Ballotters: Shown below are proposed changes to the body of RP 574 and a new Annex D to reflect the results from updated structural minimum thickness calculations performed by E2G for API. E2G presented their methodology and results at the API Spring 2023 task group meeting. This content is open to review and comment with the intent of incorporating into the RP 574 upon successful ballot.

10.2.4.3 Structural Minimum Thickness

In low-pressure and low-temperature applications, the required pipe thicknesses determined by the Barlow formula can be so small that the pipe would have insufficient structural strength. For this reason, an absolute minimum thickness to prevent sag, buckling, and collapse at supports should be determined by the user for each size of pipe, dependent upon the materials of construction. The pipe wall should not be permitted to deteriorate below this minimum thickness regardless of the results obtained by the ASME B31.3 or Barlow formulas.

The owner-operator shall specify how structural minimum thicknesses are determined. Example tables of calculated structural minimum thickness for straight spans of carbon steel pipe at 400°F and 750 °F, of 1-1/4Cr-1/2Mo at 750 °F and 1100°F, and of austenitic stainless steel at 400°F and 1000°F, at various pressure classes is provided in Annex D. Annex D also details the assumptions used in calculating the thicknesses and limitations of the calculated values. Additional consideration and allowances may be required for the following conditions:

a) screwed piping and fittings.

b) Piping diameters greater than 24 in. (610 mm).

c) Temperatures exceeding the upper limits noted above for the respective materials.

d) Higher alloys (other than carbon steel, 1-1/4Cr-1/2Mo and austenitic stainless steel).

e) Spans in excess of 20 ft (6 m).

f) High external loads (e.g. refractory lined, pipe that is also used to support other pipe, rigging loads, and personnel support loading).

g) Excessive vibration.

Engineering calculations, typically using a computerized piping stress analysis program, may be required in these instances to determine structural minimum thickness.

10.2.4.4 Minimum Required Thickness

Generally, piping is replaced and/or repaired when it reaches the minimum required thickness unless a Fitness-For-Service analysis has been performed which defined additional remaining life. The minimum required thickness is the greater value of the pressure design thickness or the structural minimum thickness. The following steps should be followed when determining the minimum required thickness at a CML.

a) Step 1: Calculate the pressure design thickness per rating code.

b) Step 2: Determine the structural minimum thickness per the owner-operator table or engineering calculations.

c) Step 3: Select the minimum required thickness. This is the larger of the pressure design thickness or structural minimum thickness determined in Step 1 and Step 2.

For services with high potential consequences if a failure were to occur, the piping engineer should consider increasing the minimum allowed thickness above the one determined above in Step 3. This would provide extra thickness for unanticipated or unknown loadings, undiscovered metal loss, or resistance to normal abuse.

Example 1: Determine the minimum required thickness for Class 150 NPS 2, ASTM A106, Grade B pipe designed for 100 psig @ 100 °F. P = 100 psig, D = 2.375 in., S = 20,000 psi, E = 1.0 (since seamless), Y = 0.4.

Step 1: Calculate pressure design thickness per rating code. (In this example, the ASME B31.3 design formula was used.)

$$t = \frac{P \cdot D}{2 \cdot S \cdot E + (P \cdot 0.4)} = \frac{100 \cdot 2.375}{2 \cdot 20000 \cdot 1 + (100 \cdot 0.4)} = 0.006 \text{ inches}$$

NOTE: If this NPS 2 pipe was 100% supported (e.g., laying on flat ground), then 0.006 in. would hold the 100 psig of pressure. This thickness includes a 3-to-1 safety factor; however, it would not hold up in the pipe rack.

Step 2: Determine structural minimum thickness per owner-operator table or engineering calculations. From Annex D Table D2/D2M, the default structural minimum thickness is 0.030 in. (0.76 mm).

Step 3: Select the minimum required thickness. This is the larger of the pressure design thickness or structural minimum thickness determined in Step 1 and Step 2. The larger value of 0.006 in. and 0.070 in. is 0.070 in.

Example 2: Determine the minimum required thickness for a Class 300 NPS14, ASTM A106, Grade B pipe designed for 600 psig @ 100 °F, D = 14 in., S = 20,000 psi, E = 1.0 (seamless), Y = 0.4.

Step 1: Calculate pressure design thickness per rating code. (In this example, the ASME B31.3 design formula was used.)

$$t = \frac{P \cdot D}{2 \cdot S \cdot E + (P \cdot 0.4)} = \frac{600 \cdot 14.0}{2 \cdot 20000 \cdot 1 + (600 \cdot 0.4)} = 0.208 \text{ inches}$$

Step 2: Determine structural minimum thickness per owner-operator table or engineering calculations. From Annex D Table D2/D2M, the structural minimum thickness is 0.155 in (3.94 mm).

