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FITNESS-FOR-SERVICE EVALUATION OF THE VESSEL TO CALCULATE THE MINIMUM RETIREMENT THICKNESS VALUES FOR VARIOUS COMPONENTS OF THE VESSEL

PROBLEM DESCRIPTION:

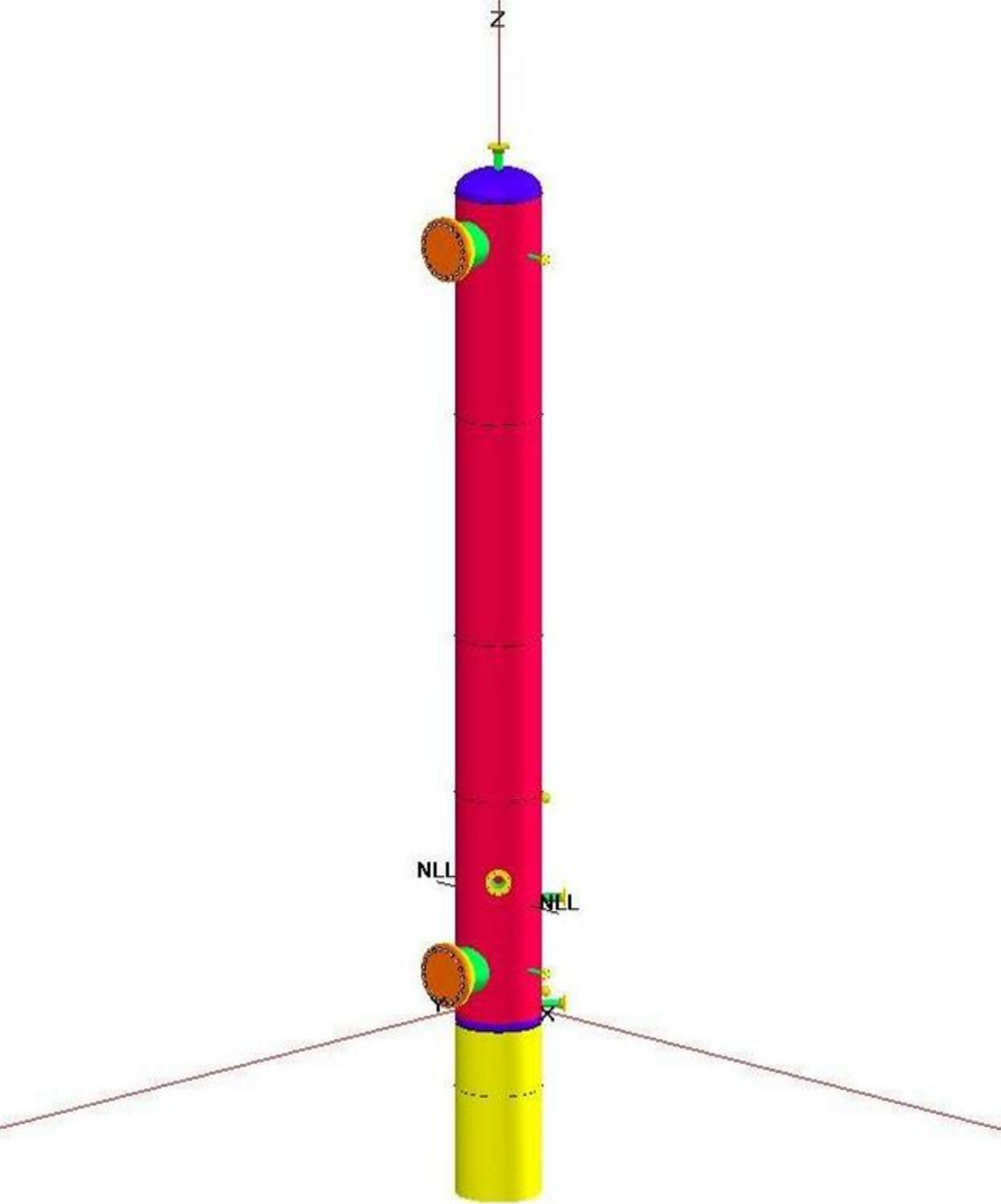
The 1981 original carbon steel vessel was good for 160 psig /15 psi (FV) @ 320 °F. Based on the inspection data and the thickness readings, the replacement stainless steel vessel built in 1987 was indicating low remaining vessel life.

