Annex K
(informative)

Sample Applications of the Variable-Design-Point Method to Determine Shell-Plate Thickness

K.1 Variable-Design-Point, Example #1

K.1.1 Data

[ ] Design condition [x] Test condition

Design specific gravity of liquid, G: 1.0

Corrosion allowance: .... 0.0 mm (0.0 in.)

Tank diameter, D: .... 85.0 m (280 ft)

Design Liquid Level (also total height of tank for the examples in this Annex), H: .... 19.2 m (64 ft)

Number of courses: 8.0

Allowable stress for design, S_d: .... —

Allowable stress for testing, S_t: .... 208 MPa (30,000 lbf/in.^{2})

Height of bottom course, h_1: .... 2,400 mm (96 in.)

Nominal tank radius, r: .... 42,500 mm (1,680 in.)

(See 5.6.4 for definition of nomenclature.)

K.1.2 Calculations

First Course (t_1)

For the test condition, t_1 is equal to t_{1t} but not greater than t_{pt}.

In SI units:

$$t_{pt} = \frac{4.9D(H-0.3)}{St} = \frac{(4.9)(85)(19.2-0.3)}{208} = 37.85$$

$$t_{1t} = \left[1.06 - \frac{0.0696D}{H}\sqrt{\frac{H}{S_t}}\right]\left[\frac{(4.9HD)}{S_t}\right]$$

$$= \left[1.06 - \frac{0.0696(85)}{19.2}\sqrt{\frac{19.2}{208}}\right]\left[\frac{4.9(19.2)(85)}{208}\right]$$

$$= [1.06 - (0.3081)(0.3038)][38.45]$$

$$= [1.06 - 0.0936][38.45]$$

$$= [0.9664][38.45]$$

$$= 37.15 \text{ mm} = t_1$$

In USC units:

$$t_{pt} = \frac{2.6D(H-1)}{St} = \frac{2.6(280)(64-1)}{30{,}000} = 1.529$$

$$t_{1t} = \left[1.06 - \frac{(0.463D)}{H}\sqrt{\frac{H}{S_t}}\right]\left[\frac{(2.6HD)}{S_t}\right]$$

$$= \left[1.06 - \frac{0.463(280)}{64}\sqrt{\frac{64}{30{,}000}}\right]\left[\frac{2.6(64)(280)}{30{,}000}\right]$$

$$= [1.06 - (2.026)(0.0462)][1.553]$$

$$= [1.06 - 0.0936][1.553]$$

$$= [0.9664][1.553]$$

$$= 1.501 \text{ in.} = t_1$$

K.1.3 SECOND COURSE (t_2)

In SI units:

$$\frac{h_1}{(rt_1)^{0.5}} = \frac{2400}{[(42{,}500)(37.2)]^{0.5}} = 1.909$$

$$\text{If } \frac{h_1}{(rt_1)^{0.5}} \le 1.375,\ t_2 = t_1; \quad \text{if } \frac{h_1}{(rt_1)^{0.5}} \ge 2.625,\ t_2 = t_{2a}$$

$$\text{If } 1.375 < \frac{h_1}{(rt_1)^{0.5}} < 2.625$$

$$t_2 = t_{2a} + (t_1 - t_{2a})\left[2.1 - \frac{h_1}{1.25(rt_1)^{0.5}}\right]$$

$$= 31.28 + (5.87)\left[2.1 - \frac{2400}{1.25[(42{,}500)(37.16)]^{0.5}}\right]$$

$$= 31.28 + (5.87)[2.1 - 1.528]$$

$$= 31.28 + (5.87)[0.572]$$

$$= 31.28 + 3.36$$

$$= 34.64 \text{ mm}$$

In US Customary units:

$$\frac{h_1}{(rt_1)^{0.5}} = \frac{96}{[(1680)(1.501)]^{0.5}} = \frac{96}{50.216} = 1.912$$

$$\text{If } \frac{h_1}{(rt_1)^{0.5}} \le 1.375, t_2 = t_1; \quad \text{if } \frac{h_1}{(rt_1)^{0.5}} \ge 2.625, t_2 = t_{2a}$$

$$\text{If } 1.375 < \frac{h_1}{(rt_1)^{0.5}} < 2.625$$

$$t_2 = t_{2a} + (t_1 - t_{2a})\left[2.1 - \frac{h_1}{1.25(rt_1)^{0.5}}\right]$$

$$= 1.263 + (0.238)\left[2.1 - \frac{96}{1.25[(1680)(1.501)]^{0.5}}\right]$$

$$= 1.263 + (0.238)[2.1 - 1.529]$$

$$= 1.263 + (0.238)[0.571]$$

$$= 1.263 + 0.136$$

$$= 1.399 \text{ in.}$$

K.1.4 UPPER COURSES

K.1.4.1 Course 2

NOTE $H = 16.8$ m (56 ft).

K.1.4.1.1 First Trial

In SI units:

$$t_{tx} = \frac{4.9D(H - 0.3)}{S_t} = \frac{4.9(85)(16.8 - 0.3)}{208}$$

$$= 33.04 \text{ mm} = t_u$$

$$t_L = 37.15 \text{ mm}$$

$$K = \frac{t_L}{t_u} = \frac{37.15}{33.04} = 1.124$$

$$K^{0.5} = 1.060$$

$$C = \frac{K^{0.5}(K-1)}{1 + K^{1.5}} = \frac{(1.06)(0.124)}{1 + 1.192} = 0.060$$

$$(rt_u)^{0.5} = [(42{,}500)(33.04)]^{0.5} = 1185.0$$

$$x_1 = 0.61(rt_u)^{0.5} + 320CH$$

$$= 0.61(1185) + 320(0.060)(16.8) = 1045.4$$

$$x_2 = 1000CH = 1000(0.060)(16.8) = 1008$$

$$x_3 = 1.22(rt_u)^{0.5} = 1.22(1185) = 1445.7$$

$$x = \min(x_1, x_2, x_3) = 1008$$

$$x/1000 = 1.008$$

$$t_{tx} = \frac{4.9D(H-x)}{S_t} = \frac{4.9(85)(16.8-1.008)}{208} = 31.62 \text{ mm}$$

In US Customary units:

$$t_{tx} = \frac{2.6D(H-1)}{S_t} = \frac{2.6(280)(55)}{30{,}000}$$

$$= 1.335 \text{ in.} = t_u$$

$$t_L = 1.501 \text{ in.}$$

$$K = \frac{t_L}{t_u} = \frac{1.501}{1.335} = 1.124$$

$$K^{0.5} = 1.060$$

$$C = \frac{K^{0.5}(K-1)}{1+K^{1.5}} = \frac{(1.06)(0.124)}{1+1.191} = 0.060$$

$$(rt_u)^{0.5} = [(1680)(1.335)]^{0.5} = 47.358$$

$$x_1 = 0.61(rt_u)^{0.5} + 3.84CH$$

$$= 0.61(47.358) + 3.84(0.060)(56) = 28.89 + 12.90 = 41.79$$

$$x_2 = 12CH = 12(0.060)(56) = 40.32$$

$$x_3 = 1.22(rt_u)^{0.5} = 1.22(47.358) = 57.78$$

$$x = \min(x_1, x_2, x_3) = 40.32$$

$$x/12 = 3.36$$

$$t_{tx} = \frac{2.6D(H-x/12)}{S_t} = \frac{2.6(280)(56-3.36)}{30{,}000} = 1.277 \text{ in.}$$

With this value of t_{tx}, start the second trial.

