



پتروشیمی توسعه پارک  
سناستی گوهر آفوغ



BINA EPC Contractor Co.

(Executor of Oil, Gas, Petrochemical & Power Industries)

Toase-eh Park Sanati Gohar Ofogh Petrochemical Co.

**CONCEPTUAL, BASIC and DETAIL DESIGN  
ENGINEERING OF STYRENE PARK OFFSITE**

Document Title: Strength Calculation-Active Carbon Filter

Document No. : EI027-HRC-VD-ME-CAL-003

**ENBR**  
TEKNOLOJI



Rev.: 01

Page 1 of 149

# STYRENE PARK OFFSITE

**Document Title:**

**Strength Calculation-Active Carbon Filter**

Rev.	Issued Date	DESCRIPTION	PREPARED	CHECKED	APPROVED
01	08 / Apr. / 2024	Issued for Approval	A. Azodi	E. Malek	M. Shariati
00	27 / Feb. / 2024	Issued for Approval	A. Azodi	E. Malek	M. Shariati



**B** BINA EPC Contractor Co.  
(Executor of Oil, Gas, Petrochemical & Power Industries)

Toase-eh Park Sanati Gohar Ofogh Petrochemical Co.

**CONCEPTUAL, BASIC and DETAIL DESIGN ENGINEERING OF STYRENE  
PARK OFFSITE**

Document Title: Strength Calculation-Active Carbon Filter

Document No. : EI027-HRC-VD-ME-CAL-003



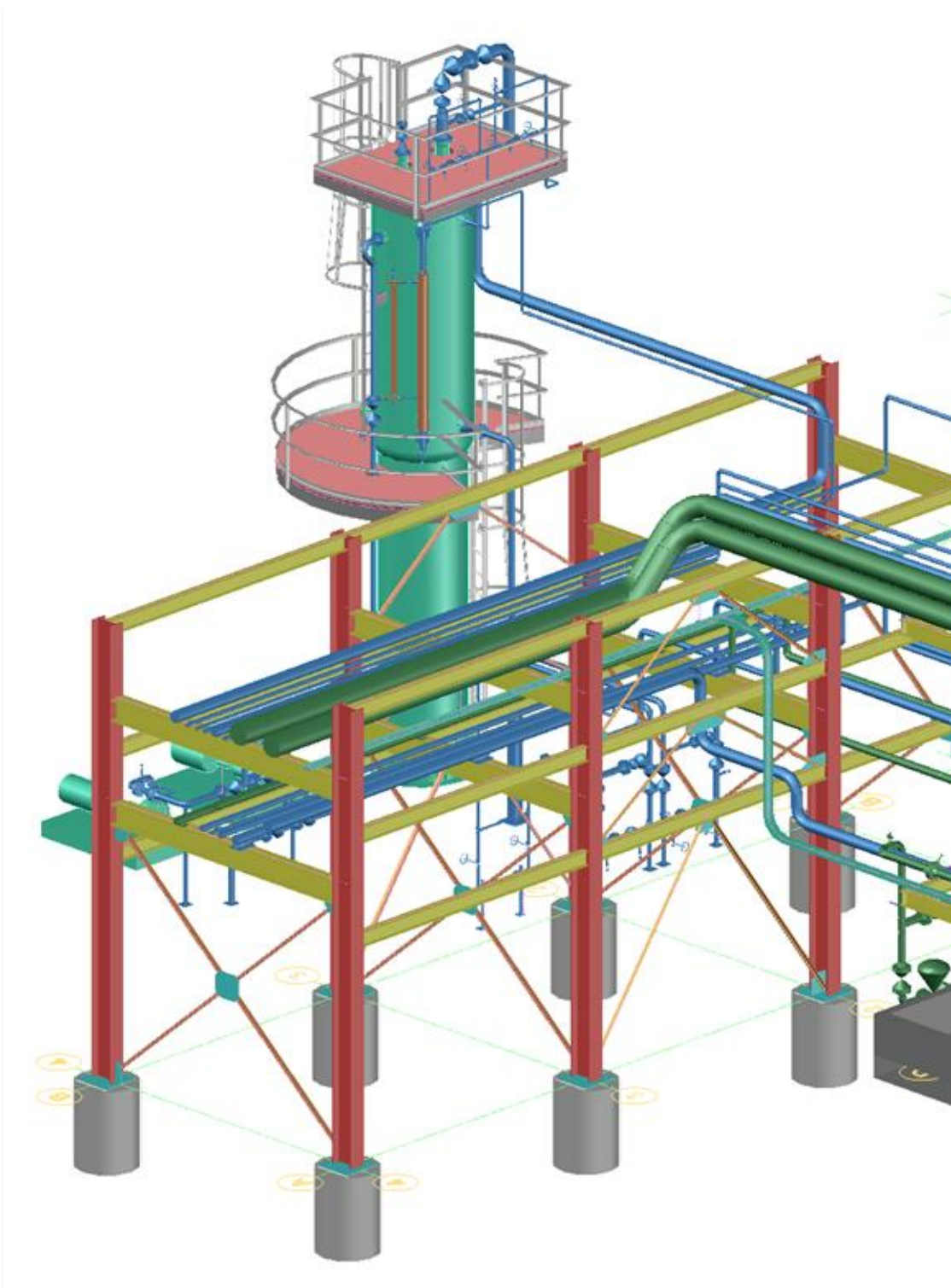
Rev.: 01

Page 2 of 149

Page	Revisions						
	00	01	02	03	04	05	06
1	X	X					
2	X	X					
3	X	X					
4	X	X					
5	X	X					
6	X	X					
7	X	X					
8	X	X					
9	X	X					
10	X	X					
11	X	X					
12	X	X					
13	X	X					
14	X	X					
15	X	X					
16	X	X					
17	X	X					
18	X	X					
19	X	X					
20	X	X					
21	X	X					
22	X	X					
23	X	X					
24	X	X					
25	X	X					
26	X	X					
27	X	X					
28	X	X					
29	X	X					
30	X	X					
31	X	X					
32	X	X					
33	X	X					
34	X	X					
35	X	X					
36	X	X					
37	X	X					
38	X	X					
39	X	X					
40	X	X					

Page	Revisions						
	00	01	02	03	04	05	06
41	X	X					
42	X	X					
43	X	X					
44	X	X					
45	X	X					
46	X	X					
47	X	X					
48	X	X					
49	X	X					
50	X	X					
51	X	X					
52	X	X					
53	X	X					
54	X	X					
55	X	X					
56	X	X					
57	X	X					
58	X	X					
59	X	X					
60	X	X					
61	X	X					
62	X	X					
63	X	X					
64	X	X					
65	X	X					
66	X	X					
67	X	X					
68	X	X					
69	X	X					
70	X	X					
71	X	X					
72	X	X					
.	X	X					
.	X	X					
.	X	X					
149	X	X					
.	X						
.	X						
.	X						
155	X						

## Project Data Page:

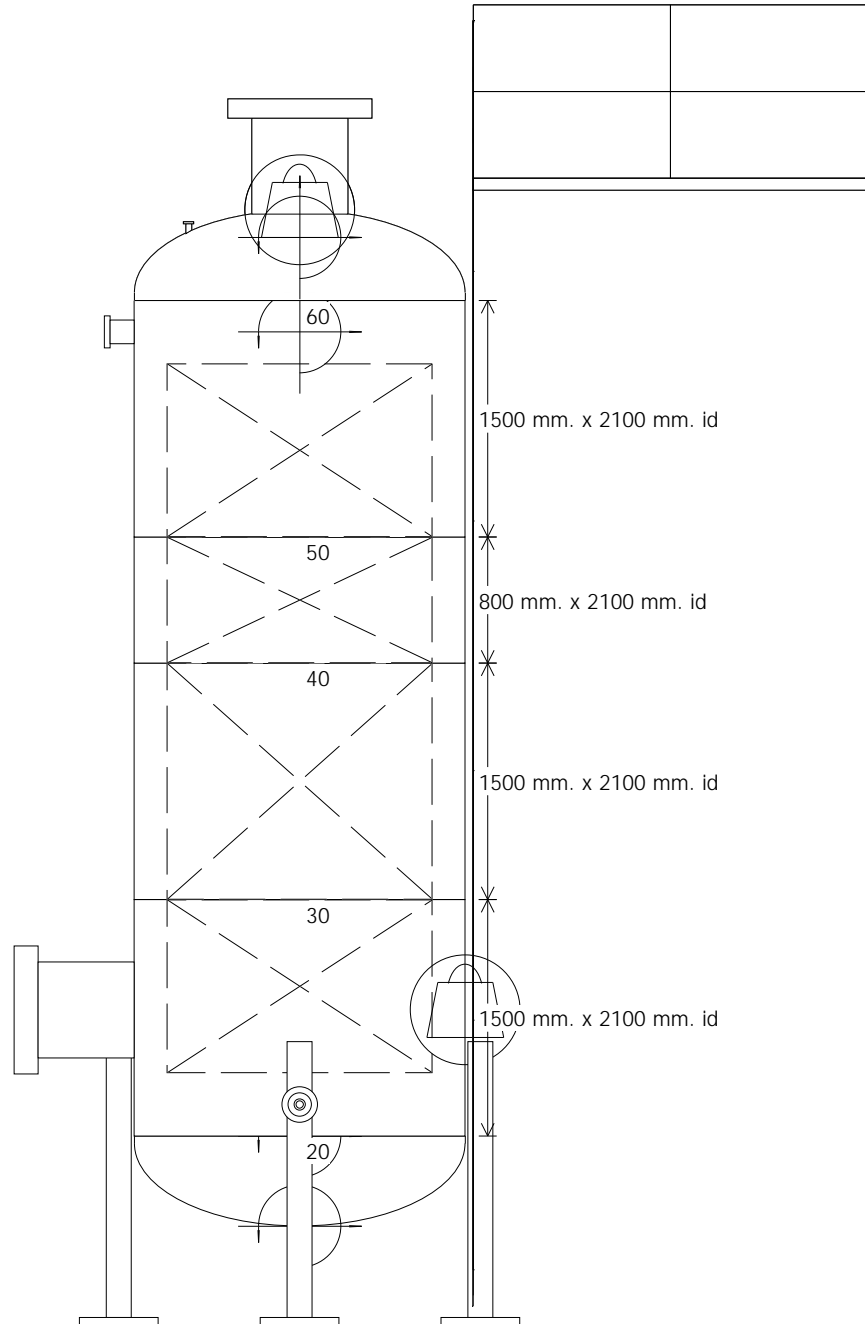




**PV Elite<sup>®</sup> 2019**



**HEXAGON**  
PPM





Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

---

Table of Contents

Cover Page	1
Title Page	2
Warnings and Errors:	3
Input Echo:	4
XY Coordinate Calculations:	14
Internal Pressure Calculations:	15
External Pressure Calculations:	23
Element and Detail Weights:	28
Nozzle Flange MAWP:	31
Natural Frequency Calculation:	32
Forces/Moments Applied to Vessel	33
Wind Load Calculation:	34
Earthquake Load Calculation:	36
User Force/Moment Shear and Bendi	38
Wind/Earthquake Shear, Bending:	39
Wind Deflection:	40
Longitudinal Stress Constants:	42
Longitudinal Allowable Stresses:	43
Longitudinal Stresses due to:	44
Stress due to Combined Loads:	46
Center of Gravity Calculation:	51
Lifting Lug Calcs: Lifting Lugs	53
Leg Check, (Operating Case):	62
Nozzle Summary:	74
Nozzle Calcs.: Drain - 3in	75
Nozzle Calcs.: MH1 - 24in	84
Nozzle Calcs.: Gas In - 6in	90
Nozzle Calcs.: Utility - 2in	102
Nozzle Calcs.: Gas Out - 6in	106
Nozzle Calcs.: PG - 1in	118
Nozzle Calcs.: MH2 - 24in	121
Nozzle Calcs.: Vent - 2in	127
Nozzle Schedule:	137
MDMT Summary:	139
Vessel Design Summary:	141



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

**DESIGN CALCULATION**

*In Accordance with ASME Section VIII Division 1*

ASME Code Version : 2017

Analysis Performed by : SPLM Licensed User

Job File : C:\USERS\A.AZODI\DESKTOP\EI027-HRC-VD-ME-CAL-003

Date of Analysis : Apr 8,2024 1:37pm

PV Elite 2019 SP1, March 2019

---



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.

---



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 3 of 143

Warnings and Errors:

Step: 0

1:37pm

Apr 8, 2024

Class From To : Basic Element Checks.

```
=====  
Note 10 20 The wind diameter multiplier is very big.  
Note 20 30 The wind diameter multiplier is very big.  
Note 30 40 The wind diameter multiplier is very big.  
Note 40 50 The wind diameter multiplier is very big.  
Note 50 60 The wind diameter multiplier is very big.  
Note 60 70 The wind diameter multiplier is very big.
```

Class From To: Check of Additional Element Data

```
=====
```

There were no geometry errors or warnings.

**PV Elite is a trademark of Intergraph CADWorx & Analysis Solutions, Inc. 2019**



Strength Calculation-Active Carbon Filter
Design by A. Azodi
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 4 of 143

Input Echo:

Step: 1 1:37pm Apr 8,2024

• PV Elite Vessel Analysis Program: Input Data

Strength Calculation-Active Carbon Filter
Design by A. Azodi
Rev.01

Design Internal Pressure (for Hydrotest) 0.2 bars
Design Internal Temperature 85.0 °C
Type of Hydrotest UG-99(b)
Hydrotest Position Horizontal
Projection of Nozzle from Vessel Top 0 mm.
Projection of Nozzle from Vessel Bottom 0 mm.
Minimum Design Metal Temperature -5.0 °C
Type of Construction Welded
Special Service Air/Water/Steam
Degree of Radiography RT-1
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 Y

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 UBC-94/97
UBC Design Wind Speed 125 Km/hr
UBC Exposure Constant C: Open Terrain
UBC Importance Factor 1.15
UBC Base Elevation 0 mm.
UBC Percent Wind for Hydrotest 33.0
Using User defined Wind Press. Vs Elev. N
Damping Factor (Beta) for Wind (Ope) 0.0100
Damping Factor (Beta) for Wind (Empty) 0.0000
Damping Factor (Beta) for Wind (Filled) 0.0000

Seismic Design Code ASCE/SEI 7-16



Strength Calculation-Active Carbon Filter
Design by A. Azodi
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 5 of 143

Input Echo: Step: 1 1:37pm Apr 8,2024

Table with 2 columns: Parameter and Value. Parameters include Seismic Load Reduction Scale Factor (0.714), Importance Factor (1.250), Table Value Fa (1.050), Table Value Fv (1.100), Max. Mapped Res. Acceleration [Ss] (1.310), Max. Eff. Ground Acceleration [S] (0.460), Force Modification Factor R (2.000), Site Class (C), Component Elevation Ratio z/h (0.000), Amplification Factor Ap (0.000), Force Factor (0.000), Consider Vertical Acceleration (No), Minimum Acceleration Multiplier (0.000), User Value of Sds (used if > 0) (0.920), User Value of Sd1 (used if > 0) (0.340), Moment Reduction Factor Tau (1.000).

Table with 2 columns: Parameter and Value. Parameters include Design Pressure + Static Head (Y), Consider MAP New and Cold in Noz. Design (N), Consider External Loads for Nozzle Des. (Y), Use ASME VIII-1 Appendix 1-9 (N).

Material Database Year Current w/Addenda or Code Year

Configuration Directives:

Table with 2 columns: Directive and Value. Directives include Do not use Nozzle MDMT Interpretation VIII-1 01-37 (No), Use Table G instead of exact equation for "A" (Yes), Shell Head Joints are Tapered (Yes), Compute "K" in corroded condition (Yes), Use Code Case 2286 (No), Use the MAWP to compute the MDMT (Yes), 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) (No).

Complete Listing of Vessel Elements and Details:

Table with 2 columns: Parameter and Value. Parameters include Element From Node (10), Element To Node (20), Element Type (Elliptical), Description (Lower Head), Distance "FROM" to "TO" (50 mm.), Inside Diameter (2100 mm.), Element Thickness (5.5 mm.), Internal Corrosion Allowance (3 mm.), Nominal Thickness (8 mm.), External Corrosion Allowance (0 mm.), Design Internal Pressure (0.2 bars), Design Temperature Internal Pressure (85 °C), Design External Pressure (0.1 bars), Design Temperature External Pressure (85 °C), Effective Diameter Multiplier (1.6).



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User  
FileName : EI027-HRC-VD-ME-CAL-003-01

Input Echo: Step: 1 1:37pm Apr 8,2024

Material Name	SA-516 70
Allowable Stress, Ambient	137.9 N./mm <sup>2</sup>
Allowable Stress, Operating	137.9 N./mm <sup>2</sup>
Allowable Stress, Hydrotest	235.8 N./mm <sup>2</sup>
Material Density	0.00775 kg./cm <sup>3</sup>
P Number Thickness	30.988 mm.
Yield Stress, Operating	241.8 N./mm <sup>2</sup>
UCS-66 Chart Curve Designation	B
External Pressure Chart Name	CS-2
UNS Number	K02700
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	10
Detail Type	Liquid
Detail ID	Liquid: 10
Dist. from "FROM" Node / Offset dist	-525 mm.
Height/Length of Liquid	575 mm.
Liquid Density	0.11996E-05 kg./cm <sup>3</sup>

Element From Node	10
Detail Type	Nozzle
Detail ID	Drain - 3in
Dist. from "FROM" Node / Offset dist	0 mm.
Nozzle Diameter	3 in.
Nozzle Schedule	80
Nozzle Class	150
Layout Angle	0.0
Blind Flange (Y/N)	Y
Weight of Nozzle ( Used if > 0 )	16.958 Kgf
Grade of Attached Flange	GR 1.1
Nozzle Matl	SA-106 B

Element From Node	10
Detail Type	For./Mom.
Detail ID	Drain - 3"
Dist. from "FROM" Node / Offset dist	-525 mm.
Force in X Direction	0 Kgf
Force in Y Direction	-76.28 Kgf
Force in Z Direction	0 Kgf
Moment about X Axis	0 Kg-m.
Moment about Y Axis	0 Kg-m.
Moment about Z Axis	0 Kg-m.
Force/Moment Combination Method	SRSS

Element From Node	10
Detail Type	For./Mom.
Detail ID	Gas In - 6" T
Dist. from "FROM" Node / Offset dist	50 mm.
Force in X Direction	180.71 Kgf
Force in Y Direction	-180.71 Kgf
Force in Z Direction	180.71 Kgf
Moment about X Axis	172.37 Kg-m.
Moment about Y Axis	0 Kg-m.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 7 of 143

Input Echo:

Step: 1 1:37pm Apr 8,2024

Moment about Z Axis 172.37 Kg-m.  
Force/Moment Combination Method SRSS

Element From Node 20  
Element To Node 30  
Element Type Cylinder  
Description Shell #1  
Distance "FROM" to "TO" 1500 mm.  
Inside Diameter 2100 mm.  
Element Thickness 8 mm.  
Internal Corrosion Allowance 3 mm.  
Nominal Thickness 8 mm.  
External Corrosion Allowance 0 mm.  
Design Internal Pressure 0.2 bars  
Design Temperature Internal Pressure 85 °C  
Design External Pressure 0.1 bars  
Design Temperature External Pressure 85 °C  
Effective Diameter Multiplier 1.6  
Material Name SA-516 70  
Efficiency, Longitudinal Seam 0.85  
Efficiency, Circumferential Seam 0.85  
Weld is pre-Heated No

Element From Node 20  
Detail Type Packing  
Detail ID Carbon Active  
Dist. from "FROM" Node / Offset dist 400 mm.  
Height of Packed Section 1100 mm.  
Density 0.00045 kg./cm³  
Percent Volume Holdup 0.0  
Specific Gravity of Packing Liquid 0.0

Element From Node 20  
Detail Type Liquid  
Detail ID Liquid: 20  
Dist. from "FROM" Node / Offset dist 0 mm.  
Height/Length of Liquid 1500 mm.  
Liquid Density 0.11996E-05 kg./cm³

Element From Node 20  
Detail Type Nozzle  
Detail ID MH1 - 24in  
Dist. from "FROM" Node / Offset dist 800 mm.  
Nozzle Diameter 24 in.  
Nozzle Schedule None  
Nozzle Class 150  
Layout Angle 180.0  
Blind Flange (Y/N) Y  
Weight of Nozzle ( Used if > 0 ) 377.66 Kgf  
Grade of Attached Flange GR 1.1  
Nozzle Matl SA-516 70

Element From Node 20  
Detail Type Nozzle  
Detail ID Gas In - 6in



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 8 of 143

Input Echo:

Step: 1 1:37pm Apr 8,2024

Dist. from "FROM" Node / Offset dist	200	mm.
Nozzle Diameter	6	in.
Nozzle Schedule	80	
Nozzle Class	150	
Layout Angle	105.0	
Blind Flange (Y/N)	N	
Weight of Nozzle ( Used if > 0 )	103.22	Kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	

Element From Node	20	
Detail Type	Nozzle	
Detail ID	Utility - 2in	
Dist. from "FROM" Node / Offset dist	200	mm.
Nozzle Diameter	2	in.
Nozzle Schedule	160	
Nozzle Class	150	
Layout Angle	255.0	
Blind Flange (Y/N)	Y	
Weight of Nozzle ( Used if > 0 )	10.74	Kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	

Element From Node	20	
Detail Type	Leg	
Detail ID	LEGS	
Dist. from "FROM" Node / Offset dist	600	mm.
Diameter at Leg Centerline	2292	mm.
Leg Orientation	1	
Number of Legs	4	
Section Identifier	HE160B	
Length of Legs	1750	mm.

Element From Node	20	
Detail Type	Weight	
Detail ID	DAVIT 1	
Dist. from "FROM" Node / Offset dist	800	mm.
Miscellaneous Weight	50	Kgf
Offset from Element Centerline	1050	mm.

Element From Node	30	
Element To Node	40	
Element Type	Cylinder	
Description	Shell #2	
Distance "FROM" to "TO"	1500	mm.
Inside Diameter	2100	mm.
Element Thickness	8	mm.
Internal Corrosion Allowance	3	mm.
Nominal Thickness	8	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	0.2	bars
Design Temperature Internal Pressure	85	°C
Design External Pressure	0.1	bars
Design Temperature External Pressure	85	°C
Effective Diameter Multiplier	1.6	



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User  
FileName : EI027-HRC-VD-ME-CAL-003-01

Input Echo: Step: 1 1:37pm Apr 8,2024

Material Name	SA-516 70	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Weld is pre-Heated	No	
Element From Node	30	
Detail Type	Packing	
Detail ID	Carbon Active	
Dist. from "FROM" Node / Offset dist	0	mm.
Height of Packed Section	1500	mm.
Density	0.00045	kg./cm <sup>3</sup>
Percent Volume Holdup	0.0	
Specific Gravity of Packing Liquid	0.0	
Element From Node	30	
Detail Type	Liquid	
Detail ID	Liquid: 30	
Dist. from "FROM" Node / Offset dist	0	mm.
Height/Length of Liquid	1500	mm.
Liquid Density	0.11996E-05	kg./cm <sup>3</sup>

Element From Node	40	
Element To Node	50	
Element Type	Cylinder	
Description	Shell #3	
Distance "FROM" to "TO"	800	mm.
Inside Diameter	2100	mm.
Element Thickness	8	mm.
Internal Corrosion Allowance	3	mm.
Nominal Thickness	8	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	0.2	bars
Design Temperature Internal Pressure	85	°C
Design External Pressure	0.1	bars
Design Temperature External Pressure	85	°C
Effective Diameter Multiplier	1.6	
Material Name	SA-516 70	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Weld is pre-Heated	No	

Element From Node	40	
Detail Type	Packing	
Detail ID	Carbon Active	
Dist. from "FROM" Node / Offset dist	0	mm.
Height of Packed Section	800	mm.
Density	0.00045	kg./cm <sup>3</sup>
Percent Volume Holdup	0.0	
Specific Gravity of Packing Liquid	0.0	

Element From Node	40	
Detail Type	Liquid	
Detail ID	Liquid: 40	
Dist. from "FROM" Node / Offset dist	0	mm.
Height/Length of Liquid	800	mm.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User  
FileName : EI027-HRC-VD-ME-CAL-003-01

Input Echo: Step: 1 1:37pm Apr 8,2024

Liquid Density 0.11996E-05 kg./cm³

Element From Node	50
Element To Node	60
Element Type	Cylinder
Description	Shell #4
Distance "FROM" to "TO"	1500 mm.
Inside Diameter	2100 mm.
Element Thickness	8 mm.
Internal Corrosion Allowance	3 mm.
Nominal Thickness	8 mm.
External Corrosion Allowance	0 mm.
Design Internal Pressure	0.2 bars
Design Temperature Internal Pressure	85 °C
Design External Pressure	0.1 bars
Design Temperature External Pressure	85 °C
Effective Diameter Multiplier	1.6
Material Name	SA-516 70
Efficiency, Longitudinal Seam	0.85
Efficiency, Circumferential Seam	0.85
Weld is pre-Heated	No

Element From Node	50
Detail Type	Packing
Detail ID	Carbon Active
Dist. from "FROM" Node / Offset dist	0 mm.
Height of Packed Section	1100 mm.
Density	0.00045 kg./cm³
Percent Volume Holdup	0.0
Specific Gravity of Packing Liquid	0.0

Element From Node	50
Detail Type	Liquid
Detail ID	Liquid: 50
Dist. from "FROM" Node / Offset dist	0 mm.
Height/Length of Liquid	1500 mm.
Liquid Density	0.11996E-05 kg./cm³

Element From Node	50
Detail Type	Nozzle
Detail ID	Gas Out - 6in
Dist. from "FROM" Node / Offset dist	1300 mm.
Nozzle Diameter	6 in.
Nozzle Schedule	STD
Nozzle Class	150
Layout Angle	180.0
Blind Flange (Y/N)	N
Weight of Nozzle ( Used if > 0 )	26.993 Kgf
Grade of Attached Flange	GR 1.1
Nozzle Matl	SA-106 B

Element From Node	50
Detail Type	Nozzle
Detail ID	PG - 1in
Dist. from "FROM" Node / Offset dist	1400 mm.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 11 of 143

Input Echo:

Step: 1 1:37pm Apr 8,2024

Nozzle Diameter	2.25	in.
Nozzle Schedule	None	
Nozzle Class	None	
Layout Angle	20.0	
Blind Flange (Y/N)	N	
Weight of Nozzle ( Used if > 0 )	0.685	Kgf
Grade of Attached Flange	None	
Nozzle Matl	SA-105	

Element From Node	50	
Detail Type	For./Mom.	
Detail ID	Gas Out - 6"	
Dist. from "FROM" Node / Offset dist	1300	mm.
Force in X Direction	180.71	Kgf
Force in Y Direction	-180.71	Kgf
Force in Z Direction	180.71	Kgf
Moment about X Axis	136.23	Kg-m.
Moment about Y Axis	0	Kg-m.
Moment about Z Axis	136.23	Kg-m.
Force/Moment Combination Method	SRSS	

Element From Node	60	
Element To Node	70	
Element Type	Elliptical	
Description	Upper Head	
Distance "FROM" to "TO"	50	mm.
Inside Diameter	2100	mm.
Element Thickness	5.5	mm.
Internal Corrosion Allowance	3	mm.
Nominal Thickness	8	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	0.2	bars
Design Temperature Internal Pressure	85	°C
Design External Pressure	0.1	bars
Design Temperature External Pressure	85	°C
Effective Diameter Multiplier	1.6	
Material Name	SA-516 70	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Elliptical Head Factor	2.0	
Weld is pre-Heated	No	

Element From Node	60	
Detail Type	Platform	
Detail ID	TOP PLATFORM	
Dist. from "FROM" Node / Offset dist	900	mm.
Platform Start Angle (degrees)	0.0	
Platform End Angle (degrees)	0.0	
Platform Wind Area	34320	cm <sup>2</sup>
Platform Weight	820.01	Kgf
Platform Railing Weight	0.003	Kgf/mm.
Platform Grating Weight	0.015	Kgs/cm <sup>2</sup>
Platform Width	2200	mm.
Platform Height	1100	mm.
Platform Clearance or End Offset	1200	mm.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User  
FileName : EI027-HRC-VD-ME-CAL-003-01

Input Echo: Step: 1 1:37pm Apr 8,2024

Platform Force Coefficient	1.3	
Ladder Layout Angle	0.0	
Ladder Start Elevation	0	mm.
Ladder End Elevation	0	mm.
Unit Weight of Ladder	0	Kgf/mm.
Platform Length (top head platform)	2400	mm.

Element From Node	60	
Detail Type	Platform	
Detail ID	TOP LADDER	
Dist. from "FROM" Node / Offset dist	1700	mm.
Platform Start Angle (degrees)	0.0	
Platform End Angle (degrees)	0.0	
Platform Wind Area	0	cm <sup>2</sup>
Platform Weight	244.5	Kgf
Platform Railing Weight	0	Kgf/mm.
Platform Grating Weight	0	Kgs/cm <sup>2</sup>
Platform Width	0	mm.
Platform Height	0	mm.
Platform Clearance or End Offset	0	mm.
Platform Force Coefficient	1.3	
Ladder Layout Angle	0.0	
Ladder Start Elevation	0	mm.
Ladder End Elevation	8150	mm.
Unit Weight of Ladder	0.03	Kgf/mm.
Platform Length (top head platform)	0	mm.

Element From Node	60	
Detail Type	Liquid	
Detail ID	Liquid: 60	
Dist. from "FROM" Node / Offset dist	0	mm.
Height/Length of Liquid	575	mm.
Liquid Density	0.11996E-05	kg./cm <sup>3</sup>

Element From Node	60	
Detail Type	Nozzle	
Detail ID	MH2 - 24in	
Dist. from "FROM" Node / Offset dist	0	mm.
Nozzle Diameter	24	in.
Nozzle Schedule	None	
Nozzle Class	150	
Layout Angle	0.0	
Blind Flange (Y/N)	Y	
Weight of Nozzle ( Used if > 0 )	409.88	Kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-516 70	

Element From Node	60	
Detail Type	Nozzle	
Detail ID	Vent - 2in	
Dist. from "FROM" Node / Offset dist	750	mm.
Nozzle Diameter	2	in.
Nozzle Schedule	160	
Nozzle Class	150	
Layout Angle	200.0	
Blind Flange (Y/N)	Y	
Weight of Nozzle ( Used if > 0 )	18.184	Kgf



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 13 of 143

Input Echo: Step: 1 1:37pm Apr 8,2024

Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	
Element From Node	60	
Detail Type	Weight	
Detail ID	DAVIT 2	
Dist. from "FROM" Node / Offset dist	575	mm.
Miscellaneous Weight	50	Kgf
Offset from Element Centerline	0	mm.
Element From Node	60	
Detail Type	For./Mom.	
Detail ID	PSV - 2"	
Dist. from "FROM" Node / Offset dist	400	mm.
Force in X Direction	0	Kgf
Force in Y Direction	0	Kgf
Force in Z Direction	0	Kgf
Moment about X Axis	13.868	Kg-m.
Moment about Y Axis	0	Kg-m.
Moment about Z Axis	13.868	Kg-m.
Force/Moment Combination Method	SRSS	



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 14 of 143

XY Coordinate Calculations: Step: 2 1:37pm Apr 8,2024

XY Coordinate Calculations:

From	To	X (Horiz.) mm.	Y (Vert.) mm.	DX (Horiz.) mm.	DY (Vert.) mm.
Lower Head		...	50	...	50
Shell #1		...	1550	...	1500
Shell #2		...	3050	...	1500
Shell #3		...	3850	...	800
Shell #4		...	5350	...	1500
Upper Head		...	5400	...	50



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User  
FileName : EI027-HRC-VD-ME-CAL-003-01

Internal Pressure Calculations: Step: 3 1:37pm Apr 8,2024

Element Thickness, Pressure, Diameter and Allowable Stress :

From	To	Int. Press + Liq. Hd bars	Nominal Thickness mm.	Total Corr Allowance mm.	Element Diameter mm.	Allowable Stress(SE) N./mm <sup>2</sup>
Lower Head		0.2008	8	3	2100	117.21
Shell #1		0.2007	8	3	2100	117.21
Shell #2		0.2005	8	3	2100	117.21
Shell #3		0.2003	8	3	2100	117.21
Shell #4		0.2002	8	3	2100	117.21
Upper Head		0.2001	8	3	2100	117.21

Element Required Thickness and MAWP :

From	To	Design Pressure bars	M.A.W.P. Corroded bars	M.A.P. New & Cold bars	Minimum Thickness mm.	Required Thickness mm.
Lower Head		0.2	2.79186	6.13626	5.5	5.5
Shell #1		0.2	5.54894	8.88951	8	5.5
Shell #2		0.2	5.54912	8.88951	8	5.5
Shell #3		0.2	5.54929	8.88951	8	5.5
Shell #4		0.2	5.54939	8.88951	8	5.5
Upper Head		0.2	2.79256	6.13626	5.5	5.5

Minimum 2.792 6.136

MAWP: 2.792 bars, limited by: Lower Head.