The engineering analysis and fitness-for-service evaluation of the vessel was required to see if the vessel can be qualified for continued operation with current design parameters.

RESULTS:

The vessel was analyzed using the Pressure vessel design and analysis software COMPRESS. While evaluating the vessel, it was determined that the replacement stainless steel vessel built in 1987 had the design deficiency and it was not capable of taking FV @ 320 °F even though it was so stated on the U-1 form. Hence, it was recommended to de-rate the vessel from 160 psig / FV @ 320 °F to 160 psig / 6.4 psi @ 320 °F. The de-rated external pressure value was acceptable for the operation of the vessel. The new recommended minimum retirement thickness values were based on the de-rated MAWP of 160 psig / 6.4 psi @ 320 °F.

It was also determined that with the new retirement thickness values, the vessel had enough safe and useful life for continued operation for next 3 - 4 years.



Pressure Summary

Pressure Summary for Chamber bounded by Bottom Head - Ellipsoidal and Top Head - Ellipsoidal

Identifier	T Design (°F)	MAWP (psi)	MAP (psi)	MAEP (psi)	T _e external (°F)	MDMT Rating		Corrosion Allowance (in)	Impact Test
						MDMT (°F)	Exemption		
Top Head - Ellipsoidal	320.0	164.48	180.95	43.97	320.0	-425.0	Note 1, 2	0.000	No
Straight Flange on Top Head - Ellipsoidal	320.0	163.44	179.80	6.41	320.0	-425.0	Note 2	0.000	No
Shell Ring #4	320.0	163.44	179.80	6.41	320.0	-425.0	Note 2	0.000	No
Shell Ring #3	320.0	163.44	179.80	6.41	320.0	-425.0	Note 2	0.000	No
Shell Ring #2	320.0	163.44	179.80	6.41	320.0	-425.0	Note 2	0.000	No
Shell Ring #1	320.0	161.63	179.80	6.41	320.0	-425.0	Note 2	0.000	No
Straight Flange on Bottom Head - Ellipsoidal	320.0	161.56	179.80	6.41	320.0	-425.0	Note 2	0.000	No
Bottom Head - Ellipsoidal	320.0	162.28	180.95	43.97	320.0	-425.0	Note 1, 2	0.000	No
Nozzle L1A - 3" Dia. (L1A)	320.0	170.34	170.34	6.41	320.0	-425.0	Note 3	0.000	No
Nozzle L1B - 3" Dia. (L1B)	320.0	172.00	172.00	6.41	320.0	-425.0	Note 3	0.000	No
Manway M1 - 20" Dia. (M1)	320.0	166.18	166.18	6.41	320.0	-425.0	Note 3, 3	0.000	No
Manway M2 - 20" Dia. (M2)	320.0	167.50	167.50	6.41	320.0	-425.0	Note 3, 3	0.000	No
Nozzle N1 - 1-1/2" Dia. (N1)	320.0	172.00	172.00	6.41	320.0	-425.0	Note 3	0.000	No
Nozzle N2 - 4" Dia. (N2)	320.0	172.00	172.00	43.97	320.0	-425.0	Note 3, 3	0.000	No
Nozzle N3 - 2" Dia. (N3)	320.0	169.43	169.43	43.97	320.0	-425.0	Note 3	0.000	No

