What to Consider When Rerating Pressure Vesssels

By Mike Russell, Mechanical Engineering Resource Manager, with Linda Ricard

Pressure vessels storing gases, vapors, or fluids such as hydrogen, liquid nitrogen, compressed natural gas, or other combustible chemicals in industrial plants, sites, and refineries, can fail for a number of reasons, whether from leaks, cracks, corrosion, erosion, or operating above the allowable pressure limit. When not contained, the vessels can release highly pressurized chemicals, vapors, and gases into the air or water, which can lead to explosions or fire. For this reason, there are government regulations in place to safeguard from potential pressure vessel failures.

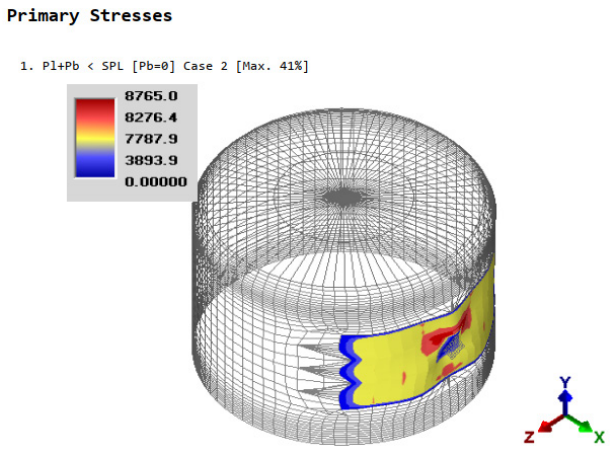
It takes meticulous, detailed engineering to design safety into these potentially hazardous types of equipment of different shapes, material, sizes, wall thickness, and operating pressures and temperatures. Every variable feeding into each design must maximize safety and performance.

"At Anvil, we do 50 rerates a year on average across over 400 projects at a time. 10-15% of the vessel rerates we work on exhibit non-standard, geometric shapes and anomalies. As a result, our engineers and designers use SOLIDWORKS and ANSYS Finite Element Analysis (FEA) simulation software to conduct structural performance analysis of these kinds of non-traditional vessels." - Michael Russell, Mechanical Engineering Resource Manager, Anvil Corporation.

Detailed engineering is also required when facility/refinery owners and operators want to rerate their vessels to higher maximum allowable working pressures (MAWP) and/or maximum allowable working temperatures (MAWT).

Some of these reasons may include a change of service, additional throughput, extending the life of older equipment, debottlenecking units/systems, or altering a safety relief system that may have a PSV set higher than the vessel's design limitations. Engineers and designers then validate if a vessel can operate at these design conditions and what the new corrosion allowances will be.

The type of equipment that owners/operators typically want to rerate are within process units (e.g., overhead knock-out drums, flash drums, shell tube heat exchangers, disengager columns with internal trays, and distillation columns) that exhibit higher corrosion or erosion levels.



All rerated pressure vessels must be in accordance with NBIC Part 3 and within government and industry safety standards and follow ASME Sec. 8 Division 1 and Division 2.

Steps to Rerating Pressure Vessels

Step 1: Gather Data. To begin the rerate process, engineers first review the vessel's historical records and current operational data to determine if a rerate is even feasible. Documentation includes the following:

- Equipment drawings
- Client specifications
- Manufacturing standard code U forms
- Inspection records
- NBIC compliance checklists
- R-1 and R-2 repair forms

Step 2: Investigate. Based on the information, engineers then investigate further by asking critical questions to understand the operational history of the unit. Exploratory questions can include:

- How has the vessel operated throughout its life?
- Has it been repaired or altered?
- Has it changed service?
- Has it been rerated before?
- What was the original code of construction?
- Can the engineering team use the original code of construction when altering the vessel's design?