Internal Pressure Calculation Results :

ASME Code, Section VIII Division 1, 2017

Elliptical Head From 10 To 20 SA-516 70 , UCS-66 Crv. B at 85 °C

Lower Head

Material UNS Number: K02700

Appendix 1-4(f) was also used in determining the required thickness of this head. The required thickness for this geometry is shown below. The required thickness is determined by iteration.

Required thickness per Appendix 1-4(f) : 0.530 mm.  
The value of ts/L : 0.001321

Appendix 1-4(f) does not govern the design of this head.

Required Thickness due to Internal Pressure [tr]:  
= (P\*D\*Kcor)/(2\*S\*E-0.2\*P) Appendix 1-4(c)  
= (0.201\*2106.0\*0.996)/(2\*137.9\*0.85-0.2\*0.201)  
= 0.1797 + 3.0000 = 3.1797 mm.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 16 of 143

Internal Pressure Calculations: Step: 3 1:37pm Apr 8,2024

*Note: The thickness required was less than the Code Minimum, therefore the Code Minimum value of 2.5000 mm. per UG-16 will be used.*

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

Less Operating Hydrostatic Head Pressure of 0.001 bars

$$= (2 * S * E * t) / (K * D + 0.2 * t) \text{ per Appendix 1-4 (c)}$$
$$= (2 * 137.9 * 0.85 * 2.5) / (0.996 * 2106.0 + 0.2 * 2.5)$$
$$= 2.793 - 0.001 = 2.792 \text{ bars}$$

Maximum Allowable Pressure, New and Cold [MAPNC]:

$$= (2 * S * E * t) / (K * D + 0.2 * t) \text{ per Appendix 1-4 (c)}$$
$$= (2 * 137.9 * 0.85 * 5.5) / (1.0 * 2100.0 + 0.2 * 5.5)$$
$$= 6.136 \text{ bars}$$

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

$$= (P * (K * D + 0.2 * t)) / (2 * E * t)$$
$$= (0.201 * (0.996 * 2106.0 + 0.2 * 2.5)) / (2 * 0.85 * 2.5)$$
$$= 9.913 \text{ N./mm}^2$$

Straight Flange Required Thickness:

$$= (P * R) / (S * E - 0.6 * P) + c \text{ per UG-27 (c)(1)}$$
$$= (0.201 * 1053.0) / (137.9 * 0.85 - 0.6 * 0.201) + 3.0$$
$$= 3.180 \text{ mm.}$$

Straight Flange Maximum Allowable Working Pressure:

Less Operating Hydrostatic Head Pressure of 0.001 bars

$$= (S * E * t) / (R + 0.6 * t) \text{ per UG-27 (c)(1)}$$
$$= (137.9 * 0.85 * 5.0) / (1053.0 + 0.6 * 5.0)$$
$$= 5.550 - 0.001 = 5.549 \text{ bars}$$

Factor K, corroded condition [Kcor]:

$$= (2 + (\text{Inside Diameter} / (2 * \text{Inside Head Depth}))^2) / 6$$
$$= (2 + (2106.0 / (2 * 528.0))^2) / 6$$
$$= 0.996217$$

Percent Elong. per UCS-79, VIII-1-01-57  $(75 * t_{nom} / R_f) * (1 - R_f / R_o)$  1.662 %

**MDMT Calculations in the Knuckle Portion:**

Govrn. thk, tg = 5.5, tr = 2.5, c = 3.0 mm., E\* = 0.85

Thickness Ratio =  $tr * (E^*) / (tg - c) = 0.85$ , Temp. Reduction = 8 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C

Min Metal Temp. at Required thickness (UCS 66.1) -37 °C

**MDMT Calculations in the Head Straight Flange:**

Govrn. thk, tg = 8.0, tr = 2.512, c = 3.0 mm., E\* = 0.85

Thickness Ratio =  $tr * (E^*) / (tg - c) = 0.427$ , Temp. Reduction = 44 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C

Min Metal Temp. at Required thickness (UCS 66.1) -48 °C

Cylindrical Shell From 20 To 30 SA-516 70, UCS-66 Crv. B at 85 °C

Shell #1



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 17 of 143

Internal Pressure Calculations: Step: 3 1:37pm Apr 8,2024

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:  
=  $(P \cdot R) / (S \cdot E - 0.6 \cdot P)$  per UG-27 (c)(1)  
=  $(0.201 \cdot 1053.0) / (137.9 \cdot 0.85 - 0.6 \cdot 0.201)$   
=  $0.1803 + 3.0000 = 3.1803$  mm.

*Note: The thickness required was less than the Code Minimum, therefore the Code Minimum value of 2.5000 mm. per UG-16 will be used.*

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

Less Operating Hydrostatic Head Pressure of 0.001 bars

=  $(S \cdot E \cdot t) / (R + 0.6 \cdot t)$  per UG-27 (c)(1)  
=  $(137.9 \cdot 0.85 \cdot 5.0) / (1053.0 + 0.6 \cdot 5.0)$   
=  $5.550 - 0.001 = 5.549$  bars

Maximum Allowable Pressure, New and Cold [MAPNC]:

=  $(S \cdot E \cdot t) / (R + 0.6 \cdot t)$  per UG-27 (c)(1)  
=  $(137.9 \cdot 0.85 \cdot 8.0) / (1050.0 + 0.6 \cdot 8.0)$   
= 8.890 bars

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

=  $(P \cdot (R + 0.6 \cdot t)) / (E \cdot t)$   
=  $(0.201 \cdot (1053.0 + 0.6 \cdot 5.0)) / (0.85 \cdot 5.0)$   
= 4.987 N./mm<sup>2</sup>

% Elongation per Table UG-79-1 ( $50 \cdot t_{nom} / R_f \cdot (1 - R_f / R_o)$ ) 0.380 %

**Minimum Design Metal Temperature Results:**

Govrn. thk, tg = 8.0, tr = 2.512, c = 3.0 mm., E\* = 0.85  
Thickness Ratio =  $tr \cdot (E^*) / (tg - c) = 0.427$ , Temp. Reduction = 44 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C  
Min Metal Temp. at Required thickness (UCS 66.1) -48 °C

**Cylindrical Shell From 30 To 40 SA-516 70 , UCS-66 Crv. B at 85 °C**

**Shell #2**

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:  
=  $(P \cdot R) / (S \cdot E - 0.6 \cdot P)$  per UG-27 (c)(1)  
=  $(0.201 \cdot 1053.0) / (137.9 \cdot 0.85 - 0.6 \cdot 0.201)$   
=  $0.1802 + 3.0000 = 3.1802$  mm.

*Note: The thickness required was less than the Code Minimum, therefore the Code Minimum value of 2.5000 mm. per UG-16 will be used.*

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

Less Operating Hydrostatic Head Pressure of 0.001 bars

=  $(S \cdot E \cdot t) / (R + 0.6 \cdot t)$  per UG-27 (c)(1)  
=  $(137.9 \cdot 0.85 \cdot 5.0) / (1053.0 + 0.6 \cdot 5.0)$   
=  $5.550 - 0.001 = 5.549$  bars



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 18 of 143

Internal Pressure Calculations: Step: 3 1:37pm Apr 8, 2024

Maximum Allowable Pressure, New and Cold [MAPNC]:  
=  $(S \cdot E \cdot t) / (R + 0.6 \cdot t)$  per UG-27 (c)(1)  
=  $(137.9 \cdot 0.85 \cdot 8.0) / (1050.0 + 0.6 \cdot 8.0)$   
= 8.890 bars

Actual stress at given pressure and thickness, corroded [Sact]:  
=  $(P \cdot (R + 0.6 \cdot t)) / (E \cdot t)$   
=  $(0.201 \cdot (1053.0 + 0.6 \cdot 5.0)) / (0.85 \cdot 5.0)$   
= 4.982 N./mm<sup>2</sup>

% Elongation per Table UG-79-1  $(50 \cdot t_{nom} / R_f \cdot (1 - R_f / R_o))$  0.380 %

**Minimum Design Metal Temperature Results:**

Govern. thk, tg = 8.0, tr = 2.512, c = 3.0 mm., E\* = 0.85  
Thickness Ratio =  $tr \cdot (E^*) / (tg - c) = 0.427$ , Temp. Reduction = 44 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C  
Min Metal Temp. at Required thickness (UCS 66.1) -48 °C

**Cylindrical Shell From 40 To 50 SA-516 70, UCS-66 Crv. B at 85 °C**

**Shell #3**

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:  
=  $(P \cdot R) / (S \cdot E - 0.6 \cdot P)$  per UG-27 (c)(1)  
=  $(0.2 \cdot 1053.0) / (137.9 \cdot 0.85 - 0.6 \cdot 0.2)$   
= 0.1800 + 3.0000 = 3.1800 mm.

*Note: The thickness required was less than the Code Minimum, therefore the Code Minimum value of 2.5000 mm. per UG-16 will be used.*

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

Less Operating Hydrostatic Head Pressure of 0.000 bars

=  $(S \cdot E \cdot t) / (R + 0.6 \cdot t)$  per UG-27 (c)(1)  
=  $(137.9 \cdot 0.85 \cdot 5.0) / (1053.0 + 0.6 \cdot 5.0)$   
= 5.550 - 0.000 = 5.549 bars

Maximum Allowable Pressure, New and Cold [MAPNC]:  
=  $(S \cdot E \cdot t) / (R + 0.6 \cdot t)$  per UG-27 (c)(1)  
=  $(137.9 \cdot 0.85 \cdot 8.0) / (1050.0 + 0.6 \cdot 8.0)$   
= 8.890 bars

Actual stress at given pressure and thickness, corroded [Sact]:  
=  $(P \cdot (R + 0.6 \cdot t)) / (E \cdot t)$   
=  $(0.2 \cdot (1053.0 + 0.6 \cdot 5.0)) / (0.85 \cdot 5.0)$   
= 4.978 N./mm<sup>2</sup>

% Elongation per Table UG-79-1  $(50 \cdot t_{nom} / R_f \cdot (1 - R_f / R_o))$  0.380 %

**Minimum Design Metal Temperature Results:**

Govern. thk, tg = 8.0, tr = 2.512, c = 3.0 mm., E\* = 0.85



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 19 of 143

Internal Pressure Calculations: Step: 3 1:37pm Apr 8,2024

Thickness Ratio =  $tr * (E*) / (tg - c) = 0.427$ , Temp. Reduction = 44 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C  
Min Metal Temp. at Required thickness (UCS 66.1) -48 °C

Cylindrical Shell From 50 To 60 SA-516 70 , UCS-66 Crv. B at 85 °C

Shell #4

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:  
=  $(P * R) / (S * E - 0.6 * P)$  per UG-27 (c) (1)  
=  $(0.2 * 1053.0) / (137.9 * 0.85 - 0.6 * 0.2)$   
=  $0.1799 + 3.0000 = 3.1799$  mm.

*Note: The thickness required was less than the Code Minimum, therefore the Code Minimum value of 2.5000 mm. per UG-16 will be used.*

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

Less Operating Hydrostatic Head Pressure of 0.000 bars  
=  $(S * E * t) / (R + 0.6 * t)$  per UG-27 (c) (1)  
=  $(137.9 * 0.85 * 5.0) / (1053.0 + 0.6 * 5.0)$   
=  $5.550 - 0.000 = 5.549$  bars

Maximum Allowable Pressure, New and Cold [MAPNC]:

=  $(S * E * t) / (R + 0.6 * t)$  per UG-27 (c) (1)  
=  $(137.9 * 0.85 * 8.0) / (1050.0 + 0.6 * 8.0)$   
= 8.890 bars

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

=  $(P * (R + 0.6 * t)) / (E * t)$   
=  $(0.2 * (1053.0 + 0.6 * 5.0)) / (0.85 * 5.0)$   
= 4.976 N./mm<sup>2</sup>

% Elongation per Table UG-79-1 ( $50 * t_{nom} / R_f * (1 - R_f / R_o)$ ) 0.380 %

**Minimum Design Metal Temperature Results:**

Govrn. thk, tg = 8.0, tr = 2.512, c = 3.0 mm., E\* = 0.85  
Thickness Ratio =  $tr * (E*) / (tg - c) = 0.427$ , Temp. Reduction = 44 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C  
Min Metal Temp. at Required thickness (UCS 66.1) -48 °C

Elliptical Head From 60 To 70 SA-516 70 , UCS-66 Crv. B at 85 °C

Upper Head

Material UNS Number: K02700

*Appendix 1-4(f) was also used in determining the required thickness of this head. The required thickness for this geometry is shown below. The required thickness is determined by iteration.*



Strength Calculation-Active Carbon Filter  
 Design by A. Azodi  
 Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 20 of 143

Internal Pressure Calculations: Step: 3 1:37pm Apr 8,2024

Required thickness per Appendix 1-4(f) : 0.529 mm.  
 The value of ts/L : 0.001321

*Appendix 1-4(f) does not govern the design of this head.*

Required Thickness due to Internal Pressure [tr]:  
 =  $(P \cdot D \cdot K_{cor}) / (2 \cdot S \cdot E - 0.2 \cdot P)$  Appendix 1-4(c)  
 =  $(0.2 \cdot 2106.0 \cdot 0.996) / (2 \cdot 137.9 \cdot 0.85 - 0.2 \cdot 0.2)$   
 =  $0.1791 + 3.0000 = 3.1791$  mm.

*Note: The thickness required was less than the Code Minimum, therefore the Code Minimum value of 2.5000 mm. per UG-16 will be used.*

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:  
 Less Operating Hydrostatic Head Pressure of 0.000 bars  
 =  $(2 \cdot S \cdot E \cdot t) / (K \cdot D + 0.2 \cdot t)$  per Appendix 1-4 (c)  
 =  $(2 \cdot 137.9 \cdot 0.85 \cdot 2.5) / (0.996 \cdot 2106.0 + 0.2 \cdot 2.5)$   
 =  $2.793 - 0.000 = 2.793$  bars

Maximum Allowable Pressure, New and Cold [MAPNC]:  
 =  $(2 \cdot S \cdot E \cdot t) / (K \cdot D + 0.2 \cdot t)$  per Appendix 1-4 (c)  
 =  $(2 \cdot 137.9 \cdot 0.85 \cdot 5.5) / (1.0 \cdot 2100.0 + 0.2 \cdot 5.5)$   
 = 6.136 bars

Actual stress at given pressure and thickness, corroded [Sact]:  
 =  $(P \cdot (K_{cor} \cdot D + 0.2 \cdot t)) / (2 \cdot E \cdot t)$   
 =  $(0.2 \cdot (0.996 \cdot 2106.0 + 0.2 \cdot 2.5)) / (2 \cdot 0.85 \cdot 2.5)$   
 = 9.879 N./mm<sup>2</sup>

Straight Flange Required Thickness:  
 =  $(P \cdot R) / (S \cdot E - 0.6 \cdot P) + c$  per UG-27 (c)(1)  
 =  $(0.2 \cdot 1053.0) / (137.9 \cdot 0.85 - 0.6 \cdot 0.2) + 3.0$   
 = 3.180 mm.

Straight Flange Maximum Allowable Working Pressure:  
 Less Operating Hydrostatic Head Pressure of 0.000 bars  
 =  $(S \cdot E \cdot t) / (R + 0.6 \cdot t)$  per UG-27 (c)(1)  
 =  $(137.9 \cdot 0.85 \cdot 5.0) / (1053.0 + 0.6 \cdot 5.0)$   
 = 5.550 - 0.000 = 5.550 bars

Factor K, corroded condition [Kcor]:  
 =  $(2 + (\text{Inside Diameter} / (2 \cdot \text{Inside Head Depth}))^2) / 6$   
 =  $(2 + (2106.0 / (2 \cdot 528.0))^2) / 6$   
 = 0.996217

Percent Elong. per UCS-79, VIII-1-01-57  $(75 \cdot t_{nom} / R_f) \cdot (1 - R_f / R_o)$  1.662 %

**MDMT Calculations in the Knuckle Portion:**

Govern. thk, tg = 5.5, tr = 2.5, c = 3.0 mm., E\* = 0.85  
 Thickness Ratio =  $tr \cdot (E^*) / (tg - c) = 0.85$ , Temp. Reduction = 8 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C  
 Min Metal Temp. at Required thickness (UCS 66.1) -37 °C

**MDMT Calculations in the Head Straight Flange:**



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 21 of 143

Internal Pressure Calculations: Step: 3 1:37pm Apr 8,2024

Govrn. thk, tg = 8.0, tr = 2.512, c = 3.0 mm., E\* = 0.85  
Thickness Ratio = tr \* (E\*)/(tg - c) = 0.427, Temp. Reduction = 44 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C  
Min Metal Temp. at Required thickness (UCS 66.1) -48 °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	3.629 bars
Pressure per UG99b[36]	= 1.30 * Design Pres * Sa/S	0.260 bars
Pressure per UG99c	= 1.30 * M.A.P. - Head(Hyd)	7.771 bars
Pressure per UG100	= 1.10 * M.A.W.P. * Sa/S	3.071 bars
Pressure per PED	= max(1.43*DP, 1.25*DP*ratio)	0.286 bars
Pressure per App 27-4	= M.A.W.P.	2.792 bars

**UG-99(b), Test Pressure Calculation:**

= Test Factor \* MAWP \* Stress Ratio  
= 1.3 \* 2.792 \* 1.0  
= 3.629 bars

Horizontal Test performed per: UG-99b

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<sup>2</sup> & bars):**

From To	Stress	Allowable	Ratio	Pressure
Lower Head	189.4	235.8	0.803	3.84
Shell #1	95.3	235.8	0.404	3.84
Shell #2	95.3	235.8	0.404	3.84
Shell #3	95.3	235.8	0.404	3.84
Shell #4	95.3	235.8	0.404	3.84
Upper Head	189.4	235.8	0.803	3.84

**Stress ratios for Nozzle and Pad Materials (N./mm<sup>2</sup>):**

Description	Pad/Nozzle	Ambient	Operating	Ratio
Drain - 3in	Nozzle	117.90	117.90	1.000
Drain - 3in	Pad	137.90	137.90	1.000
MH1 - 24in	Nozzle	137.90	137.90	1.000
MH1 - 24in	Pad	137.90	137.90	1.000
Gas In - 6in	Nozzle	117.90	117.90	1.000
Gas In - 6in	Pad	137.90	137.90	1.000
Utility - 2in	Nozzle	117.90	117.90	1.000
Gas Out - 6in	Nozzle	117.90	117.90	1.000
Gas Out - 6in	Pad	137.90	137.90	1.000
PG - 1in	Nozzle	137.90	137.90	1.000
MH2 - 24in	Nozzle	137.90	137.90	1.000
MH2 - 24in	Pad	137.90	137.90	1.000



Strength Calculation-Active Carbon Filter

Design by A. Azodi

Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 22 of 143

Internal Pressure Calculations: Step: 3 1:37pm Apr 8,2024

Vent - 2in	Nozzle	117.90	117.90	1.000
Vent - 2in	Pad	137.90	137.90	1.000

Minimum 1.000

Stress ratios for Pressurized Vessel Elements (N./mm²):

Description	Ambient	Operating	Ratio
Lower Head	137.90	137.90	1.000
Shell #1	137.90	137.90	1.000
Shell #2	137.90	137.90	1.000
Shell #3	137.90	137.90	1.000
Shell #4	137.90	137.90	1.000
Upper Head	137.90	137.90	1.000

Minimum 1.000

Hoop Stress in Nozzle Wall during Pressure Test (N./mm²):

Description	Ambient	Operating	Ratio
Drain - 3in	4.50	217.19	0.021
MH1 - 24in	23.23	235.81	0.099
Gas In - 6in	4.74	217.19	0.022
Utility - 2in	2.34	217.19	0.011
Gas Out - 6in	9.86	217.19	0.045
PG - 1in	1.08	223.40	0.005
MH2 - 24in	23.23	235.81	0.099
Vent - 2in	2.34	217.19	0.011

Elements Suitable for Internal Pressure.

PV Elite is a trademark of Intergraph CADWorx & Analysis Solutions, Inc. 2019



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 23 of 143

External Pressure Calculations: Step: 4 1:37pm Apr 8,2024

**External Pressure Calculation Results :**

**External Pressure Calculations:**

From	To	Section Length mm.	Outside Diameter mm.	Corroded Thickness mm.	Factor A	Factor B N./mm <sup>2</sup>
10	20	No Calc	2111	2.5	0.00016448	16.4445
20	30	5750	2116	5	0.54451E-04	5.44386
30	40	5750	2116	5	0.54451E-04	5.44386
40	50	5750	2116	5	0.54451E-04	5.44386
50	60	5750	2116	5	0.54451E-04	5.44386
60	70	No Calc	2111	2.5	0.00016448	16.4445

**External Pressure Calculations:**

From	To	External Actual T. mm.	External Required T. mm.	External Design Pressure bars	External M.A.W.P. bars
10	20	5.5	5.5	0.1	0.21637
20	30	8	7.03049	0.1	0.1715
30	40	8	7.03049	0.1	0.1715
40	50	8	7.03049	0.1	0.1715
50	60	8	7.03049	0.1	0.1715
60	70	5.5	5.5	0.1	0.21637

Minimum

0.172

**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	No Calc	No Calc	No Calc	No Calc
20	30	5750	9647.55	No Calc	No Calc
30	40	5750	9647.55	No Calc	No Calc
40	50	5750	9647.55	No Calc	No Calc
50	60	5750	9647.55	No Calc	No Calc
60	70	No Calc	No Calc	No Calc	No Calc

**Elements Suitable for External Pressure.**

ASME Code, Section VIII Division 1, 2017

Elliptical Head From 10 to 20 Ext. Chart: CS-2 at 85 °C

**Lower Head**

Elastic Modulus from Chart: CS-2 at 85 °C : 0.200E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 24 of 143

External Pressure Calculations: Step: 4 1:37pm Apr 8,2024

Tca	OD	D/t	Factor A	B
2.500	2111.00	844.40	0.0001645	16.44

EMAP =  $B/(K0*D/t) = 16.4445/(0.9 * 844.3997) = 0.2164$  bars

Results for Required Thickness (Tca):

Tca	OD	D/t	Factor A	B
1.700	2111.00	1242.03	0.0001118	11.18

EMAP =  $B/(K0*D/t) = 11.1799/(0.9 * 1242.0328) = 0.1$  bars

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

Material UNS Number: K02700

Appendix 1-4(f) was also used in determining the required thickness of this head. The required thickness for this geometry is shown below. The required thickness is determined by iteration.

Required thickness per Appendix 1-4(f) : 0.487 mm.  
The value of ts/L : 0.001321

Appendix 1-4(f) does not govern the design of this head.

Required Thickness due to Internal Pressure [tr]:  
=  $(P*D*Kcor)/(2*S*E-0.2*P)$  Appendix 1-4(c)  
=  $(0.167*2106.0*0.996)/(2*137.9*1.0-0.2*0.167)$   
=  $0.1270 + 3.0000 = 3.1270$  mm.

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:  
=  $((2*S*E*t)/(Kcor*D+0.2*t))/1.67$  per Appendix 1-4 (c)  
=  $((2*137.9*1.0*2.5)/(0.996*2106.0+0.2*2.5))/1.67$   
= 1.792 bars

Maximum Allowable External Pressure [MAEP]:  
= min( MAEP, MAWP )  
= min( 0.22, 1.792 )  
= 0.216 bars

Thickness requirements per UG-33(a)(1) govern the required thickness of this head.

Cylindrical Shell From 20 to 30 Ext. Chart: CS-2 at 85 °C

Shell #1

Elastic Modulus from Chart: CS-2 at 85 °C : 0.200E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
5.000	2116.00	5750.00	423.20	2.7174	0.0000545	5.44

EMAP =  $(4*B)/(3*(D/t)) = (4*5.4439)/(3*423.2) = 0.1715$  bars

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
4.030	2116.00	5750.00	525.00	2.7174	0.0000394	3.94

EMAP =  $(4*B)/(3*(D/t)) = (4*3.9379)/(3*524.9977) = 0.1$  bars



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User  
FileName : EI027-HRC-VD-ME-CAL-003-01

External Pressure Calculations: Step: 4 1:37pm Apr 8,2024

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
5.000	2116.00	9647.55	423.20	4.5593	0.0000318	3.18

EMAP = (4\*B)/(3\*(D/t)) = (4\*3.1764)/(3\*423.2) = 0.1001 bars

Cylindrical Shell From 30 to 40 Ext. Chart: CS-2 at 85 °C

Shell #2

Elastic Modulus from Chart: CS-2 at 85 °C : 0.200E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
5.000	2116.00	5750.00	423.20	2.7174	0.0000545	5.44

EMAP = (4\*B)/(3\*(D/t)) = (4\*5.4439)/(3\*423.2) = 0.1715 bars

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
4.030	2116.00	5750.00	525.00	2.7174	0.0000394	3.94

EMAP = (4\*B)/(3\*(D/t)) = (4\*3.9379)/(3\*524.9977) = 0.1 bars

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
5.000	2116.00	9647.55	423.20	4.5593	0.0000318	3.18

EMAP = (4\*B)/(3\*(D/t)) = (4\*3.1764)/(3\*423.2) = 0.1001 bars

Cylindrical Shell From 40 to 50 Ext. Chart: CS-2 at 85 °C

Shell #3

Elastic Modulus from Chart: CS-2 at 85 °C : 0.200E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
5.000	2116.00	5750.00	423.20	2.7174	0.0000545	5.44

EMAP = (4\*B)/(3\*(D/t)) = (4\*5.4439)/(3\*423.2) = 0.1715 bars

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
4.030	2116.00	5750.00	525.00	2.7174	0.0000394	3.94

EMAP = (4\*B)/(3\*(D/t)) = (4\*3.9379)/(3\*524.9977) = 0.1 bars

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
5.000	2116.00	9647.55	423.20	4.5593	0.0000318	3.18

EMAP = (4\*B)/(3\*(D/t)) = (4\*3.1764)/(3\*423.2) = 0.1001 bars

Cylindrical Shell From 50 to 60 Ext. Chart: CS-2 at 85 °C

Shell #4

Elastic Modulus from Chart: CS-2 at 85 °C : 0.200E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
5.000	2116.00	5750.00	423.20	2.7174	0.0000545	5.44



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User  
FileName : EI027-HRC-VD-ME-CAL-003-01

External Pressure Calculations: Step: 4 1:37pm Apr 8,2024

$$EMAP = (4*B)/(3*(D/t)) = (4*5.4439)/(3*423.2) = 0.1715 \text{ bars}$$

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
4.030	2116.00	5750.00	525.00	2.7174	0.0000394	3.94

$$EMAP = (4*B)/(3*(D/t)) = (4*3.9379)/(3*524.9977) = 0.1 \text{ bars}$$

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
5.000	2116.00	9647.55	423.20	4.5593	0.0000318	3.18

$$EMAP = (4*B)/(3*(D/t)) = (4*3.1764)/(3*423.2) = 0.1001 \text{ bars}$$

Elliptical Head From 60 to 70 Ext. Chart: CS-2 at 85 °C

Upper Head

Elastic Modulus from Chart: CS-2 at 85 °C : 0.200E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	D/t	Factor A	B
2.500	2111.00	844.40	0.0001645	16.44

$$EMAP = B/(K0*D/t) = 16.4445/(0.9 * 844.3997) = 0.2164 \text{ bars}$$

Results for Required Thickness (Tca):

Tca	OD	D/t	Factor A	B
1.700	2111.00	1242.03	0.0001118	11.18

$$EMAP = B/(K0*D/t) = 11.1799/(0.9 * 1242.0328) = 0.1 \text{ bars}$$

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

Material UNS Number: K02700

*Appendix 1-4(f) was also used in determining the required thickness of this head. The required thickness for this geometry is shown below. The required thickness is determined by iteration.*

*Required thickness per Appendix 1-4(f) : 0.487 mm.  
The value of ts/L : 0.001321*

*Appendix 1-4(f) does not govern the design of this head.*

Required Thickness due to Internal Pressure [tr]:

$$= (P*D*Kcor)/(2*S*E-0.2*P) \text{ Appendix 1-4(c)}$$

$$= (0.167*2106.0*0.996)/(2*137.9*1.0-0.2*0.167)$$

$$= 0.1270 + 3.0000 = 3.1270 \text{ mm.}$$

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

$$= ((2*S*E*t)/(Kcor*D+0.2*t))/1.67 \text{ per Appendix 1-4 (c)}$$

$$= ((2*137.9*1.0*2.5)/(0.996*2106.0+0.2*2.5))/1.67$$

$$= 1.792 \text{ bars}$$

Maximum Allowable External Pressure [MAEP]:

$$= \min( MAEP, MAWP )$$

$$= \min( 0.22, 1.792 )$$

$$= 0.216 \text{ bars}$$



Strength Calculation-Active Carbon Filter

Design by A. Azodi

Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 27 of 143

External Pressure Calculations: Step: 4 1:37pm Apr 8,2024

---

*Thickness requirements per UG-33(a)(1) govern the required thickness of this head.*

**PV Elite is a trademark of Intergraph CADWorx & Analysis Solutions, Inc. 2019**



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User  
FileName : EI027-HRC-VD-ME-CAL-003-01

Element and Detail Weights: Step: 5 1:37pm Apr 8,2024

Element and Detail Weights:

From	To	Element Metal Wgt. kg.	Element ID Volume Cm.	Corroded Metal Wgt. kg.	Corroded ID Volume Cm.	Extra due Misc % kg.
10	20	350.294	1385690	218.934	1397104	17.5147
20	30	615.929	5196340	385.501	5226076	30.7965
30	40	615.929	5196340	385.501	5226076	30.7965
40	50	328.496	2771381	205.602	2787240	16.4248
50	60	615.929	5196340	385.501	5226076	30.7965
60	70	350.294	1385690	218.934	1397104	17.5147
Total		2876	21131784.00	1799	21259678.00	143

Weight of Details:

From	Type	Weight of Detail kg.	X Offset, Dtl. Cent. mm.	Y Offset, Dtl. Cent. mm.	Description
10	Liqd	1.66182	...	-262.5	Liquid: 10
10	Nozl	17.8062	...	-625	Drain - 3in
10	Forc	...	...	-525	Drain - 3"
10	Forc	...	...	50	Gas In - 6" T
20	Pack	1714.35	...	950	Carbon Active
20	Liqd	6.23182	...	750	Liquid: 20
20	Nozl	396.541	1354.8	800	MH1 - 24in
20	Nozl	108.386	1134.14	200	Gas In - 6in
20	Nozl	11.2773	1080.16	200	Utility - 2in
20	Legs	677.752	...	-275	LEGS
20	Wght	50	1050	800	DAVIT 1
30	Pack	2337.75	...	750	Carbon Active
30	Liqd	6.23182	...	750	Liquid: 30
40	Pack	1246.8	...	399.999	Carbon Active
40	Liqd	3.32363	...	400	Liquid: 40
50	Pack	1714.35	...	550	Carbon Active
50	Liqd	6.23182	...	750	Liquid: 50
50	Nozl	28.343	1134.14	1300	Gas Out - 6in
50	Nozl	0.71921	1078.58	1400	PG - 1in
50	Forc	...	...	1300	Gas Out - 6"
60	Plat	861.007	...	900	TOP PLATFORM
60	Plat	256.725	...	1700	TOP LADDER
60	Liqd	1.66182	...	312.5	Liquid: 60
60	Nozl	430.378	...	837.496	MH2 - 24in
60	Nozl	19.0933	-704.769	817.423	Vent - 2in
60	Wght	50	...	575	DAVIT 2
60	Forc	...	...	400	PSV - 2"

Total Weight of Each Detail Type:

Platforms	1117.7
Packing	7013.2
Liquid	25.3
Nozzles	1012.5



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User  
FileName : EI027-HRC-VD-ME-CAL-003-01

Element and Detail Weights: Step: 5 1:37pm Apr 8,2024

Legs	677.8
Weights	100.0
<hr/>	
Sum of the Detail Weights	9946.6 kg.

**Weight Summation Results: (kg.)**

	Fabricated	Shop Test	Shipping	Erected	Empty	Operating
Main Elements	3020.7	3020.7	3020.7	3020.7	3020.7	3020.7
Nozzles	1012.5	1012.5	1012.5	1012.5	1012.5	1012.5
Legs	677.8	677.8	677.8	677.8	677.8	677.8
Wld Weights	100.0	100.0	100.0	100.0	100.0	100.0
Platforms	...	...	...	...	1117.7	1117.7 *
Packing	...	...	...	...	7013.2	7013.2 *
Ope. Liquid	...	...	...	...	...	25.3
Test Liquid	...	21118.9	...	...	...	...
Totals	4811.0	25929.9	4811.0	4811.0	12942.0	12967.3

**Field Installation Options:**

- \* Platforms installed after lifting.
- \* Packing installed after lifting.

