

OWNER

Flange, Gasket and Bolting, and Pressure-Temperature Rating Checks

Calculation



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1. OBJECTIVE

This calculation checks the pressure-temperature rating of every class of flanged and valved component in the station piping against its design condition, and sets the shell, seat and system test pressures. It then checks the bolt loads of every flange size and class in the piping by the method of ASME Section VIII Division 1 Mandatory Appendix 2, selects the gaskets and bolting, and issues the bolt torque table for construction. It closes with the pressure rating of the class T1 instrument and analyzer tubing.

2. METHODOLOGY

Flange and valve ratings were taken from ASME B16.5 Table 2-1.1 (Group 1.1: A105N, A216 WCB, A350 LF2, A352 LCC) and Table 2-2.1 (Group 2.1: dual-certified 304/304L). Ratings between the tabulated temperatures were interpolated linearly, as B16.5 permits. Class 800 socket-weld valves carry the ASME B16.34 intermediate rating, interpolated by class number between Classes 600 and 900. Each system's design pressure was compared with the rating at its coincident temperature.

ASME B31.8 accepts B16.5 flanges at their ratings without calculation, but B16.5 does not address the gasket and bolting combination. TORUS therefore checked every flange size and class in the piping model by Appendix 2. The check confirms that the bolting can seat the selected gasket (W_{m2}) and hold it at design pressure (W_{m1}), with the required bolt area A_m compared with the actual root area A_b . The bolt stress at the hydrostatic test pressure was also calculated. Assembly bolt loads follow ASME PCC-1, with a target bolt stress and the torque from the nut factor.

Tubing was checked by the ASME B31.8 design formula, which governs the station, and by the ASME B31.3 304.1.2 form for comparison. The lower allowable pressure governs.

3. DESIGN INPUTS

The inputs in Table 3-1 govern the calculation.

Table 3-1: Design Inputs

Input	Value	Source
Class A6 design pressure	1,440 psig	GEN-DB-001
Class A6 design temperature, above grade; maximum operating temperature	-20 to 150 °F; 120 °F (case C4)	GEN-DB-001
Line 1022, heater outlet, coincident condition	1,360 psig at 200 °F	GEN-RPT-002
H-101 coil design	1,440 psig at 250 °F	MEC-DS-003

Input	Value	Source
Classes A1 and D1	285 psig at -20 to 100 °F	PIP-SPC-001
Class S1, dual-certified 304/304L	275 psig at -150 to 100 °F	PIP-SPC-001
Flanges, Classes 600 and 900	ASTM A105N, weld neck, raised face	PIP-SPC-001
Gasket, Classes 600 and 900	Spiral-wound, 316 winding, flexible graphite filler, inner and outer rings; $m = 3.0$, $y = 10,000$ psi	ASME B16.20; ASME VIII-1 Table 2-5.1
Gasket, Class 150	Flexible graphite laminate with 316 tanged insert, 1/16 in; $m = 2.0$, $y = 2,500$ psi	ASME B16.21; typical, HOLD H-15
Bolting, carbon steel classes	ASTM A193 B7 studs, two A194 2H nuts, PTFE coated; $S_a = S_b = 25,000$ psi, yield 105,000 psi	ASME II-D
Bolting, class S1	ASTM A193 B8M Class 2 studs, two A194 8M nuts, nickel anti-seize; $S_b = 20,000$ psi, yield 95,000 psi	ASME II-D; Assumption 4
Assembly target bolt stress on tensile stress area	50,000 psi (B7, 48 % of yield); 40,000 psi (B8M Class 2, 42 % of yield)	ASME PCC-1
Nut factor K	0.12 PTFE coated; 0.16 moly lubricated; 0.18 nickel anti-seize on stainless	Typical, HOLD H-15
Maximum seating stress, spiral-wound with inner ring	30,000 psi	Typical, HOLD H-15
Class 900 NPS 12 flange	OD 24.00 in, 20 studs 1-3/8 in on 21.00 in bolt circle, stud length 11.00 in	ASME B16.5; Assumption 5
T1 tubing	ASTM A269 TP316 SMLS; SMYS 30,000 psi; B31.3 allowable 20,000 psi	ASTM A269; ASME B31.3

