Health and Safety Executive

Welded and Non-Welded Connections 2021

The Regulator's View

Daniel Shuter – Offshore Mechanical Team Lead

Energy Division

Health and Safety Executive

Background

Mechanical Engineering:

- Over 25 years in HSE; 10+ years' experience regulating onshore COMAH sites and Offshore Installations
- Managing a small team of Offshore Mechanical specialist inspectors covering UKCS
- The team are responsible for inspecting against HSE Maintenance Management and Lifting inspection guides, Investigation, Safety case assessment, etc
- Covering topside pressure vessels and pipework integrity, rotating equipment, cranes and lifting equipment….and usually much more!

Outline

- Introductions – the Regulator
- Regulatory Framework wrt Connectors
- Weldless Mechanical Connectors
  - Overview
  - The drivers for the use non-welded mechanical connectors
  - Safely managing the use of mechanical connectors
- Welded Hub-Clamp Connectors
  - Overview
  - Hub clamp connector failures/HSE Safety Alerts
  - Ring Type Joints (RTJs)
  - RTJ failure

Who we are…

HSE ED – Energy Division

- Offshore
- Gas & Pipelines
- Mines

HSE ED Offshore

- Responsible for regulating the risks to health and safety arising from work activities in the offshore industry on the UK continental shelf.

Regulatory Framework – The Act

Health and Safety at Work etc Act 1974

- **HSW Act** – based on the principle that those who create risks to employees or others in the course of carrying out work activities are responsible for controlling those risks.
- **Sections 2 & 3** – General duties of **employers** to ensure the health, safety and wellbeing in relation to:
  - Employees (Section 2);
  - Others (Section 3)
- **Section 6** – General duties of manufacturers etc.
  - **Any person who designs, manufactures, imports or supplies** an article for use at work should ensure it is safe *'…when it is being set, **used**, cleaned or maintained…'.*

Regulatory Framework – Statutory Instruments/Regulations

Provision and Use of Work Equipment Regulations 1998 (PUWER)

Regulations outlining **employers'** duties:

- **Regulation 4** – Suitability of work equipment.
  (1) *'…is so constructed or adapted as to be suitable for the purpose for which it is used or provided'*

  And

  (3) *'…is used only for operations for which, and under conditions for which, it is suitable'*

Regulatory Framework – Statutory Instruments/Regulations

PUWER cont.

- **Regulation 5** – Maintenance
  (1) *'…work equipment is maintained in an efficient state, in efficient working order and in good repair'*
- **Regulation 6** – Inspection
  (2) *'…work equipment exposed to conditions causing deterioration which is liable to result in dangerous situations is inspected -*

  (a) *at suitable intervals; and*

  (b) '…[in] *exceptional circumstances'*

Regulatory Framework – Statutory Instruments/Regulations

Pressure Equipment (Safety) Regulations 2016

- **Regulation 4** - Excluded pressure equipment and assemblies

  (1) These Regulations do not apply to the items listed in Schedule 1 (of these Regs) – incl. Pipelines, simple PVs, etc.

  (2) These Regulations do not apply to the assembly of pressure equipment on the site of and under the responsibility of a user who is not the manufacturer

- Modifications to an assembly being carried out on site under the responsibility of the user do not come within the scope of the PER.
- Repairs to pressure equipment do not come within the scope of the PER
- However, PER general requirements (e.g. conformity assessment) will apply to the Mechanical Connectors (pressure accessories) themselves

Regulatory Framework – Statutory Instruments/Regulations

- **PFEER (Prevention of Fire and Explosion, and Emergency Response) (offshore), Regulation 9(1)**

*'The **duty holder** shall…prevent the uncontrolled release of flammable or explosive substances'*

- **COMAH (control of Major Accident Hazards) (onshore), Regulation 5(1)**

*'Every **operator** must take all measures necessary to prevent major accidents and to limit their consequences for human health and the environment'*