Nozzle N4 - 6" Dia. (N4)	320.0	172.00	172.00	6.41	320.0	-425.0	Note 3, 3	0.000	No
Nozzle N5 - 1-1/2" Dia. (N5)	320.0	170.99	170.99	6.41	320.0	-425.0	Note 3	0.000	No
Nozzle P1 - 1-1/2" Dia. (P1)	320.0	172.00	172.00	6.41	320.0	-425.0	Note 3	0.000	No
Nozzle P2 - 1-1/2" Dia. (P2)	320.0	172.00	172.00	6.41	320.0	-425.0	Note 3	0.000	No
Nozzle T1 - 1-1/2" Dia. (T1)	320.0	170.34	170.34	6.41	320.0	-425.0	Note 3	0.000	No

Chamber design MDMT is 20.00°F

Chamber rated MDMT is -425.00°F

Chamber MAWP hot & corroded is 161.56 psi @ 320.0°F

Chamber MAP cold & new is 166.18 psi @ 70.0°F

Chamber MAEP is 6.41 psi @ 320.0°F

Vacuum rings did not govern the external pressure rating.

Design notes are available on the [Settings Summary](#) page.

Thickness Summary

Component Identifier	Material	Diameter (in)	Length (in)	Nominal t (in)	Design t (in)	Joint E	Load
Top Head - Ellipsoidal	SA-240 304L	36.50 OD	9.24	0.2300*	0.2239	0.8500	Internal
Straight Flange on Top Head - Ellipsoidal	SA-240 304L	36.50 OD	1.50	0.2300	0.3158	0.8500	External
Shell Ring #4	SA-240 304L	36.50 OD	96.00	0.2300	0.3158	0.8500	External
Shell Ring #3	SA-240 304L	36.50 OD	96.00	0.2300	0.3158	0.8500	External
Shell Ring #2	SA-240 304L	36.50 OD	68.00	0.2300	0.3158	0.8500	External
Shell Ring #1	SA-240 304L	36.50 OD	96.00	0.2300	0.3158	0.8500	External
Straight Flange on Bottom Head - Ellipsoidal	SA-240 304L	36.50 OD	2.00	0.2300	0.3158	0.8500	External
Bottom Head - Ellipsoidal	SA-240 304L	36.50 OD	9.24	0.2300*	0.2269	0.8500	Internal
Support Skirt - Top	SA-240 304L	36.50 OD	28.00	0.2500	0.1177	0.5500	Wind
Support Skirt - Bottom	SA-516 70	36.50 OD	46.00	0.3000	0.0678	0.7000	Wind

Nominal t: Vessel wall nominal thickness

Design t: Required vessel thickness due to governing loading + corrosion

Joint E: Longitudinal seam joint efficiency

* Head minimum thickness

Load

internal: Circumferential stress due to internal pressure governs

external: External pressure governs

Wind: Combined longitudinal stress of pressure + weight + wind governs

Seismic: Combined longitudinal stress of pressure + weight + seismic governs

Nozzle Summary

Nozzle mark	OD (in)	t_n (in)	Req t_n (in)	$A_1?$	$A_2?$	Shell			Reinforcement Pad		Corr (in)	A_a/A_r (%)
						Nom t (in)	Design t (in)	User t (in)	Width (in)	t_{pad} (in)		
L1A	3.50	0.1800	0.0714	Yes	Yes	0.2300	N/A		N/A	N/A	0.0000	Exempt
L1B	3.50	0.1800	0.0714	Yes	Yes	0.2300	N/A		N/A	N/A	0.0000	Exempt
M1	20.00	0.3000	0.1451	Yes	Yes	0.2300	0.2005		6.0000	0.2500	0.0000	100.0
M2	20.00	0.3000	0.1450	Yes	Yes	0.2300	0.2005		6.0000	0.2500	0.0000	100.1
N1	1.90	0.1200	0.0714	Yes	Yes	0.2300	N/A		N/A	N/A	0.0000	Exempt
N2	4.50	0.2000	0.0714	Yes	Yes	0.2300*	0.1853		2.0000	0.2500	0.0000	172.7
N3	2.38	0.1200	0.0714	Yes	Yes	0.2300*	N/A		N/A	N/A	0.0000	Exempt
N4	6.63	0.2400	0.0714	Yes	Yes	0.2300	0.2059		2.0000	0.2500	0.0000	114.3
N5	1.90	0.1200	0.0714	Yes	Yes	0.2300	N/A		N/A	N/A	0.0000	Exempt
P1	1.90	0.1200	0.0714	Yes	Yes	0.2300	N/A		N/A	N/A	0.0000	Exempt
P2	1.90	0.1200	0.0714	Yes	Yes	0.2300	N/A		N/A	N/A	0.0000	Exempt
T1	1.90	0.1200	0.0714	Yes	Yes	0.2300	N/A		N/A	N/A	0.0000	Exempt

