



Design Codes and Standard for Process Pressure Equipment

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Pressure Equipment

- Unfired/Fired
 - PV (pressure vessels, Heat exchangers...)
 - Piping
 - Accessories (valves, safety valves...)
 - Boilers
- Regulations vs Codes/Standards – unfired pressure vessels
 - Regulations: PED, TR CU 032, IBR, SANS 347, NR13, DOSH, MOM, MHLW...
 - Standards: ASME Section VIII Div 1/Div 2/ Div 3, EN13445, AS1210, IS2825, CODAP, AD-2000, PD5500, GB150.....

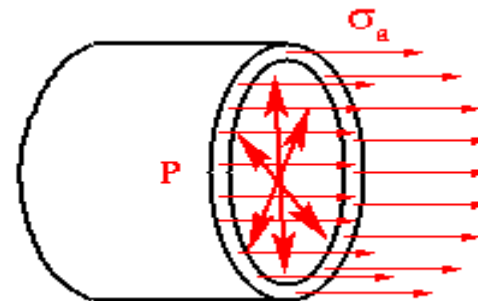
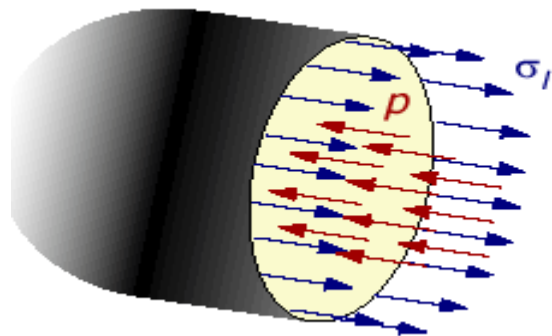
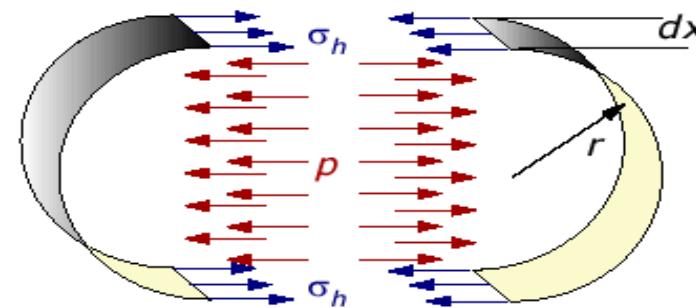
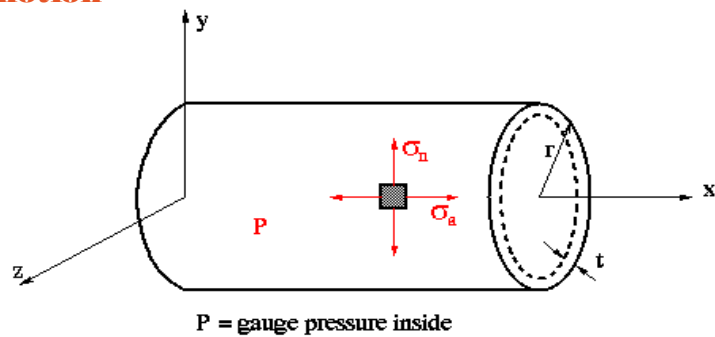
Pressure Vessel - basics

Thin cylinders:

P= pressure, D= diameter, t= thickness, L= length, r= radius

Longitudinal Stresses and Hoop Stresses

Since the vessel is under static equilibrium, it must satisfy Newton's first law of motion



Pressure Vessel Standards – Shell Thickness

Here are the basic dimensions We shall ignore joint efficiency **E**

We now do the calculation for the cylinder:

Cylinder based on the equilibrium equation

$$t = \frac{P \cdot D}{2 \cdot S}$$

That is why the differences are so small – the formulae are nearly the same !

