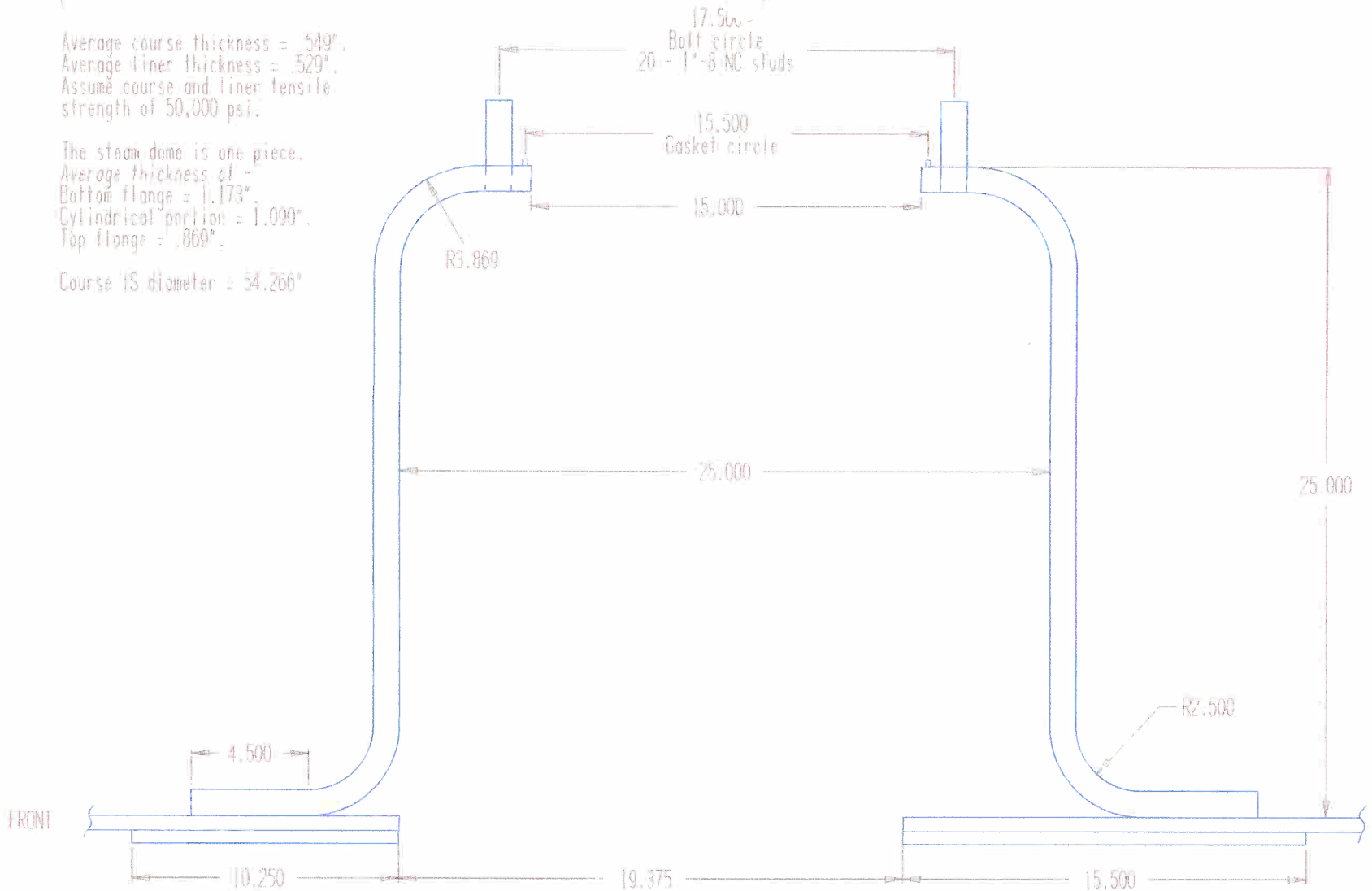
Average course thickness = .549".
Average liner thickness = .529".
Assume course and liner tensile strength of 50,000 psi.

The steam dome is one piece.
Average thickness of -
Bottom flange = 1.173".
Cylindrical portion = 1.090".
Top flange = .869".