Miscellaneous Weight Percent: 5.0 %

*Note that the above value for the miscellaneous weight percent has been applied to the shells/heads/flange/tubesheets/tubes etc. in the weight calculations for metallic components.*

**Weight Summary:**

Fabricated Wt.	- Bare Weight without Removable Internals	4811.0 kg.
Shop Test Wt.	- Fabricated Weight + Water ( Full )	25929.9 kg.
Shipping Wt.	- Fab. Weight + removable Intls.+ Shipping App.	4811.0 kg.
Erected Wt.	- Fab. Wt + or - loose items (trays,platforms etc.)	4811.0 kg.
Ope. Wt. no Liq	- Fab. Weight + Internals. + Details + Weights	12942.0 kg.
Operating Wt.	- Empty Weight + Operating Liq. Uncorroded	12967.3 kg.
Field Test Wt.	- Empty Weight + Water (Full)	26044.7 kg.
Mass of the Upper 1/3 of the Vertical Vessel		4461.3 kg.

Note: The Field Test weight as computed in the corroded condition.

**Outside Surface Areas of Elements:**

From	To	Surface Area cm <sup>2</sup>
10	20	51858.8
20	30	99714.2
30	40	99714.2
40	50	53180.9
50	60	99714.2
60	70	51858.8

Total 456040.938 cm<sup>2</sup>



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 30 of 143

Element and Detail Weights: Step: 5 1:37pm Apr 8,2024

Element and Detail Weights:

From	To	Total Ele. Empty Wgt. kg.	Total. Ele. Oper. Wgt. kg.	Total. Ele. Hydro. Wgt. kg.	Total Dtl. Offset Mom. Kg-m.	Oper. Wgt. No Liquid kg.
10	20	385.615	387.277	1643.94	...	385.615
20	Legs	485.172	1173.4	2477.55	289.942	1170.91
Legs	30	727.758	1760.11	3716.32	434.913	1756.37
30	40	646.726	2990.71	5627.66	...	2984.47
40	50	344.921	1595.04	3001.42	...	1591.72
50	60	675.788	2396.37	5656.73	32.9212	2390.14
60	70	867.28	1986.67	3243.34	13.4566	1985.01

Empty Support Force + the Sum of the Y forces	4570.95	Kgf
Operating Support Force + the Sum of the Y forces	12727.27	Kgf
Hydro Support Force + the Sum of the Y forces	25804.64	Kgf

Cumulative Vessel Weight

From	To	Cumulative Ope Wgt. No Liquid kg.	Cumulative Oper. Wgt. kg.	Cumulative Hydro. Wgt. kg.
10	20	...	...	...
20	Legs	-385.615	-387.277	-1643.94
Legs	30	10707.7	10728.9	21245.5
30	40	8951.34	8968.79	17529.1
40	50	5966.87	5978.08	11901.5
50	60	4375.15	4383.04	8900.06
60	70	1985.01	1986.67	3243.34

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. Kg-m.	Cumulative Oper. Mom. Kg-m.	Cumulative Hydro. Mom. Kg-m.
10	20	...	...	...
20	Legs	289.942	289.942	289.942
Legs	30	481.29	481.29	481.29
30	40	46.3778	46.3778	46.3778
40	50	46.3778	46.3778	46.3778
50	60	46.3778	46.3778	46.3778
60	70	13.4566	13.4566	13.4566



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 31 of 143

Nozzle Flange MAWP:

Step: 6 1:37pm Apr 8,2024

Nozzle Flange MAWP Results:

Nozzle Description	Flange Rating		Design Temp °C	Class	Grade/ Group	Equiv. Press	Max Pressure		
	Oper. bars	Ambient bars					PVP	50%	DNV bars
Drain - 3in	18.15	19.60	85	150	GR 1.1	...	...	...	...
MH1 - 24in	18.15	19.60	85	150	GR 1.1	...	...	...	...
Gas In - 6in	18.15	19.60	85	150	GR 1.1	...	...	...	...
Utility - 2in	18.15	19.60	85	150	GR 1.1	...	...	...	...
Gas Out - 6in	18.15	19.60	85	150	GR 1.1	...	...	...	...
MH2 - 24in	18.15	19.60	85	150	GR 1.1	...	...	...	...
Vent - 2in	18.15	19.60	85	150	GR 1.1	...	...	...	...
Min Rating	18.150	19.600 bars [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 Metric Edition

PV Elite is a trademark of Intergraph CADWorx & Analysis Solutions, Inc. 2019



Strength Calculation-Active Carbon Filter

Design by A. Azodi

Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 32 of 143

Natural Frequency Calculation: Step: 7 1:37pm Apr 8,2024

---

The Natural Frequencies for the vessel have been computed iteratively by solving a system of matrices. These matrices describe the mass and the stiffness of the vessel. This is the generalized eigenvalue/eigenvector problem and is referenced in some mathematical texts.

The Natural Frequency for the Vessel (Empty.) is 12.052 Hz.

The Natural Frequency for the Vessel (Ope...) is 12.0411 Hz.

**PV Elite is a trademark of Intergraph CADWorx & Analysis Solutions, Inc. 2019**



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 33 of 143

Forces/Moments Applied to Vessel Step: 8 1:37pm Apr 8,2024

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

From	To	X and Z Dir Force Res. Kgf	X,Z Moment and For Res Kg-m.
10	20	255.557	243.767
20	30	...	...
30	40	...	...
40	50	...	...
50	60	255.557	524.886
60	70	...	19.6116

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

From	To	X and Z Dir Force Res. Kgf	X,Z Moment and For Res Kg-m.
10	20	255.557	243.767
20	30	...	...
30	40	...	...
40	50	...	...
50	60	255.557	524.886
60	70	...	19.6116

**User Input Forces and Moments:**

From Node	Distance From	----- Fx	Forces Fy	----- Fz	----- Mx	Moments My	----- Mz
10	-525.00		-76.				
10	50.00	181.	-181.	181.	172.		172.
50	1300.00	181.	-181.	181.	136.		136.
60	400.00				14.		14.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 34 of 143

Wind Load Calculation: Step: 9 1:37pm Apr 8,2024

**Wind Analysis Results per UBC 1994 or UBC 1997**

Importance Factor as Entered by the User is	1.150	
Wind Stagnation Pressure (qs) from Table 16-F	75.6	Kgs/m <sup>2</sup>
Pressure Coefficient from Table 16-H	Cq 0.800	
User Entered Basic Wind Speed	125.0	Km/hr

$P(\text{height}) = C_e(\text{height,Exp}) * C_q * q_s * \text{Imp Fact. [18-1](1994) or [20-1](1997)}$

The values of Ce are shown as the in the table below:

Element	Ce
Lower Head	1.0600
Shell #1	1.0600
Shell #2	1.0600
Shell #3	1.0600
Shell #4	1.0853
Upper Head	1.1288

**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<sup>2</sup>)(10<sup>4</sup>)
- 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, <= 0.320E-06 (High); 0.320E-06 < 0.400E-06 (Probable)
- P30 - wind pressure 30 feet above the base

**Check other Conditions and Basic Assumptions:**

#1 - Total Cone Length / Total Length < 0.5  
 $0.0/5400.0 = 0.0$

#2 - ( D / L<sup>2</sup> ) \* 10<sup>4</sup> < 8.0 (English Units)  
 $- ( 6.94/17.72^2 ) * 10^4 = 221.169$  [Geometry Violation]

Compute the vibration possibility. If Vp > 0.400E-06 no chance. [Vp]:  
 $= W / ( L * D_r^2 )$   
 $= 11837 / ( 5400.0 * 2106.0^2 )$



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User  
FileName : EI027-HRC-VD-ME-CAL-003-01

Wind Load Calculation: Step: 9 1:37pm Apr 8,2024

= 0.49422E-06

Since Vp is > 0.400E-06 no further vibration analysis is required !

**Platform Load Calculations**

ID	Wind Area cm <sup>2</sup>	Elevation mm.	Pressure Kgs/m <sup>2</sup>	Force Kgf	Cf
TOP PLATFORM	34320.00	6250.00	78.06	267.89	1.30
TOP LADDER	0.00	7050.00	78.06	0.00	1.30

**Wind Loads on Masses/Equipment/Piping**

ID	Wind Area cm <sup>2</sup>	Elevation mm.	Pressure Kgs/m <sup>2</sup>	Force Kgf
DAVIT 1	0.00	850.00	73.70	0.00
DAVIT 2	0.00	5925.00	77.88	0.00

The Natural Frequency for the Vessel (Ope...) is 12.0411 Hz.

**Wind Load Calculation:**

From	To	Wind Height mm.	Wind Diameter mm.	Wind Area cm <sup>2</sup>	Wind Pressure Kgs/m <sup>2</sup>	Element Wind Load Kgf
10	20	332.151	3377.6	15761.7	73.6976	116.16
20	30	1325	3385.6	50784	73.6976	374.267
30	40	2825	3385.6	50784	73.6976	374.267
40	50	3975	3385.6	27084.8	73.6976	199.609
50	60	5125	3385.6	50784	75.4595	383.214
60	70	6123.35	3377.6	15761.7	78.4809	397.134



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 36 of 143

Earthquake Load Calculation: Step: 10 1:37pm Apr 8,2024

**Earthquake Load Calculation:**

**Input Values:**

Seismic Design Code		ASCE/SEI 7-16
Seismic Load Reduction Scale Factor		0.714
Importance Factor		1.250
Table Value Fa		1.050
Table Value Fv		1.100
Max. Mapped Res. Acceleration	[Ss]	1.310
Max. Eff. Ground Acceleration	[S]	0.460
Force Modification Factor R		2.000
Site Class		C
Component Elevation Ratio	z/h	0.000
Amplification Factor	Ap	0.000
Force Factor		0.000
Consider Vertical Acceleration		No
Minimum Acceleration Multiplier		0.000
User Value of Sds (used if > 0 )		0.920
User Value of Sd1 (used if > 0 )		0.340
Moment Reduction Factor Tau		1.000

**Seismic Analysis Results:**

$$Sms = Fa * Ss = 1.05 * 1.31 = 1.375$$

$$Sm1 = Fv * S1 = 1.1 * 0.46 = 0.506$$

$$Sds = 2/3 * Sms = 2/3 * 1.375 = 0.917$$

$$Sds = \text{Max}( 0.8*Sds, SdsUser )$$

$$= \text{Max}( 0.734, 0.92 )$$

$$= 0.920$$

$$Sd1 = 2/3 * Sm1 = 2/3 * 0.506 = 0.337$$

$$Sd1 = \text{Max}( 0.8*Sd1, Sd1User )$$

$$= \text{Max}( 0.27, 0.34 )$$

$$= 0.340$$

**Check Approximate Fundamental Period from 12.8-7 [Ta]:**

$$= Ct * hn^{(x)} \text{ where } Ct = 0.020, x = 0.75 \text{ and } hn = \text{Structural Height (ft.)}$$

$$= 0.020 * ( 23.0479^{(0.75)})$$

$$= 0.210 \text{ seconds}$$

The Coefficient Cu from Table 12.8-1 is : 1.400

**Fundamental Period (1/Frequency) [T]:**

$$= ( 1/\text{Natural Frequency} ) = ( 1/12.041 )$$

$$= 0.083$$

**Check the Value of T which is the smaller of Cu\*Ta and T:**

$$= \text{Minimum Value of } (1.4 * 0.21, 0.083 ) \text{ per 12.8.2}$$

$$= 0.083$$

**Compute the Seismic Response Coefficient per equation 12.8-2 [Cs]:**

$$= Sds / ( R / I )$$

$$= 0.92 / ( 2.0 / 1.25 )$$



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 37 of 143

Earthquake Load Calculation: Step: 10 1:37pm Apr 8,2024

= 0.575

Check the Maximum value of Cs per equation 12.8-3 [Cs]:

=  $S_{d1} / ( T * ( R / I_e ) )$   
=  $0.34 / ( 0.083 * ( 2.0 / 1.25 ) )$   
= 2.559

Check the Minimum value of Cs per equation 15.4-1 [Cs]:

=  $\max( ( 0.044 * SDS * I_e ), 0.030 )$   
=  $\max( ( 0.044 * 0.92 * 1.25 ), 0.030 )$   
= 0.051

Total Base Shear [V]:

=  $C_s * W$  (Equation 12.8-1):  
=  $0.575 * 12289.6$   
= 7066.507 Kgf

Final Base Shear, V = 5045.49 Kgf

Distribute the Base shear force to each element according to the equations  $F_x = C_{vx} * V$  (eqn. 12.8-11) and the vertical distribution factor

$C_{vx} = W_x * h_x^k / ( \text{Sum of } W_i * h_i^k )$  and k is an exponent which is related to the period of Vibration.

In this case, the value of k was 1.0

The Natural Frequency for the Vessel (Ope...) is 12.0411 Hz.

Earthquake Load Calculation:

From	To	Earthquake Height mm.	Earthquake Weight Kgf	Element Ope Load Kgf	Element Emp Load Kgf
10	20	25	387.277	1.32774	1.41351
20	Legs	650	1173.4	104.596	46.2395
Legs	30	1100	1760.11	265.512	117.377
30	40	2300	2990.71	943.311	218.098
40	50	3450	1595.04	754.647	174.479
50	60	4600	2396.37	1511.7	455.798
60	70	5375	1986.67	1464.4	683.505

Note:

The Earthquake Loads calculated and printed in the Earthquake Load calculation report have been factored by the input scalar/load reduction factor of: 0.714.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 38 of 143

User Force/Moment Shear and Bending Step: 11 1:37pm Apr 8,2024

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 Kg-f	Cumulative Shr Eqk Cas Kg-f	Wind Bending Kg-m.	Earthquake Bending Kg-m.
10	20	848.349	...	...	...	...
20	Legs	300	255.557	255.557	243.767	243.767
Legs	30	450	511.114	511.114	1759.4	1759.4
30	40	1650	255.557	255.557	1132.29	1132.29
40	50	2800	255.557	255.557	748.947	748.947
50	60	3950	255.557	255.557	544.498	544.498
60	70	4948.35	...	...	19.6116	19.6116

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: 0.714.

Note:  
Review the Vessel Design Summary for the cumulative shear force and bending moment on the support.

PV Elite is a trademark of Intergraph CADWorx & Analysis Solutions, Inc. 2019



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 39 of 143

Wind/Earthquake Shear, Bending: Step: 12 1:37pm Apr 8,2024

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 Kg-m.	Earthquake Bending Kg-m.
10	20	848.349	...	...	...	...
20	Legs	300	116.16	1.32774	28.8488	0.32975
Legs	30	450	1694.94	4940.89	4612.99	16974.3
30	40	1650	1354.22	4674.05	3436.57	12680.6
40	50	2800	979.957	3730.74	1685.9	6376.91
50	60	3950	780.348	2976.09	981.759	3694.12
60	70	4948.35	397.134	1464.4	98.6295	363.687

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: 0.714.

Note:  
Review the Vessel Design Summary for the cumulative shear force and bending moment on the support.

PV Elite is a trademark of Intergraph CADWorx & Analysis Solutions, Inc. 2019



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 40 of 143

Wind Deflection:

Step: 13

1:37pm

Apr 8, 2024

**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	...	0.65013	0.65013	0.00055506
20	Legs	255.557	0.65036	0.65104	0.00055804
Legs	30	511.114	0.65276	0.65516	0.00056108
30	40	255.557	0.66046	0.66717	0.00056479
40	50	255.557	0.67121	0.67553	0.00056616
50	60	255.557	0.68397	0.69252	0.00056649
60	70	...	0.6928	0.69309	0.00056649

Allowable deflection at the Tower Top (For)( 6.000"/100ft. Criteria)  
Allowable deflection : 27.000 Actual deflection : 0.693 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	...	2.15655	2.15655	0.0018426
20	Legs	116.16	2.15716	2.15897	0.0018505
Legs	30	1694.94	2.16378	2.17079	0.0018604
30	40	1354.22	2.18646	2.20588	0.0018704
40	50	979.957	2.21735	2.22938	0.0018733
50	60	780.348	2.25297	2.27728	0.0018752
60	70	397.134	2.2781	2.27891	0.0018752

**Critical Wind Velocity for Tower Vibration:**

From	To	1st Crit. Wind Speed Km/hr	2nd Crit. Wind Speed Km/hr
10	20	730.091	4563.07
20	30	731.82	4573.88
30	40	731.82	4573.88
40	50	731.82	4573.88
50	60	731.82	4573.88
60	70	730.091	4563.07

Allowable deflection at the Tower Top (Ope)( 6.000"/100ft. Criteria)



Strength Calculation-Active Carbon Filter

Design by A. Azodi

Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 41 of 143

Wind Deflection:

Step: 13 1:37pm Apr 8,2024

---

Allowable deflection : 27.000 Actual deflection : 2.279 mm.

Total Deflection in the Operating Condition + Applied Forces :

Allowable deflection : 27.000 Actual deflection : 2.972 mm.

**PV Elite is a trademark of Intergraph CADWorx & Analysis Solutions, Inc. 2019**



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 42 of 143

Longitudinal Stress Constants: Step: 14 1:37pm Apr 8,2024

Longitudinal Stress Constants:

From	To	Metal Area New cm <sup>2</sup>	Metal Area Corroded cm <sup>2</sup>	Section Modulus New mm. <sup>3</sup>	Section Modulus Corroded mm. <sup>3</sup>
10	20	363.8	165.598	19099846	8718717
20	30	529.796	331.594	27815242	17458646
30	40	529.796	331.594	27815242	17458646
40	50	529.796	331.594	27815242	17458646
50	60	529.796	331.594	27815242	17458646
60	70	363.8	165.598	19099846	8718717



Strength Calculation-Active Carbon Filter

Design by A. Azodi

Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 43 of 143

Longitudinal Allowable Stresses: Step: 15 1:37pm Apr 8,2024

Longitudinal Allowable Stresses:

From	To	Tensile N./mm <sup>2</sup>	Hydrotest Tensile N./mm <sup>2</sup>	Compressive N./mm <sup>2</sup>	Hydrotest Compressive N./mm <sup>2</sup>
10	20	140.658	240.516	-35.5202	-35.5202
20	Legs	140.658	240.516	-70.8725	-70.8725
Legs	30	140.658	240.516	-70.8725	-70.8725
30	40	140.658	240.516	-70.8725	-70.8725
40	50	140.658	240.516	-70.8725	-70.8725
50	60	140.658	240.516	-70.8725	-70.8725
60	70	140.658	240.516	-35.5202	-35.5202



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 44 of 143

Longitudinal Stresses due to: Step: 16 1:37pm Apr 8,2024

**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 also been computed in the corroded condition.

Longitudinal Pressure Stresses due to:

From	To	Longitudinal Stress Internal Pressure N./mm <sup>2</sup>	Longitudinal Stress External Pressure N./mm <sup>2</sup>	Longitudinal Stress Hydrotest Pressure N./mm <sup>2</sup>
10	20	4.20824	-2.11367	76.3674
20	30	2.10212	-1.06057	38.1474
30	40	2.10212	-1.06057	38.1474
40	50	2.10212	-1.06057	38.1474
50	60	2.10212	-1.06057	38.1474
60	70	4.20824	-2.11367	76.3674

Longitudinal Stresses due to Weight Loads for these Conditions:

From	To	Wght. Str. Empty N./mm <sup>2</sup>	Wght. Str. Operating N./mm <sup>2</sup>	Wght. Str. Hydrotest N./mm <sup>2</sup>	Wght. Str. Emp. Mom. N./mm <sup>2</sup>	Wght. Str. Opr. Mom. N./mm <sup>2</sup>
10	20	...	...	...	...	...
20	Legs	0.11404	0.11454	...	0.16286	0.16286
Legs	30	-3.16678	-3.16605	...	0.27034	0.27034
30	40	-2.64734	-2.64734	...	0.026051	0.026051
40	50	-1.76469	-1.76469	...	0.026051	0.026051
50	60	-1.29394	-1.29394	...	0.026051	0.026051
60	70	-1.17554	-1.17554	...	0.015136	0.015136

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

From	To	Wght. Str. Hyd. Mom. N./mm <sup>2</sup>	Bend. Str. Oper. Wind N./mm <sup>2</sup>	Bend. Str. Oper. Equ. N./mm <sup>2</sup>	Bend. Str. Hyd. Wind N./mm <sup>2</sup>	Bend. Str. Hyd. Equ. N./mm <sup>2</sup>
10	20	...	...	...	...	...
20	Legs	...	0.016205	0.00018522	...	...
Legs	30	...	2.59114	9.53459	...	...
30	40	...	1.93034	7.12279	...	...
40	50	...	0.94698	3.58195	...	...
50	60	...	0.55146	2.07501	...	...
60	70	...	0.11094	0.40907	...	...

Longitudinal Stresses due to these Conditions:

From	To	Vortex Shedding Operating Case N./mm <sup>2</sup>	Vortex Shedding Empty Case N./mm <sup>2</sup>	Vortex Shedding Test Case N./mm <sup>2</sup>	Earthquake Empty Case N./mm <sup>2</sup>



Strength Calculation-Active Carbon Filter

Design by A. Azodi

Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 45 of 143

Longitudinal Stresses due to: Step: 16 1:37pm Apr 8,2024

10	20	...	...	...	...
20	Legs	...	...	...	0.00019719
Legs	30	...	...	...	3.40894
30	40	...	...	...	2.6133
40	50	...	...	...	1.41445
50	60	...	...	...	0.86328
60	70	...	...	...	0.19093

Longitudinal Stresses due to Applied Axial Forces:

From	To	Longitudinal Stress Y Forces Wind N./mm <sup>2</sup>	Longitudinal Stress Y Forces Seismic N./mm <sup>2</sup>
10	20	0.15219	0.15219
20	Legs	0.12945	0.12945
Legs	30	-0.053443	-0.053443
30	40	-0.053443	-0.053443
40	50	-0.053443	-0.053443
50	60	-0.053443	-0.053443
60	70	...	...

Longitudinal Stresses due to User Forces and Moments:

From	To	Wind For/Mom Corroded N./mm <sup>2</sup>	Earthquake For/Mom Corroded N./mm <sup>2</sup>	Wind For/Mom No Corrosion N./mm <sup>2</sup>	Earthquake For/Mom No Corrosion N./mm <sup>2</sup>
10	20	...	...	...	...
20	Legs	0.13693	0.13693	0.085943	0.085943
Legs	30	0.98827	0.98827	0.6203	0.6203
30	40	0.63601	0.63601	0.3992	0.3992
40	50	0.42069	0.42069	0.26405	0.26405
50	60	0.30585	0.30585	0.19197	0.19197
60	70	0.022059	0.022059	0.010069	0.010069



Strength Calculation-Active Carbon Filter
Design by A. Azodi
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 46 of 143

Stress due to Combined Loads: Step: 17 1:37pm Apr 8,2024

Stress Combination Load Cases for Vertical Vessels:

Load Case Definition Key

- IP = Longitudinal Stress due to Internal Pressure
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

General Notes:

Case types HI and HE are in the 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

Table with 7 columns: From Node, Tensile Stress, All. Tens. Stress, Comp. Stress, All. Comp. Stress, Tens. Ratio, Comp. Ratio. Rows for nodes 10, 20, 30, 40, 50, 60.

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

Table with 7 columns: From Node, Tensile Stress, All. Tens. Stress, Comp. Stress, All. Comp. Stress, Tens. Ratio, Comp. Ratio. Row for node 10.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User  
FileName : EI027-HRC-VD-ME-CAL-003-01

Stress due to Combined Loads: Step: 17 1:37pm Apr 8,2024

20	0.54	140.66	-0.06	70.87	0.0039	0.0008
20	1.45	140.66	-7.89	70.87	0.0103	0.1113
30	0.57	140.66	-5.98	70.87	0.0041	0.0843
40	0.04	140.66	-3.68	70.87	0.0003	0.0519
50		140.66	-2.54	70.87		0.0359
60		140.66	-1.40	35.52		0.0395

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	0.15	140.66		35.52	0.0011	
20	0.56	140.66	-0.07	70.87	0.0040	0.0010
20	0.63	140.66	-7.07	70.87	0.0045	0.0997
30		140.66	-5.29	70.87		0.0747
40		140.66	-3.21	70.87		0.0453
50		140.66	-2.23	70.87		0.0315
60		140.66	-1.32	35.52		0.0373

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	0.15	140.66		35.52	0.0011	
20	0.54	140.66	-0.06	70.87	0.0039	0.0008
20	7.57	140.66	-14.01	70.87	0.0538	0.1977
30	5.08	140.66	-10.49	70.87	0.0361	0.1480
40	2.21	140.66	-5.85	70.87	0.0157	0.0825
50	1.06	140.66	-3.75	70.87	0.0075	0.0530
60		140.66	-1.62	35.52		0.0457

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	0.00	240.52	0.00	35.52	0.0000	0.0000
20	0.00	240.52	0.00	70.87	0.0000	0.0000
20	0.00	240.52	0.00	70.87	0.0000	0.0000
30	0.00	240.52	0.00	70.87	0.0000	0.0000
40	0.00	240.52	0.00	70.87	0.0000	0.0000
50	0.00	240.52	0.00	70.87	0.0000	0.0000
60	0.00	240.52	0.00	35.52	0.0000	0.0000

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	0.00	240.52	0.00	35.52	0.0000	0.0000
20	0.00	240.52	0.00	70.87	0.0000	0.0000
20	0.00	240.52	0.00	70.87	0.0000	0.0000
30	0.00	240.52	0.00	70.87	0.0000	0.0000
40	0.00	240.52	0.00	70.87	0.0000	0.0000
50	0.00	240.52	0.00	70.87	0.0000	0.0000
60	0.00	240.52	0.00	35.52	0.0000	0.0000

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	4.36	140.66		35.52	0.0310	
20	2.66	140.66		70.87	0.0189	
20	2.73	140.66	-4.97	70.87	0.0194	0.0701



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User  
FileName : EI027-HRC-VD-ME-CAL-003-01

Stress due to Combined Loads: Step: 17 1:37pm Apr 8,2024

30	1.99	140.66	-3.19	70.87	0.0142	0.0450
40	1.68	140.66	-1.11	70.87	0.0119	0.0157
50	1.64	140.66	-0.13	70.87	0.0116	0.0018
60	3.18	140.66		35.52	0.0226	

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	4.36	140.66		35.52	0.0310	
20	2.65	140.66		70.87	0.0188	
20	9.68	140.66	-11.91	70.87	0.0688	0.1681
30	7.19	140.66	-8.38	70.87	0.0511	0.1183
40	4.31	140.66	-3.74	70.87	0.0307	0.0528
50	3.16	140.66	-1.65	70.87	0.0225	0.0233
60	3.48	140.66		35.52	0.0247	

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		140.66	-1.96	35.52		0.0552
20		140.66	-1.13	70.87		0.0160
20		140.66	-8.13	70.87		0.1147
30		140.66	-6.35	70.87		0.0897
40		140.66	-4.27	70.87		0.0603
50		140.66	-3.29	70.87		0.0464
60		140.66	-3.44	35.52		0.0968

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		140.66	-1.96	35.52		0.0552
20		140.66	-1.12	70.87		0.0158
20	6.51	140.66	-15.07	70.87	0.0463	0.2127
30	4.02	140.66	-11.55	70.87	0.0286	0.1629
40	1.15	140.66	-6.91	70.87	0.0082	0.0975
50		140.66	-4.81	70.87		0.0679
60		140.66	-3.74	35.52		0.1052

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	76.37	240.52		35.52	0.3175	
20	38.15	240.52		70.87	0.1586	
20	38.15	240.52		70.87	0.1586	
30	38.15	240.52		70.87	0.1586	
40	38.15	240.52		70.87	0.1586	
50	38.15	240.52		70.87	0.1586	
60	76.37	240.52		35.52	0.3175	

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	76.37	240.52		35.52	0.3175	
20	38.15	240.52		70.87	0.1586	
20	38.15	240.52		70.87	0.1586	
30	38.15	240.52		70.87	0.1586	
40	38.15	240.52		70.87	0.1586	



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 49 of 143

Stress due to Combined Loads: Step: 17 1:37pm Apr 8,2024

50	38.15	240.52	70.87	0.1586
60	76.37	240.52	35.52	0.3175

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	4.21	140.66		35.52	0.0299	
20	2.38	140.66		70.87	0.0169	
20		140.66	-1.34	70.87		0.0188
30		140.66	-0.57	70.87		0.0081
40	0.36	140.66		70.87	0.0026	
50	0.83	140.66		70.87	0.0059	
60	3.05	140.66		35.52	0.0217	

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	4.21	140.66		35.52	0.0299	
20	2.17	140.66		70.87	0.0155	
20	0.12	140.66		70.87	0.0009	
30	0.45	140.66		70.87	0.0032	
40	1.00	140.66		70.87	0.0071	
50	1.29	140.66		70.87	0.0092	
60	3.67	140.66		35.52	0.0261	

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	4.21	140.66		35.52	0.0299	
20	2.38	140.66		70.87	0.0169	
20		140.66	-1.33	70.87		0.0188
30		140.66	-0.57	70.87		0.0081
40	0.36	140.66		70.87	0.0026	
50	0.83	140.66		70.87	0.0059	
60	3.05	140.66		35.52	0.0217	

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	4.21	140.66		35.52	0.0299	
20	2.38	140.66		70.87	0.0169	
20		140.66	-1.34	70.87		0.0188
30		140.66	-0.57	70.87		0.0081
40	0.36	140.66		70.87	0.0026	
50	0.83	140.66		70.87	0.0059	
60	3.05	140.66		35.52	0.0217	

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	0.00	140.66	0.00	35.52	0.0000	0.0000
20	0.28	140.66	-0.05	70.87	0.0020	0.0007
20		140.66	-3.44	70.87		0.0485
30		140.66	-2.67	70.87		0.0377
40		140.66	-1.79	70.87		0.0253
50		140.66	-1.32	70.87		0.0186
60		140.66	-1.19	35.52		0.0335



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 50 of 143

Stress due to Combined Loads: Step: 17 1:37pm Apr 8,2024

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	4.36	140.66		35.52	0.0310	
20	2.65	140.66		70.87	0.0188	
20	0.14	140.66	-2.38	70.87	0.0010	0.0335
30	0.06	140.66	-1.26	70.87	0.0005	0.0178
40	0.73	140.66	-0.16	70.87	0.0052	0.0023
50	1.09	140.66		70.87	0.0077	
60	3.07	140.66		35.52	0.0218	

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		140.66	-1.96	35.52		0.0552
20		140.66	-1.12	70.87		0.0158
20		140.66	-5.54	70.87		0.0781
30		140.66	-4.42	70.87		0.0624
40		140.66	-3.33	70.87		0.0469
50		140.66	-2.74	70.87		0.0387
60		140.66	-3.33	35.52		0.0936

Absolute Maximum of the all of the Stress Ratio's 0.3175

Governing Element: Lower Head  
Governing Load Case 11 : HP+HW+HI



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User  
FileName : EI027-HRC-VD-ME-CAL-003-01

Center of Gravity Calculation: Step: 18 1:37pm Apr 8,2024

**Shop/Field Installation Options :**

Platform(s) installed in the Field after being lifted.  
Packing is installed in the Field after being lifted.

Note : The CG is computed from the first Element From Node

Center of Gravity of Platforms	6433.747 mm.
Center of Gravity of Packing	2699.999 mm.
Center of Gravity of Liquid	2700.000 mm.
Center of Gravity of Nozzles	3245.595 mm.
Center of Gravity of Legs	-225.000 mm.
Center of Gravity of Added Weights (Operating)	3387.500 mm.
Center of Gravity of Added Weights (Empty)	3387.500 mm.
Center of Gravity of Bare Shell New and Cold	2700.000 mm.
Center of Gravity of Bare Shell Corroded	2700.000 mm.
Vessel CG in the Operating Condition	2937.575 mm.
Vessel CG in the Fabricated (Shop/Empty) Condition	2417.058 mm.
Vessel CG in the Test Condition	2647.503 mm.

**Rigging Analysis Results:**

Lifting Weight based the calculated Erected Weight.

Total Effective Length of Vessel for this analysis	5400.00 mm.
Total vessel weight (No Liquid)	Twt 5456.49 Kgf
Impact weight multiplication factor	Imp 2.00
Design lifting weight, DWT = Imp * Twt	10912.98 Kgf
Elevation of the Tailing Lug (bottom)	0.00 mm.
Elevation of the Lifting Lug (top )	5400.00 mm.
Design Reaction force at the tailing lug	6028.29 Kgf
Design Reaction force at the lifting lug	4884.69 Kgf
CG Distance from Tailing Lug	2417.06 mm.
CG Distance from the Nearer Lifting Lug	2417.06 mm.

**Critical Values:**

	Max Stress N./mm <sup>2</sup>	Elevation mm.	Allowables N./mm <sup>2</sup>
Bending	1.72	2750.00	83.55 (UG-23)
Shear	1.14	5360.00	96.53 (0.7*S)

Forces and Moments at selected elevations (not all analysis points shown):

Distance mm.	Bending Moment Kg-m.	Bending Stress N./mm <sup>2</sup>	Shear Force Kgf	Shear Stress N./mm <sup>2</sup>
0.00	0.0	0.0	3881.6	1.0
50.00	47.8	0.0	3725.7	0.7
1550.00	4137.8	1.5	607.7	0.1
3050.00	4815.5	1.7	951.3	0.2



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 52 of 143

Center of Gravity Calculation: Step: 18 1:37pm Apr 8,2024

---

3850.00	3929.7	1.4	2510.3	0.5
5350.00	69.6	0.0	4069.3	1.1

Unity Check (Actual Stress / Allowable Stress):

Maximum Unity Check is 0.0205 at elevation 2750.0 mm. - Must be <=1

Note: The rigging analysis is performed using a uniformly distributed load.