K.1.4.1.2 Second Trial

In SI units:

$$t_u = t_{tx} \text{ from first trial} = 31.62 \text{ mm}$$

$$t_L = 37.15 \text{ mm}$$

$$K = \frac{t_L}{t_u} = \frac{37.15}{31.62} = 1.175$$

$$K^{0.5} = 1.084$$

$$C = \frac{K^{0.5}(K-1)}{1+K^{1.5}} = \frac{(1.084)(0.175)}{1+1.175^{1.5}} = 0.0834$$

$$(rt_u)^{0.5} = [(42{,}500)(31.62)]^{0.5} = 1159.2$$

$$x_1 = 0.61(rt_u)^{0.5} + 320CH$$

$$= 0.61(1159.2) + 320(0.0834)(16.8) = 1155.5$$

$$x_2 = 1000CH = 1000(0.0834)(16.8) = 1401.1$$

$$x_3 = 1.22(rt_u)^{0.5} = 1.22(1159.2) = 1414.2$$

$$x = \min(x_1, x_2, x_3) = 1155.5$$

$$x/1000 = 1.155$$

$$t_{tx} = \frac{4.9D(H - x/1000)}{S_t} = \frac{4.9(85)(16.8 - 1.155)}{208} = 31.33 \text{ mm}$$

In US Customary units:

t_u = t_{tx} from first trial = 1.277 in.

t_L = 1.501 in.

$$K = \frac{t_L}{t_u} = \frac{1.501}{1.277} = 1.175$$

$K^{0.5}$ = 1.084

$$C = \frac{K^{0.5}(K-1)}{1+K^{1.5}} = \frac{(1.084)(0.175)}{1 + 1.274} = 0.0834$$

$(rt_u)^{0.5} = [(1680)(1.277)]^{0.5} = 46.32$

$x_1 = 0.61(rt_u)^{0.5} + 3.84CH$

$= 0.61(46.32) + 3.84(0.0834)(56) = 28.25 + 17.93 = 46.19$

$x_2 = 12CH = 12(0.0834)(56) = 56.04$

$x_3 = 1.22(rt_u)^{0.5} = 1.22(46.32) = 56.51$

$x = \min(x_1, x_2, x_3) = 46.19$

$x/12 = 3.80$

$$t_{tx} = \frac{2.6D(H - x/12)}{S_t} = \frac{2.6(280)(56 - 3.80)}{30{,}000} = 1.267 \text{ in.}$$

With this value of t_{tx}, start the third trial.

K.1.4.1.3 Third Trial

In SI units:

t_u = t_{tx} from second trial = 31.33 mm

t_L = 37.15 mm

$$K = \frac{t_L}{t_u} = \frac{37.15}{31.33} = 1.186$$

$K^{0.5}$ = 1.089

$$C = \frac{K^{0.5}(K-1)}{1+K^{1.5}} = \frac{(1.089)(0.186)}{1 + 1.186^{1.5}} = 0.088$$

$(rt_u)^{0.5} = [(42{,}500)(31.33)]^{0.5} = 1153.9$

$x_1 = 0.61(rt_u)^{0.5} + 320CH$

$= 0.61(1153.9) + 320(0.088)(16.8) = 1177.0$

$x_2 = 1000CH = 1000(0.088)(16.8) = 1478.4$

$x_3 = 1.22(rt_u)^{0.5} = 1.22(1153.9) = 1407.8$

$x = \min(x_1, x_2, x_3) = 1177$

$x/1000 = 1.177$

$$t_{tx} = \frac{4.9D(H - x/1000)}{S_t} = \frac{4.9(85)(16.8 - 1.177)}{208} = 31.28 \text{ mm} = t_{2a}$$

In US Customary units:

$$t_u = t_{tx} \text{ from first trial} = 1.267 \text{ in.}$$

$$t_L = 1.501 \text{ in.}$$

$$K = \frac{t_L}{t_u} = \frac{1.501}{1.267} = 1.185$$

$$K^{0.5} = 1.089$$

$$C = \frac{K^{0.5}(K-1)}{1+K^{1.5}} = \frac{(1.089)(0.185)}{1+1.290} = 0.088$$

$$(rt_u)^{0.5} = [(1680)(1.266)]^{0.5} = 46.12$$

$$x_1 = 0.61(rt_u)^{0.5} + 3.84CH$$

$$= 0.61(46.12) + 3.84(0.088)(56) = 28.13 + 18.92 = 47.05$$

$$x_2 = 12CH = 59.14$$

$$x_3 = 1.22(rt_u)^{0.5} = 1.22(46.12) = 56.27$$

$$x = \min(x_1, x_2, x_3) = 47.05$$

$$x/12 = 3.92$$

$$t_{tx} = \frac{2.6D(H - x/12)}{S_t} = \frac{2.6(280)(56 - 3.92)}{30{,}000} = 1.263 \text{ in.} = t_{2a}$$

Use this value to calculate t_2.

K.1.4.2 Course 3

NOTE H = 14.4 m (48 ft).

K.1.4.2.1 First Trial

In SI units:

$$t_{tx} = \frac{4.9D(H - 0.3)}{S_t} = \frac{4.9(85)(14.4 - 0.3)}{208}$$

$$= 28.23 \text{ mm} = t_u$$

$$t_L = 34.64 \text{ mm}$$

$$K = \frac{t_L}{t_u} = \frac{34.64}{28.23} = 1.227$$

$$K^{0.5} = 1.108$$

$$C = \frac{K^{0.5}(K-1)}{1+K^{0.5}} = \frac{(1.108)(0.227)}{1+1.227^{1.5}} = 0.107$$

$$(rt_u)^{0.5} = [(42{,}500)(28.23)]^{0.5} = 1095$$

$$x_1 = 0.61(rt_u)^{0.5} + 320CH$$

$$= 0.61(1095) + 320(0.107)(14.4) = 1161$$

$$x_2 = 1000CH = 1000(0.107)(14.4) = 1541$$

$$x_3 = 1.22(rt_u)^{0.5} = 1.22(1095) = 1336$$

$$x = \min(x_1, x_2, x_3) = 1161$$

$$x/1000 = 1.161$$

$$t_{tx} = \frac{4.9D(H - x/1000)}{S_t} = \frac{4.9(85)(14.4 - 1.161)}{208} = 26.51 \text{ mm}$$

