt Root Area                                               = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}             = 123659 N
K         = Coefficient of Thread Friction                               = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                      = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                     = 6351 N
Fact      = Actual force on bolt                                         = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact   = 0.069

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi         = 124866 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                   = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                   = 144439 N
Ratio     = Fb / Fbcomb                                                  = 0.864

Sh        = Shear on Bolt                                                = 304 N
Sallow    = Allowable Shear on Bolt                                      = 92281 N
Ratio     = Sh / Sallow                                                  = 0.003

Check Welding
Iw        = Bending Moment of Inertia for Weld                           = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                             = 22621.48
cm^4
Aw        = Area of Weld                                                 = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                           = 13303.0 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                  = 124.11 MPa
Ratio     = Fba / Sw                                                     = 0.107

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                 = 87.6 mm
Lg        = Gross Flange area for each bolt                              = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                   = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                    = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                             = 54.0 mm
A         = Distance from Bolt CL to Flange OD                           = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                   = 42.9 mm
Rho       = Calculated Parameter                                         = 3.377
Beta      = Calulcated Parameter                                         = 6.1714
Alpha'    = Alpha where treq'd is minimum                                = 1
Tc        = Required thickness to develop load w/no prying               = 9.9 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                             = 0
Q         = Prying Force per bolt                                        = 0 N
Treq'd    = Required Flange Thickness                                    = 7.8 mm
Ratio     = Treqd / Tf                                                   = 0.247
```

Structural Flange Analysis, Angle = 30 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 30 Deg , Load # 4

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Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

M	= Moment on Flange	= 8466.2 N-m
V	= Vertical Load on Flange (- is compression, + is tension)	= -1942 N
S	= Shear Load on Flange	= 3364 N
Ds	= Outer Diameter of Shell	= 323.8 mm
Do	= Outside Diameter of Flange	= 482.6 mm
Dbc	= Bolt Circle Diameter	= 431.8 mm
Tf	= Thickness of Flange	= 31.8 mm
Tw	= Fillet Weld Size	= 6.0 mm
Db	= Nominal Bolt Diameter	= 22.2 mm
Nb	= Number of Bolts	= 12
Fu	= Ultimate Bolt Tensile Stress	= 1034.21 MPa
Ft	= Allowable Bolt Tensile Stress: (ASD) 0.38*Fu	= 393.00 MPa
Fv	= Allowable Bolt Shear Stress: (ASD) 0.23*Fy	= 237.87 MPa
Fp	= Pre-Load % of Allowable Bolt	= 60.00 %
Eb	= Modulus of Elasticity for Bolt	= 202705.50 MPa
Fys	= Yield Stress of Shell	= 215.81 MPa
Fw	= Tensile Stress of Weld	= 413.68 MPa
Fyc	= Yield Stress of Flange	= 215.81 MPa
Fbwp	= Allowable Plate Weak Bending: (ASD) 0.9*Fy	= 194.22 MPa
E	= Modulus of Elasticity of Flange	= 193742.33 MPa

Check Bolt Spacing:

Sp	= Center to Center Bolt Spacing: Dbc*PI / Nbolt	= 113.0 mm
Bspace	= Max bolt spacing in terms of # of bolt diameters	= 10.00
Spmax	= Maximum bolt spacing: Bspace*Db	= 222.3 mm
Sp_UR	= Unity Ratio for Spacing: Sp / SpMax	= 0.509

BOLT LOADING:

P	= Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N	= 6374 N
Ab	= Nominal Area of Bolt	= 3.879 sq cm
Km	= Stiffness of Material	= 5922221.21 N/mm
Kb	= Stiffness of Bolt	= 1238416.78 N/mm
CC	= Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)	= 0.173
Fby	= Bolt Yield Stress	= 896316.8 KPa
Fproof	= Bolt Proof Stress (0.85*Fby)	= 761869.3 KPa
Aroot	= Bolt Root Area	= 2.705 sq cm
Fi	= Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}	= 123659 N
K	= Coefficient of Thread Friction	= 0.000
Tb	= Bolt Torque to Produce Preload: K*Fi*Db	= 0.00 N-m
Fmin	= Min. Force to keep Flange in Compression	= 5799 N
Fact	= Actual force on bolt	= 91479 N
Ratio	= Enough Pre-load to keep Joint in Compression: Fmin / Fact	= 0.063
Fb	= Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi	= 124761 N

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```
Fballow   = Allowable Bolt Tensile Load (Pure Tension)          = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)          = 144439 N
Ratio     = Fb / Fbcomb                                         = 0.864

Sh        = Shear on Bolt                                       = 280 N
Sallow    = Allowable Shear on Bolt                             = 92281 N
Ratio     = Sh / Sallow                                         = 0.003

Check Welding
Iw        = Bending Moment of Inertia for Weld                  = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                    = 22621.48
cm^4
Aw        = Area of Weld                                        = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                  = 12343.3 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw         = 124.11 MPa
Ratio     = Fba / Sw                                            = 0.099

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                        = 87.6 mm
Lg        = Gross Flange area for each bolt                     = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area          = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge           = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                    = 54.0 mm
A         = Distance from Bolt CL to Flange OD                  = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole          = 42.9 mm
Rho       = Calculated Parameter                                = 3.377
Beta      = Calulcated Parameter                                = 6.7874
Alpha'    = Alpha where treq'd is minimum                       = 1
Tc        = Required thickness to develop load w/no prying      = 9.5 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                    = 0
Q         = Prying Force per bolt                               = 0 N
Treq'd    = Required Flange Thickness                           = 7.5 mm
Ratio     = Treqd / Tf                                          = 0.236
```

Structural Flange Analysis, Angle = 40 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 40 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                    = 7488.8 N-m
V         = Vertical Load on Flange (- is compression, + is tension)  = -2497 N
S         = Shear Load on Flange                                = 2977 N

Ds        = Outer Diameter of Shell                             = 323.8 mm
Do        = Outside Diameter of Flange                          = 482.6 mm
Dbc       = Bolt Circle Diameter                                = 431.8 mm
Tf        = Thickness of Flange                                 = 31.8 mm
Tw        = Fillet Weld Size                                    = 6.0 mm

Db        = Nominal Bolt Diameter                               = 22.2 mm
Nb        = Number of Bolts                                     = 12
Fu        = Ultimate Bolt Tensile Stress                        = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu        = 393.00 MPa
```

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```
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                    = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                                  = 60.00 %
Eb        = Modulus of Elasticity for Bolt                                = 202705.50
MPa

Fys       = Yield Stress of Shell                                         = 215.81 MPa
Fw        = Tensile Stress of Weld                                        = 413.68 MPa
Fyc       = Yield Stress of Flange                                        = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                    = 194.22 MPa
E         = Modulus of Elasticity of Flange                               = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt                 = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters              = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                               = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                          = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N       = 5573 N
Ab        = Nominal Area of Bolt                                          = 3.879 sq cm
Km        = Stiffness of Material                                         = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                             = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)        = 0.173
Fby       = Bolt Yield Stress                                             = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                                  = 761869.3
KPa
Aroot     = Bolt Root Area                                                = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}              = 123659 N
K         = Coefficient of Thread Friction                                = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                       = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                      = 5070 N
Fact      = Actual force on bolt                                          = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact    = 0.055

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi          = 124622 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                    = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                    = 144439 N
Ratio     = Fb / Fbcomb                                                   = 0.863

Sh        = Shear on Bolt                                                 = 248 N
Sallow    = Allowable Shear on Bolt                                       = 92281 N
Ratio     = Sh / Sallow                                                   = 0.003

Check Welding
Iw        = Bending Moment of Inertia for Weld                            = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                              = 22621.48
cm^4
Aw        = Area of Weld                                                  = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                            = 11008.5 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                   = 124.11 MPa
Ratio     = Fba / Sw                                                      = 0.089
```

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```
Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                = 87.6 mm
Lg        = Gross Flange area for each bolt                             = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                  = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                   = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                            = 54.0 mm
A         = Distance from Bolt CL to Flange OD                          = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                  = 42.9 mm
Rho       = Calculated Parameter                                        = 3.377
Beta      = Calulcated Parameter                                        = 7.8052
Alpha'    = Alpha where treq'd is minimum                               = 1
Tc        = Required thickness to develop load w/no prying              = 8.9 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                            = 0
Q         = Prying Force per bolt                                       = 0 N
Treq'd    = Required Flange Thickness                                   = 7.0 mm
Ratio     = Treqd / Tf                                                  = 0.221
```

Structural Flange Analysis, Angle = 50 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 50 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                            = 6283.8 N-m
V         = Vertical Load on Flange (- is compression, + is tension)    = -2975 N
S         = Shear Load on Flange                                        = 2497 N

Ds        = Outer Diameter of Shell                                     = 323.8 mm
Do        = Outside Diameter of Flange                                  = 482.6 mm
Dbc       = Bolt Circle Diameter                                        = 431.8 mm
Tf        = Thickness of Flange                                         = 31.8 mm
Tw        = Fillet Weld Size                                            = 6.0 mm

Db        = Nominal Bolt Diameter                                       = 22.2 mm
Nb        = Number of Bolts                                             = 12
Fu        = Ultimate Bolt Tensile Stress                                = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu                = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                  = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                                = 60.00 %
Eb        = Modulus of Elasticity for Bolt                              = 202705.50
MPa

Fys       = Yield Stress of Shell                                       = 215.81 MPa
Fw        = Tensile Stress of Weld                                      = 413.68 MPa
Fyc       = Yield Stress of Flange                                      = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                  = 194.22 MPa
E         = Modulus of Elasticity of Flange                             = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt              = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters            = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                             = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                        = 0.509
```

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```
BOLT LOADING:
P          = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N          = 4603 N
Ab         = Nominal Area of Bolt                                             = 3.879 sq cm
Km         = Stiffness of Material                                            = 5922221.21
N/mm
Kb         = Stiffness of Bolt                                                = 1238416.78
N/mm
CC         = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)           = 0.173
Fby        = Bolt Yield Stress                                                = 896316.8
KPa
Fproof     = Bolt Proof Stress (0.85*Fby)                                     = 761869.3
KPa
Aroot      = Bolt Root Area                                                   = 2.705 sq cm
Fi         = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}                 = 123659 N
K          = Coefficient of Thread Friction                                   = 0.000
Tb         = Bolt Torque to Produce Preload: K*Fi*Db                          = 0.00 N-m
Fmin       = Min. Force to keep Flange in Compression                         = 4188 N
Fact       = Actual force on bolt                                             = 91479 N
Ratio      = Enough Pre-load to keep Joint in Compression:  Fmin / Fact       = 0.046

Fb         = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi             = 124455 N
Fballow    = Allowable Bolt Tensile Load (Pure Tension)                       = 152464 N
Fbcomb     = Allowable Bolt Tensile Load (Tens & Shear)                       = 144439 N
Ratio      = Fb / Fbcomb                                                      = 0.862

Sh         = Shear on Bolt                                                    = 208 N
Sallow     = Allowable Shear on Bolt                                          = 92281 N
Ratio      = Sh / Sallow                                                      = 0.002

Check Welding
Iw         = Bending Moment of Inertia for Weld                               = 11310.74
cm^4
Jw         = Polar Moment of Inertia for Weld                                 = 22621.48
cm^4
Aw         = Area of Weld                                                     = 86.303 sq
cm
Fba        = Weld Stress due to Axial & Bending                               = 9339.3 KPa
Sw         = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                      = 124.11 MPa
Ratio      = Fba / Sw                                                         = 0.075

Design Flange: NO GUSSETS
Ln         = Net Flange area at each bolt                                     = 87.6 mm
Lg         = Gross Flange area for each bolt                                  = 113.0 mm
Delta      = Ratio of net area(@bolt line) & gross area                       = 0.7753
A'         = Distance from Flange OD to Bolt Hole Edge                        = 12.7 mm
B          = Distance from Bolt CL to Pipe OD                                 = 54.0 mm
A          = Distance from Bolt CL to Flange OD                               = 25.4 mm
B'         = Distance from Pipe OD to edge of Bolt Hole                       = 42.9 mm
Rho        = Calculated Parameter                                             = 3.377
Beta       = Calulcated Parameter                                             = 9.5125
Alpha'     = Alpha where treq'd is minimum                                    = 1
Tc         = Required thickness to develop load w/no prying                   = 8.0 mm
Alpha      = Ratio mom@ BL to Mom @ stem line                                 = 0
Q          = Prying Force per bolt                                            = 0 N
Treq'd     = Required Flange Thickness                                        = 6.4 mm
Ratio      = Treqd / Tf                                                       = 0.200
```

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Structural Flange Analysis, Angle = 60 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 60 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

M	= Moment on Flange	= 4887.9 N-m
V	= Vertical Load on Flange (- is compression, + is tension)	= -3364 N
S	= Shear Load on Flange	= 1942 N
Ds	= Outer Diameter of Shell	= 323.8 mm
Do	= Outside Diameter of Flange	= 482.6 mm
Dbc	= Bolt Circle Diameter	= 431.8 mm
Tf	= Thickness of Flange	= 31.8 mm
Tw	= Fillet Weld Size	= 6.0 mm
Db	= Nominal Bolt Diameter	= 22.2 mm
Nb	= Number of Bolts	= 12
Fu	= Ultimate Bolt Tensile Stress	= 1034.21 MPa
Ft	= Allowable Bolt Tensile Stress: (ASD) 0.38*Fu	= 393.00 MPa
Fv	= Allowable Bolt Shear Stress: (ASD) 0.23*Fy	= 237.87 MPa
Fp	= Pre-Load % of Allowable Bolt	= 60.00 %
Eb	= Modulus of Elasticity for Bolt	= 202705.50 MPa
Fys	= Yield Stress of Shell	= 215.81 MPa
Fw	= Tensile Stress of Weld	= 413.68 MPa
Fyc	= Yield Stress of Flange	= 215.81 MPa
Fbwp	= Allowable Plate Weak Bending: (ASD) 0.9*Fy	= 194.22 MPa
E	= Modulus of Elasticity of Flange	= 193742.33 MPa

Check Bolt Spacing:

Sp	= Center to Center Bolt Spacing: Dbc*PI / Nbolt	= 113.0 mm
Bspace	= Max bolt spacing in terms of # of bolt diameters	= 10.00
Spmax	= Maximum bolt spacing: Bspace*Db	= 222.3 mm
Sp_UR	= Unity Ratio for Spacing: Sp / SpMax	= 0.509

BOLT LOADING:

P	= Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N	= 3493 N
Ab	= Nominal Area of Bolt	= 3.879 sq cm
Km	= Stiffness of Material	= 5922221.21 N/mm
Kb	= Stiffness of Bolt	= 1238416.78 N/mm
CC	= Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)	= 0.173
Fby	= Bolt Yield Stress	= 896316.8 KPa
Fproof	= Bolt Proof Stress (0.85*Fby)	= 761869.3 KPa
Aroot	= Bolt Root Area	= 2.705 sq cm
Fi	= Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}	= 123659 N
K	= Coefficient of Thread Friction	= 0.000
Tb	= Bolt Torque to Produce Preload: K*Fi*Db	= 0.00 N-m
Fmin	= Min. Force to keep Flange in Compression	= 3178 N
Fact	= Actual force on bolt	= 91479 N

