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FEATURING:

BEST PRACTICES OF A JOINT INTEGRITY PROGRAM

NEIL FERGUSON, JOINT INTEGRITY LEADER: AMERICAS, HYDRATIGHT
FEATURE

Best Practices of a Joint Integrity Program

By: Neil Ferguson, Hydratight Joint Integrity Leader: Americas

INTRODUCTION

Joint integrity programs (JIP) should be an integral part of every refinery, petrochemical, production, or other industrial-complex facility operations. This article advises and outlines deliberate, sequential steps to take when creating processes and procedures, as they relate to flange joint integrity. It discusses new standards and the best practices available for companies needing to standardize their joint integrity management systems, or for those who need to implement a joint integrity management process from the ground up. This series of guiding principles align, meet or exceed joint integrity management practices detailed in current U.S. standards and requirements by the American Society of Mechanical Engineers (ASME), and will assist in compliance with Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency’s (EPA) performance rules.

HISTORY

Historically, the management of bolted-joint flanges has been subject to limited guidance compared with the highly regulated welded joint. This is despite the fact that bolted joints are used in the same types of process conditions and under the same pressures as welded joints, therefore posing a similar, if not higher, risk due to this limited guidance (See Figure 1). However, recent events have illustrated the need for new processes and procedures, which apply similar management practices to bolted joints as welded joints.

In a recent example in the North Sea, a four bolt hub joint connector passed a nitrogen-helium leak test as required by the operators’ safety and codes program on an offshore oil and gas production platform. However, three years later the joint failed, causing an explosion and leading to an estimated $30 million in damage to the platform. The cause of the failure was determined to be galvanic corrosion due to the use of a carbon-steel seal ring between two stainless-steel hubs, instead of using a stainless-steel seal ring. The accident could have been avoided with proper seal ring selection, positive material identification during inspection and assembly, and appropriate personnel training and competency management.

In fact, some operators estimate that the repair costs of a leaking flange can reach six figures worth of manpower and material cost per flange. Taking a facility though a turnaround might uncover 10 leaking flanges. During such an event, the repair and replacement costs could be as much as $1 million, even before including the cost of lost production through delayed start-up and schedule creep.

Clearly, the cost of preventing a leak is much less than the cost of repairing a leak or failure caused by a leak, and all leaks can be avoided. In addition to complying with industry guidelines, a well-developed Joint Integrity Program (JIP) that includes significant preventative measures, inspections, and personnel training and competency can avoid costly and life-threatening events from occurring. Plants are designed to be safe, and well-executed JIPs help ensure this is achieved – the overriding philosophy is to do it right the first time to avoid leaks or failures down the road.

NEW STANDARDS

In a break with the past, 2013 proved to be a landmark year for the integrity of the bolted joint. Two major standards were published concerned with defining the requirements for competent bolting craft personnel. First, ASME on the 12th of November 2013, updated their 2010 PCC-1” Guidelines for Pressure Boundary Bolted Flange Joint Assembly”; primarily to include an appendix defining the requirements for training and qualification of bolted joint personnel. According to ASME, “To understand the importance of bolted joint assembler training, it is worthwhile to compare bolted joints with the current practices for other pressure boundary joints: the welded joint. By contrast, there are practically no requirements for bolted joints even though they are holding back the same process conditions and therefore pose a similar risk. However, bolted joint leakage contributes to the loss of life on an annual basis and an average in excess of $100 million of documented cost to the industry in any given year.”

In addition to detailing the qualification requirements for both assemblers and trainers, ASME’s published standard, PCC-1 2013, also provides comprehensive guidance for the assembly and assurance of new and in-service bolted joint
assemblies (see Figure 2). Hydratight has practiced the essentials of this standard for more than 20 years, pioneering the concept of treating the bolted joint as though it were a weld, which is now a cornerstone of the ASME standard. This approach underpins a successful JIP.

Second, CEN (the European committee for standardization) republished EN1591 Part 4 with modifications as a standard, now entitled “Flanges and their Joints—Part 4: Qualification of Personnel Competency in the Assembly of the Bolted Connections of Critical Service Pressurized Systems.”

THE JIP ESSENTIALS
A successful JIP essentially consists of three key elements:

1. Quality products fit for a specific purpose and correctly and accurately designed and calibrated;
2. Well trained, competent operators and technicians; and
3. An effective management control process, including the collection and storage of vital information.