In US Customary units:

$$t_{tx} = \frac{2.6D(H-1)}{S_t} = \frac{2.6(280)(47)}{30{,}000}$$

$$= 1.141 \text{ in.} = t_u$$

$$t_L = 1.399 \text{ in.}$$

$$K = \frac{t_L}{t_u} = \frac{1.399}{1.141} = 1.226$$

$$K^{0.5} = 1.107$$

$$C = \frac{K^{0.5}(K-1)}{1+K^{1.5}} = \frac{(1.107)(0.266)}{1 + 1.357} = 0.106$$

$$(rt_u)^{0.5} = [(1680)(1.141)]^{0.5} = 43.78$$

$$x_1 = 0.61(rt_u)^{0.5} + 3.84CH$$

$$= 0.61(43.78) + 3.84(0.106)(48) = 26.71 + 19.54 = 46.25$$

$$x_2 = 12CH = 12(0.106)(48) = 61.06$$

$$x_3 = 1.22(rt_u)^{0.5} = 1.22(43.78) = 53.41$$

$$x = \min(x_1, x_2, x_3) = 46.25$$

$$x/12 = 3.85$$

$$t_{tx} = \frac{2.6D(H - x/12)}{S_t} = \frac{2.6(280)(48 - 3.85)}{30{,}000} = 1.071 \text{ in.}$$

With this value of t_{tx}, start the second trial.

K.1.4.2.2 Second Trial

In SI units:

$$t_u = t_{tx} \text{ from the first trial} = 26.51 \text{ mm}$$

$$t_L = 34.64 \text{ mm}$$

$$K = \frac{t_L}{t_u} = \frac{34.64}{26.51} = 1.307$$

$$K^{0.5} = 1.143$$

$$C = \frac{K^{0.5}(K-1)}{1+K^{1.5}} = \frac{(1.143)(0.307)}{1 + 1.307^{1.5}} = 0.141$$

$$(rt_u)^{0.5} = [(42{,}500)(26.51)]^{0.5} = 1061$$

$$x_1 = 0.61(rt_u)^{0.5} + 320CH$$

$$= 0.61(1061) + 320(0.141)(14.4) = 1297$$

$$x_2 = 1000CH = 1000(0.141)(14.4) = 2030$$

$$x_3 = 1.22(rt_u)^{0.5} = 1.22(1061) = 1294$$

$$x = \min(x_1, x_2, x_3) = 1294$$

$$x/1000 = 1.294$$

$$t_{tx} = \frac{4.9D(H - x/1000)}{S_t} = \frac{4.9(85)(14.4 - 1.294)}{208} = 26.24 \text{ mm}$$

In US Customary units:

$$t_u = t_{tx} \text{ from first trial} = 1.071 \text{ in.}$$

$$t_L = 1.399 \text{ in.}$$

$$K = \frac{t_L}{t_u} = \frac{1.399}{1.071} = 1.306$$

$$K^{0.5} = 1.143$$

$$C = \frac{K^{0.5}(K-1)}{1 + K^{1.5}} = \frac{(1.143)(0.306)}{1 + 1.493} = 0.140$$

$$(rt_u)^{0.5} = [(1680)(1.071)]^{0.5} = 42.42$$

$$x_1 = 0.61(rt_u)^{0.5} + 3.84CH$$

$$= 0.61(42.42) + 3.84(0.140)(48) = 25.88 + 25.80 = 51.68$$

$$x_2 = 12CH = 12(0.140)(48) = 80.64$$

$$x_3 = 1.22(rt_u)^{0.5} = 1.22(42.42) = 51.75$$

$$x = \min(x_1, x_2, x_3) = 51.68$$

$$x/12 = 4.31$$

$$t_{tx} = \frac{2.6D(H - x/12)}{S_t} = \frac{2.6(280)(48 - 4.31)}{30{,}000} = 1.060 \text{ in.}$$

With this value of t_{tx}, start the third trial.

K.1.4.2.3 Third Trial

In SI units:

$$t_u = t_{tx} \text{ from the second trial} = 26.24 \text{ mm}$$

$$t_L = 34.64 \text{ mm}$$

$$K = \frac{t_L}{t_u} = \frac{34.64}{26.24} = 1.320$$

$$K^{0.5} = 1.149$$

$$C = \frac{K^{0.5}(K-1)}{1 + K^{1.5}} = \frac{(1.149)(0.320)}{1 + 1.320^{1.5}} = 0.146$$

$$(rt_u)^{0.5} = [(42{,}500)(26.24)]^{0.5} = 1056$$

$$x_1 = 0.61(rt_u)^{0.5} + 320CH$$

$$= 0.61(1056) + 320(0.146)(14.4) = 1317$$

$$x_2 = 1000CH = 1000(0.146)(14.4) = 2102$$

$$x_3 = 1.22(rt_u)^{0.5} = 1.22(1056) = 1288$$

$$x = \min(x_1, x_2, x_3) = 1288$$

$$x/1000 = 1.288$$

$$t_{tx} = \frac{4.9D(H - x/1000)}{S_t} = \frac{4.9(85)(14.4 - 1.288)}{208} = 26.26 \text{ mm for Course 3}$$

In US Customary units:

$$t_u = t_{tx} \text{ from second trial} = 1.060 \text{ in.}$$

$$t_L = 1.399 \text{ in.}$$

$$K = \frac{t_L}{t_u} = \frac{1.399}{1.060} = 1.320$$

$$K^{0.5} = 1.149$$

$$C = \frac{K^{0.5}(K-1)}{1 + K^{1.5}} = \frac{(1.149)(0.320)}{1 + 1.517} = 0.146$$

$$(rt_u)^{0.5} = [(1680)(1.06)]^{0.5} = 42.20$$

$$x_1 = 0.61(rt_u)^{0.5} + 3.84CH$$

$$= 0.61(42.40) + 3.84(0.146)(48) = 25.74 + 26.91 = 52.65$$

$$x_2 = 12CH = 12(0.146)(48) = 84.10$$

$$x_3 = 1.22(rt_u)^{0.5} = 1.22(42.20) = 51.48$$

$$x = \min(x_1, x_2, x_3) = 51.48$$

$$x/12 = 4.29$$

$$t_{tx} = \frac{2.6D(H - x/12)}{S_t} = \frac{2.6(280)(48 - 4.29)}{30{,}000} = 1.061 \text{ in. for Course 3}$$

(Sample calculated shell-plate thicknesses for various tank sizes and allowable stresses are given in Tables K-1a through K-3b.)

