Pressure Vessel Newsletter

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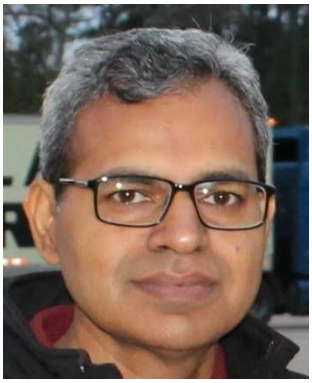
From The Editor's Desk:



Safety through Maintenance

Process plants need to be ready to operate whenever production requires. Therefore, it is essential that a) these plants be in a good operating condition at all times, and b) the preventive maintenance be completed in the scheduled downtime; i.e., there should be no slack for schedule slippage and unplanned downtime. Proper maintenance of plant equipment can significantly reduce the overall operating cost while boosting the productivity of the plant.

According to Processing Magazine, knowing the following major issues regarding the maintenance of industrial process equipment can help in meeting the challenge of today's hectic production schedule:

1. Know the real value of maintenance: Preventive maintenance is a smart economic choice because the price of downtime due to a malfunction can be much higher that of a good maintenance regime.
2. Make use of condition based monitoring for smart maintenance: Techniques such as vibration analysis and ultrasound provide an insight into the possibility of failure during any given period and can significantly improve efficiency in the use of a maintenance resource.
3. Ensure all maintenance personnel are properly trained: Regular refresher training will help keep personnel motivated to carry out otherwise routine and mundane maintenance tasks.
4. Skilled project leadership: Preventive maintenance is all about getting the right balance while ordering components so that they are in place when needed for the scheduled work. A delay will result in an extended and costly downtime, and ordering too early will result in unnecessary storage costs.
5. Include maintenance engineers in equipment purchase activities: They are tasked with the responsibility for maintaining the process equipment and are the best judge as to which equipment option will be most accessible and easy to look after.

Experience has shown that most industrial disasters can be averted by proper adherence to good maintenance practices. If basic equipment conditions and proper operation practices are achieved, it will lead to zero accident and zero failure.

In this issue…

NATIONAL BOARD INSPECTION CODE VS. API 510

This article discusses the repair, alteration and rerating of coded pressure vessel.It will cover pertinent code and jurisdiction requirements and the differences among the ASME Code, NBIC and API requirements. We will discuss the following: design of repairs, planning and approval, responsible organization, materials, replacement parts, welding, postweld heat treatment (PWHT), inspections and hydrotest procedures, and documentation and nameplates.

A pressure vessel inspection program will from time to time reveal that some form of deterioration is occurring in the vessel. Analysis of the deterioration may indicate that the vessel must either be repaired under the original design conditions, or that the vessel must be rerated for less severe design conditions. Rerating for new design conditions may also be necessary because of changes in operating requirements.

The size and location of a pressure vessel with in a process can make repair or alteration considerably more difficult than construction of a new vessel in a fabrication shop. Construction of a vessel in a fabrication shop permits positioning of the vessel to obtain favorable access and orientation for welding and other necessary work. Access to a vessel within a process can be obstructed by adjacent equipment, resulting in welding and other work having to be performed in unfavorable orientations and/ or with restricted access for tools and equipment. Therefore, it may not be possible to comply with all of the requirements of the ASME code that were mandated for the original design and construction of the vessel. The inability to repair a pressure vessel while it is within the process may make it necessary to move the vessel to a fabrication shop. Repairs of this nature will normally require more time than if performed with the vessel remaining in place. Plans should be made well in advance of the scheduled shutdown to make certain that the repair organization has room for the vessel in their shop floor and manpower available to complete the repairs on schedule.

What is Repair, Alteration and Rerating of Pressure Vessel?

Repair of a pressure vessel is the work necessary to restore the vessel to a suitable condition for safe operation at the original design pressure and temperature, providing there is no change in design that affects the rating of the vessel. A vessel must either be repaired or replaced when deterioration renders it unsatisfactory for continued service.

It is generally more economical to repair a pressure vessel than to replace it, but the primary consideration is integrity and reliability for continued service. Some forms of deterioration, such as creep and hydrogen attack, may indicate that the useful remaining life of the vessel is too short to justify the expense of a repair. Furthermore, the detection of other forms of deterioration, such as H_2S stress cracking, may indicate that the vessel is not satisfactory for the service environment and that the deterioration will recur after repair (presenting a continuing maintenance problem).