```
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact      = 0.035

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi           = 124263 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                     = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                     = 144439 N
Ratio     = Fb / Fbcomb                                                    = 0.860

Sh        = Shear on Bolt                                                  = 162 N
Sallow    = Allowable Shear on Bolt                                        = 92281 N
Ratio     = Sh / Sallow                                                    = 0.002

Check Welding
Iw        = Bending Moment of Inertia for Weld                             = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                               = 22621.48
cm^4
Aw        = Area of Weld                                                   = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                             = 7386.2 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                    = 124.11 MPa
Ratio     = Fba / Sw                                                       = 0.060

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                   = 87.6 mm
Lg        = Gross Flange area for each bolt                                = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                     = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                      = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                               = 54.0 mm
A         = Distance from Bolt CL to Flange OD                             = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                     = 42.9 mm
Rho       = Calculated Parameter                                           = 3.377
Beta      = Calulcated Parameter                                           = 12.6293
Alpha'    = Alpha where treq'd is minimum                                  = 1
Tc        = Required thickness to develop load w/no prying                 = 7.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                               = 0
Q         = Prying Force per bolt                                          = 0 N
Treq'd    = Required Flange Thickness                                      = 5.5 mm
Ratio     = Treqd / Tf                                                     = 0.175
```

Structural Flange Analysis, Angle = 70 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 70 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                               = 3343.5 N-m
V         = Vertical Load on Flange (- is compression, + is tension)       = -3650 N
S         = Shear Load on Flange                                           = 1328 N

Ds        = Outer Diameter of Shell                                        = 323.8 mm
Do        = Outside Diameter of Flange                                     = 482.6 mm
Dbc       = Bolt Circle Diameter                                           = 431.8 mm
Tf        = Thickness of Flange                                            = 31.8 mm
Tw        = Fillet Weld Size                                               = 6.0 mm

Db        = Nominal Bolt Diameter                                          = 22.2 mm
```

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```
Nb        = Number of Bolts                                          = 12
Fu        = Ultimate Bolt Tensile Stress                             = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu             = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy               = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                             = 60.00 %
Eb        = Modulus of Elasticity for Bolt                           = 202705.50
MPa

Fys       = Yield Stress of Shell                                    = 215.81 MPa
Fw        = Tensile Stress of Weld                                   = 413.68 MPa
Fyc       = Yield Stress of Flange                                   = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy               = 194.22 MPa
E         = Modulus of Elasticity of Flange                          = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt           = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters         = 10.00
Spmax     = Maximum bolt spacing: Bspace*Db                          = 222.3 mm
Sp_UR     = Unity Ratio for Spacing:  Sp / SpMax                     = 0.509

BOLT LOADING:
P         = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N  = 2277 N
Ab        = Nominal Area of Bolt                                     = 3.879 sq cm
Km        = Stiffness of Material                                    = 5922221.21
N/mm
Kb        = Stiffness of Bolt                                        = 1238416.78
N/mm
CC        = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)   = 0.173
Fby       = Bolt Yield Stress                                        = 896316.8
KPa
Fproof    = Bolt Proof Stress (0.85*Fby)                             = 761869.3
KPa
Aroot     = Bolt Root Area                                           = 2.705 sq cm
Fi        = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}         = 123659 N
K         = Coefficient of Thread Friction                           = 0.000
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                  = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                 = 2071 N
Fact      = Actual force on bolt                                     = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact = 0.023

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi     = 124052 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)               = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)               = 144440 N
Ratio     = Fb / Fbcomb                                              = 0.859

Sh        = Shear on Bolt                                            = 111 N
Sallow    = Allowable Shear on Bolt                                  = 92281 N
Ratio     = Sh / Sallow                                              = 0.001

Check Welding
Iw        = Bending Moment of Inertia for Weld                       = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                         = 22621.48
cm^4
Aw        = Area of Weld                                             = 86.303 sq
cm
```

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```
Fba       = Weld Stress due to Axial & Bending                          = 5208.8 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                 = 124.11 MPa
Ratio     = Fba / Sw                                                    = 0.042

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                = 87.6 mm
Lg        = Gross Flange area for each bolt                             = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                  = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                   = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                            = 54.0 mm
A         = Distance from Bolt CL to Flange OD                          = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                  = 42.9 mm
Rho       = Calculated Parameter                                        = 3.377
Beta      = Calulcated Parameter                                        = 19.5326
Alpha'    = Alpha where treq'd is minimum                               = 1
Tc        = Required thickness to develop load w/no prying              = 5.7 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                            = 0
Q         = Prying Force per bolt                                       = 0 N
Treq'd    = Required Flange Thickness                                   = 4.5 mm
Ratio     = Treqd / Tf                                                  = 0.141
```

Structural Flange Analysis, Angle = 80 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 80 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact

Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M         = Moment on Flange                                            = 1697.6 N-m
V         = Vertical Load on Flange (- is compression, + is tension)    = -3825 N
S         = Shear Load on Flange                                        = 674 N

Ds        = Outer Diameter of Shell                                     = 323.8 mm
Do        = Outside Diameter of Flange                                  = 482.6 mm
Dbc       = Bolt Circle Diameter                                        = 431.8 mm
Tf        = Thickness of Flange                                         = 31.8 mm
Tw        = Fillet Weld Size                                            = 6.0 mm

Db        = Nominal Bolt Diameter                                       = 22.2 mm
Nb        = Number of Bolts                                             = 12
Fu        = Ultimate Bolt Tensile Stress                                = 1034.21 MPa
Ft        = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu                = 393.00 MPa
Fv        = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                  = 237.87 MPa
Fp        = Pre-Load % of Allowable Bolt                                = 60.00 %
Eb        = Modulus of Elasticity for Bolt                              = 202705.50
MPa

Fys       = Yield Stress of Shell                                       = 215.81 MPa
Fw        = Tensile Stress of Weld                                      = 413.68 MPa
Fyc       = Yield Stress of Flange                                      = 215.81 MPa
Fbwp      = Allowable Plate Weak Bending: (ASD) 0.9*Fy                  = 194.22 MPa
E         = Modulus of Elasticity of Flange                             = 193742.33
MPa

Check Bolt Spacing:
Sp        = Center to Center Bolt Spacing:  Dbc*PI / Nbolt              = 113.0 mm
Bspace    = Max bolt spacing in terms of # of bolt diameters            = 10.00
```

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```
Spmax      = Maximum bolt spacing: Bspace*Db                                  = 222.3 mm
Sp_UR      = Unity Ratio for Spacing:  Sp / SpMax                             = 0.509

BOLT LOADING:
P          = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N          = 992 N
Ab         = Nominal Area of Bolt                                             = 3.879 sq cm
Km         = Stiffness of Material                                            = 5922221.21
N/mm
Kb         = Stiffness of Bolt                                                = 1238416.78
N/mm
CC         = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)           = 0.173
Fby        = Bolt Yield Stress                                                = 896316.8
KPa
Fproof     = Bolt Proof Stress (0.85*Fby)                                     = 761869.3
KPa
Aroot      = Bolt Root Area                                                   = 2.705 sq cm
Fi         = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}                 = 123659 N
K          = Coefficient of Thread Friction                                   = 0.000
Tb         = Bolt Torque to Produce Preload: K*Fi*Db                          = 0.00 N-m
Fmin       = Min. Force to keep Flange in Compression                         = 902 N
Fact       = Actual force on bolt                                             = 91479 N
Ratio      = Enough Pre-load to keep Joint in Compression:  Fmin / Fact       = 0.010

Fb         = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi             = 123830 N
Fballow    = Allowable Bolt Tensile Load (Pure Tension)                       = 152464 N
Fbcomb     = Allowable Bolt Tensile Load (Tens & Shear)                       = 144440 N
Ratio      = Fb / Fbcomb                                                      = 0.857

Sh         = Shear on Bolt                                                    = 56 N
Sallow     = Allowable Shear on Bolt                                          = 92281 N
Ratio      = Sh / Sallow                                                      = 0.001

Check Welding
Iw         = Bending Moment of Inertia for Weld                               = 11310.74
cm^4
Jw         = Polar Moment of Inertia for Weld                                 = 22621.48
cm^4
Aw         = Area of Weld                                                     = 86.303 sq
cm
Fba        = Weld Stress due to Axial & Bending                               = 2873.1 KPa
Sw         = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                      = 124.11 MPa
Ratio      = Fba / Sw                                                         = 0.023

Design Flange: NO GUSSETS
Ln         = Net Flange area at each bolt                                     = 87.6 mm
Lg         = Gross Flange area for each bolt                                  = 113.0 mm
Delta      = Ratio of net area(@bolt line) & gross area                       = 0.7753
A'         = Distance from Flange OD to Bolt Hole Edge                        = 12.7 mm
B          = Distance from Bolt CL to Pipe OD                                 = 54.0 mm
A          = Distance from Bolt CL to Flange OD                               = 25.4 mm
B'         = Distance from Pipe OD to edge of Bolt Hole                       = 42.9 mm
Rho        = Calculated Parameter                                             = 3.377
Beta       = Calulcated Parameter                                             = 45.2309
Alpha'     = Alpha where treq'd is minimum                                    = 1
Tc         = Required thickness to develop load w/no prying                   = 3.7 mm
Alpha      = Ratio mom@ BL to Mom @ stem line                                 = 0
Q          = Prying Force per bolt                                            = 0 N
```

```
Treq'd     = Required Flange Thickness                                  = 3.0 mm
Ratio      = Treqd / Tf                                                 = 0.093
```

Structural Flange Analysis, Angle = 90 Deg

Structural Flange # 1: Elev 11.440 m, Lift Angle = 90 Deg , Load # 4
Load Combination # 4, Dead Weight + Impact
Controlling: Max Bolt Spacing, Bolt Tension, Bolt Preload, Bolt Shear, Weld Stress, Flange Thk

```
M          = Moment on Flange                                           = 0.0 N-m
V          = Vertical Load on Flange (- is compression, + is tension)   = -3884 N
S          = Shear Load on Flange                                       = 0 N

Ds         = Outer Diameter of Shell                                    = 323.8 mm
Do         = Outside Diameter of Flange                                 = 482.6 mm
Dbc        = Bolt Circle Diameter                                       = 431.8 mm
Tf         = Thickness of Flange                                        = 31.8 mm
Tw         = Fillet Weld Size                                           = 6.0 mm

Db         = Nominal Bolt Diameter                                      = 22.2 mm
Nb         = Number of Bolts                                            = 12
Fu         = Ultimate Bolt Tensile Stress                               = 1034.21 MPa
Ft         = Allowable Bolt Tensile Stress: (ASD) 0.38*Fu               = 393.00 MPa
Fv         = Allowable Bolt Shear Stress: (ASD) 0.23*Fy                 = 237.87 MPa
Fp         = Pre-Load % of Allowable Bolt                               = 60.00 %
Eb         = Modulus of Elasticity for Bolt                             = 202705.50
MPa

Fys        = Yield Stress of Shell                                      = 215.81 MPa
Fw         = Tensile Stress of Weld                                     = 413.68 MPa
Fyc        = Yield Stress of Flange                                     = 215.81 MPa
Fbwp       = Allowable Plate Weak Bending: (ASD) 0.9*Fy                 = 194.22 MPa
E          = Modulus of Elasticity of Flange                            = 193742.33
MPa

Check Bolt Spacing:
Sp         = Center to Center Bolt Spacing:  Dbc*PI / Nbolt             = 113.0 mm
Bspace     = Max bolt spacing in terms of # of bolt diameters           = 10.00
Spmax      = Maximum bolt spacing: Bspace*Db                            = 222.3 mm
Sp_UR      = Unity Ratio for Spacing:  Sp / SpMax                       = 0.509

BOLT LOADING:
P          = Bolt Load due to Vertical and Moment: 4*M/(N*Dbc) + V/N    = 0 N
Ab         = Nominal Area of Bolt                                       = 3.879 sq cm
Km         = Stiffness of Material                                      = 5922221.21
N/mm
Kb         = Stiffness of Bolt                                          = 1238416.78
N/mm
CC         = Ratio of Bolt Stiffness to Total Stiffness: Kb/(Km+Kb)     = 0.173
Fby        = Bolt Yield Stress                                          = 896316.8
KPa
Fproof     = Bolt Proof Stress (0.85*Fby)                               = 761869.3
KPa
Aroot      = Bolt Root Area                                             = 2.705 sq cm
Fi         = Bolt Preload: Fproof*Aroot*Fp {Shigley Eqn 8-19}           = 123659 N
K          = Coefficient of Thread Friction                             = 0.000
```

```
Tb        = Bolt Torque to Produce Preload: K*Fi*Db                          = 0.00 N-m
Fmin      = Min. Force to keep Flange in Compression                         = 0 N
Fact      = Actual force on bolt                                             = 91479 N
Ratio     = Enough Pre-load to keep Joint in Compression:  Fmin / Fact       = 0.000

Fb        = Actual Resultant Bolt Tensile Load: Kb*P/(Kb+Km) +Fi             = 123659 N
Fballow   = Allowable Bolt Tensile Load (Pure Tension)                       = 152464 N
Fbcomb    = Allowable Bolt Tensile Load (Tens & Shear)                       = 144440 N
Ratio     = Fb / Fbcomb                                                      = 0.856

Sh        = Shear on Bolt                                                    = 0 N
Sallow    = Allowable Shear on Bolt                                          = 92281 N
Ratio     = Sh / Sallow                                                      = 0.000

Check Welding
Iw        = Bending Moment of Inertia for Weld                               = 11310.74
cm^4
Jw        = Polar Moment of Inertia for Weld                                 = 22621.48
cm^4
Aw        = Area of Weld                                                     = 86.303 sq
cm
Fba       = Weld Stress due to Axial & Bending                               = 450.1 KPa
Sw        = Allowable Fillet Weld Stress: (ASD) 0.3*Fuw                      = 124.11 MPa
Ratio     = Fba / Sw                                                         = 0.004

Design Flange: NO GUSSETS
Ln        = Net Flange area at each bolt                                     = 87.6 mm
Lg        = Gross Flange area for each bolt                                  = 113.0 mm
Delta     = Ratio of net area(@bolt line) & gross area                       = 0.7753
A'        = Distance from Flange OD to Bolt Hole Edge                        = 12.7 mm
B         = Distance from Bolt CL to Pipe OD                                 = 54.0 mm
A         = Distance from Bolt CL to Flange OD                               = 25.4 mm
B'        = Distance from Pipe OD to edge of Bolt Hole                       = 42.9 mm
Rho       = Calculated Parameter                                             = 3.377
Beta      = Calulcated Parameter                                             = 0
Alpha'    = Alpha where treq'd is minimum                                    = 0
Tc        = Required thickness to develop load w/no prying                   = 0.0 mm
Alpha     = Ratio mom@ BL to Mom @ stem line                                 = 0
Q         = Prying Force per bolt                                            = 0 N
Treq'd    = Required Flange Thickness                                        = 0.0 mm
Ratio     = Treqd / Tf                                                       = 0.000
```