--- Plot data successfully generated ...----

PV Elite is a trademark of Intergraph CADWorx & Analysis Solutions, Inc. 2019



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User  
FileName : EI027-HRC-VD-ME-CAL-003-01

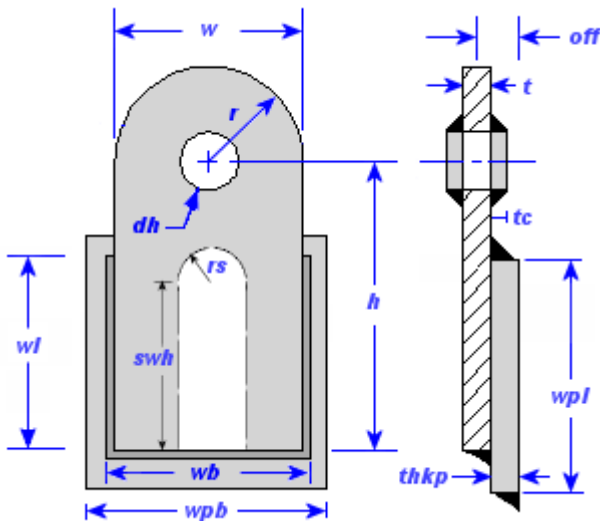
Lifting Lug Calcs: Lifting Lugs Step: 19 1:37pm Apr 8,2024

Lifting Lug Calculations:

Input Values:

Lifting Lug Material		SA-283 C
Lifting Lug Yield Stress	Yield	206.85 N./mm <sup>2</sup>
Width of Lifting Lug	w	250.0000 mm.
Thickness of Lifting Lug	t	12.0000 mm.
Diameter of Hole in Lifting Lug	dh	50.0000 mm.
Radius of Semi-Circular Arc of Lifting Lug	r	125.0000 mm.
Height of Lug from bottom to Center of Hole	h	650.0000 mm.
Offset from Vessel OD to Center of Hole	off	14.0000 mm.
Lug Fillet Weld Size	tw	8.0000 mm.
Length of weld along side of Lifting Lug	wl	200.0000 mm.
Length of Weld along Bottom of Lifting Lug	wb	250.0000 mm.
Thickness of Collar (if any)	tc	0.0000 mm.
Diameter of Collar (if any)	dc	0.0000 mm.
Impact Factor	Impfac	2.00
Slot Radius		50.0000 mm.
Slot Height		100.0000 mm.
Number of Lugs in Group		2

Lifting Lug Orientation to Vessel: Flat  
Lift Orientation : From Horizontal to Vertical



PV Elite does not compute weak axis bending forces on the lugs. It is assumed that a spreader bar is used.

Lifting Lug and Weld Stresses at various Angles: N/mm<sup>2</sup>

Angle	----- Weld Stresses			----- Lug Stresses		Maximum Ratio
	Primary	Secondary	Allowable	Combined	Allowable	
0	8.6	43.5	110.0	86.2	155.1	0.556
5	9.0	44.3	110.0	88.6	155.1	0.571



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 54 of 143

Lifting Lug Calcs: Lifting Lugs Step: 19 1:37pm Apr 8,2024

10	9.4	44.7	110.0	90.2	155.1	0.581
15	9.8	44.8	110.0	91.0	155.1	0.587
20	10.1	44.5	110.0	91.2	155.1	0.588
25	10.5	43.8	110.0	90.6	155.1	0.584
30	10.9	42.8	110.0	89.3	155.1	0.576
35	11.3	41.3	110.0	87.3	155.1	0.563
40	11.7	39.6	110.0	84.5	155.1	0.545
45	12.1	37.4	110.0	81.1	155.1	0.523
50	12.5	34.9	110.0	76.9	155.1	0.496
55	12.9	32.1	110.0	72.1	155.1	0.465
60	13.4	29.0	110.0	66.7	155.1	0.430
65	14.0	25.5	110.0	60.6	155.1	0.391
70	14.7	21.7	110.0	53.9	155.1	0.347
75	15.6	17.4	110.0	46.5	155.1	0.299
80	16.9	12.7	110.0	38.3	155.1	0.247
85	18.8	7.1	110.0	29.0	155.1	0.187
90	22.2	1.6	110.0	17.8	155.1	0.202

**Computed Results:**

Total vessel weight (No Liquid) 5456.49 Kgf  
 Design Reaction force at the tailing lug 6028.29 Kgf  
 Design Reaction force at the lifting lug 4884.69 Kgf

Worst Case Lift Angle for Primary Weld Stresses 90 deg  
 Tangential Force at this Angle 0.0 Kgf  
 Axial Force at this Angle 5456.5 Kgf

Worst Case Lift Angle for Secondary Weld Stresses 13 deg  
 Tangential Force at this Angle 2517.6 Kgf  
 Axial Force at this Angle 581.2 Kgf

Worst Case Lift Angle for Lug Stresses 19 deg  
 Tangential Force at this Angle 2504.2 Kgf  
 Axial Force at this Angle 862.3 Kgf

*Converting the weld leg dimension (tw) to the weld throat dimension.*

**Weld Group Inertia Calculations:**

Weld Group Inertia about the Circumferential Axis I1c 1844.960 cm\*\*4  
 Weld Group Centroid distance in the Long. Direction Y11 123.350 mm.  
 Dist. of Weld Group Centroid from Lug bottom Y11\_b 76.650 mm.  
 Weld Group Inertia about the Longitudinal Axis I1l 4915.609 cm\*\*4  
 Weld Group Centroid Distance in the Circ. Direction Y1c 130.656 mm.

*Note: The Impact Factor is applied to the Forces acting on the Lug.*

**Primary Shear Stress in the Welds due to Shear Loads [Ssll]:**

$$= \sqrt{(Fax^{(2)} + Ft^{(2)} + Fn^{(2)}) / ((2 * wl + wb) * tw)}$$

$$= \sqrt{(5456^{(2)} + 0^{(2)} + 0^{(2)}) / ((2 * 200.0 + 150.0) * 5.656)}$$

$$= 17.20 \text{ N./mm}^2$$

**Shear Stress in the Welds due to Bending Loads [Sblf]:**

$$= (Fn(h-Y11_b))Y11/I1c + (Fax * off * Y11/I1c) + (Ft * off * Y1c/I1l)$$

$$= (0(650.0-76.65))123.35/1844.96 +$$



Strength Calculation-Active Carbon Filter

Design by A. Azodi

Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 55 of 143

Lifting Lug Calcs: Lifting Lugs

Step: 19

1:37pm

Apr 8, 2024

$$(5456 * 14.0 * 123.35/1844.96) + (0 * 14.0 * 130.656/4915.609) = 5.01 \text{ N./mm}^2$$

Total Shear Stress for Combined Loads [St]:

$$= S_{s11} + S_{b1f} = 17.202 + 5.009 = 22.21 \text{ N./mm}^2$$

Allowable Shear Stress for Combined Loads [Sta]:

$$= 0.4 * \text{Yield} * \text{Occfac} \text{ (AISC Shear Allowable)} = 0.4 * 207 * 1.33 = 110.04 \text{ N./mm}^2$$

**Secondary Shear Stress in the Welds due to Shear Loads:**

Unit Weld Polar Section Modulus [Uwsm]:

$$= (2 * w_l + w)^3 / 12 - w_l^2 (w_l + w)^2 / (2 * w_l + w) = 10423878.00 \text{ mm.}^3$$

**Loads on Welds due to Torsional Moment:**

Shear Stress in Normal Direction [Fth]:

$$= F_t * (h - (w_l - \text{Cent})) * (w_b / 2) / U_{wsm} = 10.66 \text{ Kg/mm.}$$

Shear Stress in Circumferential Direction [Ftv]:

$$= F_t * (h - (w_l - \text{Cent})) * \text{Cent} / U_{wsm} = 19.68 \text{ Kg/mm.}$$

Primary Shear Stress [Fsv]:

$$= F_t / (2 * w_l + w) = 3.87 \text{ Kg/mm.}$$

Resultant Load on Weld Group [Fr]:

$$= \sqrt{F_{th}^2 + (F_{tv} + F_{sv})^2} = \sqrt{10.7^2 + (19.7 + 3.9)^2} = 25.85 \text{ Kg/mm.}$$

Resultant Secondary Weld Stress [Fws]:

$$= F_r / T_{weld} = 25.852 / 5.656 = 44.82 \text{ N./mm}^2$$

Allowable Resultant Secondary Weld Stress [Psa]:

$$= 0.4 * \text{Yield} * \text{Occfac} = 0.4 * 206.9 * 1.33 = 110.04 \text{ N./mm}^2$$

Shear Stress in Lug above Hole [Shs]:

$$= \sqrt{P_l^2 + F_n^2} / S_{ha} = \sqrt{5456^2 + 0^2} / 24.0 = 22.30 \text{ N./mm}^2$$

Allowable Shear Stress in Lug above Hole [Sas]:

$$= 0.4 * \text{Yield} * \text{Occfac} = 0.4 * 207 * 1.33$$



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User  
FileName : EI027-HRC-VD-ME-CAL-003-01

Lifting Lug Calcs: Lifting Lugs Step: 19 1:37pm Apr 8,2024

= 110.04 N./mm<sup>2</sup>

Pin Hole Bearing Stress [Pbs]:

= sqrt( Fax<sup>(2)</sup> + Fn<sup>(2)</sup> ) / ( t \* dh )  
= sqrt( 862<sup>(2)</sup> + 5456<sup>(2)</sup> )/( 12.0 \* 50.0 )  
= 89.18 N./mm<sup>2</sup>

Allowable Bearing Stress [Pba]:

= min( 0.75 \* Yield \* Occfac, 0.9 \* Yield ) AISC Bearing All.  
= min( 0.75 \* 207 \* 1.33, 186.2 )  
= 186.17 N./mm<sup>2</sup>

Bending Stress at the Base of the Lug [Fbs]:

= Fn\*(h-wl)/(w\*t<sup>2</sup> / 6) + Ft\*(h-wl) / (w<sup>2</sup>\*t / 6)  
= 0 \*(650.0 - 200.0)/(250.0 \*12.0<sup>(2)</sup>/6) +  
2504 \*(650.0 - 200.0)/(250.0<sup>(2)</sup> \*12.0/6)  
= 88.41 N./mm<sup>2</sup>

Tensile Stress at the Base of the Lug [Fa]:

= Fax / (w \* t)  
= 862/(250.0 \* 12.0)  
= 2.82 N./mm<sup>2</sup>

Total Combined Stress at the Base of the Lug:

= Fbs + Fa  
= 88.4 + 2.8  
= 91.23 N./mm<sup>2</sup>

Lug Allowable Stress for Bending and Tension:

= min( 0.66 \* Yield \* Occfac, 0.75\*Yield )  
= min( 0.66 \* 207 \* 1.33, 155.1 )  
= 155.14 N./mm<sup>2</sup>

Required Shackle Pin Diameter [Spd]:

= sqrt[(2 \* sqrt(Pl<sup>(2)</sup> + Fn<sup>(2)</sup>))/( Pi \* Sta)])  
= sqrt[2 \* sqrt(5456<sup>(2)</sup> + 0<sup>(2)</sup>)/( Pi \* 110)]  
= 17.5945 mm.

**WRC 107/537 Stress Analysis for the Lifting Lug to Shell Junction in the new and Cold Condition (no corrosion applied).**

*Note: The full lug load is applied in both the circumferential and longitudinal directions simultaneously.*

Input Echo, WRC107/537 Item 1, Description: Lift Lug

Diameter Basis for Vessel	Vbasis	ID
Cylindrical or Spherical Vessel	Cylsph	Cylindrical
Internal Corrosion Allowance	Cas	0.0000 mm.
Vessel Diameter	Dv	2100.000 mm.
Vessel Thickness	Tv	8.000 mm.

Note: Lifting lug calculations are performed at ambient temperature conditions.

Attachment Type	Type	Rectangular
Parameter C11	C11	266.00 mm.
Parameter C22	C22	208.00 mm.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User  
FileName : EI027-HRC-VD-ME-CAL-003-01

Lifting Lug Calcs: Lifting Lugs Step: 19 1:37pm Apr 8,2024

Thickness of Reinforcing Pad	Tpad	8.000	mm.
Pad Parameter C11P	C11p	366.000	mm.
Pad Parameter C22P	C22p	258.000	mm.
Design Internal Pressure	Dp	0.000	bars
Include Pressure Thrust		No	

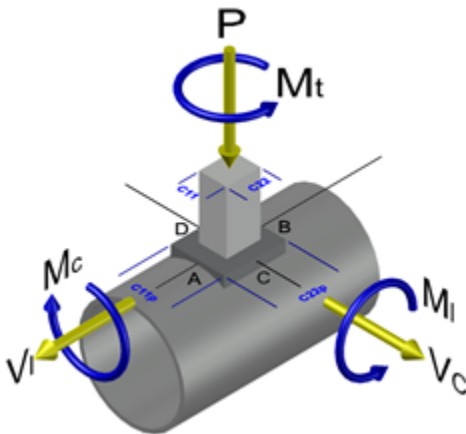
External Forces and Moments in WRC 107/537 Convention:

Radial Load (SUS)	P	0.0	Kgf
Longitudinal Shear (SUS)	Vl	5456.5	Kgf
Circumferential Shear (SUS)	Vc	5456.5	Kgf
Circumferential Moment (SUS)	Mc	0.0	Kg-m.
Longitudinal Moment (SUS)	Ml	76.4	Kg-m.
Torsional Moment (SUS)	Mt	3001.1	Kg-m.

Use Interactive Control	No
WRC107 Version	Version March 1979
Include Pressure Stress Indices per Div. 2	No
Compute Pressure Stress per WRC-368	No
Local Loads applied at end of Nozzle/Attachment	No

Note:

WRC Bulletin 537 provides equations for the dimensionless curves found in bulletin 107. As noted in the foreword to bulletin 537, "537 is equivalent to WRC 107". Where 107 is printed in the results below, "537" can be interchanged with "107".



WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	0.0	Kgf
Circumferential Shear	VC	5456.5	Kgf
Longitudinal Shear	VL	5456.5	Kgf
Circumferential Moment	MC	0.0	Kg-m.
Longitudinal Moment	ML	76.4	Kg-m.
Torsional Moment	MT	3001.1	Kg-m.

Dimensionless Parameters used : Gamma = 66.12

Dimensionless Loads for Cylindrical Shells at Attachment Junction:



Strength Calculation-Active Carbon Filter
Design by A. Azodi
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User
FileName : EI027-HRC-VD-ME-CAL-003-01

Lifting Lug Calcs: Lifting Lugs Step: 19 1:37pm Apr 8,2024

Table with 5 columns: Curves read for 1979, Beta, Figure, Value, Location. Rows include N(PHI) / ( P/Rm ), M(PHI) / ( P ), N(x) / ( P/Rm ), etc.

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction (N./mm²)

Table with 10 columns: Type of Stress, Load, Au, Al, Bu, Bl, Cu, Cl, Du, Dl. Rows include Circ. Memb. P, Long. Memb. P, Shear VC, etc.

Dimensionless Parameters used : Gamma = 131.75



Strength Calculation-Active Carbon Filter
Design by A. Azodi
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User
FileName : EI027-HRC-VD-ME-CAL-003-01

Lifting Lug Calcs: Lifting Lugs Step: 19 1:37pm Apr 8,2024

Dimensionless Loads for Cylindrical Shells at Pad edge:

Table with 5 columns: Curves read for 1979, Beta, Figure, Value, Location. Rows include N(PHI) / ( P/Rm ), M(PHI) / ( P ), N(x) / ( P/Rm ), M(x) / ( P ), etc.

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 (N./mm²)

Table with 10 columns: Type of Stress, Load, Au, Al, Bu, Bl, Cu, Cl, Du, D1. Rows include Circ. Memb. P, Long. Memb. P, Tot. Circ. Str., Tot. Long. Str., Shear VC, etc.





Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 61 of 143

Lifting Lug Calcs: Lifting Lugs Step: 19 1:37pm Apr 8,2024

Long. Pl (SUS)	-2.3	-2.3	2.3	2.3	0.0	0.0	0.0	0.0
Long. Q (SUS)	-10.8	10.8	10.8	-10.8	0.0	0.0	0.0	0.0
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	9.1	9.1	-9.1	-9.1	-13.0	-13.0	13.0	13.0
Shear Q (SUS)	155.8	155.8	155.8	155.8	155.8	155.8	155.8	155.8
Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pm+Pl (SUS)	18.9	18.9	18.9	18.9	25.9	25.9	25.9	25.9
Pm+Pl+Q (Total)	330.0	330.0	293.4	293.5	285.8	285.8	337.6	337.6

**Vessel Stress Summation Comparison (N/mm²):**

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	0.00	137.90	Passed
Pm+Pl (SUS)	25.93	206.85	Passed
Pm+Pl+Q (TOTAL)	337.60	413.70	Passed

*Because only sustained loads were specified, the Pm+Pl+Q allowable was 3 \* Smh.*



Strength Calculation-Active Carbon Filter
Design by A. Azodi
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 62 of 143

Leg Check, (Operating Case): Step: 20 1:37pm Apr 8,2024

RESULTS FOR LEGS : Operating Case Description: LEGS

Legs attached to: Shell #1

Section Properties : I Beam HE160B

European Structural Steel Data

Table with 4 columns: Property, Value, Unit, and Additional Info. Rows include Overall Leg Length (1750.000 mm), Effective Leg Length (1200.000 mm), Distance Leg Up Side of Vessel (600.000 mm), Number of Legs (4), Cross Sectional Area for HE160B (54.000 cm²), Section Inertia (strong/weak axis), Section Modulus (strong/weak axis), Radius of Gyration (strong/weak axis).

Leg Orientation - Strong Axis

Table with 4 columns: Property, Value, Unit, and Additional Info. Rows include Overturning Moment at top of Legs (18786.2 Kg-m), Total Weight Load at top of Legs (12759.5 Kgf), Total Shear force at top of Legs (5556.6 Kgf), Additional force in Leg due to Bracing (0.0 Kgf), Occasional Load Factor (1.000), Effective Leg End Condition Factor (0.650).

Note: The Legs are Not Cross Braced
The Leg Shear Force includes Wind and Seismic Effects

Table with 4 columns: Property, Value, Unit, and Additional Info. Rows include Pad Width along Circumference (400.000 mm), Pad Length along Vessel Axis (600.000 mm), Pad Thickness (8.000 mm).

Maximum Shear at top of one Leg [Vleg]:
= ( max( Wind, Seismic ) + applied forces )( Imax / Itot )
= ( 5556.6 )( 2482.3/6736.01 )
= 2047.65 Kgf

Axial Compression, Leg furthest from the Neutral Axis [Sma]:
= W/Nleg + (Mleg/(Nlegm\*Rn))/Aleg
= 125127/4 + (.18422E+09/( 2 \* 1146.004 ))/5399.989
= 20.68 N./mm²

Axial Compression, Leg closest to the Neutral Axis [Sva]:
= ( W / Nleg ) / Aleg
= ( 12760/4 )/54.0
= 5.79 N./mm²

Allowable Comp. for the Selected Leg (KL/r < Cc) [Sa]:
= Occfac \* ( 1-(kl/r)²/(2\*Cc²) ) \* Fy /
( 5/3+3\*(KL/r)/(8\*Cc)-(KL/r³)/(8\*Cc³) )
= 1.0 \* ( 1-( 19.26 )²/(2 \* 127.18² ) ) \* 248 /
( 5/3+3\*( 19.26 )/(8\* 127.18)-( 19.26³)/(8\* 127.18³) )



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 63 of 143

Leg Check, (Operating Case): Step: 20 1:37pm Apr 8,2024

= 142.41 N./mm<sup>2</sup>

Bending at the Bottom of the Leg closest to the N.A. [S]:

= ( Vleg \* Leglen / Smdsa )  
= ( 2047.65 \* 1200.0/312001.28 )  
= 77.23 N./mm<sup>2</sup>

Allowable Bending Stress[Sb]:

= ( 0.6 \* Fy \* Occfac )  
= ( 0.6 \* 248 \* 1.0 )  
= 148.93 N./mm<sup>2</sup>

AISC Unity Check [Sc]( must be < or = to 1.00 ) :

= ( Sma/Sa)+(0.85\*S)/((1-Sma/Spex)\*Sb)  
= ( 21/142 )+( 0.85 \*77.234 )/(( 1 -21/2824 ) \*149 )  
= 0.5893

WRC 107 Stress Analysis for Leg to Shell Junction, Ope Condition

Rectangular Attachment Parameter	C11	160.000	mm.
Rectangular Attachment Parameter	C22	580.950	mm.

**Input Echo, WRC107/537 Item 1, Description: LEGS**

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm.
Vessel Diameter	Dv	2100.000	mm.
Vessel Thickness	Tv	8.000	mm.
Design Temperature	T1	85.0	°C
Attachment Type	Type	Rectangular	
Parameter C11	C11	160.00	mm.
Parameter C22	C22	580.95	mm.
Thickness of Reinforcing Pad	Tpad	8.000	mm.
Pad Parameter C11P	C11p	400.000	mm.
Pad Parameter C22P	C22p	600.000	mm.
Design Internal Pressure	Dp	0.200	bars
Include Pressure Thrust		No	
Vessel Centerline Direction Cosine	Vx	0.000	
Vessel Centerline Direction Cosine	Vy	1.000	
Vessel Centerline Direction Cosine	Vz	0.000	
Nozzle Centerline Direction Cosine	Nx	1.000	
Nozzle Centerline Direction Cosine	Ny	0.000	
Nozzle Centerline Direction Cosine	Nz	0.000	
Global Force (SUS)	Fx	133.2	Kgf
Global Force (SUS)	Fy	3189.9	Kgf
Global Force (SUS)	Fz	133.2	Kgf
Global Moment (SUS)	Mx	0.0	Kg-m.
Global Moment (SUS)	My	0.0	Kg-m.
Global Moment (SUS)	Mz	393.7	Kg-m.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 64 of 143

Leg Check, (Operating Case): Step: 20 1:37pm Apr 8,2024

Internal Pressure (SUS) P 0.20 bars  
Include Pressure Thrust No

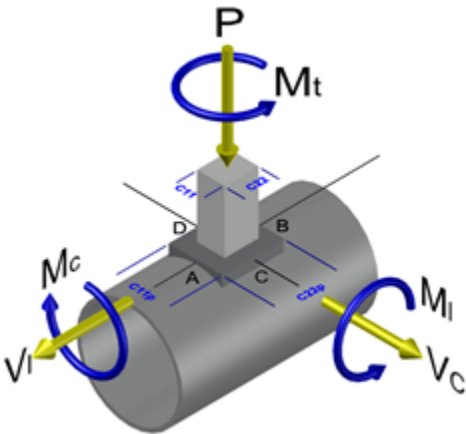
Global Force (OCC) Fx 2047.7 Kgf  
Global Force (OCC) Fy 8196.3 Kgf  
Global Force (OCC) Fz 0.0 Kgf  
Global Moment (OCC) Mx 0.0 Kg-m.  
Global Moment (OCC) My 0.0 Kg-m.  
Global Moment (OCC) Mz 1949.9 Kg-m.

Occasional Internal Pressure (OCC) Pvar 0.00 bars

Use Interactive Control No  
WRC107 Version Version March 1979

Include Pressure Stress Indices per Div. 2 No  
Compute Pressure Stress per WRC-368 No  
Local Loads applied at end of Nozzle/Attachment No

*Note:*  
WRC Bulletin 537 provides equations for the dimensionless curves found in bulletin 107. As noted in the foreword to bulletin 537, "537 is equivalent to WRC 107". Where 107 is printed in the results below, "537" can be interchanged with "107".



WRC 107 Stress Calculation for SUStained loads:

Radial Load P 133.2 Kgf  
Circumferential Shear VC -133.2 Kgf  
Longitudinal Shear VL 3189.9 Kgf  
Circumferential Moment MC 0.0 Kg-m.  
Longitudinal Moment ML -393.7 Kg-m.  
Torsional Moment MT 0.0 Kg-m.

Dimensionless Parameters used : Gamma = 81.50

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979 Beta Figure Value Location



Strength Calculation-Active Carbon Filter
Design by A. Azodi
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 65 of 143

Leg Check, (Operating Case):

Step: 20

1:37pm

Apr 8, 2024

Table with 5 columns: Parameter, Value, Curve, Stress, and Location. Rows include N(PHI) / ( P/Rm ), M(PHI) / ( P ), N(x) / ( P/Rm ), etc.

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 Attachment Junction (N./mm²)

Table with 10 columns: Type of Stress, Load, Au, Al, Bu, Bl, Cu, Cl, Du, Dl. Rows include Circ. Memb. P, Long. Memb. P, Tot. Circ. Str., etc.



Strength Calculation-Active Carbon Filter
Design by A. Azodi
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 66 of 143

Leg Check, (Operating Case):

Step: 20

1:37pm

Apr 8, 2024

Dimensionless Parameters used : Gamma = 211.10

Dimensionless Loads for Cylindrical Shells at Pad edge:

Table with 5 columns: Curves read for 1979, Beta, Figure, Value, Location. Rows include N(PHI) / ( P/Rm ), M(PHI) / ( P ), N(x) / ( P/Rm ), etc.

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 (N./mm²)

Table with 10 columns: Type of Stress, Load, Au, Al, Bu, Bl, Cu, Cl, Du, Dl. Rows include Circ. Memb. P, Long. Memb. P, Tot. Circ. Str., etc.



Strength Calculation-Active Carbon Filter

Design by A. Azodi

Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 67 of 143

Leg Check, (Operating Case): Step: 20 1:37pm Apr 8,2024

Tot. Shear	-0.3	-0.3	0.3	0.3	-5.2	-5.2	5.2	5.2
Str. Int.	35.6	1.9	47.0	11.7	24.9	22.4	24.9	22.4

WRC 107 Stress Calculation for OCCasional loads:

Radial Load	P	2047.7	Kgf
Circumferential Shear	VC	0.0	Kgf
Longitudinal Shear	VL	8196.3	Kgf
Circumferential Moment	MC	0.0	Kg-m.
Longitudinal Moment	ML	-1949.9	Kg-m.
Torsional Moment	MT	0.0	Kg-m.

Dimensionless Parameters used : Gamma = 81.50

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction (N./mm²)

Type of Stress	Load	Stress Intensity Values at							
		Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb.	P	-13.4	-13.4	-13.4	-13.4	-6.5	-6.5	-6.5	-6.5
Circ. Bend.	P	-31.0	31.0	-31.0	31.0	-54.8	54.8	-54.8	54.8
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	31.8	31.8	-31.8	-31.8	0.0	0.0	0.0	0.0
Circ. Bend.	ML	99.0	-99.0	-99.0	99.0	0.0	0.0	0.0	0.0
Tot. Circ. Str.		86.3	-49.6	-175.2	84.8	-61.2	48.3	-61.2	48.3
Long. Memb.	P	-8.6	-8.6	-8.6	-8.6	-15.1	-15.1	-15.1	-15.1
Long. Bend.	P	-38.7	38.7	-38.7	38.7	-25.6	25.6	-25.6	25.6
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	25.3	25.3	-25.3	-25.3	0.0	0.0	0.0	0.0
Long. Bend.	ML	58.8	-58.8	-58.8	58.8	0.0	0.0	0.0	0.0
Tot. Long. Str.		36.8	-3.3	-131.5	63.7	-40.7	10.5	-40.7	10.5
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	-5.3	-5.3	5.3	5.3
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	-5.3	-5.3	5.3	5.3
Str. Int.		86.3	49.6	175.2	84.8	62.5	49.0	62.5	49.0

Dimensionless Parameters used : Gamma = 211.10

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (N./mm²)

Type of Stress	Load	Stress Intensity Values at							
		Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb.	P	-48.1	-48.1	-48.1	-48.1	-12.1	-12.1	-12.1	-12.1





Strength Calculation-Active Carbon Filter
Design by A. Azodi
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 69 of 143

Leg Check, (Operating Case): Step: 20 1:37pm Apr 8, 2024

Table with 10 columns and 18 rows showing stress calculations for Shear Pm, Shear Pl, Shear Q, and Pm (SUS, SUS+OCC, SUS+OCC, Total).

Vessel Stress Summation Comparison (N/mm²):

Table with 4 columns: Type of Stress Int., Max. S.I., S.I. Allowable, Result. Rows include Pm (SUS), Pm (SUS+OCC), Pm+Pl (SUS), Pm+Pl (SUS+OCC), and Pm+Pl+Q (TOTAL).

The Pm+Pl+Q allowable was based on a temperature range cycling from ambient to design temperature. This allowable is computed per ASME VIII-2, 5.5.6.1(1) Part 5, 3((Smc + Smh)/2).

WRC 107/537 Stress Summations:

Vessel Stress Summation at Reinforcing Pad Edge (N/mm²)

Table with 10 columns: Type of Stress, Load, Au, Al, Bu, Bl, Cu, Cl, Du, Dl. Rows include Circ. Pm, Circ. Pl, Circ. Q, Long. Pm, and Long. Pl for SUS, OCC, and TOTAL conditions.



Strength Calculation-Active Carbon Filter
Design by A. Azodi
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 70 of 143

Leg Check, (Operating Case): Step: 20 1:37pm Apr 8,2024

Table with 10 columns and 20 rows showing stress calculations for Long. Pl, Shear Pm, Shear Pl, Shear Q, and Pm under various conditions (TOTAL, SUS, OCC).

Vessel Stress Summation Comparison (N/mm²):

Table with 4 columns: Type of Stress Int., Max. S.I., S.I. Allowable, and Result. Rows include Pm (SUS), Pm (SUS+OCC), Pm+Pl (SUS), Pm+Pl (SUS+OCC), and Pm+Pl+Q (TOTAL).

The Pm+Pl+Q allowable was based on a temperature range cycling from ambient to design temperature. This allowable is computed per ASME VIII-2, 5.5.6.1(1) Part 5, 3((Smc + Smh)/2).

Bolting Size Requirement for Leg Baseplates :

Table with 5 columns: Parameter, Unit, Value, Unit, Value. Lists baseplate material (SA-283 C), allowable stress (108.25 N./mm²), dimensions, bolt material (SA-36), and concrete strength (20.685 N./mm²).