Alteration of a pressure vessel is a physical change to any component of the vessel that affects the pressure containing capability. An alteration can change the maximum allowable working pressure (MAWP) and temperature rating of a vessel from that given on the original nameplate with a “U” stamp applied by the manufacturer. However, alterations can usually be designed not to affect the original rating of a vessel when the operating pressure and temperature of the process are not changed.

Alterations to a pressure vessel are usually made to accommodate changes in process design. The installation of new nozzles in the vessel shell is a common alteration. Occasionally, internal components have to be changed for the new process designs. Although the internals are not pressure-containing components, the loads that they transmit to the vessel shell can affect its pressure-containing capability. The effect of these loads upon the stresses in the vessel shell should be calculated to determine if the MAWP of the vessel has to be changed.

Rerating a pressure vessel consists of changing the design pressure or (MAWP) and/ or temperature from those displayed on the vessel's nameplate. Rerating usually does not involve a physical alteration of the pressure containing capability of the vessel, but can be required by alterations that are not designed for the original design pressure and/ or temperature.

Rerating is most commonly necessitated by 1) a change in operating conditions for the process, and 2) deterioration (i.e. the occurrence of corrosion or cracking) that affects vessel integrity and reliability for the original design pressure and temperature, and a repair cannot be economically justified.

ASME Code

The ASME Code applies directly only to the "design, fabrication, and inspection during [the original] construction of pressure vessels…" This statement is normally interpreted to mean that the direct applicability of the ASME Code terminates when the AI authorizes application of the ASME Code stamp to the nameplate on a new vessel. The ASME Code is formulated around design details and fabrication procedures (welding procedures and PWHT, etc.) that are obtainable with good shop practices, and that are known to provide a high level of quality.

Most jurisdictions have pressure vessel laws that require owner/ operators to operate and maintain their pressure vessels in a "safe condition". The majority of these jurisdictions have established regulations for repair, alteration, and rerating of pressure vessels that refer to either:

- The National Board Inspection Code (NBIC), or
- The API Pressure Vessel Inspection Code (API 510)

The facility will need to determine which code governs their repair, based on local jurisdictional requirements. Many flammable liquid processing plants and refineries prefer to use API Code whenever possible because it is specifically oriented to the needs of the hydrocarbon processing industry and provides greater flexibility for exercising "engineering judgment". All repairs, alterations, and re-ratings of pressure vessels MUST be accomplished in a manner to assure the continued integrity and reliability of the vessels by properly exercising the best engineering judgment.

NBIC vs. API 510

The technical requirements of NBIC concerning repair, alteration, and re-rating are similar to those in API 510. However, the procedural and administrative aspects of these two codes differ considerably. The major differences are that NBIC:

- Requires an authorized inspector (AI) to hold a commission from the National Board.
- Restricts the authority of an authorized inspector employed by the owner/ operator.
- Requires preparation and approval of an R-1 form, and attachment of a new nameplate for repairs and alterations that do not change the maximum allowable working pressure (MAWP) and design temperature.

The more elaborate procedural and administrative details of NBIC do not necessarily result in repairs and alterations that have higher integrity, but they can considerably increase the costs incurred, especially if they delay the return of a pressure vessel to service.

In general, to expedite the repair, the API 510 permits greater flexibility through the exercise of "engineering judgment" by the owner/ operator than is usually possible when following NBIC. The owner/ operator has more responsibility for the integrity of a repair completed under API 510 than for repairs made under the rules and requirements of NBIC, which are subject to the review and approval of an AI.

References to the ASME Code

Both the NBIC and API 510 refer to the ASME Code for making repairs, alterations, and re-ratings of pressure vessels. However, the wordings used by the National Board and API conveys somewhat different implications.

NBIC requires all repairs and alterations to conform to the ASME Code whenever possible, whereas the API Code requires “following the principles of the ASME Code”. Both NBIC and API 510 recognize that it may not always be possible to adhere strictly to the ASME Code when making repairs or alterations. However, the implication of the wording in the NBIC is that the ASME Code must be complied with whenever possible. By comparison, API 510 permits more flexibility for deviating from the ASME Code by exercising “engineering judgment”. Strictly complying with the design details and fabrication requirements in the ASME Code may not always result in a repair or alteration with the greatest integrity and reliability because of the working conditions where the vessel is installed.

