Pressure Vessel Newsletter

Volume 2014, December Issue

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From The Editor’s Desk:

While the statistics on the number of pressure vessels placed in service every year is hard to come by, it is reasonable to assume that the number of existing pressure vessels currently in service far outnumber the new vessels. Maintaining the health of these existing pressure vessels is often a cost effective way of meeting the plant needs as opposed to procuring new pressure vessels.

A plant objective is to attain the maximum economic benefit and service life from existing equipment without sacrificing integrity. This requires accurate assessment of the condition of the equipment and their suitability for the actual service. Fitness-for-service (FFS) assessments are quantitative engineering evaluations that are performed to demonstrate the structural integrity of an in-service component containing a flaw or damage. API RP 579 provides clear guidelines for dealing with degraded equipment in a manner that allows continued service without requiring repair, replacement, or reduction of the pressure rating.

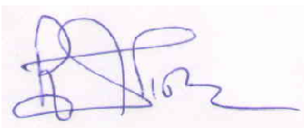
Common degradation mechanisms include corrosion, localized corrosion, pitting and crevice corrosion, hydrogen attack, embrittlement, fatigue, high temperature creep, and mechanical distortion. Reasons for FFS assessment for equipment may include the discovery of a flaw such as a locally thin area (LTA) or crack, failure to meet current design standards, and plans for operating under more severe conditions than originally expected. The main products of FFS are 1) a decision to run, alter, repair, monitor or replace the equipment, and 2) guidance on inspection interval for the equipment.

The procedures provided in API RP 579 are aimed at equipment operating in petroleum and chemical industries. They apply to the following items:

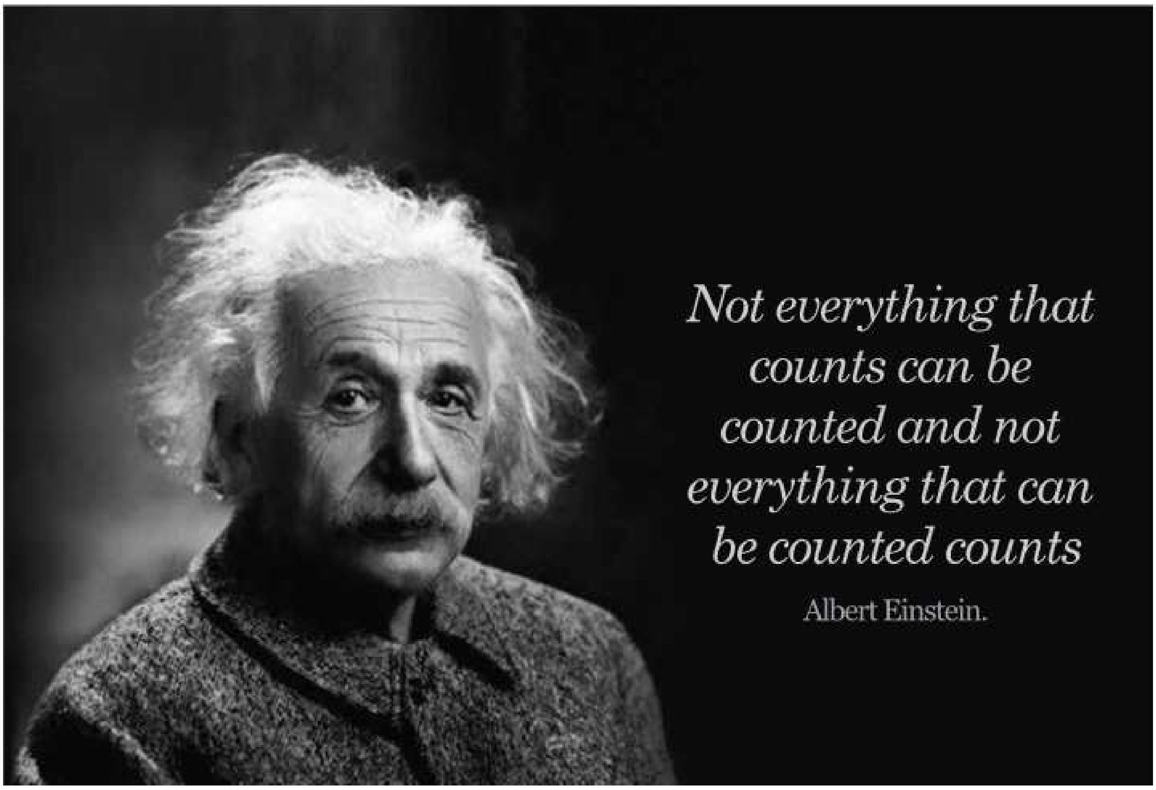
1) Components designed and constructed to the ASME Boiler and Pressure Vessel, Section I, and Section VIII, Divisions 1 and 2.
2) Piping designed to ASME B31.1 and 31.3 piping codes.
3) Storage tanks designed and constructed to API 620 and API 650 codes.

On a different topic, I have had frequent requests from the readers of the newsletter to provide a listing of the articles covered in the last seven years sorted by subject. Since the newsletter itself started as an informal exercise, and has since undergone many format changes, it has taken me a while to put this information together. I am now pleased to announce that the compilation of the articles covered is now complete. You may find this compilation in a tabulated form starting from page 9 in this newsletter. I am now working to place all the issues (with the articles) online. Meanwhile, if you require a copy of a previous newsletter that is not available on the website (www.codesignengg.com), you may make a request – I will be happy to oblige.