Strength Calculation-Active Carbon Filter

Design by A. Azodi

Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 71 of 143

Leg Check, (Operating Case): Step: 20 1:37pm Apr 8,2024

Shear Stress in a Single Bolt [taub]:

$$\begin{aligned}
 &= \text{Shear Force} / ( 2 * \text{Bolt Area} * \text{Number of Bolts} ) \\
 &= 5557 / ( 2 * 4.14 * 4 ) \\
 &= 16.5 \text{ N./mm}^2. \text{ Must be less than } 68.7 \text{ N./mm}^2.
 \end{aligned}$$

LEG BASEPLATE and BOLTING Analysis, including Moments

I-Beam Leg

Base Plate Available Area (AA):

$$\begin{aligned}
 &= B * D \\
 &= 500.0 * 500.0 \\
 &= 2500.00 \text{ cm}^2
 \end{aligned}$$

Clearance Between The Bolt And The Leg Edge (BCL):

$$\begin{aligned}
 &= z - \text{BOD} / 2 \\
 &= 70.0 - 27.0 / 2 \\
 &= 56.50 \text{ mm.}
 \end{aligned}$$

Moment at Baseplate (MOMENT):

$$\begin{aligned}
 &= V_{\text{leg}} * L_{\text{leg}} \\
 &= 2047.65 * 1750.0 \\
 &= 3583.46 \text{ Kg-m.}
 \end{aligned}$$

Axial Load on the baseplate (P):

$$\begin{aligned}
 &= \text{Operating Weight per leg (as Seismic + Operating case is controlling)} \\
 &= 3241.83 \text{ Kgf}
 \end{aligned}$$

Eccentricity (e):

$$\begin{aligned}
 &= \text{MOMENT} * \text{Conv\_Factor} / P \\
 &= 3583.46 * 9806.64 / 3241.83 \\
 &= 1105.36 \text{ mm.} > D/6 \text{ [Plate Uplift Condition]}
 \end{aligned}$$

$$a = (D - d) / 2$$

$$\begin{aligned}
 &= (500.0 - 160.0) / 2 \\
 &= 170.00 \text{ mm.}
 \end{aligned}$$

Modular Ratio Of Steel/Concrete (n):

$$\begin{aligned}
 &= E_S / E_C \\
 &= 203402.5 / 21526.32 \\
 &= 9.45
 \end{aligned}$$

$$F = 0.5 * d + z$$

$$\begin{aligned}
 &= 0.5 * 160.0 + 70.0 \\
 &= 150.00 \text{ mm.}
 \end{aligned}$$

$$K1 = 3.0 (e - 0.5 * D)$$

$$\begin{aligned}
 &= 3.0 (1105.36 - 0.5 * 500.0) \\
 &= 2566.08
 \end{aligned}$$

$$K2 = 6 * n * A_{st} / B * (F + e)$$

$$\begin{aligned}
 &= 6 * 9.45 * 8.28 / 500.0 * (150.0 + 1105.36) \\
 &= 1178.18
 \end{aligned}$$

$$K3 = -K2 * (0.5 * D + F)$$

$$\begin{aligned}
 &= -1178.18 * (0.5 * 500.0 + 150.0)
 \end{aligned}$$



Strength Calculation-Active Carbon Filter

Design by A. Azodi

Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 72 of 143

Leg Check, (Operating Case):

Step: 20

1:37pm

Apr 8, 2024

$$= -471271.45$$

Solving For The Effective Bearing Length Using Iteration:

$$Y^3 + K1 * Y^2 + K2 * Y + K3 = 0$$

$$Y^3 + 101.03 * Y^2 + 182.62 * Y - 2875.87 = 0$$

$$Y = 112.46 \text{ mm.}$$

$$NUM = (D / 2 - Y / 3 - e)$$

$$= (500.0/2 - 112.46/3 - 1105.36)$$

$$= -892.85$$

$$DENOM = (D / 2 - Y / 3 + F)$$

$$= (500.0/2 - 112.46/3 + 150.0)$$

$$= 362.51$$

Total Bolt Tension Force (T):

$$= - P * NUM / DENOM$$

$$= - 3241.83 * -892.85/362.51$$

$$= 7984.45 \text{ Kgf}$$

Overturing Moment Due To Bolt In Tension (Mt):

$$= T * (0.5 * D + F - Y)$$

$$= 7984.45 * (0.5 * 500.0 + 150.0 - 112.46)$$

$$= 2295.88 \text{ Kg-m.}$$

Bearing Pressure (FC):

$$= 2 * (P + T) / (Y * B)$$

$$= 2 * (3241.83 + 7984.45)/(112.46 * 500.0)$$

$$= 39.16 \text{ bars [ } \leq \text{ FCPRIME ( 206.84) ]}$$

Equivalent Bearing Pressure (f1):

$$= FC * (Y - a) / Y$$

$$= 39.16 * (112.46 - 170.0)/112.46$$

$$= -20.03 \text{ bars}$$

Overturing Moment Due To Bearing Pressure (Mc):

$$= (a^2 * B / 6) * (f1 + 2 * FC)$$

$$= (170.0^2 * 500.0/6) * (-20.03 + 2 * 39.16)$$

$$= 1431.29 \text{ Kg-m.}$$

The Baseplate Required Thickness (TREQ):

$$= (6 * \text{MAX}(Mt, Mc) / (B * 1.5 * SBA))^{1/2}$$

$$= (6 * 2295.88/(500.0 * 162.38))^{1/2}$$

$$= 40.79 \text{ mm.}$$

Required bolt area (ABREQM): per D. Moss

$$= T / STBA$$

$$= 7984.45/114.46$$

$$= 6.8412 \text{ cm}^2 [ < \text{Ast ( 8.28) } \rightarrow \text{ PASSED}]$$

Distance from Top of Legs to Vessel CG (CD\_DIST):

$$= 2287.58 \text{ mm.}$$

Total Overturing Moment at Baseplate (Mbb):

$$= ( Mleg / \text{max}([CD\_DIST], \text{minDist}) ) * ( CD\_DIST + Lleg )$$

$$= ( 18786.23/\text{max}( 2287.58, 38.1 ) ) * ( 2287.58 + 1750.0 )$$

$$= 33157.73 \text{ Kg-m.}$$



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 73 of 143

Leg Check, (Operating Case): Step: 20 1:37pm Apr 8,2024

Required Total Bolt Area per Leg (ABREQB): per H. Bednar

$$= (1 / (Nleg * STBA)) * ((4 * Mbb / (Rn * 2)) - W)$$

$$= (1 / (4 * 114.46)) * ((4 * 33157.73 / (2292.0)) - 12967.33)$$

$$= 9.6174 \text{ cm}^2$$

Available Total Bolt Corr. Area per Leg (ABAVL):

$$= As * NBT$$

$$= 4.14 * 4.0$$

$$= 16.5541 \text{ cm}^2 [ > ABREQB ( 9.62) --> PASSED]$$

Summary of Results:

		Actual	Required	Pass/Fail
Baseplate Thickness	( mm. ):	45.000	40.791	Pass
Bolt Root Area (Bednar)	( cm <sup>2</sup> ):	16.55	9.62	Pass
Bolt Root Area (D. Moss)	( cm <sup>2</sup> ):	8.28	6.84	Pass

Note: The required thickness calculation is performed based on:  
Strong axis orientation of the beam leg  
Even number of bolts installed only on the B dimension sides



Strength Calculation-Active Carbon Filter
Design by A. Azodi
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 74 of 143

Nozzle Summary:

Step: 30 1:37pm Apr 8,2024

Nozzle Calculation Summary:

Table with 8 columns: Description, MAWP bars, Ext, MAPNC bars, UG-45, [tr] mm., Weld Path, Areas or Stresses. Rows include Drain - 3in, MH1 - 24in, Gas In - 6in, Utility - 2in, Gas Out - 6in, PG - 1in, MH2 - 24in, Vent - 2in.

MAWP Summary:

Minimum MAWP Nozzles : 2.792 Nozzle : Drain - 3in
Minimum MAWP Shells/Flanges : 2.792 Element : Lower Head
Minimum MAPnc Shells/Flanges : 6.136 Element : Upper Head

Computed Vessel M.A.W.P. : 2.792 bars

[\*] - 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

Table with 5 columns: From Node, Nozzle Description, Y Coordinate mm., Layout Angle deg, Dia. Limit mm. Rows list nozzle details for nodes 10, 20, 50, and 60.

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 !



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 75 of 143

Nozzle Calcs.: Drain - 3in

Nozl: 9

1:37pm

Apr 8, 2024

Input, Nozzle Desc: Drain - 3in

From: 10

Pressure for Reinforcement Calculations	P	0.201	bars
Temperature for Internal Pressure	Temp	85	°C
Design External Pressure	Pext	0.10	bars
Temperature for External Pressure	Tempex	85	°C

Shell Material		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm <sup>2</sup>
Shell Allowable Stress At Ambient	Sva	137.90	N./mm <sup>2</sup>

Inside Diameter of Elliptical Head	D	2100.00	mm.
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	5.5000	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 -5.00 °C

**Type of Element Connected to the Shell : Nozzle**

Material		SA-106	B
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm <sup>2</sup>
Allowable Stress At Ambient	Sna	117.90	N./mm <sup>2</sup>

Diameter Basis (for tr calc only)		OD	
Layout Angle		0.00	deg
Diameter		3.0000	in.

Size and Thickness Basis		Minimum	
Nominal Thickness	tn	80	

Flange Material		SA-105	
Flange Type		Slip on	

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	100.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	6.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	5.5000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.

Pad Material		SA-516	70
Pad Allowable Stress at Temperature	Sp	137.90	N./mm <sup>2</sup>
Pad Allowable Stress At Ambient	Spa	137.90	N./mm <sup>2</sup>
Diameter of Pad along vessel surface	Dp	190.0000	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	6.0000	mm.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 76 of 143

Nozzle Calcs.: Drain - 3in

Nozl: 9

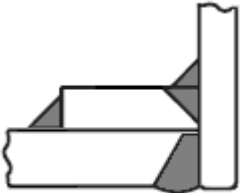
1:37pm

Apr 8, 2024

Reinforcing Pad Width	50.5500 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: Drain - 3in

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	3.500 in.
Actual Thickness Used in Calculation	0.263 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Elliptical Head, Tr [Int. Press]  
 $= (P \cdot K_1 \cdot D) / (2 \cdot S_v \cdot E - 0.2 \cdot P)$  per UG-37(a)(3)  
 $= (0.2 \cdot 0.898 \cdot 2106.0) / (2 \cdot 137.9 \cdot 1.0 - 0.2 \cdot 0.2)$   
 $= 0.1376 \text{ mm.}$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]  
 $= (P \cdot R_o) / (S_n \cdot E + 0.4 \cdot P)$  per Appendix 1-1 (a)(1)  
 $= (0.2 \cdot 44.45) / (118 \cdot 1.0 + 0.4 \cdot 0.2)$   
 $= 0.0076 \text{ mm.}$

Required Nozzle thickness under External Pressure per UG-28 : 0.1175 mm.

**UG-40, Limits of Reinforcement : [Internal Pressure]**

Parallel to Vessel Wall (Diameter Limit)	D1	163.1300 mm.
Parallel to Vessel Wall, opening length	d	81.5650 mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp		6.2500 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: Drain - 3in.  
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



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 77 of 143

Nozzle Calcs.: Drain - 3in

Noz1: 9

1:37pm

Apr 8, 2024

*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 = 3.1175 mm.
Wall Thickness per UG16(b),	tr16b = 5.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 3.5303 mm.
Wall Thickness	tb1 = max(trb1, tr16b) = 5.5000 mm.
Wall Thickness, shell/head, external pressure	trb2 = 3.3830 mm.
Wall Thickness	tb2 = max(trb2, tr16b) = 5.5000 mm.
Wall Thickness per table UG-45	tb3 = 7.8000 mm.

**Determine Nozzle Thickness candidate [tb]:**

= min[ tb3, max( tb1,tb2 ) ]  
 = min[ 7.8, max( 5.5, 5.5 ) ]  
 = 5.5000 mm.

**Minimum Wall Thickness of Nozzle Necks [tUG-45]:**

= max( ta, tb )  
 = max( 3.1175, 5.5 )  
 = 5.5000 mm.

Available Nozzle Neck Thickness = 6.6675 mm. --> OK

**Stresses on Nozzle due to External and Pressure Loads per the ASME**

**B31.3 Piping Code (see 319.4.4 and 302.3.5):**

Sustained	: 18.1,	Allowable	: 117.9 N./mm <sup>2</sup>	Passed
Expansion	: 0.0,	Allowable	: 276.7 N./mm <sup>2</sup>	Passed
Occasional	: 0.1,	Allowable	: 156.8 N./mm <sup>2</sup>	Passed
Shear	: 12.6,	Allowable	: 82.5 N./mm <sup>2</sup>	Passed

*Note : The number of cycles on this nozzle was assumed to be 7000 or less for the determination of the expansion stress allowable.*

**Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:**

**Nozzle Neck to Flange Weld, Curve: B**

Govrn. thk, tg = 6.668, tr = 0.008, c = 3.0 mm., E\* = 1.0  
 Thickness Ratio = tr \* (E\*)/(tg - c) = 0.002, 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

**Nozzle Neck to Pad Weld for the Nozzle, Curve: B**

Govrn. thk, tg = 6.668, tr = 0.008, c = 3.0 mm., E\* = 1.0  
 Thickness Ratio = tr \* (E\*)/(tg - c) = 0.002, 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

**Nozzle Neck to Pad Weld for Reinforcement pad, Curve: B**

Govrn. thk, tg = 6.668, tr = 0.008, c = 3.0 mm., E\* = 1.0  
 Thickness Ratio = tr \* (E\*)/(tg - c) = 0.002, Temp. Reduction = 78 °C



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 78 of 143

Nozzle Calcs.: Drain - 3in Nozl: 9 1:37pm Apr 8,2024

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, Curve: B**

Govrn. thk, tg = 5.5, tr = 0.138, c = 3.0 mm., E\* = 1.0  
Thickness Ratio =  $tr * (E*) / (tg - c) = 0.055$ , 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

**Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B**

Govrn. thk, tg = 5.5, tr = 0.138, c = 3.0 mm., E\* = 1.0  
Thickness Ratio =  $tr * (E*) / (tg - c) = 0.055$ , 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

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:**

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -29 °C  
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -104 °C  
Flange MDMT with Temp reduction per UCS-66(b)(1)(-c) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :  
Design Pressure/Ambient Rating =  $0.20 / 19.60 = 0.010$

Note:  
Using the min value from (b)(1)(-b) and (b)(1)(-c) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: Drain - 3in

Intermediate Calc. for nozzle/shell Welds Tmin 3.6675 mm.  
Intermediate Calc. for pad/shell Welds TminPad 5.0000 mm.

**Results Per UW-16.1:**

	Required Thickness	Actual Thickness
Nozzle Weld	$2.5673 = 0.7 * t_{min}$	$4.2420 = 0.7 * W_o$ mm.
Pad Weld	$2.5000 = 0.5 * T_{minPad}$	$4.2420 = 0.7 * W_p$ 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 2.793 bars

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 0.5215 mm.  
The Cut Length for this Nozzle is, Drop + Ho + H + T : 106.0215 mm.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 79 of 143

Nozzle Calcs.: Drain - 3in

Nozl: 9

1:37pm

Apr 8,2024

Input Echo, WRC107/537 Item 1, Description: Drain - 3in :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Spherical	
Internal Corrosion Allowance	Cas	3.0000	mm.
Vessel Diameter	Dv	3780.000	mm.
Vessel Thickness	Tv	5.500	mm.
Design Temperature	T1	85.0	°C
Vessel Material		SA-516 70	
Vessel UNS Number		K02700	
Vessel Cold S.I. Allowable	Smc	137.90	N./mm <sup>2</sup>
Vessel Hot S.I. Allowable	Smh	137.90	N./mm <sup>2</sup>

Note:  
Using 2 \* Yield for Discontinuity Stress Allowable (Div 2, 4.1.6.3), Sps.  
Make sure that material properties at this temperature are not  
time-dependent for Material: SA-516 70

Attachment Type	Type	Round	
WRC107 Attachment Classification	Holsol	Hollow	
Diameter Basis for Nozzle	Nbasis	OD	
Corrosion Allowance for Nozzle	Can	3.0000	mm.
Nozzle Diameter	Dn	88.900	mm.
Nozzle Thickness	Tn	6.668	mm.
Nozzle Material		SA-106 B	
Nozzle UNS Number		K03006	
Nozzle Cold S.I. Allowable	SNmc	117.90	N./mm <sup>2</sup>
Nozzle Hot S.I. Allowable	SNmh	117.90	N./mm <sup>2</sup>
Thickness of Reinforcing Pad	Tpad	8.000	mm.
Diameter of Reinforcing Pad	Dpad	190.000	mm.
Design Internal Pressure	Dp	0.201	bars
Include Pressure Thrust		No	

External Forces and Moments in WRC 107/537 Convention:

Radial Load (SUS)	P	-76.3	Kgf
Longitudinal Shear (SUS)	(V1) V1	95.5	Kgf
Circumferential Shear (SUS)	(Vc) V2	95.5	Kgf
Circumferential Moment (SUS)	(Mc) M1	-23.7	Kg-m.
Longitudinal Moment (SUS)	(Ml) M2	30.2	Kg-m.
Torsional Moment (SUS)	Mt	38.3	Kg-m.

Use Interactive Control No  
WRC107 Version Version March 1979

Include Pressure Stress Indices per Div. 2 No  
Compute Pressure Stress per WRC-368 No  
Local Loads applied at end of Nozzle/Attachment No

Note:  
WRC Bulletin 537 provides equations for the dimensionless curves  
found in bulletin 107. As noted in the foreword to bulletin 537,

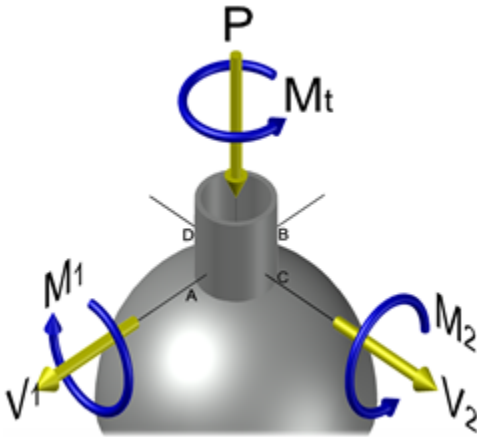
Strength Calculation-Active Carbon Filter  
 Design by A. Azodi  
 Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User  
 FileName : EI027-HRC-VD-ME-CAL-003-01

Page 80 of 143

Nozzle Calcs.: Drain - 3in Nozl: 9 1:37pm Apr 8,2024

"537 is equivalent to WRC 107". Where 107 is printed in the results below, "537" can be interchanged with "107".



Stress Attenuation Diameter (for Insert Plates) per WRC 297:

$$\begin{aligned}
 &= \text{NozzleOD} + 2 * 1.65 * \text{sqrt}( \text{Rmean}( t - ca ) ) \\
 &= 88.9 + 2 * 1.65 * \text{sqrt}( 1894.25 ( 5.5 - 3.0 ) ) \\
 &= 315.992 \text{ mm.}
 \end{aligned}$$

WRC 107 Stress Calculation for SUSTAINED loads:

Radial Load	P	-76.3	Kgf
Circumferential Shear	(VC) V2	95.5	Kgf
Longitudinal Shear	(VL) V1	95.5	Kgf
Circumferential Moment	(MC) M1	-23.7	Kg-m.
Longitudinal Moment	(ML) M2	30.2	Kg-m.
Torsional Moment	MT	38.3	Kg-m.

Dimensionless Parameters: U = 0.31 TAU = 11.62 RHO = 2.86

Dimensionless Loads for Spherical Shells at Attachment Junction:

Curves read for 1979	Figure	Value	Location
N(x) * T / P	SP 3	0.07312	(A,B,C,D)
M(x) / P	SP 3	0.06082	(A,B,C,D)
N(x) * T * SQRT(Rm * T) / MC	SM 3	0.20459	(A,B,C,D)
M(x) * SQRT(Rm * T) / MC	SM 3	0.19265	(A,B,C,D)
N(x) * T * SQRT(Rm * T) / ML	SM 3	0.20459	(A,B,C,D)
M(x) * SQRT(Rm * T) / ML	SM 3	0.19265	(A,B,C,D)
N(y) * T / P	SP 3	0.28747	(A,B,C,D)
M(y) / P	SP 3	0.10214	(A,B,C,D)
N(y) * T * SQRT(Rm * T) / MC	SM 3	0.17941	(A,B,C,D)
M(y) * SQRT(Rm * T) / MC	SM 3	0.39379	(A,B,C,D)
N(y) * T * SQRT(Rm * T) / ML	SM 3	0.17941	(A,B,C,D)
M(y) * SQRT(Rm * T) / ML	SM 3	0.39379	(A,B,C,D)

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction (N./mm²)



Strength Calculation-Active Carbon Filter
Design by A. Azodi
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User
FileName : EI027-HRC-VD-ME-CAL-003-01

Nozzle Calcs.: Drain - 3in Nozl: 9 1:37pm Apr 8,2024

Table with 10 columns: Type of Stress, Load, Au, Al, Bu, Bl, Cu, Cl, Du, D1. Rows include Rad. Memb. P, Rad. Bend. P, Rad. Memb. MC, Rad. Memb. ML, Tot. Rad. Str., Tang. Memb. P, Tang. Bend. P, Tang. Memb. MC, Tang. Bend. MC, Tang. Memb. ML, Tang. Bend. ML, Tot. Tang. Str., Shear VC, Shear VL, Shear MT, Tot. Shear, Str. Int.

Unitless Prm: U = 1.38 TAU = 0.00 ( 25.40) RHO = 0.00 ( 0.68)

Dimensionless Loads for Spherical Shells at Pad edge:

Table with 4 columns: Curves read for 1979, Figure, Value, Location. Rows include N(x) \* T / P, M(x) / P, N(x) \* T \* SQRT(Rm \* T) / MC, M(x) \* SQRT(Rm \* T) / MC, N(x) \* T \* SQRT(Rm \* T) / ML, M(x) \* SQRT(Rm \* T) / ML, N(y) \* T / P, M(y) / P, N(y) \* T \* SQRT(Rm \* T) / MC, M(y) \* SQRT(Rm \* T) / MC, N(y) \* T \* SQRT(Rm \* T) / ML, M(y) \* SQRT(Rm \* T) / ML.

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (N./mm²)

Table with 10 columns: Type of Stress, Load, Au, Al, Bu, Bl, Cu, Cl, Du, D1. Header: Stress Intensity Values at



Strength Calculation-Active Carbon Filter

Design by A. Azodi

Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 82 of 143

Nozzle Calcs.: Drain - 3in

Nozl: 9

1:37pm

Apr 8, 2024

Rad. Memb. P	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
Rad. Bend. P	15.3	-15.3	15.3	-15.3	15.3	-15.3	15.3	-15.3	15.3
Rad. Memb. MC	0.0	0.0	0.0	0.0	24.3	24.3	-24.3	-24.3	24.3
Rad. Memb. MC	0.0	0.0	0.0	0.0	112.8	-112.8	-112.8	112.8	112.8
Rad. Memb. ML	-31.0	-31.0	31.0	31.0	0.0	0.0	0.0	0.0	0.0
Rad. Bend. ML	-143.9	143.9	143.9	-143.9	0.0	0.0	0.0	0.0	0.0
Tot. Rad. Str.	-154.5	102.8	195.3	-123.2	157.5	-98.8	-116.6	78.4	78.4
Tang. Memb. P	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Tang. Bend. P	4.6	-4.6	4.6	-4.6	4.6	-4.6	4.6	-4.6	4.6
Tang. Memb. MC	0.0	0.0	0.0	0.0	7.3	7.3	-7.3	-7.3	7.3
Tang. Bend. MC	0.0	0.0	0.0	0.0	33.9	-33.9	-33.9	33.9	33.9
Tang. Memb. ML	-9.3	-9.3	9.3	9.3	0.0	0.0	0.0	0.0	0.0
Tang. Bend. ML	-43.3	43.3	43.3	-43.3	0.0	0.0	0.0	0.0	0.0
Tot. Tang. Str.	-46.4	30.9	58.7	-37.0	47.3	-29.7	-35.1	23.6	23.6
Shear VC	1.3	1.3	-1.3	-1.3	0.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-1.3	-1.3	1.3	1.3	1.3
Shear MT	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Tot. Shear	3.9	3.9	1.4	1.4	1.4	1.4	3.9	3.9	3.9
Str. Int.	154.6	103.0	195.3	123.2	157.5	98.8	116.8	78.6	78.6

WRC 107/537 Stress Summations:

Vessel Stress Summation at Attachment Junction (N/mm²)

Type of Stress	Load	Stress Intensity Values at							
		Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Rad. Pm (SUS)		1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Rad. Pl (SUS)		-3.4	-3.4	4.4	4.4	3.5	3.5	-2.6	-2.6
Rad. Q (SUS)		-19.5	19.5	24.5	-24.5	19.7	-19.7	-14.8	14.8
Long. Pm (SUS)		1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Long. Pl (SUS)		-1.5	-1.5	5.4	5.4	4.6	4.6	-0.7	-0.7
Long. Q (SUS)		-40.8	40.8	49.1	-49.1	39.4	-39.4	-31.1	31.1
Shear Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)		0.6	0.6	-0.6	-0.6	-0.6	-0.6	0.6	0.6
Shear Q (SUS)		2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Pm (SUS)		1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Pm+Pl (SUS)		2.3	2.3	7.5	7.5	6.7	6.7	2.2	2.2
Pm+Pl+Q (Total)		41.0	41.6	56.5	42.1	46.0	33.2	30.8	32.8

Vessel Stress Summation Comparison (N/mm²):

Type of	Max. S.I.	S.I. Allowable	Result
---------	-----------	----------------	--------



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 83 of 143

Nozzle Calcs.: Drain - 3in

Nozl: 9

1:37pm

Apr 8, 2024

Stress Int.			
Pm (SUS)	1.81	137.90	Passed
Pm+Pl (SUS)	7.49	206.85	Passed
Pm+Pl+Q (TOTAL)	56.46	413.70	Passed

Because only sustained loads were specified, the Pm+Pl+Q allowable was 3 \* Smh.

WRC 107/537 Stress Summations:

Vessel Stress Summation at Reinforcing Pad Edge (N/mm<sup>2</sup>)

Type of Stress	Load	Stress Intensity Values at							
		Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Rad.	Pm (SUS)	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
Rad.	Pl (SUS)	-25.8	-25.8	36.1	36.1	29.4	29.4	-19.1	-19.1
Rad.	Q (SUS)	-128.6	128.6	159.3	-159.3	128.1	-128.1	-97.5	97.5
Long.	Pm (SUS)	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
Long.	Pl (SUS)	-7.8	-7.8	10.8	10.8	8.8	8.8	-5.7	-5.7
Long.	Q (SUS)	-38.7	38.7	47.9	-47.9	38.5	-38.5	-29.3	29.3
Shear	Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear	Pl (SUS)	1.3	1.3	-1.3	-1.3	-1.3	-1.3	1.3	1.3
Shear	Q (SUS)	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
	Pm (SUS)	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
	Pm+Pl (SUS)	18.3	18.3	43.7	43.7	37.1	37.1	13.6	13.6
	Pm+Pl+Q (Total)	147.0	110.6	202.9	115.6	165.1	91.2	109.2	86.2

Vessel Stress Summation Comparison (N/mm<sup>2</sup>):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	7.60	137.90	Passed
Pm+Pl (SUS)	43.74	206.85	Passed
Pm+Pl+Q (TOTAL)	202.95	413.70	Passed

Because only sustained loads were specified, the Pm+Pl+Q allowable was 3 \* Smh.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 84 of 143

Nozzle Calcs.: MH1 - 24in

Nozl: 10

1:37pm

Apr 8, 2024

Input, Nozzle Desc: MH1 - 24in

From: 20

Pressure for Reinforcement Calculations	P	0.201	bars
Temperature for Internal Pressure	Temp	85	°C
Design External Pressure	Pext	0.10	bars
Temperature for External Pressure	Tempex	85	°C

Shell Material		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm <sup>2</sup>
Shell Allowable Stress At Ambient	Sva	137.90	N./mm <sup>2</sup>

Inside Diameter of Cylindrical Shell	D	2100.00	mm.
Design Length of Section	L	5749.9995	mm.
Shell Finished (Minimum) Thickness	t	8.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.

Distance from Bottom/Left Tangent 850.00 mm.

User Entered Minimum Design Metal Temperature -5.00 °C

**Type of Element Connected to the Shell : Nozzle**

Material		SA-516	70
Material UNS Number		K02700	
Material Specification/Type		Plate	
Allowable Stress at Temperature	Sn	137.90	N./mm <sup>2</sup>
Allowable Stress At Ambient	Sna	137.90	N./mm <sup>2</sup>

Diameter Basis (for tr calc only)		OD	
Layout Angle		180.00	deg
Diameter		24.0000	in.

Size and Thickness Basis		Actual	
Actual Thickness	tn	8.0000	mm.

Flange Material		SA-105	
Flange Type		Slip on	

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	250.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	6.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	6.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.

Pad Material		SA-516	70
Pad Allowable Stress at Temperature	Sp	137.90	N./mm <sup>2</sup>
Pad Allowable Stress At Ambient	Spa	137.90	N./mm <sup>2</sup>
Diameter of Pad along vessel surface	Dp	1000.0000	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	6.0000	mm.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 85 of 143

Nozzle Calcs.: MH1 - 24in

Nozl: 10

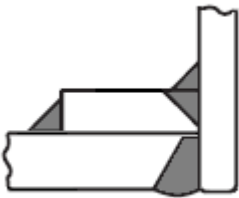
1:37pm

Apr 8,2024

Reinforcing Pad Width	195.2000 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)**



**Insert/Set-in Nozzle With Pad, no Inside projection**

Reinforcement CALCULATION, Description: MH1 - 24in

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	24.000 in.
Actual Thickness Used in Calculation	0.315 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]

$$= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c)(1)}$$

$$= (0.2 \cdot 1053.0) / (138 \cdot 1.0 - 0.6 \cdot 0.2)$$

$$= 0.1532 \text{ mm.}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$= (P \cdot R_o) / (S_n \cdot E + 0.4 \cdot P) \text{ per Appendix 1-1 (a)(1)}$$

$$= (0.2 \cdot 304.8) / (138 \cdot 1.0 + 0.4 \cdot 0.2)$$

$$= 0.0443 \text{ mm.}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.5333 mm.

**UG-40, Limits of Reinforcement : [Internal Pressure]**

Parallel to Vessel Wall (Diameter Limit)	D1	1199.2001 mm.
Parallel to Vessel Wall, opening length	d	599.6000 mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp		12.5000 mm.

Weld Strength Reduction Factor [fr1]:

$$= \min( 1, S_n / S_v )$$

$$= \min( 1, 137.9 / 137.9 )$$

$$= 1.000$$

Weld Strength Reduction Factor [fr2]:

$$= \min( 1, S_n / S_v )$$

$$= \min( 1, 137.9 / 137.9 )$$



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 86 of 143

Nozzle Calcs.: MH1 - 24in

Nozl: 10

1:37pm

Apr 8, 2024

= 1.000

Weld Strength Reduction Factor [fr4]:

= min( 1, Sp/Sv )

= min( 1, 137.9/137.9 )

= 1.000

Weld Strength Reduction Factor [fr3]:

= min( fr2, fr4 )

= min( 1.0, 1.0 )

= 1.000

Results of Nozzle Reinforcement Area Calculations: (cm<sup>2</sup>)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.919	12.083	NA
Area in Shell	A1	29.061	5.813	NA
Area in Nozzle Wall	A2	1.239	1.117	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.698	0.698	NA
Area in Element	A5	23.424	23.424	NA
TOTAL AREA AVAILABLE	Atot	54.422	31.051	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations

90.00 Degs.

The area available without a pad is Insufficient.

The area available with the given pad is Sufficient.

SELECTION OF POSSIBLE REINFORCING PADS:	Diameter	Thickness
Based on given Pad Thickness:	683.8680	8.0000 mm.
Based on given Pad Diameter:	1000.0000	1.5219 mm.
Based on Shell or Nozzle Thickness:	683.8680	8.0000 mm.

Area Required [A]:

= 0.5( d \* tr\*F + 2 \* tn \* tr\*F(1-fr1) ) per UG-37(d)

= 0.5(599.6\*4.0305\*1+2\*5.0\*4.0305\*1(1-1.0))

= 12.083 cm<sup>2</sup>

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 )

= 599.6( 1.0 \* 5.0 - 1.0 \* 4.03 ) - 2 \* 5.0

( 1.0 \* 5.0 - 1.0 \* 4.0305 ) \* ( 1 - 1.0 )

= 5.813 cm<sup>2</sup>

Area Available in Nozzle Wall Projecting Outward [A2]:

= ( 2 \* Tlwp ) \* ( tn - trn ) \* fr2

= ( 2 \* 12.5 ) \* ( 5.0 - 0.53 ) \* 1.0

= 1.117 cm<sup>2</sup>

Area Available in Welds [A41 + A42 + A43]:

= ( Wo<sup>2</sup> - Ar Lost ) \* Fr3 + ((Wi-can/0.707)<sup>2</sup> - Ar Lost) \* fr2 + Wp<sup>2</sup> \* fr4

= ( 0.3375 ) \* 1.0 + ( 0.0 ) \* 1.0 + 152.4<sup>2</sup> \* 1.0



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User  
FileName : EI027-HRC-VD-ME-CAL-003-01

Nozzle Calcs.: MH1 - 24in Nozl: 10 1:37pm Apr 8,2024

= 0.698 cm<sup>2</sup>

Area Available in Element, also see UG-37(h) [A5]:

= (min(Dp,DL)-(Nozzle OD))(min(tp,Tlwp,te)) \* fr4 \* 0.75  
= ( 1000.0 - 609.6 )8.0 \* 1.0 \* 0.75  
= 23.424 cm<sup>2</sup>

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

**Nozzle Neck to Flange Weld, Curve: B**

Govern. thk, tg = 8.0, tr = 0.044, c = 3.0 mm., E\* = 1.0  
Thickness Ratio = tr \* (E\*)/(tg - c) = 0.009, 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

**Nozzle Neck to Pad Weld for the Nozzle, Curve: B**

Govern. thk, tg = 8.0, tr = 0.044, c = 3.0 mm., E\* = 1.0  
Thickness Ratio = tr \* (E\*)/(tg - c) = 0.009, 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

**Nozzle Neck to Pad Weld for Reinforcement pad, Curve: B**

Govern. thk, tg = 8.0, tr = 0.044, c = 3.0 mm., E\* = 1.0  
Thickness Ratio = tr \* (E\*)/(tg - c) = 0.009, 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, Curve: B**

Govern. thk, tg = 8.0, tr = 0.153, c = 3.0 mm., E\* = 1.0  
Thickness Ratio = tr \* (E\*)/(tg - c) = 0.031, 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

**Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B**

Govern. thk, tg = 8.0, tr = 0.153, c = 3.0 mm., E\* = 1.0  
Thickness Ratio = tr \* (E\*)/(tg - c) = 0.031, 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

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:**

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -29 °C  
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -104 °C



Strength Calculation-Active Carbon Filter

Design by A. Azodi

Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 88 of 143

Nozzle Calcs.: MH1 - 24in

Nozl: 10

1:37pm

Apr 8, 2024

Flange MDMT with Temp reduction per UCS-66(b)(1)(-c) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = 0.20/19.60 = 0.010

Note:

Using the min value from (b)(1)(-b) and (b)(1)(-c) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: MH1 - 24in

Intermediate Calc. for nozzle/shell Welds	Tmin	5.0000	mm.
Intermediate Calc. for pad/shell Welds	TminPad	5.0000	mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	3.5000 = 0.7 * tmin.	4.2420 = 0.7 * Wo mm.
Pad Weld	2.5000 = 0.5*TminPad	4.2420 = 0.7 * Wp mm.