Operators can achieve industry guideline compliance, leak-free start-up and production through:

- Specially engineered products
- Advanced engineering services
- Improved management control procedures

In the past, the requirement for the assembly of bolted joints has focused on the tools required to tighten the joint – manual torque wrenches, hydraulic torque wrenches, and hydraulic bolt tensioners. However, an additional set of requirements for successful joint assembly and integrity includes bolt load calculation software, trained and competent technicians, best practice on site procedures, tags for the components, an electronic Flange Data Management System (FDMS), project managers, inspectors, and integrity specialists; all of which need to be embedded in a management control process.

Although the group of tools may have been used individually in the past, a successful JIP requires bundling all of these tools with the additional requirements outlined above in a holistic approach, underpinned by a management control process. All are essential components of a successful JIP. Applying these additional requirements when using the bolting tools increases the levels of control over the process of bolting, while simultaneously reducing and eliminating leaks (see Figure 3). Traceable and validated bolt load calculation software is required to generate the correct bolt loads. Trained, competent technicians are required to ensure correct procedures and processes are followed and the right components are installed. Tags are needed to identify each component to ensure they are working on the correct joint. Data must be captured in a system and the data must be manageable. Inspectors and integrity specialists are required to ensure the process is implemented correctly across all joints.

MANAGEMENT PERSPECTIVE AND ASSURANCE
From a management perspective, nine areas must be addressed for JIP assurance. These nine essential areas range from client ownership to key performance indicators (KPI). Without appropriately addressing all nine areas, the aim of leak-free operations and ASME compliance can be very difficult, if not impossible to achieve.

1. Ownership: A JIP “owner” within the organization must be appointed. The chosen individual, designated as a subject matter expert (SME), supports the entire strategy of JIP and becomes the linkage to external and internal parties. The SME should work with all tiers in the supply chain to analyze best practices, rollout new processes, develop new procedures, and support risk assessments.

2. Best industry practices and procedures: The organization should seek, identify, and benchmark against best practices and guidelines in the industry. This can be done by looking at either industry peers or industry associations, including but not limited to ASME, API, CEN, and the UK’s Energy Institute (EI). The best practices should be applied within the organization’s JIP processes, procedures and documentation. Often, these best practices can be acquired from JIP service companies.

3. Assess criticality, set rules: A typical facility, such as a refinery, might have as many as 50,000 flanges. Some of the flanges can be associated with water, while others can be cryogenic, thermal expanding, or high-risk hydrocarbon pipelines. The flanges must be categorized as either low risk, medium risk, or high risk. The risk assessment process should assess media, temperature and pressure, and be rated according to the leak and
loss potential, the risk of human injury, and the environmental impact, among others. Based on this risk analysis, the type of bolting and inspection process is determined for each level of risk. For high-risk joints, a dedicated contractor that specializes in bolting might be required. For low risk joints, the facility’s own general technicians may be sufficient, providing they meet the new ASME standards as “Qualified Bolting Specialists.” It is considered a best practice to rate every joint in the plant irrespective of the level of risk, and that the same discipline applied to welded joints be applied to all joints, as stated by ASME in their new PCC-1 guidelines.

4. Training and competency management: This area is concerned with ensuring that technicians working with bolted joints are sufficiently trained, experienced, and qualified to work within each level and risk. A designated person should manage the competency of technicians, establish requirements for critical and non-critical joints, and oversee the complete joint cycle with an increased emphasis on disassembly, make-up and inspection. These steps should be taken even with bolted joints as small as 1” in diameter or even less.

To assist with competency assurance, companies can benchmark against performance standards such as the Engineering Construction Industry Training Board (ECITB) National Skills Development Scheme (NSDS) Mechanical Joint Integrity (MJI) 10, 18 and 019. The competency assessor should be externally accredited in accordance with industry bodies, such as ASME, OSHA, and CEN. Training programs should contain content relevant to the organization’s needs and should require at least six months of training and practical experience to be classified as a Qualified Bolting Specialist based on compliance to ASME PCC-1-2013.

