Maintaining integrity - a managed approach

by Colin Bickerstaff, Furmanite Australia

Challenging environmental and economic demands are increasingly focusing attention on leak reduction and joint integrity. Effective management of critical joint integrity can pay dividends but the causing factors and level of management required to eliminate leaking joints are not widely recognised.

In the quest for optimum plant performance and maximum efficiency, avoiding leaking joints and glands and associated emissions clearly has a significant role to play. It is not surprising, then, that joint integrity is enjoying an increasingly high profile within asset 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. In the UK, figures from UKOOA (UK Offshore Operators Association) indicate that offshore 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's thought that such joint failures could be even higher.

Initiatives 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

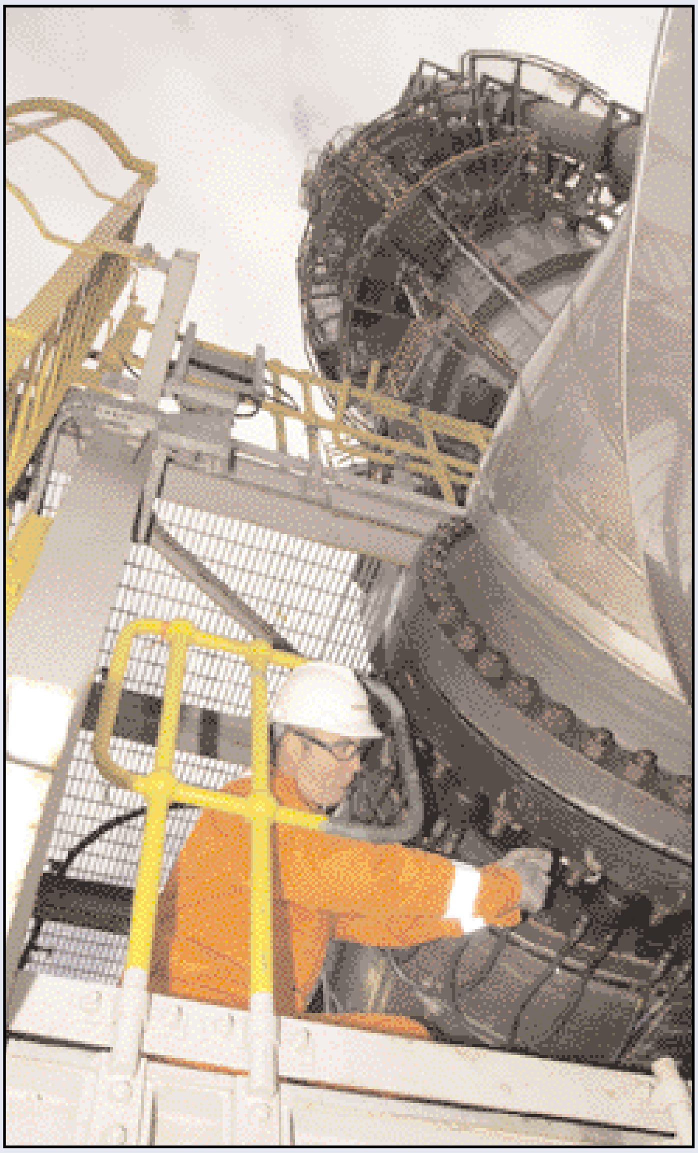
While there is a growing acceptance of the need to manage joint integrity as a key tenet of good maintenance practice, what is often not realised is the level of engineering and management required to ensure leak-free performance. Simply installing a gasket and tightening the bolts will not ensure a reliable leak-free joint.

A range of criteria will affect the level of management required for any one critical joint, from its operating pressure and temperature, and physical size, 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, appropriately trained and skilled technicians, using suitable tools and equipment, and having detailed procedures to work to, with effective supervision and inspection, is vital in leak-free joint strategies. The importance of keeping effective records of work undertaken, loads applied, and other relevant data is also to be stressed, 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 and compressors, reactors, and more. In one shutdown project in Queensland, for instance, 970 critical flanges were dismantled, overhauled and reinstalled over a 20 day period, as well as overhaul work on steam traps, gate and globe valves, and PSV valves, with a successful zero-leak start-up. The service is now attracting attention among oil and gas operators on and offshore around the world, including the North Sea and Caspian.

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. This will involve reviewing the flange against the relevant design standard to establish the optimum bolt load, and therefore the target load to seal the flange. While this load must be sufficient to overcome all forces acting to part the flange, it is equally critical that it is 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 an old one 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 reason, 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 grip length of the bolt. 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. Furmanite's 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 electronically 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, using advanced hydraulic technology to induce accurate bolt stresses, is generally accepted as the most reliable method of tightening without creating torsional or bending stress. The bolt is gripped and stretched axially, using hydraulic pressure, to the pre-determined load. Ultrasonic or mechanical stress measuring equipment can be used to confirm the residual stud tension. 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.

A large number of tensioners can be used simultaneously to keep time to a minimum, and can be 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 bolts, regardless of size, to be tightened to specific design requirements without needing wrenches or spanner extensions.

On the other hand, where tensioning is not required or hydraulic tensioning equipment cannot be used, torque tightening (involving stretching the bolt by turning the nut) offers a simple and safe method of ensuring controlled bolt tightening and loosening. Furmanite, for example, will use a wide range of compact, safe and user-friendly hydraulic torque tools, and a complete range of wrenches to a torque load of 80,000 ft lb or 108 Nm. Various measurement techniques again enable the bolt loading to be verified, using ultrasonic or mechanical means to measure bolt elongation.

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, a full and detailed history for each critical joint should be retained. Ideally this should be built up as work proceeds (as with the PSI Management system for example), 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 importance of training and competence is often highlighted when it comes to bolting associated with flanged joints for pressurised systems. 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, or indeed new build projects. 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, the advantages of investing in such management programmes become even greater. For any oil and gas operators, on or offshore, seeking to cut leakage and emissions, avoid delays and keep maintenance or build programmes on schedule, and reduce operating cost, a programme to provide effective management of joint integrity will certainly pay dividends.