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)

Weld Load [W]:

$$= \max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv )$$

$$= \max( 0, (12.0834 - 5.8132 + 2 * 5.0 * 1.0 * (1.0 * 5.0 - 4.0305) )138 )$$

$$= 8953.33 \text{ Kgf}$$

Note: F is always set to 1.0 throughout the calculation.

Weld Load [W1]:

$$= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv$$

$$= ( 1.1167 + 23.424 + 0.6975 - 0.0 * 1.0 ) * 138$$

$$= 35488.98 \text{ Kgf}$$

Weld Load [W2]:

$$= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv$$

$$= ( 1.1167 + 0.0 + 0.36 + ( 0.5 ) ) * 138$$

$$= 2779.53 \text{ Kgf}$$

Weld Load [W3]:

$$= (A2+A3+A4+A5+(2*tn*t*fr1))*S$$

$$= ( 1.1167 + 0.0 + 0.6975 + 23.424 + ( 0.5 ) ) * 138$$

$$= 36192.06 \text{ Kgf}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$= (\pi/2) * Dlo * Wo * 0.49 * Snw$$

$$= ( 3.1416/2.0 ) * 609.6 * 6.0 * 0.49 * 138$$

$$= 39587. \text{ Kgf}$$

Shear, Pad Element Weld [Spew]:

$$= (\pi/2) * DP * WP * 0.49 * SEW$$

$$= ( 3.1416/2.0 ) * 1000.0 * 6.0 * 0.49 * 138$$

$$= 64939. \text{ Kgf}$$

Shear, Nozzle Wall [Snw]:

$$= (\pi * ( Dlr + Dlo ) / 4 ) * ( Thk - Can ) * 0.7 * Sn$$



Strength Calculation-Active Carbon Filter

Design by A. Azodi

Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 89 of 143

Nozzle Calcs.: MH1 - 24in

Nozl: 10

1:37pm

Apr 8,2024

$$= (3.1416 * 302.3) * (8.0 - 3.0) * 0.7 * 138$$

$$= 46740. \text{ Kgf}$$

Tension, Pad Groove Weld [Tpgw]:

$$= (\pi/2) * D_{lo} * W_{gpn} * 0.74 * S_{eg}$$

$$= (3.1416/2) * 609.6 * 6.0 * 0.74 * 138$$

$$= 59784. \text{ Kgf}$$

Tension, Shell Groove Weld [Tngw]:

$$= (\pi/2) * D_{lo} * (W_{gnvi} - C_{as}) * 0.74 * S_{ng}$$

$$= (3.1416/2.0) * 609.6 * (6.0 - 3.0) * 0.74 * 138$$

$$= 29892. \text{ Kgf}$$

Strength of Failure Paths:

$$PATH11 = (SPEW + SNW) = (64939 + 46740) = 111679 \text{ Kgf}$$

$$PATH22 = (Sonw + Tpgw + Tngw + Sinw)$$

$$= (39587 + 59784 + 29892 + 0) = 129262 \text{ Kgf}$$

$$PATH33 = (Spew + Tngw + Sinw)$$

$$= (64939 + 29892 + 0) = 94830 \text{ Kgf}$$

Summary of Failure Path Calculations:

Path 1-1 = 111678 Kgf, must exceed W = 8953 Kgf or W1 = 35488 Kgf  
 Path 2-2 = 129262 Kgf, must exceed W = 8953 Kgf or W2 = 2779 Kgf  
 Path 3-3 = 94830 Kgf, must exceed W = 8953 Kgf or W3 = 36192 Kgf

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 5.550 bars

Note: The MAWP of this junction was limited by the parent Shell/Head.

Nozzle is O.K. for the External Pressure 0.100 bars

The Drop for this Nozzle is : 45.2129 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 303.2129 mm.

Percent Elongation Calculations:

% Elongation per Table UG-79-1 (50\*tnom/Rf\*(1-Rf/Ro)) 1.330 %

PV Elite is a trademark of Intergraph CADWorx & Analysis Solutions, Inc. 2019



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User  
FileName : EI027-HRC-VD-ME-CAL-003-01

Nozzle Calcs.: Gas In - 6in Nozl: 11 1:37pm Apr 8,2024

Input, Nozzle Desc: Gas In - 6in From: 20

Pressure for Reinforcement Calculations	P	0.201	bars
Temperature for Internal Pressure	Temp	85	°C
Design External Pressure	Pext	0.10	bars
Temperature for External Pressure	Tempex	85	°C

Shell Material		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm <sup>2</sup>
Shell Allowable Stress At Ambient	Sva	137.90	N./mm <sup>2</sup>

Inside Diameter of Cylindrical Shell	D	2100.00	mm.
Design Length of Section	L	5749.9995	mm.
Shell Finished (Minimum) Thickness	t	8.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.

Distance from Bottom/Left Tangent 250.00 mm.

User Entered Minimum Design Metal Temperature -5.00 °C

**Type of Element Connected to the Shell : Nozzle**

Material		SA-106	B
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm <sup>2</sup>
Allowable Stress At Ambient	Sna	117.90	N./mm <sup>2</sup>

Diameter Basis (for tr calc only)		OD	
Layout Angle		105.00	deg
Diameter		6.0000	in.

Size and Thickness Basis		Minimum	
Nominal Thickness	tn	80	

Flange Material		SA-105	
Flange Type		Slip on	

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	150.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	8.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	8.0000	mm.
Inside Projection	h	2000.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.

Pad Material		SA-516	70
Pad Allowable Stress at Temperature	Sp	137.90	N./mm <sup>2</sup>
Pad Allowable Stress At Ambient	Spa	137.90	N./mm <sup>2</sup>
Diameter of Pad along vessel surface	Dp	270.0000	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	6.0000	mm.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

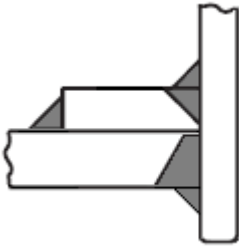
PV Elite 2019 SP1 Licensee: SPLM Licensed User  
FileName : EI027-HRC-VD-ME-CAL-003-01

Nozzle Calcs.: Gas In - 6in Nozl: 11 1:37pm Apr 8,2024

Reinforcing Pad Width	50.8625 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: Gas In - 6in

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	6.625 in.
Actual Thickness Used in Calculation	0.378 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]  
 $= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P)$  per UG-27 (c)(1)  
 $= (0.2 \cdot 1053.0) / (138 \cdot 1.0 - 0.6 \cdot 0.2)$   
 $= 0.1533$  mm.

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]  
 $= (P \cdot R_o) / (S_n \cdot E + 0.4 \cdot P)$  per Appendix 1-1 (a)(1)  
 $= (0.2 \cdot 84.1375) / (118 \cdot 1.0 + 0.4 \cdot 0.2)$   
 $= 0.0143$  mm.

Required Nozzle thickness under External Pressure per UG-28 : 0.2031 mm.

**UG-40, Limits of Reinforcement : [Internal Pressure]**

Parallel to Vessel Wall (Diameter Limit)	D1	310.1452	mm.
Parallel to Vessel Wall, opening length	d	155.0726	mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp		12.5000	mm.
Normal to Vessel Wall, Inward		9.0030	mm.

**Weld Strength Reduction Factor [fr1]:**

$= \min( 1, S_n / S_v )$   
 $= \min( 1, 117.9 / 137.9 )$   
 $= 0.855$

**Weld Strength Reduction Factor [fr2]:**

$= \min( 1, S_n / S_v )$   
 $= \min( 1, 117.9 / 137.9 )$



Strength Calculation-Active Carbon Filter

Design by A. Azodi

Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 92 of 143

Nozzle Calcs.: Gas In - 6in

Nozl: 11

1:37pm

Apr 8, 2024

= 0.855

Weld Strength Reduction Factor [fr4]:

= min( 1, Sp/Sv )

= min( 1, 137.9/137.9 )

= 1.000

Weld Strength Reduction Factor [fr3]:

= min( fr2, fr4 )

= min( 0.855, 1.0 )

= 0.855

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.241	3.164	NA
Area in Shell	A1	7.423	1.485	NA
Area in Nozzle Wall	A2	1.408	1.368	NA
Area in Inward Nozzle	A3	0.554	0.554	NA
Area in Welds	A41+A42+A43	0.802	0.802	NA
Area in Element	A5	6.103	6.103	NA
TOTAL AREA AVAILABLE	Atot	16.292	10.313	NA

The External 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]:

= 0.5( d \* tr\*F + 2 \* tn \* tr\*F(1-fr1) ) per UG-37(d)

= 0.5(155.0726\*4.0305\*1+2\*6.6012\*4.0305\*1(1-0.86))

= 3.164 cm²

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 )

= 155.073( 1.0 \* 5.0 - 1.0 \* 4.03 ) - 2 \* 6.601

( 1.0 \* 5.0 - 1.0 \* 4.0305 ) \* ( 1 - 0.855 )

= 1.485 cm²

Area Available in Nozzle Wall Projecting Outward [A2]:

= ( 2 \* Tlwp ) \* ( tn - trn ) \* fr2

= ( 2 \* 12.5 ) \* ( 6.6 - 0.2 ) \* 0.855

= 1.368 cm²

Area Available in Inward Nozzle [A3]:

= 2 \* ti \* min( h, Tl, 2.5 \* ti ) \* fr2

= 2 \* 3.6012 \* ( 9.003 ) \* 0.855

= 0.554 cm²

Area Available in Welds [A41 + A42 + A43]:

= ( Wo² - Ar Lost ) \* Fr3 + ((Wi-can/0.707)² - Ar Lost) \* fr2 + Wp² \* fr4

= ( 0.5175 ) \* 0.86 + ( 0.0 ) \* 0.86 + 152.4² \* 1.0



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 93 of 143

Nozzle Calcs.: Gas In - 6in

Noz1: 11

1:37pm

Apr 8, 2024

= 0.802 cm<sup>2</sup>

Area Available in Element, also see UG-37(h) [A5]:

= (min(Dp,DL)-(Nozzle OD))(min(tp,Tlwp,te)) \* fr4 \* 0.75  
= ( 270.0 - 168.275 )8.0 \* 1.0 \* 0.75  
= 6.103 cm<sup>2</sup>

**UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]**

Wall Thickness for Internal/External pressures	ta = 3.2031 mm.
Wall Thickness per UG16(b),	tr16b = 5.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 3.1533 mm.
Wall Thickness	tb1 = max(trb1, tr16b) = 5.5000 mm.
Wall Thickness	tb2 = max(trb2, tr16b) = 5.5000 mm.
Wall Thickness per table UG-45	tb3 = 9.2200 mm.

Determine Nozzle Thickness candidate [tb]:

= min[ tb3, max( tb1,tb2 ) ]  
= min[ 9.22, max( 5.5, 5.5 ) ]  
= 5.5000 mm.

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

= max( ta, tb )  
= max( 3.2031, 5.5 )  
= 5.5000 mm.

Available Nozzle Neck Thickness = 9.6012 mm. --> OK

**Stresses on Nozzle due to External and Pressure Loads per the ASME**

**B31.3 Piping Code (see 319.4.4 and 302.3.5):**

Sustained	: 9.9,	Allowable	: 117.9 N./mm <sup>2</sup>	Passed
Expansion	: 0.0,	Allowable	: 284.8 N./mm <sup>2</sup>	Passed
Occasional	: 0.1,	Allowable	: 156.8 N./mm <sup>2</sup>	Passed
Shear	: 6.9,	Allowable	: 82.5 N./mm <sup>2</sup>	Passed

*Note : The number of cycles on this nozzle was assumed to be 7000 or less for the determination of the expansion stress allowable.*

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

**Nozzle Neck to Flange Weld, Curve: B**

Govern. thk, tg = 9.601, tr = 0.014, c = 3.0 mm., E\* = 1.0  
Thickness Ratio = tr \* (E\*)/(tg - c) = 0.002, 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

**Nozzle Neck to Pad Weld for the Nozzle, Curve: B**

Govern. thk, tg = 8.0, c = 3.0 mm., E\* = 1.0  
Thickness Ratio = tr \* (E\*)/(tg - c) = 0.031, 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 Neck to Pad Weld for Reinforcement pad, Curve: B**



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 94 of 143

Nozzle Calcs.: Gas In - 6in

Noz1: 11

1:37pm

Apr 8, 2024

Govern. thk, tg = 8.0, c = 3.0 mm., E\* = 1.0  
Thickness Ratio =  $tr * (E^*) / (tg - c) = 0.031$ , 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

**Shell to Pad Weld Junction at Pad OD, Curve: B**

Govern. thk, tg = 8.0, tr = 0.153, c = 3.0 mm., E\* = 1.0  
Thickness Ratio =  $tr * (E^*) / (tg - c) = 0.031$ , 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

**Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B**

Govern. thk, tg = 8.0, tr = 0.153, c = 3.0 mm., E\* = 1.0  
Thickness Ratio =  $tr * (E^*) / (tg - c) = 0.031$ , 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

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:**

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -29 °C  
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -104 °C  
Flange MDMT with Temp reduction per UCS-66(b)(1)(-c) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :  
Design Pressure/Ambient Rating = 0.20/19.60 = 0.010

Note:  
Using the min value from (b)(1)(-b) and (b)(1)(-c) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: Gas In - 6in

Intermediate Calc. for nozzle/shell Welds Tmin 6.6012 mm.  
Intermediate Calc. for pad/shell Welds TminPad 5.0000 mm.

**Results Per UW-16.1:**

	Required Thickness	Actual Thickness
Nozzle Weld	4.6208 = 0.7 * tmin.	5.6560 = 0.7 * Wo mm.
Pad Weld	2.5000 = 0.5 * TminPad	4.2420 = 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, (3.1637 - 1.4849 + 2 \* 6.6012 \* 0.855 \* (1.0 \* 5.0 - 4.0305) )138 )  
= 2514.55 Kgf



Strength Calculation-Active Carbon Filter

Design by A. Azodi

Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 95 of 143

Nozzle Calcs.: Gas In - 6in

Nozl: 11

1:37pm

Apr 8, 2024

Note: F is always set to 1.0 throughout the calculation.

Weld Load [W1]:

$$= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv$$

$$= ( 1.3676 + 6.1035 + 0.8025 - 0.0 * 0.86 ) * 138$$

$$= 11633.98 \text{ Kgf}$$

Weld Load [W2]:

$$= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv$$

$$= ( 1.3676 + 0.5544 + 0.5472 + ( 0.5644 ) ) * 138$$

$$= 4265.76 \text{ Kgf}$$

Weld Load [W3]:

$$= (A2+A3+A4+A5+(2*tn*t*fr1))*S$$

$$= ( 1.3676 + 0.5544 + 0.8025 + 6.1035 + ( 0.5644 ) ) * 138$$

$$= 13207.21 \text{ Kgf}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$= (\pi/2) * Dlo * Wo * 0.49 * Snw$$

$$= ( 3.1416/2.0 ) * 168.275 * 8.0 * 0.49 * 118$$

$$= 12457. \text{ Kgf}$$

Shear, Pad Element Weld [Spew]:

$$= (\pi/2) * DP * WP * 0.49 * SEW$$

$$= ( 3.1416/2.0 ) * 270.0 * 6.0 * 0.49 * 138$$

$$= 17533. \text{ Kgf}$$

Shear, Nozzle Wall [Snw]:

$$= (\pi * ( Dlr + Dlo ) / 4 ) * ( Thk - Can ) * 0.7 * Sn$$

$$= ( 3.1416 * 80.8369 ) * ( 9.6012 - 3.0 ) * 0.7 * 118$$

$$= 14109. \text{ Kgf}$$

Tension, Pad Groove Weld [Tpgw]:

$$= (\pi/2) * Dlo * Wgpn * 0.74 * Seg$$

$$= ( 3.1416/2 ) * 168.275 * 6.0 * 0.74 * 138$$

$$= 16503. \text{ Kgf}$$

Tension, Shell Groove Weld [Tngw]:

$$= (\pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng$$

$$= ( 3.1416/2.0 ) * 168.275 * ( 8.0 - 3.0 ) * 0.74 * 138$$

$$= 13752. \text{ Kgf}$$

Strength of Failure Paths:

$$PATH11 = ( SPEW + SNW ) = ( 17533 + 14109 ) = 31642 \text{ Kgf}$$

$$PATH22 = ( Sonw + Tpgw + Tngw + Sinw )$$

$$= ( 12457 + 16503 + 13752 + 0 ) = 42713 \text{ Kgf}$$

$$PATH33 = ( Spew + Tngw + Sinw )$$

$$= ( 17533 + 13752 + 0 ) = 31286 \text{ Kgf}$$

Summary of Failure Path Calculations:

Path 1-1 = 31641 Kgf, must exceed W = 2514 Kgf or W1 = 11633 Kgf  
 Path 2-2 = 42712 Kgf, must exceed W = 2514 Kgf or W2 = 4265 Kgf  
 Path 3-3 = 31285 Kgf, must exceed W = 2514 Kgf or W3 = 13207 Kgf



Strength Calculation-Active Carbon Filter
Design by A. Azodi
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 96 of 143

Nozzle Calcs.: Gas In - 6in Nozl: 11 1:37pm Apr 8,2024

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 5.550 bars

Note: The MAWP of this junction was limited by the parent Shell/Head.

Nozzle is O.K. for the External Pressure 0.100 bars

The Drop for this Nozzle is : 3.3764 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 2158.0000 mm.

Input Echo, WRC107/537 Item 1, Description: Gas In - 6in :

Table with 4 columns: Parameter, Vbasis, ID, Value. Rows include Diameter Basis for Vessel, Internal Corrosion Allowance, Vessel Diameter, Vessel Thickness, Design Temperature, Vessel Material, Vessel UNS Number, Vessel Cold S.I. Allowable, Vessel Hot S.I. Allowable.

Note:
Using 2 \* Yield for Discontinuity Stress Allowable (Div 2, 4.1.6.3), Sps.
Make sure that material properties at this temperature are not time-dependent for Material: SA-516 70

Table with 4 columns: Attachment Type, Type, Round, Value. Rows include Attachment Type, Diameter Basis for Nozzle, Corrosion Allowance for Nozzle, Nozzle Diameter, Nozzle Thickness, Nozzle Material, Nozzle UNS Number, Nozzle Cold S.I. Allowable, Nozzle Hot S.I. Allowable, Thickness of Reinforcing Pad, Diameter of Reinforcing Pad, Design Internal Pressure, Include Pressure Thrust.

External Forces and Moments in WRC 107/537 Convention:

Table with 4 columns: Force/Moment, (SUS), Type, Value. Rows include Radial Load, Longitudinal Shear, Circumferential Shear, Circumferential Moment, Longitudinal Moment, Torsional Moment.



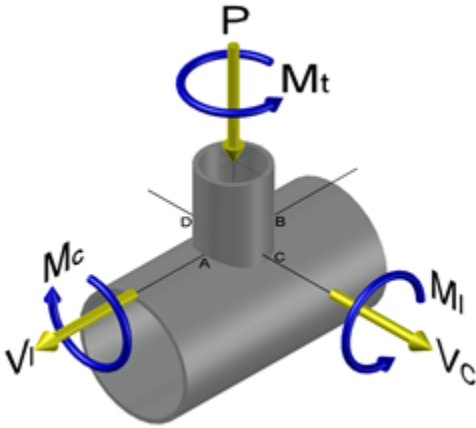
Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User  
FileName : EI027-HRC-VD-ME-CAL-003-01

Nozzle Calcs.: Gas In - 6in Nozl: 11 1:37pm Apr 8,2024

Use Interactive Control	No
WRC107 Version	Version March 1979
Include Pressure Stress Indices per Div. 2	No
Compute Pressure Stress per WRC-368	No
Local Loads applied at end of Nozzle/Attachment	No

*Note:*  
WRC Bulletin 537 provides equations for the dimensionless curves found in bulletin 107. As noted in the foreword to bulletin 537, "537 is equivalent to WRC 107". Where 107 is printed in the results below, "537" can be interchanged with "107".



Stress Attenuation Diameter (for Insert Plates) per WRC 297:  
= NozzleOD + 2 \* 1.65 \* sqrt( Rmean( t - ca ) )  
= 168.275 + 2 \* 1.65 \* sqrt( 1055.5 ( 8.0 - 3.0 ) )  
= 408.008 mm.

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	-144.4	Kgf
Circumferential Shear	VC	180.7	Kgf
Longitudinal Shear	VL	180.7	Kgf
Circumferential Moment	MC	-84.4	Kg-m.
Longitudinal Moment	ML	106.9	Kg-m.
Torsional Moment	MT	136.2	Kg-m.

Dimensionless Parameters used : Gamma = 81.50

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / ( P/Rm )	0.069	4C	13.955	(A,B)
N(PHI) / ( P/Rm )	0.069	3C	12.730	(C,D)
M(PHI) / ( P )	0.069	2C1	0.090	(A,B)
M(PHI) / ( P )	0.069	1C	0.126	(C,D)
N(PHI) / ( MC/(Rm**2 * Beta) )	0.069	3A	2.311	(A,B,C,D)
M(PHI) / ( MC/(Rm * Beta) )	0.069	1A	0.095	(A,B,C,D)
N(PHI) / ( ML/(Rm**2 * Beta) )	0.069	3B	8.145	(A,B,C,D)
M(PHI) / ( ML/(Rm * Beta) )	0.069	1B	0.046	(A,B,C,D)



Strength Calculation-Active Carbon Filter
Design by A. Azodi
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User
FileName : EI027-HRC-VD-ME-CAL-003-01

Nozzle Calcs.: Gas In - 6in Nozl: 11 1:37pm Apr 8,2024

Table with 6 columns: N(x) / ( P/Rm ), M(x) / ( P ), N(x) / ( MC/(Rm\*\*2 \* Beta) ), M(x) / ( MC/(Rm \* Beta) ), N(x) / ( ML/(Rm\*\*2 \* Beta) ), M(x) / ( ML/(Rm \* Beta) ). Includes values for 3C, 4C, 1C1, 2C, 4A, 2A, 4B, 2B.

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction (N./mm²)

Table with 10 columns: Type of Stress, Load, Au, Al, Bu, Bl, Cu, Cl, Du, Dl. Rows include Circ. Memb. P, Circ. Bend. P, Circ. Memb. MC, Circ. Memb. ML, Long. Memb. P, Long. Bend. P, Long. Memb. MC, Long. Bend. MC, Long. Memb. ML, Long. Bend. ML, Tot. Circ. Str., Tot. Long. Str., Shear VC, Shear VL, Shear MT, Tot. Shear, Str. Int.

Dimensionless Parameters used : Gamma = 211.10
Dimensionless Loads for Cylindrical Shells at Pad edge:

Table with 5 columns: Curves read for 1979, Beta, Figure, Value, Location. Rows include N(PHI) / ( P/Rm ), M(PHI) / ( P ), N(PHI) / ( MC/(Rm\*\*2 \* Beta) ), M(PHI) / ( MC/(Rm \* Beta) ), N(PHI) / ( ML/(Rm\*\*2 \* Beta) ), M(PHI) / ( ML/(Rm \* Beta) ).



Strength Calculation-Active Carbon Filter
Design by A. Azodi
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User
FileName : EI027-HRC-VD-ME-CAL-003-01

Nozzle Calcs.: Gas In - 6in Nozl: 11 1:37pm Apr 8,2024

Table with 6 columns: N(x) / ( P/Rm ), value, code, value, (A,B,C,D). Rows include 3C, 4C, 1C1, 2C, 4A, 2A, 4B, 2B.

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 (N./mm²)

Table with 10 columns: Type of Stress, Load, Au, Al, Bu, Bl, Cu, Cl, Du, D1. Rows include Circ. Memb. P, Long. Memb. P, Shear VC, etc.

WRC 107/537 Stress Summations:

Vessel Stress Summation at Attachment Junction (N./mm²)

Table with 10 columns: Type of Stress, Load, Au, Al, Bu, Bl, Cu, Cl, Du, D1. Row for Str. Int.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 100 of 143

Nozzle Calcs.: Gas In - 6in

Nozl: 11

1:37pm

Apr 8, 2024

Circ. Pm (SUS)	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Circ. Pl (SUS)	-7.0	-7.0	9.9	9.9	3.2	3.2	-0.6	-0.6
Circ. Q (SUS)	-18.9	18.9	28.0	-28.0	44.3	-44.3	-31.6	31.6
Long. Pm (SUS)	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Long. Pl (SUS)	-1.1	-1.1	3.7	3.7	4.1	4.1	-1.2	-1.2
Long. Q (SUS)	-30.0	30.0	43.2	-43.2	26.1	-26.1	-17.1	17.1
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	0.5	0.5	-0.5	-0.5	-0.5	-0.5	0.5	0.5
Shear Q (SUS)	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Pm (SUS)	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Pm+Pl (SUS)	5.4	5.4	11.5	11.5	5.4	5.4	1.8	1.8
Pm+Pl+Q (Total)	31.4	30.2	48.1	38.8	49.3	39.7	31.1	33.1

**Vessel Stress Summation Comparison (N/mm²):**

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	1.64	137.90	Passed
Pm+Pl (SUS)	11.53	206.85	Passed
Pm+Pl+Q (TOTAL)	49.30	413.70	Passed

Because only sustained loads were specified, the Pm+Pl+Q allowable was 3 \* Smh.

**WRC 107/537 Stress Summations:**

**Vessel Stress Summation at Reinforcing Pad Edge (N/mm²)**

Type of Stress	Load	Stress Intensity Values at							
		Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)		4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Circ. Pl (SUS)		-24.5	-24.5	38.9	38.9	15.0	15.0	-7.2	-7.2
Circ. Q (SUS)		-26.3	26.3	45.0	-45.0	137.0	-137.0	-90.8	90.8
Long. Pm (SUS)		2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
Long. Pl (SUS)		-10.4	-10.4	18.1	18.1	30.6	30.6	-16.2	-16.2
Long. Q (SUS)		-27.4	27.4	65.2	-65.2	62.4	-62.4	-37.3	37.3
Shear Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)		0.8	0.8	-0.8	-0.8	-0.8	-0.8	0.8	0.8
Shear Q (SUS)		2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Pm (SUS)		4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Pm+Pl (SUS)		20.3	20.3	43.1	43.1	32.7	32.7	14.1	14.1
Pm+Pl+Q (Total)		47.4	19.9	88.7	45.0	156.2	117.8	94.1	88.0



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 101 of 143

Nozzle Calcs.: Gas In - 6in

Nozl: 11

1:37pm

Apr 8, 2024

**Vessel Stress Summation Comparison (N/mm<sup>2</sup>):**

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	4.24	137.90	Passed
Pm+Pl (SUS)	43.14	206.85	Passed
Pm+Pl+Q (TOTAL)	156.20	413.70	Passed

*Because only sustained loads were specified, the Pm+Pl+Q allowable was 3 \* Smh.*

**PV Elite is a trademark of Intergraph CADWorx & Analysis Solutions, Inc. 2019**



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 102 of 143

Nozzle Calcs.: Utility - 2in

Nozl: 12

1:37pm

Apr 8,2024

Input, Nozzle Desc: Utility - 2in

From: 20

Pressure for Reinforcement Calculations	P	0.201	bars
Temperature for Internal Pressure	Temp	85	°C
Design External Pressure	Pext	0.10	bars
Temperature for External Pressure	Tempex	85	°C

Shell Material		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm <sup>2</sup>
Shell Allowable Stress At Ambient	Sva	137.90	N./mm <sup>2</sup>

Inside Diameter of Cylindrical Shell	D	2100.00	mm.
Design Length of Section	L	5749.9995	mm.
Shell Finished (Minimum) Thickness	t	8.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.

Distance from Bottom/Left Tangent 250.00 mm.

User Entered Minimum Design Metal Temperature -5.00 °C

**Type of Element Connected to the Shell : Nozzle**

Material		SA-106	B
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm <sup>2</sup>
Allowable Stress At Ambient	Sna	117.90	N./mm <sup>2</sup>

Diameter Basis (for tr calc only)		OD	
Layout Angle		255.00	deg
Diameter		2.0000	in.

Size and Thickness Basis		Minimum	
Nominal Thickness	tn	160	

Flange Material		SA-105	
Flange Type		Slip on	

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	150.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	6.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	6.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	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)**



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

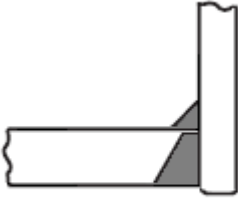
Page 103 of 143

Nozzle Calcs.: Utility - 2in

Nozl: 12

1:37pm

Apr 8,2024



**Insert/Set-in Nozzle No Pad, no Inside projection**

Reinforcement CALCULATION, Description: Utility - 2in

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

Actual Outside Diameter Used in Calculation 2.375 in.  
Actual Thickness Used in Calculation 0.301 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)  
= (0.2\*1053.0)/(138\*1.0-0.6\*0.2)  
= 0.1533 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)  
= (0.2\*30.1625)/(118\*1.0+0.4\*0.2)  
= 0.0051 mm.

Required Nozzle thickness under External Pressure per UG-28 : 0.1107 mm.

**UG-40, Limits of Reinforcement : [Internal Pressure]**

Parallel to Vessel Wall (Diameter Limit) D1 102.0684 mm.  
Parallel to Vessel Wall, opening length d 51.0342 mm.  
Normal to Vessel Wall (Thickness Limit), no pad Tlnp 11.6135 mm.

**Note:**

*Taking a UG-36(c)(3)(a) exemption for nozzle: Utility - 2in.  
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 = 3.1107 mm.  
Wall Thickness per UG16(b), tr16b = 5.5000 mm.  
Wall Thickness, shell/head, internal pressure trb1 = 3.1533 mm.  
Wall Thickness tb1 = max(trb1, tr16b) = 5.5000 mm.  
Wall Thickness tb2 = max(trb2, tr16b) = 5.5000 mm.  
Wall Thickness per table UG-45 tb3 = 6.4200 mm.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 104 of 143

Nozzle Calcs.: Utility - 2in

Nozl: 12

1:37pm

Apr 8, 2024

**Determine Nozzle Thickness candidate [tb]:**

= min[ tb3, max( tb1,tb2) ]  
= min[ 6.42, max( 5.5, 5.5 ) ]  
= 5.5000 mm.

**Minimum Wall Thickness of Nozzle Necks [tUG-45]:**

= max( ta, tb )  
= max( 3.1107, 5.5 )  
= 5.5000 mm.

Available Nozzle Neck Thickness = 7.6454 mm. --> OK

**Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:**

**Nozzle Neck to Flange Weld, Curve: B**

Govern. thk, tg = 7.645, tr = 0.005, c = 3.0 mm., E\* = 1.0  
Thickness Ratio = tr \* (E\*)/(tg - c) = 0.001, 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

**Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B**

Govern. thk, tg = 7.645, tr = 0.005, c = 3.0 mm., E\* = 1.0  
Thickness Ratio = tr \* (E\*)/(tg - c) = 0.001, 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

Governing MDMT of all the sub-joints of this Junction : -104 °C

**ANSI Flange MDMT including Temperature reduction per UCS-66.1:**

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c)	-29 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b)	-104 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-c)	-104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :  
Design Pressure/Ambient Rating = 0.20/19.60 = 0.010

*Note:*  
Using the min value from (b)(1)(-b) and (b)(1)(-c) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: Utility - 2in

Intermediate Calc. for nozzle/shell Welds    Tmin        4.6454 mm.

**Results Per UW-16.1:**

	Required Thickness	Actual Thickness
Nozzle Weld	3.2518 = 0.7 * tmin.	4.2420 = 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:**



Strength Calculation-Active Carbon Filter

Design by A. Azodi

Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 105 of 143

Nozzle Calcs.: Utility - 2in                      Nozl: 12      1:37pm      Apr 8,2024

---

Converged Max. Allow. Pressure in Operating case                      5.550 bars

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 0.4333 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 158.4333 mm.

PV Elite is a trademark of Intergraph CADWorx & Analysis Solutions, Inc. 2019



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User  
FileName : EI027-HRC-VD-ME-CAL-003-01

Nozzle Calcs.: Gas Out - 6in Nozl: 13 1:37pm Apr 8,2024

Input, Nozzle Desc: Gas Out - 6in From: 50

Pressure for Reinforcement Calculations	P	0.200	bars
Temperature for Internal Pressure	Temp	85	°C
Design External Pressure	Pext	0.10	bars
Temperature for External Pressure	Tempex	85	°C

Shell Material		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm <sup>2</sup>
Shell Allowable Stress At Ambient	Sva	137.90	N./mm <sup>2</sup>

Inside Diameter of Cylindrical Shell	D	2100.00	mm.
Design Length of Section	L	5749.9990	mm.
Shell Finished (Minimum) Thickness	t	8.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.