HSE Safety Notice on Weldless Repairs to Safety Critical Pipework

- HSE Safety Notice 4/2005:
  HSE Offshore: Safety Notice 4/2005 - Weldless repair of piping systems
- For safety-critical pipework the repair philosophy should be:
  - Replace like for like
  - Temporary repair until replacement can be carried out
  - Permanent repair only where replacement is not practical

HSE Safety Notice on Weldless Repairs to Safety Critical Pipework

- Before any repair is carried out a risk informed decision-making process should be implemented – considering:
  - Risk Assessment: Hazards/consequences associated with system failure
  - Additional degradation mechanisms
  - Lifecycle expectations
  - Cumulative effects of other degraded areas on the system
  - Inspectability throughout the intended lifecycle
  - Requirement for management of change (MOC) procedure

Weldless Mechanical Connectors

- Numerous drivers for use – ageing installations, life extension, Changing COP dates, Reduced TAR durations, pipework repair backlog, etc.
- Useful where there are limited opportunities to carry out hot work.
- Convenient way of replacing sections of pipework when no longer fit for service
- Several key players with different product designs, e.g.:
  - Grooved Flange Type – e.g. QuickFlange
  - Elastic Strain Preload Type – e.g. LOKRING

  (Metal-to-metal gas tight seals without O-rings or other elastomeric seals)
  - Tapered Locking System Type – e.g. MORGRIP

  (employs at least one compressible seal between the pipe and the clamp body per length of pipe to be joined; Some designs use a dual seal arrangement)

Safely Managing the use of Weldless Mechanical Connectors (1)

- The key points from the 2005 HSE Safety Alert apply to all weldless connections.
- Careful consideration of where they are acceptable to use – duty holder policy should be developed
- Testing – needs to be comprehensive. e.g.
  - Leakage, Pressure, Loading, Fatigue, Vibration, Corrosion, Fire, etc
- Consideration of qualification/type approvals, e.g. from ASME or notified bodies – need to be consistent
- Potential additional degradation mechanisms must be identified
  - e.g. External chloride stress corrosion cracking of stainless steel Lokring pipe connectors was identified as an issue (2015)
  - HSE Safety Alert - External chloride stress corrosion cracking of stainless steel lokring pipe connectors
  - Lokring since carried out a lot of work with various coatings

Safely Managing the use of Weldless Mechanical Connectors (2)

- Some duty holders treat as deviation from standard and assess use under management of change
- Some duty holders have included in pipe specifications for lower risk systems
- Ensure fitted by trained and competent personnel, with some form of client approval
- Installation sheets recording specification, pre -installation and post installation checks
- Must be included within integrity management system/ Written Schemes
- Records always to be kept of where installed
- Useful to have marked on isometric drawings

Weldless Mechanical Connectors - Conclusions

- Weldless mechanical connectors are useful components in maintaining ageing piping systems
- The Regulatory Framework places duties on suppliers and users
- Range of approaches in recognising deviation from usual ASME B31.3 pipe specification, etc
- Can bring their own specific integrity challenges which should be considered in the decision-making process

Welded Hub/Clamp Connectors (1)

