APRAGAZ
V.Z.W.
Your Notified Body

Member of CEOC INTERNATIONAL

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Taizhou City Outstanding Industry & Trade Co., Ltd
Fao M. YUNYI CHEN
Shangma Industrial zone, Shitang town,Wenling city
315300 ZHEJIANG
CHINA

Y/Ref. : **SPV OD158 to OD395**
O/Ref. : **MES004/MD – P17675/001**
Subject : **Steel Air Tanks - Simple pressure vessels OD158, OD178, OD218, OD236, OD278, OD298, OD350 and OD395 according to module B production + C2 or C of the SPV directive 2014/29/EU**

Brussels, 7/12/2018

Dear Sir,

With reference to your correspondence we send you in annex 1 set of following documents which have been verified by us:

- Drawing OD395 rev.1 from 6/12/18.
- Calculation note OD395 rev.0.
- Calculation note OD218 rev.1.
- Calculation note OD350 rev.1.

These documents have been examined by us according to the SPV prescriptions in the frame of a CE-approval and resulted into no remark.

Please also note that:

- Minimum thickness after forming for shell and heads has to be greater or equal to the actual thickness ea + 0,5 mm corrosion allowance. The minimum thickness after forming for shell and heads has to be checked after manufacturing.
- Table 10.2.1-1 (Kc = 1, Ks = 1) has to be followed for non destructive and destructive tests.
- Table 7.3-1 and annex H of A2 have to be followed. Values to be checked after manufacturing.
- B production type certificate will be issued after satisfactory inspection of all prototypes.

We wish you good receipt.

