Maintaining integrity - a managed approach

Leakages from valve stems have been well documented and many companies are taking steps to reduce emission levels. However, have you stopped to consider the flanges on your valves and other piping components? They too can be a major factor to overall plant leakages. In the light of a new service recently introduced to eliminate critical joint failure, Tony Nicholls, Furmanite International, examines the factors causing leaking joints, and the actions required to ensure joint integrity.

By Tony Nicholls, Furmanite International.

Increasingly challenging environmental and economic demands are driving a need to reduce leaks and fugitive emissions that is perhaps greater today than ever before. As industry strives for optimum performance and maximum efficiency from its assets, in sectors from refining and petrochem to power and all process industries, high level joint integrity is vital.

It is not surprising, then, that joint integrity is enjoying an increasingly high profile within plant maintenance programmes. Leaking joints are both costly - in terms of lost product and inefficient plant operation, downtime and repair costs, and potential fines - and potentially damaging or dangerous with safety and environmental consequences, not to mention the negative impact on corporate image. Worryingly, however, while effective maintenance programmes should be sufficient to ensure leak-free joints, planned maintenance shutdowns are all too often followed by leaking joints on start-up. Offshore, figures from UKOOA (UK Offshore Operators Association) indicate that 25% of critical joints leak on start-up and research shows that 10% of hydrocarbon leaks offshore are from leaking flanged and bolted joints. Downstream, it is believed such joint failures may be even higher.

Initiatives by bodies such as the Health and Safety Executive (HSE) seeking to improve performance regarding hydrocarbon and other releases highlight the need to build strategies to cut leaks. Where critical joints are concerned - that is, where leakage would cause plant shutdown, the process to be affected, or danger to personnel or equipment - failure can be costly in many senses and integrity is particularly crucial. By contrast, steps taken to eliminate leaking joints will help directly to drive down costs, and in the case of safety-critical joints will remove unacceptable risk. Further, achieving a leak-free start-up after a scheduled shutdown will avoid delays, reduce equipment and testing costs, avoid re-work, and enable earlier demobilisation of labour. ▶

Managing integrity

While there is a growing acceptance of the need to manage joint integrity as a key tenet of good maintenance practice, what is often not realised is the level of engineering and management required to ensure leak-free performance. Simply installing a gasket and tightening the bolts will not ensure a reliable leak-free joint. A range of criteria will affect the level of management required for any one critical joint, from its physical size and operating pressure and temperature, to factors such as any fluctuations in temperature that it may be subjected to. Causes of leaking flanged joints vary, but as a general rule, flange distortion, sealing surface damage, inappropriate gasket selection, incorrect bolt loads, and uncontrolled tightening methods are typically among the primary ones. Further, bodies such as the Health and Safety Executive underline the importance of appropriately trained and skilled technicians, using suitable tools and equipment, and of having detailed procedures to work to, with effective supervision and inspection, in leak-free joint strategies. The importance of keeping effective records of work undertaken, loads applied, and other relevant data is also stressed by the HSE, particularly on safety-critical systems.

Joint integrity of critical joints can be successfully achieved, given effective controls - in other words a programme that addresses the issues associated with joint failure, managing every stage from engineering analysis of the joint through all the necessary work to closure and bolting, all with full documentation.

Furmanite, for example, the engineering company geared to maximising asset uptime, has launched a Pressurized Systems Integrity (PSI) Management service to achieve this, which can be applied to critical joints from pipework flanges to heat exchangers, pressure vessels, pumps, valves, compressors, reactors, and more. In one shutdown project, for example, 970 critical flanges were dismantled, overhauled and reinstalled over a twenty day period, as well as overhaul work on steam traps, gate and globe valves, and PSV valves, with a successful zero-leak start-up.

Ensuring joint integrity requires a certain level of engineering and management - simply installing a gasket and tightening the bolts will not guarantee a reliable, leak-free joint.

Steps to cut leaks

The first stage in managing critical joint integrity is to identify the critical flanges and allocate a criticality rating as a result of a risk assessment. Whether a flange is operating at high or fluctuating pressures or temperatures, has a history of leaking, is inaccessible, or is non-standard, are all factors to consider in the rating allocation.

Engineering analysis of the identified critical joints is then undertaken. Here, the flange must be reviewed against the relevant design standard to determine the optimum bolt load, and therefore the target load to seal the flange. Crucially, this load must be sufficient to overcome all forces acting to part the flange, but not too high as this can place unduly high stresses on the flange.

As part of the joint analysis, gasket design is assessed for any alternatives that may be better suited to the application, especially, for example, if the joint is old and still using the original gasket type. Flange and bolt materials are also considered and the thermal co-efficient reviewed, since any problems resulting from differential thermal expansion (which can be the cause, for example, behind a joint that leaks on start up or coming off line, but seals when up to temperature) can be overcome by measures such as using a different bolt material or altering the bolt's grip length. Additionally, stress relaxation behaviour of bolt materials over a range of temperatures is examined, since high relaxation can be a contributory factor where a flange leaks some time after plant start-up, so selection of a bolt material with reduced relaxation can be advantageous. These factors are all applied to calculate the optimum bolt load and select the tightening method - torquing or tensioning. Importantly, since the method selected will affect the accuracy of the bolt loading, this in itself has a potential impact on the long-term sealing of the joint.