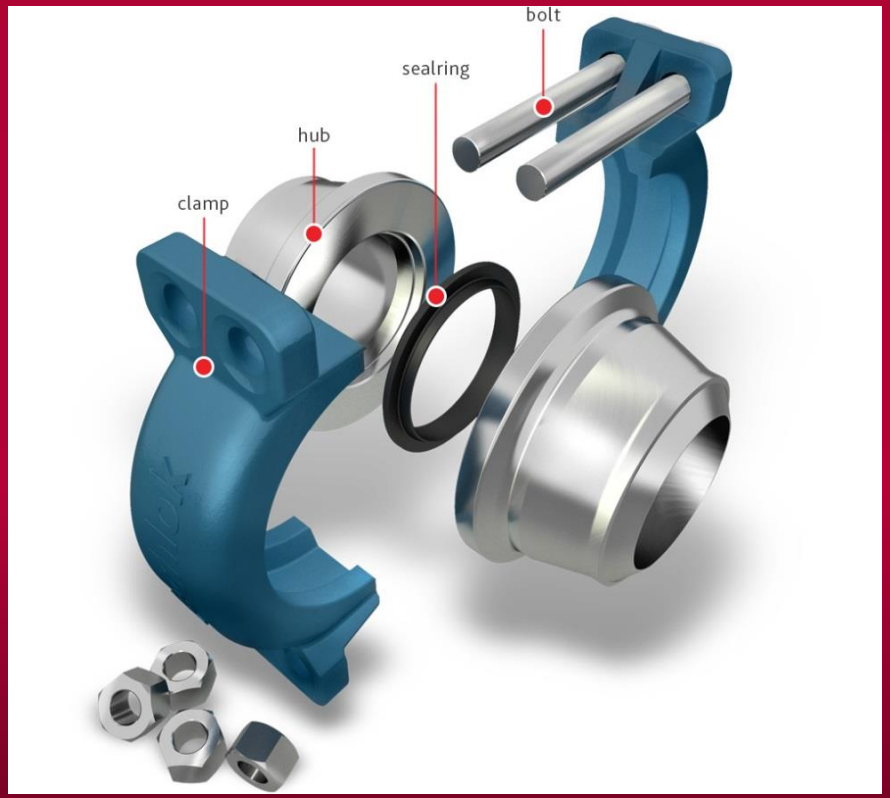
Hub/Clamp Connectors:

- Large variety currently on the market – Techlok, Destec & Grayloc used extensively offshore
- Commonly used on topside process pipework; can also be used on well head and Christmas tree components.
- Benefits include:
  - Size & Weight Up to 75% lighter and significantly smaller than a comparable ANSI or API flange.
  - Radial bolting allows 360° orientation around the pipe
  - Less Bolting, No Alignment - Only 4 bolts to tighten rather than up to 24 on a conventional flange, with no bolt holes to align
  - Minimize Maintenance Downtime

Welded Hub/Clamp Connectors (2)

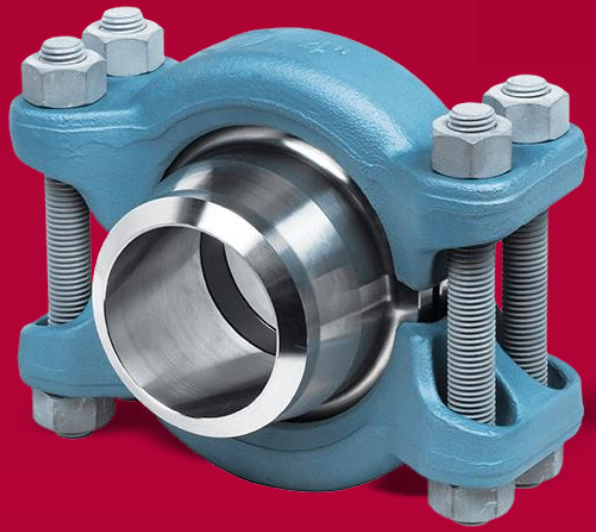
How they work:

- Hubs may be fabricated to pipe or other component equipment by established welding procedures.
- The hub connector contains pressure in pipework by rigidly holding the hubs together.
- A sealing ring is contained inside the hubs which engages with pressure
- Provides Metal-Metal seal



Techlok Connectors (1)

Pre-installation:



In-service:

Techlok Connectors (2)

Failure occurred in 2017 – 1” dia pipework clamp body failed leading to gas release:

- Clamp connector segments – forged AISI 4140 alloy steel with a recommended Rockwell hardness value of 22 Rockwell
- Failure attributed to issues with the heat treatment process.
- The final material properties did not meet required specs – higher hardness levels measured in the failed clamp
- The clamp in question failed due to hydrogen cracking of the hardened material

Techlok Connectors (3)

HSE Safety Alert issued on "*Catastrophic failure of a pipework clamp connector*" (2015)

http://www.hse.gov.uk/safetybulletins/catastrophic-failure-of-a-techlok-clamp.htm

