Compare ANSI and EN codes

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14th July 2022

Presentation plan

1. Mechanical calculations
   - Material properties comparison
   - Pipes wall thickness
   - Allowable stresses
   - Load cases

2. Testing and quality assurance
   - Pressure test
   - Non destructive weld tests

European standards used

All modules designed by WUST meet the requirements of the following standards:

1. Process pipes
   - EN 13480-2 Metallic industrial piping. Part 2: Materials
   - EN 13480-3 Metallic industrial piping. Part 3: Design and calculations
   - EN 10216-5 Seamless steel tubes for pressure purposes. Technical delivery conditions. Part 5: Stainless steel tubes.
   - EN 10220 Seamless and welded steel tubes, Dimensions and masses per unit length
   - EN 14917 Metal bellows expansion joints for pressure applications
2. Vacuum vessel
   - EN 13480-2 Metallic industrial piping. Part 2: Materials
   - EN 13458-2 Cryogenic vessels, static vacuum insulated vessels. Part 2 design, fabrication, inspection and testing
   - EN 10217-7 Welded steel tubes for pressure purposes - Technical delivery conditions - Part 7: Stainless steel tubes
   - EN 10220 Seamless and welded steel tubes, Dimensions and masses per unit length

Proposed ASME standards

1. Process pipes
   - ASME B31.3-2020 Process Piping: ASME Code for Pressure Piping, B31
2. Vacuum vessel
   - ASME Boiler and Pressure Vessel Code: Section VIII-Rules for Construction of Pressure Vessels Division 2-Alternative Rules
   - ASME Boiler and Pressure Vessel Code: Section II-Materials

Material properties

	1.4306 (AISI 304L)				1.4301 (AISI 304)			
	EN		ASME		EN		ASME	
Tensile strength, MPa/ksi	460	68	485	70	500	73	515	75
Minimum metal temperature, °C/ °F	-273	-459	-253	-425	-196	-320	-253	-425
Yield stress, MPa/ksi	-	-	172.4	25	-	-	205	30
Proof stress 1%, MPa/ksi	180	26.1	-	-	195	28.3	-	-

Table 1: Material properties comparison in acc. to EN 13480-2 and ASME B31.3-2020

Straight Pipe Under Internal Pressure

EN	ASME
$e_{min} = \frac{p_s D_o}{2fZ+p_s}$	$t=PD\frac{}{2(SEW+PY)}$

where:

p_s - design pressure
D_0 - pipe external diameter
f - allowable stress
Z - joint coefficient, Z=1

P - design pressure
D - pipe external diameter
S - allowable stress
E - quality factor
W - weld joint strength reduction factor
Y - reduction coefficient

Process pipes allowable stresses

	1.4306 (AISI 304L)			
	EN		ASME	
Allowable stress, MPa/ksi	143.3	20.7	115	16.7
Pipe wall thickness, mm/inch	0.418	0.016	0.52	0.021

Table 2: Comparison of allowable stress in process pipes in acc. to EN 13480-3 and ASME B31.3-2020

Pipe wall thickness was calculated for DN50 (60.3 mm) pipe with internal pressure of 20 bar(a).

Process pipes allowable stresses

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Conclusion

The assumed pipe wall thickness is 2.9 mm (0.11")

Straight Pipe Under External Pressure

In accordance with EN 13458-2 the external critical pressure is:

- Elastic buckling

$$p_e = \frac{E}{S_k} \frac{20}{1-\nu^2} \left(\frac{s}{D_a}\right)^3 = 5.5 bar$$

- Plastic buckling

$$p_p = \frac{20 R_{p1\%}}{S_p} \frac{s}{D_a} = 49.9 bar$$

In accordance with ASME BPVC the maximum external pressure is:

$$P_a = \frac{4B}{3\frac{D_o}{t}} = 4.6 bar$$

Vacuum vessel allowable stresses

In acc. to EN 13458-2 allowable stresses in vacuum vessel are:

1. The primary membrane stress intensity shall not exceed $f_m < 2/3 \cdot R_{p1.0}$
2. The primary local membrane stress intensity shall not exceed $f_L < R_{p1.0}$
3. The stress intensity due to the sum of primary membrane or primary local membrane stress and primary bending stresses shall not exceed $f_m + f_b$ or $f_L + f_b < R_{p1.0}$
4. The stress intensity due to the sum of primary membrane stresses, primary bending stresses and thermal stresses shall not exceed $f_m + f_b + f_g < 2 \cdot R_{p1.0}$

Vacuum vessel allowable stresses

In acc. to EN 13458-2 allowable stresses in attachments and supports are:

1. The primary membrane stress intensity shall not exceed $f_m < 0.8 \cdot R_{p1.0}$
2. The stress intensity due to the sum of primary membrane or primary local membrane stress and primary bending stresses shall not exceed $f_m + f_b < 4/3 \cdot R_{p1.0}$
3. The stress intensity due to the sum of primary membrane stresses, primary bending stresses and thermal stresses shall not exceed $f_m + f_b + f_g < 2 \cdot R_{p1.0}$