Step 3: Select the minimum required thickness. This is the larger of the pressure design thickness or structural minimum thickness determined in Step 1 and Step 2. The larger value of 0.208 in. and 0.110 in. is 0.208 in.

Annex D

(Informative)

Example Minimum Structural Thicknesses Tables

Tables D2/D2M, D3/D3M and D4/D4M contain calculated minimum structural thicknesses for carbon steel, austenitic stainless steel and 1-1/4Cr-1/2Mo. The following summarize critical assumptions used in the calculations and limitations of the values calculated. The owner-operator should consider these when reviewing the tables and values.

1. Limited to 400F and 750F for Cabon Steel, 400F and 1000F for Austenitic Stainless Steel, and 750F and 1100F for 1-1/4Cr-1/2Mo. Interpolation/Extrapolation between tables and values is not advised.
2 Results assume unsupported flange pair and valve at the midspan plus an additional 250 lb force.
   a) For size NPS 2 and lower, the 250 lb force is neglected
   b) For pressure Classes 900 and greater, the valve weight is neglected. Tables are not applicable if system has Class 900 and higher valves that are not individually supported.
   c) For pressure Class 2500 and sizes NPS 14 and greater there are no standard flanges in ASME B16.5; thus, flange weight is neglected. For systems with Class 2500 NPS 14 and larger flanges, these tables are not applicable.
3 Results are limited to maximum span lengths listed in Table D1 which align with ASME B31.1 span lengths for water filled piping but with a max span length of 20 feet. These tables are not applicable when your span lengths exceed those shown in Table 1.
4 Results for 1-1/4Cr-1/2Mo assume a weld strength reduction factor of 1.0.
5 Values for Class 150 for austenitic stainless steel and 1-1/4Cr-1/2Mo materials were developed from analysis of Carbon Steel local support stresses. The owner-operator may have to develop their own minimum structural thickness of austenitic stainless steel and 1-1/4Cr-1/2Mo materials at supports.
6 Results for Class 150 and sizes less than NPS 10 may be limited by local support stresses not captured in these results.
7 The tables are limited to NPS 24 and smaller pipe sizes.
8 These charts were developed for specific grades of material, but they can be applied to other grades which have similar allowable stresses.
   a) Carbon steel charts were developed for ASME SA106-B pipe so other carbon steel pipe with similar allowable stress can be utilize these tables.
   b) Austenitic stainless steel charts were developed for ASME SA312-316 pipe so other austenitic stainless steel pipe with similar allowable stress can be utilize these tables.
   c) The 1-1/4Cr-1/2Mo charts were developed for A335-P11 pipe so other 1-1/4Cr-1/2Mo pipe with similar allowable stress can be utilize these tables.
9 These tables are not applicable for piping systems with high external loads (e.g., refractory lined, pipe supporting other pipe, rigging loads, personnel support loading, etc.)
10 These tables are not applicable to piping systems experiencing vibration in excess of typical vibration screening criteria.
11 These tables assumed the piping aligns with a five span simply supported beam for the calculation of the required thickness. For pipng systems that have a layout such that this assumption cannot be applied, the individual unique piping layout will require its own minimum thickness assessment.
12 These tables assumed the pipe is full of water. If actual system is a gas or mix-phase with a significantly lower content specific gravity than water (S.G.=1.0), a lower minimum required thickness may be warranted but would require an individual assessment for the actual piping system.
13 For details on all the assessment assumptions, methodology, and detailed results, see XYZ.

Table D1: Span Lengths	
NPS	**Span Length (in)**
0.5	60
0.75	70
1	84

1.5	102
2	120
3	144
4	168
6	186
8	228
10 - 24	240

Table D2: Carbon Steel Minimum Structural Thicknesses

Minimum Structural Thickness (in.) : Carbon Steel at 400F						
NPS	Pressure Class					
	150	300	600	900	1500	2500
0.5	0.015	0.025	0.040	0.045	0.055	0.080
0.75	0.015	0.030	0.045	0.045	0.060	0.090
1	0.020	0.030	0.055	0.055	0.070	0.105
1.5	0.020	0.040	0.070	0.070	0.090	0.145
2	0.030	0.055	0.080	0.080	0.115	0.180
3	0.065	0.095	0.135	0.135	0.195	0.295
4	0.060	0.095	0.155	0.155	0.225	0.350
6	0.050	0.100	0.175	0.190	0.295	0.475
8	0.060	0.115	0.215	0.240	0.375	0.605
10	0.080	0.130	0.245	0.290	0.455	0.745
12	0.090	0.145	0.270	0.335	0.530	0.865
14	0.090	0.155	0.300	0.365	0.585	0.885
16	0.100	0.175	0.330	0.410	0.655	1.005
18	0.110	0.185	0.355	0.455	0.730	1.125
20	0.120	0.210	0.385	0.500	0.805	1.245
24	0.140	0.245	0.450	0.595	0.960	1.485