Course IS diameter = 54.266"



HYDRO. TEST TEMP: 70F-120F	HYDRO. TEST PRESSURE:	MATERIAL:		STRASBURG RAIL ROAD	
HEAT TREATMENT:				DESCRIPTION: Huckleberry Railroad #2 - Steam Dome	
WPS:	NDE:	TOLERANCE:	FINISH:	PART NAME: 2 dome	LAYOUT NAME: 1
	SCALE:	QUANTITY:	PAGE #: 01	DRAWN BY: RLM	DATE: 4/28/14

Min Thickness - for comparison only

Sta	Input	Name	Output	Unit	Comment
		t	.1999	in	minimum required thickness
	185.	P		psi	maximum allowable working pressure
	27.1800	D		in	outside diameter of cylinder
	12500.	S		psi	maximum allowable stress value of shell material at design temperature
	1.0000	E			efficiency
	.4000	y			temperature coefficient; 900F and below - y = 0.4
	0.0000	C			minimum allowance for threading and structural stability; 4" dia. nominal and above - C = 0
					ref. ASME SECTION I, 1998, PG-27
					t=(P*D)/(2*S*E+2*y*P)+C

ok @ 5/29/14
see new calc

Sta	Input	Name	Output	Unit	Comment
	185	P		psi	MAWP ref. ASME Sect. III, 1952, L-21
	50000.	TS		psi	tensile strength of plate (use 35,000 for welded long seam on old construction)
		t	.1850	in.	thickness of plate
	4.0000	FS			factor of safety
	1	E		percent/100	efficiency of longitudinal joint (use 1 for welded construction)
	12.5	R		in	inside radius of dome shell

ok @ 5/29/14

Sta	Input	Name	Output	Unit	Comment
		P	1090	psi	MAWP ref. ASME Sect. III, 1952, L-21
	50000.	TS		psi	tensile strength of plate (use 35,000 for welded long seam on old construction)
	1.0900	t		in.	thickness of plate
	4.0000	FS			factor of safety
	1	E		percent/100	efficiency of longitudinal joint (use 1 for welded construction)
	12.5	R		in	inside radius of dome shell

Sta	Input	Name	Output	Unit	Comment
	185	P		psi	MAWP ref. ASME Sect. I, 1971, PFT-31
	3.869	r		in.	outer radius of flange
	.809	t		in.	minimum required head thickness
	12.5	R		in.	inside radius of dome top
	12.5	H		in.	distance from center to inside surface of shell = R
		d	4.7583	in.	distance from shell on flanged head being the larger of d1 and d2 d=max(d1,d2)
		d1	4.7583	in.	distance from shell on flanged head d1=(80*t)/sqrt(P)
		d2	3.8690	in.	outer radius of flange knuckle or 8t, whichever is smaller d2=min(r,8*t)
		A	94.2823	sq. in.	area of flanged head to be stayed A=((4*(H-d)^2)/3)*sqrt((2*(R-d))/(H-d)-.608)
		AS	188.5645	sq in	area requiring stayed AS=A*2
		D	15.4948	in	diameter of area AS; If this is smaller than GD, no staying is needed D=sqrt(AS/pi())*2
	15.5	GD		in	diameter of gasket centerline
		msg	"Flange OK"		message indicating result of calculations
					If D<GD THEN msg ="Flange OK" ELSE msg ="Flange Too Thin"

OK 5/29/14
See new calc

If it is assumed that any part of the dome inside the gasket is not subject to pressure.

Sta	Input	Name	Output	Unit	Comment
	185	P		psi	MAWP ref. ASME Sect. I, 1971, PFT-31
	3.869	r		in.	outer radius of flange
	.869	t		in.	minimum required head thickness
	12.5	R		in.	inside radius of dome top
	12.5	H		in.	distance from center to inside surface of shell = R
		d	5.1112	in.	distance from shell on flanged head being the larger of d1 and d2 d=max(d1,d2)
		d1	5.1112	in.	distance from shell on flanged head d1=(80*t)/sqrt(P)
		d2	3.8690	in.	outer radius of flange knuckle or 8t, whichever is smaller d2=min(r,8*t)
		A	85.8825	sq. in.	area of flanged head to be stayed A=((4*(H-d)^2)/3)*sqrt((2*(R-d))/(H-d)-.608)
		AS	171.7650	sq in	area requiring stayed AS=A*2
		D	14.7884	in	diameter of area AS; If this is smaller than GD, no staying is needed D=sqrt(AS/pi())*2
	15.5	GD		in	diameter of gasket centerline
		msg	"Flange OK"		message indicating result of calculations
					If D<GD THEN msg ="Flange OK" ELSE msg ="Flange Too Thin"

If it is assumed that any part of the dome inside the gasket is not subject to pressure.