This formula looks odd, but is actually just about the same as the others

By ASME VIII Division 1

$$t = \frac{P \cdot D}{2 \cdot S - 1.2P} \quad t = 0.454 \text{ in (11.534 mm)}$$

By ASME VIII Division 2

$$t = \frac{D}{2} \cdot \left(\exp\left(\frac{P}{S}\right) - 1 \right) \quad t = 0.453 \text{ in (11.516 mm)}$$

By EN 13445

$$e = \frac{P \cdot D}{2 \cdot f - P} \quad t = 0.453 \text{ in (11.516 mm)}$$

By PD 5500

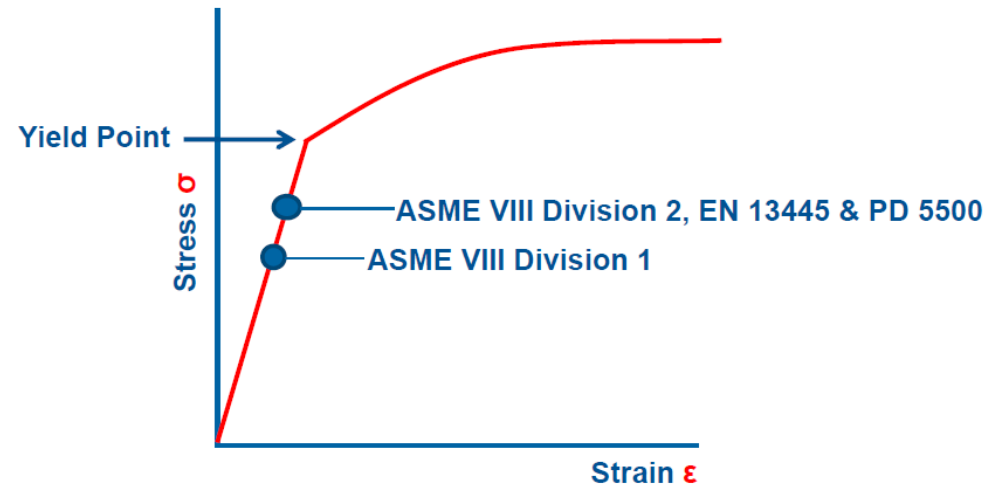
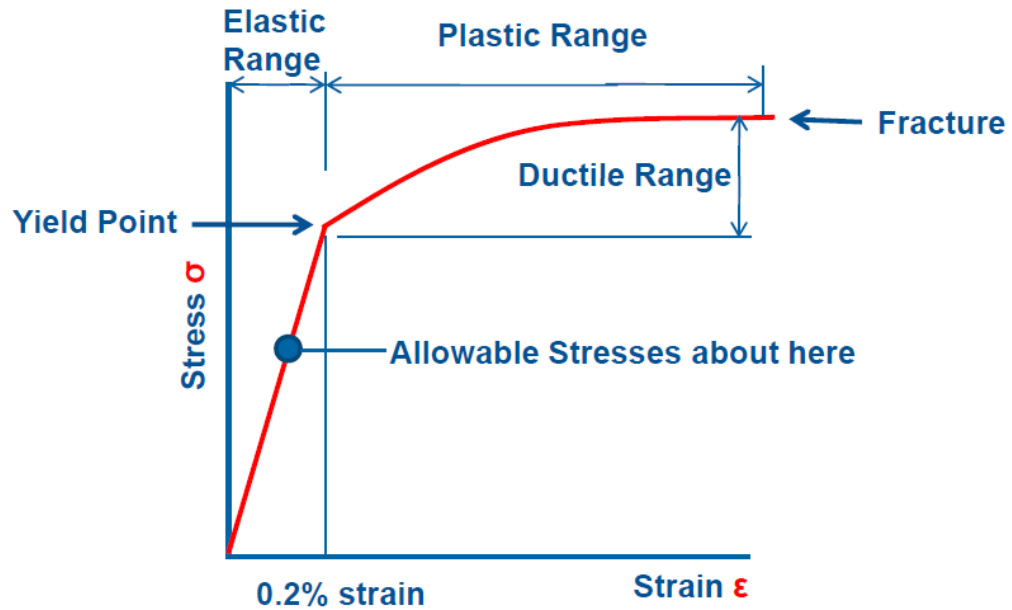
$$e = \frac{P \cdot D}{2 \cdot f - P} \quad t = 0.453 \text{ in (11.516 mm)}$$

Pressure Vessel Standards – what is different

- Allowable Stress – Factor of Safety
- What is allowable stress (S)?
- Material Characteristics
- Different codes use different factors – for example for CS
- ASME Section VIII Div 1: $S = \text{smaller of } UTS/3.5 \text{ or } YS/1.5$
- ASME Section VIII Div 2: $S = \text{smaller of } UTS/2.4 \text{ or } YS/1.5$
- EN13445: $S = \text{smaller of } UTS/2.4 \text{ or } YS/1.5$
- PD5500: $S = \text{smaller of } UTS/2.35 \text{ or } YS/1.5$

Allowable Stress

Let us look at the important features of our steel



Are some standards more safe than others?