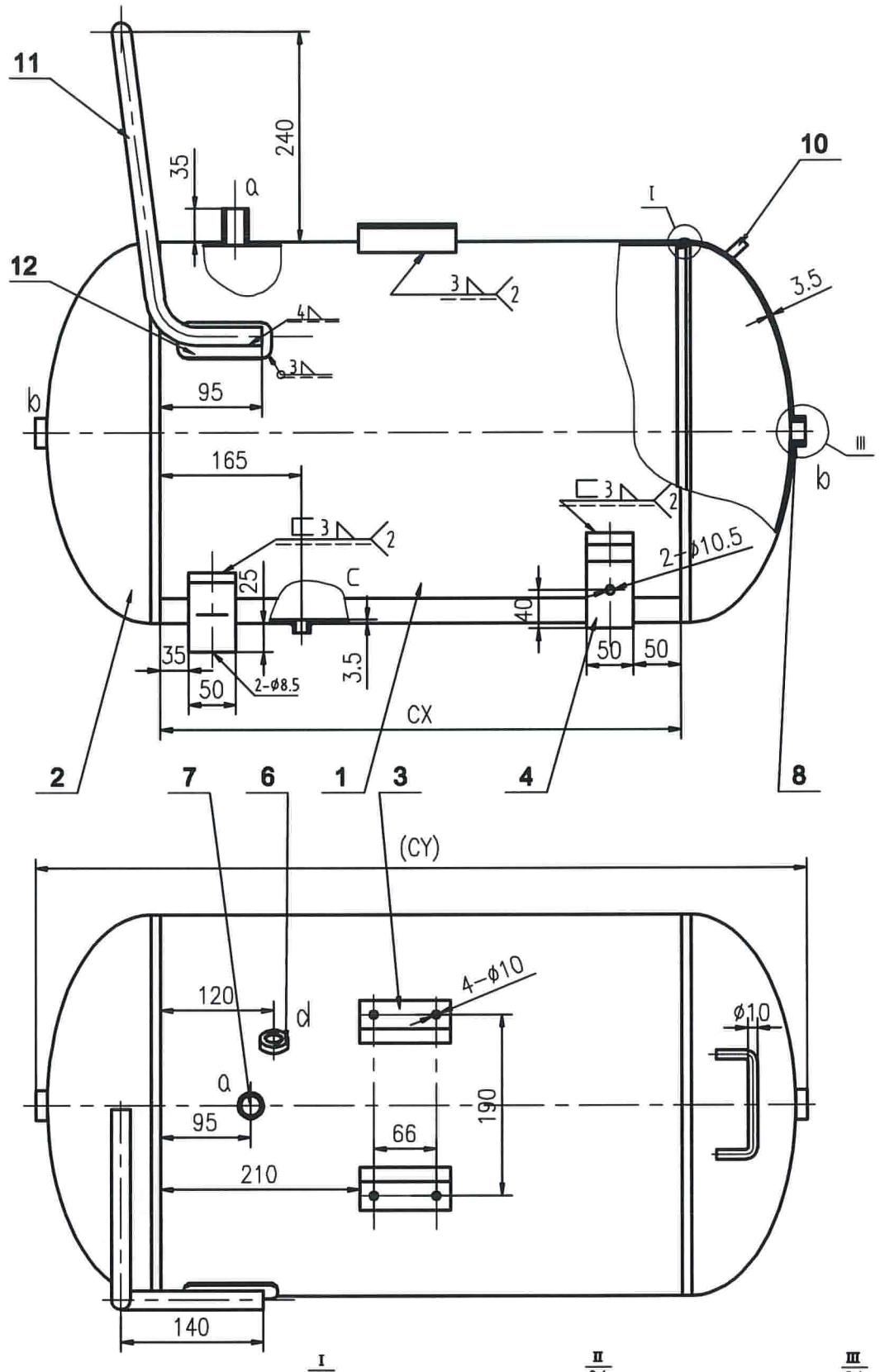
Kind regards,

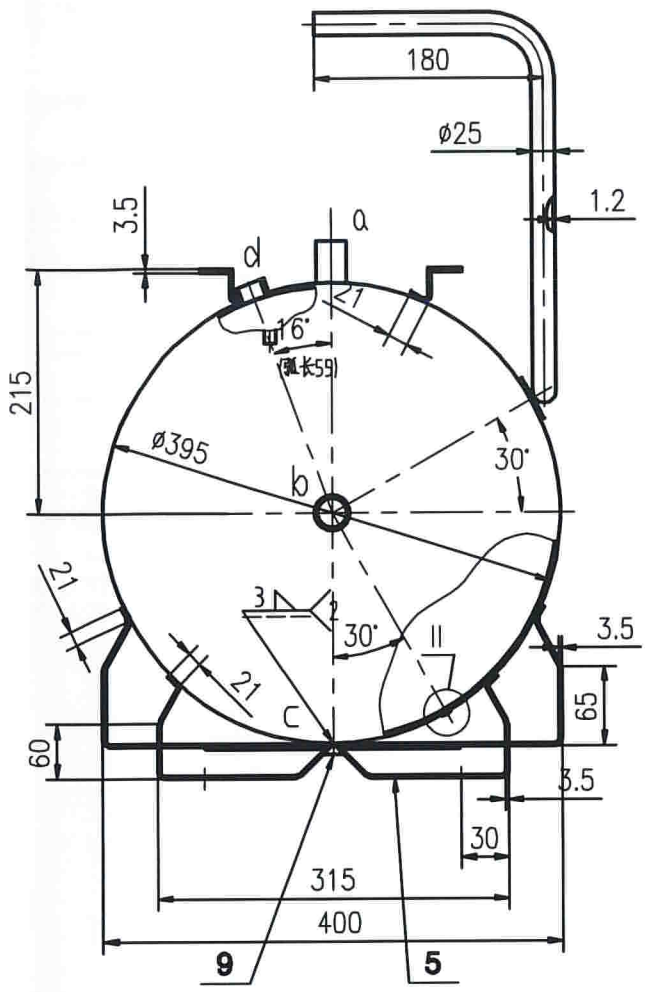
Eng. S. Mertens
Study Department

Please indicate our ref. P17675/001 on all correspondence.

Annexes : Above mentioned documents

P17675/001





No.	Items	Index
1	The material of tank	P235S
2	Design pressure P	8.8bar
3	Design temperature Ts	-10℃/+100℃
4	Max.working pressure Ps	8bar
5	Kc/Ks	1/1
6	Corrosion allowance c	0.5mm
7	Working medium	Air
8	Hydraulic pressure Ph	13.2bar
9	Max. additional loading	100Kg

No.	Vol.	TANK Dia	TANK CX	TANK CY	N.W.
	L	mm	mm	Cymm	kg
1	100	ø395	720	945	43
2	120	ø395	890	1115	49
3	150	ø395	1145	1370	58
4	160	ø395	1230	1455	61
5	200	ø395	1450	1650	69

Index	Size	NOZZLE O.D.X WALL	Orlfice	Style	Q'ty
a	G1/2"	ø27X3.5	20	Inside	1
b	G1"	ø42X5.5	30	Inside	2
c	G3/8"	ø25X4.15	15	Inside	1
d	G1/2"	ø27X3.5	20	Inside	1

APRAGAZ
Your Notified Body n° : 0029

TECHNICAL FILE EXAMINATION :
WITHOUT COMMENT ☒
WITH COMMENT ☐

REJECTED AND TO BE RESUBMITTED ☐

DESIGN DEPARTMENT
DATE : 07/12/18

APRAGAZ
Eng. St. MERTENS
Design & Steam Dept

Technological Requirements

1.The gas receiver tank must be manufactured in accordance with the requirement of the european Directive SPV 2014/29/EU and EN286-1:1998+A1:2002+A2:2006.
2.All welds must be performed according to approved welding procedures according to PQR-EN ISO 15614-1:2017 by APRAGAZ
3.The longitudinal circular welding of the tanks must be performed by qualified operators according to WPQ-EN ISO 14732:2013 by APRAGAZ
Other welds must be performed by qualified welders according to WPQ-EN9606-1:2017 by APRAGAZ
4.The X-ray of the material must be performed in accordance with the EN286-1 Table 10.2.1.KC=1,Ks=1.
5.After completion of the gas receiver, it must be subjected to a pressure test with (or under) water at a pressure of 13.2 bar with a calibrated pressure gauge.

#	Part No.	Name	Q'ty	Material	Weight (kg)	Total Weight (kg)	Comment
12	OD395-06	handlle support	1	Q235B	0.12	0.12	t:3.5
11	OD278-05	bigger handle	1	Q235B	0.36	0.36	
10	OD350-07	handle ø10	1	Q235B	0.21	0.21	
9	OD158-07	tube	1	20# NB/T47008-2010	0.025	0.025	
8	OD350-07	sighthole	2	20# NB/T47008-2010	0.1	0.2	
7	OD350-06	tube	1	20# NB/T47008-2010	0.07	0.07	
6	OD158-05	tube	1	20# NB/T47008-2010	0.025	0.025	
5	OD395-05	front support	1	Q235B	0.55	0.55	t:3.5
4	OD395-04	back support	1	Q235B	0.68	0.68	t:3.5
3	OD395-03	deck	1	Q235B	0.45	0.45	t:3.5
2	OD395-02	ell.head 2:1	2	P235S	5.25	10.5	h:98.75
1	OD395-01	main body	1	P235S	23.65	23.65	

Rev.		2018-12-06					
Designer	周宗磊	2018-12-06					
Approval	金建华	2018-12-06					

Mark of stage | Weight | Scale
S

Taizhou City Outstanding Industry & Trade Co., Ltd.

TANK

OD395

Record of barrow (universal)parts
Several nmber of old base map
Several nmber of base map
Signature
date

P 17675/001

Pressure Vessel Calculation

Drawing No.:OD395 Rev.0
Standards: EN 286-1 1998+A1:2002+A2:2006

Designed by: 郑云杰 Date:2018-11-25
Approved by:朱靖华 Date:2018-11-25

Taizhou City Outstanding Industry & Trade Co., Ltd.