5. Joint identification and tagging: This process is critical to ensure that technicians are aware of which bolted joint is currently under work and into which level of risk the equipment is categorized. In a turnaround or construction environment, as many as 2,000 to 3,000 workers can be on site at any time, which can become chaotic. Therefore, a good joint identification program must be in place. The identification and tagging program should be as efficient as possible. While some companies might use alpha-numeric numbers, if they are not associated with specific equipment, the tag may fall off and potentially result in accidents if not reinstalled on the correct flange. It is recommended to use “intelligent” joint identification that aligns to the project.

For example, the first two numbers can represent the default joint size, the second two letters can be a service code for risk assessment, the third set of numbers can refer to the placement, the fourth set of letters can refer to the pipe specification for enabling a link directly to the joint details, and a final sequence of numbers can indicate a unique joint number (see Figure 4).

6. Comprehensive data tracking: ASME now requires three levels of data tracking. The nomenclature is short form, medium form, and long form. Each category has a specific amount of data that must be captured. Various types of data are recorded in the data-tracking program (see Figure 5). The tracking system covers traceability of the technician that performed a job, the materials that were used and the procedures that were followed.

Data tracking can also extend to include the development of an electronic Flange Data Management Systems (FDMS). This can be used to manage the joint identification, tagging and data tracking process outlined above. The inventory of joints should be permanently stored so that their history can be tracked and each joint linked back to any agreed piping specification, bolting manual, isometric drawings, P&ID’s, and any other relevant asset or plant documentation.

7. Inspection and Compliance: Inspection of bolted joints is an integral activity to ensure the continued integrity of the joints and, as such, should be included in every inspection program, i.e. ‘you get what you inspect, not what you expect’. This area of JIP assurance looks at the possible flange damage that can occur, the inspection methods available for detection of defects, and mitigation measures that can be put into place to minimize effects due to degradation and improper assembly.

Operators should ensure that QA/QC personnel are
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well-trained and well-versed in the fundamentals of bolting so they can support the craft, execute tasks effectively, and recognize any deviations to mandated procedures during the QA/QC process. QA/QC cannot be retroactive. It must be ingrained into the process, as many of the inspections occur during pipe assembly. Once the joint is completed and closed, inspectors can no longer adequately inspect the bolted joint. For example, an inspector must inspect the flange face for damage during the assembly process, as this cannot be accomplished after the fact.

8. **Leak management**: The objective of a correctly designed and assembled bolted joint is to provide a long-term tight seal and prevent ingress or egress of process materials through the joint. However, leaks can occur, so managing the investigation and repair of the leak is essential to avoid recurrence. This analysis can also provide useful data for leak prevention on other projects.

   A good leak management program is a learning process. Companies must understand what caused a leak and ensure it does not happen again. Leak decision trees and processes should be developed and implemented to ensure the highest degree of confidence in the bolted flanges.

9. **KPI, analysis and improvement**: Analysis and key performance indicators (KPI) of leakage and inspection data, coupled with formal reviews of the management system, should occur at agreed intervals by the owner and users. The results obtained from commissioning, incident analysis and in-service inspections should be used to generate ideas for continuous improvement. Easily monitored but meaningful performance standards should be put in place at the launch of the process to quantify the contributions being made by the management system and evaluate user satisfaction. Feedback on good practices in integrity issues and causes or solutions to incidents should be provided both internally and to the industry to contribute to industry-wide continuous improvement.

Other benefits include monitoring contractor performance and providing management visibility on the return on investment from the JIP.

Once the nine fundamental areas have been addressed and processes, procedures, training and competency management programs put in place, it is important to ensure those responsible for implementing and managing the JIP on site are competent and fully versed in bolting. Below is a review of the Joint Integrity Inspector and Joint Integrity Assurance Specialist roles and their duties as part of a joint integrity assurance program.

**Figure 5. Sample flange inspection and tightening data tracking form.**

**JOINT INTEGRITY INSPECTOR (JII)**

A well-trained and experienced JII alongside a fully implemented JIP is an asset to an organization. Whether in-house or out-sourced, the work of the JII can reduce re-work costs, remove rework delays, eliminate the risk of needing second tests, and significantly reduce operational issues in relation to bolted joints. Their work includes providing full and traceable QA/QC documentation to ensure permanent process containment, facilitating the lowest-cost, leak-free plant or facility. Typically, the JII associated with the JIP ensures ASME PCC-1 compliance by establishing the JIP on site.
JII’s are charged with looking for flange damage, correct material identification, ensuring mandated procedures are followed by those involved in joint assembly, as well as the following:

