VIOLATIONS OF PRESSURE VESSEL CODES

Indian and International Codes of practice for Pressure Vessels are very specific without any ambiguities and are proven over the years to ensure safe operation under relevant design conditions.

However, those familiar with design, manufacture, testing and operation of Pressure Vessels will agree that in each of the above activities, violation of the codes are encountered due to various reasons.

This article attempts to highlight some of the violations often encountered in the case of un-fired pressure vessels, during practical application, with the sole objective of increasing awareness and elimination of such violations to continuously improve safety standards.

DEFINITION OF QUALITY ASSURANCE AND QUALITY CONTROL

Since both terminologies have various overlapping functions, it is sometimes difficult to differentiate the functions coming under each activity. For simplicity of understanding, the following definitions can be a good guideline with reference to Pressure Vessels.

QUALITY ASSURANCE

"Adaptation of accepted and approved Manufacturing Process to assure **DESIGNED QUALITY** of the Pressure Vessel **DURING DESIGNED OPERATING LIFE.**

QUALITY CONTROL

"Inspection and Verification at various Intermediate and Final stages of manufacture to **ENSURE CONFORMITY** to approved design, drawings and adaptation of accepted and **APPROVED MANUFACTURING PROCEDURES."**

MAIN REASONS FOR VIOLATIONS

In over 30 years of involvement with Pressure Vessels it is found that majority of the violations are due to one of the following reasons.

1. Cost reduction

One of the main reasons for violations is to achieve cost reduction by the owners, their employees or manufacturers.

2. Ignorance of Code requirements

Very often owners are ignorant about code requirement and procure Pressure Vessels from sources who do not possess adequate knowledge or experience in the subject and do not have the necessary infrastructure.

3. Inadequate Comprehension of owners' Accountability

Very often owners are not aware of the Statutory and Social accountability and business calamity, which can be caused by Pressure Vessel failures, while in operation. Actual investigation of various cases prove that Pressure Vessel failures in almost all cases have resulted in

- Loss of life
- Loss of business
- Prolonged legal action.

4. Non-involvement of experienced professionals

In many cases owners entrust design, manufacture, testing, installation and operation to individuals with insufficient knowledge and experience in relevant fields concerning Pressure Vessels.

Some of the violations often encountered, at various stages, are listed below:

This list is not conclusive by any measure and each participant will be in a position to probably add to the list from their own experience.

A. DESIGN OF PRESSURE VESSELS

Design criteria are well laid down in various codes. However these are not strictly followed by designers at times. Designers tend to twist the interpretation of code requirements for various reasons and get away with it since mandatory rules and enforcement laws leave a lot of room for manipulations.

In almost all cases any violations in design of Pressure Vessels get detected only during enquiries undertaken after accidents, by which time it is already too late and results in only an academic postmortem. .

A1 Inadequate Design Conditions

Design Conditions specified is not adequate to meet most severe operational conditions in terms of temp, pressure, corrosion allowance, specific gravity of contents etc.

A2 Non-Conformation to Specific Codes

Design is not according to latest revisions of specific code and design code is not specified. In some cases it is a mixture of various codes.

A3 Improper Selection of M O C

Materials of construction are not carefully selected to with stand most severe operational conditions especially in case of high and low temperature and corrosive conditions.

A4. Inadequate Thinning and Corrosion allowance

Thickness mentioned does not provide for thinning during forming, especially in case of dished ends.

Corrosion allowance for operating conditions for the selected MOC is not considered, like in the case of Nozzle neck thicknesses etc.

A 5. Incorrect allowable stress values and factors

Factors and allowable stress values are adopted to arrive at minimum thickness for economic reasons.

Some of them being:

a. Allowable stresses of different materials for required temperatures are not correctly taken as per codes but are extrapolated from some values available.

b. Joint efficiencies assumed are on the higher side without required weld geometry, NDT, Heat Treatment etc.,

A6. Inadequate thickness provided

Required thicknesses as per calculation are not provided, thus reducing mandatory safety margins built into the code.