APRAGAZ
Your Notified Body n° : 0029
TECHNICAL FILE EXAMINATION :
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DESIGN DEPARTMENT
DATE: 07/12/18

APRAGAZ
Eng. St. MERTENS
Design & Steam Dept

一、Design Data

Item No.	Item	Units	Value	Remarks
1	V- Volume	L	/	N.A.
2	Medium	N.A.	Air	N.A.
3	D_{os} - Outside diameter of the shell	mm	395	N.A.
4	D_{oh} - Outside diameter of the head	mm	395	N.A.
5	PS - Max. working pressure	N/mm_2	0.80	N.A.
6	P - Design pressure	N/mm_2	0.88	N.A.
7	T_{max} - Max. working temperature	℃	100	N.A.
8	T_{min} - Min. working temperature	℃	-10	N.A.
9	Matl. Spe. of Shell and Head	EN 10207: P235S		N.A.
10	Fitting	NB/T 47008: 20#		N. A.
11	f - Nominal design stress at design temperature	N/mm_2 N/mm_2	102.6 123	N.A.
12	e_s - Nominal thickness of the shell	mm	3.50	N.A.
13	e_h - Nominal thickness of the head	mm	3.50	N.A.
14	C - Corrode allowance	mm	0.5	N.A.
15	Kc - Calculation coefficient	N.A.	1	N.A.
16	Ks - Shell coefficient	N.A.	1	N.A.
17	t - Absolute value of the negative tolerance	mm	0	N.A.
18	ms -Thinning during the manufacturing process of shell	mm	0	N.A.
19	m_h -Thinning during the manufacturing process of head	mm	0.0	N.A.
20	h - Outside height of the head	mm	98.75	N.A.

1. f Calculation per 6.4.1.1

Rm,P235S(MPa)	360	Ret,P235S(MPa)	171
Rm, 20#(MPa)	410	Ret,20#(MPa)	210

$$f_{P235S} = Min(0.6R_{eT,p235S}, 0.3R_{m,p235S}) = \quad 102.6 \text{ MPa}$$

$$f_{20} = Min(0.6R_{eT,20}, 0.3R_{m,20}) = \quad 123.0 \text{ MPa}$$

Where:
Ret,P235S - value of yield strength at the max.working temperature of P235S (N/mm2)
R m,P235S - Min. value of tensile strength at room temperature of P235S (N/mm2)
fP235S- Nominal design stress at design temperature of P235S (N/mm2)
Ret,20#- value of yield strength at the max.working temperature of 20# (N/mm2)
R m,20# - Min. value of tensile strength at room temperature of 20# (N/mm2)
f20#- Nominal design stress at design temperature of 20# (N/mm2)

2. Calculation for shell :Per.6.4.2

e_{as} mm	3.00	e_s mm	3.5	t mm	0
P MPa	0.88	D_{Os} mm	395	f (MPa)	102.6
m_s mm	0	K_C	1	K_S	1
c mm	0.5	e_a mm	≥2 per 6.3.2-2		

2.1 Calculated thickenss of shell

$$e_{cs} = \frac{PD_{os}}{2f+P}K_cK_s = \quad 1.69 \text{ mm}$$

2.2 Calculation for actual thickness of shell

$$e_{as} = e_s - t - m_s - c = \quad 3.00 \text{ mm}$$

$$e_{as} = 3.0 \geq e_{cs} = \quad 1.69 \text{ mm}$$

The shell thickness is acceptable

where:
eas - Actual thickness for shell (mm)
es - Nominal thickness of shell (mm)
t - Absolute value of the negative tolerance (mm)
ms - Thinning during the manufacturing process of shell (mm)
C - Corrosion allowance (mm)
ecs - Calculated thickness of shell (mm)
P - Design pressure (N/mm²)
f - Nominal design stress at design temperature (N/mm2)

Kc - Calculation coefficient
Ks - Shell coefficient

3. Calculation for head :Per.6.4.3

e_{ah} mm	3.00	e_h mm	3.5	t mm	0
P MPa	0.88	D_{Oh} mm	395	f (MPa)	102.6
c mm	0.5	h mm	98.75	m_h mm	0
e_a mm	⩾2 per 6.3.2-2				

3.1 calculation for actual thickness of head

$$e_{ah} = e_h - t - m_h - c = \quad 3.00 \quad \text{mm}$$

where:
eah - Actual thickness for head (mm)
eh - Nominal thickness of head (mm)
t- Absolute value of the negative tolerance (mm)
mh - Thinning during the manufacturing process of head (mm)
C - Corrosion allowance (mm)
tmin-min thickness of shell
3.2 Calculated thickenss of head
3.2.1 checking condition:
The head is elliptical head.

eah=	3.0	mm⩽0.08D_{oh}=	31.6	mm
eah=	3.0	mm⩾0.002D_{oh}=	0.79	mm
h=	98.75	mm⩾0.18D_{oh}=	71.1	mm

so the head calculated thickness:

$$e_{ch} = \frac{aD_{oh}}{1000} = \quad 1.90 \quad \text{mm}$$

$$e_{ah} = 3.0 \geq e_{ch} = \quad 1.90 \quad \text{mm}$$

The head thickness is acceptable

where:

$P/f =$ 0.0086 $h_e = h =$ 98.75 mm

$h_e / D_{oh} =$ 0.25

Select the value 'a' from table 6.4.3.2-1 4.821

ech - Calculated thickness of head (mm)
P - Design pressure (N/mm2)
h - Outside height of the head (mm)

Doh - Outside diameter of the head (mm)
f - Nominal design stress at design temperature (N/mm2)

4.Compensation calculation for head:Per,6.4.6.7.1 and Figure 6.4.6.3-1h where :the max. nozzle be cacluated for max. nozzle.