Minimum Structural Thickness (in.) : Carbon Steel at 750F						
NPS	Pressure Class					
	150	300	600	900	1500	2500
0.5	0.020	0.035	0.050	0.055	0.070	0.100
0.75	0.020	0.040	0.055	0.055	0.075	0.110
1	0.025	0.045	0.075	0.075	0.085	0.130
1.5	0.030	0.050	0.090	0.090	0.110	0.175
2	0.040	0.070	0.100	0.100	0.135	0.215
3	0.090	0.130	0.180	0.180	0.245	0.365
4	0.080	0.125	0.200	0.200	0.270	0.420
6	0.060	0.125	0.225	0.230	0.350	0.565
8	0.065	0.145	0.270	0.290	0.445	0.710
10	0.085	0.160	0.305	0.345	0.535	0.875
12	0.090	0.175	0.330	0.395	0.620	1.010
14	0.100	0.190	0.365	0.430	0.680	1.015
16	0.110	0.210	0.400	0.480	0.765	1.150
18	0.110	0.225	0.430	0.530	0.850	1.285
20	0.130	0.250	0.460	0.585	0.935	1.420
24	0.140	0.290	0.535	0.690	1.110	1.690

Table D3: Austenitic Stainless Steel Minimum Structural Thicknesses

Minimum Structural Thickness (in) : Austenitic Stainless Steel at 400F						
NPS	Pressure Class					
	150	300	600	900	1500	2500
0.5	0.015	0.025	0.035	0.040	0.050	0.075
0.75	0.015	0.030	0.040	0.040	0.055	0.080
1	0.020	0.030	0.055	0.055	0.065	0.095
1.5	0.025	0.035	0.065	0.065	0.080	0.130
2	0.030	0.050	0.075	0.075	0.100	0.160
3	0.070	0.095	0.130	0.130	0.175	0.265
4	0.060	0.090	0.145	0.145	0.200	0.310
6	0.055	0.090	0.160	0.170	0.260	0.420
8	0.060	0.105	0.195	0.210	0.325	0.530
10	0.080	0.120	0.220	0.255	0.395	0.650
12	0.090	0.130	0.240	0.290	0.460	0.755
14	0.090	0.140	0.265	0.315	0.505	0.760
16	0.100	0.155	0.290	0.355	0.565	0.865
18	0.110	0.165	0.315	0.390	0.630	0.965
20	0.120	0.185	0.335	0.430	0.695	1.065
24	0.140	0.215	0.390	0.510	0.820	1.270

Minimum Structural Thickness (in) : Austenitic Stainless Steel at 1000F						
NPS	Pressure Class					
	150	300	600	900	1500	2500
0.5	0.020	0.030	0.045	0.050	0.060	0.085
0.75	0.020	0.035	0.050	0.050	0.060	0.085
1	0.020	0.040	0.065	0.065	0.065	0.100
1.5	0.025	0.045	0.080	0.080	0.085	0.135
2	0.035	0.065	0.085	0.085	0.105	0.165
3	0.080	0.115	0.155	0.155	0.195	0.285
4	0.070	0.110	0.170	0.170	0.210	0.325
6	0.050	0.105	0.180	0.180	0.265	0.425
8	0.055	0.120	0.215	0.215	0.330	0.535
10	0.085	0.130	0.240	0.255	0.395	0.655
12	0.090	0.140	0.255	0.290	0.455	0.750
14	0.100	0.150	0.285	0.315	0.500	0.740
16	0.110	0.165	0.305	0.350	0.555	0.835
18	0.110	0.175	0.325	0.385	0.615	0.930
20	0.130	0.190	0.345	0.420	0.675	1.025
24	0.140	0.225	0.400	0.495	0.800	1.215

