DATA SHEET
SMOKE TUBE BOILER

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PROJECT No.	SW6861-EQ1D-BDG-104
PROJECT NAME	W-SOOPE KOREA
ITEM No.	DMXR-1000PG
CODE	BS EN 12953 SHELL BOILERS
No. Req.d	8 SET
TYPE	FLUE TUBE-SMOKE TUBE BOILER
FLACE	■ INDOOR □ OUTDOOR
SIZE (mm)	4,220(W) x 4,670(H) x 7,990(L)
MAX. WATER VOLUME	24.5 m^3
EFF. WATER VOLUME	20.3 m^3
EMPTY WEIGHT	28.3 Ton

DESIGN DATA

CAPACITY	10 kg/hr
HEATING SURFACE	180 m^2
FLUID TYPE	STEAM
DESIGN PRESSURE	0.98 Mpa
OPERATING PRESSURE	0.3 ~ 0.8 Mpa
DESIGN TEMPERATURE	183.3 ℃
OPERATING TEMPERATURE	143.2 ~ 174.7 ℃
FUEL CONSUMPTION	650 Nm^3/hr
BOILER FEED WATER	44 ℃ (Economizer Outlet Temperature)
PROOF HYDROSTATIC TEST	2.12 Mpa
VOLUME OFF FIRE CHAMBER	9.4 m^3
RADIOGRAPHIC EXAMINATION	50%

BOILER PROPER

TYPE	SMOKE TUBE BOILER		
	Diameter (mm)	Thickness (mm)	Merterial
SHEEL	⌀ 2,700	t 16	SB410
SMOKE TUBE	⌀ 63.5	t 3.2	STBH340E
TUBE STAY	⌀ 63.5	t 5.0	STBH340E
BAR STAY	⌀ 45	-	SS275
FURNACE (Mirison)	⌀ 1336 x 5288L	t 16	SB410

SAFETY VALVE	SIZE	65A/50A	TYPE	FULL BORE	2EA

AIR PREHEATER

DESCRIPTION	SUPPLY SIDE	EXHAUST SIDE
KIND OF FLUID	FRESH AIR	WASTE GAS
FLOW RATE	10,485 Nm^3/hr	9,770 Nm^3/hr
PRESSURE DROP	57 mmAq	92 mmAq
INLET TEMPERATURE	40 ℃	193 ℃
OUTLET TEMPERATURE	74 ℃	164 ℃
HEAT DUTY	141,877 Kcal/hr	
EMPTY WEIGHT	1,100 kg	

FIN-TUBE SPECIFICATION	
FIN	O.D 50.6 x t0.7 x 11H x 9.3 FPI
TUBE (HEAT-PIPE)	O.D 27.2 x t2.8 x STPG38 #40
TUBE ARRANGEMENT	11STEP x 2ROW +10STEP x 2ROW = 42 TUBES
TUBE LAY-OUT	54 x 47 TRIANGULAR PITCH

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ECONOMIZER			
TYPE	HORIZONTAL		
FLOW RATE (WATER)	10,300 kg/hr		
FLOW RATE (WASTE GAS)	9,003 Nm^3/hr		
INLET TEMPERATURE(WATER)	20 ℃		
OUTLET TEMPERATURE(WATER)	44 ℃		
INLET TEMPERATURE(WASTE GAS)	164 ℃		
OUTLET TEMPERATURE(WASTE GAS)	90 ℃		
TYPE	ECONOMIZER		
	Diameter (mm)	Thickness (mm)	Merterial
ROLLING TUBE	⌀ 34	t 2.0	STS316LTB
DUCT	-	t 4.0	A240M-304
TUBE SHEET	-	t 7.0	A240-316L

AUXILIARY EQUIPMIENT			
BURNER TYPE	SBG-10F		
CAPACITY	8,000,000 Kcal/hr		
	CAPACITY	HEAD	POWER
FEED WATER PUMP - 2대	17.2 m^3/hr	127m	400V 50Hz
F.D FAN	240m^3 x 740mmAq x55kw		400V 50Hz

Thermal Design Calculation

Daeyeol Boiler R&D Center

2022. 03. 15.

W-SCOPE KOREA

Capacity	10.00	Ton/hr
Operation Load	100.00	%
Design Pressure	0.98	Mpa
Working Pressure	0.8	Mpa

Daeyeol Boiler Co., LTD.
Technical Research Center

Basic Design Data

Boiler Type	:	Twin Fire & Smoke Tube	
Waste Heat Recovery System	:	A/H & Eco	
Capacity	:	10.0000	Ton/hr
Design Pressure	:	0.98	Mpa
Operation Pressure	:	0.8	Mpa
Feed Water Temperature	:	20.0000	DegC
Blow Down	:	3.0000	%
Kind of Fuel	:	LNGS	
Lower Calorific Value	:	10000.0000	kcal/Nm3
Density	:	0.0000	kg/Nm3
Burner Inlet Temp	:	20.0000	DegC
O2 Vol % in Dry Gas	:	3.2000	%
Temp of Supply Air (FDF Inlet)	:	20.0000	DegC
Relative Humidity	:	70.0000	%
Velocity of Ambient Air	:	0.5000	m/s
Temp. Diff. (Outcasing-Air)	:	30.0000	DegC
Reference Temperature	:	20.0000	DegC

Dimension of Boiler

Drum InDiameter	:	2.7000	m
Drum Length	:	6.1080	m
Fire Tube InDiameter	:	1.3360	m
Smoke Tube Out Diameter	:	0.0635	m
Length	:	5.2880	m
Number	:	135	EA
Thickness	:	0.0032	m
Pitch	:	0.0870	m
Tube Stay Out Diameter	:	0.0635	m
Number	:	20	EA
Thickness	:	0.0050	m

Combustion Air

Vol. per Fuel Nm3	:	12.3564	Nm3/Nm3 F
Wt. per Fuel Nm3	:	15.8736	kg/Nm3 F
Total Air Flow Rate(Vol.)	:	8288.2524	Nm3/hr
(Wt.)	:	10647.4926	kg/hr

Combustion Gas (Include FGR)

Stoichiometric Dry Gas/Air	:	15.6315	Nm3/Nm3 F
Wt. per Fuel Nm3	:	19.4159	kg/Nm3 F
Total Flue Gas Flow Rate(Vol.)	:	10485.0953	Nm3/hr
(Wt.)	:	13023.5632	kg/hr

Flue Gas Recirculation

FGR Rate	:	14.1325	%
FGR Flow Rate (Vol.)	:	1481.8040	Nm3/hr
(Wt.)	:	1840.5524	kg/hr

================ Combustion Calculation ================

Furnace Geometry

Projected Heat Absorption Area	:	27.6461	m2
Effective Area Ratio	:	0.9447	
Effective Heat Absorption Area	:	26.1185	m2
Flame Chamber Volume	:	8.2180	m3

Thermal Calculation

Estimated Flame Surface Area	:	17.5161	m2
Emissivity of Flame	:	0.3058	
Emissivity of Furnace Wall	:	0.8000	
Total Heat Input To Furnace	:	7050311.27	kcal/hr
Heat Load in Furnace			
per Volume	:	857915.7357	kcal/m3-hr
per Projected Area	:	255020.4201	kcal/m2-hr
per Effective Area	:	269935.0402	kcal/m2-hr
Overall Radiation Coefficient	:	0.1823	
Adiabatic Flame Temperature	:	1791.81	DegC
Mean Flame Temperature	:	1577.83	DegC
Outlet Gas Temperature	:	1143.50	DegC
Total Heat Absorbed	:	2872612.12	kcal/hr

Gas Chamber Geometry

Projected Area In 1st Gas Chamber	:	10.7436	m2
Effective Area Ratio	:	1.0000	
Volume of Chamber	:	1.2429	m3
Surface Area of Gas	:	8.6199	m3

Thermal Calculation

Layer Thickness of Gas	:	0.4902	m2
Emissivity of Gas	:	0.1637	
Absorptivity of Gas	:	0.2871	
Emissivity of Wall	:	0.8000	
Overall Radiation Coefficient	:	0.2679	
Outlet Gas Temperature	:	1077.40	DegC
Total Heat Absorbed	:	285048.63	kcal/hr

================= Smoke Tube Calculation =================

Smoke Tube

Total Cooling Surface	:	163.4932	m2
Gas Flow Area	:	0.4908	m2
Gas Linear Velocity	:	5.9346	Nm/s
Gas Mass Velocity	:	7.3714	kg/m2-s
Mean Specific Heat of Gas	:	0.3014	kg/m2-s
Mean Temp. Difference	:	254.1373	DegC
Radiation Heat Transfer Coef.	:	3.1448	kcal/hr-m2-DegC
Convection Heat Transfer Coef.	:	80.0790	kcal/hr-m2-DegC
Fouling Factor	:	0.0001	hr-m2-DegC/kcal
Overall Heat Transfer Coef.	:	82.5368	kcal/hr-m2-DegC
Outlet Gas Temperature	:	203.69	DegC
Total Heat Absorbed	:	3429383.52	kcal/hr

================== Air PreHeater ==================

Flue Gas (Shell Side)

Fluid	:	Waste Gas	
Flow Rate	:	10485.10	Nm3/hr
	:	13023.56	kg/hr
Inlet Gas Temperature	:	203.69	DegC

Air + FGR (Shell Side)

Fluid	:	Combustion Gas	
Flow Rate	:	9770.06	Nm3/hr
	:	12488.04	kg/hr
Inlet Air Temperature	:	40.00	DegC

Heat Pipe Side

Working Fluid	:	Water	
Evaporation Heat Transfer rate	:	7738.61	kcal/hr m2 DegC
Condensation Heat Transfer rate	:	10318.14	kcal/hr m2 DegC
Working Ref. Temperature	:	100.00	DegC

Geometry Design Data

Flue Gas & Air (Shell Side)

Wide(Duct)	:	0.600000	m
Length(Duct)	:	0.454000	m
Flue Gas Length(Duct)	:	1.119000	m
Air Length(Duct)	:	1.159000	m