OK 5/29/14
see new calc

Sta	Input	Name	Output	Unit	Comment
	27.133	IR		in	largest inside radius of shell at dome opening
	4	FS			factor of safety
	185	WP		psi	working pressure
	50000	TS		psi	tensile strength of shell plate
	.8234	E			efficiency of shell; if opening is part of longitudinal seam use seam efficiency - else use 1.00
	.254	t1		in	flange thickness
	.375	t2		in	liner thickness
	19.375	L		in	opening in shell on longitudinal center line
	10.25	L1a		in	actual liner length in front of dome opening
	15.5	L2a		in	actual liner length in rear of dome opening
		L1	9.6875	in	liner length in front of dome opening within the limits of compensation allowed L1=min(L1a,.5*L)
		L2	9.6875	in	liner length in front of dome opening within the limits of compensation allowed L2=min(L2a,.5*L)
	2.5	R		in	inside radius of flange
	4.5	f		in	length of flange on horizontal portion on one side of dome
	.937	d		in	rivet hole diameter
		t	.4877	in	minimum shell thickness required for working pressure WP
		RA	2.0963	sq in	flange bend area allowed for compensation
		VA	-1.0119	sq in	vertical portion of flange allowed for compensation
		FA	1.81	sq in	horizontal portion of flange allowed for compensation
		LA	6.5629	sq in	liner area allowed for compensation
		MR	9.4491	sq in	area of shell material on longitudinal center line requiring compensation
		TC	9.4572	sq in	total compensation available MUST BE EQUAL TO OR GREATER THAN MR
					ref. ASME SECTION III, 1952, L-30
					RA=(((R+t1)^2*pi())-(R^2*pi()))/2
					VA=2*((t1*3*t1)-(t1*(t1+R)))

REVISED

Sta	Input	Name	Output	Unit	Comment
					FA=2*((f-d)*t1)
					LA=(L1*t2+L2*t2)-(2*d*t2)
					TC=LA+FA+VA+RA
					THE ASME ALLOWS.250" AS THE MINIMUM THICKNESS FOR NEW CONSTRUCTION.
					(NOTE THE LINER WAS REDUCED TO .375")
					THESE MINIMUMS ARE EXTREME AND CARE MUST BE TAKEN TO MONITOR THE OTHER
					COMPONENTS AS THEY WILL FAIL LONG BEFORE THIS MUCH WASTAGE TAKES PLACE.

St	Rule
*	t=(IR*FS*WP)/(TS*E)
*	MR=L*t
*	RA=(((R+t1)^2*pi())-(R^2*pi()))/2
*	VA=2*((t1*3*t1)-(t1*(t1+R)))
*	FA=2*((f-d)*t1)
*	LA=(L1*t2+L2*t2)-(2*d*t2)
*	TC=LA+FA+VA+RA
*	L1=min(L1a,.5*L)
*	L2=min(L2a,.5*L)