Conical Transition Analysis, Angle = 0 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 0 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63

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E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	10.17	0.00	12.19
V:	Vertical Axial Loading (KN)	0.00	0.00	0.00
Sx:	Section Modulus (cm^3)	750.3	750.3	1910.2
Ax:	Cross Sectional Area (sq cm)	98.583	98.583	156.451
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.00	0.00	0.00
fb:	Bending Strss - M/Sx (MPa)	13.56	13.94	6.38
fb':	Localized Bending Stress (MPa)	15.66	15.66	9.23
fh':	Hoop Stress (MPa)	8.30	0.00	4.90
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08	1596.11
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	220.63
Stot:	Total Stress Check 1: fa + fb (MPa)	13.56	13.94	6.38
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	29.21	29.60	15.62
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	132.38
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	110.32

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.102	PASS	0.105	PASS	0.048	PASS
Check 2: Stot1 / Ft	0.071	PASS	0.072	PASS	0.038	PASS
Check 3: fh' < Fh	0.075	PASS	0.000	PASS	0.044	PASS
Stiff Ring Req'd?	0.102	Not Req'd	0.105	Cone OK	0.048	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 0 Deg

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Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	33.40	0.00	38.78
V:	Vertical Axial Loading (KN)	0.00	0.00	0.00
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.00	0.00	0.00
fb:	Bending Strss - M/Sx (MPa)	17.48	18.15	4.46
fb':	Localized Bending Stress (MPa)	29.54	29.54	10.93
fh':	Hoop Stress (MPa)	15.67	0.00	5.80
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	198.75
Stot:	Total Stress Check 1: fa + fb (MPa)	17.48	18.15	4.46
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	47.03	47.69	15.39
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	119.25
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	100.34

Check	Small	Small	Cone	Cone	Large	Large

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	Ratio	Result	Ratio	Result	Ratio	Result
Check 1: Stot / Fb	0.132	PASS	0.137	PASS	0.037	PASS
Check 2: Stot1 / Ft	0.114	PASS	0.116	PASS	0.037	PASS
Check 3: fh' < Fh	0.142	PASS	0.000	PASS	0.058	PASS
Stiff Ring Req'd?	0.142	Not Req'd	0.137	Cone OK	0.058	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 10 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 10 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	10.02	0.00	12.01
V:	Vertical Axial Loading (KN)	0.84	0.00	0.95
Sx:	Section Modulus (cm^3)	750.3	750.3	1910.2
Ax:	Cross Sectional Area (sq cm)	98.583	98.583	156.451
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.09	0.09	0.06
fb:	Bending Strss - M/Sx (MPa)	13.35	13.73	6.29
fb':	Localized Bending Stress (MPa)	15.52	15.52	9.18
fh':	Hoop Stress (MPa)	8.23	0.00	4.87
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08	1596.11
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16

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```
Fxc:   Crit Lcl Bklng  (MPa)                          220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)             13.44       13.81
6.35
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)       28.95       29.33
15.53
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                 132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                         110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.101	PASS	0.104	PASS	0.048	PASS
Check 2: Stot1 / Ft	0.070	PASS	0.071	PASS	0.038	PASS
Check 3: fh' < Fh	0.075	PASS	0.000	PASS	0.044	PASS
Stiff Ring Req'd?	0.101	Not Req'd	0.104	Cone OK	0.048	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 10 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0      1000.0
0.0
OD:    Outer Diameter (mm)                          508.0         0.0
1066.8
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                     34.29        0.00
39.93
V:     Vertical Axial Loading (KN)                    1.54        0.00
0.83
Sx:    Section Modulus (cm^3)                       1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                      0.10        0.10
0.03
fb:    Bending Strss - M/Sx (MPa)                    17.95       18.64
4.59
```

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fb':	Localized Bending Stress (MPa)	30.50	30.50	11.31
fh':	Hoop Stress (MPa)	16.17	0.00	6.00
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	198.75
Stot:	Total Stress Check 1: fa + fb (MPa)	18.05	18.74	4.62
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	48.55	49.24	15.93
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	119.25
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	100.34

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.136	PASS	0.142	PASS	0.039	PASS
Check 2: Stot1 / Ft	0.118	PASS	0.119	PASS	0.039	PASS
Check 3: fh' < Fh	0.147	PASS	0.000	PASS	0.060	PASS
Stiff Ring Req'd?	0.147	Not Req'd	0.142	Cone OK	0.060	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 20 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 20 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65

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M:	Overturning Moment (KN-m)	9.56	0.00	11.46
V:	Vertical Axial Loading (KN)	1.65	0.00	1.88
Sx:	Section Modulus (cm^3)	750.3	750.3	1910.2
Ax:	Cross Sectional Area (sq cm)	98.583	98.583	156.451

CALCULATE STRESSES:

fa:	Axial Stress - V/Ax (MPa)	0.17	0.17	0.12
fb:	Bending Strss - M/Sx (MPa)	12.74	13.10	6.00
fb':	Localized Bending Stress (MPa)	14.91	14.91	8.85
fh':	Hoop Stress (MPa)	7.91	0.00	4.69
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08	1596.11
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	220.63
Stot:	Total Stress Check 1: fa + fb (MPa)	12.91	13.27	6.12
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	27.81	28.18	14.97
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	132.38
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	110.32

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.097	PASS	0.100	PASS	0.046	PASS
Check 2: Stot1 / Ft	0.067	PASS	0.068	PASS	0.036	PASS
Check 3: fh' < Fh	0.072	PASS	0.000	PASS	0.043	PASS
Stiff Ring Req'd?	0.097	Not Req'd	0.100	Cone OK	0.046	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 20 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8

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T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	34.11	0.00	39.81
V:	Vertical Axial Loading (KN)	3.16	0.00	1.75
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.20	0.21	0.05
fb:	Bending Strss - M/Sx (MPa)	17.85	18.54	4.58
fb':	Localized Bending Stress (MPa)	30.51	30.51	11.35
fh':	Hoop Stress (MPa)	16.18	0.00	6.02
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	198.75
Stot:	Total Stress Check 1: fa + fb (MPa)	18.06	18.75	4.63
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	48.57	49.26	15.98
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	119.25
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	100.34

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.136	PASS	0.142	PASS	0.039	PASS
Check 2: Stot1 / Ft	0.118	PASS	0.119	PASS	0.039	PASS
Check 3: fh' < Fh	0.147	PASS	0.000	PASS	0.060	PASS
Stiff Ring Req'd?	0.147	Not Req'd	0.142	Cone OK	0.060	Not Req'd

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All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 30 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 30 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	8.81	0.00	10.56
V:	Vertical Axial Loading (KN)	2.41	0.00	2.74
Sx:	Section Modulus (cm^3)	750.3	750.3	1910.2
Ax:	Cross Sectional Area (sq cm)	98.583	98.583	156.451
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.24	0.25	0.18
fb:	Bending Strss - M/Sx (MPa)	11.74	12.07	5.53
fb':	Localized Bending Stress (MPa)	13.84	13.84	8.25
fh':	Hoop Stress (MPa)	7.34	0.00	4.38
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08	1596.11
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	220.63
Stot:	Total Stress Check 1: fa + fb (MPa)	11.98	12.32	5.70
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	25.83	26.17	13.95

```
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                    132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                            110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.091	PASS	0.093	PASS	0.043	PASS
Check 2: Stot1 / Ft	0.063	PASS	0.063	PASS	0.034	PASS
Check 3: fh' < Fh	0.067	PASS	0.000	PASS	0.040	PASS
Stiff Ring Req'd?	0.091	Not Req'd	0.093	Cone OK	0.043	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 30 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0      1000.0
0.0
OD:    Outer Diameter (mm)                            508.0         0.0
1066.8
T:     Thickness (mm)                                  10.0        10.0
10.0
Fys:   Yield Stress (MPa)                             220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                 202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                   117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                           412.65      412.65
412.65

M:     Overturning Moment (KN-m)                       32.85        0.00
38.44
V:     Vertical Axial Loading (KN)                      4.81        0.00
2.76
Sx:    Section Modulus (cm^3)                         1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                 156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                        0.31        0.32
0.08
fb:    Bending Strss - M/Sx (MPa)                      17.19       17.85
4.42
fb':   Localized Bending Stress (MPa)                  29.57       29.57
11.03
fh':   Hoop Stress (MPa)                               15.68        0.00
5.85
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                 1596.11     1596.11
760.05
```

Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	198.75
Stot:	Total Stress Check 1: fa + fb (MPa)	17.50	18.17	4.51
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	47.08	47.75	15.54
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	119.25
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	100.34

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.132	PASS	0.137	PASS	0.038	PASS
Check 2: Stot1 / Ft	0.114	PASS	0.116	PASS	0.038	PASS
Check 3: fh' < Fh	0.142	PASS	0.000	PASS	0.058	PASS
Stiff Ring Req'd?	0.142	Not Req'd	0.137	Cone OK	0.058	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 40 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 40 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large	
Ht:	Height of Cone (mm)	0.0	385.0	0.0	
OD:	Outer Diameter (mm)	323.8	0.0	508.0	
T:	Thickness (mm)	10.0	10.0	10.0	
Fys:	Yield Stress (MPa)	220.63	220.63	220.63	
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50	
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90	
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65	
M:	Overturning Moment (KN-m)	7.79	0.00	9.34	
V:	Vertical Axial Loading (KN)	3.10	0.00	3.53	
Sx:	Section Modulus (cm^3)	750.3	750.3	1910.2	

Ax:	Cross Sectional Area (sq cm)	98.583	98.583	156.451
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.31	0.32	0.23
fb:	Bending Strss - M/Sx (MPa)	10.38	10.68	4.89
fb':	Localized Bending Stress (MPa)	12.36	12.36	7.40
fh':	Hoop Stress (MPa)	6.55	0.00	3.92
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08	1596.11
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	220.63
Stot:	Total Stress Check 1: fa + fb (MPa)	10.70	11.00	5.11
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	23.06	23.36	12.51
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	132.38
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	110.32

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.081	PASS	0.083	PASS	0.039	PASS
Check 2: Stot1 / Ft	0.056	PASS	0.057	PASS	0.030	PASS
Check 3: fh' < Fh	0.059	PASS	0.000	PASS	0.036	PASS
Stiff Ring Req'd?	0.081	Not Req'd	0.083	Cone OK	0.039	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 40 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50

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```
Sa:     Allowable Axial Stress (MPa)                    117.90      117.90
117.90
Ft:     Tensile Stress (MPa)                            412.65      412.65
412.65

M:      Overturning Moment (KN-m)                        30.54        0.00
35.83
V:      Vertical Axial Loading (KN)                       6.48        0.00
3.84
Sx:     Section Modulus (cm^3)                          1910.2      1910.2
8690.0
Ax:     Cross Sectional Area (sq cm)                    156.451     156.451
332.002

CALCULATE STRESSES:
fa:     Axial Stress - V/Ax (MPa)                         0.41        0.43
0.12
fb:     Bending Strss - M/Sx (MPa)                       15.99       16.60
4.12
fb':    Localized Bending Stress (MPa)                   27.71       27.71
10.38
fh':    Hoop Stress (MPa)                                14.70        0.00
5.51
Fhe:    Elas Hoop - 0.4*E*T/OD (MPa)                    1596.11     1596.11
760.05
Fhc:    Hoop Comp - Fys (MPa)                            220.63      220.63
200.67
FhcA:   Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
100.34
Fxe:    Crit Elas-2*0.3*E*T/OD (MPa)                    2394.16     2394.16
1140.08
Fxc:    Crit Lcl Bklng  (MPa)                            220.63      220.63
198.75
Stot:   Total Stress Check 1: fa + fb (MPa)              16.40       17.03
4.24
Stot1:  Total Stress Check 2: fa + fb + fbp (MPa)        44.12       44.74
14.62
Fb:     Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
119.25
Fh:     Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.124	PASS	0.129	PASS	0.036	PASS
Check 2: Stot1 / Ft	0.107	PASS	0.108	PASS	0.035	PASS
Check 3: fh' < Fh	0.133	PASS	0.000	PASS	0.055	PASS
Stiff Ring Req'd?	0.133	Not Req'd	0.129	Cone OK	0.055	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 50 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 50 Deg

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Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	385.0	0.0
OD:	Outer Diameter (mm)	323.8	0.0	508.0
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	6.54	0.00	7.84
V:	Vertical Axial Loading (KN)	3.70	0.00	4.20
Sx:	Section Modulus (cm^3)	750.3	750.3	1910.2
Ax:	Cross Sectional Area (sq cm)	98.583	98.583	156.451
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.38	0.39	0.27
fb:	Bending Strss - M/Sx (MPa)	8.71	8.96	4.10
fb':	Localized Bending Stress (MPa)	10.50	10.50	6.32
fh':	Hoop Stress (MPa)	5.57	0.00	3.35
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08	1596.11
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	220.63
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	110.32
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12	2394.16
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	220.63
Stot:	Total Stress Check 1: fa + fb (MPa)	9.09	9.35	4.37
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	19.59	19.84	10.69
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	132.38
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	110.32

Check	Small	Small	Cone	Cone	Large	Large

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	Ratio	Result	Ratio	Result	Ratio	Result
Check 1: Stot / Fb	0.069	PASS	0.071	PASS	0.033	PASS
Check 2: Stot1 / Ft	0.047	PASS	0.048	PASS	0.026	PASS
Check 3: fh' < Fh	0.050	PASS	0.000	PASS	0.030	PASS
Stiff Ring Req'd?	0.069	Not Req'd	0.071	Cone OK	0.033	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 50 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	27.24	0.00	32.06
V:	Vertical Axial Loading (KN)	8.17	0.00	5.03
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.52	0.54	0.15
fb:	Bending Strss - M/Sx (MPa)	14.26	14.81	3.69
fb':	Localized Bending Stress (MPa)	24.98	24.98	9.41
fh':	Hoop Stress (MPa)	13.25	0.00	4.99
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	198.75

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```
Stot:  Total Stress Check 1: fa + fb (MPa)                  14.78       15.35
3.84
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)            39.76       40.33
13.25
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                      132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                              110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.112	PASS	0.116	PASS	0.032	PASS
Check 2: Stot1 / Ft	0.096	PASS	0.098	PASS	0.032	PASS
Check 3: fh' < Fh	0.120	PASS	0.000	PASS	0.050	PASS
Stiff Ring Req'd?	0.120	Not Req'd	0.116	Cone OK	0.050	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 60 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 60 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone       Large
Ht:    Height of Cone (mm)                              0.0       385.0
0.0
OD:    Outer Diameter (mm)                            323.8         0.0
508.0
T:     Thickness (mm)                                  10.0        10.0
10.0
Fys:   Yield Stress (MPa)                             220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                 202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                   117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                           412.65      412.65
412.65

M:     Overturning Moment (KN-m)                        5.09        0.00
6.10
V:     Vertical Axial Loading (KN)                      4.18        0.00
4.75
Sx:    Section Modulus (cm^3)                          750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                    98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                        0.42        0.44
0.30
fb:    Bending Strss - M/Sx (MPa)                       6.78        6.97
3.19
```