Heat Pipe & Fin (Tube Side)

Tube Out. Diameter	:	0.027200	m
Tube Thickness	:	0.002800	m
Tube In. Diameter	:	0.021600	m
Tube Tranvers Pitch	:	0.047000	m
Tube Longitudinal Pitch	:	0.054000	m
Flue Gas Side Pipe Length	:	1.119000	m
Air Side Pipe Length	:	1.159000	m
Heat Pipe Decline Angle	:	81.00	Deg
Fin Height	:	0.011000	m
Fin Thickness	:	0.000700	m
Fin Pitch	:	0.002730	m

Heat Pipe Row Num.	:	4	EA
1 No. Row Heat Pipe Num.	:	11	EA
2 No. Row Heat Pipe Num.	:	10	EA
3 No. Row Heat Pipe Num.	:	11	EA
4 No. Row Heat Pipe Num.	:	10	EA
Total Heat Pipe	:	42	EA

Heat Transfer Area per Row

1 Eva Heat Transfer Area	:	13.1740	m2/Row
2 Eva Heat Transfer Area	:	11.9764	m2/Row
3 Eva Heat Transfer Area	:	13.1740	m2/Row
4 Eva Heat Transfer Area	:	11.9764	m2/Row
Eva Total Heat Transfer Area	:	50.3009	m2
1 Con Heat Transfer Area	:	13.6450	m2/Row
2 Con Heat Transfer Area	:	12.4045	m2/Row
3 Con Heat Transfer Area	:	13.6450	m2/Row
4 Con Heat Transfer Area	:	12.4045	m2/Row
Con Total Heat Transfer Area	:	52.0990	m2

Thermal Calculation Result

Heat Pipe Side Working Temperature

1	No. Heat Pipe Work Temp.	146.92	DegC
2	No. Heat Pipe Work Temp.	135.70	DegC
3	No. Heat Pipe Work Temp.	125.73	DegC
4	No. Heat Pipe Work Temp.	114.37	DegC

Equipment Velocity

Evaporation Side Velocity

1	No. Eva. Velocity	18.8200	m/s
2	No. Eva. Velocity	16.1952	m/s
3	No. Eva. Velocity	18.0225	m/s
4	No. Eva. Velocity	15.4890	m/s

Condensation Side Velocity

1	No. Con. Velocity	12.6753	m/s
2	No. Con. Velocity	10.7822	m/s
3	No. Con. Velocity	11.8526	m/s
4	No. Con. Velocity	10.0546	m/s

Evaporation Side Heat Transfer

1	No. Eva. Heat Transfer	37621.2955	kcal/hr
2	No. Eva. Heat Transfer	32958.5418	kcal/hr
3	No. Eva. Heat Transfer	38027.5223	kcal/hr
4	No. Eva. Heat Transfer	33269.7832	kcal/hr

	Eva. Heat Transfer	141877.1427	kcal/hr

Condensation Side Heat Transfer

1	No. Con. Heat Transfer	37621.2955	kcal/hr
2	No. Con. Heat Transfer	32958.5418	kcal/hr
3	No. Con. Heat Transfer	38027.5223	kcal/hr
4	No. Con. Heat Transfer	33269.7832	kcal/hr

	Con. Heat Transfer	141877.1427	kcal/hr

Eva. HT Coeffi.

1	No. Eva. HT Coeffi.	62.1110	kcal/hr m2 DegC
2	No. Eva. HT Coeffi.	57.3986	kcal/hr m2 DegC
3	No. Eva. HT Coeffi.	61.2847	kcal/hr m2 DegC
4	No. Eva. HT Coeffi.	56.5986	kcal/hr m2 DegC

	Eva. Total Heat Transfer	70.3512	kcal/hr m2 DegC

Con. Heat Transfer

1	No. Con. HT Coeffi.	56.3247	kcal/hr m2 DegC
2	No. Con. HT Coeffi.	51.7107	kcal/hr m2 DegC
3	No. Con. HT Coeffi.	55.2928	kcal/hr m2 DegC
4	No. Con. HT Coeffi.	50.7153	kcal/hr m2 DegC

	Con. Total HT Coeffi.	59.2733	kcal/hr m2 DegC

Evaporation Side Temperature

1	No. Eva. In :	203.69	Out: 193.10	DegC
2	No. Eva. In :	193.10	Out: 183.79	DegC
3	No. Eva. In :	183.79	Out: 173.03	DegC
4	No. Eva. In :	173.03	Out: 163.60	DegC

Condensation Side Temperature

1	No. Con. In :	85.94	Out: 73.78	DegC
2	No. Con. In :	73.78	Out: 63.11	DegC
3	No. Con. In :	63.11	Out: 50.79	DegC
4	No. Con. In :	50.79	Out: 40.00	DegC

Evaporation Side Pressure Drop

1	No. Gas. Pressure Drop	:	26.7499	mmAq
2	No. Gas. Pressure Drop	:	20.2263	mmAq
3	No. Gas. Pressure Drop	:	25.6289	mmAq
4	No. Gas. Pressure Drop	:	19.3520	mmAq

Total Gas Pressure Drop	:	91.9571	mmAq

Condensation Side Pressure Drop

1	No. Air. Pressure Drop	:	16.7672	mmAq
2	No. Air. Pressure Drop	:	12.5260	mmAq
3	No. Air. Pressure Drop	:	15.6966	mmAq
4	No. Air. Pressure Drop	:	11.6922	mmAq

Total Air Pressure Drop	:	56.6820	mmAq

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Economizer Calculation
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Geometry

Tube Arrangement	:	Triangle	
Width	:	0.8480	m
Length	:	1.5240	m
Tube Length (Gas Flow)	:	0.9550	m
Tube Length (Real)	:	0.9550	m
Tube Length (Heating)	:	0.9550	m
No. of Tubes (In Width)	:	17.0	EA
No. of Tubes (In Length)	:	20.0	EA
Parallel Tube Pass	:	1	pass
Tube Diameter	:	0.0340	m
Tube Thickness	:	0.0020	m
Tube Pitch in Width	:	0.0460	m
Tube Pitch in Length	:	0.0650	m
Header Size (Equal Velocity)	:	0.1237	m
Total Heating Area(Out)	:	34.6826	m2

Thermal Calculation

Shell Side (Gas)

Flow Rate	:	9003.29	Nm3/hr
Inlet Temperature	:	163.60	Deg C
Outlet Temperature	:	79.98	Deg C
Velocity	:	9.70	Nm/s
Fouling Factor	:	0.000500	m2-hr-C/kcal
Film Heat Transfer Coefficient	:	93.38	kcal/m2-hr-C

Tube Side (Water)

Flow Rate	:	10300.00	kg/hr
Inlet Temperature	:	20.00	Deg C
Enthalpy	:	20.24	kcal/kg
Outlet Temperature	:	44.41	Deg C
Enthalpy	:	44.59	kcal/kg
Velocity	:	0.24	Nm/s
Fouling Factor	:	0.000100	m2-hr-C/kcal
Film Heat Transfer Coefficient	:	968.59	kcal/m2-hr-C
Log Mean Temp Diff	:	86.22	Deg C
Corrected Log Mean Temp Diff	:	85.89	Deg C
Overall Heat Transfer Coeffi	:	93.38	kcal/m2-hr-C
Total Heat Absorbed	:	250763.04	kcal/hr
Total Pressure Drop (Gas)	:	75.65	mmAq
Total Pressure Drop (Water)	:	204.26	mmAq

The Wall Temperature of Tube

Gas Inlet Side Wall Tube	:	55.46	Deg C
Gas Middle Side Wall Tube	:	40.62	Deg C
Gas Outlet Side Wall Tube	:	25.78	Deg C
Flue Gas Dew Point	:	57.45	Deg C

DMXR-1000PG

Strength calculation of Boiler

DESIGN DATA

TYPE	FLUE TUBE-SMOKE TUBE BOILER				
CAPACITY	10.0	T/H	HEATING SURFACE	180	㎡
Applied specification	BS EN 12953 SHELL BOILERS				
SECTION	SHELL		SECTION	SHELL	
Fluid type	STEAM		Post weld heat treatment	YES	
Design pressure	0.98	Mpa	Radiographic examination	50	%
Normal pressure	0.3 - 0.8	Mpa	Joint efficiency of welding	100	%
Design temperature	183.3	℃	Corrosion allowance	1	㎜
Normal temperature	143.2 - 174.7	℃			
Proof hydrostatic test	2.12	Mpa			

Structural specification of flue tube-smoke tube boiler

Maker			Daeyeol boiler co., ltd			Model		DMXR-1000PG				
Design pressure			0.98 Mpa			Capacity		10.0 T/H				
Heating surface			180 (㎡)									
STRUCTURAL OF BOILER	Item		Material	Shape		Maximum Inside diameter		Length & radius		Thickness		
	Shell plate		SB410	Cylinder type		2700	(㎜)	5900	(㎜)	16	(㎜)	
	End plate		SB410	Flat type		2688	(㎜)	126 / R66	(㎜)	22	(㎜)	
	Furnace	Flat					(㎜)		(㎜)		(㎜)	
		Corrugated	SB410	Morison		1336	(㎜)	5288	(㎜)	16	(㎜)	
		End plate					(㎜)		(㎜)		(㎜)	
	1st tube	Fire tube	STB340(E)	Outside diameter		63.5	(㎜)	135	EA	3.2	(㎜)	
		Stay tube	STB340(E)	Outside diameter		63.5	(㎜)	20	EA	5	(㎜)	
	2nd tube	Fire tube					(㎜)		EA		(㎜)	
		Stay tube					(㎜)		EA		(㎜)	
	Joint type of Shell		Joint efficiency	100 %		Joint type		V butt joint				
	Stay type		Material	Outside diameter or width				Thickness		Quantity		
	Gusset stay		SB410	199/346			(㎜)	19	(㎜)	4/4		
	Tube stay		STB340(E)	63.5			(㎜)	5	(㎜)	20		
	Bar stay		SS275	45			(㎜)		(㎜)	35		
	Hole		Manhole	420-320	(㎜)	1	EA	Water level (from top)				
			Cleaning Hole	210-150 /	(㎜)	2/	EA	Low water level	577	(㎜)		
			Inspection hole	160-95 /	(㎜)	6/	EA	Normal water level	477	(㎜)		
	Safety valve		Type	Spring type	Type	Full bore type	Size	65A / 50A	Quantity	1 / 1		
	Water level indicating instrument		Type	Reflex type water gauge					Quantity	2		