- **Overall Equivalent level of safety**
 - **Material – type of material as well as material testing (confidence in material)**
 - **Factor of safety**
 - **Design – detail analysis or empirical formula**
 - **Controls and inspections during manufacturing...**
 - **NDE**
 - **Testing**

Pressure Vessel Standards – what is different

- Others things that differ
 - Opening Reinforcement – area replacement, pressure area.....
 - Flanges
 - Flat plates/Tubesheets
 - External Pressure
 - Analysis...

Conformity assessment

ASME– standard procedure.. use of AIA..RPE/PE in some cases

PED /TR CU 032– based on risk – modular process – various options to the manufacturer under PED

PED vs ASME

- Manufacturer concept
- Regulation vs Product standard
- Conformity Assessment - Risk based involvement of 3rd Party vs full
- Materials – including certifications
- Welding/NDE approvals
- Modules – standard audit regime

Product Classification

- To know how the PED will apply to specific items of pressure equipment, the equipment must be classified by category according to its perceived level of hazard due to pressure, by reference to Conformity Assessment Charts (*Tables*) [Annex II]
- There are 5 Hazard Categories, i.e.:
 - Sound Engineering Practice (*SEP*)
 - Category I
 - Category II
 - Category III
 - Category IV
- There are 9 Conformity Assessment Tables (*Charts*) used to determine the category for each item of pressure equipment, i.e.:
 - 4 Charts (*Tables*) for *Vessels*
 - 1 Chart (*Table*) for *Steam Generators*
 - 4 Charts (*Tables*) for *Piping*



Increase in level of pressure hazard

PED Product Classification

To categorise the pressure equipment correctly, the following steps should be followed:

1. Confirm whether the equipment is within the scope of the PED
2. Decide on the type of equipment being considered, ie *vessel, steam generator or piping*
3. Confirm the state of the fluid in the equipment - *gas or liquid*
4. Determine the hazard group of the fluid in the equipment - *Group 1 or Group 2*
5. Select the most appropriate Conformity Assessment Chart (*Table*)
6. Confirm the *maximum allowable pressure (PS)*, ie the maximum pressure for which the equipment is designed
7. Determine the defining dimension of the equipment, ie *volume in litres* or the *nominal size (DN)*, as appropriate
8. Establish the PED hazard category

Conformity Assessment Modules by category

Category I (Module)	Category II (Modules)	Category III (Modules)	Category IV (Modules)
A	A2	B (Design Type) + D	B (Production Type) + D
	D1	B (Design Type) + F	B (Production Type) + F
	E1	B (Production Type) + E	G
		B (Production Type) + C2	H1
		H	

Essential Safety Requirements (ESRs)

Preliminary Observations

- Analyse the hazards due to pressure, design and build equipment based on analysis

General

- Protection principles

Design

- For adequate strength and safety in operation

Manufacturing

- Including inspection, joining, testing, marking, instructions

Materials

- Suitable for the application and scheduled lifetime unless a replacement is foreseen

Specific Pressure Equipment Requirements

- Fired or otherwise heated equipment with a risk of over heating
- Piping

Specific Quantitative Requirements for Certain Pressure Equipment

- Allowable stresses, test pressure, joint coefficients, pressure limiting devices, ductility and toughness,

Custom Union Technical Regulation

- Depending on the type of equipment involved for pressure equipment the CU TR 032 works along similar lines as PED does, that is to say classification of equipment determines if there will be a declaration of conformity, or a certificate of conformity.
- Depending on the type of equipment it might be possible to allow to group similar types of equipment. This grouping will determine how many documents will have to be made in order to be able to ship equipment to the Russian Customs Union. Documents required could be:
 - o CoC or DoC
 - o Russian passport
 - o Safety case
 - o Recalculation according to Russian regulation
 - o Russian Manual.