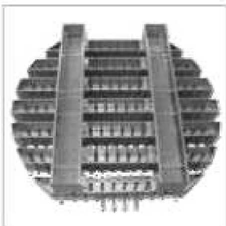
Best wishes for a very happy and prosperous 2015.



In this issue…




Random Packings


Tower Internals


Fractionation Trays


Structured Packings


Mist Eliminators

THE FRACTURE MECHANICS APPROACH TO DESIGN

Figure 1 contrasts the fracture mechanics approach with the traditional approach to structural design and material selection. In the latter case, the anticipated design stress is compared to the flow properties of candidate materials; a material is assumed to be adequate if its strength is greater than the expected applied stress. Such an approach may attempt to guard against brittle fracture by imposing a safety factor on stress, combined with minimum tensile elongation requirements on the material. Figure 1(b) has three important variables, rather than two as in Figure 1(a). The additional structural variable is the flaw size, and fracture toughness replaces strength as the relevant material property. Fracture mechanics quantifies the critical combinations of these three variables.

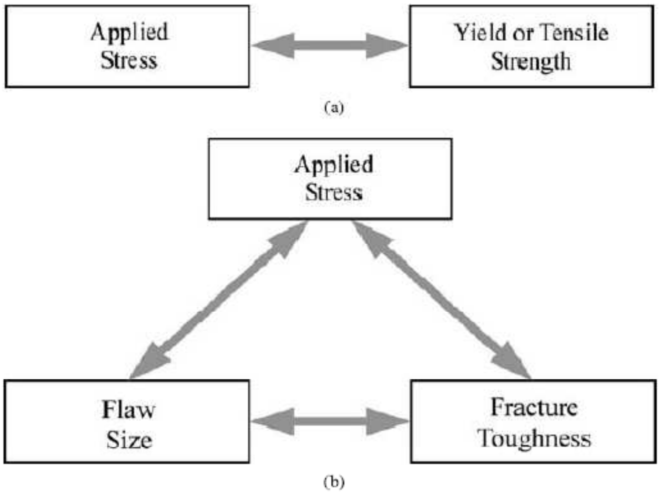


Figure 1: Comparison of Fracture Mechanics Approach (a) Strength of Materials Approach, and (b) Fracture Mechanics Approach

There are two alternative approaches to fracture analysis: the energy criterion and the stress-intensity approach. These two approaches are equivalent in certain circumstances. Both are discussed briefly below.

The Energy Criterion

The energy approach states that crack extension (i.e., fracture) occurs when the energy available for crack growth is sufficient to overcome the resistance of the material. The material resistance may include the surface energy, plastic work, or other types of energy dissipation associated with a propagating crack. The energy release rate, *G*, is defined as the rate of change in potential energy with the crack area for a linear elastic material. At the moment of fracture $G = G_C$, the critical energy release rate, which is a measure of fracture toughness.

Referring to Figure 2, for a crack of length *2a* in an infinite plate subject to a remote tensile stress, the energy release rate is given by:

$$G = \frac{\pi\sigma^2 a}{E}$$

where*E* is the Young's modulus, σ is the remotely applied stress, and *a* is the half crack length. At fracture, $G = G_C$, and the above equation describes the critical combinations of stress and crack size for failure.

$$G_C = \frac{\pi{\sigma_f}^2 a_c}{E}$$

Note that for a constant G_C value, failure stress σ_f varies with $1/\sqrt{a}$. The energy release rate *G* is the driving force for fracture, while G_C is the material's resistance to fracture. To draw an analogy to the strength of materials approach of Figure 1, the applied stress can be viewed as the driving force for plastic deformation, while the yield stress is a measure of material's resistance to deformation.

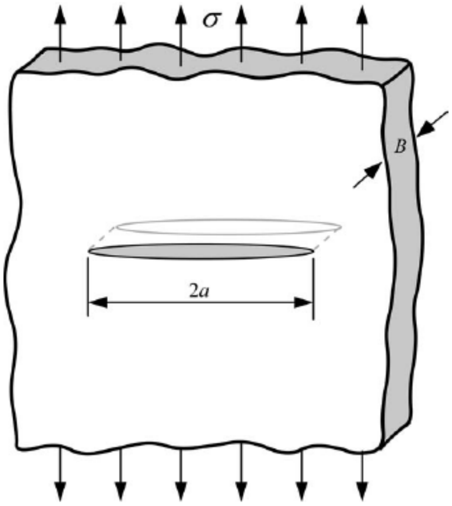


Figure 2: Through-thickness Crack in an Infinite Plate Subject to a Remote Tensile Stress

One of the fundamental assumptions of fracture mechanics is that fracture toughness (G_C in this case) is independent of the size and geometry of the cracked body; a fracture toughness measurement on a laboratory specimen should be applicable to a structure. As long as this assumption is valid, all configuration effects are taken into account by the driving force G_C. The similitude assumption is valid as long as the material behavior is predominantly linear elastic.

The Stress-Intensity Approach

Figure 3 schematically shows an element near the tip of a crack in an elastic material, together with the in-plane stress on this element. Note that each stress component is proportional to a single constant K_I. If this constant is known, the entire stress distribution at the crack-tip can be computed with the equations in Figure 3. This constant, called the stress-intensity factor, completely characterizes the crack-tip conditions in a linear elastic material. If one assumes that the material fails locally at some critical combinations of stress and strain, then it follows that fracture must occur at a critical stress intensity K_{Ic}. This K_{Ic} is an alternate measure of fracture toughness.