Heating surface calculation of flue tube-smoke tube boiler

Description	Calculation
· Corrugated furnace	$\pi \cdot D_1 \cdot L_1 = \pi \times 1.336 \times 5.288 = 22.19$ ㎡
· Plain cylindrical furnace	$\pi \cdot D_2 \cdot L_2 =$
· End plate of furnace	$\frac{\pi}{4} \cdot d^2 =$
Sub total	**22.19**
· 1st smoke tube	$\pi \cdot d_1 \cdot L_1 \cdot n = \pi \times 0.0571 \times 5.288 \times 135 = 128.06$ ㎡
· 1st stay tube	$\pi \cdot d_1 \cdot L_1 \cdot n = \pi \times 0.0535 \times 5.288 \times 20 = 17.78$ ㎡
Sub total	**145.84**
· 2nd smoke tube	$\pi \cdot d_2 \cdot L_2 \cdot n =$
· 2nd stay tube	$\pi \cdot d_2 \cdot L_2 \cdot n =$
Sub total	
· Others	· Front end plate of shell or front plate of firebox $\frac{\pi}{4} \times 2.48^2 \times 0.5 + ((1.24 \times 0.607) + (2 \times (1.24^2 \times \frac{29.3}{360} \times \pi)))$ $- \frac{\pi}{4} \times 0.0635^2 \times 155 - \frac{\pi}{4} \times 1.368^2 = 1.897 \times 2 =$ **3.79**
· Firebox	Circumference plate of firebox : $0.506 \times 2.1626 + 0.506 \times 5.164 = 3.71$ ㎡ Rear plate of firebox : $\frac{\pi}{4} \times 2.48^2 \times 0.5 + ((1.24 \times 0.607) + (2 \times (1.24^2 \times \frac{29.3}{360} \times \pi)))$ $+ \pi \times 0.4 \times 0.292 - \frac{\pi}{4} \times 0.4^2 =$ **4.10**
Total	22.19 + 145.84 + 3.79 + 3.71 + 4.10 = **180 ㎡**

FLUE TUBE-SMOKE TUBE BOILER

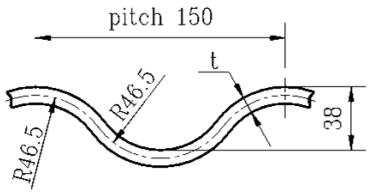
Minimum thickness calculation of shell

DESCRIPTION \ ITEM			NO. 1
Design pressure	P	Mpa	0.98
Inside diameter	D	㎜	2700
Allowable tensile stress	δa	㎏/㎟	102
Material	-	-	SB410
Joint efficiency of welding	η	-	1
K (chart 4.1)	K	-	0.4
Corrosion allowance	α	㎜	1
$tr = \frac{PD}{2\delta a\eta - 2P(1-K)} + \alpha$			$\frac{0.98 \times 2700}{2 \times 102 \times 1 - 2 \times 0.98 \times (1 - 0.4)} + 1$
Calculation thickness	tr	㎜	14.05
When efficiency 1 (η=1)	th	㎜	14.05
Normal dimension	t	㎜	16
Tolerance limits(-) of thickness	-	㎜	0.25
Actual Thickness	tn	㎜	15.75
Minimum thickness	tm	㎜	12
Examination	tn≥tr		15.75 ≥ 14.05
	t≥tm		16 ≥ 12

Minimum thickness calculation of corrugated furnace

DESCRIPTION \ ITEM			NO. 3
Design pressure	P	Mpa	0.98
Material	–	–	SB410
Inside diameter	D_0	mm	1336
Averaged inside diameter	D	mm	1322
Shape of corrugated furnace	–	–	MORISON
Shape factor	C	–	1100
$tr = \frac{10PD}{C}$			$\frac{10 \times 0.98 \times 1322}{1100}$
Calculation thickness	tr	mm	11.8
Normal dimension	t	mm	16
Tolerance limits(–) of thickness	–	mm	0.25
Manufacture allowance	–	mm	0.5
Actual Thickness	tn	mm	15.25
Examination	tn ≥ tr		15.25 ≥ 11.8
	22mm ≥ t ≥ 8mm		22 ≥ 16 ≥ 8

The average diameter of the furunace is a morrison type, and the minimum inner diameter is 50mm



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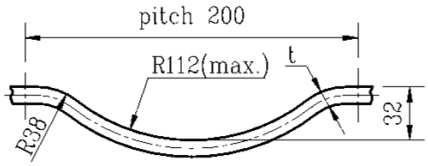
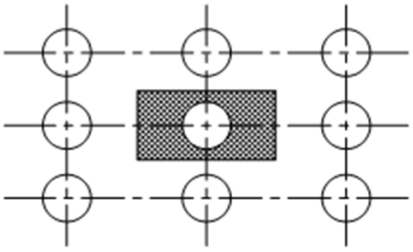


MORISON TYPE

Strength calculation of bar stay

DESCRIPTION \ ITEM			A10
Design pressure	P	Mpa	0.98
Support Total area of bar stay	A	㎟	92604
Diameter of bar stay	d	㎜	45
$S = \frac{\pi}{4} d^2$			$\frac{\pi}{4} \times 45^2$
Sectional area of bar stay	S	㎟	1590
A Exclusion area	a	㎟	1590
Support area of bar stay	A − a	㎟	91014
$\delta s = \frac{(A-a)P}{S}$			$\frac{91014 \times 0.98}{1590}$
Support stress of bar stay	δs	㎏/㎟	56.1
Maximum distance of point	D	㎜	437
$b = \frac{D}{d}$			$\frac{437}{45}$
Distance multiple	b	−	9.7
Allowable tensile stress	δa	N/㎟	72
Examination	δa ≥ δs		72 ≥ 56.1

*The valve of the stay support area minus the hole



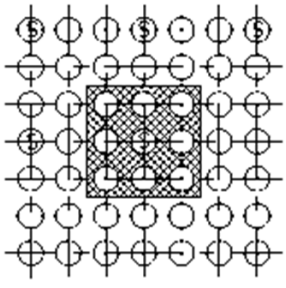
**Allowavle tensile stress according to distance multiplier

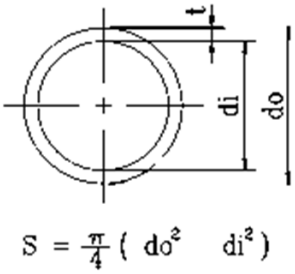
ITEM	Maximum distance of points is less than 120-times the diameter	Maximum distance of points is exc-eeds than 120 -times the diameter
Bar stay 38mm or less	66	59
Bar stay diameter over 38mm	72	62

Strength calculation of tube stay

DESCRIPTION \ ITEM			A9
Design pressure	P	Mpa	0.98
Support Total area of tube stay	A	㎟	51651
A Exclusion area	a	㎟	8579
Support area of tube stay	A − a	㎟	43072
$S = \frac{2(A-a)P}{100}$			$\frac{2 \times 43072 \times 0.98}{100}$
Sectional area of tube stay	S	㎟	844
Normal dimension	t	㎜	5.0
Outside diameter of tube stay	d_0	㎜	63.5
Inside diameter of tube stay	di	㎜	53.5
$Sa = \frac{\pi}{4}(d_0^2 - di^2)$			$\frac{\pi}{4}(63.5^2 - 53.5^2)$
Actual sectional area of tube stay	Sa	㎟	918.9
Examination	Sa ≥ S		918.9 ≥ 844.2
	t ≥ 4		5 ≥ 4

* The value minus the hole part from the stay support area.

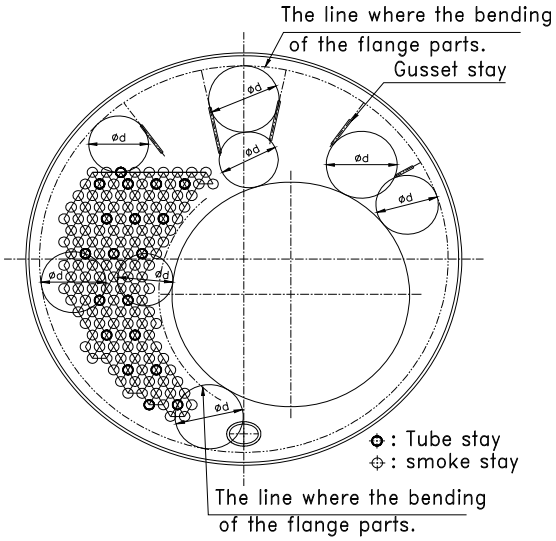




$S = \frac{\pi}{4}(do^2 \quad di^2)$

Strength calculation of end plate

DESCRIPTION \ ITEM			℄ A	℄ B	℄ C	℄ D
Design pressure	P	Mpa	0.98	0.98	0.98	0.98
Material	–	–	SB410	SB410	SB410	SB410
Diameter of fixation circle	b	mm	512	535	325	382
Point factor value	c	–	3190	3190	2550	2763
$tr = d\sqrt{\frac{10P}{2c}}$			$512\sqrt{\frac{10 \times 0.98}{2 \times 3190}}$	$535\sqrt{\frac{10 \times 0.98}{2 \times 3190}}$	$325\sqrt{\frac{10 \times 0.98}{2 \times 2550}}$	$382\sqrt{\frac{10 \times 0.98}{2 \times 2763.3}}$
Calculation thickness	tr	mm	20.07	20.97	14.25	16.09
Normal dimension	t	mm	22	22	22	22
Tolerance limits(–) of thickness	–	mm	0.25	0.25	0.25	0.25
Actual Thickness	tn	mm	21.75	21.75	21.75	21.75
Examination	tn ≥ tr		21.75 ≥ 20.07	21.75 ≥ 20.97	21.75 ≥ 14.25	21.75 ≥ 16.09
	t ≥ *tm		22 ≥ 14	22 ≥ 14	22 ≥ 14	22 ≥ 14



* Minimum thickness of tube plate is based on the following values.

