

Pressure Vessel Inspections

ASME

American Society of Mechanical
Engineers

Pressure Vessel Definition article provides you the definition and boundaries of pressure vessel based API code and ASME Code.

- Based on the ASME Code Section VIII, pressure vessels are containers for the containment of pressure, either internal or external. The ASME Code is a construction code for pressure vessels and contains mandatory requirements, specific prohibitions and non-mandatory guidance for pressure vessel materials, design, fabrication, examination, inspection, testing, and certification.

Pressure Vessel Definition - Scope

These scopes are based ASME Code Sec VIII Div 1

- The vessel with maximum allowable working pressure(MAWP) higher than 15 psi
- •Inside diameter to be higher than 152 mm
- •No piping or piping component
- •No rotating or reciprocating Equipment
- •Not Water Vessel up to 300psi or 210°F
- •Not within the scope of other Sections

Vessel MAWP

- Vessel MAWP represents the maximum safe pressure holding capacity of the vessel. Vessel MAWP is measured at top-most point and is lowest of vessel part MAWPs, adjusted for hydrostatic head.

Boundaries

- The welding end of the first circumferential joint for welded connections
- •The first threaded joint for screwed connections
- •The face of the first flange for bolted, flanged connections
- •The first sealing surface for proprietary connections or fittings
- •Non pressure parts welded directly to a pressure retaining surface
- •Pressure retaining covers
- •Pressure relief devices

What is API Code Definition from Pressure Vessel ?

- Contrary of ASME Code Sec VIII, which was developed for construction, the API STD 510 covers the in-service inspection, repair, alteration, and rerating activities for pressure vessels.
- This inspection code applies to all refining and chemical process vessels that have been placed in service.



ASME Code Section 8

- The ASME Code Section 8 is the construction code for pressure vessel and covers design, manufacturing and pressure vessel inspection

ASME Code Section 8

- ASME Code Section 8 has three divisions.
- Division 1 covers pressure up to 3000 psi,
- Division 2 has an alternative rule and covers up to 10,000 psi
- Division 3 can be used for pressure higher than 10,000 psi.

Hierarchy of Standard

- Law and Regulation at Location of Installation
- Mandatory application of ASME pressure vessel code is determined by rule and regulation at location of installation.

Regulation by Location

Mandatory

Minnesota

Not Mandatory

South Carolina

ASME Boiler and Pressure Vessel Code

- the ASME Code generally is divided into three groups as following:
- Group 1: Construction Codes
- Some of them are: Section VIII for pressure vessel, Section I for Power Boiler, section III for Nuclear Power Plant and Section IV for heating Boiler

ASME Boiler and Pressure Vessel Code

- Group 2: Reference Codes
- These are the codes which are referenced from construction codes as explained in group 1.
- The ASME Section IX for welding and Section V for Non Destructive Testing are in this Group.
- For example, ASME Code section VIII for welding requirement such as WPS (Welding Procedure Specification), PQR (Procedure Qualification Record), Welder Performance Qualification, etc. refer you to ASME Section IX.

ASME Boiler and Pressure Vessel Code

- Group 3: In-Service Codes
- These are the codes for in-service inspection after placing the equipment into service.
- The ASME Section VI for the heating boiler and Section VII are from this group.

National Board Inspection Code(NBIC):

- ASME has a separate section for Heating Boilers, the NBIC is making certification for ASME Authorized Inspectors and is also certifying R stamp for Repair services for stamped pressure vessels.

Foreword	
Introduction:	U-1, U-2, U-3
Subsection A:	UG - General Requirements
Subsection B:	Methods of Fabrication
	UW - Welding
	UF - Forging
	UB - Brazing
Subsection C:	Classes of Material - Special Constructions
	UCS - Carbon and Low Alloy Steel
	UNF - Non ferrous Materials
	UHA - High Alloy Steel
	UCI - Cast Iron
	UCL - Cladding and Lining
	UCD - Cast Ductile Iron
	UHT - Ferritic Steels with Heat Treatment
	ULW - Layered Constructions
	ULT - Low Temperature Service
	UHX - Rules for Shell and Tube Heat Exchangers
	Mandatory and Nonmandatory Appendices

This section is divided into three Subsections, Mandatory Appendices, and Nonmandatory Appendices.