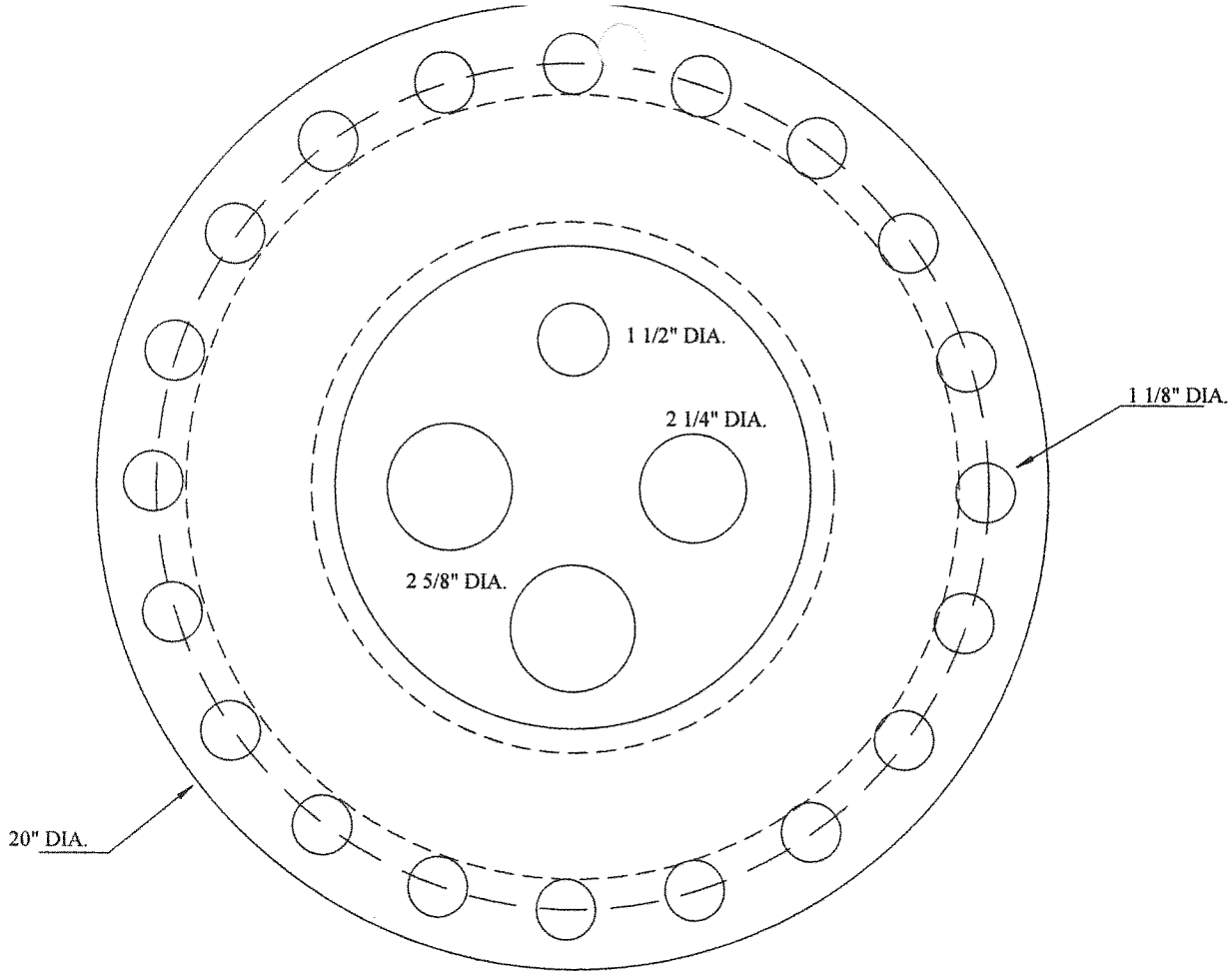
Sta	Input	Name	Output	Unit	Comment
	27.133	IR		in	largest inside radius of shell at dome opening
	4	FS			factor of safety
	185	WP		psi	working pressure
	50000	TS		psi	tensile strength of shell plate
	.8234	E			efficiency of shell; if opening is part of longitudinal seam use seam efficiency - else use 1.00
	1.173	t1		in	flange thickness
	.529	t2		in	liner thickness
	19.375	L		in	opening in shell on longitudinal center line
	10.25	L1a		in	actual liner length in front of dome opening
	15.5	L2a		in	actual liner length in rear of dome opening
		L1	9.6875	in	liner length in front of dome opening within the limits of compensation allowed L1=min(L1a,.5*L)
		L2	9.6875	in	liner length in front of dome opening within the limits of compensation allowed L2=min(L2a,.5*L)
	2.5	R		in	inside radius of flange
	4.5	f		in	length of flange on horizontal portion on one side of dome
	.937	d		in	rivet hole diameter
		t	.4877	in	minimum shell thickness required for working pressure WP
		RA	11.374	sq in	flange bend area allowed for compensation
		VA	-.3613	sq in	vertical portion of flange allowed for compensation
		FA	8.3588	sq in	horizontal portion of flange allowed for compensation
		LA	9.258	sq in	liner area allowed for compensation
		MR	9.4491	sq in	area of shell material on longitudinal center line requiring compensation
		TC	28.6296	sq in	total compensation available MUST BE EQUAL TO OR GREATER THAN MR
					ref. ASME SECTION III, 1952, L-30
					RA=(((R+t1)^2*pi())-(R^2*pi()))/2
					VA=2*((t1*3*t1)-(t1*(t1+R)))