SECTION	O.D	MIN. THICKNESS
TUBE PLATE	1350 Minimum	10
	1350 ~ 1850	12
	1850 Maximum	14
SMOKE TUBE	38 ~ 102	$5 + \frac{d0}{10}$

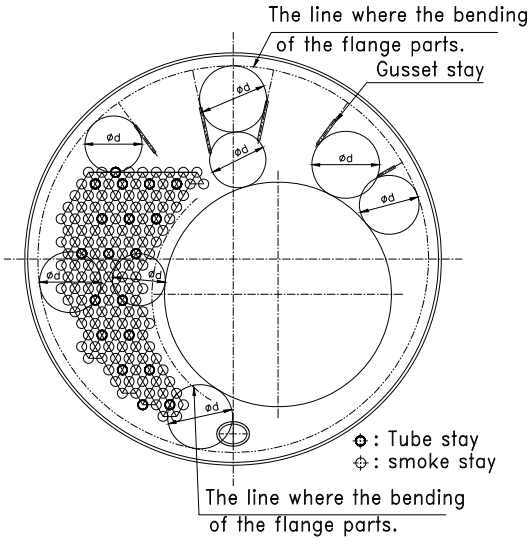
* d0 maximum of smoke tube.

* Horizontal smoke tube boilers for outside combustion a manhole must be installed in the lower part of the front end plate.

(Only, if the minimum of 1200mm or there is a gap of 230mm or more in the center it means that there is a obround opening.)

Strength calculation of end plate

DESCRIPTION \ ITEM			℄ E	℄ F	℄ G	℄ H
Design pressure	P	Mpa	0.98	0.98	0.98	0.98
Material	–	–	SB410	SB410	SB410	SB410
Diameter of fixation circle	b	mm	494	482	407	437
Point factor value	c	–	2977	2937	2683	2430
$tr = d\sqrt{\frac{10P}{2c}}$			$494\sqrt{\frac{10 \times 0.98}{2 \times 2977}}$	$482\sqrt{\frac{10\ \ 0.98}{2 \times 2937}}$	$407\sqrt{\frac{10 \times 0.98}{2 \times 2683}}$	$437\sqrt{\frac{10 \times 0.98}{2 \times 2430}}$
Calculation thickness	tr	mm	20.04	19.69	17.39	19.62
Normal dimension	t	mm	22	22	22	22
Tolerance limits(–) of thickness	–	mm	0.25	0.25	0.25	0.25
Actual Thickness	tn	mm	21.75	21.75	21.75	21.75
Examination	tn ≥ tr		21.75 ≥ 20.04	21.75 ≥ 19.69	21.75 ≥ 17.39	21.75 ≥ 19.62
	t ≥ *tm		22 ≥ 14	22 ≥ 14	22 ≥ 14	22 ≥ 14



* Minimum thickness of tube plate is based on the following values.

SECTION	O.D	MIN. THICKNESS
TUBE PLATE	1350 Minimum	10
	1350 ~ 1850	12
	1850 Maximum	14
SMOKE TUBE	38 ~ 102	$5 + \frac{d0}{10}$

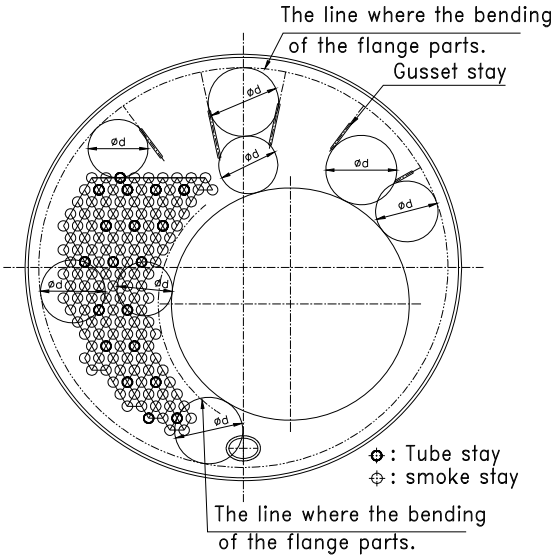
* d0 maximum of smoke tube.

* Horizontal smoke tube boilers for outside combustion a manhole must be installed in the lower part of the front end plate.

(Only, if the minimum of 1200mm or there is a gap of 230mm or more in the center it means that there is a obround opening.)

Strength calculation of end plate

DESCRIPTION \ ITEM			₡ I			
Design pressure	P	Mpa	0.98			
Material	–	–	SB410			
Diameter of fixation circle	b	㎜	460			
Point factor value	c	–	2683			
$tr = d\sqrt{\frac{10P}{2c}}$			$460\sqrt{\frac{10 \times 0.98}{2 \times 2683.3}}$			
Calculation thickness	tr	㎜	19.66			
Normal dimension	t	㎜	22			
Tolerance limits(–) of thickness	–	㎜	0.25			
Actual Thickness	tn	㎜	21.75			
Examination	tn ≥ tr		21.75 ≥ 19.66			
	t ≥ *tm		22 ≥ 14			



* Minimum thickness of tube plate is based on the following values.

SECTION	O.D	MIN. THICKNESS
TUBE PLATE	1350 Minimum	10
	1350 ~ 1850	12
	1850 Maximum	14
SMOKE TUBE	38 ~ 102	$5 + \frac{d0}{10}$

* d0 maximum of smoke tube.

* Horizontal smoke tube boilers for outside combustion a manhole must be installed in the lower part of the front end plate.

(Only, if the minimum of 1200mm or there is a gap of 230mm or more in the center it means that there is a obround opening.)

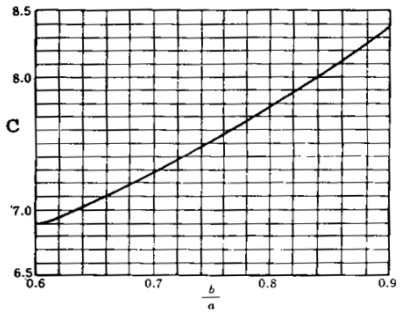
Minimum pitch of smoke tube

DESCRIPTION \ ITEM			
Diameter of tube hole	d	mm	64.5
Thickness of end plate	t	mm	22
$P = \left(1 + \frac{4.5}{t}\right) \times d$			$\left(1 + \frac{4.5}{22}\right) \times 64.5$
Minimum hole pitch of smoke tube	P	mm	77.7
Pitch of actual hole	P'	mm	87
Examination	$P' \geq P$		$87 \geq 77.7$

Minimum thickness of hole cover

DESCRIPTION \ ITEM			(MANHOLE) NO. 17	(ICLEANING HOLE) NO. 23
Design pressure	P	Mpa	0.98	0.98
Long diameter of hole	a	㎜	420	210
Short diameter of hole	b	㎜	320	150
Material	–	–	SB410	SB410
Allowable tensile stress	δa	㎏/㎟	102	102
Shape factor	c	–	7.6	7.3
$tr = \frac{b}{2c}\sqrt{\frac{100 \times P}{\delta a}}$			$\frac{320}{2 \times 7.6}\sqrt{\frac{100 \times 0.98}{102}}$	$\frac{150}{2 \times 7.3}\sqrt{\frac{100 \times 0.98}{102}}$
Calculation thickness	tr	㎜	20.7	10.0
Normal dimension	t	㎜	22	16
Tolerance limits(−) of thickness	–	㎜	0.25	0.25
Actual Thickness	tn	㎜	21.75	15.75
Examination	tn ≥ tr		21.75 ≥ 20.7	15.75 ≥ 10.0
	t >**tm		22 > 14	16 > 14
	***tn > $\frac{2}{3}$ tr		21.75 > 13.8	15.75 > 6.7

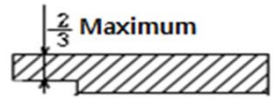
*Shape factor



b / a = 1 The shape factor can be ste to 9.

** The minimum thickness of the manhole cover is 14mm.

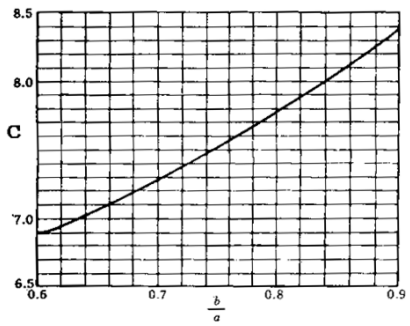
*** When specutt is installed.



Minimum thickness of hole cover

DESCRIPTION \ ITEM			(INSPECTION HOLE) NO. 26	
Design pressure	P	Mpa	0.98	
Long diameter of hole	a	㎜	160	
Short diameter of hole	b	㎜	95	
Material	–	–	SB410	
Allowable tensile stress	δa	㎏/㎟	102	
Shape factor	c	–	6.9	
$tr = \frac{b}{2c}\sqrt{\frac{100 \times P}{\delta a}}$			$\frac{95}{2 \times 6.9}\sqrt{\frac{100 \times 0.98}{102}}$	
Calculation thickness	tr	㎜	6.7	
Normal dimension	t	㎜	16	
Tolerance limits(−) of thickness	–	㎜	0.25	
Actual Thickness	tn	㎜	15.75	
Examination	tn ≥ tr		15.75 ≥ 6.7	
	t > **tm		16 > 14	
	***tn > $\frac{2}{3}$ tr		15.75 > 4.5	

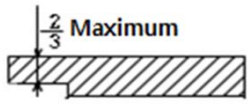
*Shape factor

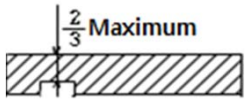


b / a = 1 The shape factor can be ste to 9.