	Nozzle b	Nozzle b			
size	G1	G1			
Nozzle ODXwall	Φ42X5.5	Φ42X5.5			
Open location	head	head			
P MPa	0.88	0.88			
f MPa	102.6	102.6			
d_{eb} mm	42.00	42.00			
R_{ib} mm	18.00	18.00			
c mm	0.50	0.50			
e_n mm	5.50	5.50			
e_{ab} mm	5.00	5.00			
e_{as} mm	3.00	3.00			
D_{os} mm	395.00	395.00			
D_{is} mm	389.00	389.00			
e_{ah} mm	3.00	3.00			
A_P mm2	12329.3	12329.3			
A_{fm} mm2	126.82	126.82			
A_{fb} mm2	58.27	58.27			
l_m mm	42.27	42.27			
R_{ih} mm	383.09	383.09			
l_b min(lb,lm,lao)mm	8.65	8.65			
l_{bi} min(lbi,lai)mm	0.00	0.00			
l_{ao} mm	14.00	14.00			
l_{ai} mm	0.00	0.00			
$P\left[\frac{A_p}{A_{fm}+A_{fb}}+0.5\right]=$	59.06	59.06			
	≤f	≤f			
	Acceptable	Acceptable			

When the following condition shall be satisfied:

$$P\left[\frac{A_p}{A_{fm}+A_{fb}}+0.5\right]\le f$$

Where:

Ap - Area required (mm2) $A_p=(d_{eb}/2+l_m)R_{ih}/2+R_{ib}(l_b+e_{eh})$

Afm - Area available in shell (mm2) $A_{fm}=l_m e_{ah}$

Afb - Area available in branch (mm2) $A_{fb} = e_{ab}(l_b + e_{ah} + l_{bi})$

Rih - Inside radius of curvature of the head (mm) $R_{is} = D^2_{is} / 4h$

lm - Effective length of main body (mm) $l_m = \sqrt{(2R_{ih} + e_{ah})e_{ah}}$

deb-External diameter of branch(mm)

Rib - Inside radius of the branch (mm)

lb-Effective length of branch min,(lb,lm,actual length)(mm) $l_b = 0.8\sqrt{(d_{eb} - e_{eb})e_{ab}}$

eas- Actual thickness of shell(mm)

eah- Actual thickness of head (mm)

eab-Actualthickness of branch(mm)

lbi-Effective length for inside part ot branch min,(lbi, actual length)(mm) $l_{bi} = 0.5l_b$

P-Design pressure (N/mm2)

f-Nominal design stress at design temperature (N/mm2)

Dos-Outside diameter of the shell(mm)

Dis-inside diameter of the head(mm) $D_{is} = D_{os} - 2e_{as}$

lao-actual length of branch(mm)

lai-actual length for branch inside part of branch(mm)

5.Compensation calculation for shell:Per,6.4.6.7.1 and Figure 6.4.6.3-1g

	Nozzle a	Nozzle c	Nozzle d		
size	G1/2	G3/8	G1/2		
Nozzle ODXwall	Φ27X3.5	Φ25X4.15	Φ27X3.5		
Open location	shell	shell	shell		
P MPa	0.88	0.88	0.88		
f MPa	102.6	102.6	102.6		
d_{eb} mm	27.00	25.00	27.00		
R_{ib} mm	10.50	8.85	10.50		
c mm	0.50	0.50	0.50		
e_n mm	3.50	4.15	3.50		
e_{ab} mm	3.00	3.65	3.00		
D_{os} mm	395.00	395.00	395.00		

e_{as} mm	3.00	3.00	3.00		
A_P mm2	9398.5	9190.3	9398.5		
A_{fm} mm2	102.88	102.88	102.88		
A_{fb} mm2	29.36	36.73	29.36		
l_m mm	34.29	34.29	34.29		
R_{is} mm	194.50	194.50	194.50		
l_b min(lb,lm,lao)mm	6.79	7.06	6.79		
l_{bi} min(lbi,lai)mm	0.00	0.00	0.00		
l_{ao} mm	35.00	12.00	12.00		
l_{ai} mm	0.00	0.00	0.00		
$P\left[\frac{A_p}{A_{fm}+A_{fb}}+0.5\right]=$	62.98	58.37	62.98		
	≤f	≤f	≤f		
	Acceptable	Acceptable	Acceptable		

When the following condition shall be satisfied:

$$P\left[\frac{A_p}{A_{fm}+A_{fb}}+0.5\right]\le f$$

Where:

Ap - Area required (mm2) $A_p = R_{is}(l_m + d_{eb}/2) + R_{ib}(l_b + e_{es})$

Afm - Area available in shell (mm2) $A_{fm} = l_m e_{as}$

Afb - Area available in branch (mm2) $A_{fb} = e_{ab}(l_b + e_{as} + l_{bi})$

Ris - Inside radius of curvature of the shell (mm) $R_{is} = D_{os}/2 - e_{as}$

lm - Effective length of main body (mm) $l_m = \sqrt{(2R_{is} + e_{as})e_{as}}$

deb-External diameter of branch(mm)

Rib - Inside radius of the branch (mm)

lb-Effective length of branch min,(lb,lm,actual length)(mm) $l_b = 0.8\sqrt{(d_{eb} - e_{eb})e_{ab}}$

eas- Actual thickness of shell(mm)

eab-Actualthickness of branch(mm)

lbi-Effective length for inside part ot branch min,(lbi, actual length)(mm) $l_{bi} = 0.5l_b$

P-Design pressure (N/mm2)

f-Nominal design stress at design temperature (N/mm2)

Dos-Outside diameter of the shell(mm)

lao-actual length of branch(mm)

lai-actual length for branch inside part of branch(mm)

Pressure Vessel Calculation

Drawing No.:OD218 Rev.1
Standards: EN 286-1 1998+A1:2002+A2:2006

Designed by:郑云杰 **Date:2018-12-06**
Approved by:朱靖华 **Date:2018-12-06**

Taizhou City Outstanding Industry & Trade Co., Ltd.