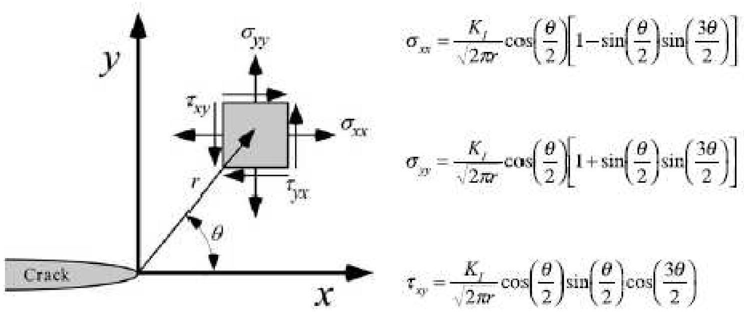


Figure 3: Stresses near the tip of a crack in an elastic material

For the plate illustrated in Figure 2, the stress-intensity factor is given by

$$K_I = \sigma\sqrt{\pi a}$$

Failure occurs when $K_I = K_{Ic}$. In this case, K_I is the driving force for fracture and K_{Ic} is a measure of material resistance. As with G_C, the property of similitude should apply to K_{Ic}. That is, K_{Ic} is assumed to be a size-independent material property. The relationship between K_I and G is given as

$$G = \frac{K_I^2}{E}$$

This same relationship obviously holds for G_C and K_{Ic}. Thus, the energy and stress-intensity approaches to fracture mechanics are essentially equivalent for linear elastic material.

Time-Dependent Crack Growth and Damage Tolerance

Fracture mechanics often plays a role in life prediction of components that are subject to time-dependent crack-growth mechanisms such as fatigue or stress corrosion cracking. The rate of cracking can be correlated with fracture mechanics parameters such as stress-intensity factor, and the critical crack size for failure can be computed if the fracture toughness is known. For example, the fatigue crack growth rate in metals can usually be described by the following empirical relationship:

$$\frac{da}{dN} = C(\Delta K)^m$$

Where *da/dN* is the crack growth per cycle, ΔK is the stress-intensity range, and C and m are material constants.

Damage tolerance, as its name suggests, entails allowing subcritical flaws to remain in a structure. Repairing flawed material or scrapping a flawed structure is expensive and is often unnecessary. Fracture mechanics provides a rational basis for establishing flaw tolerance limits.

Consider a flaw in a structure that grows with time (e.g., a fatigue crack or a stress corrosion crack) as illustrated schematically in Figure 4. The initial crack size is inferred from nondestructive examination (NDE), and the critical crack size is computed from the applied stress and fracture toughness. Normally, an allowable flaw size would be defined by dividing the critical size by a critical factor. The predicted service life of the structure can then be inferred by calculating the time required for the flaw to grow from its initial size to the maximum allowable size.

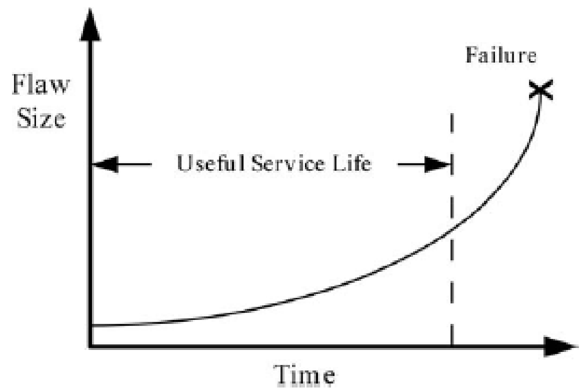


Figure 4: The damage tolerance approach to design

Effect of Material Properties on Fracture

Consider the cracked plate from Figure 2 that is loaded to failure. Figure 5 is a schematic plot of failure stress vs. fracture toughness K_{Ic}. For low toughness materials, brittle fracture is the governingfailure mechanism, and critical stress varies linearly with K_{Ic}. At very high toughness values, LEFM is no longer valid, and the failure is governed by the flow properties of the material. At intermediate toughness levels, there is a transition between brittle fracture under linear elastic conditions and ductile overload. Nonlinear fracture mechanics bridges the gap between LEFM and collapse. If toughness is low, LEFM is applicable to the problem, but if toughness is sufficiently high, fracture mechanics ceases to be relevant to the problem because failure stress is insensitive to toughness; a simple limit load analysis is all that is required to predict failure stress in a material with very high fracture toughness.

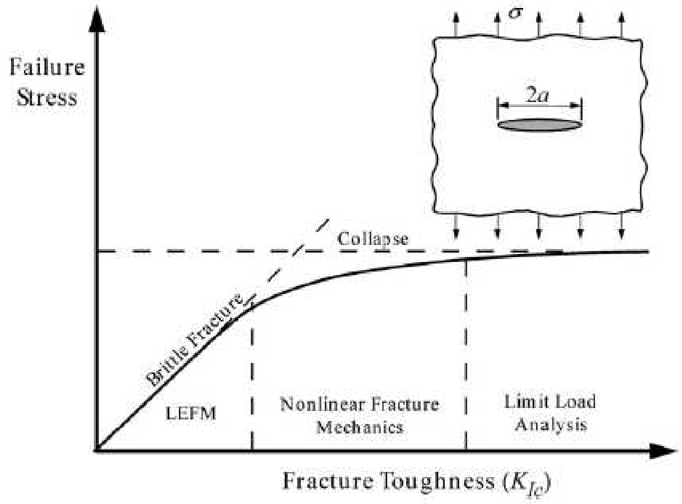


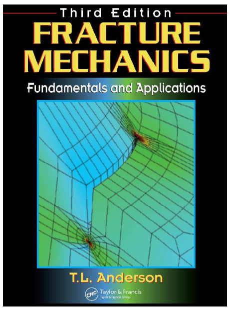
Figure 5: Effect of fracture toughness on the governing failure mechanism

Table 1 lists various materials, together with the typical fracture regime for each material.