K.2 Variable-Design-Point, Example #2

K.2.1 Data

In USC units:

$$D = 280 \text{ ft}$$

$$H = 40 \text{ ft}$$

$$G = 0.85$$

Course	Course Height	Course Height (h)	H	CA	Material
	ft	in.	ft	in.	
1	8	96	40	0.125	A573-70
2	8	96	32	0.125	A573-70
3	8	96	24	0.0625	A573-70
4	8	96	16	0	A36
5	8	96	8	0	A36

Material	S_d	S_t
	psi	psi
A573-70	28,000	30,000
A36	23,200	24,900

K.2.2 Bottom Course (Course 1)

K.2.2.1 Design Condition

t_{pd} = $2.6 \times D \times (H - 1) \times G/S_d + CA$= 0.987 in.

t_{1d} = $(1.06 - (0.463 \times D/H) \times (HG/S_d)^{0.5}) \times (2.6HDG/S_d) + CA$ = 0.962 in.

t_{1d} need not be greater than t_{pd}

t_{1d} = minimum of above thicknesses = 0.962 in.

K.2.2.2 Hydrostatic Test Condition

t_{pt} = $2.6 \times D \times (H - 1) / S_t$ = 0.946 in.

$t_{1d\,t}$ = $(1.06 - (0.463 \times D/H) \times (H/S_t)^{0.5}) \times (2.6HD/S_t)$ = 0.914 in.

t_{1t} need not be greater than t_{pt}

t_{1t} = minimum of above thicknesses = 0.914 in.

t_{use} = nominal thickness used

t_{min} = minimum nominal thickness required, the greater of t_d or t_t

t_{min} = 0.962 in. (controlled by t_{1d})

t_{use} = 1.000 in.

NOTE $t_{use} > t_{min}$ The greater thickness will be used for subsequent calculations and noted as the required thickness, therefore, t_{1d} = 1.000 in.

K.2.2.3 Check $L/H \leq 2$

L = $(6Dt)^{0.5}$

t = $t_{use} - CA$ = 0.875 in.

L = 38.34

L/H = $0.96 \leq 2$

K.2.3 Shell Course 2

K.2.3.1 Design Condition

h_1 = 96 in.

r = 1680 in.

t_{1d} = 1.000 in.

CA = 0.125 in.

t_1 = 0.875 in.

$h_1/(r \times t_1)^{0.5} = 2.504 > 1.375$ and < 2.625

$t_2 = t_{2a} + (t_1 - t_{2a})(2.1 - h_1/(1.25 \times (rt_1)^{0.5})$

t_{2a} = 0.634 in. (see K.2.4)

t_2 = 0.657 in.

$t_{2d} = t_2 + CA = 0.782$ in.

K.2.3.2 Hydrostatic Test Condition

h_1 = 96 in.

r = 1680 in.

t_{1t} = 1.000 in.

t_1 = 1.000 in.

$h_1/(r \times t_1)^{0.5} = 2.342 > 1.375$ and < 2.625

$t_2 = t_{2a} + (t_1 - t_{2a})(2.1 - h_1/(1.25 \times (rt_1)^{0.5})$

t_{2a} = 0.699 in. (See K.2.4)

t_2 = 0.767 in.

t_{2t} = 0.767 in.

t_{min} = greater of t_{2d} or t_{2t} = 0.782 in.

t_{use} = 0.8125 in.

NOTE $t_{use} > t_{min}$, however, the extra thickness will not be used for subsequent calculations, therefore, t_{2d} = 0.782 in.

K.2.4 Second Course as Upper Shell Course

K.2.4.1 Design Condition

D = 280 ft

Material A573-70

S_d = 28,000 psi

S_t = 30,000 psi

CA = 0.125 in.

G = 0.85

H = 32 ft

r = 1680 in.

$C = (K^{0.5}(K - 1))/(1+K^{1.5})$

$K = t_L/t_u$

$x_1 = 0.61(rt_u)^{0.5} + 3.84CH$

$x_2 = 12CH$

$x_3 = 1.22 \times (rt_u)^{0.5}$

t_L = 0.875 in. (thickness of bottom shell course less CA)

K.2.4.2 Trials

starting $t_u = 2.6D(H - 1)G/S_d = 0.6851$ in.

	t_u	K	C	x_1	x_2	x_3	x	$t_d - CA$
	in.			in.	in.	in.	in.	in.
1	0.685	1.277	0.128	36.449	49.231	41.390	36.449	0.640
2	0.640	1.367	0.165	40.298	63.420	40.006	40.006	0.634
3	0.634	1.381	0.171	40.885	65.575	39.801	39.801	0.634
4	0.634	1.380	0.170	40.851	65.450	39.813	39.813	0.634

$t_d - CA$ = 0.634 in.

t_d = 0.759 in.

K.2.4.3 Hydrotest Condition

t_L = 0.914 in. (calculated hydrostatic thickness of bottom shell course)

K.2.4.4 Trials

starting $t_u = 2.6D(H - 1)/S_t = 0.752$ in.

	t_u	K	C	x_1	x_2	x_3	x	t_t
	in.			in.	in.	in.	in.	in.
1	0.752	1.215	0.101	34.137	38.909	43.371	34.137	0.708
2	0.708	1.292	0.134	37.548	51.616	42.061	37.548	0.701
3	0.701	1.305	0.140	38.098	53.658	41.855	38.098	0.699
4	0.699	1.307	0.141	38.188	53.989	41.822	38.188	0.699

t_t = 0.699 in.

K.2.5 Shell Course 3

K.2.5.1 Design Condition

D = 280 ft

Material A573-70

S_d = 28,000 psi

S_t = 30,000 psi

CA = 0.0625 in.

G = 0.85

H = 24 ft

r = 1680 in.

$C = (K^{0.5}(K - 1))/(1 + K^{1.5})$

$K = t_L/t_u$

$x_1 = 0.61(rt_u)^{0.5} + 3.84CH$

$x_2 = 12CH$

$x_3 = 1.22 \times (rt_u)^{0.5}$

t_L = 0.657 in. (t_d of lower shell course less CA)

K.2.5.2 Trials

starting $t_u = 2.6D(H - 1)G/S_d = 0.508$ in.

	t_u	K	C	x_1	x_2	x_3	x	$t_d - CA$
	in.			in.	in.	in.	in.	in.
1	0.508	1.293	0.135	30.256	38.846	35.651	30.256	0.475
2	0.475	1.385	0.172	33.089	49.572	34.452	33.089	0.469
3	0.469	1.400	0.178	33.550	51.310	34.262	33.550	0.469
4	0.469	1.403	0.179	33.626	51.595	34.231	33.626	0.468

$t_d - CA$ = 0.468 in.

t_d = 0.531 in.