Table D4: 1-1/4Cr-1/2 Mo Minimum Structural Thicknesses

Minimum Structural Thickness (in.) : 1-1/4Cr-1/2Mo at 750F						
NPS	Pressure Class					
	150	300	600	900	1500	2500
0.5	0.020	0.035	0.050	0.055	0.070	0.100
0.75	0.020	0.040	0.055	0.055	0.075	0.105
1	0.025	0.045	0.075	0.075	0.085	0.125
1.5	0.025	0.050	0.090	0.090	0.110	0.170
2	0.035	0.070	0.100	0.100	0.135	0.205
3	0.085	0.140	0.190	0.190	0.245	0.360
4	0.075	0.140	0.210	0.210	0.280	0.420
6	0.060	0.125	0.220	0.225	0.345	0.565
8	0.070	0.150	0.280	0.280	0.435	0.710
10	0.080	0.165	0.310	0.330	0.525	0.865
12	0.090	0.175	0.330	0.380	0.610	0.995
14	0.090	0.190	0.360	0.415	0.670	1.010
16	0.100	0.210	0.395	0.465	0.755	1.140
18	0.110	0.220	0.420	0.520	0.835	1.275
20	0.120	0.245	0.450	0.570	0.920	1.405
24	0.140	0.285	0.525	0.675	1.095	1.675

Minimum Structural Thickness (in.) : 1-1/4Cr-1/2Mo at 1100F					
NPS	Pressure Class				
	300	600	900	1500	2500
0.5	--	--	--	--	--
0.75	--	--	--	--	--
1	0.285	--	0.245	0.275	--
1.5	0.250	--	0.225	0.255	--
2	--	--	0.270	0.315	--
3	--	--	--	--	--
4	--	--	0.580	--	--
6	0.465	--	0.465	0.670	1.325
8	0.490	1.005	1.005	1.005	1.460
10	0.470	0.920	0.920	0.920	1.655
12	0.450	0.835	0.835	0.945	1.705
14	0.480	0.925	0.925	1.035	1.300
16	0.495	0.920	0.920	1.095	1.415
18	0.490	0.905	0.905	1.175	1.535
20	0.545	0.895	0.895	1.255	1.655
24	0.580	0.975	0.975	1.430	1.905

Table D2M: Carbon Steel Minimum Structural Thicknesses

Minimum Structural Thickness (mm) : Carbon Steel at 400F						
NPS	Pressure Class					
	150	300	600	900	1500	2500
0.5	0.38	0.64	1.02	1.14	1.40	2.03
0.75	0.38	0.76	1.14	1.14	1.52	2.29
1	0.51	0.76	1.40	1.40	1.78	2.67
1.5	0.51	1.02	1.78	1.78	2.29	3.68
2	0.76	1.40	2.03	2.03	2.92	4.57
3	1.65	2.41	3.43	3.43	4.95	7.49
4	1.52	2.41	3.94	3.94	5.72	8.89
6	1.27	2.54	4.45	4.83	7.49	12.07
8	1.52	2.92	5.46	6.10	9.53	15.37
10	2.03	3.30	6.22	7.37	11.56	18.92
12	2.29	3.68	6.86	8.51	13.46	21.97
14	2.29	3.94	7.62	9.27	14.86	22.48
16	2.54	4.45	8.38	10.41	16.64	25.53
18	2.79	4.70	9.02	11.56	18.54	28.58
20	3.05	5.33	9.78	12.70	20.45	31.62
24	3.56	6.22	11.43	15.11	24.38	37.72

Minimum Structural Thickness (mm) : Carbon Steel at 750F						
NPS	Pressure Class					
	150	300	600	900	1500	2500
0.5	0.51	0.89	1.27	1.40	1.78	2.54
0.75	0.51	1.02	1.40	1.40	1.91	2.79
1	0.64	1.14	1.91	1.91	2.16	3.30
1.5	0.76	1.27	2.29	2.29	2.79	4.45
2	1.02	1.78	2.54	2.54	3.43	5.46
3	2.29	3.30	4.57	4.57	6.22	9.27
4	2.03	3.18	5.08	5.08	6.86	10.67
6	1.52	3.18	5.72	5.84	8.89	14.35
8	1.65	3.68	6.86	7.37	11.30	18.03
10	2.16	4.06	7.75	8.76	13.59	22.23
12	2.29	4.45	8.38	10.03	15.75	25.65
14	2.54	4.83	9.27	10.92	17.27	25.78
16	2.79	5.33	10.16	12.19	19.43	29.21
18	2.79	5.72	10.92	13.46	21.59	32.64
20	3.30	6.35	11.68	14.86	23.75	36.07
24	3.56	7.37	13.59	17.53	28.19	42.93