Table 1: Typical Fracture Behavior of Selected Materials

Material	**Typical Fracture Behavior**
High strength steel	Linear elastic
Low- and medium-strength steel	Elastic-plastic/ fully plastic
Austenitic stainless steel	Fully plastic
Precipitation-hardened aluminum	Linear elastic
Metals at high temperatures	Visco-plastic
Metals at high strain rates	Dynamic/ visco-plastic
Polymers below glass transition temperature	Linear elastic/ visco-elastic
Polymers above glass transition temperature	Visco-elastic
Monolithic ceramics	Linear elastic
Ceramic composites	Linear elastic
Ceramics at high temperatures	Visco-plastic

Source: Fracture Mechanics – Fundamentals and Applications *by* T.L. Anderson



A GUIDE TO PRESSURE VESSEL NEWSLETTER ARTICLES BY SUBJECT

Subject	Topic	Reference
General	Definitions	Volume 1, Issue 26
	Economic Considerations in Pressure Vessel Design	Volume 3, Issue 9
	Pressure Vessel Design Criteria	Volume 2012, Issue 11
	A-Z of Pressure Vessels	Volume 2013, August Issue
	A-Z of Pressure Vessels – 2	Volume 2013, October Issue
	General Definitions in Pressure Vessels	Volume 2014, September Issue
Codes and Standards	Changes in 2007 Edition of ASME Boiler Code, Section VIII, Division 1	Volume 1, Issue 6
	ASME Section VIII, Division 1 Primer	Volume 2, Issue 3
	ASME Section VIII, Division 1 Primer 2	Volume 2, Issue 4
	History and Organization of Code	Volume 3, Issue 6
	Introduction to ASME Boiler & Pressure Vessel Code, Section VIII, Division 1	Volume 2012, Issue 1
	Introduction to ASME Section VIII, Division 2	Volume 2012, Issue 8
	ASME Boiler and Pressure Vessel Codes	Volume 2012, Issue 12
	EN13445: Unfired Pressure Vessels	Volume 2014, August Issue
	FAQ – Single Certification Mark	Volume 2014, August Issue
Stresses in Pressure Vessels	Stresses in Pressure Vessels	Volume 1, Issue 4
	Stresses in Pressure Vessels – Part 1	Volume 3, Issue 7
	Stresses in Pressure Vessels – Part 2	Volume 3, Issue 8
	Stresses in Pressure Vessels	Volume 2014, January Issue
	Local Stresses in Pressure Vessels due to Internal Pressure and Nozzle Loadings	Volume 2014, February Issue
	Discontinuity Stresses in Pressure Vessels	Volume 2014, September Issue
Design	Design of Thin Cylindrical Shells	Volume 1, Issue 7
	Reinforcement of Openings in Pressure Vessels	Volume 1, Issue 20
	ASME Section VIII, Division 1 – Rules for Openings and Reinforcements	Volume 1, Issue 21
	Bolted Flange Connections with Ring Type Gaskets	Volume 2, Issue 1
	Design: UG-1 Through UG-26	Volume 2012, Issue 3
	Design of Shell Sections	Volume 2012, Issue 5
	ASME Section VIII, Division 2 – Design by Rules	Volume 2012, Issue 9
	Openings and Reinforcements	Volume 2014, October Issue
	Bolted Flange Connections	Volume 2014, October Issue
Wind and Seismic Loads	Design of Tall Vertical Vessels for Wind Loads	Volume 1, Issue 2
	Design of Tall Vertical Vessels for Seismic Loads	Volume 1, Issue 19
	Seismic Design for Vessels per ASCE 7-05	Volume 1, Issue 22
	Earthquake Loads on Pressure Vessels	Volume 3, Issue 4
	Tall Vertical Pressure Vessels	Volume 2012, Issue 6