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fb':	Localized Bending Stress (MPa)	8.32	8.32
5.06			
fh':	Hoop Stress (MPa)	4.41	0.00
2.68			
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	2504.08	2504.08
1596.11			
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63
220.63			
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32
110.32			
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	3756.12	3756.12
2394.16			
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63
220.63			
Stot:	Total Stress Check 1: fa + fb (MPa)	7.20	7.41
3.49			
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	15.52	15.72
8.55			
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38
132.38			
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32
110.32			

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.054	PASS	0.056	PASS	0.026	PASS
Check 2: Stot1 / Ft	0.038	PASS	0.038	PASS	0.021	PASS
Check 3: fh' < Fh	0.040	PASS	0.000	PASS	0.024	PASS
Stiff Ring Req'd?	0.054	Not Req'd	0.056	Cone OK	0.026	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 60 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	
0.0				
OD:	Outer Diameter (mm)	508.0	0.0	
1066.8				
T:	Thickness (mm)	10.0	10.0	
10.0				
Fys:	Yield Stress (MPa)	220.63	220.63	
220.63				
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	
202705.50				
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	
117.90				
Ft:	Tensile Stress (MPa)	412.65	412.65	
412.65				
M:	Overturning Moment (KN-m)	23.00	0.00	
27.18				

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```
V:     Vertical Axial Loading (KN)                          9.98        0.00
6.43
Sx:    Section Modulus (cm^3)                             1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                       156.451     156.451
332.002

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                            0.64        0.66
0.19
fb:    Bending Strss - M/Sx (MPa)                          12.04       12.50
3.13
fb':   Localized Bending Stress (MPa)                      21.43       21.43
8.13
fh':   Hoop Stress (MPa)                                   11.36        0.00
4.31
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                      1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                              220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                       110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                      2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                              220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)                 12.68       13.17
3.32
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)           34.11       34.59
11.46
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                     132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                             110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.096	PASS	0.099	PASS	0.028	PASS
Check 2: Stot1 / Ft	0.083	PASS	0.084	PASS	0.028	PASS
Check 3: fh' < Fh	0.103	PASS	0.000	PASS	0.043	PASS
Stiff Ring Req'd?	0.103	Not Req'd	0.099	Cone OK	0.043	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 70 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 70 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                          Small        Cone       Large
Ht:    Height of Cone (mm)                                  0.0       385.0
0.0
OD:    Outer Diameter (mm)                                323.8         0.0
508.0
```

```
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                      3.48        0.00
4.17
V:     Vertical Axial Loading (KN)                    4.54        0.00
5.16
Sx:    Section Modulus (cm^3)                       750.3       750.3
1910.2
Ax:    Cross Sectional Area (sq cm)                  98.583      98.583
156.451

CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                      0.46        0.47
0.33
fb:    Bending Strss - M/Sx (MPa)                     4.64        4.77
2.18
fb':   Localized Bending Stress (MPa)                 5.89        5.89
3.63
fh':   Hoop Stress (MPa)                              3.12        0.00
1.93
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                2504.08     2504.08
1596.11
Fhc:   Hoop Comp - Fys (MPa)                        220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                 110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                        220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)            5.10        5.24
2.51
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)     10.98       11.13
6.15
Fb:    Allow Bend (ASD): .6*Fxc (MPa)               132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                       110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.038	PASS	0.040	PASS	0.019	PASS
Check 2: Stot1 / Ft	0.027	PASS	0.027	PASS	0.015	PASS
Check 3: fh' < Fh	0.028	PASS	0.000	PASS	0.017	PASS
Stiff Ring Req'd?	0.038	Not Req'd	0.040	Cone OK	0.019	Not Req'd

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All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 70 Deg
Load Combination # 4, Dead Weight + Impact

		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	17.86	0.00	21.22
V:	Vertical Axial Loading (KN)	12.20	0.00	8.35
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	0.78	0.81	0.25
fb:	Bending Strss - M/Sx (MPa)	9.35	9.71	2.44
fb':	Localized Bending Stress (MPa)	17.12	17.12	6.59
fh':	Hoop Stress (MPa)	9.08	0.00	3.50
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	198.75
Stot:	Total Stress Check 1: fa + fb (MPa)	10.13	10.52	2.69
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	27.24	27.63	9.29
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	119.25

```
Fh:     Min(Fb, 0.5*Fhc) (MPa)                          110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.077	PASS	0.079	PASS	0.023	PASS
Check 2: Stot1 / Ft	0.066	PASS	0.067	PASS	0.023	PASS
Check 3: fh' < Fh	0.082	PASS	0.000	PASS	0.035	PASS
Stiff Ring Req'd?	0.082	Not Req'd	0.079	Cone OK	0.035	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 80 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 80 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                      Small        Cone        Large
Ht:     Height of Cone (mm)                             0.0       385.0
0.0
OD:     Outer Diameter (mm)                           323.8         0.0
508.0
T:      Thickness (mm)                                 10.0        10.0
10.0
Fys:    Yield Stress (MPa)                            220.63      220.63
220.63
E:      Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:     Allowable Axial Stress (MPa)                  117.90      117.90
117.90
Ft:     Tensile Stress (MPa)                          412.65      412.65
412.65

M:      Overturning Moment (KN-m)                       1.77        0.00
2.12
V:      Vertical Axial Loading (KN)                     4.75        0.00
5.40
Sx:     Section Modulus (cm^3)                         750.3       750.3
1910.2
Ax:     Cross Sectional Area (sq cm)                   98.583      98.583
156.451

CALCULATE STRESSES:
fa:     Axial Stress - V/Ax (MPa)                       0.48        0.50
0.35
fb:     Bending Strss - M/Sx (MPa)                      2.35        2.42
1.11
fb':    Localized Bending Stress (MPa)                  3.28        3.28
2.10
fh':    Hoop Stress (MPa)                               1.74        0.00
1.12
Fhe:    Elas Hoop - 0.4*E*T/OD (MPa)                 2504.08     2504.08
1596.11
```

```
Fhc:   Hoop Comp - Fys (MPa)                          220.63      220.63
220.63
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                   110.32      110.32
110.32
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                  3756.12     3756.12
2394.16
Fxc:   Crit Lcl Bklng  (MPa)                          220.63      220.63
220.63
Stot:  Total Stress Check 1: fa + fb (MPa)              2.84        2.92
1.45
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)        6.11        6.19
3.56
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                 132.38      132.38
132.38
Fh:    Min(Fb, 0.5*Fhc) (MPa)                         110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.021	PASS	0.022	PASS	0.011	PASS
Check 2: Stot1 / Ft	0.015	PASS	0.015	PASS	0.009	PASS
Check 3: fh' < Fh	0.016	PASS	0.000	PASS	0.010	PASS
Stiff Ring Req'd?	0.021	Not Req'd	0.022	Cone OK	0.011	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 80 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                    Small        Cone       Large
Ht:    Height of Cone (mm)                            0.0      1000.0
0.0
OD:    Outer Diameter (mm)                          508.0         0.0
1066.8
T:     Thickness (mm)                                10.0        10.0
10.0
Fys:   Yield Stress (MPa)                           220.63      220.63
220.63
E:     Modulus of Elasticity (MPa)                202705.50   202705.50
202705.50
Sa:    Allowable Axial Stress (MPa)                 117.90      117.90
117.90
Ft:    Tensile Stress (MPa)                         412.65      412.65
412.65

M:     Overturning Moment (KN-m)                     11.56        0.00
13.85
V:     Vertical Axial Loading (KN)                   16.12        0.00
12.08
Sx:    Section Modulus (cm^3)                       1910.2      1910.2
8690.0
Ax:    Cross Sectional Area (sq cm)                156.451     156.451
332.002
```

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```
CALCULATE STRESSES:
fa:    Axial Stress - V/Ax (MPa)                          1.03        1.07
0.36
fb:    Bending Strss - M/Sx (MPa)                         6.05        6.28
1.59
fb':   Localized Bending Stress (MPa)                    11.97       11.97
4.79
fh':   Hoop Stress (MPa)                                  6.35        0.00
2.54
Fhe:   Elas Hoop - 0.4*E*T/OD (MPa)                    1596.11     1596.11
760.05
Fhc:   Hoop Comp - Fys (MPa)                            220.63      220.63
200.67
FhcA:  Allow Hoop Comp-Fhc*.5 (MPa)                     110.32      110.32
100.34
Fxe:   Crit Elas-2*0.3*E*T/OD (MPa)                    2394.16     2394.16
1140.08
Fxc:   Crit Lcl Bklng  (MPa)                            220.63      220.63
198.75
Stot:  Total Stress Check 1: fa + fb (MPa)                7.08        7.35
1.96
Stot1: Total Stress Check 2: fa + fb + fbp (MPa)          19.05       19.32
6.75
Fb:    Allow Bend (ASD): .6*Fxc (MPa)                   132.38      132.38
119.25
Fh:    Min(Fb, 0.5*Fhc) (MPa)                           110.32      110.32
100.34
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.053	PASS	0.056	PASS	0.016	PASS
Check 2: Stot1 / Ft	0.046	PASS	0.047	PASS	0.016	PASS
Check 3: fh' < Fh	0.058	PASS	0.000	PASS	0.025	PASS
Stiff Ring Req'd?	0.058	Not Req'd	0.056	Cone OK	0.025	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Conical Transition Analysis, Angle = 90 Deg

Cone Analysis per API RP 2A-WSD: Elev 11.385 m to 11.000 m, Lift Angle = 90 Deg
Load Combination # 4, Dead Weight + Impact

```
                                                        Small         Cone        Large
Ht:    Height of Cone (mm)                                0.0        385.0
0.0
OD:    Outer Diameter (mm)                              323.8          0.0
508.0
T:     Thickness (mm)                                    10.0         10.0
10.0
Fys:   Yield Stress (MPa)                               220.63       220.63
220.63
E:     Modulus of Elasticity (MPa)                   202705.50    202705.50
202705.50
```

```
Sa:     Allowable Axial Stress (MPa)                    117.90      117.90
117.90
Ft:     Tensile Stress (MPa)                            412.65      412.65
412.65

M:      Overturning Moment (KN-m)                         0.00        0.00
0.00
V:      Vertical Axial Loading (KN)                       4.83        0.00
5.49
Sx:     Section Modulus (cm^3)                           750.3       750.3
1910.2
Ax:     Cross Sectional Area (sq cm)                     98.583      98.583
156.451

CALCULATE STRESSES:
fa:     Axial Stress - V/Ax (MPa)                         0.49        0.50
0.35
fb:     Bending Strss - M/Sx (MPa)                        0.00        0.00
0.00
fb':    Localized Bending Stress (MPa)                    0.57        0.57
0.51
fh':    Hoop Stress (MPa)                                 0.30        0.00
0.27
Fhe:    Elas Hoop - 0.4*E*T/OD (MPa)                   2504.08     2504.08
1596.11
Fhc:    Hoop Comp - Fys (MPa)                           220.63      220.63
220.63
FhcA:   Allow Hoop Comp-Fhc*.5 (MPa)                    110.32      110.32
110.32
Fxe:    Crit Elas-2*0.3*E*T/OD (MPa)                   3756.12     3756.12
2394.16
Fxc:    Crit Lcl Bklng  (MPa)                           220.63      220.63
220.63
Stot:   Total Stress Check 1: fa + fb (MPa)               0.49        0.50
0.35
Stot1:  Total Stress Check 2: fa + fb + fbp (MPa)         1.06        1.07
0.86
Fb:     Allow Bend (ASD): .6*Fxc (MPa)                  132.38      132.38
132.38
Fh:     Min(Fb, 0.5*Fhc) (MPa)                          110.32      110.32
110.32
```

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result
Check 1: Stot / Fb	0.004	PASS	0.004	PASS	0.003	PASS
Check 2: Stot1 / Ft	0.003	PASS	0.003	PASS	0.002	PASS
Check 3: fh' < Fh	0.003	PASS	0.000	PASS	0.002	PASS
Stiff Ring Req'd?	0.004	Not Req'd	0.004	Cone OK	0.003	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Cone Analysis per API RP 2A-WSD: Elev 6.456 m to 5.456 m, Lift Angle = 90 Deg
Load Combination # 4, Dead Weight + Impact

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		Small	Cone	Large
Ht:	Height of Cone (mm)	0.0	1000.0	0.0
OD:	Outer Diameter (mm)	508.0	0.0	1066.8
T:	Thickness (mm)	10.0	10.0	10.0
Fys:	Yield Stress (MPa)	220.63	220.63	220.63
E:	Modulus of Elasticity (MPa)	202705.50	202705.50	202705.50
Sa:	Allowable Axial Stress (MPa)	117.90	117.90	117.90
Ft:	Tensile Stress (MPa)	412.65	412.65	412.65
M:	Overturning Moment (KN-m)	0.00	0.00	0.00
V:	Vertical Axial Loading (KN)	36.15	0.00	32.04
Sx:	Section Modulus (cm^3)	1910.2	1910.2	8690.0
Ax:	Cross Sectional Area (sq cm)	156.451	156.451	332.002
CALCULATE STRESSES:				
fa:	Axial Stress - V/Ax (MPa)	2.31	2.40	0.97
fb:	Bending Strss - M/Sx (MPa)	0.00	0.00	0.00
fb':	Localized Bending Stress (MPa)	3.90	3.90	2.36
fh':	Hoop Stress (MPa)	2.07	0.00	1.25
Fhe:	Elas Hoop - 0.4*E*T/OD (MPa)	1596.11	1596.11	760.05
Fhc:	Hoop Comp - Fys (MPa)	220.63	220.63	200.67
FhcA:	Allow Hoop Comp-Fhc*.5 (MPa)	110.32	110.32	100.34
Fxe:	Crit Elas-2*0.3*E*T/OD (MPa)	2394.16	2394.16	1140.08
Fxc:	Crit Lcl Bklng (MPa)	220.63	220.63	198.75
Stot:	Total Stress Check 1: fa + fb (MPa)	2.31	2.40	0.97
Stot1:	Total Stress Check 2: fa + fb + fbp (MPa)	6.21	6.30	3.33
Fb:	Allow Bend (ASD): .6*Fxc (MPa)	132.38	132.38	119.25
Fh:	Min(Fb, 0.5*Fhc) (MPa)	110.32	110.32	100.34

Check	Small Ratio	Small Result	Cone Ratio	Cone Result	Large Ratio	Large Result

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Check 1: Stot / Fb	0.017	PASS	0.018	PASS	0.008	PASS
Check 2: Stot1 / Ft	0.015	PASS	0.015	PASS	0.008	PASS
Check 3: fh' < Fh	0.019	PASS	0.000	PASS	0.012	PASS
Stiff Ring Req'd?	0.019	Not Req'd	0.018	Cone OK	0.012	Not Req'd