A7. Static head not considered

Static head of vessel and above vessel piping not considered for thickness calculations.

A8. Structural Stability requirements not considered

Especially for Horizontal and mobile Pressure Vessels very often-structural stability is often assumed and not calculated to ascertain adequacy. Similarly calculations are not carried out to with stand stresses of static and Dynamic load of vessel mounted heavy accessories like Agitators, Condensers etc.,

A9. Dissimilar metals Designed to be welded on pressure parts

Dissimilar materials are designed to be welded to pressure parts without due consideration for loss of allowable stress especially in case of supports, Limpet Coils etc.

A10. Specific Heat treatment required

Heat treatment is not specified in drawings.

B. MANUFACTURE OF PRESSURE VESSELS

Acceptable manufacturing processes and quality assurance methods are very clearly specified under the codes. However in actual practice many of these requirements are violated. Some of the most common ones are listed below:

B1. Unacceptable Fabrication Process

Often, manufacturers use short cut methods and manufacturing processes, which are not acceptable, under the provisions of the codes. This is most often encountered in flanging and dishing processes.

B2. WPS, PQR, WPQ

Welding Procedures Specification (WPS), Procedure Qualification Record (PQR), and Welding Performance Qualifications (WPQ) are not carried out and records not maintained by fabricators.

B3. Use of Equivalent Materials

For some reason or the other, mostly in the pretext of non-availability, materials specified in the drawing are not utilised. Instead, equivalent materials are selected often on the basis of meeting only one or two requirements like Tensile Strength, Yield strength or Chemical analysis of some components only.

B4 Sources of Material Unknown

Some times materials of unknown sources are utilised.

B5. Re-rolled or re-drawn materials

Very often materials of minimum thickness shown in the drawing are utilised, from re-rolled or re-drawn materials, since these thicknesses may not be available from steel mills.

B6. Check analysis not carried out

Verification of Chemical and Physical properties are not carried out through check analysis.

B7. Pitted and Corroded Materials Utilised

Fabricators and owners tend to use pitted and corroded materials just because they happened to be in stock, or were available at cheap rates from the market.

B8 Owner supplied material

Owner supplied materials are not verified. In most of the cases all materials supplied by the owner is utilised at face value without any verification.

B9. Improper Weld Joint Preparation

Weld joint preparation not carried out to ensure sound base metal, full penetration, clean welding surface etc.,

B10. Defective Weld Equipments

Some times the welding equipments used by fabricators are defective and incapable of providing continuous specific welding currents without fluctuation.

B11. Fabrication tolerance

Very often fabrication tolerances are not maintained within permissible limits of the code.

C. NON DESTRUCTIVE TESTING

Many shortfalls are encountered in NDT during Quality Assurance / Quality Control monitoring.

C1. Mixing of various codes

In radiographic testing different codes are mixed during radiography and during interpretation.

C2. Unqualified Personnel

Very often radiography and interpretation are carried out by persons not qualified to the grade of levels mentioned in the codes.

C3. Wrong Radiographic sources and accessories

Wrong selection of radiographic sources, penetrameters, marking and labeling, density, angle etc., are encountered due to ignorance of the code condition, by the operators.

C4. Manipulation of Radiographic Testing

Radiographic shots presented are not of the specified joint, but repeated shots of some other joints, which have already been accepted earlier.

C5. Use of Non acceptable pressure gauge

Pressure gauges used for hydrostatic tests are often having very wide range, or non-calibrated or without check pressure gauges.

C6. Higher Test Pressures

Pressure vessels are tested to higher test pressures than specified or allowed under design conditions.

C7. Unsuitable test media

Hydrostatic test carried out with unknown quality of water having non-allowable components like Chlorides etc.,

C8. Repairs during Testing

Some times repair is carried out while the test is in progress involving hammering, welding etc., which can have very serious consequences.