However, design details for repairs and alterations that deviate from the rules of the ASME Code should be justified by an appropriate stress analysis to verify that the maximum allowable stress permitted by the Code is not exceeded. Fabrications procedures that differ from the original construction must be properly qualified.

Authorizations and Approvals

There are significant differences between the NBIC and API 510 in granting authorizations for and approvals of repairs, alterations and re-ratings. Both the NBIC and API 510 require obtaining authorizations and approvals from an AI. However, the NBIC requires the AI to hold a commission from the National Board, whereas the API 510 requires only that the inspector “be qualified to perform the inspection by virtue of his knowledge and experience”.

NBIC emphasizes compliance with its rules through the scrutiny of an AI. API 510 relies to a much greater extent on the experience of pressure vessel or materials engineers to assure the continued integrity and reliability of a pressure vessel, and allows the AI to base his authorizations and approvals on consultations with pressure vessel engineers. This practice follows from its underlying concept of adhering to the principles of the ASME Code while allowing flexibility to use engineering judgment.

Both codes permit the AI to be an employee of the owner/ operator, but the NBIC prohibits an employee from approving work performed by his employer unless the governing jurisdiction (or National Board) has given its consent upon review of the owner/ operator inspection procedures. The API Code contains no such restriction.

Reports, Records and Nameplates

NBIC establishes a formal administrative procedure for documenting and recording repairs, alterations and re-ratings of pressure vessels. An “R-1 Form” must be completed by the company performing the work and submitted to the AI for approval. Copies of the R-1 Form are subsequently sent to the owner/ user, governing jurisdiction, and National Board for permanent record. In contrast, API 510 requires only that the owner/ user maintain permanent records that document the work performed.

Both NBIC and API 510 require attaching a new nameplate adjacent to the original nameplate when the vessel is altered or re-rated. It must be attached to the altered or re-rated vessel by the company performing the work after the R-1 form has been approved by the AI.

REPAIR

Planning and Approval:

Both NBIC and API 510 require obtaining authorization for making a repair from the AI before work is initiated, except for “routine repairs” when prior approval has been given by the AI. Authorization is obtained by preparing and submitting a repair plan. The repair plan generally includes the following information:

1. Area of vessel to be repaired
2. Repair procedures to be used for each area

3. Welding procedures
4. Non-destructive examination (NDE) of repairs

It may not always be possible to obtain authorization from an AI before making emergency repairs. Under these circumstances, the repair can be initiated prior to submitting the plan, but complete documentation should be preserved and submitted to the AI for his acceptance as soon as possible. The vessel cannot be returned to service until acceptance of the repair has been obtained from the AI.

Organization Making Repair

NBIC requires the organization performing the repair to have either a Certificate of Authorization from the National Board for the use of an "R" stamp, or a Certificate of Authorization from ASME for the use of a "U" stamp. API 510 also accepts an organization having an ASME "U" stamp as qualified to make repairs, but makes no mention of National Board "R" stamp.

Repair Materials

Both NBIC and API 510 require that the materials used for the repair must be an acceptable material of construction in the ASME Code. This material should be the same as those used for the original construction whenever possible. When this is not possible, the selection of alternative materials should be discussed with the pressure vessel and the material engineers.

Replacement Parts

A repair can involve replacing a deteriorated part with a new part of the same design that is manufactured in a shop. Manufacturing a replacement part generally requires welding. If the ASME Code requires inspection of the weld joints by an AI, the NBIC requires the replacement part to be manufactured by an organization that has an ASME Certificate for a "U" stamp. "U" stamp with the word "part" is applied to the part when it is accepted by the AI. Replacement parts that do not require inspection by an AI are not required to be manufactured by a holder of an ASME Certificate of Authorization.

API 510 requires replacement parts to be manufactured according to the principles of the ASME Code, but has no requirement concerning the qualifications of the manufacturer. A general recommendation, however, is that all replacement parts should be manufactured by an organization that has a Certificate of Authorization from ASME for the use of "U" stamp.

Repair Welding

NBIC requires qualification of all welding procedures used for the repair of a pressure vessel, including the manufacture of replacement parts, according to ASME Section IX Code. Furthermore, all welders working on the repair must pass a welding performance qualification for each welding procedure used. The repair organization must make the records of procedure and performance qualification available to the AI before the actual repair welding is started.