All cone analysis checks Passed And the cone design Is Acceptable

Stack Deflection Lift Angle = 0 Deg
Load Combination Dead Weight

Elev m	Dx mm	Dy mm	Dz mm	Dres mm	Limit mm	Ratio	Rresult
16.500	0.0	-1.6	0.0	1.6	29.0	0.055	Pass
13.452	0.0	0.0	0.0	0.0	13.8	0.001	Pass
11.500	0.0	0.2	0.0	0.2	4.0	0.061	Pass
11.467	0.0	0.2	0.0	0.2	3.8	0.062	Pass
11.385	0.0	0.2	0.0	0.2	3.4	0.063	Pass
11.257	0.0	0.2	0.0	0.2	2.8	0.065	Pass
11.128	0.0	0.1	0.0	0.1	2.1	0.067	Pass
11.000	0.0	0.1	0.0	0.1	1.5	0.068	Pass
10.699	0.0	0.0	0.0	0.0	52.7	0.000	Pass
10.400	0.0	-0.1	0.0	0.1	52.7	0.002	Pass
8.400	0.0	-0.9	0.0	0.9	52.7	0.016	Pass
6.456	0.0	-1.2	0.0	1.2	52.7	0.023	Pass
6.123	0.0	-1.2	0.0	1.2	52.7	0.022	Pass
5.789	0.0	-1.1	0.0	1.1	52.7	0.022	Pass
5.456	0.0	-1.1	0.0	1.1	52.7	0.021	Pass
5.137	0.0	-1.0	0.0	1.0	52.7	0.020	Pass
5.000	0.0	-1.0	0.0	1.0	52.7	0.019	Pass
4.863	0.0	-1.0	0.0	1.0	52.7	0.019	Pass
3.100	0.0	-0.7	0.0	0.7	52.7	0.013	Pass
2.450	0.0	-0.5	0.0	0.5	52.7	0.010	Pass
1.385	0.0	-0.3	0.0	0.3	52.7	0.006	Pass
1.275	0.0	-0.3	0.0	0.3	52.7	0.005	Pass
1.165	0.0	-0.3	0.0	0.3	52.7	0.005	Pass
0.950	0.0	-0.2	0.0	0.2	52.7	0.004	Pass
0.446	0.0	-0.1	0.0	0.1	52.7	0.001	Pass
0.350	0.0	0.0	0.0	0.0	52.7	0.001	Pass
0.305	0.0	0.0	0.0	0.0	52.7	0.001	Pass
0.153	0.0	0.0	0.0	0.0	52.7	0.000	Pass
0.000	0.0	0.0	0.0	0.0	0.8	0.050	Pass

Dres = Max Lateral Displacement: (Dx^2 + Dy^2 + Dz^2)
Ratio = Dres / Limit

Lifting Reactions Summary - Dead Load
*** Angle of Lift relative to grade. 0 Deg is Horizontal and 90 Deg is vertical**

Lift Angle Deg	Lifting Load N	Tailing Load N
0.0	17443	18398
10.0	17666	18174
20.0	17898	17943

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30.0	18155	17686
40.0	18459	17381
50.0	18854	16987
60.0	19425	16416
70.0	20400	15441
80.0	22655	13186
90.0	35841	0

Lifting Reactions Summary - Dead + Impact Load
*** Angle of Lift relative to grade. 0 Deg is Horizontal and 90 Deg is vertical**

Lift Angle Deg	Lifting Load N	Tailing Load N
0.0	26164	27597
10.0	26499	27262
20.0	26847	26914
30.0	27232	26529
40.0	27689	26072
50.0	28281	25480
60.0	29137	24624
70.0	30599	23162
80.0	33982	19779
90.0	53761	0

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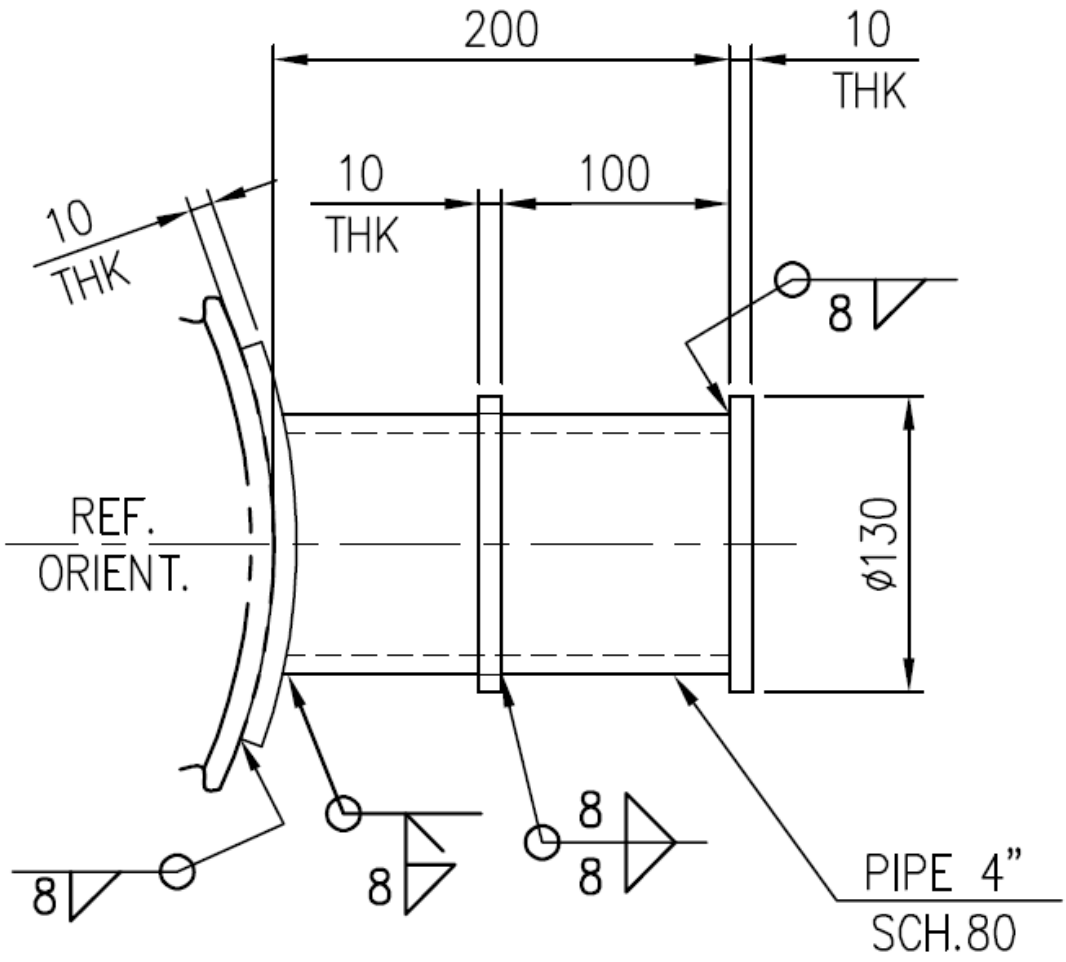
D – LIFTING LUGS ANALYSIS

The desing of the liftign lugs is performed using the loads amplified by a contingency factor that safely envelope the results of both configuration of lifting. The loads are included in the drawing 1724000887-MAC-DD-00019_01 (23-0193-0530A_01) and they are reported hereafter.

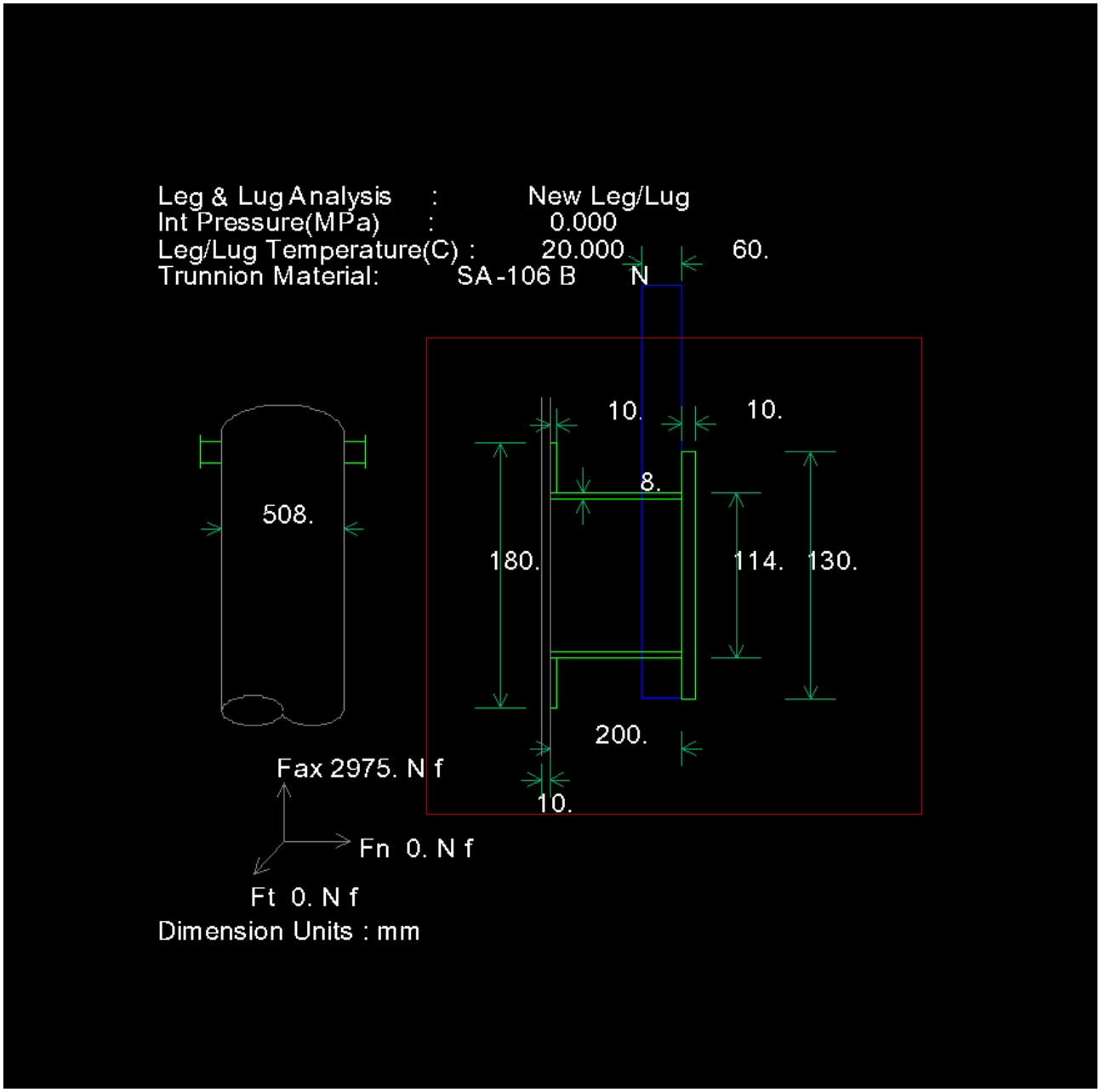
LIFT ANGLE Deg.	LIFTING LOAD kN	TAILING LOAD kN
0	24.95	34.62
10	25.37	34.20
20	25.80	33.77
30	26.29	33.29
40	26.86	32.71
50	27.60	31.97
60	28.68	30.89
70	30.51	29.06
80	34.76	24.82
90	59.57	0.00

D.1 LIFTING TRUNNIONS

The trunnion geoemtry is reported here after.



D.1.1 90° Angle WRC107 ANALYSIS




```
nput Echo, Leg & Lug Item     1,         Description: New Leg/Lug

Design Internal Pressure                              0.00  MPa
Design Temperature for Attachment           TEMP      20.00  C
Vessel Outside Diameter                       OD    508.000  mm.
Vessel Wall Thickness                         Ts    10.0000  mm.
Vessel Corrosion Allowance                   Cas     0.0000  mm.
Vessel Material                                  SA-516 70
Vessel Material UNS Number                          K02700
Vessel Allowable Stress at Design              S    137.90  MPa
```

```
Analysis Type:                                    Trunnion

Empty Weight of Vessel                    Wemp       0.00  N f
Operating Weight of Vessel (vertical load )  W       0.00  N f

Trunnion Material                                  SA-106 B
Trunnion Material UNS Number                         K03006
Trunnion Yield Stress                       SY     241.32  MPa
Trunnion Outside Diameter                  TOD    114.300  mm.
Trunnion Thickness                        TTHK     8.0000  mm.
Trunnion Length                             TL   200.0000  mm.
Bail/Sling Width                            TT    60.0000  mm.
Pad Outside Diameter                       POD    180.000  mm.
Pad Thickness                             PTHK    10.0000  mm.
Ring Outside Diameter                      Rod     130.00  mm.
Ring Thickness                            Rthk      10.00  mm.
Trunnion Type                                      Hollow
Lift Orientation                                   Horizontal
Impact Factor                          Impfac       1.00

Force Along Vessel Axis                     Fax    2975.00  N f
Force Normal to Vessel                       Fn       0.00  N f
Force Tangential to Vessel                   Ft       0.00  N f
Perform WRC-107 Analysis on the Trunnion                   Yes

Occasional Load Factor (AISC A5.2)      Occfac       1.00


Results for Trunnions,  Description :  New Leg/Lug

Trunnion Lifting Load [Tlf]:
 = ((Fa^2 + Ft^2)^1/2)
 = ((2975.00^2 + 0.00^2)^1/2) * 1.00
 = 2975.00 N f

Z = pi * (TOD^4 - TID^4) / (32.0 * TOD)
  = 3.14 * ( 114.30^4 - 98.30^4) / (32.0 * 114.30 )
  = 66402.77 mm.^3

Trunnion Bending Moment [Tmom]:
 = (TL - 0.5 * TT)/1.000* Tlf
 = ( 200.00 - 0.5 * 60.00 )/1.000 * 2975.00
 = 505955.12 N-mm 0.

Trunnion Calculated Bending Stress [SBC]:
 = TMOM * 1.000/ Z
 = 505955 *1.000/ 66402.77
 = 7.62 MPa [Passed] SBC < Min(0.66* SY* Occfac, 0.75* SY) (159.27)

Trunnion Cross Section Area [Txsa]:
 = pi / 4 * (TOD^2- TID^2)
 = 3.14 /4 * ( 114.30^2- 98.30^2)
 = 2671.61 mm^2

Trunnion Calculated Shear Stress [SSC]:
 = Tlf / Txsa
 = 2975.00 / 2671.61
 = 1.11 MPa [Passed] SSC < 0.4 * SY * Occfac (96.53)

Trunnion Unity Check [UCHK]:
 = SBC / SBA + SSC / SSA
 = 7.62 / 159.27 + 1.11 / 96.53
 = 0.06 [Passed] UCHK, Must be less than 1.
```

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Trunnion Bearing Contact Area [Tbca]:
 = TOD * TT
 = 114.30 * 60.00
 = 6858.00 mm^2

Trunnion Bearing Stress [SBEC]:
 = Tlf / Tbca
 = 2975.00 / 6858.00
 = 0.43 MPa [Passed] SBEC < Min(0.75* SY* Occfac, 0.9* SY) (180.99)

Results of WRC-107 Analysis on the trunnion:

Note: This following Stress Analysis assumes that the Trunnion
 passes through the pad and is welded to the shell via a groove weld.
 Additionally the re-pad is welded to the shell at the outside
 edge via a fillet weld.