- Subsection A consists of Part UG, covering the general requirements applicable to all pressure vessels.

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- Subsection B covers specific requirements that are applicable to the various methods used in the fabrication of pressure vessels.
- It consists of Parts UW, UF, and UB dealing with welded, forged, and brazed methods, respectively.

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- Subsection C covers specific requirements applicable to the several classes of materials used in pressure vessel construction.
- It consists of Parts UCS, UNF, UHA, UCI, UCL, UCD, UHT, ULW, and ULT dealing with carbon and low alloy steels, nonferrous metals, high alloy steels, cast iron, clad and lined material, cast ductile iron, ferritic steels with properties enhanced by heat treatment, layered construction, and low temperature materials, respectively.

Summary of Important Points in ASME Code Section 8 [just a few]

- Category A:
 - - All longitudinal welds in shell and nozzles.
 - - All welds in heads, Hemisph-head to shell weld joint
- Category B:
 - - All circumferential welds in shell and nozzles
 - - Head to shell joint (other than Hemisph.)
- Category C and D are flange welds and nozzle attachment welds respectively.

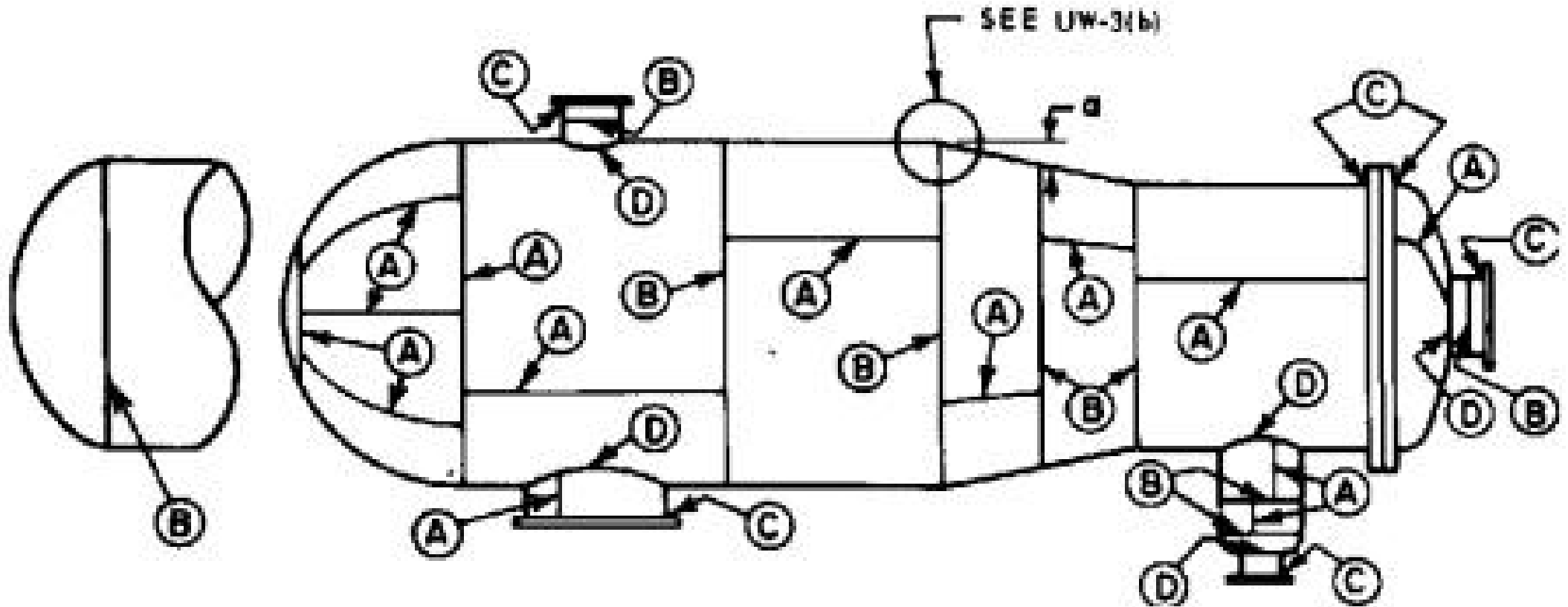
Summary of Important Points in ASME Code Section 8 [just a few]

- Category B:
 - - All circumferential welds in shell and nozzles
 - - Head to shell joint (other than Hemisph.)
- Category C and D are flange welds and nozzle attachment welds respectively.