4. ASSUMPTIONS

1. The nut factors and the maximum seating stress of the spiral-wound gasket are typical values. *Verification required against the coating and gasket suppliers' data (HOLD H-15).*
2. The flexible graphite gasket factors $m = 2.0$ and $y = 2,500$ psi are typical manufacturer values; Table 2-5.1 does not list this gasket type. *Verification required (HOLD H-15).*
3. Valve soft seats are rated for at least 200 °F, so they do not limit line 1022. *Verification required (HOLD H-15).*
4. The B8M Class 2 allowable of 20,000 psi is a conservative value for studs of 3/4 in and smaller. *Verification required against ASME II-D.*
5. The Class 900 NPS 12 stud length is from the B16.5 tables. *Verification required before purchase.*
6. The insulating joints IJ-101 and IJ-102 are rated by their manufacturer for 1,440 psig at -20 to 150 °F and tested to 2,160 psig (MEC-DS-008). They are butt-welded and not rated by B16.5.

7. Tube fitting ratings are typical for two-ferrule 316 fittings. *Verification required against the fitting manufacturer's data (HOLD H-15).*

5. REFERENCES

1. ASME B16.5-2020, Pipe Flanges and Flanged Fittings: Section 2 ratings and system hydrostatic testing, Tables 2-1.1 and 2-2.1.
2. ASME B16.34-2020, Valves: Flanged, Threaded, and Welding End, intermediate rating.
3. API Specification 6D, 25th Edition (2021), Pipeline and Piping Valves, shell and seat tests.
4. ASME Boiler and Pressure Vessel Code, Section VIII Division 1 (2023), Mandatory Appendix 2 and Tables 2-5.1 and 2-5.2; Section II Part D (2023).
5. ASME B16.20-2017, Metallic Gaskets for Pipe Flanges; ASME B16.21-2021, Nonmetallic Flat Gaskets for Pipe Flanges.
6. ASME PCC-1-2022, Pressure Boundary Bolted Flange Joint Assembly.
7. ASTM A193, A194, A269.
8. ASME B31.8-2022, 831.2 flanges, 841.1.1 design formula; ASME B31.3-2022, 304.1.2 (comparison only); 49 CFR 192.201.
9. GEN-DB-001, Basis of Design; GEN-RPT-002, Design Decisions Register.
10. MEC-CAL-001, Pipe Wall Thickness, Hoop Stress and Buried Lateral External Loads; MEC-CAL-003, Hydrostatic Test Calculation; PRO-CAL-007, Pressure Relief Devices and Tank Venting.
11. PIP-SPC-001, Piping Material Specification; SPC-SPC-011, Hydrostatic Testing, Dewatering and Drying; SPC-SPC-014, Instrumentation Installation, Tubing and Calibration.
12. MEC-DS-003, H-101 Indirect-Fired Line Heater; MEC-DS-008, Monolithic Insulating Joints IJ-101 and IJ-102.

6. CALCULATION

6.1. PRESSURE-TEMPERATURE RATINGS

Table 6-1 gives the Group 1.1 ratings at the temperatures that matter for this station. The Class 600 rating falls from 1,480 psig at 100 °F to 1,360 psig at 200 °F. At the 150 °F design temperature:

ASME B16.5 Table 2-1.1, linear interpolation

$$P_{150} = P_{100} + (P_{200} - P_{100}) \frac{150 - 100}{200 - 100} = 1480 + (1360 - 1480)(0.5) = 1,420 \text{ psig}$$

The Class 600 rating equals the 1,440 psig MAOP at:



$$T = 100 + \frac{1480 - 1440}{1480 - 1360} \times 100 = 133 \text{ } ^\circ\text{F}$$

Table 6-1: ASME B16.5 Group 1.1 Pressure-Temperature Ratings

Class	-20 °F	100 °F	120 °F	133 °F	150 °F	200 °F	250 °F	300 °F
150	285	285	280	277	272	260	245	230
600	1,480	1,480	1,456	1,440	1,420	1,360	1,335	1,310
800 (B16.34 intermediate)	1,973	1,973	1,941	1,919	1,892	1,810	1,778	1,747
900	2,220	2,220	2,183	2,159	2,128	2,035	2,000	1,965

Class S1 uses Group 2.1 components, rated as in Table 6-2. Austenitic stainless steel needs no rating reduction below -20 °F, so the -20 °F rating applies at the -150 °F minimum design temperature. The dual-certified 304/304L material meets the strength requirements of 304 and carries the Group 2.1 rating.