Distance from Bottom/Left Tangent 5150.00 mm.

User Entered Minimum Design Metal Temperature -5.00 °C

**Type of Element Connected to the Shell : Nozzle**

Material		SA-106	B
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm <sup>2</sup>
Allowable Stress At Ambient	Sna	117.90	N./mm <sup>2</sup>

Diameter Basis (for tr calc only)		OD	
Layout Angle		180.00	deg
Diameter		6.0000	in.

Size and Thickness Basis		Minimum	
Nominal Thickness	tn	STD	

Flange Material		SA-105	
Flange Type		Slip on	

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	150.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	6.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	6.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.

Pad Material		SA-516	70
Pad Allowable Stress at Temperature	Sp	137.90	N./mm <sup>2</sup>
Pad Allowable Stress At Ambient	Spa	137.90	N./mm <sup>2</sup>
Diameter of Pad along vessel surface	Dp	270.0000	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	6.0000	mm.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

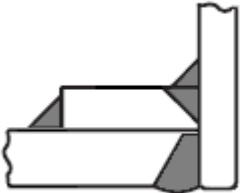
PV Elite 2019 SP1 Licensee: SPLM Licensed User  
FileName : EI027-HRC-VD-ME-CAL-003-01

Nozzle Calcs.: Gas Out - 6in Nozl: 13 1:37pm Apr 8,2024

Reinforcing Pad Width	50.8625 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: Gas Out - 6in

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	6.625 in.
Actual Thickness Used in Calculation	0.245 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]  
 $= (P \cdot R) / (S_v \cdot E - 0.6 \cdot P)$  per UG-27 (c)(1)  
 $= (0.2 \cdot 1053.0) / (138 \cdot 1.0 - 0.6 \cdot 0.2)$   
 $= 0.1528 \text{ mm.}$

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 0.0975 and the shell thk. is 8.0000 mm.

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]  
 $= (P \cdot R_o) / (S_n \cdot E + 0.4 \cdot P)$  per Appendix 1-1 (a)(1)  
 $= (0.2 \cdot 84.1375) / (118 \cdot 1.0 + 0.4 \cdot 0.2)$   
 $= 0.0143 \text{ mm.}$

Required Nozzle thickness under External Pressure per UG-28 : 0.2031 mm.

**UG-40, Limits of Reinforcement : [Internal Pressure]**

Parallel to Vessel Wall (Diameter Limit)	D1	323.6580 mm.
Parallel to Vessel Wall, opening length	d	161.8290 mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp		12.5000 mm.

**Weld Strength Reduction Factor [fr1]:**

$= \min( 1, S_n / S_v )$   
 $= \min( 1, 117.9 / 137.9 )$



Strength Calculation-Active Carbon Filter

Design by A. Azodi

Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 108 of 143

Nozzle Calcs.: Gas Out - 6in

Noz1: 13

1:37pm

Apr 8, 2024

= 0.855

Weld Strength Reduction Factor [fr2]:

= min( 1, Sn/Sv )

= min( 1, 117.9/137.9 )

= 0.855

Weld Strength Reduction Factor [fr4]:

= min( 1, Sp/Sv )

= min( 1, 137.9/137.9 )

= 1.000

Weld Strength Reduction Factor [fr3]:

= min( fr2, fr4 )

= min( 0.855, 1.0 )

= 0.855

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.793	3.280	NA
Area in Shell	A1	7.261	1.560	NA
Area in Nozzle Wall	A2	0.686	0.646	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.649	0.649	NA
Area in Element	A5	6.103	6.103	NA
TOTAL AREA AVAILABLE	Atot	14.699	8.957	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations

90.00 Degs.

The area available without a pad is Insufficient.

The area available with the given pad is Sufficient.

SELECTION OF POSSIBLE REINFORCING PADS:	Diameter	Thickness
Based on given Pad Thickness:	175.3772	8.0000 mm.
Based on given Pad Diameter:	270.0000	0.5585 mm.
Based on Shell or Nozzle Thickness:	177.4053	6.2230 mm.

Area Required [A]:

= 0.5( d \* tr\*F + 2 \* tn \* tr\*F(1-fr1) ) per UG-37(d)

= 0.5(161.829\*4.0305\*1+2\*3.223\*4.0305\*1(1-0.86))

= 3.280 cm²

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 )

= 161.829( 1.0 \* 5.0 - 1.0 \* 4.03 ) - 2 \* 3.223

( 1.0 \* 5.0 - 1.0 \* 4.0305 ) \* ( 1 - 0.855 )

= 1.560 cm²

Area Available in Nozzle Wall Projecting Outward [A2]:

= ( 2 \* Tlwp ) \* ( tn - trn ) \* fr2

= ( 2 \* 12.5 ) \* ( 3.22 - 0.2 ) \* 0.855



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 109 of 143

Nozzle Calcs.: Gas Out - 6in Nozl: 13 1:37pm Apr 8,2024

= 0.646 cm<sup>2</sup>

Area Available in Welds [A41 + A42 + A43]:

= (Wo<sup>2</sup> - Ar Lost)\*Fr3+((Wi-can/0.707)<sup>2</sup> - Ar Lost)\*fr2 + Wp<sup>2</sup>\*fr4  
= ( 0.3375 ) \* 0.86 + (0.0 ) \* 0.86 + 152.4<sup>2</sup> \* 1.0  
= 0.649 cm<sup>2</sup>

Area Available in Element, also see UG-37(h) [A5]:

= (min(Dp,DL)-(Nozzle OD))(min(tp,Tlwp,te)) \* fr4 \* 0.75  
= ( 270.0 - 168.275 )8.0 \* 1.0 \* 0.75  
= 6.103 cm<sup>2</sup>

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness for Internal/External pressures	ta = 3.2031 mm.
Wall Thickness per UG16(b),	tr16b = 5.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 3.1528 mm.
Wall Thickness	tb1 = max(trb1, tr16b) = 5.5000 mm.
Wall Thickness	tb2 = max(trb2, tr16b) = 5.5000 mm.
Wall Thickness per table UG-45	tb3 = 9.2200 mm.

Determine Nozzle Thickness candidate [tb]:

= min[ tb3, max( tb1,tb2) ]  
= min[ 9.22, max( 5.5, 5.5 ) ]  
= 5.5000 mm.

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

= max( ta, tb )  
= max( 3.2031, 5.5 )  
= 5.5000 mm.

Available Nozzle Neck Thickness = 6.2230 mm. --> OK

Stresses on Nozzle due to External and Pressure Loads per the ASME

B31.3 Piping Code (see 319.4.4 and 302.3.5):

Sustained	: 19.1,	Allowable	: 117.9 N./mm <sup>2</sup>	Passed
Expansion	: 0.0,	Allowable	: 275.6 N./mm <sup>2</sup>	Passed
Occasional	: 0.2,	Allowable	: 156.8 N./mm <sup>2</sup>	Passed
Shear	: 13.1,	Allowable	: 82.5 N./mm <sup>2</sup>	Passed

Note : The number of cycles on this nozzle was assumed to be 7000 or less for the determination of the expansion stress allowable.

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, Curve: B

Govrn. thk, tg = 6.223, tr = 0.014, c = 3.0 mm., E\* = 1.0  
Thickness Ratio = tr \* (E\*)/(tg - c) = 0.004, 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

Nozzle Neck to Pad Weld for the Nozzle, Curve: B

Govrn. thk, tg = 6.223, tr = 0.014, c = 3.0 mm., E\* = 1.0  
Thickness Ratio = tr \* (E\*)/(tg - c) = 0.004, Temp. Reduction = 78 °C



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 110 of 143

Nozzle Calcs.: Gas Out - 6in Nozl: 13 1:37pm Apr 8,2024

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 Neck to Pad Weld for Reinforcement pad, Curve: B**

Govern. thk, tg = 6.223, tr = 0.014, c = 3.0 mm., E\* = 1.0  
Thickness Ratio =  $tr * (E^*) / (tg - c) = 0.004$ , 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, Curve: B**

Govern. thk, tg = 8.0, tr = 0.153, c = 3.0 mm., E\* = 1.0  
Thickness Ratio =  $tr * (E^*) / (tg - c) = 0.031$ , 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

**Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B**

Govern. thk, tg = 6.223, tr = 0.014, c = 3.0 mm., E\* = 1.0  
Thickness Ratio =  $tr * (E^*) / (tg - c) = 0.004$ , 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

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:**

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -29 °C  
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -104 °C  
Flange MDMT with Temp reduction per UCS-66(b)(1)(-c) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :  
Design Pressure/Ambient Rating = 0.20/19.60 = 0.010

Note:  
Using the min value from (b)(1)(-b) and (b)(1)(-c) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: Gas Out - 6in

Intermediate Calc. for nozzle/shell Welds Tmin 3.2230 mm.  
Intermediate Calc. for pad/shell Welds TminPad 5.0000 mm.

**Results Per UW-16.1:**

	Required Thickness	Actual Thickness
Nozzle Weld	2.2561 = 0.7 * tmin.	4.2420 = 0.7 * Wo mm.
Pad Weld	2.5000 = 0.5 * TminPad	4.2420 = 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)



Strength Calculation-Active Carbon Filter

Design by A. Azodi

Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 111 of 143

Nozzle Calcs.: Gas Out - 6in

Nozl: 13

1:37pm

Apr 8,2024

$$= \max( 0, (3.2801 - 1.5599 + 2 * 3.223 * 0.855 * (1.0 * 5.0 - 4.0305) ) / 138 )$$

$$= 2494.03 \text{ Kgf}$$

Note: F is always set to 1.0 throughout the calculation.

Weld Load [W1]:

$$= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv$$

$$= ( 0.6455 + 6.1035 + 0.6486 - 0.0 * 0.86 ) * 138$$

$$= 10402.20 \text{ Kgf}$$

Weld Load [W2]:

$$= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv$$

$$= ( 0.6455 + 0.0 + 0.3078 + ( 0.2756 ) ) * 138$$

$$= 1728.01 \text{ Kgf}$$

Weld Load [W3]:

$$= (A2+A3+A4+A5+(2*tn*t*fr1))*S$$

$$= ( 0.6455 + 0.0 + 0.6486 + 6.1035 + ( 0.2756 ) ) * 138$$

$$= 10789.69 \text{ Kgf}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$= (\pi/2) * Dlo * Wo * 0.49 * Snw$$

$$= ( 3.1416/2.0 ) * 168.275 * 6.0 * 0.49 * 118$$

$$= 9343. \text{ Kgf}$$

Shear, Pad Element Weld [Spew]:

$$= (\pi/2) * DP * WP * 0.49 * SEW$$

$$= ( 3.1416/2.0 ) * 270.0 * 6.0 * 0.49 * 138$$

$$= 17533. \text{ Kgf}$$

Shear, Nozzle Wall [Snw]:

$$= (\pi * ( Dlr + Dlo ) / 4 ) * ( Thk - Can ) * 0.7 * Sn$$

$$= ( 3.1416 * 82.526 ) * ( 6.223 - 3.0 ) * 0.7 * 118$$

$$= 7032. \text{ Kgf}$$

Tension, Pad Groove Weld [Tpgw]:

$$= (\pi/2) * Dlo * Wgpn * 0.74 * Seg$$

$$= ( 3.1416/2 ) * 168.275 * 6.0 * 0.74 * 138$$

$$= 16503. \text{ Kgf}$$

Tension, Shell Groove Weld [Tngw]:

$$= (\pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng$$

$$= ( 3.1416/2.0 ) * 168.275 * ( 6.0 - 3.0 ) * 0.74 * 138$$

$$= 8251. \text{ Kgf}$$

Strength of Failure Paths:

$$PATH11 = ( SPEW + SNW ) = ( 17533 + 7032 ) = 24566 \text{ Kgf}$$

$$PATH22 = ( Sonw + Tpgw + Tngw + Sinw )$$

$$= ( 9343 + 16503 + 8251 + 0 ) = 34097 \text{ Kgf}$$

$$PATH33 = ( Spew + Tngw + Sinw )$$

$$= ( 17533 + 8251 + 0 ) = 25785 \text{ Kgf}$$

Summary of Failure Path Calculations:



Strength Calculation-Active Carbon Filter
Design by A. Azodi
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 112 of 143

Nozzle Calcs.: Gas Out - 6in Nozl: 13 1:37pm Apr 8,2024

Path 1-1 = 24565 Kgf, must exceed W = 2494 Kgf or W1 = 10402 Kgf
Path 2-2 = 34097 Kgf, must exceed W = 2494 Kgf or W2 = 1728 Kgf
Path 3-3 = 25784 Kgf, must exceed W = 2494 Kgf or W3 = 10789 Kgf

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 4.213 bars

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 3.3764 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 161.3764 mm.

Input Echo, WRC107/537 Item 1, Description: Gas Out - 6in :

Table with 4 columns: Parameter, Vbasis, ID, Value. Rows include Diameter Basis for Vessel, Internal Corrosion Allowance, Design Temperature, Vessel Material, etc.

Note:
Using 2 \* Yield for Discontinuity Stress Allowable (Div 2, 4.1.6.3), Sps.
Make sure that material properties at this temperature are not time-dependent for Material: SA-516 70

Table with 4 columns: Attachment Type, Type, Round, Value. Rows include Diameter Basis for Nozzle, Thickness of Reinforcing Pad, Design Internal Pressure, etc.

External Forces and Moments in WRC 107/537 Convention:

Table with 5 columns: Force/Moment, (SUS), Code, Value, Unit. Rows include Radial Load, Longitudinal Shear, Circumferential Shear, etc.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 113 of 143

Nozzle Calcs.: Gas Out - 6in

Nozl: 13

1:37pm

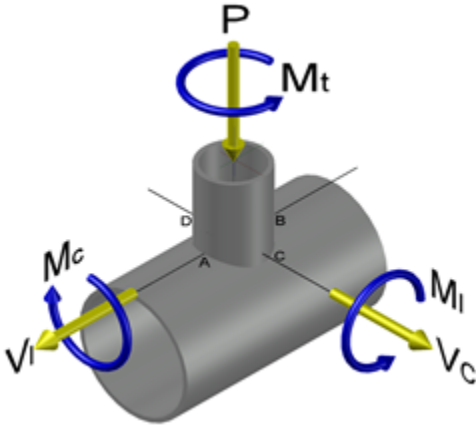
Apr 8, 2024

Use Interactive Control No  
WRC107 Version Version March 1979

Include Pressure Stress Indices per Div. 2 No  
Compute Pressure Stress per WRC-368 No  
Local Loads applied at end of Nozzle/Attachment No

Note:

WRC Bulletin 537 provides equations for the dimensionless curves found in bulletin 107. As noted in the foreword to bulletin 537, "537 is equivalent to WRC 107". Where 107 is printed in the results below, "537" can be interchanged with "107".



Stress Attenuation Diameter (for Insert Plates) per WRC 297:  
= NozzleOD + 2 \* 1.65 \* sqrt( Rmean( t - ca ) )  
= 168.275 + 2 \* 1.65 \* sqrt( 1055.5 ( 8.0 - 3.0 ) )  
= 408.008 mm.

WRC 107 Stress Calculation for SUSTAINED loads:

Radial Load	P	-144.4	Kgf
Circumferential Shear	VC	180.7	Kgf
Longitudinal Shear	VL	180.7	Kgf
Circumferential Moment	MC	-84.4	Kg-m.
Longitudinal Moment	ML	106.9	Kg-m.
Torsional Moment	MT	136.2	Kg-m.

Dimensionless Parameters used : Gamma = 81.50

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / ( P/Rm )	0.069	4C	13.955	(A,B)
N(PHI) / ( P/Rm )	0.069	3C	12.730	(C,D)
M(PHI) / ( P )	0.069	2C1	0.090	(A,B)
M(PHI) / ( P )	0.069	1C	0.126	(C,D)
N(PHI) / ( MC/(Rm**2 * Beta) )	0.069	3A	2.311	(A,B,C,D)
M(PHI) / ( MC/(Rm * Beta) )	0.069	1A	0.095	(A,B,C,D)
N(PHI) / ( ML/(Rm**2 * Beta) )	0.069	3B	8.145	(A,B,C,D)
M(PHI) / ( ML/(Rm * Beta) )	0.069	1B	0.046	(A,B,C,D)



Strength Calculation-Active Carbon Filter
Design by A. Azodi
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 114 of 143

Nozzle Calcs.: Gas Out - 6in

Nozl: 13

1:37pm

Apr 8, 2024

Table with 6 columns: Parameter, Value, Figure, Value, Location. Rows include N(x) / ( P/Rm ), M(x) / ( P ), and N(x) / ( MC/(Rm\*\*2 \* Beta) ) for various figures (3C, 4C, 1C1, 2C, 4A, 2A, 4B, 2B).

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction (N./mm²)

Table with 9 columns: Type of Stress, Load, Au, Al, Bu, Bl, Cu, Cl, Du, Dl. Rows include Circ. Memb. P, Long. Memb. P, Tot. Circ. Str., Tot. Long. Str., and Str. Int.

Dimensionless Parameters used : Gamma = 211.10

Dimensionless Loads for Cylindrical Shells at Pad edge:

Table with 5 columns: Curves read for 1979, Beta, Figure, Value, Location. Rows include N(PHI) / ( P/Rm ), M(PHI) / ( P ), and N(PHI) / ( ML/(Rm\*\*2 \* Beta) ) for various figures (4C, 3C, 2C1, 1C, 3A, 1A, 3B).



Strength Calculation-Active Carbon Filter
Design by A. Azodi
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User
FileName : EI027-HRC-VD-ME-CAL-003-01

Nozzle Calcs.: Gas Out - 6in Nozl: 13 1:37pm Apr 8,2024

Table with 6 columns: Parameter, Value, Curve, Value, Curve, Value. Rows include M(PHI) / ( ML/(Rm \* Beta) ), N(x) / ( P/Rm ), M(x) / ( P ), N(x) / ( MC/(Rm\*\*2 \* Beta) ), etc.

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 (N./mm²)

Table with 10 columns: Type of Stress, Load, Au, Al, Bu, Bl, Cu, Cl, Du, D1. Rows include Circ. Memb. P, Long. Memb. P, Shear VC, etc.

WRC 107/537 Stress Summations:

Vessel Stress Summation at Attachment Junction (N./mm²)

Table with 2 columns: Type of, Stress Intensity Values at



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 116 of 143

Nozzle Calcs.: Gas Out - 6in

Nozl: 13

1:37pm

Apr 8,2024

Stress	Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)		1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Circ. Pl (SUS)		-7.0	-7.0	9.9	9.9	3.2	3.2	-0.6	-0.6
Circ. Q (SUS)		-18.9	18.9	28.0	-28.0	44.3	-44.3	-31.6	31.6
Long. Pm (SUS)		0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Long. Pl (SUS)		-1.1	-1.1	3.7	3.7	4.1	4.1	-1.2	-1.2
Long. Q (SUS)		-30.0	30.0	43.2	-43.2	26.1	-26.1	-17.1	17.1
Shear Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)		0.5	0.5	-0.5	-0.5	-0.5	-0.5	0.5	0.5
Shear Q (SUS)		2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Pm (SUS)		1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Pm+Pl (SUS)		5.4	5.4	11.5	11.5	5.4	5.4	1.8	1.8
Pm+Pl+Q (Total)		31.4	30.2	48.1	38.8	49.3	39.7	31.2	33.1

**Vessel Stress Summation Comparison (N/mm²):**

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	1.63	137.90	Passed
Pm+Pl (SUS)	11.52	206.85	Passed
Pm+Pl+Q (TOTAL)	49.30	413.70	Passed

Because only sustained loads were specified, the Pm+Pl+Q allowable was 3 \* Smh.

**WRC 107/537 Stress Summations:**

**Vessel Stress Summation at Reinforcing Pad Edge (N/mm²)**

Type of Stress	Load	Stress Intensity Values at							
		Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)		4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Circ. Pl (SUS)		-24.5	-24.5	38.9	38.9	15.0	15.0	-7.2	-7.2
Circ. Q (SUS)		-26.3	26.3	45.0	-45.0	137.0	-137.0	-90.8	90.8
Long. Pm (SUS)		2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
Long. Pl (SUS)		-10.4	-10.4	18.1	18.1	30.6	30.6	-16.2	-16.2
Long. Q (SUS)		-27.4	27.4	65.2	-65.2	62.4	-62.4	-37.3	37.3
Shear Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)		0.8	0.8	-0.8	-0.8	-0.8	-0.8	0.8	0.8
Shear Q (SUS)		2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Pm (SUS)		4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Pm+Pl (SUS)		20.3	20.3	43.1	43.1	32.7	32.7	14.1	14.1
Pm+Pl+Q (Total)		47.4	19.8	88.7	45.0	156.2	117.8	94.1	88.0



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 117 of 143

Nozzle Calcs.: Gas Out - 6in

Nozl: 13

1:37pm

Apr 8, 2024

**Vessel Stress Summation Comparison (N/mm<sup>2</sup>):**

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	4.22	137.90	Passed
Pm+Pl (SUS)	43.12	206.85	Passed
Pm+Pl+Q (TOTAL)	156.19	413.70	Passed

*Because only sustained loads were specified, the Pm+Pl+Q allowable was 3 \* Smh.*

**PV Elite is a trademark of Intergraph CADWorx & Analysis Solutions, Inc. 2019**



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 118 of 143

Nozzle Calcs.: PG - 1in

Nozl: 14

1:37pm

Apr 8, 2024

Input, Nozzle Desc: PG - 1in

From: 50

Pressure for Reinforcement Calculations	P	0.200	bars
Temperature for Internal Pressure	Temp	85	°C
Design External Pressure	Pext	0.10	bars
Temperature for External Pressure	Tempex	85	°C

Shell Material		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm <sup>2</sup>
Shell Allowable Stress At Ambient	Sva	137.90	N./mm <sup>2</sup>

Inside Diameter of Cylindrical Shell	D	2100.00	mm.
Design Length of Section	L	5749.9990	mm.
Shell Finished (Minimum) Thickness	t	8.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.

Distance from Bottom/Left Tangent 5250.00 mm.

User Entered Minimum Design Metal Temperature -5.00 °C

**Type of Element Connected to the Shell : Nozzle**

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	137.90	N./mm <sup>2</sup>
Allowable Stress At Ambient	Sna	137.90	N./mm <sup>2</sup>

Diameter Basis (for tr calc only)		OD	
Layout Angle		20.00	deg
Diameter		2.2500	in.

Size and Thickness Basis		Actual	
Actual Thickness	tn	11.8745	mm.

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	52.3250	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	6.0000	mm.
Groove weld depth between Nozzle and Vessel Wgnv		6.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.

The Pressure Design option was Design Pressure + static head.

**Nozzle Sketch (may not represent actual weld type/configuration)**



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

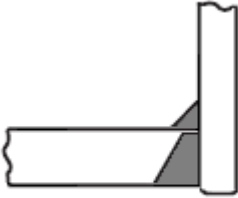
Page 119 of 143

Nozzle Calcs.: PG - 1in

Nozl: 14

1:37pm

Apr 8,2024



**Insert/Set-in Nozzle No Pad, no Inside projection**

Reinforcement CALCULATION, Description: PG - 1in

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

Actual Outside Diameter Used in Calculation 2.250 in.  
Actual Thickness Used in Calculation 0.468 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)  
= (0.2\*1053.0)/(138\*1.0-0.6\*0.2)  
= 0.1528 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 0.0975 and the shell thk. is 8.0000 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)  
= (0.2\*28.575)/(138\*1.0+0.4\*0.2)  
= 0.0041 mm.

Required Nozzle thickness under External Pressure per UG-28 : 0.0698 mm.

**UG-40, Limits of Reinforcement : [Internal Pressure]**

Parallel to Vessel Wall (Diameter Limit)	D1	78.8020	mm.
Parallel to Vessel Wall, opening length	d	39.4010	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	12.5000	mm.

**Note:**

*Taking a UG-36(c)(3)(a) exemption for nozzle: PG - 1in.  
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 = 3.0698 mm.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 120 of 143

Nozzle Calcs.: PG - 1in

Nozl: 14

1:37pm

Apr 8,2024

Wall Thickness per UG16(b),	tr16b = 5.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 = 3.1528 mm.
Wall Thickness	tb1 = max(trb1, tr16b) = 5.5000 mm.
Wall Thickness	tb2 = max(trb2, tr16b) = 5.5000 mm.
Wall Thickness per table UG-45	tb3 = 6.4200 mm.

Determine Nozzle Thickness candidate [tb]:  
= min[ tb3, max( tb1,tb2) ]  
= min[ 6.42, max( 5.5, 5.5 ) ]  
= 5.5000 mm.

Minimum Wall Thickness of Nozzle Necks [tUG-45]:  
= max( ta, tb )  
= max( 3.0698, 5.5 )  
= 5.5000 mm.

Available Nozzle Neck Thickness = 11.8745 mm. --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

**Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B**

Govrn. thk, tg = 8.0, tr = 0.153, c = 3.0 mm., E\* = 1.0  
Thickness Ratio = tr \* (E\*)/(tg - c) = 0.031, 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

Governing MDMT of all the sub-joints of this Junction : -104 °C

Weld Size Calculations, Description: PG - 1in

Intermediate Calc. for nozzle/shell Welds Tmin 5.0000 mm.

**Results Per UW-16.1:**

	Required Thickness	Actual Thickness
Nozzle Weld	3.5000 = 0.7 * tmin.	4.2420 = 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 5.549 bars

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 0.3888 mm.  
The Cut Length for this Nozzle is, Drop + Ho + H + T : 60.7138 mm.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 121 of 143

Nozzle Calcs.: MH2 - 24in

Noz1: 15

1:37pm

Apr 8, 2024

Input, Nozzle Desc: MH2 - 24in

From: 60

Pressure for Reinforcement Calculations	P	0.200	bars
Temperature for Internal Pressure	Temp	85	°C
Design External Pressure	Pext	0.10	bars
Temperature for External Pressure	Tempex	85	°C

Shell Material		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm <sup>2</sup>
Shell Allowable Stress At Ambient	Sva	137.90	N./mm <sup>2</sup>

Inside Diameter of Elliptical Head	D	2100.00	mm.
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	5.5000	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 -5.00 °C

**Type of Element Connected to the Shell : Nozzle**

Material		SA-516	70
Material UNS Number		K02700	
Material Specification/Type		Plate	
Allowable Stress at Temperature	Sn	137.90	N./mm <sup>2</sup>
Allowable Stress At Ambient	Sna	137.90	N./mm <sup>2</sup>

Diameter Basis (for tr calc only)		OD	
Layout Angle		0.00	deg
Diameter		24.0000	in.

Size and Thickness Basis		Actual	
Actual Thickness	tn	8.0000	mm.

Flange Material		SA-105	
Flange Type		Slip on	

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	525.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	6.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	5.5000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.

Pad Material		SA-516	70
Pad Allowable Stress at Temperature	Sp	137.90	N./mm <sup>2</sup>
Pad Allowable Stress At Ambient	Spa	137.90	N./mm <sup>2</sup>
Diameter of Pad along vessel surface	Dp	1000.0000	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	6.0000	mm.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 122 of 143

Nozzle Calcs.: MH2 - 24in

Nozl: 15

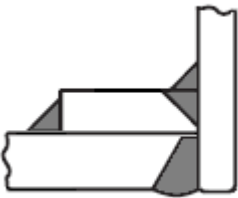
1:37pm

Apr 8,2024

Reinforcing Pad Width	195.2000 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)**



**Insert/Set-in Nozzle With Pad, no Inside projection**

Reinforcement CALCULATION, Description: MH2 - 24in

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	24.000 in.
Actual Thickness Used in Calculation	0.315 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Elliptical Head, Tr [Int. Press]

$$= (P \cdot K_1 \cdot D) / (2 \cdot S_v \cdot E - 0.2 \cdot P) \text{ per UG-37(a)(3)}$$

$$= (0.2 \cdot 0.898 \cdot 2106.0) / (2 \cdot 137.9 \cdot 1.0 - 0.2 \cdot 0.2)$$

$$= 0.1371 \text{ mm.}$$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]

$$= (P \cdot R_o) / (S_n \cdot E + 0.4 \cdot P) \text{ per Appendix 1-1 (a)(1)}$$

$$= (0.2 \cdot 304.8) / (138 \cdot 1.0 + 0.4 \cdot 0.2)$$

$$= 0.0442 \text{ mm.}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.7248 mm.

**UG-40, Limits of Reinforcement : [Internal Pressure]**

Parallel to Vessel Wall (Diameter Limit)	D1	1199.2001 mm.
Parallel to Vessel Wall, opening length	d	599.6000 mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp		6.2500 mm.

**Weld Strength Reduction Factor [fr1]:**

$$= \min( 1, S_n / S_v )$$

$$= \min( 1, 137.9 / 137.9 )$$

$$= 1.000$$

**Weld Strength Reduction Factor [fr2]:**

$$= \min( 1, S_n / S_v )$$

$$= \min( 1, 137.9 / 137.9 )$$



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 123 of 143

Nozzle Calcs.: MH2 - 24in

Nozl: 15

1:37pm

Apr 8, 2024

= 1.000

Weld Strength Reduction Factor [fr4]:

= min( 1, Sp/Sv )

= min( 1, 137.9/137.9 )

= 1.000

Weld Strength Reduction Factor [fr3]:

= min( fr2, fr4 )

= min( 1.0, 1.0 )

= 1.000

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.822	7.495	NA
Area in Shell	A1	14.168	0.000	NA
Area in Nozzle Wall	A2	0.619	0.534	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.360	0.360	NA
Area in Element	A5	18.300	18.300	NA
TOTAL AREA AVAILABLE	Atot	33.448	19.194	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations

90.00 Degs.

The area available without a pad is Insufficient.

The area available with the given pad is Sufficient.

SELECTION OF POSSIBLE REINFORCING PADS:	Diameter	Thickness
Based on given Pad Thickness:	750.4127	8.0000 mm.
Based on given Pad Diameter:	1000.0000	2.2543 mm.
Based on Shell or Nozzle Thickness:	769.6144	5.5000 mm.

Area Required [A]:

= 0.5( d \* tr\*F + 2 \* tn \* tr\*F(1-fr1) ) per UG-37(d)

= 0.5(599.6\*2.5\*1+2\*5.0\*2.5\*1(1-1.0))

= 7.495 cm²

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 )

= 599.6( 1.0 \* 2.5 - 1.0 \* 2.5 ) - 2 \* 5.0

( 1.0 \* 2.5 - 1.0 \* 2.5 ) \* ( 1 - 1.0 )

= 0.000 cm²

Area Available in Nozzle Wall Projecting Outward [A2]:

= ( 2 \* Tlwp ) \* ( tn - trn ) \* fr2

= ( 2 \* 6.25 ) \* ( 5.0 - 0.72 ) \* 1.0

= 0.534 cm²

Area Available in Welds [A41 + A42 + A43]:

= (Wo² - Ar Lost)\*Fr3+((Wi-can/0.707)² - Ar Lost)\*fr2 + Wp²\*fr4

= (0.0 ) \* 1.0 + (0.0 ) \* 1.0 + 152.4² \* 1.0



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 124 of 143

Nozzle Calcs.: MH2 - 24in

Noz1: 15

1:37pm

Apr 8,2024

= 0.360 cm<sup>2</sup>

Area Available in Element, also see UG-37(h) [A5]:

= (min(Dp,DL)-(Nozzle OD))(min(tp,Tlwp,te)) \* fr4 \* 0.75  
= ( 1000.0 - 609.6 )6.25 \* 1.0 \* 0.75  
= 18.300 cm<sup>2</sup>

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

**Nozzle Neck to Flange Weld, Curve: B**

Govern. thk, tg = 8.0, tr = 0.044, c = 3.0 mm., E\* = 1.0  
Thickness Ratio = tr \* (E\*)/(tg - c) = 0.009, 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

**Nozzle Neck to Pad Weld for the Nozzle, Curve: B**

Govern. thk, tg = 8.0, tr = 0.044, c = 3.0 mm., E\* = 1.0  
Thickness Ratio = tr \* (E\*)/(tg - c) = 0.009, 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

**Nozzle Neck to Pad Weld for Reinforcement pad, Curve: B**

Govern. thk, tg = 8.0, tr = 0.044, c = 3.0 mm., E\* = 1.0  
Thickness Ratio = tr \* (E\*)/(tg - c) = 0.009, 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, Curve: B**

Govern. thk, tg = 5.5, tr = 0.137, c = 3.0 mm., E\* = 1.0  
Thickness Ratio = tr \* (E\*)/(tg - c) = 0.055, 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

**Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B**

Govern. thk, tg = 5.5, tr = 0.137, c = 3.0 mm., E\* = 1.0  
Thickness Ratio = tr \* (E\*)/(tg - c) = 0.055, 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

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:**

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -29 °C  
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -104 °C



Strength Calculation-Active Carbon Filter

Design by A. Azodi

Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 125 of 143

Nozzle Calcs.: MH2 - 24in

Nozl: 15

1:37pm

Apr 8, 2024

Flange MDMT with Temp reduction per UCS-66(b)(1)(-c) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = 0.20/19.60 = 0.010

**Note:**

Using the min value from (b)(1)(-b) and (b)(1)(-c) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: MH2 - 24in

Intermediate Calc. for nozzle/shell Welds T<sub>min</sub> 5.0000 mm.  
 Intermediate Calc. for pad/shell Welds T<sub>minPad</sub> 5.0000 mm.