Table D3M: Austenitic Stainless Steel Minimum Structural Thicknesses

Minimum Structural Thickness (mm) : Austenitic Stainless Steel at 400F						
NPS	Pressure Class					
	150	300	600	900	1500	2500
0.5	0.38	0.64	0.89	1.02	1.27	1.91
0.75	0.38	0.76	1.02	1.02	1.40	2.03
1	0.51	0.76	1.40	1.40	1.65	2.41
1.5	0.64	0.89	1.65	1.65	2.03	3.30
2	0.76	1.27	1.91	1.91	2.54	4.06
3	1.78	2.41	3.30	3.30	4.45	6.73
4	1.52	2.29	3.68	3.68	5.08	7.87
6	1.40	2.29	4.06	4.32	6.60	10.67
8	1.52	2.67	4.95	5.33	8.26	13.46
10	2.03	3.05	5.59	6.48	10.03	16.51
12	2.29	3.30	6.10	7.37	11.68	19.18
14	2.29	3.56	6.73	8.00	12.83	19.30
16	2.54	3.94	7.37	9.02	14.35	21.97
18	2.79	4.19	8.00	9.91	16.00	24.51
20	3.05	4.70	8.51	10.92	17.65	27.05
24	3.56	5.46	9.91	12.95	20.83	32.26

Minimum Structural Thickness (mm) : Austenitic Stainless Steel at 1000F						
NPS	Pressure Class					
	150	300	600	900	1500	2500
0.5	0.51	0.76	1.14	1.27	1.52	2.16
0.75	0.51	0.89	1.27	1.27	1.52	2.16
1	0.51	1.02	1.65	1.65	1.65	2.54
1.5	0.64	1.14	2.03	2.03	2.16	3.43
2	0.89	1.65	2.16	2.16	2.67	4.19
3	2.03	2.92	3.94	3.94	4.95	7.24
4	1.78	2.79	4.32	4.32	5.33	8.26
6	1.27	2.67	4.57	4.57	6.73	10.80
8	1.40	3.05	5.46	5.46	8.38	13.59
10	2.16	3.30	6.10	6.48	10.03	16.64
12	2.29	3.56	6.48	7.37	11.56	19.05
14	2.54	3.81	7.24	8.00	12.70	18.80
16	2.79	4.19	7.75	8.89	14.10	21.21
18	2.79	4.45	8.26	9.78	15.62	23.62
20	3.30	4.83	8.76	10.67	17.15	26.04
24	3.56	5.72	10.16	12.57	20.32	30.86

Table D4M: 1-1/4Cr-1/2 Mo Minimum Structural Thicknesses

Minimum Structural Thickness (mm) : 1-1/4Cr-1/2Mo at 750F						
NPS	Pressure Class					
	150	300	600	900	1500	2500
0.5	0.51	0.89	1.27	1.40	1.78	2.54
0.75	0.51	1.02	1.40	1.40	1.91	2.67
1	0.64	1.14	1.91	1.91	2.16	3.18
1.5	0.64	1.27	2.29	2.29	2.79	4.32
2	0.89	1.78	2.54	2.54	3.43	5.21
3	2.16	3.56	4.83	4.83	6.22	9.14
4	1.91	3.56	5.33	5.33	7.11	10.67
6	1.52	3.18	5.59	5.72	8.76	14.35
8	1.78	3.81	7.11	7.11	11.05	18.03
10	2.03	4.19	7.87	8.38	13.34	21.97
12	2.29	4.45	8.38	9.65	15.49	25.27
14	2.29	4.83	9.14	10.54	17.02	25.65
16	2.54	5.33	10.03	11.81	19.18	28.96
18	2.79	5.59	10.67	13.21	21.21	32.39
20	3.05	6.22	11.43	14.48	23.37	35.69
24	3.56	7.24	13.34	17.15	27.81	42.55

Minimum Structural Thickness (mm) : 1-1/4Cr-1/2Mo at 1100F					
NPS	Pressure Class				
	300	600	900	1500	2500
0.5	--				
0.75	--	--	--	--	--
1	7.24	--	6.22	6.99	--
1.5	6.35	--	5.72	6.48	--
2	--	--	6.86	8.00	--
3	--	--	--	--	--
4	--	--	14.73	--	--
6	11.81		11.81	17.02	33.66
8	12.45	25.53	25.53	25.53	37.08
10	11.94	23.37	23.37	23.37	42.04
12	11.43	21.21	21.21	24.00	43.31
14	12.19	23.50	23.50	26.29	33.02
16	12.57	23.37	23.37	27.81	35.94
18	12.45	22.99	22.99	29.85	38.99
20	13.84	22.73	22.73	31.88	42.04
24	14.73	24.77	24.77	36.32	48.39