Summary of Important Points in ASME Code Section 8 [just a few]

- Hydro-Test is Standard Pressure test on Completed Vessels.
- Hyd. Test Pr. = $1.3 \times \text{MAWP} \times \text{stress ratio}$
- Insp. Pressure (hydro) = test pr. / 1.3
- Min. Test temp. = $\text{MDMT} + 30^\circ\text{F}$
- Max. Inspection temp. = 120°F
- Pneumatic test is performed if hydro is not possible due to design or process reasons. Prior to the test, NDT as per UW-50 is mandatory.
- Pneumatic test pressure = $1.1 \times \text{MAWP} \times \text{stress ratio}$, Pressure should be increased in steps (Total 6).
- 1st step – 50% of test pressure
- 2nd to 6 step – 10% of test pressure
- Insp. Pr. (pneumatic) = test pressure / 1.1

Inspection points



Creep and Creep Failures

- What is creep?
- Creep may be defined as a time-dependent deformation at elevated temperature and constant stress.
- It follows, then, that a failure from such a condition is referred to as a creep failure or, occasionally, a stress rupture.

Creep and Creep Failures

- Creep failures are characterized by:
- bulging or blisters in the tube
- thick-edged fractures often with very little obvious ductility
- longitudinal "stress cracks" in either or both ID and OD oxide scales
- external or internal oxide-scale thicknesses that suggest higher-than-expected temperatures
- intergranular voids and cracks in the microstructure

Relief Valves Often Overlooked

- The most neglected safety device on pressure vessels is the relief valve.

it is imperative that the relief valve be inspected regularly

- relief valve is constructed to relieve either pressure or temperature, manually testing the valve with the test lever only tests the mechanical freedom of movement of the valve and ensures the waterways are clear.

[this test may change the proper setting of the valve]

- Manufacturers recommend that valves that have been in service more than three years be removed and visually inspected for accumulations of corrosion deposits, such as those shown in the photographs.
- The probe should be inspected for corrosion and scale accumulations which will insulate the valve and probe from the tanks internals , and also for any illegal alterations, repairs or tampering.
- **Leaking relief valves must be replaced.**

**Don't become a statistic;
conduct regular routine inspections and
correct all of the deficiencies discovered**

Pressure Vessel Fatigue

- Section VIII, Division 2 of the ASME Boiler and Pressure Vessel Code (ASME 2010) defines fatigue as “... conditions leading to fracture under repeated or fluctuating stresses having a maximum value less than the tensile strength of the material.”(1

Pressure Vessel Fatigue

- Fatigue damage in a metal is a progressive, localized, permanent structural change. This article takes a more detailed look at metal fatigue including testing for fatigue, conditions affecting fatigue life of a pressure vessel, and examining vessels for signs of fatigue.

Pressure Vessel Fatigue

- the important factor is number of stress repetitions, not time in service. Fatigue in metals is a progression beginning with submicroscopic changes in grain structure of the metal, and consists of three main stages: crack initiation, crack propagation, and rupture. Once initiation of a crack occurs, the crack grows a finite amount with each stress cycle until the remaining cross sectional area is so small rupture occurs. Straightening the wire in a paper clip and bending the wire back and forth about a point until failure is a common example of fatigue.

Pressure Vessel Fatigue

A number of conditions affect fatigue life of a pressure vessel.

Some conditions listed below have a greater effect on fatigue life than others, but all affect fatigue life of vessels in some manner.