Subject	Topic	Reference
Low Temperature Operation	Low Temperature Operation	Volume 2012, Issue 4
	ASME Impact Test Requirements	Volume 2014, February Issue
	Charpy Impact Tests	Volume 2014, June Issue
Pressure Vessel Supports	Pressure Vessel Supports – Skirt	Volume 2012, Issue 10
Fatigue	Fatigue Analysis	Volume 1, Issue 12
	Fatigue Analysis	Volume 3, Issue 3
	Basic Introduction to Fatigue	Volume 2014, March Issue
Material Selection	Pressure Vessel Materials	Volume 1, Issue 14
	General Requirements for All Materials	Volume 2012, Issue 2
Welding	Pressure Vessel Welding	Volume 1, Issue 15
	Pressure Vessel Welded Joints	Volume 1, Issue 17
	ASME Section VIII-1 Paragraph UW-11(a)(5)(b)	Volume 1, Issue 18
	Arc Welding Processes	Volume 3, Issue 2
	Taking On ASME Section VIII, Division 1 Pressure Vessel Efficiency	Volume 2014, February Issue
Pressure Vessel Inspection	API RP 572: Inspection of Pressure Vessels	Volume 1, Issue 1
	Inspection and Tests	Volume 3, Issue 5
	Nondestructive Methods of Examination	Volume 2013, December Issue
	API 510 Pressure Vessel Inspectors	Volume 2014, March Issue
	Acoustic Emission Examination of Metal Pressure Vessels	Volume 2014, January Issue
	Code Case 2235: Use of Ultrasonic Examination in Lieu of Radiography	Volume 2014, June Issue
Installation and Operation	Pressure Vessels: Installation and Operation	Volume 4, Issue 3
Failure Mechanisms	Failures in Pressure Vessels	Volume 2012, Issue 7
	Rupture Hazards of Pressure Vessels	Volume 2014, September Issue
	Fracture Mechanics – A Historical Perspective	Volume 2014, October Issue
Heat Exchangers	Basics of Closed Feedwater Heaters for Power Plants	Volume 1, Issue 8
	Shell & Tube Heat Exchangers: TEMA Types and Selection Guides	Volume 1, Issue 10
	Shell & Tube Heat Exchangers: Flow Induced Vibration	Volume 1, Issue 16
	Heat Exchanger Fouling	Volume 3, Issue 10
	Evaporators and Boilers in Process and Chemical Industries	Volume 4, Issue 2
	Introduction to Shell & Tube Heat Exchangers	Volume 2013, January Issue
	Classification of Shell & Tube Heat Exchangers	Volume 2013, February Issue
	Components of Shell & Tube Heat Exchangers	Volume 2013, March Issue
	TEMA Designation	Volume 2013, April Issue
	API 660 vs. TEMA	Volume 2013, May Issue
	Heat Exchanger Fouling	Volume 2014, April Issue
	Overview of Tube Vibration	Volume 2014, June Issue
Tanks	Fundamentals of Aboveground Storage Tanks	Volume 1, Issue 11

Subject	Topic	Reference
	Tank Accessories	Volume 2, Issue 2
	Aboveground Storage Tank Primer	Volume 2014, April Issue
Miscellaneous Topics	API RP 571: Damage Mechanisms Affecting Fixed Equipment in Refining Industry	Volume 1, Issue 3
	Petroleum Refining	Volume 1, Issue 5
	Vacuum Distillation	Volume 1, Issue 9
	Fluidized Catalytic Cracking in Petroleum Refining	Volume 1, Issue 13
	Surface Condensers	Volume 3, Issue 1
	ASTM A-212 Pressure Vessel Steel – A Case Against Its Continued Use	Volume 4, Issue 1
	New Standards for Quality Control and Assurance of Bolted Flange	Volume 2014, February Issue
	Definition of What is Meant by Cast Iron, Wrought Iron, and Steel	Volume 2014, March Issue
	Controlling Vessels and Tanks	Volume 2014, August Issue
	Identifying Pressure Vessel Nozzle Problems	Volume 2014, August Issue

TRAINING ANNOUNCEMENT

DESIGN & FABRICATION OF PRESSURE VESSELS: ASME SECTION VIII, DIVISION 1

Pressure vessels, along with tanks, are the workhorses for storage and processing applications in the chemical, petroleum, petrochemical, power, pharmaceutical, food and paper industries. ASME BPV, Section VIII, Div. 1 Code is used as a standard for the design and fabrication of pressure vessels by most companies across the world.

Wewould like to announce a one (1) day pressure vessel workshop on **January 31, 2014**at Vadodara. This course provides the information that will help you understand the ASME requirements for the design and fabrication of pressure vessels. The course material follows the contents of 2013 edition of the code, and is replete with worked examples covering important aspects of pressure vessel construction. The course is more than just a glimpse into the Code, it is packed with lots of information that includes several solved examples as well.

The contents of the training course will be as follows:

- Organization ofASME Boiler and Pressure Vessel Code
- Allowable Stresses
- Low Temperature Operation
- Welding Requirements
- Pressure Vessel Design – Shells and Heads
- Openings and Reinforcements
- Pressure Testing
- Markings and Reports
- Introduction to ASME Section VIII, Division 2
- Code Case 2695

The instructor, Ramesh Tiwari, is internationally recognized specialist in the area of pressure vessels, heat exchangers, materials, and codes and standards. He holds Bachelor's and Master's degrees in mechanical engineering from universities in India and United States. He is also a registered Professional Engineer in the State of Maryland in the United States. Mr. Tiwari is a member of ASME Boiler & Pressure Vessel, Section VIII Subgroup on Heat Transfer Equipment, and a member of ASME International Working Group on B31.1 for Power Piping in India. In this capacity, he has made invaluable contribution in resolving technical issues in compliance with the ASME codes for Code users. Mr. Tiwari has over 24 years of design engineering experience on a variety of projects spanning industries such as oil & gas, power, nuclear, chemical, petrochemical, pharmaceutical, food etc. He has provided engineering advice and code interpretations to senior management and guidance to several companies he has worked for in the US, India and Germany. He has initiated and implemented numerous innovative ideas to improve working process and quality, and developed and conducted training programs for peers as well as clients. Mr. Tiwari is an approved pressure vessel instructor at NTPC, a premier thermal power generating company in India and at several other companies, both public and private.

Registration fee for the training course is Rs. 6,500 for professionals and Rs4,500 for students (inclusive of all applicable taxes). Registration fee includes training, a collection of articles on design and fabrication of pressurevessels, electronic copy of the presentation, certificate from CoDesign Engineering, and beverages and lunch on all days. It excludes travel to and from Vadodara, accommodation, and meals and beverages other than those provided during the course. We invite you to make nominations.

In case of any queries, including the registration process, please email at learning@codesignengg.com, or call at +91 98109 33550.