K.2.5.3 Hydrotest Condition

t_L = 0.767 in. (calculated hydrostatic thickness of lower shell course)

K.2.5.4 Trials

starting $rt_u = 2.6D(H - 1)/S_t = 0.558$ in.

	t_u	K	C	x_1	x_2	x_3	x	t_t
	in.			in.	in.	in.	in.	in.
1	0.558	1.375	0.168	34.186	48.461	37.358	34.1864	0.513
2	0.513	1.495	0.214	37.637	61.641	35.825	35.825	0.510
3	0.510	1.505	0.218	37.905	62.659	35.709	35.7092	0.510
4	0.510	1.504	0.217	37.886	62.586	35.717	35.7174	0.510

t_t = 0.510 in.

t_{min} = 0.531 in.

t_{use} = 0.531 in.

K.2.6 Shell Course 4

K.2.6.1 Design Condition

D = 280 ft

Material A36

S_d = 23,200 psi

S_t = 24,900 psi

CA = 0 in.

G = 0.85

H = 16 ft

r = 1680 in.

C = $(K^{0.5}(K - 1))/(1 + K^{1.5})$

K = t_L/t_u

x_1 = $0.61(rt_u)^{0.5} + 3.84CH$

x_2 = $12CH$

x_3 = $1.22 \times (rt_u)^{0.5}$

t_L = 0.468 in. (t_d of lower shell course less CA)

K.2.6.2 Trials

starting $t_u = 2.6D(H - 1)G/S_d = 0.400$ in.

	t_u	K	C	x_1	x_2	x_3	x	$t_d - CA$
	in.			in.	in.	in.	in.	in.
1	0.400	1.171	0.082	20.827	15.665	31.629	15.665	0.392
2	0.392	1.195	0.093	21.339	17.769	31.306	17.769	0.387
3	0.387	1.210	0.099	21.640	19.001	31.118	19.001	0.385
4	0.385	1.218	0.103	21.818	19.732	31.008	19.732	0.383

$t_d - CA$ = 0.383 in.

t_d = 0.383 in.

K.2.6.3 Hydrotest Condition

t_L = 0.510 in. (calculated hydrostatic thickness of lower shell course)

K.2.6.4 Trials

starting $t_u = 2.6\text{D}(H - 1)/S_t = 0.439$ in.

	t_u	K	C	x_1	x_2	x_3	x	t_t
	in.			in.	in.	in.	in.	in.
1	0.439	1.1633	0.078	21.357	14.999	33.115	14.999	0.431
2	0.431	1.18301	0.087	21.767	16.713	32.838	16.713	0.427
3	0.427	1.19458	0.092	22.007	17.710	32.679	17.710	0.425
4	0.425	1.20142	0.095	22.147	18.295	32.586	18.295	0.423

t_t = 0.423 in.

t_{min} = 0.423 in.

t_{use} = 0.4375 in.

NOTE $t_{use} > t_{use\ min}$, however, it is controlled by hydrotest, therefore, t_{1d} remains at 0.383 for subsequent calculations

K.2.7 Shell Course 5

K.2.7.1 Design Condition

D = 280 ft

Material A36

S_d = 23,200 psi

S_t = 24,900 psi

CA = 0 in.

G = 0.85

H = 8 ft

r = 1680 in.

$C = (K^{0.5}(K - 1))/(1 + K^{1.5})$

$K = t_L/t_u$

$x_1 = 0.61(rt_u)^{0.5} + 3.84CH$

$x_2 = 12CH$

$x_3 = 1.22 \times (rt_u)^{0.5}$

t_L = 0.383 in. (t_d of lower shell course less CA)

K.2.7.2 Trials

starting $t_u = 2.6D(H - 1)G/S_d = 0.187$ in.

	t_u	K	C	x_1	x_2	x_3	x	$t_d - CA$
	in.			in.	in.	in.	in.	in.
1	0.187	2.051	0.382	22.546	36.695	21.607	21.607	0.165
2	0.165	2.316	0.443	23.762	42.486	20.334	20.334	0.168
3	0.168	2.277	0.434	23.596	41.696	20.507	20.507	0.168
4	0.168	2.282	0.435	23.619	41.803	20.484	20.484	0.168

$t_d - CA$ = 0.168 in.

t_d = 0.168 in.

K.2.7.3 Hydrotest Condition

t_L = 0.423 in. (calculated hydrostatic thickness of lower shell course)

K.2.7.4 Trials

starting $t_u = 2.6D(H - 1)/S_t = 0.205$ in.

	t_u	K	C	x_1	x_2	x_3	x	t_t
	in.			in.	in.	in.	in.	in.
1	0.205	2.06791	0.386	23.1831	37.10029	22.622	22.6219	0.179
2	0.179	2.36726	0.453	24.4925	43.50275	21.143	21.1433	0.182
3	0.182	2.3205	0.444	24.3042	42.58296	21.355	21.3553	0.182
4	0.182	2.32709	0.445	24.3311	42.71425	21.325	21.325	0.182

t_t = 0.182 in.

$t_{\text{use min}}$ = 0.182 in.

t_{use} = 0.375 in.

NOTE Minimum nominal thickness is 3/8 in.

K.2.8 Shell Design Summary

As required by W.1.5 to be listed on drawings.

Course	Material	S_d	S_t	t_d	t_t	$t_{\min}$	t_{use}
		in.	in.	in.	in.	in.	in.
1	A573-70	28,000	30,000	1.000	0.914	1.000	1.000
2	A573-70	28,000	30,000	0.782	0.767	0.782	0.813
3	A573-70	28,000	30,000	0.531	0.510	0.531	0.531
4	A36	23,200	24,900	0.383	0.423	0.423	0.438
5	A36	23,200	24,900	0.168	0.182	0.182	0.375

Table K.1a—Shell-Plate Thicknesses Based on the Variable-design-point Method (See 5.6.4) Using 2400-mm Courses and an Allowable Stress of 159 MPa for the Test Condition (SI)