Table 6-2: ASME B16.5 Group 2.1 Class 150 Ratings, Class S1

Class	-150 °F	-20 °F	100 °F	150 °F	200 °F	300 °F
150, Group 2.1	275	275	275	255	235	205

6.2. RATING CHECK OF EACH COMPONENT CLASS

Table 6-3 compares each system's design condition with the rating at its coincident temperature.

Table 6-3: Rating Check of Each Component Class

System	Class	Design pressure, psig	Temperature, °F	Rating, psig	Ratio	Result
A6 piping, maximum operating temperature (case C4)	600	1,440	120	1,456	0.989	Within rating
A6 piping, design point	600	1,440	133	1,440	1.000	Within rating
A6 piping, basis value at 150 °F	600	1,440	150	1,420	1.014	Exceeds rating
A6 piping, coincident condition at 150 °F	600	1,420	150	1,420	1.000	Within rating
Line 1022, heater outlet at bath trip	600	1,360	200	1,360	1.000	Within rating
Line 1022 at maximum supply pressure	600	1,150	200	1,360	0.846	Within rating
H-101 coil nozzles, if Class 600	600	1,440	250	1,335	1.079	Exceeds rating



System	Class	Design pressure, psig	Temperature, °F	Rating, psig	Ratio	Result
H-101 coil nozzles, Class 900	900	1,440	250	2,000	0.720	Within rating
A1 fuel gas and D1 drains	150	285	100	285	1.000	Within rating
A1 and D1 at 150 °F	150	272	150	272	0.998	Within rating
S1 vent and blowdown at -150 °F	150, Group 2.1	275	-150	275	1.000	Within rating
S1 at 150 °F	150, Group 2.1	255	150	255	1.000	Within rating
Class 800 socket-weld valves in A6	800	1,440	150	1,892	0.761	Within rating

The flanged components of class A6 limit the station to 1,440 psig from -20 to 133 °F and 1,420 psig at 150 °F. The basis value of 1,440 psig at 150 °F exceeds the Class 600 rating by 1.4 %, so the coincident condition was adopted as the class A6 design point. The pipe and fittings are not affected: they are designed at 1,440 psig with no temperature derating up to 250 °F (MEC-CAL-001). Two alternatives were considered. Lowering the design temperature to 130 °F was rejected because blocked-in piping in full sun reaches 150 °F (PRO-CAL-007). Raising the flanges to Class 900 was rejected because the maximum operating temperature of 120 °F is already within the 1,440 psig envelope, and the 150 °F case arises only in blocked-in piping protected by relief devices. Any short excursion above the rating while a device relieves is within the accumulation that 49 CFR 192.201 permits.

The other results in Table 6-3 set these requirements:

- Line 1022, between the heater and the control valves, carries a coincident rating of 1,360 psig at 200 °F, the bath trip temperature. The heater controls and the bath high-high trip keep the gas at or below 200 °F.
- The H-101 coil nozzles see 1,440 psig at 250 °F, above the Class 600 rating of 1,335 psig. They are Class 900, with Class 900 weld neck companion flanges on lines 1020 and 1022.
- API 6D ball valves, the check valve CKV-171 and the ASME B16.34 globe control valves are Group 1.1 Class 600 bodies and carry the same rating as the flanges.
- Class 800 socket-weld valves in class A6 run at 76 % of their rating.
- A1 and D1 components are at their rating at 100 °F; their design is 285 psig at 100 °F and 272 psig at 150 °F. The PSV-161 set pressure of 250 psig is below both.
- S1 components are rated 275 psig at -150 °F, which covers the auto-refrigeration of blowdown and relief discharge downstream of the restriction orifices and relief valves.