Stress Attenuation Diameter (for Insert Plates) per WRC 297:
 = NozzleOD + 2 * 1.65 * sqrt( Rmean( t - ca ) )
 = 114.300 + 2 * 1.65 * sqrt( 249.000 ( 10.000 - 0.000 ) )
 = 278.970 mm.

WRC 107 Stress Calculation for OCCasional loads:
Radial Load                                P          0.0  N f
Circumferential Shear                     VC          0.0  N f
Longitudinal Shear                        VL      -2975.0  N f
Circumferential Moment                    MC          0.0  N-mm 0.
Longitudinal Moment                       ML    -505955.1  N-mm 0.
Torsional Moment                          MT          0.0  N-mm 0.

Dimensionless Parameters used :   Gamma =   12.70

Dimensionless Loads for Cylindrical Shells at Attachment Junction:
-------------------------------------------------------------------
Curves read for 1979              Beta  Figure    Value   Location
-------------------------------------------------------------------
N(PHI) / ( P/Rm )                0.197   4C        2.157   (A,B)
N(PHI) / ( P/Rm )                0.197   3C        1.826   (C,D)
M(PHI) / ( P )                   0.197   2C1       0.075   (A,B)
M(PHI) / ( P )                   0.197   1C        0.104   (C,D)
N(PHI) / ( MC/(Rm**2 * Beta) )   0.197   3A        0.423   (A,B,C,D)
M(PHI) / ( MC/(Rm    * Beta) )   0.197   1A        0.094   (A,B,C,D)
N(PHI) / ( ML/(Rm**2 * Beta) )   0.197   3B        1.393   (A,B,C,D)
M(PHI) / ( ML/(Rm    * Beta) )   0.197   1B        0.044   (A,B,C,D)

N(x)   / ( P/Rm )                0.197   3C        1.826   (A,B)
N(x)   / ( P/Rm )                0.197   4C        2.157   (C,D)
M(x)   / ( P )                   0.197   1C1       0.107   (A,B)
M(x)   / ( P )                   0.197   2C        0.074   (C,D)
N(x)   / ( MC/(Rm**2 * Beta) )   0.197   4A        0.663   (A,B,C,D)
M(x)   / ( MC/(Rm    * Beta) )   0.197   2A        0.053   (A,B,C,D)
N(x)   / ( ML/(Rm**2 * Beta) )   0.197   4B        0.416   (A,B,C,D)
M(x)   / ( ML/(Rm    * Beta) )   0.197   2B        0.069   (A,B,C,D)


Stress Concentration Factors: Kn = 1.00,   Kb = 1.00

Stresses in the Vessel at the Attachment Junction (MPa)

               |                   Stress Intensity Values at                                |
Type of        |                                                                             |
Stress    Load |       Au        Al        Bu        Bl        Cu        Cl        Du        Dl|
```

Circ. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML	2.8	2.8	-2.8	-2.8	0.0	0.0	0.0	0.0
Circ. Bend. ML	6.7	-6.7	-6.7	6.7	0.0	0.0	0.0	0.0
Tot. Circ. Str.	9.4	-3.9	-9.4	3.9	0.0	0.0	0.0	0.0
Long. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	0.8	0.8	-0.8	-0.8	0.0	0.0	0.0	0.0
Long. Bend. ML	10.5	-10.5	-10.5	10.5	0.0	0.0	0.0	0.0
Tot. Long. Str.	11.3	-9.7	-11.3	9.7	0.0	0.0	0.0	0.0
Shear VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	0.8	0.8	-0.8	-0.8
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	0.0	0.0	0.0	0.0	0.8	0.8	-0.8	-0.8
Str. Int.	11.3	9.7	11.3	9.7	1.7	1.7	1.7	1.7

Dimensionless Parameters used : Gamma = 24.90

Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.316	4C	3.031	(A,B)
N(PHI) / (P/Rm)	0.316	3C	1.702	(C,D)
M(PHI) / (P)	0.316	2C1	0.022	(A,B)
M(PHI) / (P)	0.316	1C !	0.059	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.316	3A	1.066	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.316	1A	0.075	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.316	3B	2.165	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.316	1B	0.018	(A,B,C,D)
N(x) / (P/Rm)	0.316	3C	1.702	(A,B)
N(x) / (P/Rm)	0.316	4C	3.031	(C,D)
M(x) / (P)	0.316	1C1	0.046	(A,B)
M(x) / (P)	0.316	2C !	0.030	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.316	4A	2.164	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.316	2A	0.032	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.316	4B	1.001	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.316	2B	0.030	(A,B,C,D)

Note - The ! mark next to the figure name denotes curve value exceeded.

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (MPa)

Type of Stress	Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Circ. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML	5.6	5.6	-5.6	-5.6	0.0	0.0	0.0	0.0
Circ. Bend. ML	7.1	-7.1	-7.1	7.1	0.0	0.0	0.0	0.0
Tot. Circ. Str.	12.6	-1.5	-12.6	1.5	0.0	0.0	0.0	0.0
Long. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	2.6	2.6	-2.6	-2.6	0.0	0.0	0.0	0.0
Long. Bend. ML	11.7	-11.7	-11.7	11.7	0.0	0.0	0.0	0.0
Tot. Long. Str.	14.2	-9.1	-14.2	9.1	0.0	0.0	0.0	0.0
Shear VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	1.1	1.1	-1.1	-1.1
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	0.0	0.0	0.0	0.0	1.1	1.1	-1.1	-1.1
Str. Int.	14.2	9.1	14.2	9.1	2.1	2.1	2.1	2.1

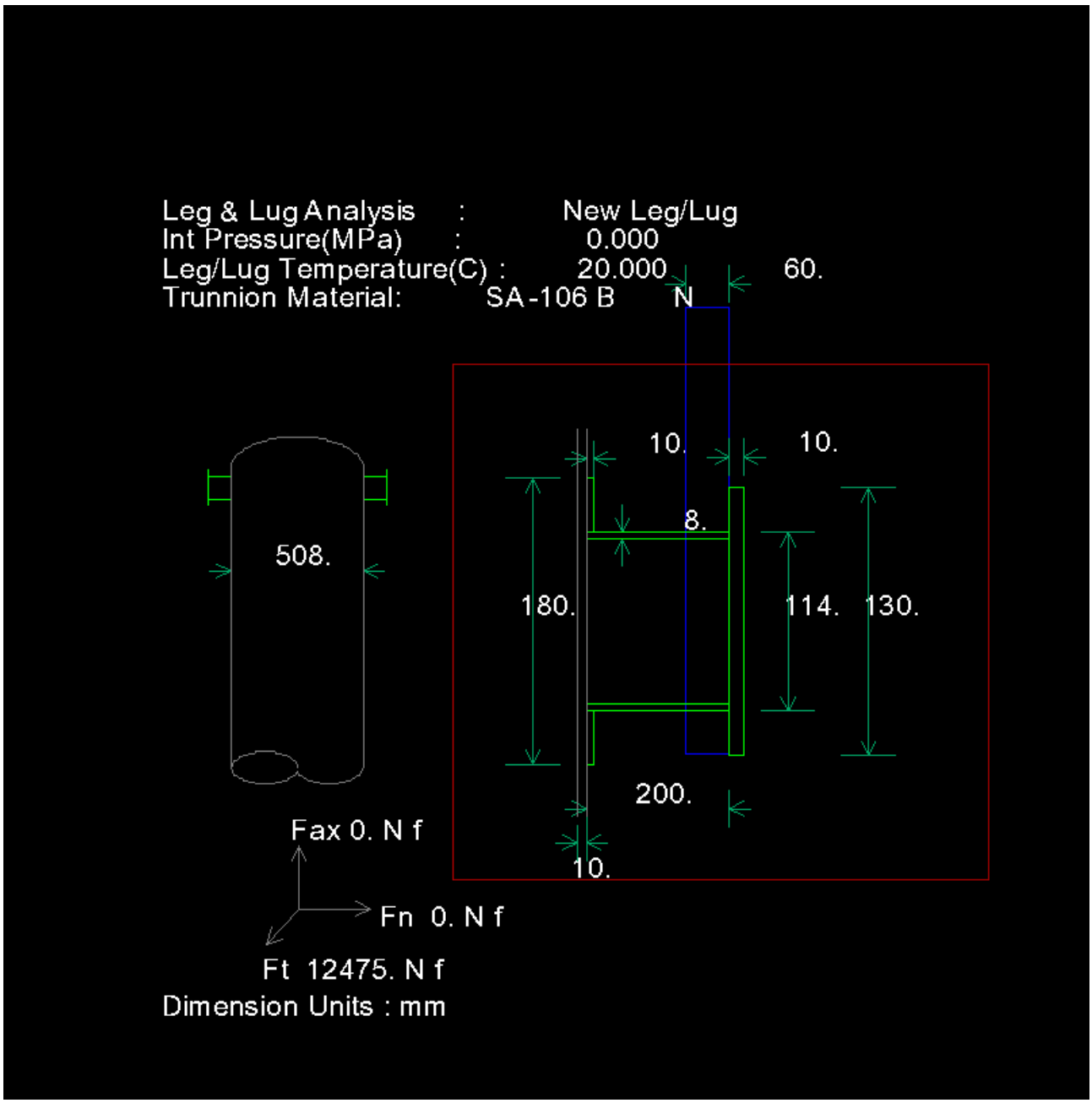
SUMMARY OF RESULTS:

Trunnion unity check value: 0.0594

	Actual	Allowable	Pass/Fail
Bending Stress (MPa)	7.62	159.27	Pass
Shear Stress (MPa)	1.11	96.53	Pass
Bearing Stress (MPa)	0.43	180.99	Pass

Vessel Maximum Stress Intensity Comparison:
At Nozzle Edge: 11.32 Allowable: 1.5 * S: 206.85 MPa [Passed]
At Pad Edge : 14.24 Allowable: 1.5 * S: 206.85 MPa [Passed]

D.1.2 0° Angle WRC107 ANALYSIS




```
nput Echo, Leg & Lug Item     1,         Description: New Leg/Lug

Design Internal Pressure                              0.00  MPa
Design Temperature for Attachment           TEMP     20.00  C
Vessel Outside Diameter                       OD    508.000  mm.
Vessel Wall Thickness                         Ts    10.0000  mm.
Vessel Corrosion Allowance                   Cas     0.0000  mm.
```

```
Vessel Material                                    SA-516 70
Vessel Material UNS Number                           K02700
Vessel Allowable Stress at Design              S     137.90  MPa
Analysis Type:                                     Trunnion

Empty Weight of Vessel                      Wemp       0.00  N f
Operating Weight of Vessel (vertical load )    W       0.00  N f

Trunnion Material                                  SA-106 B
Trunnion Material UNS Number                         K03006
Trunnion Yield Stress                         SY     241.32  MPa
Trunnion Outside Diameter                    TOD    114.300  mm.
Trunnion Thickness                          TTHK     8.0000  mm.
Trunnion Length                               TL   200.0000  mm.
Bail/Sling Width                              TT    60.0000  mm.
Pad Outside Diameter                         POD    180.000  mm.
Pad Thickness                               PTHK    10.0000  mm.
Ring Outside Diameter                        Rod     130.00  mm.
Ring Thickness                              Rthk      10.00  mm.
Trunnion Type                                      Hollow
Lift Orientation                                   Horizontal
Impact Factor                             Impfac       1.00

Force Along Vessel Axis                       Fax       0.00  N f
Force Normal to Vessel                         Fn       0.00  N f
Force Tangential to Vessel                     Ft   12475.00  N f
Perform WRC-107 Analysis on the Trunnion           Yes

Occasional Load Factor (AISC A5.2)        Occfac       1.00


Results for Trunnions,  Description :  New Leg/Lug

Trunnion Lifting Load [Tlf]:
 = ((Fa^2 + Ft^2)^1/2)
 = ((.00^2 + 12475.00^2)^1/2) * 1.00
 = 12475.00 N f

Z = pi * (TOD^4 - TID^4) / (32.0 * TOD)
  = 3.14 * ( 114.30^4 - 98.30^4) / (32.0 * 114.30 )
  = 66402.77 mm.^3

Trunnion Bending Moment [Tmom]:
 = (TL - 0.5 * TT)/1.000* Tlf
 = ( 200.00 - 0.5 * 60.00 )/1.000 * 12475.00
 = 2121610.00 N-mm 0.

Trunnion Calculated Bending Stress [SBC]:
 = TMOM * 1.000/ Z
 = 2121610 *1.000/ 66402.77
 = 31.94 MPa [Passed] SBC < Min(0.66* SY* Occfac, 0.75* SY) (159.27)

Trunnion Cross Section Area [Txsa]:
 = pi / 4 * (TOD^2- TID^2)
 = 3.14 /4 * ( 114.30^2- 98.30^2)
 = 2671.61 mm^2

Trunnion Calculated Shear Stress [SSC]:
 = Tlf / Txsa
 = 12475.00 / 2671.61
 = 4.67 MPa [Passed] SSC < 0.4 * SY * Occfac (96.53)

Trunnion Unity Check [UCHK]:
```

```
 = SBC / SBA + SSC / SSA
 = 31.94 / 159.27 + 4.67 / 96.53
 = 0.25 [Passed] UCHK, Must be less than 1.

Trunnion Bearing Contact Area [Tbca]:
 = TOD * TT
 = 114.30 * 60.00
 = 6858.00 mm^2

Trunnion Bearing Stress [SBEC]:
 = Tlf / Tbca
 = 12475.00 / 6858.00
 = 1.82 MPa [Passed] SBEC < Min(0.75* SY* Occfac, 0.9* SY) (180.99)

Results of WRC-107 Analysis on the trunnion:

Note: This following Stress Analysis assumes that the Trunnion
 passes through the pad and is welded to the shell via a groove weld.
 Additionally the re-pad is welded to the shell at the outside
 edge via a fillet weld.

Stress Attenuation Diameter (for Insert Plates) per WRC 297:
 = NozzleOD + 2 * 1.65 * sqrt( Rmean( t - ca ) )
 = 114.300 + 2 * 1.65 * sqrt( 249.000 ( 10.000 - 0.000 ) )
 = 278.970 mm.

WRC 107 Stress Calculation for OCCasional loads:
Radial Load                                P          0.0  N f
Circumferential Shear                      VC     -12475.0  N f
Longitudinal Shear                         VL          0.0  N f
Circumferential Moment                     MC    2121610.0  N-mm 0.
Longitudinal Moment                        ML          0.0  N-mm 0.
Torsional Moment                           MT          0.0  N-mm 0.