Tank Des. Liq. Lvl. m	Tank Diameter m	Weight of Shell Mg	Shell Plate Thickness for Course, mm								Nominal Tank Volume m^3
			1	2	3	4	5	6	7	8	
12	60	233	21.40	16.18	11.96	8.00	8.00	—	—	—	33,900
	65	282	22.99	17.42	12.90	10.00	10.00	—	—	—	39,800
	75	363	26.09	20.95	14.58	10.00	10.00	—	—	—	53,000
	80	408	27.59	22.97	15.39	10.02	10.00	—	—	—	60,300
	85	457	29.06	24.95	16.21	10.59	10.00	—	—	—	68,100
	90	510	30.51	26.88	17.01	11.16	10.00	—	—	—	76,300
	100	621	33.31	30.59	18.57	12.28	10.00	—	—	—	94,200
	105	680	34.66	32.40	19.32	12.84	10.00	—	—	—	103,900
	110	741	35.99	34.21	20.06	13.39	10.00	—	—	—	114,000
	115	804	37.29	35.94	20.78	13.93	10.00	—	—	—	124,600
14.4	55	276	23.90	18.85	14.99	11.06	8.00	8.00	—	—	34,200
	60	322	25.90	20.43	16.29	11.96	8.00	8.00	—	—	40,700
	65	388	27.85	22.54	17.49	12.89	10.00	10.00	—	—	47,800
	75	505	31.65	27.47	19.76	14.78	10.00	10.00	—	—	63,600
	80	569	33.50	29.85	20.92	15.71	10.00	10.00	—	—	72,400
	85	638	35.32	32.17	22.05	16.63	10.53	10.00	—	—	81,700
	90	711	37.11	34.44	23.17	17.54	11.08	10.00	—	—	91,600
16.8	50	306	25.42	20.83	17.30	13.69	10.15	8.00	8.00	—	33,000
	55	364	27.97	22.77	18.98	14.96	11.06	8.00	8.00	—	39,900
	60	428	30.42	25.25	20.54	16.27	11.96	8.00	8.00	—	47,500
	65	514	32.73	28.17	22.02	17.59	12.89	10.00	10.00	—	55,700
	75	671	37.24	33.81	25.01	20.17	14.72	10.00	10.00	—	74,200
	77	705	38.12	34.91	25.60	20.69	15.09	10.00	10.00	—	78,200
19.2	50	390	29.12	24.42	20.95	17.28	13.69	10.15	8.00	8.00	37,700
	55	466	32.03	27.03	22.92	18.95	14.98	11.06	8.00	8.00	45,600
	60	551	34.95	30.39	24.75	20.63	16.27	11.96	8.00	8.00	54,300
	62.5	610	36.29	32.04	25.66	21.47	16.91	12.41	10.00	10.00	58,900

Table K.1b—Shell-Plate Thicknesses Based on the Variable-design-point Method (See 5.6.4) Using 96-in. Courses and an Allowable Stress of 23,000 lbf/in.^{2} for the Test Condition (USC)

Tank Des. Liq. Lvl. ft	Tank Diameter ft	Weight of Shell tons	Shell Plate Thickness for Course, in.								Nominal Tank Volume bbl
			1	2	3	4	5	6	7	8	
40	200	272	0.871	0.659	0.487	0.317	0.313	—	—	—	224,000
	220	333	0.949	0.720	0.533	0.375	0.375	—	—	—	271,000
	240	389	1.025	0.807	0.574	0.375	0.375	—	—	—	322,500
	260	453	1.099	0.907	0.613	0.398	0.375	—	—	—	378,500
	280	522	1.171	1.004	0.653	0.427	0.375	—	—	—	439,000
	300	594	1.241	1.098	0.692	0.454	0.375	—	—	—	504,000
	320	671	1.310	1.189	0.730	0.482	0.375	—	—	—	573,400
	340	751	1.377	1.277	0.768	0.509	0.375	—	—	—	647,300
	360	835	1.433	1.362	0.804	0.536	0.375	—	—	—	725,700
	380	923	1.506	1.448	0.840	0.562	0.375	—	—	—	808,600
48	180	312	0.956	0.755	0.600	0.443	0.313	0.313	—	—	217,700
	200	376	1.055	0.832	0.664	0.487	0.317	0.313	—	—	268,800
	220	463	1.150	0.943	0.721	0.533	0.375	0.375	—	—	325,200
	240	543	1.243	1.063	0.776	0.579	0.375	0.375	—	—	387,000
	260	633	1.334	1.181	0.833	0.625	0.397	0.375	—	—	454,200
	280	729	1.423	1.295	0.889	0.669	0.424	0.375	—	—	526,800
	298	821	1.502	1.394	0.938	0.710	0.448	0.375	—	—	596,700
56	160	333	0.995	0.817	0.678	0.537	0.398	0.313	0.313	—	200,700
	180	412	1.119	0.912	0.760	0.599	0.443	0.313	0.313	—	254,000
	200	502	1.239	1.033	0.836	0.663	0.487	0.317	0.313	—	313,600
	220	615	1.351	1.175	0.908	0.727	0.532	0.375	0.375	—	379,400
	240	723	1.462	1.313	0.982	0.790	0.577	0.375	0.375	—	451,500
	247	764	1.500	1.361	1.007	0.812	0.592	0.379	0.375	—	478,300
64	160	423	1.139	0.957	0.820	0.677	0.537	0.398	0.313	0.313	229,300
	180	527	1.282	1.078	0.918	0.758	0.599	0.443	0.313	0.313	290,300
	200	646	1.423	1.242	1.007	0.841	0.662	0.487	0.317	0.313	358,400
	212	735	1.502	1.338	1.061	0.890	0.700	0.514	0.375	0.375	402,600

Table K.2a—Shell-Plate Thicknesses Based on the Variable-design-point Method (See 5.6.4) Using 2400-mm Courses and an Allowable Stress of 208 MPa for the Test Condition (SI)

