USE OF A PRESSURE VESSEL MANAGEMENT SYSTEM - A CASE STUDY

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Abstract

A Pressure Vessel Management System (PVMS) using a computer program called PVCALC has been used extensively by Conoco's Midland Division for the last two years. PVMS was originally implemented (intra-Division) to be sure that all new pressure vessels bought for the Midland Division met the ASME Code. The program has been expanded to analyze surplus equipment. Vendor designs on at least 17 new pressure vessels have been analyzed, with only 12% of the vessels meeting ASME Code on first analysis. Ten surplus pressure vessels have been analyzed with PVMS and used, saving $500,000. The paper will cover the different problems that were found and actions taken to ensure that all pressure vessels meet ASME Code.

ANALYZING NEW PRESSURE VESSELS

Midland's PVMS program was begun in January, 1991. To date, a total of nine sets of drawings have been analyzed to ensure the ASME Code is being met. Only one vessel drawing set (12%) has met Code on the first evaluation. The other eight sets required several sets of revisions before the vessels would meet ASME Code. Unfortunately, twenty four new pressure vessels were bought based on the nine sets of drawings. Only one of the 24 vessels (4%) would have met Code if built on the first design.

Some of the problems with the various vessel designs were simply inattention to Conoco's requirements. Examples of this include using a different corrosion allowance or no corrosion allowance. Other problems were more severe and will be discussed separately below.

Manway and Nozzle Design

One prevalent problem was inadequate design of the heads on horizontal vessels. In most cases, there were several nozzles and manways (largely due to requests from Conoco) on one of the heads. The design companies started with a standard design for a pressure vessel, assuming normal manways or nozzles sizes. When larger manways and extra nozzles were specified, nothing was done to accommodate the changes. In most cases, using a thicker metal for the head or repad and better welding was the answer to be sure the vessel met Code.

Many of the engineers that specify pressure vessels have limited experience and will frequently specify whatever the field personnel request. If a 10" manway is needed the engineer might specify a 14" or larger manway to have "enough room". The larger manway might require additional thicknesses for the head (or shell) and will sometimes require repad and thicker welds. This information that costly additional metal or welding will be required is not conveyed to the design engineer or field personnel.

Saddles

One of the least considered design areas is the saddle designs on horizontal vessels. These problems ranged from relatively minor to that could have led to catastrophic failure when the vessel was placed in operation. Most of the problems were caused by 1) improper placement of the saddles and 2) inadequate saddle plate design. The saddles must remain at the far ends of the vessel so a bending moment is not created in the center of the vessel. Several of the vessels analyzed were designed with the saddles set in too far from the ends of the vessels. The vessel would no longer meet Code. The saddle plate design problem stemmed from the saddle plate not extending far enough around the vessel for support. This problem was removed by increasing the contact angle of the saddle plate.

Welding

Some failures to meet Code have been a result of inadequate welding specified on the drawings. The PVCALC program calculates the minimum acceptable weld thickness as described in UW-16, and is a more conservative approach to that used in the example in Appendix L. The minimum weld dimension is calculated in PVCALC by using the smaller of the 3/4", or the thickness of the thinner parts joined by the weld. This definition would not have the corrosion allowance subtracted from the parts thickness. The example in Appendix L, however, calculates the minimum weld dimension from the smaller of 3/4" or the thickness, less corrosion allowance, of the thinner part joined. When the corrosion allowance is used in the calculation, a smaller minimum weld depth will be calculated. Any weld that causes a warning in the PVCALC program has been recalculated by hand using the less conservative example in Appendix L. If the weld is acceptable by this hand calculation, the vessel was considered adequate.

Inadequate Flange Reinforcement

Some new vessels designs did not meet CODE due to inadequate reinforcement of the flanges. After analyzing many vessels, it became obvious that standard welding specifications are applied. In the area of flange and repad welding, the standard welding was the "weak link". This welding caused the vessel not to meet ASME Code for the designed pressure. Primarily the solution was to add repad and increase both the inside and outside weld thicknesses.

Corrosion Allowance/Type of Service

Before using the PVCALC program, new vessels designs included a conservative 5/32" corrosion allowance, a company recommendation. After analyzing many vessels, some built as early as 1936, we saw minimal corrosion losses. Minimal corrosion was seen even in H_2S & CO_2 service. The general recommendation has been reduced to 1/8". This guideline applied to our "worst case" scenarios, including:

* Vessels continuously exposed to H_2S or CO_2
* Planned life of the vessel to exceed 20 years.

For applications with a smaller expected life, or exposure to a non-corrosive environment, the necessary corrosion allowance can be reduced to 1/16" or less.

Besides realizing cost savings in the purchase of new vessels, these new guidelines allowed for reuse of used vessels. The 5/32" corrosion allowance was originally selected for Refinery Operations where pressure vessels are in much more severe service.

ANALYZING USED PRESSURE VESSELS

The Midland Division has had a surplus of used pressure vessels in the past. Rather than buy new pressure vessels each time, a decision was made to use all surplus equipment. To do this, it was felt that the vessels must be inspected and analyzed before any type of use.

ASME Stamped and Non-Code Vessels

Conoco's intent is to follow all existing regulations. Therefore, the Midland Division specifies that all new pressure vessels must meet ASME Code and all welding must be done by Code welders. Pressure vessels were bought in the past that were not Code stamped and can never be "Code vessels". Our intent is to protect workers' safety. We evaluate non-Code vessels as if they are Code vessels when they are moved to a new service. Whenever a used vessel is evaluated (which is always for re-use), it must meet the Code requirements. If it does not, work is done to be sure that it would meet Code, including welding done by a Code welder. If the vessel cannot be repaired for the service in which it is intended, it is re-rated and surplused. The vessel can be re-used only if the MAWP of that piece of equipment will exceed the working pressure of the new operating environment.

Re-rating Existing Equipment

Sometimes the original design of equipment was based on severe service and a large corrosion allowance was used. After a period of years, it was found that the corrosive environment was less severe than predicted. This was the case for one of Conoco's CO2 floods. Eight test vessels were installed in 1981 that had a MAWP of 50 psi. Over time the working pressure of the gas gathering system forced a need for a MAWP at the test equipment of 90-100 psi. With the original drawings, ultrasonic thicknesses, and an estimate of corrosion rates, we were able to re-rate all eight test vessels. This extended the life of the eight vessels by 15 years, and forestalled a purchase and installation charge. Savings for re-rating the test vessels was $500,000.

In most cases though, re-rates of pressure vessels will be to a lower pressure. We have found that older equipment, originally rated at 125 psi, can still be used in a 50 psi working environment if some changes are made. Examples of changes that have been made include adding a re-pad, adding more welding, and changing out a nozzle. Each time a piece of equipment can be reused, savings average $20,000 for eliminating a purchase and install.