API 510 requires the repair organization to qualify all welding procedures and welders used for a repair according to the principles of ASME Section IX Code. This wording ("according to the principles") differs from that used in NBIC ("according to") and allows more flexibility for deviating from a welding procedure acceptable to the ASME Code when necessary to expedite a repair. The welding procedures used for repair should not deviate from what has been qualified according to ASME Section IX Code unless the proposed procedure has been reviewed by pressure vessel and materials engineers to assure adequate integrity and reliability for continued service.

Inspection of Repairs

Both NBIC and API 510 require the acceptance of repairs to a pressure vessel by the AI before the vessel is returned to service. The AI will normally require performing all of the NDE for the repair that were required by the ASME Code during the original construction. Alternate NDE methods can be proposed (such as the substitution of UT for RT) when it is not possible or practical to use the NDE method that was used during construction.

Hydrotest after Repairs

Neither NBIC nor API 510 makes it mandatory to perform a hydrostatic pressure test following the repair of a pressure vessel, but the agreement from the AI is required for it to be waived. The purpose of the hydrotest in the ASME Code is to detect gross errors in the design, or major flaws in the construction of a new vessel. Repair of the vessel restores it to a satisfactory condition without any change in design, and therefore, there is no need to verify the design of the repaired vessel.

Approval of Repairs, Documentation, and Nameplate

NBIC requires that the repair organization document the repair of a pressure vessel by completing an R-1 form that is submitted to the AI for approval. Subsequent to obtaining approval of the R-1 form, the repair organization must attach a new nameplate to the repaired vessel. This nameplate is stamped with an “R” symbol if the repair organization has a certificate of Authorization from the National Board.

API 510 requires that the documentation of repairs to pressure vessel must be kept as permanent records, but does not prescribe using a standard form. Furthermore, it does not require attaching a new nameplate to a repaired vessel unless it is required by the jurisdiction.

ALTERATIONS

Planning and Approval:

NBIC requires all alterations of pressure vessels to conform to the ASME Code, whereas API 510 requires adhering to the “principles of the ASME Code”. The wording of API 510 allows more flexibility for designing the alterations when it is not advisable or practical to strictly conform to the ASME Code, under the circumstances prevailing for making the alteration.

Both NBIC and API 510 require authorization from the AI prior to initiating an alteration on the vessel. The AI will normally

1. Verify that the design of the alteration and the calculations have followed ASME Code criteria.
2. Determine that acceptable materials will be used, and
3. Assure that the weld procedures and welders are properly qualified.

Organization Making Alterations

NBIC requires the organization performing alteration to have anASME Certificate of Authorization covering the scope of work involved. API 510 does not contain specific requirements for an organization performing an alteration. Presumably, the same requirements would apply as for a repair organization. Alterations can be designed by qualified pressure vessel and materials engineers, but it is recommended that only organizations holding an ASME Certificate of Authorization perform the work on the vessel.

Materials, Replacement Parts, Welding, PWHT, and Inspection

The requirement for the alteration of pressure vessels regarding materials, replacement parts, welding, PWHT, and inspection are identical to those for repairs.

Hydrotest after Alterations

Hydrotesting alterations is a mandatory requirement of NBIC. API states that hydrotesting is normally required after an alteration, but permits waiving the hydrotest after consultation with a pressure vessel engineer if superior design, materials, fabrication procedures and inspections are used.

A hydrotest should be performed after an alteration whenever possible. An alteration, by definition, changes the design of at least one component of the vessel shell, and the validity of the design changes cannot be verified by comprehensive inspection. In this regard, an alteration differs significantly from a repair, which does not involve design changes.

Hydrotesting pressure vessels that have been altered by the installation of a new nozzle requiring reinforcement is occasionally accomplished by welding a cap to the inside of the vessel shell covering the nozzle. This circumvents the inconvenience of preparing the entire vessel for hydrotest by preparing the entire vessel for hydrotest by providing for a “local hydrotest” of the nozzle opening. However, a local hydrotest performed in this manner will not develop the same stresses in the nozzle reinforcement and the vessel shell component surrounding the opening as would be developed by hydrotesting the entire vessel. Therefore, a local hydrotest is not a valid verification of the design of an alteration, and this practice is NOT recommended.