** The minimum thickness of the manhole cover is 14mm.

*** When specutt is installed.





Minimum thickness of smoke tube

DESCRIPTION \ ITEM			NO. 16
Design pressure	P	Mpa	0.98
Material	–	–	STB340(E)
Outside diameter of smoke tube	d_0	㎜	63.5
$tr = \frac{P \cdot d_0}{70} + 1.5$			$\frac{0.98 \times 63.5}{70} + 1.5$
Calculation thickness	tr	㎜	2.4
Minimum thickness	tm	㎜	2.6
Normal dimension	t	㎜	3.2
Tolerance limits(–) of thickness	–	㎜	
Actual Thickness	tn	㎜	3.2
Examination	tn ≥ tr		3.2 ≥ 2.4
	t ≥ tm		3.2 ≥ 2.6

* If the outer diameter of the smoke tube exceeds 150mmm follow the formula for calcuating the thickness of the flue tube.

Water nozzle and minimum outside diameter 127mm water pipe

DESCRIPTION \ ITEM			FEED WATER NOZZLE SPPS250(E) 50A #40	STEAM NOZZLE SPPS250(E) 200A #40
Design pressure	P	Mpa	1.23	0.98
Outside diameter of pipe	d_0	㎜	60.5	216.3
Material	–	–	SPPS250(E)	SPPS250(E)
Allowable tensile stress	δa	㎏/㎟	87	87
Welding joint efficiency of length direction	η	–	0.85	0.85
Value K	K	–	0.4	0.4
Corrosion allowance	α	㎜	1	1
$tr = \frac{P\,d_0}{2\delta a\eta+2PKP} + \alpha$			$tr = \frac{P\,d_0}{2\delta a\eta+2PKP} + \alpha$	
Calculation thickness	tr	㎜	1.50	2.43
When efficiency 1 (η=1)	tsr	㎜	1.42	2.21
Normal dimension	t	㎜	3.9	8.2
Tolerance limits(–) of thickness	–	㎜	0.39	0.82
Actual Thickness	tn	㎜	3.51	7.38
Minimum thickness	tm	㎜	2.9	4.0
Examination	tn ≥ tr		3.51 ≥ 1.50	7.38 ≥ 2.43
	t > tm		3.9 > 2.9	8.20 > 4.00

* 1. At least 0.7Mpa for steam nozzle

2. For feed water nozzle and drain nozzle design pressure x 1.25 or the lesser of 1.5Mpa plus pressure.

(At least 0.7Mpa)

**Joint efficiency seamlessnozzle : 1 , electric resistance welding nozzle : 0.85 , butt-welded nozzle : 0.65

Water nozzle and minimum outside diameter 127mm water pipe

DESCRIPTION \ ITEM			DRAIN NOZZLE SPPS250(E) 50A #40	
Design pressure	P	kg/㎠	1.23	
Outside diameter of pipe	d_0	㎜	60.5	
Material	–	–	SPPS250(E)	
Allowable tensile stress	δa	kg/㎟	87	
Welding joint efficiency of length dire	η	–	0.85	
Value K	K	–	0.4	
Corrosion allowance	α	㎜	1	
$tr = \frac{P\,d_0}{2\delta a\eta+2PKP} + \alpha$			$tr = \frac{P\,d_0}{2\delta a\eta+2PKP} + \alpha$	
Calculation thickness	tr	㎜	1.50	
When efficiency 1 (η=1)	tsr	㎜	1.42	
Normal dimension	t	㎜	3.9	
Tolerance limits(–) of thickness	–	㎜	0.39	
Actual Thickness	tn	㎜	3.51	
Minimum thickness	tm	㎜	2.9	
Examination	tn ≥ tr		3.51 ≥ 1.50	
	t > tm		3.9 > 2.9	

* 1. At least 0.7Mpa for steam nozzle

2. For feed water nozzle and drain nozzle design pressure x 1.25 or the lesser of 1.5Mpa plus pressure.

(At least 0.7Mpa)

**Joint efficiency seamlessnozzle : 1 , electric resistance welding nozzle : 0.85 , butt-welded nozzle : 0.65

Minimum outside diameter 127mm economizer tube

DESCRIPTION \ ITEM			ECONOMIZER TUBE	
Design pressure	P	Mpa	0.98	
Outside diameter of pipe	d_0	㎜	34	
Material	–	–	STS316LTB	
Allowable tensile stress	δa	N/㎟	87.0 (150℃)	
Corrosion allowance	α	–	1.0	
$tr = \frac{P\,d_0}{2\delta a+P} + 0.005do+\alpha$			$tr = \frac{P\,d_0}{2\delta a+P} + 0.005do+\alpha$	
Calculation thickness	tr	㎜	1.36	
Normal dimension	t	㎜	2	
Tolerance limits(–) of thickness	–	㎜	–	
Actual Thickness	tn	㎜	2.00	
Minimum thickness	tm	㎜	2.0	
Examination	tn ≥ tr		2.00 ≥ 1.36	
	t ≥tm		2.0 ≥ 2.0	

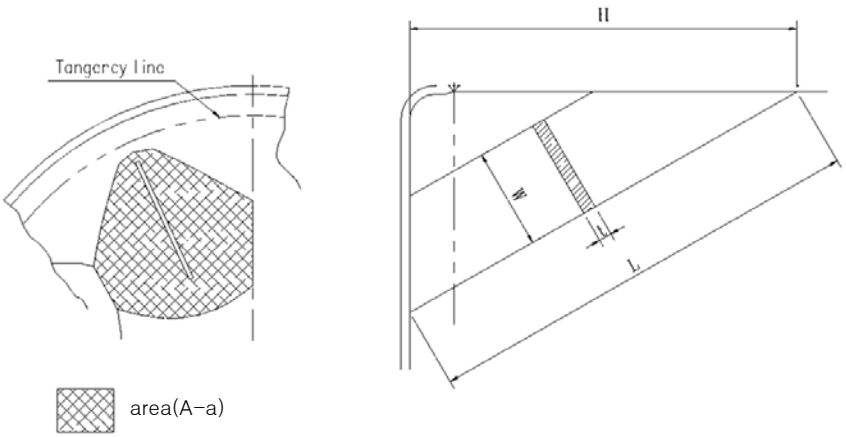
When the internal fluid dissipares heat, internal fluid(minimum saturation tenperature) is applied.

Tube outside diameter (mm)	Thickness (mm)
38.1 or less	2.0
More than 38.1 and less than 50.8	2.3
More than 50.8 and less than76.2	2.6
More than 76.2 and less than101.6	3.2
More than 101.6 and less than127	3.5

Strength calculation of gusset stay

DESCRIPTION \ ITEM			A1 4	A2 5	A3 5	A4 4
Design pressure	P	Mpa	0.98	0.98	0.98	0.98
Support Total area of stay	A	㎟	148522	232996	249084	177752
A Exclusion area	a	㎟	4370	7600	7600	4370
Stay support area	A-a	㎟	144152	225396	241484	173382
Material	-	-	SB410	SB410	SB410	SB410
Allowable tensile stress	δa	N/㎟	102	102	102	102
Stay length	L	㎜	641	1218	1218	641
Flat portion length of stay	H	㎜	740	1055	1055	740
$S = \frac{1.1P\,(A-a)L}{0.8\delta a \cdot H}$			$\frac{1.1\times0.98\times144152\times641}{0.8\times102\times740}$	$\frac{1.1\times0.98\times225396\times1218}{0.8\times102\times1055}$	$\frac{1.1\times0.98\times241484\times1218}{0.8\times102\times1055}$	$\frac{1.1\times0.98\times173382\times641}{0.8\times102\times740}$
Necessary sectional area	S	㎟	1650	3438	3683	1984
Stay width	W	㎜	199	346	346	199
Stay thickness	t	㎜	19	19	19	19
Sa = W × t			199×19	346×19	346×19	199×19
Actual sectional area of stay	Sa	㎟	3781	6574	6574	3781
Examination	Sa ≥ S		3781 ≥ 1650	6574 ≥ 3438	6574 ≥ 3683	3781 ≥ 1984

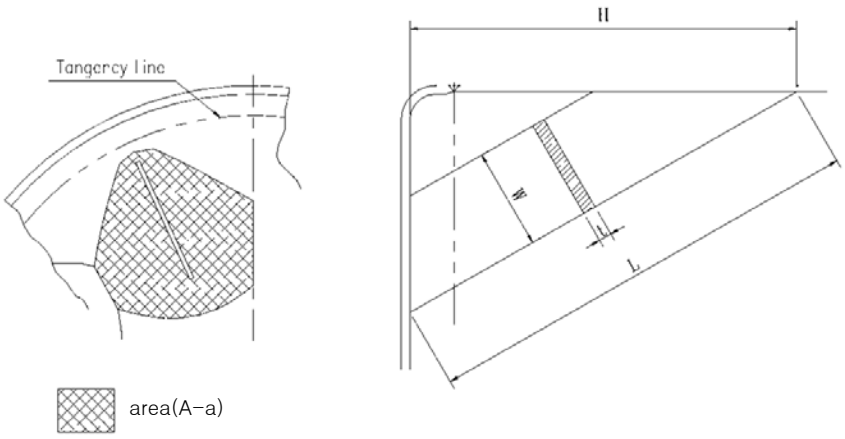
The stage area minus the stay attachment part