6.3. TEST PRESSURES

Table 6-4 gives the shell and seat test pressures of each class, at 1.5 and 1.1 times the 100 °F rating, and the station hydrotest window.

Table 6-4: Shell and Seat Test Pressures

Class	Rating at 100 °F, psig	Shell test, psig	High-pressure seat test, psig	Station hydrotest window, psig
150	285	450	315	430 to 450 (A1, D1)
600	1,480	2,225	1,630	2,160 to 2,220
900	2,220	3,350	2,445	Vendor coil test
150, Group 2.1	275	425	305	415 to 425 (S1)

Note 1: Shell tests are rounded up to the next 25 psi and seat tests to the next 5 psi, per API 6D and ASME B16.34.

The class A6 system test is 2,160 psig minimum at the high point. The Class 600 flange limit is taken as $1.5 \times 1,480 = 2,220$ psig at any flange. B16.5 would allow this to be rounded up to 2,225 psig; the project keeps 2,220 psig, which leaves 60 psi of test window and is checked at the low point in MEC-CAL-003. The system test exceeds the 1,630 psig seat test of the ball valves, so every ball valve shall be half open during the test and closed seats shall never be used as test boundaries. Test boundaries are blinds or test heads.

6.4. APPENDIX 2 BOLT LOADS

For the governing NPS 12 Class 600 joint, the spiral-wound sealing element is 12.88 in ID by 15.00 in OD. Its effective width and reaction diameter are:

ASME VIII-1 Appendix 2, Table 2-5.2

$$N = \frac{15.00 - 12.88}{2} = 1.060 \text{ in}, \quad b_0 = \frac{N}{2} = 0.530 \text{ in} > 0.25 \text{ in}$$

$$b = 0.5\sqrt{b_0} = 0.5\sqrt{0.530} = 0.364 \text{ in}, \quad G = 15.00 - 2b = 14.272 \text{ in}$$

The operating bolt load is the hydrostatic end force plus the gasket compression load:

ASME VIII-1 Appendix 2-5

$$W_{m1} = 0.785 G^2 P + 2 b \pi G m P = 230,251 + 141,012 = 371,263 \text{ lb}$$

and the gasket seating load is:

$$W_{m2} = \pi b G y = \pi(0.364)(14.272)(10,000) = 163,208 \text{ lb}$$

The required bolt area is the larger of the two loads divided by the allowable bolt stress:

ASME VIII-1 Appendix 2-5

$$A_m = \max \left(\frac{W_{m1}}{S_b}, \frac{W_{m2}}{S_a} \right) = \frac{371,263}{25,000} = 14.851 \text{ in}^2 \leq A_b = 20 \times 0.929 = 18.578 \text{ in}^2$$



Table 6-5 gives the loads for every flange size and class in the piping model, and Table 6-6 the area ratio and the bolt stress at the hydrostatic test pressure. The carbon steel Class 150 rows use the spiral-wound gasket to show why it was not selected.

Table 6-5: Appendix 2 Bolt Loads at Design Pressure

Class	NPS	Flanges	G , in	W_{m1} , lb	W_{m2} , lb	A_m , in ²	A_b , in ²
150 (A1, D1)	1	4	1.565	1,872	7,744	0.310	0.503
150 (A1, D1)	2	11	3.065	4,695	15,166	0.607	0.807
150 (A1, D1)	3	8	4.250	9,749	33,379	1.335	0.807
150 (A1, D1)	4	2	5.348	14,036	44,654	1.786	1.614
150 (S1)	3/4	1	1.216	1,315	2,263	0.113	0.503
150 (S1)	1	3	1.489	1,793	2,987	0.149	0.503
150 (S1)	2	5	2.997	5,165	7,333	0.367	0.807
150 (S1)	3	1	4.305	9,170	11,749	0.587	0.807
150 (S1)	4	2	5.454	13,355	15,755	0.788	1.614
150 (S1)	8	1	9.808	34,530	31,284	1.727	2.415
600 (A6)	1-1/2	8	2.315	19,725	15,818	0.789	1.208
600 (A6)	2	49	3.065	23,722	15,166	0.949	1.614
600 (A6)	8	7	9.936	203,807	106,717	8.152	8.731
600 (A6)	10	26	12.066	276,549	129,594	11.062	14.862
600 (A6)	12	42	14.272	371,263	163,208	14.851	18.578
900 (H-101)	12	2	14.272	371,263	163,208	14.851	23.098