Tank Des. Liq.Lvl. m	Tank Diameter m	Weight of Shell Mg	Shell Plate Thickness for Course, mm								Nominal Tank Volume m^3
			1	2	3	4	5	6	7	8	
12	75	298	20.26	15.36	11.38	10.00	10.00	—	—	—	53,000
	80	332	21.45	16.48	12.06	10.00	10.00	—	—	—	60,300
	85	369	22.63	18.07	12.65	10.00	10.00	—	—	—	68,100
	90	409	23.78	19.63	13.27	10.00	10.00	—	—	—	76,300
	100	493	26.03	22.64	14.51	10.00	10.00	—	—	—	94,200
	105	537	27.12	24.10	15.12	10.00	10.00	—	—	—	103,900
	110	585	28.20	25.52	15.72	10.37	10.00	—	—	—	114,000
	115	636	29.25	26.92	16.31	10.79	10.00	—	—	—	124,600
	120	688	30.29	28.30	16.88	11.22	10.00	—	—	—	135,700
14.4	65	316	21.55	16.99	13.52	10.00	10.00	10.00	—	—	47,800
	75	406	24.54	19.96	15.41	11.37	10.00	10.00	—	—	63,600
	80	456	26.01	21.86	16.27	12.09	10.00	10.00	—	—	72,400
	85	509	27.45	23.73	17.14	12.81	10.00	10.00	—	—	81,700
	90	565	28.87	25.55	18.02	13.52	10.00	10.00	—	—	91,600
	100	684	31.64	29.10	19.76	14.92	10.00	10.00	—	—	113,100
	105	747	33.00	30.81	20.61	15.62	10.00	10.00	—	—	124,700
	110	814	34.33	32.49	21.44	16.31	10.28	10.00	—	—	136,800
	115	885	35.65	34.18	22.26	17.01	10.68	10.00	—	—	149,600
	120	958	36.94	35.83	23.08	17.73	11.08	10.00	—	—	162,900
16.8	60	341	23.32	19.05	15.85	12.51	9.27	8.00	8.00	—	47,500
	65	410	25.27	20.53	17.13	13.50	10.00	10.00	10.00	—	55,700
	75	533	28.84	24.92	19.40	15.51	11.36	10.00	10.00	—	74,200
	80	601	30.58	27.09	20.53	16.50	12.07	10.00	10.00	—	84,400
	85	672	32.29	29.23	21.68	17.48	12.76	10.00	10.00	—	95,300
	90	747	33.98	31.33	22.82	18.46	13.46	10.00	10.00	—	106,900
	100	907	37.29	35.41	25.05	20.42	14.82	10.00	10.00	—	131,900
	105	992	38.91	37.39	26.14	21.46	15.48	10.00	10.00	—	145,500
	110	1083	40.51	39.36	27.23	22.64	16.11	10.30	10.00	—	159,700
	115	1179	42.08	41.28	28.33	23.79	16.74	10.72	10.00	—	174,500
	120	1278	43.63	43.14	29.44	24.94	17.36	11.14	10.00	—	190,000
19.2	60	433	26.71	22.34	19.19	15.83	12.52	9.27	8.00	8.00	54,300
	65	520	28.94	24.70	20.63	17.11	13.51	10.00	10.00	10.00	63,700
	75	679	33.16	29.77	23.42	19.67	15.47	11.36	10.00	10.00	84,800
	80	766	35.17	32.22	24.85	20.93	16.45	12.06	10.00	10.00	96,500
	85	858	37.15	34.64	26.25	22.18	17.41	12.77	10.00	10.00	109,000
	90	955	39.12	37.01	27.65	23.44	18.36	13.46	10.00	10.00	122,100
	100	1163	42.96	41.63	30.38	26.27	20.19	14.85	10.00	10.00	150,800
	101	1185	43.34	42.08	30.65	26.56	20.37	14.98	10.00	10.00	153,800

Table K.2b—Shell-Plate Thicknesses Based on the Variable-design-point Method (See 5.6.4) Using 96-in. Courses and an Allowable Stress of 30,000 lbf/in.^{2} for the Test Condition (USC)

Tank Des. Liq. Lvl. ft	Tank Diameter ft	Weight of Shell tons	Shell Plate Thickness for Course, in.								Nominal Tank Volume bbl
			1	2	3	4	5	6	7	8	
40	240	320	0.798	0.603	0.447	0.375	0.375	—	—	—	322,500
	260	365	0.856	0.651	0.482	0.375	0.375	—	—	—	378,500
	280	417	0.914	0.729	0.511	0.375	0.375	—	—	—	439,000
	300	472	0.971	0.806	0.541	0.375	0.375	—	—	—	504,000
	320	530	1.026	0.880	0.572	0.375	0.375	—	—	—	573,400
	340	594	1.08	0.952	0.602	0.395	0.375	—	—	—	647,300
	360	661	1.133	1.022	0.632	0.416	0.375	—	—	—	725,700
	380	731	1.185	1.090	0.660	0.437	0.375	—	—	—	800,600
	400	803	1.235	1.156	0.689	0.458	0.375	—	—	—	896,000
48	220	374	0.892	0.704	0.561	0.412	0.375	0.375	—	—	325,200
	240	436	0.966	0.773	0.608	0.446	0.375	0.375	—	—	387,000
	260	505	1.038	0.866	0.650	0.482	0.375	0.375	—	—	454,200
	280	579	1.109	0.958	0.692	0.517	0.375	0.375	—	—	526,800
	300	656	1.178	1.047	0.736	0.552	0.375	0.375	—	—	604,800
	320	739	1.247	1.135	0.778	0.587	0.375	0.375	—	—	688,100
	340	827	1.314	1.220	0.820	0.621	0.392	0.375	—	—	776,800
	360	921	1.379	1.302	0.862	0.655	0.412	0.375	—	—	870,900
	380	1019	1.444	1.383	0.902	0.688	0.433	0.375	—	—	970,300
	400	1121	1.507	1.462	0.942	0.721	0.452	0.375	—	—	1,075,200
56	200	400	0.953	0.778	0.648	0.511	0.378	0.313	0.313	—	313,600
	220	490	1.048	0.858	0.709	0.560	0.412	0.375	0.375	—	379,400
	240	575	1.135	0.968	0.764	0.609	0.446	0.375	0.375	—	451,500
	260	668	1.220	1.075	0.819	0.658	0.481	0.375	0.375	—	529,900
	280	766	1.305	1.180	0.876	0.706	0.515	0.375	0.375	—	614,600
	300	871	1.387	1.283	0.932	0.754	0.549	0.375	0.375	—	705,600
	320	981	1.469	1.383	0.987	0.801	0.583	0.375	0.375	—	802,800
	340	1100	1.549	1.481	1.041	0.849	0.616	0.393	0.375	—	906,300
	360	1225	1.627	1.577	1.094	0.895	0.649	0.413	0.375	—	1,016,000
	380	1358	1.705	1.671	1.148	0.951	0.679	0.434	0.375	—	1,132,000
	392	1441	1.750	1.726	1.180	0.986	0.698	0.446	0.375	—	1,204,700
64	200	508	1.092	0.913	0.784	0.647	0.511	0.378	0.313	0.313	358,400
	220	623	1.201	1.034	0.853	0.710	0.560	0.412	0.375	0.375	433,600
	240	734	1.304	1.159	0.922	0.772	0.608	0.447	0.375	0.375	516,000
	260	853	1.403	1.280	0.992	0.834	0.655	0.481	0.375	0.375	605,600
	280	981	1.501	1.399	1.061	0.896	0.703	0.516	0.375	0.375	702,400
	300	1116	1.597	1.515	1.129	0.957	0.749	0.550	0.375	0.375	806,400
	320	1259	1.692	1.629	1.196	1.017	0.796	0.584	0.375	0.375	917,500
	332	1350	1.748	1.696	1.236	1.059	0.822	0.604	0.384	0.375	987,600

Table K.3a—Shell-Plate Thicknesses Based on the Variable-design-point Method (See 5.6.4) Using 2400-mm Courses and an Allowable Stress of 236 MPa for the Test Condition (SI)