ASME SECTION VIII, DIVISION 2 – EXAMINATION GROUPS

The new ASME Section VIII, Division 2 Code has introduced the concept of “Examination Groups” for pressure vessels. The nondestructive examination of finished welds is a function of the examination group selected, the joint category and the weld type.

The examination groups are assigned to the welded joints based on the manufacturing complexity of the material group, the maximum thickness, the welding process and the selected joint efficiency. The examination groups are subdivided into subgroups “a” or “b” to reflect crack sensitivity of the material.

Table 1: Examination Groups for Pressure Vessels

<table>
<tr><td rowspan="2">Parameter</td><td colspan="6">Examination Groups</td></tr>
<tr><td>1a</td><td>1b</td><td>2a</td><td>2b</td><td>3a</td><td>3b</td></tr>
<tr><td>Permitted Materials</td><td>All Materials</td><td>P-No. 1 Gr 1 and 2
P-No. 8 Gr 1</td><td>P-No. 8 Gr 2
P-No 9A Gr 1
P-No. 9B Gr 1
P-No. 11A Gr 1
P-No. 11A Gr 1
P-No. 10H Gr 1</td><td>P-No. 1 Gr 1 and 2
P-No. 8 Gr 1</td><td>P-No. 8 Gr 2
P-No. 9A Gr 1
P-No. 9B Gr 1
P-No. 10H Gr 1</td><td>P-No. 1 Gr 1 and 2
P-No. 8 Gr 1</td></tr>
<tr><td rowspan="2">Maximum Thickness of Governing Welded Joints</td><td colspan="2" rowspan="2">Unlimited</td><td>1-3/16 in. (30 mm) for
P-No. 9A Gr 1
P-No. 9B Gr 1</td><td>2 in. (50 mm) for
P-No. 1 Gr 1
P-No. 8 Gr 1</td><td>1-3/16 in. (30 mm) for
P-No. 9A Gr 1
P-No. 9B Gr 1</td><td>2 in. (50 mm) for
P-No. 1 Gr 1
P-No. 8 Gr 1</td></tr>
<tr><td>5/8 in. (16 mm) for
P-No. 8 Gr 2
P-No. 11A Gr 1
P-No. 11A Gr 1
P-No. 10H Gr 1</td><td>1-3/16 in. (30 mm) for
P-No. 1 Gr 2</td><td>5/8 in. (16 mm) for
P-No. 8 Gr 2
P-No. 10H Gr 1</td><td>1-3/16 in. (30 mm) for
P-No. 1 Gr 2</td></tr>
<tr><td>Welding Process</td><td colspan="2">Unrestricted</td><td colspan="2">Mechanized Welding Only</td><td colspan="2">Unrestricted</td></tr>
<tr><td>Design Basis</td><td colspan="2">Part 4 or 5</td><td colspan="2">Part 4 or 5</td><td colspan="2">Part 4</td></tr>
<tr><td>Welded Joint Efficiency</td><td colspan="2">1.0</td><td colspan="2">1.0</td><td colspan="2">0.85</td></tr>
</table>

Extent of Nondestructive Examination

The extent of examination is a percentage of the total length of welded joints under consideration. The examination requirements pertain to all butt-welded joints. If a weld is radiographically examined, then it shall also be ultrasonically examined if

a) Weld is made by electron beam welding process, or
b) Weld is made by continuous drive friction welding process

The following welding processes shall be radiographically examined **and** ultrasonically examined over their entire length. The ultrasonic examination shall be done following the grain refining (austenitizing) heat treatment or PWHT:

a) Welds made by the electroslag welding process, and
b) Welds made by the electrogas welding process with any single pass thickness greater than 1-3/16 in. (38 mm) in ferritic materials

As far as the extent and the location of NDE when the extent of examination is less than 100% is concerned, the criteria for shells and formed heads are same as those required by ASME VIII-1 rules. For nozzles attached to the vessel, the completed circumferential and longitudinal butt joints of at least one nozzle in each group shall be examined as shown below.

1) If the extent of examination is 100%, each individual nozzle shall be examined.
2) If the extent of examination is 25%, then one complete nozzle for each group of 4 shall be examined.
3) If the extent of examination is 10%, then one complete nozzle for each group of 10 shall be examined.