REVISED

Sta	Input	Name	Output	Unit	Comment
					FA=2*((f-d)*t1)
					LA=(L1*t2+L2*t2)-(2*d*t2)
					TC=LA+FA+VA+RA

St	Rule
*	t=(IR*FS*WP)/(TS*E)
*	MR=L*t
*	RA=(((R+t1)^2*pi())-(R^2*pi()))/2
*	VA=2*((t1*3*t1)-(t1*(t1+R)))
*	FA=2*((f-d)*t1)
*	LA=(L1*t2+L2*t2)-(2*d*t2)
*	TC=LA+FA+VA+RA
*	L1=min(L1a,.5*L)
*	L2=min(L2a,.5*L)

Sta	Input	Name	Output	Unit	Comment
					Flat Dome Lid with openings
					ASME Section 1, 1971, PG-31, Section 8, Div. 1, 2-5, Flat Unstayed Heads
		Wm1	50885.8234	lbs	sum of bolt load under pressure + gasket tightness
		Wm2	113766.125	lbs	minimum required bolt load for gasket seating
	15.5	d		in.	diameter of gasket centerline
	185	P		psi	MAWP
	12500	y			factor for gasket material; use 13,000 for soft copper
	.187	b		in.	gasket seating width
	4.75	m		factor	gasket seating factor, Sect. VIII, 2-5, 4.75 for copper
		t	1.770	in.	dome cap thickness for design conditions
	.3	C		factor	Sect. I, Fig. PG-31 (j) & (k), = 0.3 for bolt circle outside the gasket
	12500	S		psi	stress value for design temperature
	1	hg		in.	gasket moment arm, radial distance between bolt circle centerline and gasket centerline
		t1	1.571	in.	dome cap thickness for gasket seating
		A	137786.58	lbs	total bolt load available at stress value of bolt material at design temperature
	20	n			number of bolts or studs
	.8377	rd		in.	root diameter of bolts or studs
	12500	S1		psi	stress value at atmospheric temperature
	12500	S3		psi	stress value of bolt material at design temperature
	0	P1		psi	pressure for gasket seating only = 0
		W	125776.353	lbs	average of required bolt load (greater of Wm1 and Wm2) and bolt load available



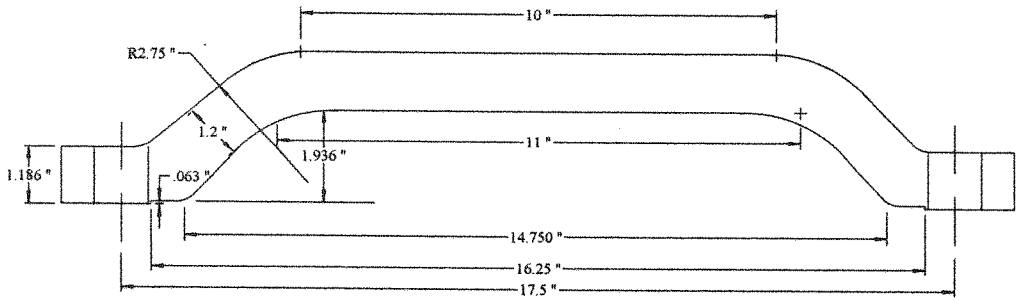
LID THICKNESS:

TOP FLAT SECTION, 1.216", 1.213", 1.208", 1.216".

DIAGONAL SECTION, 1.203", 1.225", 1.137".

FLANGE AT GASKET SEAT, 1.109", 1.064", 1.124", 1.108".

FLANGE AT BOLT CIRCLE, 1.120", 1.108", 1.118", 1.121".



HUCKLEBERRY RAILROAD 152

DOME LID

APRIL 2014