Dimensionless Parameters used :   Gamma =   12.70

Dimensionless Loads for Cylindrical Shells at Attachment Junction:
-------------------------------------------------------------------
Curves read for 1979              Beta  Figure    Value   Location
-------------------------------------------------------------------
N(PHI) / ( P/Rm )                0.197   4C        2.157   (A,B)
N(PHI) / ( P/Rm )                0.197   3C        1.826   (C,D)
M(PHI) / ( P )                   0.197   2C1       0.075   (A,B)
M(PHI) / ( P )                   0.197   1C        0.104   (C,D)
N(PHI) / ( MC/(Rm**2 * Beta) )   0.197   3A        0.423   (A,B,C,D)
M(PHI) / ( MC/(Rm    * Beta) )   0.197   1A        0.094   (A,B,C,D)
N(PHI) / ( ML/(Rm**2 * Beta) )   0.197   3B        1.393   (A,B,C,D)
M(PHI) / ( ML/(Rm    * Beta) )   0.197   1B        0.044   (A,B,C,D)

N(x)   / ( P/Rm )                0.197   3C        1.826   (A,B)
N(x)   / ( P/Rm )                0.197   4C        2.157   (C,D)
M(x)   / ( P )                   0.197   1C1       0.107   (A,B)
M(x)   / ( P )                   0.197   2C        0.074   (C,D)
N(x)   / ( MC/(Rm**2 * Beta) )   0.197   4A        0.663   (A,B,C,D)
M(x)   / ( MC/(Rm    * Beta) )   0.197   2A        0.053   (A,B,C,D)
N(x)   / ( ML/(Rm**2 * Beta) )   0.197   4B        0.416   (A,B,C,D)
M(x)   / ( ML/(Rm    * Beta) )   0.197   2B        0.069   (A,B,C,D)


Stress Concentration Factors: Kn = 1.00,   Kb = 1.00

Stresses in the Vessel at the Attachment Junction (MPa)
```

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Type of Stress	Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb.	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend.	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb.	MC	0.0	0.0	0.0	0.0	-3.5	-3.5	3.5	3.5
Circ. Memb.	MC	0.0	0.0	0.0	0.0	-60.1	60.1	60.1	-60.1
Circ. Memb.	ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend.	ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Circ. Str.		0.0	0.0	0.0	0.0	-63.6	56.5	63.6	-56.5
Long. Memb.	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend.	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb.	MC	0.0	0.0	0.0	0.0	-5.5	-5.5	5.5	5.5
Long. Bend.	MC	0.0	0.0	0.0	0.0	-33.7	33.7	33.7	-33.7
Long. Memb.	ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend.	ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Long. Str.		0.0	0.0	0.0	0.0	-39.2	28.1	39.2	-28.1
Shear	VC	-3.5	-3.5	3.5	3.5	0.0	0.0	0.0	0.0
Shear	VL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear		-3.5	-3.5	3.5	3.5	0.0	0.0	0.0	0.0
Str. Int.		6.9	6.9	6.9	6.9	63.6	56.5	63.6	56.5

Dimensionless Parameters used : Gamma = 24.90

Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.316	4C	3.031	(A,B)
N(PHI) / (P/Rm)	0.316	3C	1.702	(C,D)
M(PHI) / (P)	0.316	2C1	0.022	(A,B)
M(PHI) / (P)	0.316	1C !	0.059	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.316	3A	1.066	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.316	1A	0.075	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.316	3B	2.165	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.316	1B	0.018	(A,B,C,D)
N(x) / (P/Rm)	0.316	3C	1.702	(A,B)
N(x) / (P/Rm)	0.316	4C	3.031	(C,D)
M(x) / (P)	0.316	1C1	0.046	(A,B)
M(x) / (P)	0.316	2C !	0.030	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.316	4A	2.164	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.316	2A	0.032	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.316	4B	1.001	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.316	2B	0.030	(A,B,C,D)

Note - The ! mark next to the figure name denotes curve value exceeded.

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (MPa)

Type of	Stress Intensity Values at

Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	-11.5	-11.5	11.5	11.5
Circ. Memb. MC	0.0	0.0	0.0	0.0	-121.2	121.2	121.2	-121.2
Circ. Memb. ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Circ. Str.	0.0	0.0	0.0	0.0	-132.7	109.7	132.7	-109.7
Long. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC	0.0	0.0	0.0	0.0	-23.4	-23.4	23.4	23.4
Long. Bend. MC	0.0	0.0	0.0	0.0	-51.5	51.5	51.5	-51.5
Long. Memb. ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Long. Str.	0.0	0.0	0.0	0.0	-74.9	28.1	74.9	-28.1
Shear VC	-4.4	-4.4	4.4	4.4	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	-4.4	-4.4	4.4	4.4	0.0	0.0	0.0	0.0
Str. Int.	8.8	8.8	8.8	8.8	132.7	109.7	132.7	109.7

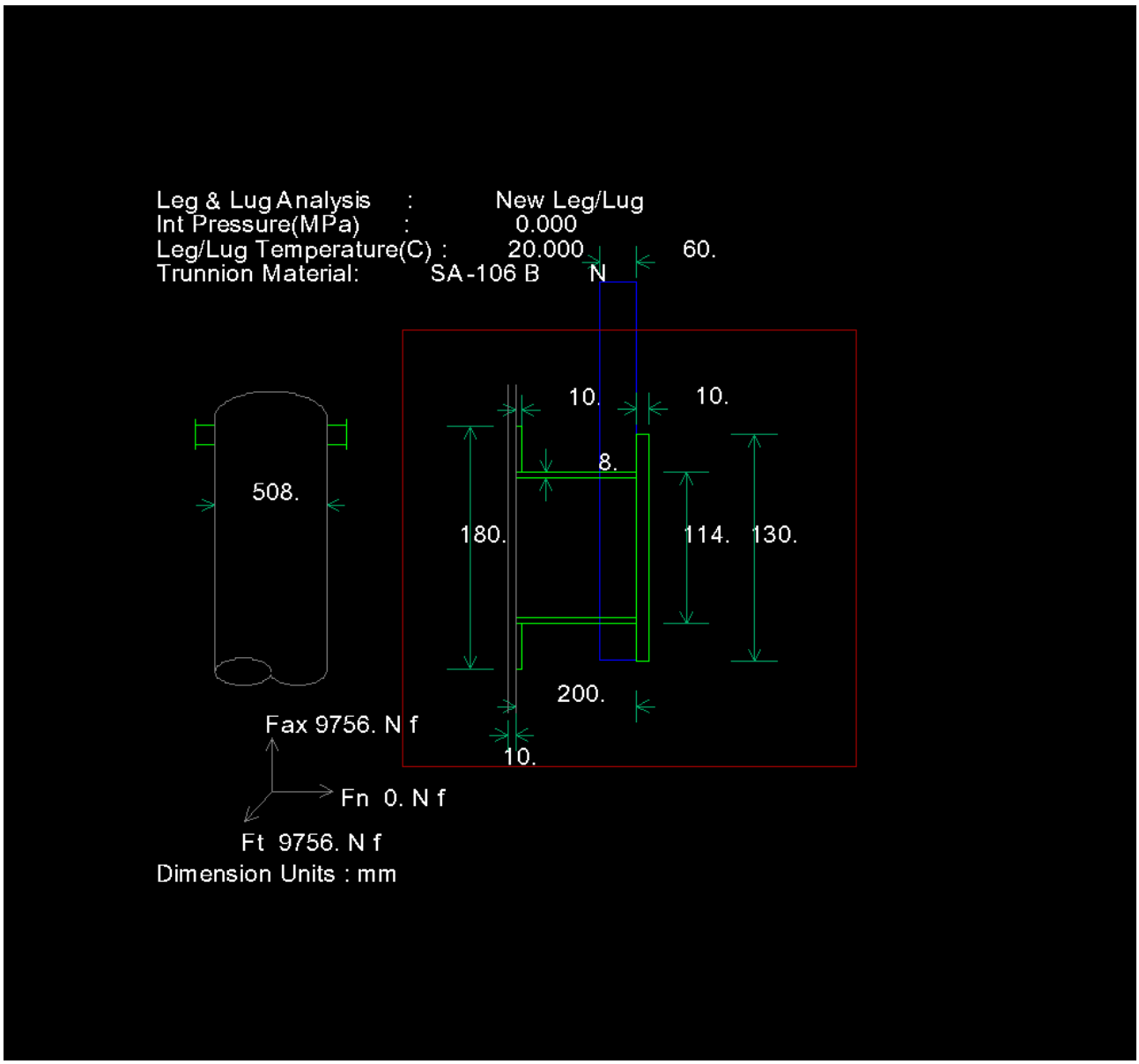
SUMMARY OF RESULTS:

Trunnion unity check value: 0.2489

	Actual	Allowable	Pass/Fail
Bending Stress (MPa)	31.94	159.27	Pass
Shear Stress (MPa)	4.67	96.53	Pass
Bearing Stress (MPa)	1.82	180.99	Pass

Vessel Maximum Stress Intensity Comparison:
At Nozzle Edge: 63.60 Allowable: 1.5 * S: 206.85 MPa [Passed]
At Pad Edge : 132.71 Allowable: 1.5 * S: 206.85 MPa [Passed]

D.1.3 45° Angle WRC107 ANALYSIS




```
nput Echo, Leg & Lug Item     1,         Description: New Leg/Lug

Design Internal Pressure                                0.00  MPa
Design Temperature for Attachment            TEMP      20.00  C
Vessel Outside Diameter                        OD     508.000  mm.
Vessel Wall Thickness                          Ts     10.0000  mm.
Vessel Corrosion Allowance                    Cas      0.0000  mm.
Vessel Material                                     SA-516 70
Vessel Material UNS Number                             K02700
Vessel Allowable Stress at Design                S     137.90  MPa
```

```
Analysis Type:                                    Trunnion

Empty Weight of Vessel                    Wemp       0.00  N f
Operating Weight of Vessel (vertical load )  W       0.00  N f

Trunnion Material                                  SA-106 B
Trunnion Material UNS Number                         K03006
Trunnion Yield Stress                       SY     241.32  MPa
Trunnion Outside Diameter                  TOD    114.300  mm.
Trunnion Thickness                        TTHK     8.0000  mm.
Trunnion Length                             TL   200.0000  mm.
Bail/Sling Width                            TT    60.0000  mm.
Pad Outside Diameter                       POD    180.000  mm.
Pad Thickness                             PTHK    10.0000  mm.
Ring Outside Diameter                      Rod     130.00  mm.
Ring Thickness                            Rthk      10.00  mm.
Trunnion Type                                      Hollow
Lift Orientation                                   Horizontal
Impact Factor                          Impfac       1.00

Force Along Vessel Axis                     Fax    9756.00  N f
Force Normal to Vessel                       Fn       0.00  N f
Force Tangential to Vessel                   Ft    9756.00  N f
Perform WRC-107 Analysis on the Trunnion                   Yes

Occasional Load Factor (AISC A5.2)     Occfac       1.00


Results for Trunnions,  Description :  New Leg/Lug

Trunnion Lifting Load [Tlf]:
 = ((Fa^2 + Ft^2)^1/2)
 = ((9756.00^2 + 9756.00^2)^1/2) * 1.00
 = 13797.07 N f

Z = pi * (TOD^4 - TID^4) / (32.0 * TOD)
  = 3.14 * ( 114.30^4 - 98.30^4) / (32.0 * 114.30 )
  = 66402.77 mm.^3

Trunnion Bending Moment [Tmom]:
 = (TL - 0.5 * TT)/1.000* Tlf
 = ( 200.00 - 0.5 * 60.00 )/1.000 * 13797.07
 = 2346452.50 N-mm 0.

Trunnion Calculated Bending Stress [SBC]:
 = TMOM * 1.000/ Z
 = 2346452 *1.000/ 66402.77
 = 35.33 MPa [Passed] SBC < Min(0.66* SY* Occfac, 0.75* SY) (159.27)

Trunnion Cross Section Area [Txsa]:
 = pi / 4 * (TOD^2- TID^2)
 = 3.14 /4 * ( 114.30^2- 98.30^2)
 = 2671.61 mm^2

Trunnion Calculated Shear Stress [SSC]:
 = Tlf / Txsa
 = 13797.07 / 2671.61
 = 5.16 MPa [Passed] SSC < 0.4 * SY * Occfac (96.53)

Trunnion Unity Check [UCHK]:
 = SBC / SBA + SSC / SSA
 = 35.33 / 159.27 + 5.16 / 96.53
 = 0.28 [Passed] UCHK, Must be less than 1.
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Trunnion Bearing Contact Area [Tbca]:
 = TOD * TT
 = 114.30 * 60.00
 = 6858.00 mm^2

Trunnion Bearing Stress [SBEC]:
 = Tlf / Tbca
 = 13797.07 / 6858.00
 = 2.01 MPa [Passed] SBEC < Min(0.75* SY* Occfac, 0.9* SY) (180.99)

Results of WRC-107 Analysis on the trunnion:

Note: This following Stress Analysis assumes that the Trunnion
 passes through the pad and is welded to the shell via a groove weld.
 Additionally the re-pad is welded to the shell at the outside
 edge via a fillet weld.

Stress Attenuation Diameter (for Insert Plates) per WRC 297:
 = NozzleOD + 2 * 1.65 * sqrt( Rmean( t - ca ) )
 = 114.300 + 2 * 1.65 * sqrt( 249.000 ( 10.000 - 0.000 ) )
 = 278.970 mm.

WRC 107 Stress Calculation for OCCasional loads:
Radial Load                                P          0.0  N f
Circumferential Shear                     VC      -9756.0  N f
Longitudinal Shear                        VL      -9756.0  N f
Circumferential Moment                    MC    1659192.5  N-mm 0.
Longitudinal Moment                       ML   -1659192.5  N-mm 0.
Torsional Moment                          MT          0.0  N-mm 0.