Table 2: Nondestructive Examination

Examination Group					1a	1b	2a	2b	3a	3b
Joint Category	Type of Weld [Note (1)]			Type of NDE. [Note (2)]	Extent of NDE [Note (10), (11), (12)]					
A	Full penetration butt weld	1	Longitudinal joints	RT or UT MT or PT	100% 10%	100% 10%[Note (4)]	100% 10%	100% 10%[Note (4)]	25% 10%	10% 10%[Note (4)]
B		1	Circumferential joints on a shell	RT or UT MT or PT	100% 10%	100% 10%[Note (4)]	100% 10%	100% 10%[Note (4)]	10% 10%	10%[Note (3)] 10%[Note (4)]
B		2,3	Circumferential joints on a shell with backing strip[Note (9)]	RT or UT MT or PT	NA NA	100% 10%	NA NA	25% 10%	NA NA	25% 10%
B		1	Circumferential joints on a nozzle where *d*> 150 mm (6 in.) or *t*> 16 mm (5/8 in.)	RT or UT MT or PT	100% 10%	100% 10%[Note (4)]	100% 10%	100% 10%[Note (4)]	10% 10%	10%[Note (3)] 10%[Note (4)]
B		2,3	Circumferential joints on a nozzle where *d*> 150 mm (6 in.) or *t*> 16 mm (5/8 in.) with backing strip[Note (9)]	RT or UT MT or PT	NA NA	100% 10%	NA NA	25% 10%	NA NA	25% 10%
B		1	Circumferential joints on a nozzle where *d* ≤ 150 mm (6 in.) or *t* ≤ 16 mm (5/8 in.)	MT or PT	100%	10%	100%	10%	10%	10%
A		1	All welds in spheres, heads, and hemispherical heads to shells	RT or UT MT or PT	100% 10%	100% 10%[Note (4)]	100% 10%	100% 10%[Note (4)]	25% 10%	10% 10%[Note (4)]
B		1	Attachment of a conical shell with a cylindrical shell at an angle ≤ 30 deg	RT or UT MT or PT	100% 10%	100% 10%[Note (4)]	100% 10%	100% 10%[Note (4)]	10% 10%	10% 10%[Note (4)]
B		8	Attachment of a conical shell with a cylindrical shell at an angle > 30 deg	RT or UT MT or PT	100% 10%	100% 10%[Note (4)]	100% 10%	100% 10%[Note (4)]	25% 10%	10% 10%[Note (4)]
C	Assembly of a flat head or tubesheet, with a cylindrical shell or Assembly of a	1, 2, 3, 7	With full penetration	UT MT or PT	100% 10%	100% 10%[Note (4)]	100% 10%	100% 10%[Note (4)]	25% 10%	10% 10%[Note (4)]
C		9, 10	With partial penetration if *a* >16 mm (5/8 in.)[Note (16)]	UT MT or PT	NA	NA	NA	NA	25% 10%	10% 10%

Examination Group				1a	1b	2a	2b	3a	3b
Joint Category	Type of Weld [Note (1)]			Type of NDE. [Note (2)]	Extent of NDE [Note (10), (11), (12)]				
C	Flange or a collar with a shell	9, 10	With partial penetration if *a*≤16 mm (5/8 in.)[Note (16)]	UT MT or PT	NA	NA	NA	NA	10%	10%
C	Assembly of a flange or a collar with a nozzle	1, 2, 3, 7	With full penetration	RT or UT MT or PT	100% 10%	100% 10%[Note (4)]	100% 10%	100% 10%[Note (4)]	25% 10%	10% 10%[Note (4)]
C		9, 10	With partial penetration	MT or PT	NA	NA	NA	NA	10%	10%
C		9, 10	With full or partial penetration *d*≤150 mm (6 in.) and *t*≤16 mm (5/8 in.)	MT or PT	10%	10%[Note (4)]	10%	10%[Note (4)]	10%	10%[Note (4)]
D	Nozzle or branch[Note (5)]	1, 2, 3, 7	With full penetration *d*>150 mm (6 in.) or *t*>16 mm (5/8 in.)	RT or UT MT or PT	100% 10%	100% 10%[Note (4)]	100% 10%	100% 10%[Note (4)]	25% 10%	10% 10%[Note (4)]
D		1, 2, 3, 7	With full penetration *d*≤150 mm (6 in.) and t ≤16 mm (5/8 in.)	MT or PT	100%	10%	100%	10%	10%	10%
D		9, 10	With partial penetration for any *d* *a*>16 mm (5/8 in.)[Note (17)]	UT MT or PT	100% 10%	100% 10%[Note (4)]	100% 10%	100% 10%[Note (4)]	25% 10%	10% 10%[Note (4)]
D		9, 10	With partial penetration *d*>150 mm (6 in.) *a*≤16 mm (5/8 in.)[Note (17)]	MT or PT	NA	NA	NA	NA	10%	10%
D		9, 10	With partial penetration *d*≤150 mm (6 in.) *a*≤16 mm (5/8 in.)	MT or PT	100%	10%	100%	10%	10%	10%
D	Tube-to-Tubesheet Welds	See Figure 4.18.13 and Table 4-C.1 of ASME VIII-2 Code		MT or PT	100%	100%	100%	100%	25%	10%
E	Permanent attachments [Note (6)]	1, 7, 9, 10	With full penetration or partial penetration[Note (15)]	RT or UT MT or PT	25%[Note (7)] 100%	10%[Note (4)] 10%	10% 100%	10%[Note (4)] 10%	10% 100%	10%[Note (4)] 10%[Note (4)]
NA	Pressure retaining areas after removal of attachments	NA	…	MT or PT	100%	100%	100%	100%	100%	100%
…	Cladding by welding	…	…	RT or UT MT or PT	[Note (13)] 100%	[Note (13)] 100%	[Note (13)] 100%	[Note (13)] 100%	[Note (13)] 100%	[Note (13)] 100%
…	Repairs [Note (14)]	…	…	RT or UT MT or PT	100% 100%	100% 100%	100% 100%	100% 100%	100% 100%	100% 100%

Notes:

(1) See paragraph 4.2 of of ASME VIII-2 Code.

(2) RT = Radiographic Examination, UT = Ultrasonic Examination, MT = Magnetic Particle Examination, PT = Liquid Penetrant Examination.

(3) 2% if t ≤ 30 mm (1-3/16 in.) and same weld procedure specification as longitudinal, for steel of P-No. 1 Gr 1 and P-No. 8 Gr 1

(4) 10% if t >30 mm (1-3/16 in.), 0% if t ≤30 mm (1-3/16 in.)

(5) Percentage in the table refers to the aggregate weld length of all the nozzles, see paragraph 7.4.3.5(b)of ASME VIII-2 Code.

(6) RT or UT is not required for weld thicknesses ≤16 mm (5/8 in.)