t_n : Nozzle thickness

Req t_n : Nozzle thickness required per UG-45/UG-16

Nom t: Vessel wall thickness

Design t: Required vessel wall thickness due to pressure + corrosion allowance per UG-37

User t: Local vessel wall thickness (near opening)

A_a : Area available per UG-37, governing condition

A_r : Area required per UG-37, governing condition

Corr: Corrosion allowance on nozzle wall

* Head minimum thickness

Nozzle Schedule

Nozzle mark	Service	Size	Materials								
			Nozzle	Impact	Norm	Fine Grain	Pad	Impact	Norm	Fine Grain	Flange
L1A	Nozzle L1A - 3" Dia.	3.14 IDx0.18	SA-312 TP304L Wld pipe	No	No	No	N/A	N/A	N/A	N/A	WN A182 F304L 150#
L1B	Nozzle L1B - 3" Dia.	3.14 IDx0.18	SA-312 TP304L Wld pipe	No	No	No	N/A	N/A	N/A	N/A	WN A182 F304L 150#
M1	Manway M1 - 20" Dia.	19.40 IDx0.30	SA-312 TP304L Wld pipe	No	No	No	SA-240 304L	No	No	No	WN A182 F304L 150#
M2	Manway M2 - 20" Dia.	19.40 IDx0.30	SA-312 TP304L Wld pipe	No	No	No	SA-240 304L	No	No	No	WN A182 F304L 150#
N1	Nozzle N1 - 1-1/2" Dia.	1.66 IDx0.12	SA-312 TP304L Wld pipe	No	No	No	N/A	N/A	N/A	N/A	WN A182 F304L 150#
N2	Nozzle N2 - 4" Dia.	4.10 IDx0.20	SA-312 TP304L Wld pipe	No	No	No	SA-240 304L	No	No	No	WN A182 F304L 150#
N3	Nozzle N3 - 2" Dia.	2.13 IDx0.12	SA-312 TP304L Wld pipe	No	No	No	N/A	N/A	N/A	N/A	WN A182 F304L 150#
N4	Nozzle N4 - 6" Dia.	6.14 IDx0.24	SA-312 TP304L Wld pipe	No	No	No	SA-240 304L	No	No	No	WN A182 F304L 150#

N5	Nozzle N5 - 1- 1/2" Dia.	1.66 IDx0.12	SA-312 TP304L Wld pipe	No	No	No	N/A	N/A	N/A	N/A	WN A182 F304L 150#
P1	Nozzle P1 - 1- 1/2" Dia.	1.66 IDx0.12	SA-312 TP304L Wld pipe	No	No	No	N/A	N/A	N/A	N/A	WN A182 F304L 150#
P2	Nozzle P2 - 1- 1/2" Dia.	1.66 IDx0.12	SA-312 TP304L Wld pipe	No	No	No	N/A	N/A	N/A	N/A	WN A182 F304L 150#
T1	Nozzle T1 - 1- 1/2" Dia.	1.66 IDx0.12	SA-312 TP304L Wld pipe	No	No	No	N/A	N/A	N/A	N/A	WN A182 F304L 150#