Strength calculation of gusset stay

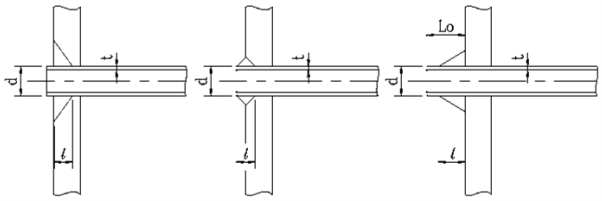
ITEM / DESCRIPTION			A5 4	A6 5	A7 5	A8 4
Design pressure	P	Mpa	0.98	0.98	0.98	0.98
Support Total area of stay	A	㎟	142614	250317	234791	137671
A Exclusion area	a	㎟	4370	7600	7600	4370
Stay support area	A-a	㎟	138244	242717	227191	133301
Material	-	-	SB410	SB410	SB410	SB410
Allowable tensile stress	δa	N/㎟	102	102	102	102
Stay length	L	㎜	641	1218	1218	641
Flat portion length of stay	H	㎜	740	1055	1055	740
$S = \frac{1.1P\,(A-a)L}{0.8\delta a \cdot H}$			$\frac{1.1\times0.98\times138244\times641}{0.8\times102\times740}$	$\frac{1.1\times0.98\times242717\times1218}{0.8\times102\times1055}$	$\frac{1.1\times0.98\times227191\times1218}{0.8\times102\times1055}$	$\frac{1.1\times0.98\times133301\times641}{0.8\times102\times740}$
Necessary sectional area	S	㎟	1582	3702	3465	1525
Stay width	W	㎜	199	346	346	199
Stay thickness	t	㎜	19	19	19	19
Sa = W × t			199×19	346×19	346×19	199×19
Actual sectional area of stay	Sa	㎟	3781	6574	6574	3781
Examination	Sa ≥ S		3781 ≥ 1582	6574 ≥ 3702	6574 ≥ 3465	3781 ≥ 1525

The stage area minus the stay attachment part



Welding portion Examination of stay

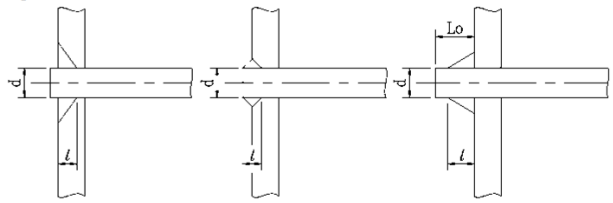
Tube stay



Sign	Title	Dimensions	Sign	Title	Dimensions
d	Ouside diameter	63.5 mm	t	Stay thickness	5 mm
ℓ	Effective throat thickness	8 mm	s	Minimum sectional area	844 mm
L_0	Projection Length	8 mm			

Calculation	Examination
ℓ ≥ t	8 ≥ 5
10 ≥ L_0 ≥ 0	10 ≥ 8 ≥ 0
πdℓ ≥ 1.25s	1596 ≥ 1055
t ≥ 4	5 ≥ 4

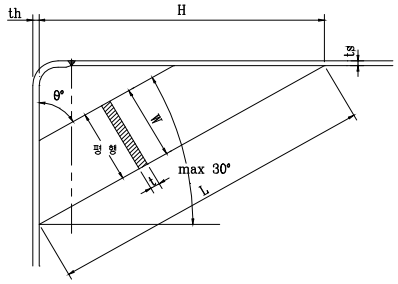
Bar stay



Sign	Title	Dimensions	Sign	Title	Dimensions
d	Ouside diameter	45 mm	Li	Excessive height	mm
ℓ	Effective throat thickness	13 mm	di	Hole diameter	mm
L_0	Projection Length	8 mm	dr	Calculation diameter	37 mm

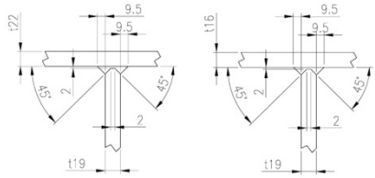
Calculation	Examination
ℓ ≥ 10 mm	13 ≥ 10
10 ≥ L_0 ≥ 0	10 ≥ 8 ≥ 0
di ≥ 5 mm	
Li ≥ 13 mm	
$\pi d\ell \geq 1.25 \frac{\pi}{4} dr^2$	1838 ≥ 1344

Gusset stay

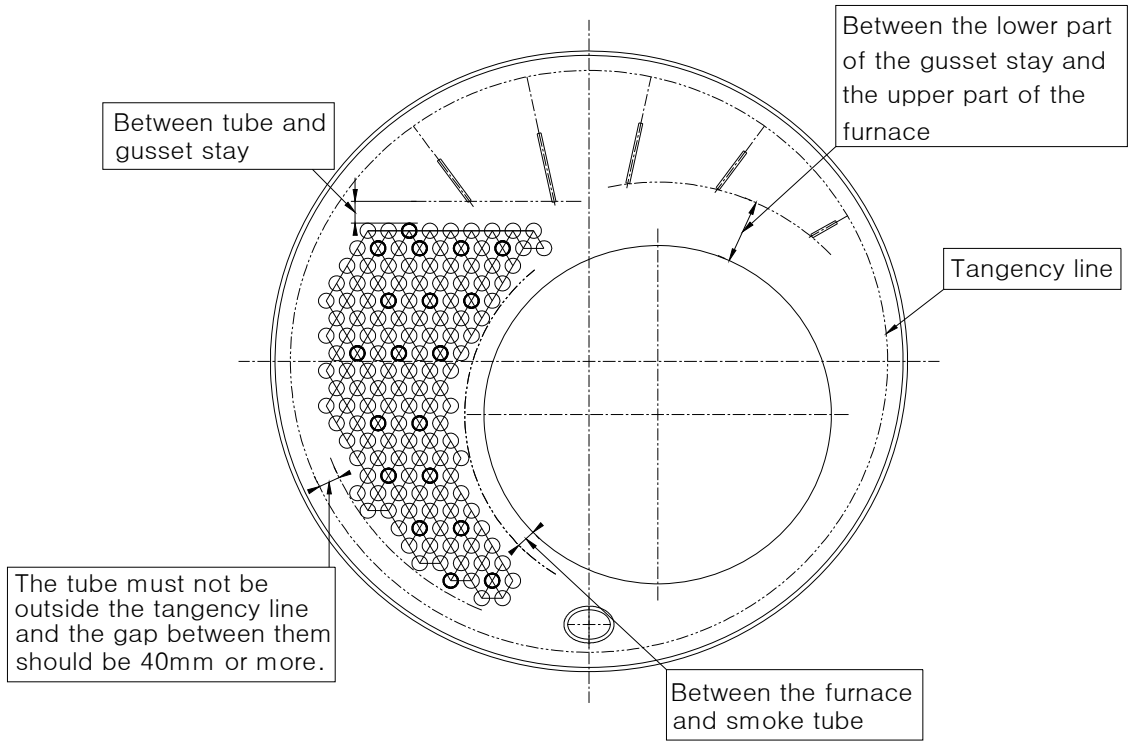


Sign	Title	Dimensions	Sign	Title	Dimensions
ts	shell thickness	16 mm	T	Gusset thickness	19 mm
th	end plate thickness	22 mm	h	Effective throat thickness	19 mm

Calculation	Examination
1.7ts ≥ T ≥ ts	27 ≥ 19 ≥ 16
T ≥ 0.7th	19 ≥ 15.4
60° ≥ Θ ≥ 30°	60° ≥ 60° ≥ 30°
2h ≥ 1.25T	38 ≥ 23.8



Boiler Buffer width, Water level , Hole



구 분	Buffer width	Examination
Between the lower end of the end plate part and the upper part of the furnace	D > 2300 : 250 or more 2300 ≥ D > 1800 : 225 or more 1800 ≥ D : 200 or more	290 ≥ 250
Between tube and gusset stays	100 or more	179 ≥ 100
Others	0.03D or 50 greater than the largest However, it does not need to exceed 100mm.	100 ≥ 85 ≥ 81

ITEM	Water level gauge mounting position	Examination
Nomal water level	Nomal water level ≥ $0.35 \times \frac{D}{2}$	477 ≥ 473
Low water level	Upper furnace – 100 ≥ Low water level	621 ≥ 577

ITEM	Hole size and Amout	Examination	
		Hole size (mm)	ea
Manhole	280 × 380 or more	420–320	1
Cleaning hole	D > 1850 : 120 × 150 or more D ≤ 1850 : 90 × 120 or more	210–150	2
Inspection hole	90 or more L > 3000 4ea or more L ≤ 3000 2ea or more	95–160	5

Spouting capacity calculation of safety valve

1. Full bore type

$W = 5.145 \times A (P' + 1) \times K \times C \times 0.9$

$= 5.145 \times 1885.7 \times (1.01 + 0.1) \times 0.864 \times 0.987 \times 0.9 =$ 8,261 kg/hr

$= 5.145 \times 1134.1 \times (0.98 + 1) \times 0.864 \times 0.987 \times 0.9 =$ 4,837 kg/hr

$\therefore$ 10,000 kg/hr $\leq$ 13,097 kg/hr (= 8261 kg/hr + 4837 kg/hr)

Condition	Calculation	
$D \geq 1.15\ dt$	58.0 ≥ 56.4	45.0 ≥ 43.7
$\pi D L \geq 1.05 A$	2095.4 ≥ 1980.0	1272.3 ≥ 1190.8
$\frac{\pi}{4} di^2 \geq 1.7 A$	3318.3 ≥ 3205.7	1963.5 ≥ 1928.0

ITEM / DESCRIPTION			Full bore type 65A	Full bore type 50A
W_0	Requirement discharge Capacity	kg/hr	10,000	
℃	Steam temp	℃	183.3	183.3
P	Design pressure	Mpa	0.98	0.98
*P'	Spouting pressure	Mpa	1.01	0.98
**A	Throat opening area	㎟	1885.7	1134.1
K	Nominal spouting factor	(0.864)	0.864	0.864
di	Steam inlet diameter	㎜	65	50
dt	Throat diameter	㎜	49	38
D	Seat opening diameter	㎜	58	45
L	Left	㎜	11.5	9
***C	Temp & pressure compensation factor	–	0.987	0.987

