P: 740-435-0240 ▪ 125 Steubenville Ave. ▪ Cambridge, OH 43725 ▪ ACIServicesInc.com

Jack-Bolt Valve Cap Risk Issues

W. Norm Shade, MSME, PE

Jack bolt valve caps were prevalent on cylinders that were designed 100 or more years ago before reliable elastomeric sealing materials were developed. The design was used so that adequate assembly preload could be applied to the metallic valve cap gasket and the metallic valve seat gasket at the same time. The design is more complex than it appears at first glance, as it involves three separate metal gaskets whose tightening interact. A typical example is shown in Figure 1 below. In this example, there is a round wire gasket for the valve cap seal, a flat metal gasket for the valve seat, and another flat metal gasket for the jack bolt cover.

Historically, there have been serious problems with this type of design. Manufacturers phased out this valve cap approach on new cylinder designs more than half a century ago; and many legacy cylinders have been retrofitted with valve caps that eliminate the jack bolts. There are a number of concerns and risks associated with the jack bolt valve cap design, as discussed below.

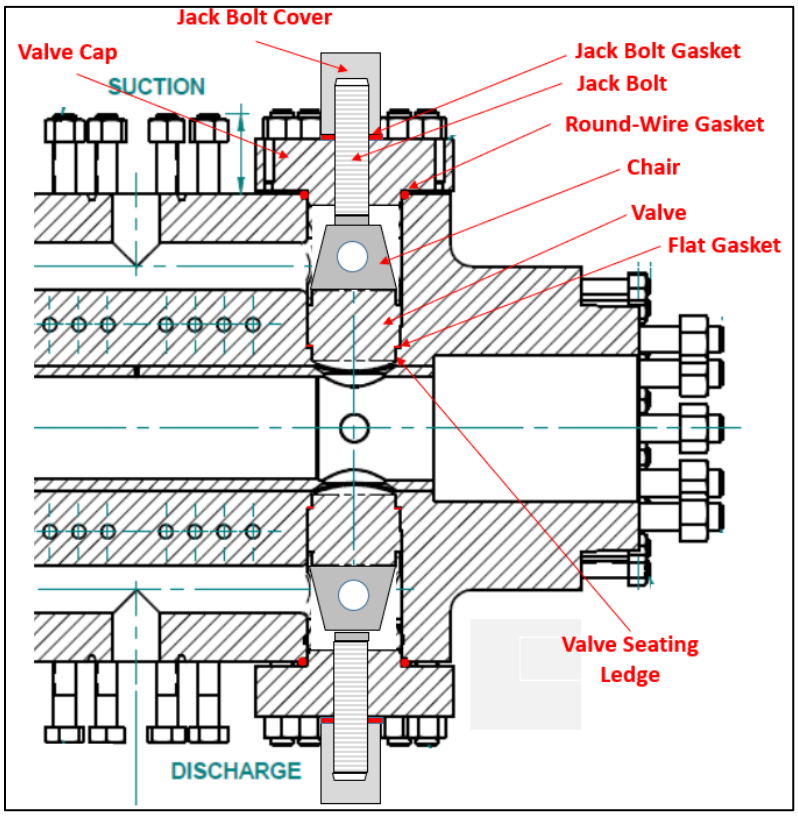

Figure 1: Valve Assemblies Retained by Jack Bolt Valve Caps

1. Proper installation and assembly requires accurate torquing of multiple threaded fasteners in the proper sequence.
   a. First, the multiple valve cap bolts must be carefully torqued to a specified torque level in order to preload the metallic gasket that seals the valve cap. This is a critical gasket that prevents gas leakage to the atmosphere.
   b. After torquing the valve cap bolts, the jack bolt must be tightened to a specified torque level. The jack bolt applies the proper preload through the valve chair and valve assembly to the metallic valve seat gasket under the valve to prevent internal leakage and loosening of the valve and cage/chair assembly during operation with the cyclic internal pressure within the cylinder.
   c. Finally, the jack bolt cover must be torqued to a specified level to apply the proper preload to the metallic jack bolt cover gasket to prevent leakage of gas along the jack bolt threads through the valve cap to atmosphere.
2. The force applied by the jack bolt has to be supported by the valve seating ledge in the valve pocket. The valve seating ledge (often called the critical corner where it is closest to the cylinder bore) is generally the highest-stressed area of any compressor cylinder. The cylinder valve seating ledge is designed to support the force resulting from the specified jack bolt preload. Overtightening the jack bolt can over-stress the valve seating ledge, leading to cracks in the corner radius of the valve pocket.
3. The force exerted by jack bolt tries to lift the cap, which reduces the force on the valve cap gasket. The specified torque on the valve cap bolts is designed to account for the gasket unloading that occurs from the internal pressure and from the specified jack bolt torque and its resulting force that tries to lift the valve cap. Overtightening the jack bolt relaxes the force on the valve seat gasket more than intended in the design. This can result in gas leakage past the gasket to atmosphere. In addition, overtightening the jack bolt tends to work harden the valve cap gasket, reducing its resiliency and its effectiveness as a seal.