**Results Per UW-16.1:**

	Required Thickness	Actual Thickness
Nozzle Weld	3.5000 = 0.7 * t <sub>min</sub> .	4.2420 = 0.7 * W <sub>o</sub> mm.
Pad Weld	2.5000 = 0.5 * T <sub>minPad</sub>	4.2420 = 0.7 * W <sub>p</sub> mm.

**Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)**

Weld Load [W]:

$$= \max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)$$

$$= \max(0, (7.495 - 0. + 2 * 5.0 * 1.0 * (1.0 * 2.5 - 2.5) ) 138)$$

$$= 10539.18 \text{ Kgf}$$

Note: F is always set to 1.0 throughout the calculation.

Weld Load [W1]:

$$= (A2+A5+A4-(Wi-Can/.707)^2*fr2)*Sv$$

$$= (0.5344 + 18.3 + 0.36 - 0.0 * 1.0) * 138$$

$$= 26990.45 \text{ Kgf}$$

Weld Load [W2]:

$$= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv$$

$$= (0.5344 + 0.0 + 0.36 + (0.25)) * 138$$

$$= 1609.21 \text{ Kgf}$$

Weld Load [W3]:

$$= (A2+A3+A4+A5+(2*tn*t*fr1))*S$$

$$= (0.5344 + 0.0 + 0.36 + 18.3 + (0.25)) * 138$$

$$= 27342.00 \text{ Kgf}$$

**Strength of Connection Elements for Failure Path Analysis**

Shear, Outward Nozzle Weld [Sonw]:

$$= (\pi/2) * D_{lo} * W_o * 0.49 * S_{nw}$$

$$= (3.1416/2.0) * 609.6 * 6.0 * 0.49 * 138$$

$$= 39587. \text{ Kgf}$$

Shear, Pad Element Weld [Spew]:

$$= (\pi/2) * D_P * W_P * 0.49 * S_{EW}$$

$$= (3.1416/2.0) * 1000.0 * 6.0 * 0.49 * 138$$

$$= 64939. \text{ Kgf}$$

Shear, Nozzle Wall [Snw]:

$$= (\pi * (D_{lr} + D_{lo}) / 4) * (Thk - Can) * 0.7 * S_n$$



Strength Calculation-Active Carbon Filter

Design by A. Azodi

Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 126 of 143

Nozzle Calcs.: MH2 - 24in

Nozl: 15

1:37pm

Apr 8,2024

$$= (3.1416 * 302.3) * (8.0 - 3.0) * 0.7 * 138$$

$$= 46740. \text{ Kgf}$$

Tension, Pad Groove Weld [Tpgw]:

$$= (\pi/2) * D_{lo} * W_{gpn} * 0.74 * S_{eg}$$

$$= (3.1416/2) * 609.6 * 6.0 * 0.74 * 138$$

$$= 59784. \text{ Kgf}$$

Tension, Shell Groove Weld [Tngw]:

$$= (\pi/2) * D_{lo} * (W_{gnvi} - C_{as}) * 0.74 * S_{ng}$$

$$= (3.1416/2.0) * 609.6 * (5.5 - 3.0) * 0.74 * 138$$

$$= 24910. \text{ Kgf}$$

Strength of Failure Paths:

$$PATH11 = (SPEW + SNW) = (64939 + 46740) = 111679 \text{ Kgf}$$

$$PATH22 = (Sonw + Tpgw + Tngw + Sinw)$$

$$= (39587 + 59784 + 24910 + 0) = 124280 \text{ Kgf}$$

$$PATH33 = (Spew + Tngw + Sinw)$$

$$= (64939 + 24910 + 0) = 89849 \text{ Kgf}$$

Summary of Failure Path Calculations:

Path 1-1 = 111678 Kgf, must exceed W = 10539 Kgf or W1 = 26990 Kgf  
 Path 2-2 = 124280 Kgf, must exceed W = 10539 Kgf or W2 = 1609 Kgf  
 Path 3-3 = 89848 Kgf, must exceed W = 10539 Kgf or W3 = 27341 Kgf

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 2.793 bars

Note: The MAWP of this junction was limited by the parent Shell/Head.

Nozzle is O.K. for the External Pressure 0.100 bars

The Drop for this Nozzle is : 24.6812 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 555.1813 mm.

Percent Elongation Calculations:

% Elongation per Table UG-79-1 (50\*tnom/Rf\*(1-Rf/Ro)) 1.330 %

PV Elite is a trademark of Intergraph CADWorx & Analysis Solutions, Inc. 2019



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 127 of 143

Nozzle Calcs.: Vent - 2in

Nozl: 16

1:37pm

Apr 8, 2024

Input, Nozzle Desc: Vent - 2in From: 60

Pressure for Reinforcement Calculations	P	0.200	bars
Temperature for Internal Pressure	Temp	85	°C
Design External Pressure	Pext	0.10	bars
Temperature for External Pressure	Tempex	85	°C

Shell Material		SA-516	70
Shell Allowable Stress at Temperature	Sv	137.90	N./mm <sup>2</sup>
Shell Allowable Stress At Ambient	Sva	137.90	N./mm <sup>2</sup>

Inside Diameter of Elliptical Head	D	2100.00	mm.
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	5.5000	mm.
Head Internal Corrosion Allowance	c	3.0000	mm.
Head External Corrosion Allowance	co	0.0000	mm.

Distance from Head Centerline L1 750.0000 mm.

User Entered Minimum Design Metal Temperature -5.00 °C

**Type of Element Connected to the Shell : Nozzle**

Material		SA-106	B
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm <sup>2</sup>
Allowable Stress At Ambient	Sna	117.90	N./mm <sup>2</sup>

Diameter Basis (for tr calc only)		OD	
Layout Angle		200.00	deg
Diameter		2.0000	in.

Size and Thickness Basis		Minimum	
Nominal Thickness	tn	160	

Flange Material		SA-105	
Flange Type		Slip on	

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	800.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	6.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	5.5000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.

Pad Material		SA-516	70
Pad Allowable Stress at Temperature	Sp	137.90	N./mm <sup>2</sup>
Pad Allowable Stress At Ambient	Spa	137.90	N./mm <sup>2</sup>
Diameter of Pad along vessel surface	Dp	160.0000	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	6.0000	mm.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 128 of 143

Nozzle Calcs.: Vent - 2in

Noz1: 16

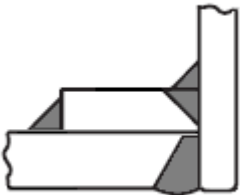
1:37pm

Apr 8, 2024

Reinforcing Pad Width	49.8375 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**

Note : Checking Nozzle in the Meridional direction.

Reinforcement CALCULATION, Description: Vent - 2in

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	2.375 in.
Actual Thickness Used in Calculation	0.301 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Elliptical Head, Tr [Int. Press]  
 $= (P \cdot K_1 \cdot D) / (2 \cdot S_v \cdot E - 0.2 \cdot P)$  per UG-37(a)(3)  
 $= (0.2 \cdot 0.898 \cdot 2106.0) / (2 \cdot 137.9 \cdot 1.0 - 0.2 \cdot 0.2)$   
 $= 0.1371 \text{ mm.}$

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]  
 $= (P \cdot R_o) / (S_n \cdot E + 0.4 \cdot P)$  per Appendix 1-1 (a)(1)  
 $= (0.2 \cdot 30.1625) / (118 \cdot 1.0 + 0.4 \cdot 0.2)$   
 $= 0.0051 \text{ mm.}$

Required Nozzle thickness under External Pressure per UG-28 : 0.2262 mm.

**UG-40, Limits of Reinforcement : [Internal Pressure]**

Parallel to Vessel Wall (Diameter Limit)	D1	114.5179	mm.
Parallel to Vessel Wall, opening length	d	57.2589	mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp		6.2500	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: Vent - 2in.  
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles*



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 129 of 143

Nozzle Calcs.: Vent - 2in

Noz1: 16

1:37pm

Apr 8,2024

*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.*

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

**Nozzle Neck to Flange Weld, Curve: B**

Govrn. thk, tg = 7.645, tr = 0.005, c = 3.0 mm., E\* = 1.0  
Thickness Ratio =  $tr * (E^*) / (tg - c) = 0.001$ , 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

**Nozzle Neck to Pad Weld for the Nozzle, Curve: B**

Govrn. thk, tg = 7.645, tr = 0.005, c = 3.0 mm., E\* = 1.0  
Thickness Ratio =  $tr * (E^*) / (tg - c) = 0.001$ , 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

**Nozzle Neck to Pad Weld for Reinforcement pad, Curve: B**

Govrn. thk, tg = 7.645, tr = 0.005, c = 3.0 mm., E\* = 1.0  
Thickness Ratio =  $tr * (E^*) / (tg - c) = 0.001$ , 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, Curve: B**

Govrn. thk, tg = 5.5, tr = 0.137, c = 3.0 mm., E\* = 1.0  
Thickness Ratio =  $tr * (E^*) / (tg - c) = 0.055$ , 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

**Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B**

Govrn. thk, tg = 5.5, tr = 0.137, c = 3.0 mm., E\* = 1.0  
Thickness Ratio =  $tr * (E^*) / (tg - c) = 0.055$ , 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

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:**

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -29 °C  
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -104 °C  
Flange MDMT with Temp reduction per UCS-66(b)(1)(-c) -104 °C



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 130 of 143

Nozzle Calcs.: Vent - 2in

Noz1: 16

1:37pm

Apr 8,2024

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :  
Design Pressure/Ambient Rating = 0.20/19.60 = 0.010

Note:  
Using the min value from (b)(1)(-b) and (b)(1)(-c) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: Vent - 2in

Intermediate Calc. for nozzle/shell Welds Tmin 4.6454 mm.  
Intermediate Calc. for pad/shell Welds TminPad 5.0000 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	3.2518 = 0.7 * tmin.	4.2420 = 0.7 * Wo mm.
Pad Weld	2.5000 = 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 2.793 bars

Note: The MAWP of this junction was limited by the parent Shell/Head.

Note : Checking Nozzle in the Latitudinal direction.

Reinforcement CALCULATION, Description: Vent - 2in

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

Actual Outside Diameter Used in Calculation 2.375 in.  
Actual Thickness Used in Calculation 0.301 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)  
= (0.2\*0.898\*2106.0)/(2 \*137.9\*1.0-0.2\*0.2)  
= 0.1371 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)  
= (0.2\*30.1625)/(118\*1.0+0.4\*0.2)  
= 0.0051 mm.

Required Nozzle thickness under External Pressure per UG-28 : 0.2262 mm.

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	D1	102.0684	mm.
Parallel to Vessel Wall, opening length	d	51.0342	mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp		6.2500	mm.

Note: The Pad diameter is greater than the Diameter Limit. The excess will not be considered.

Note:



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 131 of 143

Nozzle Calcs.: Vent - 2in

Noz1: 16

1:37pm

Apr 8, 2024

*Taking a UG-36(c)(3)(a) exemption for nozzle: Vent - 2in.  
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 = 3.2262 mm.  
Wall Thickness per UG16(b),      tr16b = 5.5000 mm.  
Wall Thickness, shell/head, internal pressure      trb1 = 3.5293 mm.  
Wall Thickness      tb1 = max(trb1, tr16b) = 5.5000 mm.  
Wall Thickness, shell/head, external pressure      trb2 = 3.3830 mm.  
Wall Thickness      tb2 = max(trb2, tr16b) = 5.5000 mm.  
Wall Thickness per table UG-45      tb3 = 6.4200 mm.

Determine Nozzle Thickness candidate [tb]:  
= min[ tb3, max( tb1, tb2) ]  
= min[ 6.42, max( 5.5, 5.5 ) ]  
= 5.5000 mm.

Minimum Wall Thickness of Nozzle Necks [tUG-45]:  
= max( ta, tb )  
= max( 3.2262, 5.5 )  
= 5.5000 mm.

Available Nozzle Neck Thickness = 7.6454 mm. --> OK

**Stresses on Nozzle due to External and Pressure Loads per the ASME B31.3 Piping Code (see 319.4.4 and 302.3.5):**

Sustained : 15.9, Allowable : 117.9 N./mm<sup>2</sup> Passed  
Expansion : 0.0, Allowable : 278.8 N./mm<sup>2</sup> Passed  
Occasional : 0.1, Allowable : 156.8 N./mm<sup>2</sup> Passed  
Shear : 11.5, Allowable : 82.5 N./mm<sup>2</sup> Passed

*Note : The number of cycles on this nozzle was assumed to be 7000 or less for the determination of the expansion stress allowable.*

Weld Size Calculations, Description: Vent - 2in

Intermediate Calc. for nozzle/shell Welds      Tmin      4.6454 mm.  
Intermediate Calc. for pad/shell Welds      TminPad      5.0000 mm.

**Results Per UW-16.1:**

                                 Required Thickness      Actual Thickness  
Nozzle Weld      3.2518 = 0.7 \* tmin.      4.2420 = 0.7 \* Wo mm.  
Pad Weld      2.5000 = 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      2.793 bars

*Note: The MAWP of this junction was limited by the parent Shell/Head.*



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 132 of 143

Nozzle Calcs.: Vent - 2in

Nozl: 16

1:37pm

Apr 8, 2024

The Drop for this Nozzle is : 13.3164 mm.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 819.3043 mm.

**Warning:**

The equations for nozzle local stress analysis pertain to radial nozzles only and this nozzle is not specified as radial. Please check the specific analysis code for all assumptions and limitations.

Input Echo, WRC107/537 Item 1, Description: Vent - 2in :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Spherical	
Internal Corrosion Allowance	Cas	3.0000	mm.
Vessel Diameter	Dv	3780.000	mm.
Vessel Thickness	Tv	5.500	mm.
Design Temperature	T1	85.0	°C
Vessel Material		SA-516 70	
Vessel UNS Number		K02700	
Vessel Cold S.I. Allowable	Smc	137.90	N./mm <sup>2</sup>
Vessel Hot S.I. Allowable	Smh	137.90	N./mm <sup>2</sup>

**Note:**

Using 2 \* Yield for Discontinuity Stress Allowable (Div 2, 4.1.6.3), Sps. Make sure that material properties at this temperature are not time-dependent for Material: SA-516 70

Attachment Type	Type	Round	
WRC107 Attachment Classification	Holsol	Hollow	
Diameter Basis for Nozzle	Nbasis	OD	
Corrosion Allowance for Nozzle	Can	3.0000	mm.
Nozzle Diameter	Dn	60.325	mm.
Nozzle Thickness	Tn	7.645	mm.
Nozzle Material		SA-106 B	
Nozzle UNS Number		K03006	
Nozzle Cold S.I. Allowable	SNmc	117.90	N./mm <sup>2</sup>
Nozzle Hot S.I. Allowable	SNmh	117.90	N./mm <sup>2</sup>
Thickness of Reinforcing Pad	Tpad	8.000	mm.
Diameter of Reinforcing Pad	Dpad	160.000	mm.
Design Internal Pressure	Dp	0.200	bars
Include Pressure Thrust		No	

**External Forces and Moments in WRC 107/537 Convention:**

Radial Load	(SUS)	P	-51.8	Kgf
Longitudinal Shear	(SUS)	(V1) V1	64.9	Kgf
Circumferential Shear	(SUS)	(Vc) V2	64.9	Kgf
Circumferential Moment	(SUS)	(Mc) M1	-11.0	Kg-m.
Longitudinal Moment	(SUS)	(M1) M2	13.9	Kg-m.
Torsional Moment	(SUS)	Mt	17.5	Kg-m.

Use Interactive Control

No



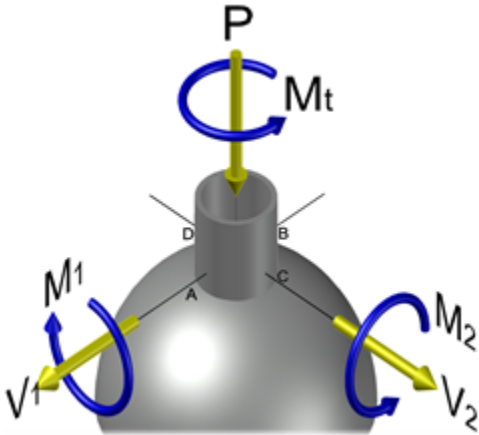
Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User  
FileName : EI027-HRC-VD-ME-CAL-003-01

Nozzle Calcs.: Vent - 2in                      Nozl: 16                      1:37pm                      Apr 8,2024

WRC107 Version	Version	March	1979
Include Pressure Stress Indices per Div. 2			No
Compute Pressure Stress per WRC-368			No
Local Loads applied at end of Nozzle/Attachment			No

*Note:*  
WRC Bulletin 537 provides equations for the dimensionless curves found in bulletin 107. As noted in the foreword to bulletin 537, "537 is equivalent to WRC 107". Where 107 is printed in the results below, "537" can be interchanged with "107".



Stress Attenuation Diameter (for Insert Plates) per WRC 297:  
= NozzleOD + 2 \* 1.65 \* sqrt( Rmean( t - ca ) )  
= 60.325 + 2 \* 1.65 \* sqrt( 1894.25 ( 5.5 - 3.0 ) )  
= 287.417 mm.

WRC 107 Stress Calculation for SUStained loads:

Radial Load		P	-51.8	Kgf
Circumferential Shear	(VC)	V2	64.9	Kgf
Longitudinal Shear	(VL)	V1	64.9	Kgf
Circumferential Moment	(MC)	M1	-11.0	Kg-m.
Longitudinal Moment	(ML)	M2	13.9	Kg-m.
Torsional Moment		MT	17.5	Kg-m.

Dimensionless Parameters: U = 0.21 TAU = 5.99 RHO = 2.26

**Dimensionless Loads for Spherical Shells at Attachment Junction:**

Curves read for 1979	Figure	Value	Location
N(x) * T / P	SP 3	0.12264	(A,B,C,D)
M(x) / P	SP 3	0.09546	(A,B,C,D)
N(x) * T * SQRT(Rm * T) / MC	SM 3	0.37094	(A,B,C,D)
M(x) * SQRT(Rm * T) / MC	SM 3	0.32626	(A,B,C,D)
N(x) * T * SQRT(Rm * T) / ML	SM 3	0.37094	(A,B,C,D)
M(x) * SQRT(Rm * T) / ML	SM 3	0.32626	(A,B,C,D)
N(y) * T / P	SP 3	0.24808	(A,B,C,D)
M(y) / P	SP 3	0.11540	(A,B,C,D)
N(y) * T * SQRT(Rm * T) / MC	SM 3	0.08430	(A,B,C,D)



Strength Calculation-Active Carbon Filter
Design by A. Azodi
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 134 of 143

Nozzle Calcs.: Vent - 2in

Nozl: 16

1:37pm

Apr 8, 2024

M(y) \* SQRT(Rm \* T) / MC SM 3 0.56317 (A,B,C,D)
N(y) \* T \* SQRT(Rm \* T) / ML SM 3 0.08430 (A,B,C,D)
M(y) \* SQRT(Rm \* T) / ML SM 3 0.56317 (A,B,C,D)

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction (N./mm²)

Table with columns: Type of Stress, Load, Au, Al, Bu, Bl, Cu, Cl, Du, D1. Rows include Rad. Memb. P, Rad. Bend. P, Rad. Memb. MC, Rad. Memb. ML, Rad. Bend. ML, Tot. Rad. Str., Tang. Memb. P, Tang. Bend. P, Tang. Memb. MC, Tang. Bend. ML, Tot. Tang. Str., Shear VC, Shear VL, Shear MT, Tot. Shear, Str. Int.

Unitless Prm: U = 1.16 TAU = 0.00 ( 16.72) RHO = 0.00 ( 0.54)

Dimensionless Loads for Spherical Shells at Pad edge:

Table with columns: Curves read for 1979, Figure, Value, Location. Rows include N(x) \* T / P, M(x) / P, N(x) \* T \* SQRT(Rm \* T) / MC, M(x) \* SQRT(Rm \* T) / MC, N(x) \* T \* SQRT(Rm \* T) / ML, M(x) \* SQRT(Rm \* T) / ML, N(y) \* T / P, M(y) / P, N(y) \* T \* SQRT(Rm \* T) / MC, M(y) \* SQRT(Rm \* T) / MC, N(y) \* T \* SQRT(Rm \* T) / ML, M(y) \* SQRT(Rm \* T) / ML.





Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 136 of 143

Nozzle Calcs.: Vent - 2in

Nozl: 16

1:37pm

Apr 8, 2024

Pm+Pl (SUS)	3.3	3.3	5.8	5.8	5.2	5.2	2.9	2.9
Pm+Pl+Q (Total)	25.3	29.3	36.8	29.4	30.7	23.5	19.4	23.6

**Vessel Stress Summation Comparison (N/mm²):**

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	1.80	137.90	Passed
Pm+Pl (SUS)	5.80	206.85	Passed
Pm+Pl+Q (TOTAL)	36.83	413.70	Passed

Because only sustained loads were specified, the Pm+Pl+Q allowable was 3 \* Smh.

**WRC 107/537 Stress Summations:**

**Vessel Stress Summation at Reinforcing Pad Edge (N/mm²)**

Type of Stress	Load	Stress Intensity Values at							
		Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Rad.	Pm (SUS)	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
Rad.	Pl (SUS)	-14.9	-14.9	23.7	23.7	19.7	19.7	-10.9	-10.9
Rad.	Q (SUS)	-84.8	84.8	112.0	-112.0	91.7	-91.7	-64.5	64.5
Long.	Pm (SUS)	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
Long.	Pl (SUS)	-4.4	-4.4	7.1	7.1	5.9	5.9	-3.2	-3.2
Long.	Q (SUS)	-25.9	25.9	34.1	-34.1	27.9	-27.9	-19.7	19.7
Shear	Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear	Pl (SUS)	1.0	1.0	-1.0	-1.0	-1.0	-1.0	1.0	1.0
Shear	Q (SUS)	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Pm (SUS)		7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
Pm+Pl (SUS)		10.6	10.6	31.3	31.3	27.3	27.3	7.9	7.9
Pm+Pl+Q (Total)		92.2	77.7	143.2	80.7	119.0	64.5	68.0	61.4

**Vessel Stress Summation Comparison (N/mm²):**

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	7.57	137.90	Passed
Pm+Pl (SUS)	31.29	206.85	Passed
Pm+Pl+Q (TOTAL)	143.19	413.70	Passed

Because only sustained loads were specified, the Pm+Pl+Q allowable was 3 \* Smh.



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 137 of 143

Nozzle Schedule:

Step: 29 1:37pm Apr 8,2024

Nozzle Schedule:

Description	Nominal or Actual Size	Schd or FVC Type	Flg Type	Nozzle O/Dia in	Wall Thk mm.	Reinforcing Diameter mm.	Pad Thk mm.	Cut Length mm.	Flg Class
Utility - 2in	2.000 in	160	SlipOn	2.375	8.738	...	...	158.43	150
Vent - 2in	2.000 in	160	SlipOn	2.375	8.738	160.00	8.00	819.30	150
PG - 1in	2.250 in	Actual	None	2.250	11.875	...	...	60.71	...
Drain - 3in	3.000 in	80	SlipOn	3.500	7.620	190.00	8.00	106.02	150
Gas In - 6in	6.000 in	80	SlipOn	6.625	10.973	270.00	8.00	2158.00	150
Gas Out - 6in	6.000 in	STD	SlipOn	6.625	7.112	270.00	8.00	161.38	150
MH1 - 24in	24.000 in	Actual	SlipOn	24.000	8.000	1000.00	8.00	303.21	150
MH2 - 24in	24.000 in	Actual	SlipOn	24.000	8.000	1000.00	8.00	555.18	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
Utility - 2	SA-106 B	6.000	6.000	...	...	...
Vent - 2in	SA-106 B	5.500	6.000	6.000	6.000	...
PG - 1in	SA-105	6.000	6.000	...	...	...
Drain - 3in	SA-106 B	5.500	6.000	6.000	6.000	...
Gas In - 6i	SA-106 B	8.000	8.000	6.000	6.000	...
Gas Out - 6	SA-106 B	6.000	6.000	6.000	6.000	...
MH1 - 24in	SA-516 70	6.000	6.000	6.000	6.000	...
MH2 - 24in	SA-516 70	5.500	6.000	6.000	6.000	...

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
Utility - 2in	250.000	255.0	150.00	0.00	Shell #1
Vent - 2in	...	200.0	800.00	0.00	Upper Head
PG - 1in	5250.000	20.0	52.33	0.00	Shell #4
Drain - 3in	...	0.0	100.00	0.00	Lower Head
Gas In - 6in	250.000	105.0	150.00	2000.00	Shell #1
Gas Out - 6in	5150.000	180.0	150.00	0.00	Shell #4



Strength Calculation-Active Carbon Filter

Design by A. Azodi

Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 138 of 143

Nozzle Schedule:

Step: 29 1:37pm Apr 8,2024

MH1 - 24in	850.000	180.0	250.00	0.00	Shell #1
MH2 - 24in	...	0.0	525.00	0.00	Upper Head

Weld Sizes for Slip On/Socket Weld Nozzle Flanges per UW-21:

Nozzle to Flange Fillet Weld Leg dimension [xmin]:

= min( 1.4 \* tn, Hub Thickness )

The Nozzle Wall thicknesses shown below are in the corroded condition. Hubs are considered to be straight.

Description	Nominal or Actual Size	Schd or FVC Type	Flg Type	Noz. O/Dia in	Wall Thk mm.	Hub Thk mm.	Throat Thk mm.	xmin Thk mm.
Utility - 2in	2.000 in	160	SlipOn	2.375	5.738	7.874	5.512	7.874
Vent - 2in	2.000 in	160	SlipOn	2.375	5.738	7.874	5.512	7.874
Drain - 3in	3.000 in	80	SlipOn	3.500	4.620	8.636	4.528	6.468
Gas In - 6in	6.000 in	80	SlipOn	6.625	7.973	10.287	7.201	10.287
Gas Out - 6in	6.000 in	STD	SlipOn	6.625	4.112	10.287	4.030	5.757
MH1 - 24in	24.000 in	Actua	SlipOn	24.000	5.000	23.749	4.900	7.000
MH2 - 24in	24.000 in	Actua	SlipOn	24.000	5.000	23.749	4.900	7.000

PV Elite is a trademark of Intergraph CADWorx & Analysis Solutions, Inc. 2019



Strength Calculation-Active Carbon Filter
Design by A. Azodi
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 139 of 143

MDMT Summary:

Step: 31 1:37pm Apr 8,2024

Minimum Design Metal Temperature Results Summary :

Table with 10 columns: Description, Notes, Curve, Basic MDMT (°C), Reduced MDMT (°C), UG-20(f) MDMT (°C), Thickness ratio, Gov Thk mm., E\*, PWHT reqd. Rows include components like Lower Head, Shell #1-4, Upper Head, Drain, Nozzle Flg, MH1, Gas In, Utility, Gas Out, PG, MH2, Vent, and Nozzle Flg.

Warmest MDMT: -29 -37

Required Minimum Design Metal Temperature -5.0 °C

Warmest Computed Minimum Design Metal Temperature -37.0 °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



Strength Calculation-Active Carbon Filter

Design by A. Azodi

Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 140 of 143

MDMT Summary:

Step: 31

1:37pm

Apr 8, 2024

---

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.

**PV Elite is a trademark of Intergraph CADWorx & Analysis Solutions, Inc. 2019**

---



Strength Calculation-Active Carbon Filter
Design by A. Azodi
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 141 of 143

Vessel Design Summary:

Step: 32

1:37pm

Apr 8,2024

ASME Code, Section VIII Division 1, 2017

Diameter Spec : 2100.000 mm. ID
Vessel Design Length, Tangent to Tangent 5400.00 mm.
Distance of Bottom Tangent above Grade 0.00 mm.
Specified Datum Line Distance 0.00 mm.
Internal Design Temperature 85 °C
Internal Design Pressure 0.200 bars
External Design Temperature 85 °C
External Design Pressure 0.100 bars
Maximum Allowable Working Pressure 2.792 bars
External Max. Allowable Working Pressure 0.172 bars
Hydrostatic Test Pressure 3.629 bars
Required Minimum Design Metal Temperature -5.0 °C
Warmest Computed Minimum Design Metal Temperature -37.0 °C
Wind Design Code UBC
Earthquake Design Code ASCE/SEI 7-16

Materials of Construction:

Table with 8 columns: Component Type, Material, Class, Thickness, UNS #, Normal ized, Impact Tested. Rows include Shell, Head, Nozzle, Re-Pad, Nozzle Flg, Leg Baseplate, Leg Bolting.

- 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 (bars & mm.):

Table with 7 columns: Element Description or Type, Design Pressure + Stat. head, Ext. Press., Element M.A.W.P, Corrosion Allowance, Str. Flg. Gov., In Creep Range. Rows include Lower Head, Shell #1-4, Upper Head.

Liquid Level: 6450.00 mm. Dens.: 0.000 kg./cm³ Sp. Gr.: 0.001



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 142 of 143

Vessel Design Summary:

Step: 32 1:37pm Apr 8,2024

Element Types and Properties:

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
Ellipse	50.0	50.0	8.0	5.5	5.5	5.5	0.85	0.85
Cylinder	1550.0	1500.0	8.0	8.0	5.5	7.0	0.85	0.85
Cylinder	3050.0	1500.0	8.0	8.0	5.5	7.0	0.85	0.85
Cylinder	3850.0	800.0	8.0	8.0	5.5	7.0	0.85	0.85
Cylinder	5350.0	1500.0	8.0	8.0	5.5	7.0	0.85	0.85
Ellipse	5400.0	50.0	8.0	5.5	5.5	5.5	0.85	0.85

Loads for Foundation/Support Design:

Factored Loads:

Total Wind Shear on top of all Legs	2356.	Kgf
Total Earthquake Shear on top of all Legs	5557.	Kgf
Total Wind Moment at top of all Legs	6425.	Kg-m.
Total Earthquake Moment at top of all Legs	18786.	Kg-m.
Max. Wind Shear on one Leg (top & bottom)	868.	Kgf
Max. Earthq. Shear on one Leg (top & bottom)	2048.	Kgf
Max. Wind Moment at base of one Leg	1519.	Kg-m.
Max. Earthquake Moment at base of one Leg	3583.	Kg-m.
Max. Vertical Load (Wt. + Wind) on one Leg	5993.	Kgf
Max. Vertical Load (Wt. + Eq.) on one Leg	11386.	Kgf

Un-Factored Loads:

Total Earthquake Shear on top of all Legs	7782.	Kgf
Total Wind Moment at top of all Legs	6425.	Kg-m.
Total Earthquake Moment at top of all Legs	26311.	Kg-m.
Max. Wind Shear on one Leg (top & bottom)	868.	Kgf
Max. Earthq. Shear on one Leg (top & bottom)	2868.	Kgf
Max. Wind Moment at base of one Leg	1519.	Kg-m.
Max. Earthquake Moment at base of one Leg	5019.	Kg-m.
Max. Vertical Load (Wt. + Wind) on one Leg	5993.	Kgf
Max. Vertical Load (Wt. + Eq.) on one Leg	15947.	Kgf

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.

Local Stress Analysis Results:

Description	Analysis Type	Max Stress Ratio	Pass Fail
Lift Lug	WRC-107/537	0.816	Passed
LEGS	WRC-107/537	0.870	Passed
Drain - 3in	WRC-107/537	0.491	Passed
Gas In - 6in	WRC-107/537	0.378	Passed



Strength Calculation-Active Carbon Filter  
Design by A. Azodi  
Rev.01

PV Elite 2019 SP1 Licensee: SPLM Licensed User

FileName : EI027-HRC-VD-ME-CAL-003-01

Page 143 of 143

Vessel Design Summary: Step: 32 1:37pm Apr 8,2024

Gas Out - 6in	WRC-107/537	0.378	Passed
Vent - 2in	WRC-107/537	0.346	Passed

**Weights:**

Fabricated - Bare W/O Removable Internals	4811.0 kg.
Shop Test - Fabricated + Water ( Full )	25929.9 kg.
Shipping - Fab. + Rem. Intls.+ Shipping App.	4811.0 kg.
Erected - Fab. + Rem. Intls.+ Insul. (etc)	4811.0 kg.
Empty - Fab. + Intls. + Details + Wghts.	12942.0 kg.
Operating - Empty + Operating Liquid (No CA)	12967.3 kg.
Field Test - Empty Weight + Water (Full)	26044.7 kg.

PV Elite is a trademark of Intergraph CADWorx & Analysis Solutions, Inc. 2019