APRAGAZ
Your Notified Body n° : 0029
TECHNICAL FILE EXAMINATION :
WITHOUT COMMENT ☒
WITH COMMENT ☐
REJECTED AND TO BE RESUBMITTED ☐
DESIGN DEPARTMENT
DATE: 07/12/18

APRAGAZ
Eng. St. MERTENS
Design & Steam Dept

一、Design Data

Item No.	Item	Units	Value	Remarks
1	V- Volume	L	/	N.A.
2	Medium	N.A.	Air	N.A.
3	D_{os} - Outside diameter of the shell	mm	218	N.A.
4	D_{oh} - Outside diameter of the head	mm	218	N.A.
5	PS - Max. working pressure	N/mm^2	0.80	N.A.
6	P - Design pressure	N/mm^2	0.88	N.A.
7	T_{max} - Max. working temperature	°C	100	N.A.
8	T_{min} - Min. working temperature	°C	-10	N.A.
9	Matl. Spe. of Shell and Head	EN 10207: P235S		N.A.
10	Fitting	NB/T 47008: 20#		N.A.
11	f - Nominal design stress at design temperature	N/mm^2 N/mm^2	102.6 123	N.A.
12	e_s - Nominal thickness of the shell	mm	2.50	N.A.
13	e_h - Nominal thickness of the head	mm	2.50	N.A.
14	C - Corrode allowance	mm	0.5	N.A.
15	Kc - Calculation coefficient	N.A.	1	N.A.
16	Ks - Shell coefficient	N.A.	1	N.A.
17	t - Absolute value of the negative tolerance	mm	0	N.A.
18	ms -Thinning during the manufacturing process of shell	mm	0	N.A.
19	m_h -Thinning during the manufacturing process of head	mm	0.0	N.A.
20	h - Outside height of the head	mm	54.50	N.A.

1. f Calculation per 6.4.1.1

Rm,P235S(MPa)	360	Ret,P235S(MPa)	171
Rm, 20#(MPa)	410	Ret,20#(MPa)	210

$$f_{P235S} = Min(0.6R_{eT,p235S}, 0.3R_{m,p235S}) = \quad 102.6 \text{ MPa}$$

$$f_{20} = Min(0.6R_{eT,20}, 0.3R_{m,20}) = \quad 123.0 \text{ MPa}$$

Where:
Ret,P235S - value of yield strength at the max.working temperature of P235S (N/mm2)
R m,P235S - Min. value of tensile strength at room temperature of P235S (N/mm2)
fP235S- Nominal design stress at design temperature of P235S (N/mm2)
Ret,20#- value of yield strength at the max.working temperature of 20# (N/mm2)
R m,20# - Min. value of tensile strength at room temperature of 20# (N/mm2)
f20#- Nominal design stress at design temperature of 20# (N/mm2)

2. Calculation for shell :Per.6.4.2

e_{as} mm	2.00	e_s mm	2.5	t mm	0
P MPa	0.88	D_{Os} mm	218	f (MPa)	102.6
m_s mm	0	K_C	1	K_S	1
c mm	0.5	e_a mm	≥2 per 6.3.2-2		

2.1 Calculated thickenss of shell

$$e_{cs} = \frac{PD_{os}}{2f + P} K_c K_s = \quad 0.93 \text{ mm}$$

2.2 Calculation for actual thickness of shell

$$e_{as} = e_s - t - m_s - c = \quad 2.00 \text{ mm}$$

$$e_{as} = 2.0 \geq e_{cs} = \quad 0.93 \text{ mm}$$

The shell thickness is acceptable

where:
eas - Actual thickness for shell (mm)
es - Nominal thickness of shell (mm)
t - Absolute value of the negative tolerance (mm)
ms - Thinning during the manufacturing process of shell (mm)
C - Corrosion allowance (mm)
ecs - Calculated thickness of shell (mm)
P - Design pressure (N/mm²)
f - Nominal design stress at design temperature (N/mm2)

Kc - Calculation coefficient
Ks - Shell coefficient

3. Calculation for head :Per.6.4.3

e_{ah} mm	2.00	e_h mm	2.5	t mm	0
P MPa	0.88	D_{Oh} mm	218	f (MPa)	102.6
c mm	0.5	h mm	54.5	m_h mm	0
e_a mm	≥2 per 6.3.2-2				

3.1 calculation for actual thickness of head

$$e_{ah} = e_h - t - m_h - c = \quad 2.00 \quad \text{mm}$$

where:
eah - Actual thickness for head (mm)
eh - Nominal thickness of head (mm)
t- Absolute value of the negative tolerance (mm)
mh - Thinning during the manufacturing process of head (mm)
C - Corrosion allowance (mm)
tmin-min thickness of shell
3.2 Calculated thickenss of head
3.2.1 checking condition:
The head is elliptical head.

eah=	2.0 mm	≤0.08D_{oh}=	17.44	mm
eah=	2.0 mm	≥0.002D_{oh}=	0.436	mm
h=	54.50 mm	≥0.18D_{oh}=	39.24	mm

so the head calculated thickness:

$$e_{ch} = \frac{aD_{oh}}{1000} = \quad 1.05 \quad \text{mm}$$

$$e_{ah} = 2.0 \geq e_{ch} = \quad 1.05 \quad \text{mm}$$

The head thickness is acceptable

where:

$P/f =$ 0.0086 $h_e = h =$ 54.5 mm

$h_e / D_{oh} =$ 0.25

Select the value 'a' from table 6.4.3.2-1 4.821

ech - Calculated thickness of head (mm)
P - Design pressure (N/mm2)
h - Outside height of the head (mm)

Doh - Outside diameter of the head (mm)
f - Nominal design stress at design temperature (N/mm2)

4.Compensation calculation for head:Per,6.4.6.7.1 and Figure 6.4.6.3-1h where :the max. nozzle be cacluated for max. nozzle.