Approval of Alterations, Documentation, and Nameplate

NBIC requires that the repair organization document the repair of a pressure vessel by completing an R-1 form that is submitted to the AI for approval. Subsequent to obtaining approval of the R-1 form, the repair organization must attach a new nameplate to the repaired vessel. This nameplate is stamped with an “R” symbol if the repair organization has a certificate of Authorization from the National Board.

API 510 requires that the documentation of alterations to pressure vessel must be kept as permanent records, but does not prescribe using a standard form. Approval of an alteration by the AI is required before the vessel is returned to service, but attachment of a new nameplate is not mandatory unless the design pressure (or MAWP) and temperature are changed by alteration.

RERATING

Organization performing rerating

NBIC requires the rerating of a pressure vessel to be performed by the original manufacturer whenever possible. The rerating can be performed, however, by a registered PE if the rerating cannot be obtained from the manufacturer.

API 510 permits either the original manufacturer or an experienced engineer employed by the owner/ operator to perform the rerating. Only engineers with appropriate experience with pressure vessel design, fabrication, and inspection should perform rerating. A consultant retained by the owner/ operator is also acceptable.

Calculations

Rerating a pressure vessel requires making calculations for every major pressure-containing component (i.e. shell, heads, nozzles, reinforcement, and flanges, etc.) to verify that they will be adequate for the new design pressure and temperature. However, it can be thought of as designing a pressure vessel in reverse. Instead of calculating the minimum required thickness for each shell for each shell component for the prescribed design pressure and temperature, the calculations are made to determine if the actual thickness of each shell component is adequate for the rerated pressure and temperature.

Both NBIC and API 510 require making the calculations according to the edition of the ASME Code controlling the original design and construction of the vessel. Alternatively, the latest edition of the ASME Code can be applied, if all details of design and fabrication can be verified to comply with this edition.

Decrease in Pressure

Rerating of a pressure vessel for a lower pressure is usually required if:

- The operating temperature is increased for new process conditions.

- Corrosion has reduced the remaining wall thickness below the minimum required thickness for the original design conditions

Increase in Pressure

Rerating of a pressure vessel for a higher pressure can usually be accomplished only if:

- The operating temperature is decreased.
- Thickness measurements of all pressure-retaining shell components indicate that the original corrosion allowance was greater than necessary for the actual corrosion experienced, and therefore, some of this corrosion allowance can be used to gain additional shell thickness.

Increase or Decrease in Temperature

An increase in temperature will almost always require decrease in pressure, unless the new temperature remains below 450^{o}F or below. A decrease in temperature will almost always permit an increase in pressure, unless the original temperature was 450^{o}F or below. Rerating for a lower temperature should never be allowed to violate the rules in the current edition of the ASME Code for low temperature operation to assure adequate resistance to brittle fracture. It is, therefore, essential to check the vessel being rerated for compliance with the current rules for low temperature operation when the new temperature will be 120^{o}F or below. This may be very difficult to do when the vessel is old and the materials used for construction are now obsolete. Under these circumstances, it may be necessary to cut samples from the vessel for CV-impact testing to perform a satisfactory rerating.

Approval of Rerating, Documentation, and Nameplate

NBIC treats the rerating of a pressure vessel as an alteration with respect to the requirements for preparation of an R-1 form, approval by an AI, and attachment of new nameplate displaying the new pressure and/or temperature. API 510 also requires approval of the rerating by an AI and attachment of a new nameplate. The new nameplate should be considered mandatory, because the pressure and/ or temperature for the new vessel differ from those displayed on the original nameplate.

Source: National Board Inspection Code vs. API 510 – Safety Engineering Network (SAFTENG)

(Written by Bryan Haywood)

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PACKINGS AND TRAYS

Introduction

Trays, random packings and structures packings are referred to as tower internals in the process industry. They are important components in the process equipment as they cannot easily be accessed after startup.

Generally speaking, trays are used in applications with high liquid flow rates, and in applications where solids are present or fouling is a concern. Structured packings are typically used in lower liquid flow rate applications, especially where minimizing column pressure drop is important. Random packings are often used in higher liquid flow rate applications where lower pressure drop is desired.

Trayed Towers

Trayed towers provide stepwise contact between liquid and vapor phases. In these towers, the liquid travels horizontally across the tray and into a vertical downcomer while the vapor passes up through holes in the tray and across the flow of fluid.

Conventional trays consist of a deck with an inlet region for liquid feed and a downcomer at the outlet. The deck is perforated for vapor flow; its primary purpose is to create a mixing region for the vapor and liquid. A vertical weir at the outlet side maintains a liquid level on the tray deck sufficient to ensure good mixing with the vapor.