* Discharge pressure : Design pressure × 1.03

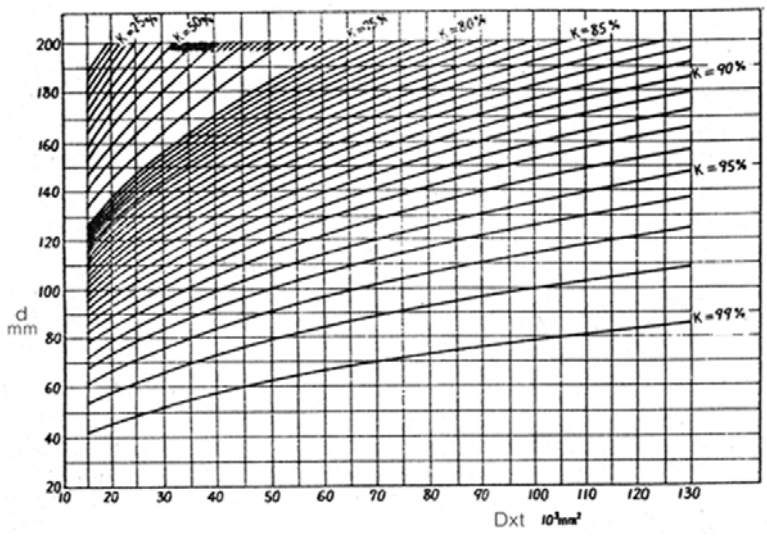
** Throat opening area $A = \frac{\pi}{4} dt^2$

*** Steam temp & pressure compensation factor

Reinforcement of hole

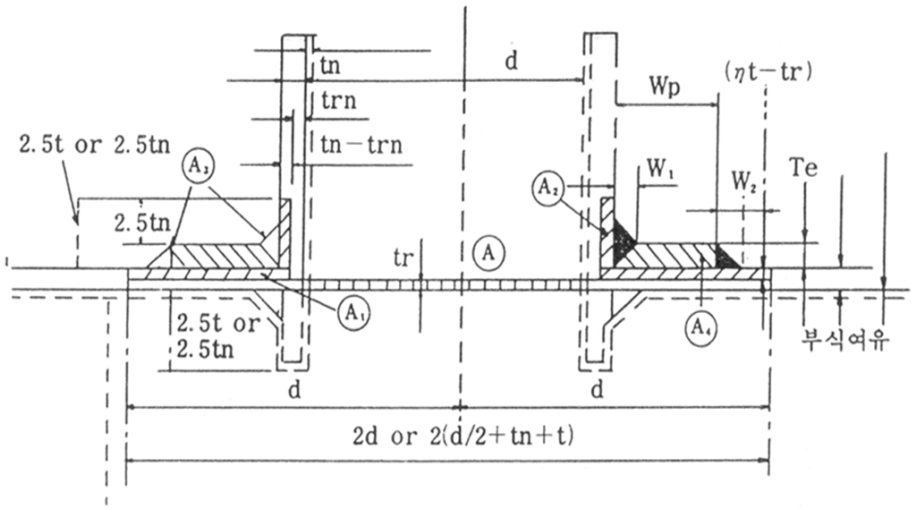
Maximum hole that does not require reinforcement

DESCRIPTION \ ITEM			SHELL
Design pressure	P	Mpa	0.98
Outside diameter	D_0	mm	2732
Material	–	–	SB410
Allowable tensile stress	δa	N/㎟	102
Normal thickness	t	mm	16
Joint efficiency of welding	η	–	1
$K = \frac{100P\ D_0}{182 \cdot \delta a \cdot \eta \cdot t}$			$\frac{100 \times 0.98 \times 2732}{182 \times 102 \times 1 \times 16}$
Calculation	K	–	0.90
$D_0 \times t$	–	–	43712
Maximum hole	d_0	mm	138



Reinforcement strength calculation of hole

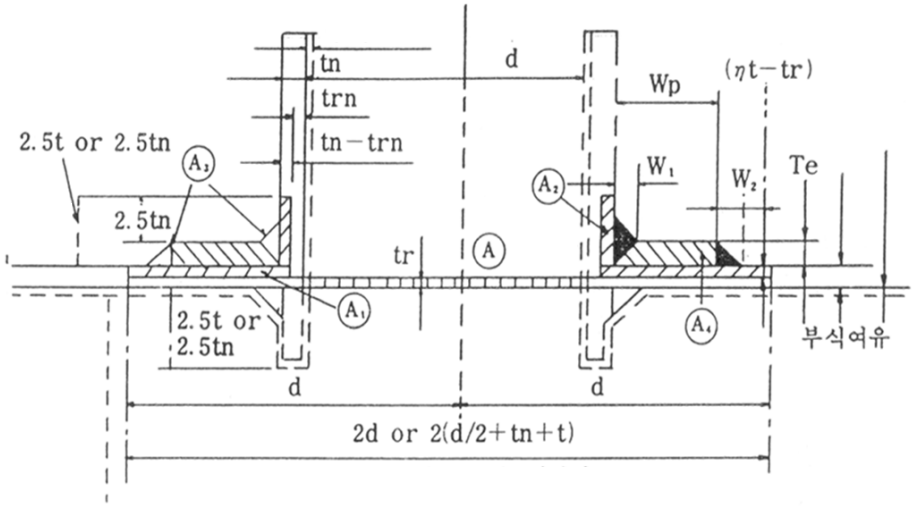
Base data	End plate		Nozzle Mark : INSPECTION HOLE		
P = Design pressure	0.98	Mpa	P = Design pressure	0.98	Mpa
σa= Allowable stress	102	N/㎟	σan= Allowable stress	87	N/㎟
D = Inside diameter	2688	mm	d = Inside diameter of pipe	160 - 95	mm
η1 = Joint efficiency of welding	95	%	η2 = Joint efficiency of welding	85	%
$tr = \frac{P \times D}{2\times\sigma a \times \eta_1 - 1.2\times P} =$	13.68		$trn = \frac{P \times d}{2\times\sigma an \times \eta_2 - 1.2\times P} =$	1.07	
t = Thickness of plate (Corrosion allowance exclusion)	21	mm	tn = Thickness of nozzel (Corrosion allowance exclusion)	17	mm



Necessary area of reinforcement	A = d×tr×F = 160×13.68 = 2189	㎟
Excess thick area of plate (Greater used)	$A_1 = (\eta_1 t - tr)d =$ 1171 $A_1 = 2(\eta_1 t - tr)(t + tn) =$ 556	1171 ㎟
Excess thick area of nozzle (Smaller used)	$A_2 = 2(^*2.5tn)(tn - trn)^{**}k =$ 1155 $A_2 = 2(2.5t)(tn - trn)^{**}k =$ 1427	1155 ㎟
Area of deposited metal zone	$A_3 = 2(\frac{(W_1)^2 + (W_2)^2}{2})$	㎟
The effective area without Reinforcement	$(A_1 + A_2 + A_3)$ 2326	㎟
Reinforcement area Material SS275	$A_4=2\cdot Wp\cdot Te\cdot^{**}k$	
The total area which is necessary to a reinforcement	$(A_1 + A_2 + A_3 + A_4) =$ **2326**	㎟
Examination	$A_1 + A_2 + A_3 + A_4 > A$ 2326 > 2189	

Reinforcement strength calculation of hole

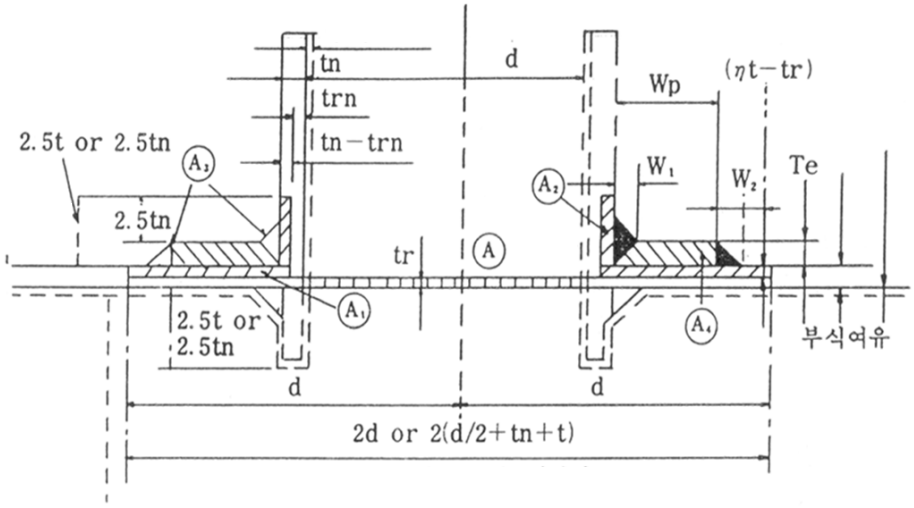
Base data	Shell		Nozzle Mark : INSPECTION HOLE		
P = Design pressure	0.98	Mpa	P = Design pressure	0.98	Mpa
σa= Allowable stress	102	N/㎟	σan= Allowable stress	87	N/㎟
D = Inside diameter	2700	mm	d = Inside diameter of pipe	160 - 95	mm
η1 = Joint efficiency of welding	100	%	η2 = Joint efficiency of welding	85	%
$tr = \frac{P \times D}{2\times\sigma a \times \eta_1 - 1.2\times P} =$	13.05		$trn = \frac{P \times d}{2\times\sigma an \times \eta_2 - 1.2\times P} =$	1.07	
t = Thickness of plate (Corrosion allowance exclusion)	15	mm	tn = Thickness of nozzel (Corrosion allowance exclusion)	17	mm