	Nozzle d	Nozzle d			
size	G1/2	G1/2			
Nozzle ODXwall	Φ27X3.5	Φ27X3.5			
Open location	head	head			
P MPa	0.88	0.88			
f MPa	102.6	102.6			
d_{eb} mm	27.00	27.00			
R_{ib} mm	10.50	10.50			
c mm	0.50	0.50			
e_n mm	3.50	3.50			
e_{ab} mm	3.00	3.00			
e_{ah} mm	2.00	2.00			
D_{os} mm	218.00	218.00			
D_{is} mm	214.00	214.00			
e_{ah} mm	2.00	2.00			
A_P mm2	4184.2	4184.2			
A_{fm} mm2	51.14	51.14			
A_{fb} mm2	22.97	22.97			
l_m mm	25.57	25.57			
R_{ih} mm	210.07	210.07			
l_b min(lb,lm,lao)mm	5.66	5.66			
l_{bi} min(lbi,lai)mm	0.00	0.00			
l_{ao} mm	12.00	12.00			
l_{ai} mm	0.00	0.00			
$P\left[\frac{A_p}{A_{fm}+A_{fb}}+0.5\right]=$	50.12	50.12			
	≤f	≤f			
	Acceptable	Acceptable			

When the following condition shall be satisfied:

$$P\left[\frac{A_p}{A_{fm}+A_{fb}}+0.5\right]\le f$$

Where:

Ap - Area required (mm2) $A_p=\left(\left(d_{eb}/2+l_m\right)R_{ih}/2\right)+R_{ib}(l_b+e_{eh})$

Afm - Area available in shell (mm2) $A_{fm}=l_m e_{ah}$

Afb - Area available in branch (mm2) $A_{fb} = e_{ab}(l_b + e_{ah} + l_{bi})$

Rih - Inside radius of curvature of the head (mm) $R_{is} = D^2_{is} / 4h$

Im - Effective length of main body (mm) $l_m = \sqrt{(2R_{ih} + e_{ah})e_{ah}}$

deb-External diameter of branch(mm)

Rib - Inside radius of the branch (mm)

lb-Effective length of branch min,(lb,lm,actual length)(mm) $l_b = 0.8\sqrt{(d_{eb} - e_{eb})e_{ab}}$

eas- Actual thickness of shell(mm)

eah- Actual thickness of head (mm)

eab-Actualthickness of branch(mm)

lbi-Effective length for inside part ot branch min,(lbi, actual length)(mm) $l_{bi} = 0.5l_b$

P-Design pressure (N/mm2)

f-Nominal design stress at design temperature (N/mm2)

Dos-Outside diameter of the shell(mm)

Dis-inside diameter of the head(mm) $D_{is} = D_{os} - 2e_{as}$

lao-actual length of branch(mm)

lai-actual length for branch inside part of branch(mm)

5.Compensation calculation for shell:Per,6.4.6.7.1 and Figure 6.4.6.3-1g

	Nozzle a	Nozzle c	Nozzle b		
size	G1/4	G3/8	G1/2		
Nozzle ODXwall	Φ16X3.5	Φ25X4.15	Φ27X3.5		
Open location	shell	shell	shell		
P MPa	0.88	0.88	0.88		
f MPa	102.6	102.6	102.6		
d_{eb} mm	16.00	25.00	28.00		
R_{ib} mm	5.00	8.85	11.00		
c mm	0.50	0.50	0.50		
e_n mm	3.50	4.15	3.50		
e_{ab} mm	3.00	3.65	3.00		
D_{os} mm	218.00	218.00	218.00		
e_{as} mm	2.00	2.00	2.00		

A_P mm2	3114.9	3641.7	3820.2		
A_{fm} mm2	41.57	41.57	41.57		
A_{fb} mm2	20.99	33.08	26.78		
l_m mm	20.78	20.78	20.78		
R_{is} mm	107.00	107.00	107.00		
l_b min(lb,lm,lao)mm	5.00	7.06	6.93		
l_{bi} min(lbi,lai)mm	0.00	0.00	0.00		
l_{ao} mm	60.00	12.00	12.00		
l_{ai} mm	0.00	0.00	0.00		
$P\left[\frac{A_p}{A_{fm}+A_{fb}}+0.5\right]=$	44.26	43.37	49.62		
	≤f	≤f	≤f		
	Acceptable	Acceptable	Acceptable		

When the following condition shall be satisfied:

$$P\left[\frac{A_p}{A_{fm}+A_{fb}}+0.5\right]\le f$$

Where:

Ap - Area required (mm2) $A_p = R_{is}(l_m + d_{eb}/2) + R_{ib}(l_b + e_{es})$

Afm - Area available in shell (mm2) $A_{fm} = l_m e_{as}$

Afb - Area available in branch (mm2) $A_{fb} = e_{ab}(l_b + e_{as} + l_{bi})$

Ris - Inside radius of curvature of the shell (mm) $R_{is} = D_{os}/2 - e_{as}$

lm - Effective length of main body (mm) $l_m = \sqrt{(2R_{is} + e_{as})e_{as}}$

deb-External diameter of branch(mm)

Rib - Inside radius of the branch (mm)

lb-Effective length of branch min,(lb,lm,actual length)(mm) $l_b = 0.8\sqrt{(d_{eb} - e_{eb})e_{ab}}$

eas- Actual thickness of shell(mm)

eab-Actualthickness of branch(mm)

lbi-Effective length for inside part ot branch min,(lbi, actual length)(mm) $l_{bi} = 0.5l_b$

P-Design pressure (N/mm2)

f-Nominal design stress at design temperature (N/mm2)

Dos-Outside diameter of the shell(mm)

lao-actual length of branch(mm)

lai-actual length for branch inside part of branch(mm)

Pressure Vessel Calculation

Drawing No.:OD350 Rev.1
Standards: EN 286-1 1998+A1:2002+A2:2006

Designed by: 郑云杰 **Date:2018-12-06**
Approved by: 朱靖华 **Date:2018-12-06**

Taizhou City Outstanding Industry & Trade Co., Ltd.