Tank Des. Liq. Lvl. m	Tank Diameter m	Weight of Shell Mg	Shell Plate Thickness for Course, mm								Nominal Tank Volume m^3
			1	2	3	4	5	6	7	8	
14.4	65	293	19.03	15.04	11.95	10.00	10.00	10.00	—	—	47,800
	75	368	21.76	17.19	13.70	10.05	10.00	10.00	—	—	63,600
	80	413	23.07	18.78	14.48	10.69	10.00	10.00	—	—	72,400
	85	460	24.36	20.45	15.24	11.33	10.00	10.00	—	—	81,700
	90	510	25.63	22.10	16.00	11.96	10.00	10.00	—	—	91,600
	100	617	28.12	25.30	17.56	13.21	10.00	10.00	—	—	113,100
	105	674	29.34	26.85	18.32	13.82	10.00	10.00	—	—	124,700
	110	733	30.54	28.37	19.07	14.44	10.00	10.00	—	—	136,800
	115	794	31.73	29.87	19.81	15.05	10.00	10.00	—	—	149,600
	120	856	32.89	31.34	20.54	15.66	10.00	10.00	—	—	162,900
16.8	60	308	20.56	16.86	14.00	11.08	8.21	8.00	8.00	—	47,500
	65	376	22.27	18.17	15.13	11.93	10.00	10.00	10.00	—	55,700
	75	480	25.56	21.48	17.24	13.70	10.05	10.00	10.00	—	74,200
	80	541	27.11	23.43	18.23	14.58	10.67	10.00	10.00	—	84,400
	85	604	28.64	25.35	19.23	15.45	11.29	10.00	10.00	—	95,300
	90	671	30.15	27.24	20.25	16.32	11.91	10.00	10.00	—	106,900
	100	815	33.12	30.92	22.24	18.04	13.12	10.00	10.00	—	131,900
	105	891	34.57	32.70	23.22	18.90	13.72	10.00	10.00	—	145,500
	110	970	36.01	34.46	24.19	19.77	14.31	10.00	10.00	—	159,700
	115	1053	37.42	36.19	25.15	20.80	14.87	10.00	10.00	—	174,500
	120	1139	38.82	37.92	26.11	21.83	15.43	10.00	10.00	—	190,000
19.2	60	389	23.54	19.76	16.94	13.98	11.08	8.21	8.00	8.00	54,300
	65	471	25.51	21.32	18.31	15.10	11.94	10.00	10.00	10.00	63,700
	75	609	29.37	25.79	20.78	17.37	13.67	10.05	10.00	10.00	84,800
	80	687	31.17	27.99	22.02	18.49	14.53	10.68	10.00	10.00	96,500
	85	769	32.94	30.16	23.27	19.60	15.39	11.30	10.00	10.00	109,000
	90	855	34.69	32.29	24.51	20.70	16.24	11.92	10.00	10.00	122,100
	100	1041	38.13	36.45	26.96	22.99	17.90	13.15	10.00	10.00	150,800
	105	1140	39.82	38.47	28.16	24.27	18.70	13.76	10.00	10.00	166,300
	110	1243	41.49	40.47	29.34	25.57	19.49	14.36	10.00	10.00	182,500
	115	1351	43.14	42.45	30.55	26.85	20.27	14.97	10.00	10.00	199,400
	117	1395	43.80[a]	43.22	31.03	27.36	20.59	15.21	10.00	10.00	206,400

[a] Exceeds maximum allowed material thickness.

Table K.3b—Shell-Plate Thicknesses Based on the Variable-design-point Method (See 5.6.4) Using 96-in. Courses and an Allowable Stress of 34,300 lbf/in.^{2} for the Test Condition (USC)

Tank Des. Liq. Lvl. ft	Tank Diameter ft	Weight of Shell tons	Shell Plate Thickness for Course, in.								Nominal Tank Volume bbl
			1	2	3	4	5	6	7	8	
48	220	341	0.784	0.619	0.492	0.375	0.375	0.375	—	—	325,200
	240	394	0.850	0.670	0.534	0.393	0.375	0.375	—	—	387,000
	260	453	0.914	0.736	0.574	0.423	0.375	0.375	—	—	454,200
	280	519	0.977	0.818	0.611	0.454	0.375	0.375	—	—	526,800
	300	588	1.039	0.898	0.649	0.485	0.375	0.375	—	—	604,800
	320	662	1.100	0.977	0.687	0.515	0.375	0.375	—	—	688,100
	340	738	1.160	1.053	0.724	0.545	0.375	0.375	—	—	776,800
	360	819	1.218	1.127	0.761	0.575	0.375	0.375	—	—	870,900
	380	904	1.276	1.200	0.797	0.605	0.381	0.375	—	—	970,300
	400	994	1.333	1.271	0.832	0.634	0.399	0.375	—	—	1,075,200
56	200	358	0.834	0.684	0.568	0.449	0.333	0.313	0.313	—	313,600
	220	441	0.917	0.747	0.623	0.491	0.375	0.375	0.375	—	379,400
	240	514	0.998	0.825	0.674	0.534	0.393	0.375	0.375	—	451,500
	260	596	1.074	0.921	0.723	0.577	0.422	0.375	0.375	—	529,900
	280	684	1.149	1.015	0.771	0.620	0.453	0.375	0.375	—	614,600
	300	777	1.222	1.107	0.821	0.662	0.483	0.375	0.375	—	705,600
	320	875	1.295	1.197	0.869	0.703	0.512	0.375	0.375	—	802,800
	340	978	1.366	1.284	0.918	0.745	0.542	0.375	0.375	—	906,300
	360	1086	1.436	1.370	0.965	0.786	0.571	0.375	0.375	—	1,016,000
	380	1200	1.505	1.454	1.012	0.827	0.600	0.382	0.375	—	1,132,000
	400	1322	1.573	1.536	1.058	0.873	0.627	0.400	0.375	—	1,254,400
64	200	453	0.955	0.801	0.687	0.567	0.449	0.333	0.313	0.313	358,400
	220	556	1.051	0.884	0.752	0.622	0.491	0.375	0.375	0.375	433,600
	240	653	1.146	0.994	0.812	0.677	0.533	0.393	0.375	0.375	516,000
	260	759	1.235	1.102	0.872	0.731	0.575	0.423	0.375	0.375	605,600
	280	872	1.321	1.208	0.933	0.786	0.617	0.453	0.375	0.375	702,400
	300	992	1.406	1.311	0.994	0.839	0.658	0.483	0.375	0.375	806,400
	320	1119	1.490	1.413	1.053	0.893	0.699	0.513	0.375	0.375	917,500
	340	1252	1.573	1.512	1.112	0.946	0.740	0.543	0.375	0.375	1,035,700
	360	1394	1.655	1.610	1.170	1.007	0.779	0.572	0.375	0.375	1,161,200
	380	1543	1.735	1.705	1.228	1.071	0.817	0.601	0.382	0.375	1,293,800
	384	1574	1.751[a]	1.724	1.240	1.083	0.824	0.607	0.385	0.375	1,321,200

[a] Exceeds maximum allowed material thickness.