- Locate and identify the joint: The JII uses drawings to locate the joint. The joints are normally located by reading the site layout drawings, isometrics, or P&IDs. The joints are identified using the line number, which is configured to match the format of the project. Ideally, the flange details should be included in the Flange Data Management System (FDMS).
- Tag the joint: Temporary, multi-part tags should be used to identify the joint. The tags should be waterproof, can be permanently marked, and include visual status and identification of all disturbed joints. Tags can also be used to cross reference data to the FDMS. Any permanent tag should have full traceability, refer to the management systems, have a unique joint number, and be fixed to the outer dimension of the pipe or flange on smaller diameter connections. Typically, the tags are made from stainless steel.
- Inspect the joint: The JII will inspect the flange faces for problems such as corrosion, scratches, defects and the correct surface finish. While the joint is undergoing assembly, the JII should ensure that all the pertinent details are known and that the components are assembled correctly. The JII should check the bolt diameter, material, length and coating, and do the same for the nuts. The flange material size, class, surface finish and alignment will also be checked. At this point, the gasket condition, size and type should be checked. The flange should be checked without the use of force. All stud bolts, including both coated and stainless steel studs, should be checked for the correct lubricant, using only the project-specified lubricant. All studs, both tension and torque, must be lubricated. As an added precaution and to avoid issues with positive material identification, XRF positive material identification can be conducted on high-risk joints.
- Inspect the process: ensure the joint is assembled correctly with the correct materials.
- Determine the correct bolt load: Without exception, this should be obtained from a traceable source—ideally the FDMS or a suitable calculation program such as Hydratight’s Informate®. Special flanges will require additional information to ensure a leak-free joint. Non-standard flange information should be referred back to local technical support personnel. Specific boundaries for tightening bolt assemblies must be followed. If the bolt tightness is too little,
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the seal will be insufficient, too much and the bolt will yield or stretch to the point of breakage, all leading to a leak.

• Ensure application of the correct bolt load using approved equipment, mandated methods and competent personnel. The JII must ensure that all procedures and work instructions are carefully followed. Some activities to be inspected include:
  » Flange breakout
  » Clamp breakout
  » Flange preparation and bolt working
  » Clamp preparation, assembly and hydraulic torque tightening
  » Clamp preparation, assembly manual torque tightening
  » Flange manual torque tightening
  » Flange bolt tightening
  » Lubrication of nut and bolt

• Inspect for valid calibration certification: The calibration validity period as a best practice is one month for hand torque wrenches and three months for hydraulic torque wrenches, gauges and tension pumps.

• Record all details and activities and report them to the Joint Integrity Assurance Specialist (JIAS): Capture all of the information on the Inspection Test Report (ITR), a Joint Completion Certificate (JCC) and forward the details to the JIAS. On specific projects there may be an ITR to complete in place of a JCC.

• Monitor and improve processes and procedures.

The JII must also ensure the joints being worked on are correct and agree with the details provided on the Joint Work Instruction. In addition, he or she must ensure that they are correctly assembled and tightened with all relevant information being recorded and passed onto the JIAS. Should a discrepancy or deviation arise, the JII should use their best judgment and involve their supervisor, JIAS, or project manager as needed.

JOINT INTEGRITY ASSURANCE SPECIALIST (JIAS)

A JIAS has the same responsibilities as a JII. In addition, a JIAS must:

• Identify problems with joints and materials. These include low-strength materials such as flanges, gaskets and bolts, as well as high-temperature flanges, difficult material combinations, custom-designed joints and other special requirements.

• Investigate leaks by using a leak-detection decision tree to determine root causes, as opposed to a test and fix procedure. Remedial work should be recommended and best practices must be used. The JIAS must record all leakage information for future use.

• Review procedures and, where conflicts or differences might occur, they must be highlighted and communicated to the relevant Technical Authority. The JIAS should enforce the use of the correct lubrication. The torque and tension requirements must be evaluated to ensure the correct tightening method is used, according to the technical specification and flange configuration.

• Provide reports to management. The JIAS must create standard reports for the project, including data sheets, JCC, JBR, and FDMS work-pack documentation. Custom FDMS should be made and management reports must be completed when necessary.

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