- Alert required DHs to:
  - Identify if they had in use any 2" or below Techlok or Destec 'G' clamp connectors supplied before 2010, or have the potential to be used (for example spares kept in stores) on any of their installations and to verify their fitness for service.
  - Remove any of these clamp connectors which exceeded acceptable hardness values

Resulted in a number of clamps being taken out of service

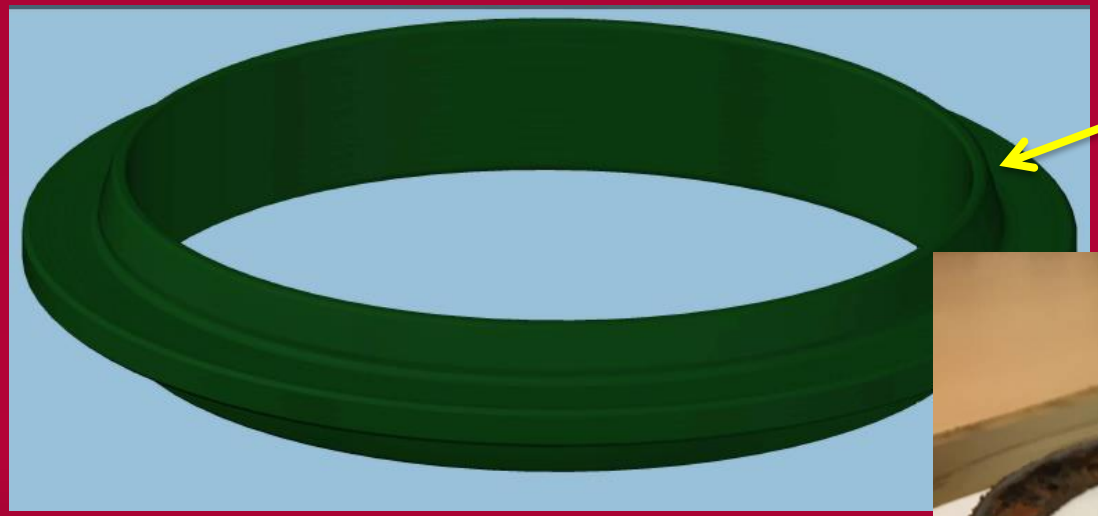
Hub/Clamp Connector – Incident (1)

Another Hub/Clamp Connector failure in 2017 –

- Normally unmanned installation (NUI)
- Connector located between LMV and spacer spool on a gas condensate producing well.
- In service for 15 years
- Carbon Steel ring fitted between 2x Stainless steel hubs
- Galvanic cell + wet gas + CO_2
- Failed Seal Ring

Hub/Clamp Connector – Incident (2)

Corrosion reduced the mass of the seal ring by over 90% by weight…..!



Connector seal ring profile – as new

Incident connector seal ring

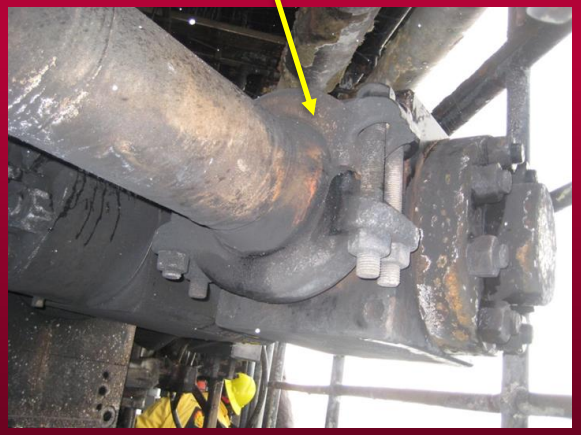
Pipework Connectors – Original Safety Alert (2010) – re-issued

Re-issued via Step Change in Safety (‘17)

Erskine Fire in 2010 – root cause attributed to incorrect seal ring material

- HSE Safety Bulletin/Safety Alert 2010: http://www.hse.gov.uk/safetybulletins/clampconnector.htm
- Duty holders advised to:
  - Ensure that their management systems applicable to assembly of pipe work connectors are robust, ensuring correct seal-rings are fitted.
  - Seal-ring identification markings should be clear and indelible.
  - If doubt exists, or as verification to provide confidence, compare assembly records with seal-rings as actually fitted. This may occur on a sample basis and when opportune.