(7) 10% for steel of P-No. 8 Gr 2, P-No. 9A Gr 1, P-No. 9B Gr 1, P-No. 11A Gr 1, P-No. 11A Gr 2, P-No. 10H Gr 1

(8) (Currently not used.)

(9) For limitations of application see paragraph 4.2of ASME VIII-2 Code.

(10) The percentage of surface examination refers to the percentage of length of the welds both on the inside and the outside.

(11) RT and UT are volumetric examination methods, and MT and PT are surface examination methods. Both volumetric and surface examinations are required to be applied the extent shown.

(12) NA means "not applicable". All Examination Groups require 100% visual examination to the maximum extent possible.

(13) See paragraph 7.4.8.1of ASME VIII-2 Code for detailed examination requirements.

(14) The percentage of examination refers only to the repair weld and the original examination methods, see paragraph 6.2.7.3 of ASME VIII-2 Code.

(15) RT is applicable only to Type 1, full penetration welds.

(16) The term “*a*” as defined in Figure 7.16of ASME VIII-2 Code.

(17) The term “*a*” as defined in Figure 7.17of ASME VIII-2 Code.

(18) For SAW welds in 2-1/4 Cr–1Mo–1/4V vessels, ultrasonic examination in accordance with 7.5.4.1(e)of ASME VIII-2 Code is required.

Selection of Examination Methods for Internal (Volumetric) Flaws

Type of Joint	Shell Thickness - t	
	t < ½ in. (13 mm)	t ≥ ½ in. (13 mm)
1, 2, 3	RT	RT or UT
7, 8	N/A	UT

Source: *ASME Boiler and Pressure Vessel Code, Section VIII, Division 2*

NEWS AND EVENTS

Shell enlists SNC-Lavalin subsidiary for EPCM work at Pearl GTL project in Qatar

December 17, 2014 | Qatar

Qatar Kentz, a member of the SNC-Lavalin Group, has been awarded a four-year multi-million-dollar call-off contract, with a possible two-year extension, by Qatar Shell for its Pearl Gas-To-Liquids (GTL) onshore and offshore facilities in Qatar. Located in RasLaffan Industrial City, Pearl GTL is the world's largest source of GTL products, capable of producing 140,000 barrels of GTL products each day. The plant also produces 120,000 barrels per day of natural gas liquids and ethane. Kentz will manage the EPCM work for all services related to plant changes, as well as minor, base and medium projects. This will include project management, engineering and specialist studies, procurement and logistics, construction and commissioning management, and the execution of construction works.

Saudi Aramco and ExxonMobil JV completes clean fuel project

December 15, 2014 | Saudi Arabia

Saudi Aramco Mobil Refinery Company Limited (SAMREF), a joint venture of Saudi Aramco and ExxonMobil, has completed construction of major desulfurization facilities, including a new hydrotreater, that dramatically cuts sulfur levels in gasoline and diesel. The SAMREF partnership, which is celebrating 30 years of joint refining operations, demonstrates the long-term collaboration and progress towards meeting the energy needs of Saudi Arabia's growing economy. The project is the largest investment in SAMREF's history and will reduce the sulfur levels in gasoline and diesel by more than 98 percent, to 10 parts per million, which makes the refinery an industry leader in emissions reduction.

Yanbu Aramco Sinopec Refining Co.:YASREF is a JV between Saudi Aramco and China Petrochemical Corp. (Sinopec). It is a 400-Mbpd full-conversion refinery located in Yanbu Industrial City. The refinery was mechanically complete in June, and test runs began in September. Major processing units include a 400-Mbpd crude distillation unit, a 124-Mbpd Chevron Lummus hydrocracker, a 177-Mbpd UOP diesel hydrotreater, an 85-Mbpd UOP naphtha hydrotreater, an 84-Mbpd UOP continuous catalytic reformer, a 20-Mbpd UOP isomerization unit, a 20-Mbpd benzene extraction unit, a 117-Mbpd ConocoPhillips (Bechtel) delayed coker, a 262-MMscfd hydrogen unit and a 34-Mtpd sulfur-recovery unit. The new refinery is designed to process Arabian heavy crude into high-quality refined products. The design includes plans for aromatics production for PX and toluene. At full capacity, YASREF will produce 263 Mbpd of diesel, 90 Mbpd of "clean" gasoline, 6.2 Mtpd of petroleum coke, 1.2 Mtpd of pelletized sulfur and 140 Mtpd of benzene. Most of the refined products will be exported to Asia and Africa, along with meeting regional demand in the Middle East. Operator/owners: Saudi Aramco and Sinopec / E&C: TécnicasReunidas, Daelim Industrial Co. and SK Engineering / Licensors: UOP, Chevron Lummus and ConocoPhillips

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October 21, 2014: The Global and Chinese Pressure Vessels Industry Report 2014 is an in-depth study on the current state of the global pressure vessels industry with a focus on China. The report provides a basic overview of the industry including definitions, classifications, applications and industry chain structure. The pressure vessels market analysis is provided including development trends, competitive landscape analysis, key regions development status and a comparison analysis between the international and Chinese markets. Development policies and plans are also discussed and manufacturing processes and cost structures analyzed. Pressure vessels industry import/export consumption, supply and demand figures and cost price and production value gross margins are also provided.The report focuses on thirty industry players providing information such as company profiles, product picture and specification, capacity production, price, cost, production value and contact information. Upstream raw materials and equipment and downstream demand analysis is also carried out. The pressure vessels industry development trends and marketing channels are analyzed. Finally the feasibility of new investment projects are assessed and overall research conclusions offered.

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