APRAGAZ
Your Notified Body n° : 0029
TECHNICAL FILE EXAMINATION :
WITHOUT COMMENT ☒
WITH COMMENT ☐
REJECTED AND TO BE RESUBMITTED ☐
DESIGN DEPARTMENT
DATE : 07/12/18

APRAGAZ
Eng. St. MERTENS
Design & Steam Dept

一、Design Data

Item No.	Item	Units	Value	Remarks
1	V- Volume	L	/	N.A.
2	Medium	N.A.	Air	N.A.
3	D_{os} - Outside diameter of the shell	mm	350	N.A.
4	D_{oh} - Outside diameter of the head	mm	350	N.A.
5	PS - Max. working pressure	N/mm_2	0.80	N.A.
6	P - Design pressure	N/mm_2	0.88	N.A.
7	T_{max} - Max. working temperature	℃	100	N.A.
8	T_{min} - Min. working temperature	℃	-10	N.A.
9	Matl. Spe. of Shell and Head	EN 10207: P235S		N.A.
10	Fitting	NB/T 47008: 20#		N. A.
11	f - Nominal design stress at design temperature	N/mm_2 N/mm_2	102.6 123	N.A.
12	e_s - Nominal thickness of the shell	mm	3.00	N.A.
13	e_h - Nominal thickness of the head	mm	3.00	N.A.
14	C - Corrode allowance	mm	0.5	N.A.
15	Kc - Calculation coefficient	N.A.	1	N.A.
16	Ks - Shell coefficient	N.A.	1	N.A.
17	t - Absolute value of the negative tolerance	mm	0	N.A.
18	ms -Thinning during the manufacturing process of shell	mm	0	N.A.
19	m_h -Thinning during the manufacturing process of head	mm	0.0	N.A.
20	h - Outside height of the head	mm	87.50	N.A.

1. f Calculation per 6.4.1.1

Rm,P235S(MPa)	360	Ret,P235S(MPa)	171
Rm, 20#(MPa)	410	Ret,20#(MPa)	210

$$f_{P235S} = Min(0.6R_{eT,p235S}, 0.3R_{m,p235S}) = \quad 102.6 \text{ MPa}$$

$$f_{20} = Min(0.6R_{eT,20}, 0.3R_{m,20}) = \quad 123.0 \text{ MPa}$$

Where:
Ret,P235S - value of yield strength at the max.working temperature of P235S (N/mm2)
R m,P235S - Min. value of tensile strength at room temperature of P235S (N/mm2)
fP235S- Nominal design stress at design temperature of P235S (N/mm2)
Ret,20#- value of yield strength at the max.working temperature of 20# (N/mm2)
R m,20# - Min. value of tensile strength at room temperature of 20# (N/mm2)
f20#- Nominal design stress at design temperature of 20# (N/mm2)

2. Calculation for shell :Per.6.4.2

e_{as} mm	2.50	e_s mm	3	t mm	0
P MPa	0.88	D_{Os} mm	350	f (MPa)	102.6
m_s mm	0	K_C	1	K_S	1
c mm	0.5	e_a mm	≥2 per 6.3.2-2		

2.1 Calculated thickenss of shell

$$e_{cs} = \frac{PD_{os}}{2f + P} K_c K_s = \quad 1.49 \text{ mm}$$

2.2 Calculation for actual thickness of shell

$$e_{as} = e_s - t - m_s - c = \quad 2.50 \text{ mm}$$

$$e_{as} = 2.5 \geq e_{cs} = \quad 1.49 \text{ mm}$$

The shell thickness is acceptable

where:
eas - Actual thickness for shell (mm)
es - Nominal thickness of shell (mm)
t - Absolute value of the negative tolerance (mm)
ms - Thinning during the manufacturing process of shell (mm)
C - Corrosion allowance (mm)
ecs - Calculated thickness of shell (mm)
P - Design pressure (N/mm²)
f - Nominal design stress at design temperature (N/mm2)

Kc - Calculation coefficient
Ks - Shell coefficient

3. Calculation for head :Per.6.4.3

e_{ah} mm	2.5	e_h mm	3	t mm	0
P MPa	0.88	D_{Oh} mm	350	f (MPa)	102.6
c mm	0.5	h mm	87.5	m_h mm	0
e_a mm	≥2 per 6.3.2-2				

3.1 calculation for actual thickness of head

$$e_{ah} = e_h - t - m_h - c = \quad 2.50 \quad \text{mm}$$

where:
eah - Actual thickness for head (mm)
eh - Nominal thickness of head (mm)
t- Absolute value of the negative tolerance (mm)
mh - Thinning during the manufacturing process of head (mm)
C - Corrosion allowance (mm)
tmin-min thickness of shell
3.2 Calculated thickenss of head
3.2.1 checking condition:
The head is elliptical head.

eah=	2.5	mm≤0.08D_{oh}=	28	mm
eah=	2.5	mm≥0.002D_{oh}=	0.7	mm
h=	87.50	mm≥0.18D_{oh}=	63	mm

so the head calculated thickness:

$$e_{ch} = \frac{aD_{oh}}{1000} = \quad 1.69 \quad \text{mm}$$

$$e_{ah} = 2.5 \geq e_{ch} = \quad 1.69 \quad \text{mm}$$

The head thickness is acceptable

where:

$P/f =$ 0.0086 $h_e = h =$ 87.5 mm

$h_e / D_{oh} =$ 0.25

Select the value 'a' from table 6.4.3.2-1 4.821

ech - Calculated thickness of head (mm)
P - Design pressure (N/mm2)
h - Outside height of the head (mm)

Doh - Outside diameter of the head (mm)
f - Nominal design stress at design temperature (N/mm2)

4.Compensation calculation for head:Per,6.4.6.7.1 and Figure 6.4.6.3-1h where :the max. nozzle be cacluated for max. nozzle.