The downcomer provides a conduit for the liquid to flow to the tray deck below. It also provides a calm region where vapor disengages from the frothy fluid so that the liquid exiting the downcomer to the tray below is clear.

The operating limits of a tray are set to prevent weeping at low throughputs and flooding at high throughputs. Weeping occurs when the vapor side pressure across the tray deck is too low to support the liquid pool on the top side, so the liquid weeps through the holes. Flooding occurs at the other end of the operating range. The tray deck generally floods when excessive vapor velocities carry liquid droplets to the tray above. This entrainment is more detrimental to tray performance than weeping because it causes backmixing of the liquid.

Packed Towers

Packed towers provide continuous contact between the vapor and liquid phases without full disengagement between the top and bottom of the packed bed. Because of their inherently large open area, packed towers can operate with lower overall pressure drops than trayed towers and are often used for vacuum service where reboiler pressures and temperatures are low.

Packed towers are generally shorter than their trayed counterparts. Their other positive characteristics are mechanical simplicity, ease of installation, and ability to be fabricated cost-effectively from corrosion-resistant materials, including plastics, ceramics and other nonmetals.

However, for good performance, packed towers require good liquid distribution to the top of the bed. They do not handle solids well, which tend to get trapped in the bed and foul liquid distributors. And at high operating pressures, the low pressure drop advantages of packings over trays diminishes.

There are two general types of tower packings – random and structured. Random packings consist of many small pieces that are loaded by emptying sacks into a tower section so that they “randomly” arrange themselves into a packed bed. Structured packings are typically constructed as blocks of alternating layers of thin corrugated sheet which can be fabricated from a wide range of metal alloys or nonmetals such as plastics, ceramics and graphite.

In general, structured packings create lower pressure drops and achieve better separation efficiencies with shorter bed heights than random packings. But they are also more expensive and are more time-consuming to install.

The separation efficiency of packings is often expressed in terms of the height of packing equivalent to a theoretical equilibrium plate (HETP). A theoretical plate, or stage, refers to the mixing or contacting of a vapor stream and liquid stream until the mixture reaches equilibrium with respect to heat, mass and composition. The number of theoretical plates and the HETP for a particular packing are used to determine the actual height of packing required to achieve the desired separation.

Liquid Distribution

Good liquid distribution is critical for efficient separation performance of both random and structured packings. Maldistribution has been reported as the most prevalent cause of problems in packed towers.

The surface area of packing needs to be fully covered and uniformly wetted by the liquid to maximize efficiency. However, there is a practical limit to the number of distribution points that can be provided while maintaining uniform liquid flow across the packing surface.

The range of liquid flowrates that a distributor must handle, known as the turndown ratio, is an important factor that must be considered in design. If the liquid flow is lower than the lowest design value, liquid levels in the distributor will be too low, flows to the individual drip points and different regions across the top of the packed bed will vary significantly, and separation efficiency will be reduced. If the liquid flow is higher than the packing's maximum design flowrate, liquid levels will be too high, overflows will occur, and separation efficiency will again suffer.

Closing Thoughts

Understanding the process and function of the internals is key to ensuring an effective design of a distillation column. Following the guideline presented in this article will allow one to make more informed decisions.

GASKET TECHNOLOGY

This article is intended to provide a clear understanding of how gaskets work and how to avoid common pitfalls in their use.

WHAT IS A GASKET?

A gasket is a mechanical seal which fills the space between two mating surfaces to prevent leakage from joined objects while under compression. The gasket material selected must be capable of sealing mating surfaces, resistant to the medium being sealed, and able to withstand the application temperatures and pressures.