- Cyclic stress state: number of stress cycles and the stress range
- Geometry: sharp corners, small radii, and small fillets decrease fatigue life of a vessel component
- Surface quality: polished surfaces increase fatigue life compared to non-polished surfaces
- Weld quality: any defect in a weld decreases fatigue life. Weld surfaces are machined to increase fatigue life of a part
- Material type: some materials are more fatigue tolerant than others

Pressure Vessel Fatigue

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- Residual stresses: stresses resulting from the manufacturing processes such as forming, welding, etc., decrease fatigue life
- Size and distribution of internal defects: inclusions such as sulfides in steel decrease fatigue life
- Grain size: fine-grain steels are more fatigue-tolerant than coarse-grain steels
- Environment: a corrosive environment decreases fatigue life
- Temperature: extreme high and low temperatures decrease fatigue life

Preventing Corrosion Under Insulation

- Galvanic corrosion, alkaline acidic corrosion, and stress-corrosion cracking have all been known to happen in certain conditions

Types of Corrosion Under Insulation

By understanding the types of corrosion that can occur under insulation, the proper materials and construction can be employed to prevent them. Intruding water is the key problem in CUI. Special care must be taken during design not to promote corrosion by permitting water to enter a system either directly or indirectly by capillary action. Moisture may be external or may be present in insulation. It is known to happen in certain conditions

Types of Corrosion Under Insulation

Galvanic corrosion

generally results from wet insulation with an electrolyte or salt present that allows a current flow between dissimilar metals (i.e., the insulated metal surface and the outer jacket or accessories). The extent and severity of the attack on the less noble metal depends not only on the difference in potential of the two metals, but also on their relative areas

Types of Corrosion Under Insulation

Alkaline or acidic corrosion

results when an alkali or acid and moisture, are present in certain fibrous or granular insulations. For hot service above 250o F, most of the water is driven off. This water vapor may condense at the edge of the insulation, and dissolve the alkaline or acidic chemicals there, resulting in corrosion of the aluminum or steel jacketing.

Types of Corrosion Under Insulation

Chloride corrosion

can be caused by the combination of insulation containing leachable chlorides with the 300 series austenitic-stainless-steel surfaces, when moisture is present and temperatures are above 140o F. Concentration of the chloride ion usually results from the evaporation of rain water, or of water used to fight fires, or of process water. Stress-corrosion cracking of insulating jackets often results from airborne salts in coastal regions.

Preventing Corrosion

The major factor in preventing Corrosion [CUI]

is to keep liquid from intruding into the insulation. Water decreases the effectiveness of the insulation and leads to corrosion of pipe or equipment. Poor conditions caused by wet insulation can be aggravated by weathering, vibration or abuse from people.

Preventing Corrosion

There are five factors in preventing CUI:

- (1) insulation selection;
- (2) equipment design;
- (3) protective paints and coatings;
- (4) weather barriers;
- (5) maintenance practices.

Preventing Corrosion Galvanic

Since this form of corrosion results from water invasion in a wet or humid atmosphere, selecting cellular insulation may be the only answer. Also, it might be best to use a plastic or synthetic-rubber jacket. Such jackets are factory applied and are fire and weather resistant. They offer protection from normal abuse and from easy penetration of water. Commercial plastic jacketings normally will not corrode.

Preventing Corrosion Galvanic

Metal surfaces can, of course, be painted. Paints can inhibit cathodic and anodic reactions, and provide a highly resistive path to current flow. However, some pigments can promote corrosion, especially in the first coat of primers. Common ones are red oxides, gypsum, ochre, graphite and lamp black. Even in the normal corrosion process, alkali is formed at the cathode; this alkaline area grows, even under paint films pigmented with zinc or aluminum.

Preventing Corrosion Galvanic

coatings to prevent galvanic corrosion, consider the following in regard to sacrificial materials: (a) as temperature increases, there is a chance of reversal in the polarity of galvanic couples; (b) salts carried into insulation and deposited onto surfaces interfere with, or destroy, the effectiveness of corrosion inhibitors; and (c) the insulation system is not freely ventilated and may have inadequate oxygen for sacrificial reactions to occur.

Preventing Corrosion

Alkaline or Acidic

An internally mounted anode beneath the primary weathering barrier and above the secondary coating has been found effective as an additional measure.

Preventing Corrosion Chloride

With stainless steels, problems have resulted because of leachable chlorides contained in some insulation. For the 300 series stainless, use insulation that meets MIL-I-24244 or ASTM C-795 specifications. This provides sufficient control, unless there is an external invasion of chlorides.

A further way to reduce the chance of chloride attack is to use an inhibited insulation