Note 1: Flanges are counted in the piping model; vendor skid internals and equipment nozzles are excluded. Class S1 rows use the flexible graphite gasket and B8M Class 2 bolting.

Table 6-6: Bolt Area Ratio and Bolt Stress at Hydrostatic Test

Class	NPS	A_b/A_m	Result at design	Test pressure, psig	Bolt stress at test, psi	Share of bolt yield, %
150 (A1, D1)	1	1.62	Adequate	450	5,879	5.6
150 (A1, D1)	2	1.33	Adequate	450	9,188	8.8
150 (A1, D1)	3	0.60	Not adequate, gasket seating	450	19,079	18.2
150 (A1, D1)	4	0.90	Not adequate, gasket seating	450	13,734	13.1
150 (S1)	3/4	4.44	Adequate	425	4,042	4.3
150 (S1)	1	3.37	Adequate	425	5,511	5.8



Class	NPS	A_b/A_m	Result at design	Test pressure, psig	Bolt stress at test, psi	Share of bolt yield, %
150 (S1)	2	2.20	Adequate	425	9,895	10.4
150 (S1)	3	1.37	Adequate	425	17,566	18.5
150 (S1)	4	2.05	Adequate	425	12,791	13.5
150 (S1)	8	1.40	Adequate	425	22,095	23.3
600 (A6)	1-1/2	1.53	Adequate	2,220	25,182	24.0
600 (A6)	2	1.70	Adequate	2,220	22,665	21.6
600 (A6)	8	1.07	Adequate	2,220	35,986	34.3
600 (A6)	10	1.34	Adequate	2,220	28,686	27.3
600 (A6)	12	1.25	Adequate	2,220	30,809	29.3
900 (H-101)	12	1.56	Adequate	3,350	37,393	35.6

Note 1: Bolt stress at test is W_{m1} at the test pressure divided by A_b . The Class 900 row uses the Class 900 shell test pressure.

Every Class 600, Class 900 and S1 joint passes. The tightest is NPS 8 Class 600, with 7 % margin. The bolt stress at test stays below 36 % of yield in every joint.

The carbon steel Class 150 joints at NPS 3 and 4 fail with a spiral-wound gasket, because Class 150 bolting cannot develop the 10,000 psi seating stress on a full-width winding. Table 6-7 checks the same joints with the flexible graphite gasket, with contact limited to the raised face. All pass, and the assembly gasket stress exceeds the seating stress y at every size.

Table 6-7: Class 150 Carbon Steel Joints with Flexible Graphite Gasket

NPS	Contact ID / OD, in	G , in	W_{m1} , lb	W_{m2} , lb	A_b/A_m	Gasket stress at assembly, psi
1	0.957 / 2.00	1.489	1,858	2,987	4.21	11,716
2	1.939 / 3.62	2.972	5,426	7,565	2.67	6,159
3	3.068 / 5.00	4.305	9,504	11,749	1.72	3,692
4	4.026 / 6.19	5.454	13,840	15,755	2.56	5,206

Every flange joint passes Appendix 2 with the gaskets and bolting of Table 6-8. All Class 150 joints, carbon steel and stainless, use the flexible graphite gasket with 316 tanged insert.

6.5. GASKET AND BOLTING SELECTION

Table 6-8 gives the selection and the reason for each choice.

