[Engineering Specs By KnightHawk Engineering]

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Reducing fugitive emissions

It has been a great week, and the plant has been running smoothly for a while. Turnarounds are over, spring break is done and now the routine "stuff" starts taking priority again. You just came out of a staff meeting with the plant manager, and he reminds everyone how fugitive emissions and environmental releases have to be addressed.

Like any engineer, you start going through the list, which includes seals, flanges, packing glands and so forth. After a brief discussion with the process and environmental departments, some key areas are identified. In your brief frustration, you realize that although you did not design or build the plant, you have to somehow make it work.

With the first pass on how to reduce releases and fugitive emissions, you have one thing on the top of your list — flanges. The problem area has to be the flanges, and there are a "gazillion" of these in service in your plant.

What is causing all the leaks? You check with materials engineering, and the gaskets are OK. Mechanical says that there are no process problems, and maintenance keeps fixing the leaks.

After a statistical analysis and reduction of the data, it was determined that the high temperature flanges in this particular service are the ones leaking. After "sniffing" the flanges, maintenance will typically tighten the flanges some more, but it really doesn't help. Now is the time to find the root cause of the leaking problem. After a rigorous analysis, it was found that thermal cycling of over-torqued flange bolts was the source of the problem.

So how do over-torqued bolts cause a problem? After all, if the torque is higher, then it would seal better, right? Well, that's not quite right. Like any component in piping systems, a gasket has an allowable stress based on its capability of recovery. If that allowable limit is exceeded, the gasket can permanently deform, and recovery will not occur. Recovery is when the gasket returns to its original thickness after experiencing a thermal cycle. It is like a spring, for instance. When a force is applied to it and then let go it will return to its original length. However, if that same spring were loaded too much, it would not return to its original length when unloaded.

In the problem above, the bolts were over-torqued, so when the flange went through the thermal cycle, there was leakage. In this application the flanges were also insulated. In this case the bolts and outer part of the flange acted as a heat sink (a cooling fin), and the resulting thermal gradient between seal area and bolt are caused by a higher load in the seal area because the bolt saw more load.

There are other types of gaskets that consist of metal or seal rings that fit on a machined surface. These types of seal rings have a finite life and usually experience local plastic deformation, causing some areas to permanently deform. The amount of plastic deformation limits the life. If the seal ring is overloaded, the life will greatly be reduced. In some cases the seal ring will fail in only one cycle. It is usually better to use bolt tensioners to ensure the correct bolt tension is applied.

One approach to difficult flange leak problems is as follows:

1. Define the process load conditions that leaking flanges experience. This includes steady state, startup, shutdown and any transient conditions.

2. Develop a heat transfer model to determine the heat distribution through the flanges.

3. Develop a nonlinear elastic/plastic model of the flange including the gasket or seal ring.

4. Load the same model through assembly and all process conditions.

5. Evaluate the contact pressure in the seal zone throughout each load cycle.

6. Revise gasket or flange design parameters where necessary.

7. Validate the design through testing for critical applications.

Look at seal alternatives such as a Taper-Lok® or equivalent. Perform the same analysis on these alternatives.

In critical applications, standard Code calculations and generally accepted methodology may not always address the governing issues in the design. Higher level numerical methodologies have been successfully employed to solve complex seal problems. For any analysis and design, make sure that a professional engineer who is competent in flange design reviews and approves any seal or flange design.

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