C9. Design and test conditions not stamped

Design and test conditions are not marked / stamped on the vessels as required by the code.

D. HEAT TREATMENT

Specific, heat treatment required to meet design conditions are not carried out during and after fabrication.

D1. Improper Heat treatment

Heat treatments are not carried out properly as per code requirements with controlled heating, holding and cooling cycles.

D2. Lined vessels and vessels with internals

Heat treatment not carried out on vessels with linings or internals although fabrication methods and operational conditions require the same.

E. TRANSPORTATION ERECTION AND OPERATION

Pressure vessels are often not handled properly during loading, unloading transportation and erection.

E1. Loading and Unloading

Pressure vessels are not gently loaded or unloaded with proper equipment and very often just dumped from the truck causing surface damages, damages to pressure parts like nozzles etc.,

E2. Hot Work during erection

Pressure vessels are subjected to hot work and hammering for effecting modifications etc during erection and commissioning.

E3. Modification of Service Condition

Operators tend to change or modify service condition without reassessment of suitability of the pressure vessels for the changed condition. There have been instances where pressure vessels have been utilized for more severe condition than originally designed, resulting in failures.

F. STATUTORY TESTING

Statutory provisions are clearly laid down for periodical testing and inspection of pressure vessels complete with documentation. Very often these are violated.