WORKING PHILOSOPHY OF A GASKET TO PREVENT LEAKAGE

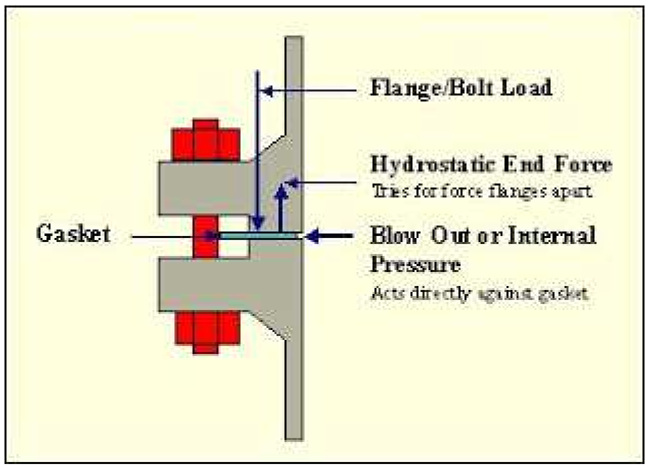

Figure 1: Three Major Forces Acting on the Gasket

Normally, the gasket is seated by tightening the bolts on the flanges before the application of the internal pressure. Refer to Figure 1 above that shows the three major forces acting on the gasket. The three forces are:

1. Bolt load which applies the initial compressive load that flows the gasket material into surface imperfections to form a seal.
2. Hydrostatic end force that tends to separate flanges when the system is pressurized.
3. Internal pressure acting on the portion of the gasket exposed to internal pressure, tending to blow the gasket out of the joint and/ or to bypass the gasket under operating condition.

The initial bolt load generated upon tightening is transferred to the gasket via the flanges. In order to ensure the maintenance of the seal throughout the life expectancy of the assembly, sufficient stress must remain on the gasket surface to prevent leakage. The hydrostatic force generated by the system pressure tends to “unload” and reduce the stress on the gasket. The stress remaining on the gasket is considered to be the “operating” or “residual” stress. This residual bolt load on the gasket should at all times be greater than the hydrostatic end force acting against it.

From a practical standpoint, the residual load on the gasket must be “X” times the internal pressure if a tight joint is required to be maintained. This unknown quantity “X” is what is specified as factor “m” in the ASME Pressure Vessel Code and will vary depending upon the type of gasket being used. The larger the value of “m”, the more assurance the designer has of obtaining a tight joint.

GASKET CATEGORIES

Gaskets can be classified into three main categories:

1. Nonmetallic–Nonmetallic gaskets are used in low to medium pressure services. With careful selection, these gaskets are not only suitable for general service but also for extreme chemical services and temperatures. Examples include elastomers, compressed fibre sheets, graphite, PTFE etc. Full face gaskets are suitable for use with flat face (FF) flanges and flat ring gaskets are suitable for raised face (RF) flanges.

Figure 2: Nonmetallic Gasket

2. Semi-metallic – Semi-metallic gaskets are composite gaskets consisting of both metallic and nonmetallic materials. The metal provides the strength and resilience of the gasket and the nonmetallic component provides the conformable sealing material. Commonly used semi-metallic gaskets are spiral wound, metal jacketed, and a variety of metal-reinforced graphite gaskets. Semi-metallic gaskets are designed for the widest range of operating conditions of temperature and pressure and are used on RF flanges.

Figure 2: Semi-metallic Gasket

3. Metallic – Metallic gaskets are fabricated from one or a combination of metals to the desired shape and size. Except for weld ring gaskets, high loads are required to seat metallic gaskets as they rely on the deformation of the material into the flanges. Common metallic gaskets are ring-joint gaskets, lens rings, weld rings and solid metal gaskets. They are suitable for high pressure and temperature applications.

Figure 3: Metallic Gasket

WHAT ARE m AND y VALUES AND HOW ARE THEY USED?

The design of bolted flanges in ASME Boiler and Pressure Vessel Code requires the gasket constants referred to as **m** and **y** to be used in the calculations. Values for constants of specific gaskets are included in the ASME Section VIII, Division 1. Additionally, gasket manufacturers publish **m** and **y** values for their own specific gasket materials and styles.

A flange must be designed to create sufficient compressive load on the gasket contact area to create an internal seal with essentially no pressure in the vessel. The gasket must conform to the flange surface and be sufficiently compressed to compensate for internal voids or spaces that could be detrimental to the seal. The gasket stress required to achieve this initial seal is considered the **y** constant.

The **m** value allows the flange designer to determine the compressive load on the gasket required to maintain tightness when the vessel is pressurized. This value is considered a multiplier or a maintenance factor. This constant is intended to ensure that the flange has adequate strength and available bolt load to hold the joint together, while withstanding the effect of the internal pressure. The design intent is that the flange and bolting will hold the flanges together under pressure and exert an additional stress on the gasket of **m** multiplied by the internal pressure.