Erskine leak was on a 6” Techlok clamp connecting flowline to wellhead



Ring Type Joints (1)

Ring Type Joints (RTJ):

- Precision machined metallic rings designed to be used with API 6B, ASME B16.5 and API 6BX flanges.
- The RTJ is essentially a metallic static seal which is located in a grooved flange.

RTJs (2)

RTJ principle:

- RTJ gaskets are generally used for high pressure and high temperature applications. Not as prevalent as clamps offshore.
- A metal-to-metal contact is formed between gasket and flange that makes a seal.

Note:

- While installing an RTJ gasket close attention must be paid to the bolting process to ensure uniform load acting on the gasket.
- RTJ gasket and groove faces must be free of imperfections and debris prior to installation.

RTJs (3)

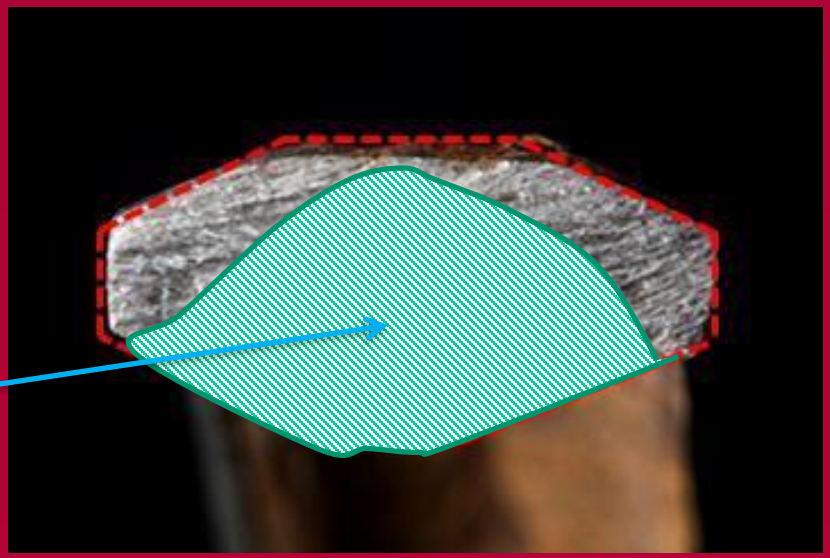
HCR Incident (late 2015):

- Normally unmanned installation (NUI)
- Large gas release from hole in an octagonal carbon steel RTJ located between a duplex stainless steel flow line and flow wing valve on a producing well.

RTJs (4)

Root cause of Failure:

- Dissimilar materials
- High CO_2 levels
- Significant Internal corrosion rates
- Extensive loss of material



Note:

- Original QA/QC Issues – possible that the Carbon steel RTJ was incorrectly identified at the time of installation in 2007
- Difficult to identify dissimilar ring materials once in service.
- Again - the advisories in HSE's 2010 (Erskine) Safety Alert still apply

Welded Hub/Clamp Connectors – Conclusions

- Difficult to identify dissimilar ring materials once in service
  - e.g. Carbon steel and stainless rings (e.g. 17-4-ph) on SS and Duplex lines
- Eddy current techniques being developed/utilised for PMI of ring material
  - Access to the seal rings & numbers in service are both issues, e.g. a single DH has identified 6000+ connectors on their assets!
- Good QA/QC on installation is key. The joint installation process must be robust – similar to "Golden Weld" scenario
- Changing DHs/Operators means that there is sometimes a lack of history available & thus dissimilar materials used in connectors remains an issue particularly for older platforms

Thanks for listening

Email: daniel.shuter@hse.gov.uk