Vacuum vessel allowable stresses

In acc. to EN 13458-2 allowable stresses in nozzles and openings are:

1. The primary membrane stress intensity shall not exceed
   $f_m < 0.8 \cdot R_{p1.0}$
2. The stress intensity due to the sum of primary membrane or primary local membrane stress and primary bending stresses shall not exceed
   $f_m + f_b < 1.5 \cdot R_{p1.0}$
3. The stress intensity due to the sum of primary membrane stresses, primary bending stresses and thermal stresses shall not exceed
   $f_m + f_b + f_g < 2 \cdot R_{p1.0}$

Allowable stress in acc. to EN and ASME standards

Standard	EN				ASME			
Material	1.4301		1.4306		1.4301		1.4306	
Unit	MPa	ksi	MPa	ksi	MPa	ksi	MPa	ksi
Vacuum vessel								
f_m	153.3	22.2	120.0	17.4	138.0	20.0	115.0	16.7
f_L	230.0	33.4	180.0	26.1	207.0	30.0	172.5	25.1
$f_m + f_b$ $f_L + f_b$	230.0	33.4	180.0	26.1	207.0	30.0	172.5	25.1
$f_m + f_b + f_g$ $f_L + f_b + f_g$	460.0	66.7	360.0	52.2	414.0	60.0	345.0	50.1
Attachments and supports								
f_m	180.0	26.1	168.0	24.4				
$f_m + f_b$ $f_L + f_b$	306.7	44.5	280.0	40.6				
$f_m + f_b + f_g$ $f_L + f_b + f_g$	460.0	66.7	420.0	60.9				
Nozzles and openings								
f_m	184.0	26.7	144.0	20.9				
$f_m + f_b$ $f_L + f_b$	345.0	50.0	270.0	39.2				
$f_m + f_b + f_g$ $f_L + f_b + f_g$	460.0	66.7	360.0	52.2				

Table 3: Comparison of allowable stress in vacuum vessel elements in acc. to EN 13458-2 and ASME BPVC

Loads in acc. to EN 13480-3 and ASME B31.3

EN 13480-3

1. internal and/or external pressure
2. temperature
3. weight of piping and contents
4. climatic loads
5. dynamic effects of the fluid
6. vibrations

ASME B31.3-2020

1. pressure
2. temperature
3. dead loads
4. live loads
5. ambient effects
6. vibrations

Load cases in acc. to EN 13480-3 and ASME B31.3

EN 13480-3

1. Normal operating conditions
2. Occasional operating conditions
3. Exceptional operating conditions
4. Test condition

ASME B31.3-2020

1. Normal operation
2. Normal operation plus occasional
3. Abnormal or start-up operation plus occasional
4. Pressure testing

Testing in accordance to EN 13480

In acc. to EN 13480-5 Metallic industrial piping. Part 5: Inspection and testing the following test during fabrication are required:

- welds NDT tests
- pressure test at $p_t = 1.43PS$

Welds NDT in acc. to EN 13458-5 Inspection and testing

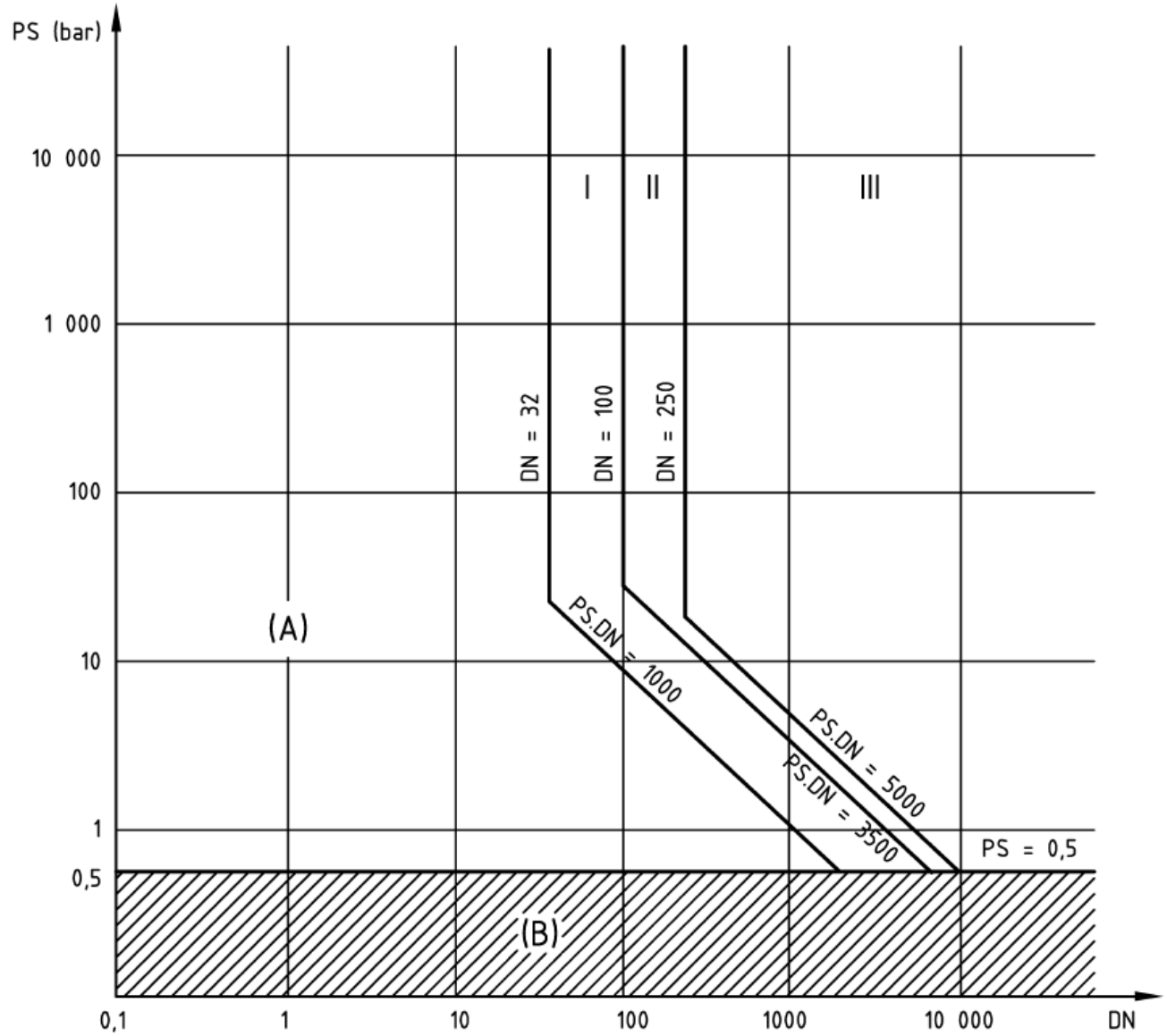

Figure 1: Pipes category classification in accordance with PED 2014/68/UE

Welds NDT in acc. to EN 13458-5 Inspection and testing

Table 8.2-1 — Extent of testing for circumferential, branch, fillet and seal welds

Material group [a]	Category	All welds	Circumferential welds			Branch welds						Socket/fillet welds		Seal welds	
			Surface testing		Volumetric testing [b]	Surface testing			Volumetric testing [b,k]			Surface testing		Surface testing	
		VT %	e_n mm	MT/PT [c] %	RT/UT %	Branch diameter	e_n [h] mm	MT/PT [c] %	Branch diameter [i]	e_n [h] mm	RT/UT %	e_n mm	MT/PT %	e_n mm	MT/PT %
1.1, 1.2, 8.1	I	100	0 (5) [f,g]		5 (10) [g]	All		0 (5) [f,g]	All		0	All	0	All	0
	II														
	III				10			10	> DN 100	> 15	10		10		10
1.3, 1.4, 1.5, 2.1, 2.2, 4.1, 4.2, 5.1, 5.2, 8.2, 8.3, 9.1, 9.2, 9.3, 10.1, 10.2	I	100	≤ 30	5	10	All [e]		10 (25) [g]	All		0	All [e]	10	All [e]	5
			> 30	10	10										
	II		≤ 30	5	10										
			> 30	10	10										
	III		≤ 30	5	10										
			> 30	10	10 (25 [d]) [f,g]	All			> DN 100	> 15	10	All	25	All	25
3.1, 3.2, 3.3, 5.3, 5.4, 6.1, 6.2, 6.3, 6.4, 7.1, 7.2	I	100	≤ 30	10	25	All		25	> DN 100	> 15	25	All	25	All	10
			> 30	25	25										
	II		≤ 30	25	25										
			> 30	25	25 (25 [d]) [f,g]										
	III		≤ 30	100	25 (100) [f,g]			100			100		100		100
			> 30	100	25 (100 [d]) [f,g]										

Figure 2: Welds NDT requirements

Testing in accordance to ASME B31.3-2020

In acc. to ASME B31.3-2020 the following test during fabrication are required:

- welds NDT tests
- leak test $P_T \geq 1.5P$

Welds NDT in acc. to ASME B31.3-2020

In acc. to ASME B31.3-2020 the following NDT are required:

- Ultrasonic Examination
  - $\leq DN50$ 10% of welds
  - $> DN50$ and $\leq DN450$ once in each 1.5m (5ft.)
- Radiographic Examination
  - 5% of welds for each welder

Main differences between EN and ASME codes

1. materials mechanical properties
2. minimum metal temperature of 1.4306 (AISI 304L) and 1.4301 (AISI 304)
3. allowable stresses
4. Pressure test pressure
5. welds NDT

Main differences between EN and ASME codes

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Conclusion

ASME standard is more conservative