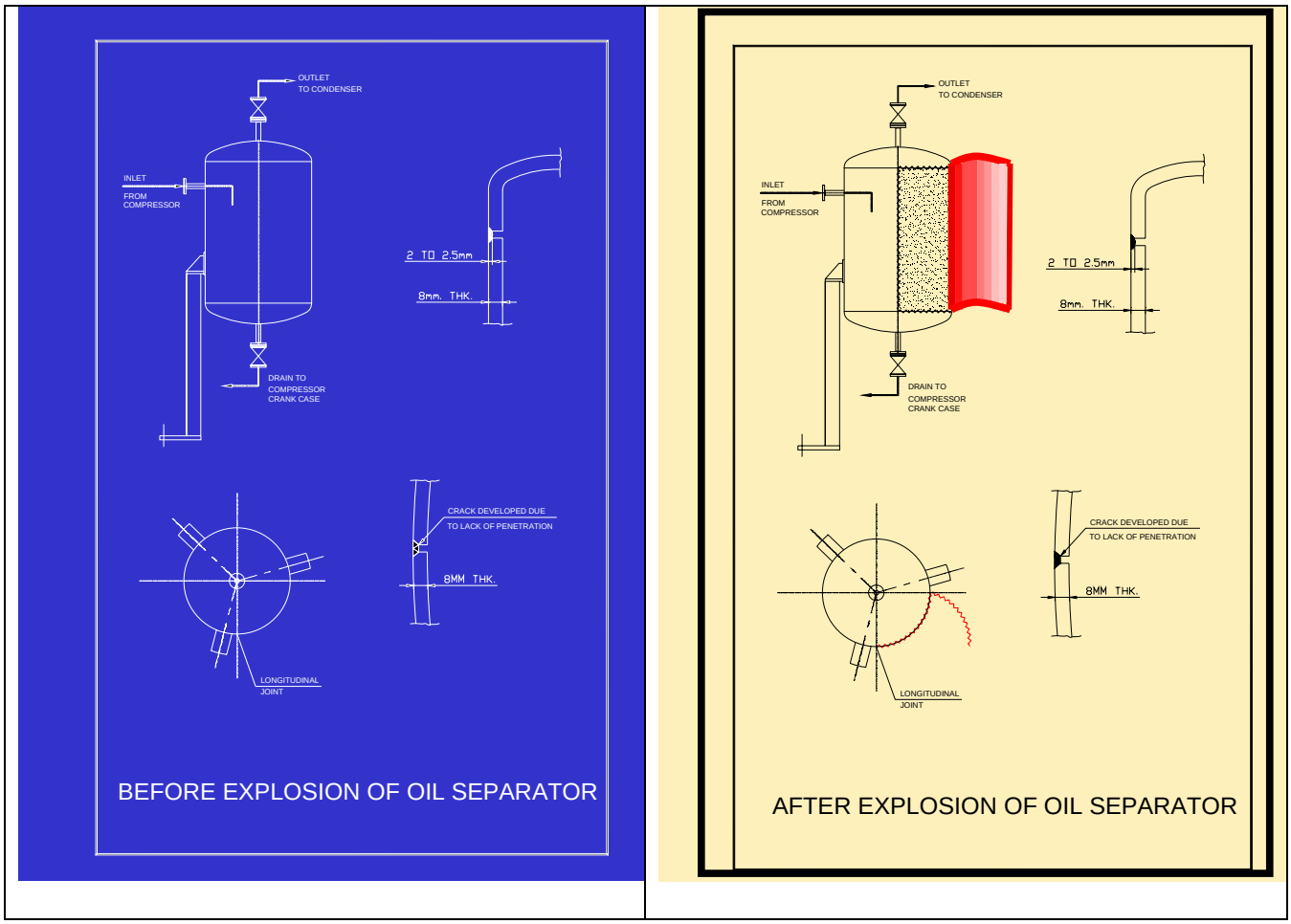
F1. Periodical Statutory test

Periodical Statutory tests are not carried out for various reasons like production exigency and non-availability. There are many instances where statutory tests are not carried out as laid down in statutes.

F2. False documents Generated

Documents as required by statutory laws are falsely generated without actually carrying out the necessary test and inspections.

CASE STUDY OF EXPLOSION OF OIL SEPARATOR



An Oil separator installed in the Refrigeration System in a large chemical plant in Madhya Pradesh suddenly exploded during afternoon tea time when some workers were sitting nearby, having tea.

The accident resulted in the death of 2 workmen and injury to 4 others.

The Oil Separator, approximately 300mm ϕ and 500mm long installed on the delivery side of an ammonia compressor, ripped apart totally from the longitudinal joint and partly from both the circumferential joins at top and bottom.

RESULTS OF INVESTIGATION

During failure analysis conducted by external Consultants, it was found that the Separator was constructed from 8mm thick Carbon Steel material, which was quite sufficient to withstand the pressures. However, the weld geometry of the joints showed penetration only to the extent of 2-2.5mm depth. This means that instead of having a full penetration weld cross section of 8mm + 1.5mm reinforcement (Since it was welded only externally), the joint had only 2.5mm + 1.5mm weld cross section, reducing the joint efficiency. This Separator must have withstood full hydrostatic pressure of 1.5 times the operating pressure in the initial stages, and was probably accepted after hydro test, six year's previously.

During operational lifetime, the equipment undergoes a lot of pulsation stresses due to pressurisation and depressurisation, according to operating cycles. This normally increases material fatigue and eventually the joint is no more capable of withstanding operational loads.

This combined with the possibility of crack development due to lack of penetration enhances probability of failure.

Design thickness of pressure vessels as per accepted codes take into consideration full penetration welds across the full plate thickness at designed joint efficiencies. This should be strictly adhered to under stringent quality control during manufacture, to ensure that the pressure vessels will last for the full-expected lifetime.

This is further to be subjected to periodical hydrostatic test at 1.5 times of operating pressure as per statutory laws to ensure that the vessel has not deteriorated due to corrosion, material fatigue etc.

Obviously, this has not been carried out, as is found normal in many Refrigeration Plants. If a periodic hydro test was carried out, the equipment would have failed during test and the accident with consequential loss of life and production could have been avoided.

VIOLATIONS COMMITTED ON THIS CASE

DESIGN

Being part of turnkey supply as a refrigeration package, design specification and drawings were not available for investigation, for this oil separator.

MANUFACTURE

B2. WPS, PQR, WPQ not followed.

B9. Improper weld geometry and joint preparation.

STATUTORY TESTING

F1. Periodical Statutory Test not carried out.

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