The advantage of undertaking such a review well in advance of the shutdown is that documented work requirements (including all data and the nominated tightening method) can then be specified for each critical joint. Equally, only those joints requiring attention need be worked on at shutdown, saving valuable time. This vital early stage thus helps to minimise time demands and workscope pressures and avoid delays during the outage.

Outage status overview

When it comes to shutdown, work to the joints must of course be monitored as it is undertaken. The PSI Management system for example implements a flange-tagging system in line with the identified work requirements for each joint, providing immediate status recognition by using a series of colour-coded tags which are updated as work progresses. Moreover, the information is simultaneously recorded electroni- ▶

cally into the innovative PSI Management system; a key component of the service. This bespoke-developed software system offers real-time reporting with the current status of each joint automatically recorded into the system and, importantly, is accessible not just to the Furmanite site manager, but also to the client, who can access the user-friendly html pages via the internet, using a secure passcode entry system. The Windows-based software system (which is held and managed by Furmanite and requires no purchase from the client) uses the same colour coding process and carries all the relevant mechanical and work status data for every joint. Accessible at any time during and after shutdown without having to be on-site, the system provides the client with exceptional clarity and a unique overview of the outage workscope status and progress, representing a valuable tool in maintenance management.

Work that needs to be undertaken during shutdown will typically include ensuring an appropriate surface finish, flatness and condition of the existing gasket face, including any re-machining as required. The rougher the surface finish the higher the bolt loads required to obtain a seal, for example, while any marks or defects greater than 30% of the flange sealing face width will be difficult to seal so should be re-machined. Re-machining should also be considered if the flatness of the face is outside the maximum tolerance. Alternatively, if a new gasket is required this will be inspected and installed. This is then followed by flange alignment (significant misalignment of the flange holes can require an additional load to overcome this) and controlled bolt tightening to the determined load using hydraulic tensioning or torquing.

Bolt tensioning is generally accepted as the most accurate method of tightening - a technique that makes use of advanced hydraulic technology to induce accurate bolt stresses without creating torsional or bending stress. The bolt is gripped and stretched axially to the pre-determined load using hydraulic pressure. Beneficially, because the stud is axially loaded no bending or torsional stress is induced, and since friction is an insignificant factor in the technique, repeatable and accurate residual bolt loads to specific requirements are obtained, and can be readily reproduced. The residual stud tension can be confirmed by ultrasonic or mechanical stress measuring equipment.

A large number of tensioners can be used simultaneously to keep time to a minimum, and can be readily applied even in areas of difficult access, thanks to the design of modern strong yet compact and lightweight equipment which can meet the most stringent requirements, and enable even the largest bolt sizes to be tightened to specific design requirements without resorting to wrenches or spanner extensions.

On the other hand, where tensioning is not required or hydraulic tensioning equipment cannot be used, torque tightening (involving turning the nut to stretch the bolt) offers a simple and safe method of ensuring controlled tightening and loosening of bolts. A wide range of light, compact, safe and user-friendly hydraulic torque tools, and a complete range of wrenches is used, to a torque load of 80,000 ft lb or 108 Nm. Once again, various measurement techniques enable the bolt loading to be verified.

Further specialist techniques that may deployed on-site include bolt breakout to disassemble bolted joints, removal and replacement of damaged, deteriorated or body-bound bolts to improve joint integrity, and hot-bolting (torquing components on-line to prevent or stop leakage). Engineering support, including CAD systems, will provide written torquing procedures and bolting patterns purpose-designed for specific applications and for any size and range of flange.

Full traceability

In line with the importance of clear instructions and procedures and appropriate record-keeping stressed by the HSE, a full and detailed history for each critical joint should be retained. Using the PSI Management system this is built up as work proceeds, providing a comprehensive and dedicated electronic record that is easily accessed, incorporating all relevant information from mechanical data to work history for full traceability. Moreover, post-shutdown these records can be accessed for future maintenance planning, helping to eliminate unscheduled downtime or disruption to operation, and enabling the next scheduled shutdown to be handled with maximum efficiency.

Further, the HSE also highlights the importance of "training and competence implications" when it comes to bolting associated with flanged joints for pressurised systems (in this instance referring to offshore installations, but equally applicable onshore). Adequately trained and competent personnel are necessary to ensure correct assembly, tightening and inspection. In the case of the PSI Management service for instance, all work is carried out by fully certified, externally accredited Furmanite technicians, working within relevant standards and guidelines.

Conclusion

Joint integrity is today firmly on the map, and is recognised as a crucial element of any plant maintenance programme. There is no doubt that effective management of critical pressure-containing joints can reap rewards in terms of cost-savings and operational efficiency, not to mention removing risk. Moreover, with a leak-free start-up guaranteed to users of the PSI Management programme for example (testament to Furmanite's confidence in its ability to eliminate leaking joints) the advantages of investing in such management programmes become even greater. ■

ABOUT THE AUTHOR

Tony Nicholls is managing director of Furmanite International, the speciality services company geared to maximising asset uptime. With a BSc Hons in Mechanical Engineering, Tony began his career with British Gas, becoming construction services engineer with Transco before moving to take up the position of general manager of pipeline services company IPSCO. He joined Furmanite as business development manager in 1998 and was appointed to managing director in 2003. For further information on Furmanite's PSI Management service, valve testing and repair or any other Furmanite services call +44 1539 817777 or visit www.furmanite.com.