Table 6-8: Gasket and Bolting Selection

Service	Gasket	Bolting	Reason
A6 Class 600; H-101 coil nozzles Class 900	ASME B16.20 spiral-wound, 316 winding, flexible graphite filler, carbon steel outer ring, 316 inner ring on all sizes	ASTM A193 B7, two A194 2H nuts, PTFE coated	The inner ring prevents radial buckling and over-compression of the winding. It matters most at NPS 2, where the assembly gasket stress of 29,804 psi is close to the 30,000 psi maximum
A1 and D1 Class 150	ASME B16.21 flexible graphite laminate with 316 tanged insert, 1/16 in, inside the bolt circle, fire tested	ASTM A193 B7, two A194 2H nuts, PTFE coated	Spiral-wound cannot be seated with Class 150 bolting at NPS 3 and 4. One gasket type for all Class 150 joints avoids mix-ups in the field
S1 Class 150, 304/304L	As A1 and D1, leachable chloride 50 ppm maximum	ASTM A193 B8M Class 2, two A194 8M nuts, nickel anti-seize	Graphite and the 316 insert remain serviceable at -150 °F. Low chloride protects the stainless flange faces. Stainless bolting keeps its toughness at -150 °F, and anti-seize prevents galling
Tie-in at the receiving pipeline operator's tap valve	Per the operator's standard; spiral-wound as class A6 by default	As class A6	Operator's interface (HOLD H-04)

Note 1: The station has no insulating flange kits; isolation is by the monolithic insulating joints IJ-101 and IJ-102. Any kit the cathodic protection design adds shall be Class 600 with a glass-reinforced epoxy retainer and full sleeves and washers.

6.6. BOLT TORQUE

For each joint, the preload per stud and the torque are:

ASME PCC-1

$$F = S_{target} A_s = 50,000 \times 1.000 = 50,000 \text{ lb}, \quad T = \frac{K F d}{12} = \frac{0.12 \times 50,000 \times 1.25}{12} = 625 \text{ ft} \cdot \text{lb}$$

for the NPS 12 Class 600 joint with 1-1/4 in PTFE-coated studs. Table 6-9 gives the torque for every joint. The total preload exceeds W_{m1} at design pressure for every Class 600 and 900 joint, and also at the 2,220 psig test pressure.

Table 6-9: Bolt Torque for Construction

Class	NPS	Studs, number x diameter x length, in	Preload per stud, lb	Torque, PTFE-coated, ft-lb	Torque, moly-lubricated, ft-lb	Gasket stress, psi
150 (A1, D1)	1	4 x 1/2 x 2.50	7,095	35	47	11,716
150 (A1, D1)	2	4 x 5/8 x 3.25	11,300	71	94	6,159



Class	NPS	Studs, number x diameter x length, in	Preload per stud, lb	Torque, PTFE-coated, ft-lb	Torque, moly-lubricated, ft-lb	Gasket stress, psi
150 (A1, D1)	3	4 x 5/8 x 3.50	11,300	71	94	3,692
150 (A1, D1)	4	8 x 5/8 x 3.50	11,300	71	94	5,206
150 (S1)	3/4	4 x 1/2 x 2.50	5,676	43 (anti-seize)	n/a	12,538
150 (S1)	1	4 x 1/2 x 2.50	5,676	43 (anti-seize)	n/a	9,373
150 (S1)	2	4 x 5/8 x 3.25	9,040	85 (anti-seize)	n/a	5,213
150 (S1)	3	4 x 5/8 x 3.50	9,040	85 (anti-seize)	n/a	2,954
150 (S1)	4	8 x 5/8 x 3.50	9,040	85 (anti-seize)	n/a	4,165
150 (S1)	8	8 x 3/4 x 4.25	13,380	151 (anti-seize)	n/a	2,776
600 (A6)	1-1/2	4 x 3/4 x 4.25	16,725	125	167	21,146
600 (A6)	2	8 x 5/8 x 4.25	11,300	71	94	29,804
600 (A6)	8	12 x 1-1/8 x 7.50	39,525	445	593	16,672
600 (A6)	10	16 x 1-1/4 x 8.50	50,000	625	833	23,051
600 (A6)	12	20 x 1-1/4 x 8.75	50,000	625	833	21,542
900 (H-101)	12	20 x 1-3/8 x 11.00	61,635	847	1,130	26,555

Note 1: Gasket stress is on the spiral-wound element for Classes 600 and 900 and on the raised-face contact of the flexible graphite gasket for Class 150.

