Design summary

Inside diameter	**1000 mm**	Calculated MAWP (corroded)	**9.34 barg**
Length, TL–TL	**1800 mm**	Nameplate MAWP	**3.5 barg**
Internal design pressure	**3.5 barg**	Hydrotest, UG-99(b)	**4.55 barg**
External design pressure	**0.01 barg**	Corrosion allowance	**0 mm**
Design temperature	**150 °C**	Joint efficiency, E	**0.85 spot RT**
MDMT	**5 °C**	Wind / seismic	**ASCE 7-16**

Materials of construction

Component	Material	UNS	Thk. mm	S at 150 °C, MPa	Impact test
Shell	SA-240 304/304L	S30403	4.0	138	Exempt UHA-51(d)
Heads, 2:1 SE	SA-240 304/304L	S30403	4.0 min	138	Exempt UHA-51(d)
Nozzle necks	SA-312 TP304/304L	S30403	SCH 80S	138	Exempt
Flanges	SA-182 F304/304L	S30403	B16.5	Group 2.3	Exempt
Support lugs	SA-516 Gr. 60	K02100	12.0	118	UCS-66 curve B
Anchor bolts	SA-193 B7	G41400	M16	172	–

Element pressures and MAWP

Element	Design P, barg	Static head, barg	tr, mm	t provided, mm	MAWP, barg	MAP new & cold, barg
Top head	3.50	0.00	1.49	4.00	9.38	9.38
Shell	**3.50**	**0.12**	**1.50**	**4.00**	**9.34**	**9.34**
Bottom head	3.50	0.14	1.50	4.00	9.38	9.38

Static head at HHL 1350 mm, ρ = 880 kg/m³. Shell governs the element MAWP.

Nozzle flange ratings at 150 °C, ASME B16.5 Group 2.3

Marks	Size	Class	Rating, barg	Design + head, barg	Margin
P1 P2 P3 S1 S2	1½″	300	31.4	3.64	8.6 ×
P4	3″	300	31.4	3.64	8.6 ×
K1A K1B K2	1″	300	31.4	3.64	8.6 ×
S3 M1	**2″ / 10″**	**150**	**12.0**	**3.64**	**3.3 ×**

Result: all elements and flanges satisfy ASME VIII-1 at 3.5 barg and 150 °C. Calculated MAWP 9.34 barg, shell governs; nameplate MAWP set to design.

Shell, cylindrical, UG-27(c)(1)

Required thickness, circumferential stress

$$t_r = P \cdot R / (S \cdot E - 0.6 \cdot P)$$
$$= 0.35 \times 500 / (138 \times 0.85 - 0.6 \times 0.35)$$
$$= 175.0 / 117.09 = 1.49 \text{ mm} \le 4.00 \text{ mm provided}$$ OK

Maximum allowable working pressure

$$MAWP = S \cdot E \cdot t / (R + 0.6 \cdot t)$$
$$= 138 \times 0.85 \times 4.0 / (500 + 2.4)$$
$$= 0.934 \text{ MPa} = 9.34 \text{ barg} \ge 3.5 \text{ barg}$$ OK

Actual stress at design pressure

$\sigma = P \cdot (R + 0.6 \cdot t) / (E \cdot t) = 0.35 \times 502.4 / (0.85 \times 4.0) = 51.7 \text{ MPa} \le S = 138 \text{ MPa}$ OK

Heads, 2:1 ellipsoidal, Appendix 1-4(c)

Required thickness, K = 1.0 for 2:1

$$t_r = P \cdot D \cdot K / (2 \cdot S \cdot E - 0.2 \cdot P)$$
$$= 0.35 \times 1000 \times 1.0 / (2 \times 138 \times 0.85 - 0.07)$$
$$= 350.0 / 234.53 = 1.49 \text{ mm} \le 4.00 \text{ mm after forming}$$ OK

Maximum allowable working pressure

$$MAWP = 2 \cdot S \cdot E \cdot t / (K \cdot D + 0.2 \cdot t) = 2 \times 138 \times 0.85 \times 4.0 / (1000 + 0.8)$$
$$= 0.938 \text{ MPa} = 9.38 \text{ barg}$$ OK

Nozzles, UG-45 and UG-37

Mark	Size, sch.	tn, mm	UG-45 tr, mm	Reinforcement	Status
P1 P2 P3 S1 S2	1½″ 80S	5.08	2.18	UG-36(c)(3) exempt	OK
P4	3″ 80S	7.62	2.55	UG-36(c)(3) exempt	OK
S3	2″ 80S	5.54	2.48	UG-36(c)(3) exempt	OK
K1A K1B K2	1″ 80S	4.55	1.97	UG-36(c)(3) exempt	OK
M1	10″ 10S	4.19	1.70	A avail ≥ A req	OK

Hydrostatic test and weights

Shop test pressure, UG-99(b)

$$P_t = 1.3 \times MAWP \times LSR$$
$$= 1.3 \times 3.5 \times (138 / 138)$$
$$= 4.55 \text{ barg at top, vertical}$$ OK

Fabricated (empty)	**450 kg**
Erected, insulated	**485 kg**
Operating, liquid to HHL	**1,535 kg**
Hydrotest, shop	**2,130 kg**
Wind shear / moment	**150 kgf · 100 kg·m**
Seismic shear / moment	**1,050 kgf · 250 kg·m**

Supports

Four type 2B lugs on 6 mm pads, M16 SA-193 B7 anchors on Ø1508 PCD. Governing case: operating weight with seismic overturning. Lug gusset and base stresses within allowables; local shell stress at the pad within 1.5 S.

All checks satisfied. No warnings or errors.