	Nozzle b	Nozzle b			
size	G1	G1			
Nozzle ODXwall	Φ42x5.5	Φ42x5.5			
Open location	head	head			
P MPa	0.88	0.88			
f MPa	102.6	102.6			
d_{eb} mm	42.00	42.00			
R_{ib} mm	18.50	18.50			
c mm	0.50	0.50			
e_n mm	5.50	5.50			
e_{ab} mm	5.00	5.00			
e_{as} mm	2.50	2.50			
D_{os} mm	350.00	350.00			
D_{is} mm	345.00	345.00			
e_{ah} mm	2.50	2.50			
A_P mm2	9945.5	9945.5			
A_{fm} mm2	90.88	90.88			
A_{fb} mm2	52.25	52.25			
l_m mm	36.35	36.35			
R_{ih} mm	340.07	340.07			
l_b min(lb,lm,lao)mm	7.95	7.95			
l_{bi} min(lbi,lai)mm	0.00	0.00			
l_{ao} mm	14.00	14.00			
l_{ai} mm	0.00	0.00			
$P\left[\frac{A_p}{A_{fm}+A_{fb}}+0.5\right]=$	61.59	61.59			
	≤f	≤f			
	Acceptable	Acceptable			

When the following condition shall be satisfied:

$$P\left[\frac{A_p}{A_{fm}+A_{fb}}+0.5\right]\le f$$

Where:

Ap - Area required (mm2) $A_p=\left(\left(d_{eb}/2+l_m\right)R_{ih}\right/2+R_{ib}(l_b+e_{eh})$

Afm - Area available in shell (mm2) $A_{fm}=l_m e_{ah}$

Afb - Area available in branch (mm2) $A_{fb} = e_{ab}(l_b + e_{ah} + l_{bi})$

Rih - Inside radius of curvature of the head (mm) $R_{is} = D^2_{is} / 4h$

lm - Effective length of main body (mm) $l_m = \sqrt{(2R_{ih} + e_{ah})e_{ah}}$

deb-External diameter of branch(mm)

Rib - Inside radius of the branch (mm)

lb-Effective length of branch min,(lb,lm,actual length)(mm) $l_b = 0.8\sqrt{(d_{eb} - e_{eb})e_{ab}}$

eas- Actual thickness of shell(mm)

eah- Actual thickness of head (mm)

eab-Actualthickness of branch(mm)

lbi-Effective length for inside part ot branch min,(lbi, actual length)(mm) $l_{bi} = 0.5l_b$

P-Design pressure (N/mm2)

f-Nominal design stress at design temperature (N/mm2)

Dos-Outside diameter of the shell(mm)

Dis-inside diameter of the head(mm) $D_{is} = D_{os} - 2e_{as}$

lao-actual length of branch(mm)

lai-actual length for branch inside part of branch(mm)

5.Compensation calculation for shell:Per,6.4.6.7.1 and Figure 6.4.6.3-1g

	Nozzle a	Nozzle c	Nozzle d		
size	G1/2	G3/8	G1/2		
Nozzle ODXwall	Φ27X3.5	Φ25X4.15	Φ27X3.5		
Open location	shell	shell	shell		
P MPa	0.88	0.88	0.88		
f MPa	102.6	102.6	102.6		
d_{eb} mm	27.00	25.00	27.00		
R_{ib} mm	10.50	8.85	10.50		
c mm	0.50	0.50	0.50		
e_n mm	3.50	4.15	3.50		
e_{ab} mm	3.00	3.65	3.00		
D_{os} mm	350.00	350.00	350.00		
e_{as} mm	2.50	2.50	2.50		

A_P mm2	7510.6	7325.2	7510.6		
A_{fm} mm2	73.69	73.69	73.69		
A_{fb} mm2	27.86	34.90	27.86		
l_m mm	29.47	29.47	29.47		
R_{is} mm	172.50	172.50	172.50		
l_b min(lb,lm,lao)mm	6.79	7.06	6.79		
l_{bi} min(lbi,lai)mm	0.00	0.00	0.00		
l_{ao} mm	35.00	12.00	12.00		
l_{ai} mm	0.00	0.00	0.00		
$P\left[\frac{A_p}{A_{fm}+A_{fb}}+0.5\right]=$	65.52	59.80	65.52		
	≤f	≤f	≤f		
	Acceptable	Acceptable	Acceptable		

When the following condition shall be satisfied:

$$P\left[\frac{A_p}{A_{fm}+A_{fb}}+0.5\right]\le f$$

Where:

Ap - Area required (mm2) $A_p = R_{is}(l_m + d_{eb}/2) + R_{ib}(l_b + e_{es})$

Afm - Area available in shell (mm2) $A_{fm} = l_m e_{as}$

Afb - Area available in branch (mm2) $A_{fb} = e_{ab}(l_b + e_{as} + l_{bi})$

Ris - Inside radius of curvature of the shell (mm) $R_{is} = D_{os}/2 - e_{as}$

lm - Effective length of main body (mm) $l_m = \sqrt{(2R_{is} + e_{as})e_{as}}$

deb-External diameter of branch(mm)

Rib - Inside radius of the branch (mm)

lb-Effective length of branch min,(lb,lm,actual length)(mm) $l_b = 0.8\sqrt{(d_{eb} - e_{eb})e_{ab}}$

eas- Actual thickness of shell(mm)

eab-Actualthickness of branch(mm)

lbi-Effective length for inside part ot branch min,(lbi, actual length)(mm) $l_{bi} = 0.5l_b$

P-Design pressure (N/mm2)

f-Nominal design stress at design temperature (N/mm2)

Dos-Outside diameter of the shell(mm)

lao-actual length of branch(mm)

lai-actual length for branch inside part of branch(mm)