4. Commonly, mechanics will remedy valve cap gasket leakage by retightening or increasing the torque on the valve cap bolts. If this is done without first loosening the jack bolt, it will cause additional force on the valve seating ledge, resulting in higher stresses than intended and increased potential for cracks in the valve pocket corner radius.
5. Tightening the jack bolt cover reduces the preload on the valve seating gasket. The original design accounts for this fact. However, if the jack bolt cover is overtightened, it may result in loss of adequate preload on the valve seat gasket and leakage of gas past the valve seat gasket.
6. The calculation of the required gasket preload is based on metal gaskets having an assumed yield strength and a specified seating area. If replacement gasket dimensions are different than specified in the design, there can be sealing problems. And if the gasket is harder than specified (or assumed) in the design, there can also be sealing problems. Valve cap leakage is commonly addressed by increasing the bolt torque, which can lead to over-stressing the valve seating ledge as explained above. The risk is exacerbated by the fact that, over the life-span of the cylinder, metal gaskets are sourced from many places. This is true whether the sourcing is done by compressor manufacturers, aftermarket parts companies, service companies or end users. Without specific dimensions and property requirements being defined, replacement gaskets may be harder (rarely softer!) than intended in the original design. Many metal gaskets today do not conform to the original design requirements for the material to be very soft (i.e., very low yield strength). In the case of steel gaskets, steel with a very low carbon content in a fully annealed condition is required. This is a serious issue that has led to the development of valve pocket corner radius cracks (and eventual failure!) in many legacy cylinders.

A modern, more reliable and safe valve cap design is shown in Figure 2. The jack bolt and the requirement for multiple assembly steps are eliminated. The valve cap bolts apply the appropriate force on the valve seat gasket, including resisting the internal pressure acting on the cap. The valve cap is sealed by an elastomeric O-ring on the periphery of the cap's nose extending into the valve pocket bore. The O-ring requires no assembly preload, so there is only one metallic gasket (the valve seat gasket) to properly preload. The O-ring location is carefully chosen to allow for component tolerances, and good designs can accommodate small variances in the stack-up as valve seats are refurbished. The upper/outermost bore of the valve pocket is precision machined to be a good sealing surface for the valve cap O-ring. Whenever possible, the sealing diameter is made comfortably larger than the OD of the valve and chair, which reduces the risk of scuffing the sealing surface during assembly or disassembly of the valve and chair. O-ring size and material are selected for compatibility with the process gas and operating pressure and temperature. This design is robust and much simpler and easier to assemble. Over the past half-century or so, it has been successfully used in well over a million valve caps on compressor cylinders of all sizes in many different services.

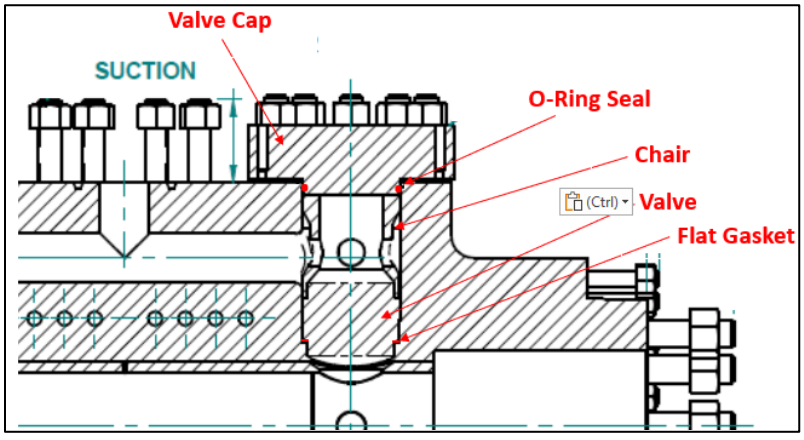

Figure 2: Modern Valve Assembly Retained by O-Ring Sealed Valve Caps