Dimensionless Parameters used :   Gamma =   12.70

Dimensionless Loads for Cylindrical Shells at Attachment Junction:
-------------------------------------------------------------------
Curves read for 1979              Beta  Figure    Value   Location
-------------------------------------------------------------------
N(PHI) / ( P/Rm )                0.197   4C        2.157   (A,B)
N(PHI) / ( P/Rm )                0.197   3C        1.826   (C,D)
M(PHI) / ( P )                   0.197   2C1       0.075   (A,B)
M(PHI) / ( P )                   0.197   1C        0.104   (C,D)
N(PHI) / ( MC/(Rm**2 * Beta) )   0.197   3A        0.423   (A,B,C,D)
M(PHI) / ( MC/(Rm    * Beta) )   0.197   1A        0.094   (A,B,C,D)
N(PHI) / ( ML/(Rm**2 * Beta) )   0.197   3B        1.393   (A,B,C,D)
M(PHI) / ( ML/(Rm    * Beta) )   0.197   1B        0.044   (A,B,C,D)

N(x)   / ( P/Rm )                0.197   3C        1.826   (A,B)
N(x)   / ( P/Rm )                0.197   4C        2.157   (C,D)
M(x)   / ( P )                   0.197   1C1       0.107   (A,B)
M(x)   / ( P )                   0.197   2C        0.074   (C,D)
N(x)   / ( MC/(Rm**2 * Beta) )   0.197   4A        0.663   (A,B,C,D)
M(x)   / ( MC/(Rm    * Beta) )   0.197   2A        0.053   (A,B,C,D)
N(x)   / ( ML/(Rm**2 * Beta) )   0.197   4B        0.416   (A,B,C,D)
M(x)   / ( ML/(Rm    * Beta) )   0.197   2B        0.069   (A,B,C,D)


Stress Concentration Factors: Kn = 1.00,   Kb = 1.00

Stresses in the Vessel at the Attachment Junction (MPa)

               |                   Stress Intensity Values at                                |
Type of        |                                                                             |
Stress    Load |       Au        Al        Bu        Bl        Cu        Cl        Du        Dl|
```

Circ. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	-2.8	-2.8	2.8	2.8
Circ. Memb. MC	0.0	0.0	0.0	0.0	-47.0	47.0	47.0	-47.0
Circ. Memb. ML	9.1	9.1	-9.1	-9.1	0.0	0.0	0.0	0.0
Circ. Bend. ML	21.8	-21.8	-21.8	21.8	0.0	0.0	0.0	0.0
Tot. Circ. Str.	30.9	-12.7	-30.9	12.7	-49.7	44.2	49.7	-44.2
Long. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC	0.0	0.0	0.0	0.0	-4.3	-4.3	4.3	4.3
Long. Bend. MC	0.0	0.0	0.0	0.0	-26.3	26.3	26.3	-26.3
Long. Memb. ML	2.7	2.7	-2.7	-2.7	0.0	0.0	0.0	0.0
Long. Bend. ML	34.4	-34.4	-34.4	34.4	0.0	0.0	0.0	0.0
Tot. Long. Str.	37.1	-31.7	-37.1	31.7	-30.7	22.0	30.7	-22.0
Shear VC	-2.7	-2.7	2.7	2.7	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	2.7	2.7	-2.7	-2.7
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	-2.7	-2.7	2.7	2.7	2.7	2.7	-2.7	-2.7
Str. Int.	38.1	32.1	38.1	32.1	50.1	44.5	50.1	44.5

Dimensionless Parameters used : Gamma = 24.90

Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.316	4C	3.031	(A,B)
N(PHI) / (P/Rm)	0.316	3C	1.702	(C,D)
M(PHI) / (P)	0.316	2C1	0.022	(A,B)
M(PHI) / (P)	0.316	1C !	0.059	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.316	3A	1.066	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.316	1A	0.075	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.316	3B	2.165	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.316	1B	0.018	(A,B,C,D)
N(x) / (P/Rm)	0.316	3C	1.702	(A,B)
N(x) / (P/Rm)	0.316	4C	3.031	(C,D)
M(x) / (P)	0.316	1C1	0.046	(A,B)
M(x) / (P)	0.316	2C !	0.030	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.316	4A	2.164	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.316	2A	0.032	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.316	4B	1.001	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.316	2B	0.030	(A,B,C,D)

Note - The ! mark next to the figure name denotes curve value exceeded.

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (MPa)

Type of Stress	Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Circ. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	-9.0	-9.0	9.0	9.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	-94.8	94.8	94.8	-94.8
Circ. Memb. ML	18.3	18.3	-18.3	-18.3	0.0	0.0	0.0	0.0
Circ. Bend. ML	23.2	-23.2	-23.2	23.2	0.0	0.0	0.0	0.0
Tot. Circ. Str.	41.5	-4.9	-41.5	4.9	-103.8	85.8	103.8	-85.8
Long. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC	0.0	0.0	0.0	0.0	-18.3	-18.3	18.3	18.3
Long. Bend. MC	0.0	0.0	0.0	0.0	-40.3	40.3	40.3	-40.3
Long. Memb. ML	8.5	8.5	-8.5	-8.5	0.0	0.0	0.0	0.0
Long. Bend. ML	38.2	-38.2	-38.2	38.2	0.0	0.0	0.0	0.0
Tot. Long. Str.	46.7	-29.8	-46.7	29.8	-58.6	22.0	58.6	-22.0
Shear VC	-3.5	-3.5	3.5	3.5	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	3.5	3.5	-3.5	-3.5
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	-3.5	-3.5	3.5	3.5	3.5	3.5	-3.5	-3.5
Str. Int.	48.4	30.2	48.4	30.2	104.0	85.9	104.0	85.9

SUMMARY OF RESULTS:

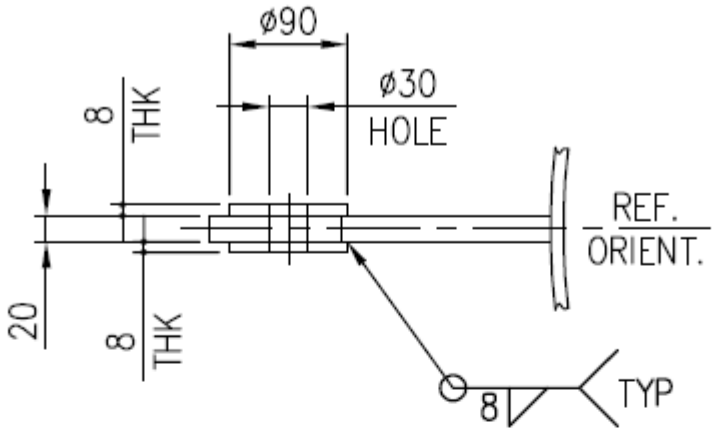
Trunnion unity check value: 0.2753

	Actual	Allowable	Pass/Fail
Bending Stress (MPa)	35.33	159.27	Pass
Shear Stress (MPa)	5.16	96.53	Pass
Bearing Stress (MPa)	2.01	180.99	Pass

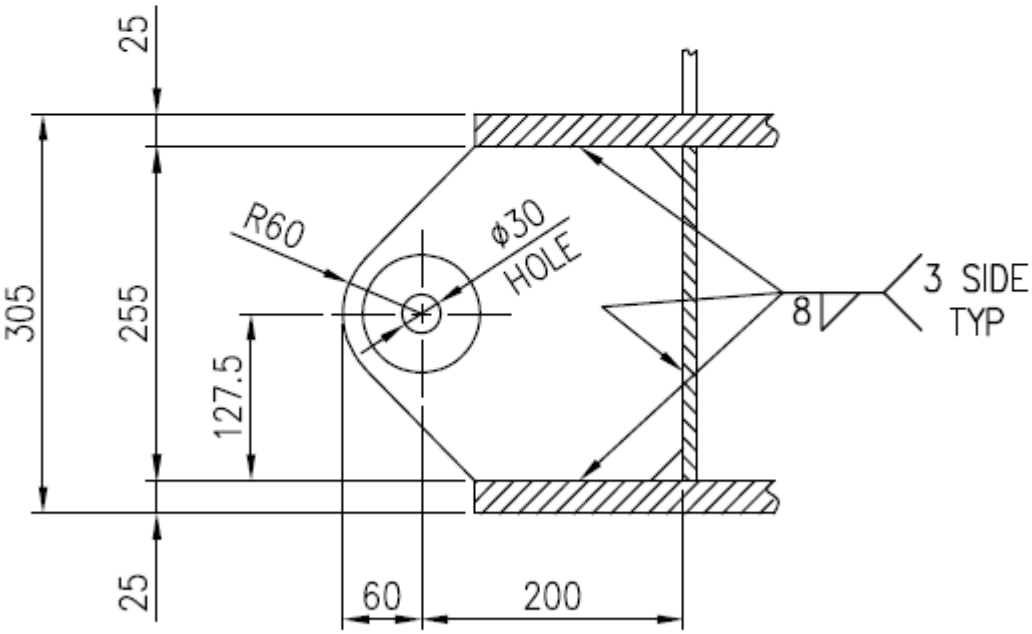
Vessel Maximum Stress Intensity Comparison:
At Nozzle Edge: 50.12 Allowable: 1.5 * S: 206.85 MPa [Passed]
At Pad Edge : 104.04 Allowable: 1.5 * S: 206.85 MPa [Passed]

D.2 TAILING LUG

The tailng lug is obtained by one hole on one of the gusset of the base plate as shown below.



PLAN VIEW



ELEVATION

TAILING LUG DETAIL

The maximum load from the analysis is at 0° and it is 34.62 kN. Considering the stiffnes of the basbearing e ring the only relevant check is related to the bearing strenght of the bolt. Copnsidering EN 1993-3 for the verification the following is the formula for the strenght.

Bearing strength of bolts

The bearing resistance of the bolt $F_{b,Rd}$ should be verified against the applied shear load $F_{v,Ed}$ in accordance with *EN1993-1-8 Table 3.4*:

$F_{b,Rd} = k_1 \cdot \alpha_b \cdot f_u \cdot d \cdot t / \gamma_{M2}$

where:

- f_u is the ultimate tensile strength of the connected plate
- d is the nominal diameter of the bolt.
- t is the thickness of the connected plate.
- γ_{M2} is the partial safety factor for the resistance of bolts in accordance with *EN1993-1-8 §2.2(2) Table 2.1* and the National Annex. The recommended value in EN1993-1-8 is $\gamma_{M2} = 1.25$.

The coefficient k_1 is:

for edge bolts: $k_1 = \min(2.8 \cdot e_2/d_0 - 1.7, 1.4 \cdot p_2/d_0 - 1.7, 2.5)$
for inner bolts: $k_1 = \min(1.4 \cdot p_2/d_0 - 1.7, 2.5)$

where e_2 is the distance between the center of the edge bolt and the end of the plate measured perpendicular to the load transfer direction, p_2 is the distance between the centers of neighboring bolts measured perpendicular to the load transfer direction, and d_0 is the diameter of the bolt hole.

The coefficient α_b is:

$\alpha_b = \min(\alpha_d, f_{ub}/f_u, 1.0)$

for end bolts: $\alpha_d = e_1/(3 \cdot d_0)$
for inner bolts: $\alpha_d = p_1/(3 \cdot d_0) - 1/4$

where e_1 is the distance between the center of the end bolt and the end of the plate measured parallel to the load direction, p_1 is the distance between the centers of neighboring bolts measured parallel to the load direction, and d_0 is the diameter of the bolt hole.

Therefore, based on the equations above, the bearing resistance of the bolt $F_{b,Rd}$ is not affected by the distances e_1, p_1, e_2, p_2 when the following conditions are satisfied:

for edge bolts: $e_1 \geq 3.0 \cdot d_0$ and $e_2 \geq 1.5 \cdot d_0$
for inner bolts: $p_1 \geq 3.75 \cdot d_0$ and $p_2 \geq 3.0 \cdot d_0$

Being:

α_b=1

K1=2.5

FU=430 FOR s275 jr

D= 27 MM

T= 20 MM

Hence the resistance is :

$$F_b = 1 \cdot 2.5 \cdot 430\ MPa \cdot 27\ mm \cdot 20\ mm \frac{1}{1.25} = 464\ kN$$

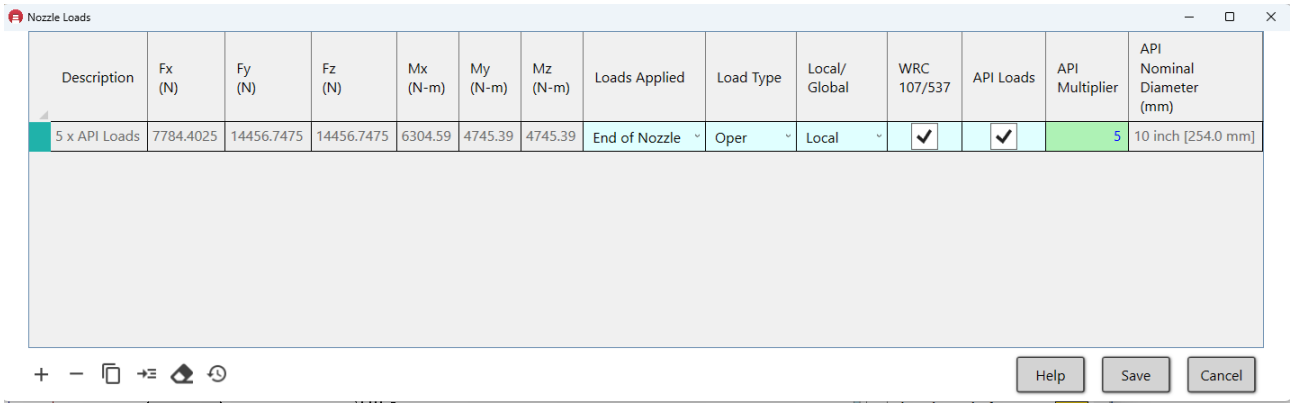
Considering a factoe LRFD action of $35\ kN \cdot 1.5 = 52.5\ kN$

The verification is passed.

E – MISCELLANEUS CALC – DERATING CALCULATION OF THE INLET FLANGE N1 AS PER UG 44(B)

The flange is loaded by the followings external loads:

Nozzle 1N's loads have been calculated with a factor of 5 times the value from API 537.



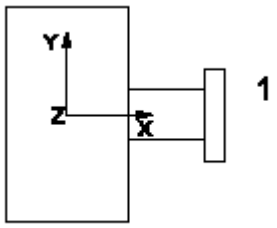


Figure 9 Nozzle 1N loads

As per Ug-44(b) due to the external loads the flange shall be derated to P_D as follow:

$$P_D = \min\left(P_R;\ F_M P_R + P_R - \frac{(16\, M_E + 4\, F_E G)}{\pi\, G^3} \right)$$

To respect the equation:

$$16\, M_E + 4\, F_E\, G \ \leq\ \pi\, G^3\, [\,(P_R - P_D) + (F_M\, P_R)]$$

Being

P_R flange pressure rating at 80°C for flange group 1 (material SA-350 LF2) is 18.42 bar

F_M as per taable UG-44-1 equal to 1.2 for ASME B16.5 Flange #150 less than NPS 12

M_E External moment resultant equal to:

$$M_E = \sqrt{M_Y^2 + M_Z^2} = 4.75\ kNm\ \cdot\sqrt{2} = 6.72\ kNm$$

F_E External tensile axiale force equal to $F_X = 7.78\ kN$

G is the mean gasket diameter (gasket reaction) equal to $G = (D_i + D_o)\frac{1}{2} = (273.05 + 339.73)mm\frac{1}{2} = 306.39\ mm$

Accordingly, the derated pressure of the flange is :

$$P_D = \min\left(18.42\ barg;\ 1.2\ \cdot 18.42\ barg + 18.42\ barg - \frac{16\ \cdot 6.72\ kNm + 4\ \cdot 7.78\ kN\ \cdot 0.306\ m}{\pi\ 0.306^3\ m^3}\ \frac{1}{100}\frac{barg}{kPa}\right)$$
$$= \min(18.42\ barg\ ; 27.52\ barg) = 18.42\ barg$$

There is no change in the pressure-temperature rating of the flange due to the external loads hence the flange doesn't have to be derated.

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