Necessary area of reinforcement	A = d×tr×F = 160×13.05 =	2088 ㎟
Excess thick area of plate (Greater used)	$A_1 = (\eta_1 t - tr)d =$ 312 $A_1 = 2(\eta_1 t - tr)(t + tn) =$ 125	312 ㎟
Excess thick area of nozzle (Smaller used)	$A_2 = 2(^{*}2.5tn)(tn - trn)^{**}k =$ 1400 $A_2 = 2(2.5t)(tn - trn)^{**}k =$ 1019	1019 ㎟
Area of deposited metal zone	$A_3 = 2(\frac{(W_1)^2 + (W_2)^2}{2})$	202 ㎟
The effective area without Reinforcement	$(A_1 + A_2 + A_3)$	1533 ㎟
Reinforcement area Material SS275	$A_4=2\cdot Wp\cdot Te\cdot^{**}k=$ 2× 50 × 9 X 0.98 =	882 ㎟
The total area which is necessary to a reinforcement	$(A_1 + A_2 + A_3 + A_4) =$	**2415** ㎟
Examination	$A_1 + A_2 + A_3 + A_4 > A$	2415 > 2088

Reinforcement strength calculation of hole

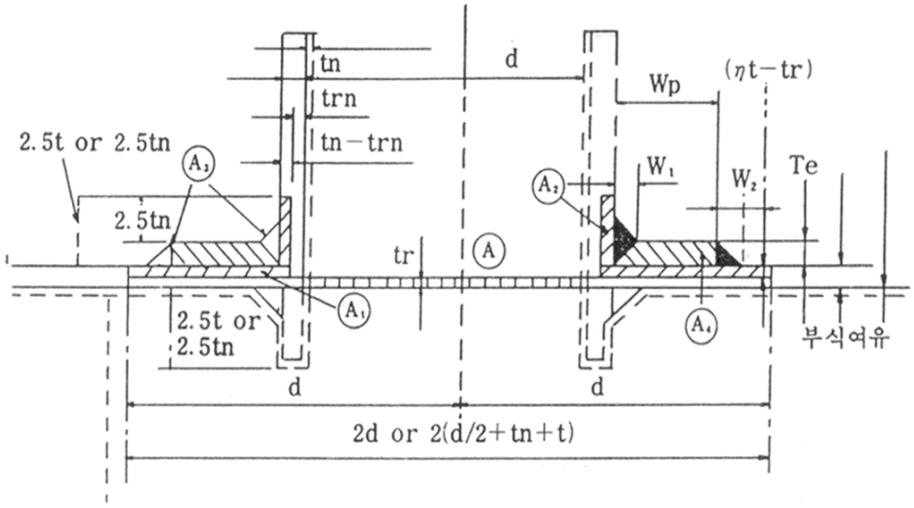
Base data	Shell		Nozzle Mark : CLEANING HOLE		
P = Design pressure	0.98	Mpa	P = Design pressure	0.98	Mpa
σa= Allowable stress	102	N/㎟	σan= Allowable stress	87	N/㎟
D = Inside diameter	2700	mm	d = Inside diameter of pipe	210 – 150	mm
η1 = Joint efficiency of welding	100	%	η2 = Joint efficiency of welding	85	%
$tr = \frac{P \times D}{200 \times \sigma a \times \eta_1 - 1.2 \times P} =$	13.05		$trn = \frac{P \times d}{2 \times \sigma an \times \eta_2 - 1.2 \times P} =$	1.40	
t = Thickness of plate (Corrosion allowance exclusion)	15	mm	tn = Thickness of nozzel (Corrosion allowance exclusion)	17	mm



Necessary area of reinforcement	A = d×tr×F = 210×13.05 =	2741	㎟
Excess thick area of plate (Greater used)	$A_1 = (\eta_1 t - tr)d =$ 410 $A_1 = 2(\eta_1 t - tr)(t + tn) =$ 125	410	㎟
Excess thick area of nozzle (Smaller used)	$A_2 = 2(^*2.5tn)(tn - trn)^{**}k =$ 1370 $A_2 = 2(2.5t)(tn - trn)^{**}k =$ 998	998	㎟
Area of deposited metal zone	$A_3 = 2(\frac{(W_1)^2 + (W_2)^2}{2})$	202	㎟
The effective area without Reinforcement	$(A_1 + A_2 + A_3)$	1610	㎟
Reinforcement area Material SS275	$A_4 = 2 \cdot Wp \cdot Te \cdot {}^{**}k =$ 2× 100 × 9 X 0.98 =	1765	㎟
The total area which is necessary to a reinforcement	$(A_1 + A_2 + A_3 + A_4) =$	**3375**	㎟
Examination	$A_1 + A_2 + A_3 + A_4 > A$	3375 > 2741	

Reinforcement strength calculation of hole

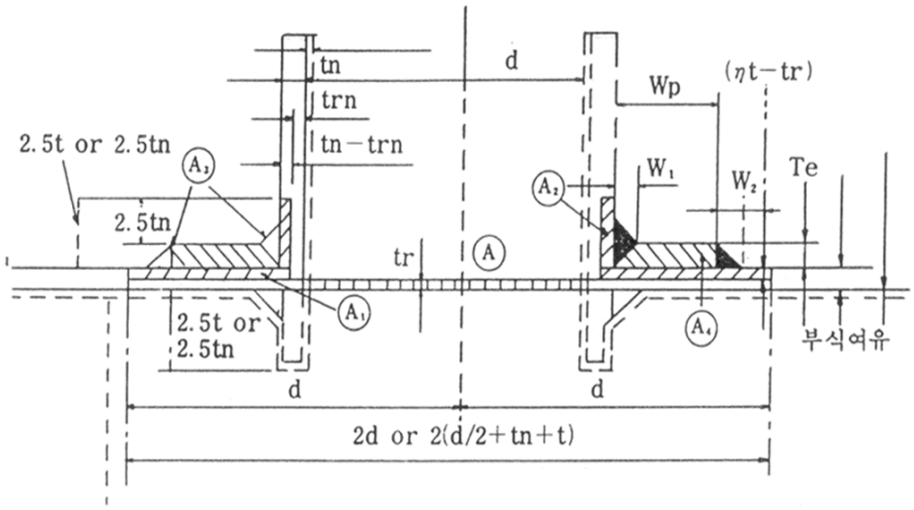
Base data	Shell		Nozzle Mark : MANHOLE		
P = Design pressure	0.98	Mpa	P = Design pressure	0.98	Mpa
σa= Allowable stress	102	N/㎟	σan= Allowable stress	102	N/㎟
D = Inside diameter	2700	mm	d = Inside diameter of pipe	420 – 320	mm
η1 = Joint efficiency of welding	100	%	η2 = Joint efficiency of welding	75	%
$tr = \frac{P \times D}{2\times\sigma a \times \eta_1 - 1.2\times P} =$	13.05		$trn = \frac{P \times d}{2\times\sigma an \times \eta_2 - 1.2\times P} =$	2.71	
t = Thickness of plate (Corrosion allowance exclusion)	15	㎜	tn = Thickness of nozzel (Corrosion allowance exclusion)	18	㎜



Necessary area of reinforcement	A = d×tr×F = 420×13.05 =	5481 ㎟
Excess thick area of plate (Greater used)	$A_1 = (\eta_1 t - tr)d =$ 819 $A_1 = 2(\eta_1 t - tr)(t + tn) =$ 129	819 ㎟
Excess thick area of nozzle (Smaller used)	$A_2 = 2(^*2.5tn)(tn - trn)^{**}k =$ 1743 $A_2 = 2(2.5t)(tn - trn)^{**}k =$ 1147	1147 ㎟
Area of deposited metal zone	$A_3 = 2(\frac{(W_1)^2 + (W_2)^2}{2})$	340 ㎟
The effective area without Reinforcement	$(A_1 + A_2 + A_3)$	2306 ㎟
Reinforcement area Material SS275	$A_4=2\cdot Wp\cdot Te\cdot^{**}k=$ 2× 150 × 12 X 0.98 =	3529.41 ㎟
The total area which is necessary to a reinforcement	$(A_1 + A_2 + A_3 + A_4) =$	**5835** ㎟
Examination	$A_1 + A_2 + A_3 + A_4 > A$ 5835 > 5481	

Reinforcement strength calculation of hole

Base data	Shell		Nozzle Mark : Steam Nozzle SPPS250(E)	200A	#40
P = Design pressure	0.98	Mpa	P = Design pressure	0.98	Mpa
σa= Allowable stress	102	N/㎟	σan= Allowable stress	87	N/㎟
D = Inside diameter	2700	mm	d = Inside diameter of pipe	199.9	mm
η1 = Joint efficiency of welding	100	%	η2 = Joint efficiency of welding	85	%
$tr = \frac{P \times D}{2\times\sigma a \times \eta_1 - 1.2\times P} =$	13.05		$trn = \frac{P \times d}{2\times\sigma an \times \eta_2 - 1.2\times P} =$	1.34	
t = Thickness of plate (Corrosion allowance exclusion)	15	mm	tn = Thickness of nozzel (Corrosion allowance exclusion)	7.2	mm



Necessary area of reinforcement	A = d×tr×F = 199.9×13.05 =	2609 ㎟
Excess thick area of plate (Greater used)	$A_1 = (\eta_1 t - tr)d =$ 390 $A_1 = 2(\eta_1 t - tr)(t + tn) =$ 87	390 ㎟
Excess thick area of nozzle (Smaller used)	$A_2 = 2(^*2.5tn)(tn - trn)^{**}k =$ 300 $A_2 = 2(2.5t)(tn - trn)^{**}k =$ 375	300 ㎟
Area of deposited metal zone	$A_3 = 2(\frac{(W_1)^2 + (W_2)^2}{2})$	340 ㎟
The effective area without Reinforcement	($A_1 + A_2 + A_3$)	1030 ㎟
Reinforcement area Material SS275	$A_4=2\cdot Wp\cdot Te\cdot^{**}k=$ 2× 90 × 12 X 0.98 =	2117 ㎟
The total area which is necessary to a reinforcement	($A_1 + A_2 + A_3 + A_4$) =	**3147** ㎟
Examination	$A_1 + A_2 + A_3 + A_4 > A$	3147 > 2609