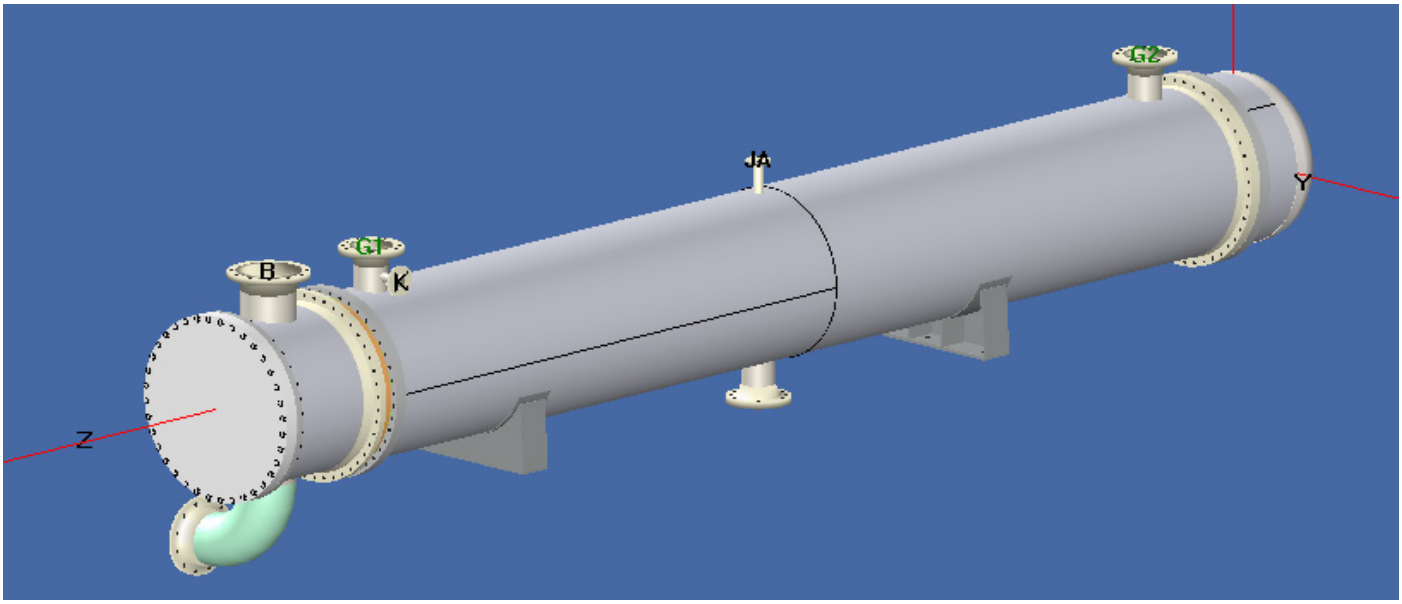
Step 3: Determine the Viability of the Altered Design and Rerate. After gathering all of the required information on the history and current operations of the pressure vessel, the engineering team ask the following questions to determine if it is even possible to alter the design of the vessel and rerate it at the owner/operator's request:

- What are the UT results in order to rerate the pressure vessel?
- Are installed protective devices (i.e., pressure safety valves) adjusted to the correct settings?
- What are the current operating conditions?
- What is the corrosion rate over the life of the vessel?
- What are the mass constraints in order to alter the pressure vessel design?
- What is the type of material?

Engineers use Compress code evaluation software to model a vessel with new temperature or pressure settings and to calculate conditions like wall thickness, seismic, wind, static, fatigue damage, metal loss, thermal loads, pitting, weld distortion, and buckling before evaluating and validating an optimal design. Adhering to either ASME Section VIII Division 1 or Division 2, Compress then validates the findings.

Step 4: Determine Root Cause of Why a Vessel Cannot be Rerated. If it is determined that a pressure vessel cannot rerate to the level the client is wanting, then it is up to the engineers to determine the root cause which can include something as simple as a flange or internal component.

Sometimes a simple adjustment to a vessel, such as adjusting the corrosion allowance, is all it takes to demonstrate that the new design will be able to withstand the new temperatures and pressures. In the case of a limiting component, the engineering and design team will run Finite Element Analyses (FEA) to determine if the modified design can withstand new temperatures and pressures.



Top Three Considerations When Rerating Pressure Vessel

Consideration 1: Undiagnosed Potential Equipment Failure. Although not a common occurrence, there are times when engineers detect errors in a pressure vessel's original design and/or discover that the pressure vessel does not meet the code of construction. At this point, engineers work with owners/operators to determine if the error is intrinsic due to the original design not meeting code and what to do about it.

Owners/operators are then presented with hypothetical modifications to see if a rerate can be done or by conducting more detailed analyses to analyze and validate the alterations and to determine if the operating conditions need to be modified to pass the original code.

Consideration 2: Customized Pressure Vessel Designs. Compress code analytical software is used to model standard vessels. However, when it comes to modeling custom-designed vessels, engineers turn to advanced modeling software to accurately calculate the vessel's geometry.

Consideration 3: Impact of Added Weight. Another consideration to keep in mind when rerating vessels is the impact of adding weight to a vessel. Engineering analyses evaluate and determine if the increased weight impacts the vessel's foundation code that it was originally designed for, which can lead to foundation problems and a new rating code requirement.

For example, a 50-year-old heat exchanger vessel and its foundation designed and built in the 1970s has to adhere to today's more stringent requirements and changing seismic codes. Engineers may even determine that the older vessel and foundation may not meet the new code. As a result, this could require additional structural modifications and the rerate may not be approved.

Summary

When altering the design of a pressure vessel to meet new client-driven or government-mandated rate codes, it is important to consider a number of factors that can impact whether a vessel can be rerated or not, such as impact of added weight to the vessel's foundation or whether the vessel's original design can even meet the code of construction. In addition, critical to the rerate process is clearly understanding the service history of the vessel. This includes securing all of the proper inspection reports throughout the life of the vessel, drawings, client specifications, manufacturing standard code U forms, NBIC compliance checklists, and R-1 and R-2 repair forms. The information is used to then develop analytical models to accurately determine new process conditions compliance. Once it has been determined that a pressure vessel can be rerated, the engineering and design team can complete the NBIC code calculation package.