Note 2: S1 torque uses $K = 0.18$ with nickel anti-seize and a 40,000 psi target; moly lubricant is not used on stainless bolting.

The torque values apply with these construction requirements:

1. Torque values assume new PTFE-coated studs and nuts at the coating supplier's nut factor. The moly column applies only to uncoated, moly-lubricated bolting. PTFE-coated nuts are not reused on critical joints without relubrication.
2. Joints are tightened in a cross pattern in at least three passes (30 %, 60 % and 100 % of target), then in circular passes at 100 % until the nuts no longer turn, per ASME PCC-1. Class 600 and 900 joints of NPS 8 and larger are tightened with calibrated hydraulic torque wrenches and recorded on a joint tag.
3. Stud lengths are the B16.5 raised-face lengths for two heavy nuts. Where hydraulic tensioners are used, studs are at least one nut height longer.



6.7. T1 TUBING

Instrument and analyzer tubing is rated for full line pressure, because a failed-open regulator can expose it to 1,440 psig. For 1/4 x 0.035 in tube by the B31.8 design formula with $F = 0.50$:

ASME B31.8 841.1.1

$$P = \frac{2 S t}{D} F = \frac{2 \times 30,000 \times 0.035}{0.250} \times 0.50 = 4,200 \text{ psig}$$

and by the B31.3 form with $Y = 0.4$:

ASME B31.3 304.1.2

$$P = \frac{2 S t}{D - 2 Y t} = \frac{2 \times 20,000 \times 0.035}{0.250 - 0.8 \times 0.035} = 6,306 \text{ psig}$$

The B31.8 formula gives the lower value and governs. Table 6-10 shows that every tube size is rated at more than 2.7 times the design pressure.

Table 6-10: T1 Tubing Pressure Rating

Tube OD x wall, in	Allowable, B31.8 design formula, psig	Allowable, B31.3 304.1.2, psig	Fitting rating, typical, psig	Governing, psig	Design, psig
1/4 x 0.035	4,200	6,306	5,100	4,200	1,440
3/8 x 0.049	3,920	5,837	5,100	3,920	1,440
1/2 x 0.065	3,900	5,804	4,700	3,900	1,440

Note 1: Fittings are two-ferrule 316 compression fittings of one manufacturer, not intermixed (SPC-SPC-014).

7. RESULTS AND CONCLUSIONS

TORUS draws the following conclusions:

1. The class A6 design point is 1,440 psig from -20 to 133 °F and 1,420 psig at 150 °F, set by the Class 600 Group 1.1 flanges. The line list, the valve and vessel datasheets and the relief device review in PRO-CAL-007 shall state both conditions.
2. Line 1022 carries a coincident condition of 1,360 psig at 200 °F, held by the heater controls and the bath high-high trip.
3. The H-101 coil nozzles and their companion flanges are Class 900, because Class 600 is rated only 1,335 psig at 250 °F.
4. Every flange joint passes ASME VIII-1 Appendix 2 with spiral-wound gaskets in Classes 600 and 900 and flexible graphite gaskets with 316 tanged insert in all Class 150 joints. Bolting is B7 with 2H nuts, PTFE coated, except class S1, which uses B8M Class 2 with 8M nuts. Joints are assembled to the torque in Table 6-9.

5. The class A6 station hydrotest is 2,160 psig minimum at the high point and 2,220 psig maximum at any flange, with every ball valve half open.
6. T1 tubing is rated at least 3,900 psig by the B31.8 formula, above the 1,440 psig design pressure.

The following items remain open: nut factors, gasket factors, valve seat temperature limits and tube fitting ratings from the vendors (HOLD H-15), the B8M Class 2 allowable stress and the Class 900 stud length (Assumptions 4 and 5), and the gasket at the tap valve tie-in (HOLD H-04).