The equation for flange design using **m** and **y** values were originally derived to assist in the design of flanged joints. They do not specifically address joint tightness. They are often used to help determine minimum required bolt loads for assembly purposes. They currently do not take into account potential joint relaxation due to temperature effects, torque scatter and the inherent inaccuracies involved in the assembly. For assembly purposes, they are more of an indication of minimum load required, and may not correspond to a bolt load required to achieve certain tightness level under a given set of operating conditions.

GASKET DESIGN AND SELECTION CRITERIA

A gasket is a key component of a bolted joint; however, the flanges, bolts (including nuts and washers) and assembly method all contribute to the ability of the joint to seal. Many factors should be considered when selecting a gasket to ensure its suitability for the intended application. Gasket properties as well as flange configuration and application details are part of the selection process. The primary selection of the gasket is based on the following:

- Temperature of the media to be contained

  Gaskets are affected in two ways by temperature. Gross physical characteristics are determined by temperature, including material state, oxidation point, and resilience. Also the mechanical (creep or stress relaxation) and chemical properties are highly temperature dependent.

- Pressure of the media to be contained

  Internal pressure acts in two ways against the gasket. First, the hydrostatic end force, equal to the pressure multiplied by the area of the pressure boundary, tends to separate the flanges. Second, the internal pressure acts to blow out the gasket across the gasket flange interface. Both these tendencies must be opposed by the flange clamping force.

- Corrosive nature of the application

  Gasket must be resistant to deterioration from corrosive attack. The severity of attack and the resulting corrosion is dependent upon temperature and time.

- Criticality of the application
- Flange compatibility

  The gasket is intended to be the renewable component in the joint system; therefore, it should be softer or more deformable than the mating surfaces. It must also be chemically compatible. For metallic gaskets, this means consideration must be given to galvanic corrosion. Galvanic effects can be minimized by selecting metals for the gasket and flange which are close together in the galvanic series, or the gasket should be sacrificial (anodic) to prevent damage to the flange.

- Environmental and regulatory standards

ASME STANDARDS

ASME B16 Committee provides B16.20 for “Metallic Gaskets for Pipe Flanges” and B16.21 for “Nonmetallic Flat Gasket for Pipe Flanges”. These standards cover types, sizes, materials, dimensions, tolerances and markings for metallic and nonmetallic flat gaskets.

Source: Wikipedia

Website www.whatispiping.com – Gaskets for leak-proof flanged joint

James Walker Moorflex – Understanding Gaskets and Dimensional Guidebook

WHAT IS A CANADIAN REGISTRATION NUMBER (CRN)?

CRN is a number issued by each province or territory of Canada to the design of a boiler, pressure vessel or fitting. The CRN identifies that design has been accepted and registered for use in that province or territory. The CRN consists of a letter, four digits, and a decimal point followed by up to ten digits and three letters. The first letter and four digits are part of a sequential numbering system used by the issuing province or territory. The first digit or letter to the right of the decimal point indicates the province or territory that issued the particular number as shown in the figure below.

The jurisdictions are:

1 - British Columbia
2 - Alberta
3 - Saskatchewan
4 - Manitoba
5 - Ontario
6 - Quebec
7 - New Brunswick
8 - Nova Scotia
9 - Prince Edward Island
0 - Newfoundland & Labrador
Y - Yukon Territory
T - Northwest Territories
N - Nunavut

The first registering province or territory is the first digit after the decimal point. For example, a design registered first in Ontario and then in Alberta might be issued the number 4321.52.

The letter C may follow the designation of the first registration if a design is subsequently registered across Canada (i.e. M4156.5C shows the design as being first registered in Ontario and then across Canada). The letters CL may follow the designation of the first registration if a design is registered in all jurisdictions that require registration and is not registered in jurisdictions that do not require registration. No jurisdiction issues the letters C or CL; it is a convenience for stamping once the manufacturer has received all required registrations.

The need to register pressure vessels and fittings in each and every province and territory that they will be used in is one of the most aggravating, expensive and time consuming aspect of the CRN system. Initial registration with one regulatory authority may be accepted by the regulatory authority in another province or territory if the latter is provided with an accepted copy of the statutory declaration form and the supporting documentation. When other provinces/ territories accept the initial review, the process goes faster and costs are lower, but this acceptance varies by province/ territory and the reviewer. Regardless of whether or not the vessel is reviewed multiple times, a lot of paperwork is involved.

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