

Guide to Mechanical Connector Selection and Lifecycle

Publication 243

Edition 1

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ISBN 978-0-85931-240-0

Imprint reference 11-2021

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Acknowledgements

This guidance is based on information provided and discussed during a series of meetings of the EEMUA Working Group 148 made up of a global team of representatives from the energy industry. The guidance reflects the discussions and also reflects general information from published articles and papers on the subject.

EEMUA acknowledges the work produced by this group and would like to formally acknowledge the following members:

Peter Hallen – BP
Robin Hastings – Harbour Energy
Duncan Kingan – Ineos FPS
Jamie Mathie – Mechanical Integrity Solutions Ltd
Scott McNeil (Chairperson) – Marsh McLennan
Ross Millar – Lokring
Mark Sindelar – LokRing
Adam Thistlethwaite – Team Inc

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1 Scope

The remit for this EEMUA document is to provide an overview with respect to selection, installation, and maintenance of a variety of the most commonly used mechanical pipe connector designs which can be used as an alternative to hot work i.e., a non-welded cold work solution. This document will prompt focus on key points for Users to select the most appropriate mechanical connector for the specific application and when developing their Maintenance and Inspection strategy for these components post installation. The User should justify the use of a mechanical connector in lieu of a conventional welded connection, however this is not the remit of this document. The primary function of the connectors covered in this guidance is to join two pipes i.e., to transfer the mechanical loads from one length of pipe to another, whilst maintaining pressure containment and not for the purpose of leak sealing or providing mechanical strength to a damaged section of piping. At the time of publication there was no known industry guidance for the management of mechanical connectors, though in-house strategies have been developed by many Users. It is the intention of this document to share good industry practices and highlight considerations to be captured when developing a strategy for mechanical connectors.

The design of the mechanical connectors included in this document are often proprietary designs and are classed as ASME B31.3 Unlisted Components. For this reason, the User should work closely with the OEM when developing their strategy, while using this document to supplement their knowledge and considerations. The remit of this document does not cover threaded fittings, flanged joints, or mechanical clamp repairs (as defined by ASME PCC-2). For guidance on repair management systems, refer to the Marsh Position Paper: Management of Temporary Repairs.

This document was developed by Engineers who work exclusively in the Oil and Gas Sector, as well as OEM Technical Specialists. Although the use of this document was originally targeted for the topside and upstream industry, it is recognised that it may be applicable to a range of other industries – Shipping, Mining, Steel, Chemicals, Nuclear, Water and Food & Beverages to name a few. It is the responsibility of the User to ensure specific details relating to their industry are considered when applying the guidance from this document.

Each Company's organisational structure will vary in terms of maintenance, engineering, and inspection departments. As such, it is the responsibility of the User or Equipment Owner to determine the strategy for mechanical connectors at their respective Companies. The strategy should be endorsed by the relevant Technical Authority for the Company.

This document will advise that a risk based approach is adopted to allow flexibility in application of mechanical connectors to the relevant situation; to ensure correct prioritisation based on design life and to ensure that the use of the mechanical connector does not adversely affect the safe operation of the piping system.

It is expected that the document reader has a basic competency in Piping Design and as such the level of detail contained within this guidance document has been set appropriately.

2 Acronyms/Abbreviations & Terminology

2.1 Acronyms/Abbreviations

ALARP	As Low As Reasonably Practicable
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATEX	Atmospheres Explosives
BS	British Standard
BSI	British Standards Institute
CRA	Corrosion Resistant Alloy
DCR	The Offshore Installation & Wells (Design and Construction etc.) Regulations
DLR	Defined Life Repair
DN	Diameter Nominal
EEMUA	Engineering Equipment and Materials Users Association
ESP	Elastic Strain Pre-Load
FLIR	Forward Looking Infrared
H2S	Hydrogen Sulphide
HSE	Health and Safety Executive
IACS	International Association of Classification Societies
ICP	Independent Competent Person
ISO	International Standards Organisation
IVB	Independent Verification Body
MC	Mechanical Connector
MoC	Management of Change
MSS	Manufacturers Standardisation Society
NACE	National Association of Corrosion Engineers
NB	Nominal Bore
NDE	Non-Destructive Examination
NDT	Non-Destructive Testing

NPS	Nominal Pipe Size
OD	Outside Diameter
OEM	Original Equipment Manufacturer
OSCR	The Offshore Installations (Offshore Safety Directive) (Safety Case etc.) Regulations
P&ID	Piping and Instrument Diagram
PCC (ASME)	Post Construction Code
PED	Pressure Equipment Directive
PER	Pressure Equipment Regulations
PMI	Positive Material Identification
PSSR	Pressure Systems Safety Regulations
PUWER	Provision and Use of Work Equipment Regulations
QA	Quality Assurance
QC	Quality Control
RBA	Risk Based Assessment
RBI	Risk Based Inspection
SCC	Stress Corrosion Cracking
SIF	Stress Intensification Factor
WSE	Written Scheme of Examination

2.2 Terminology

User	The organisation who use the equipment and have responsibility under PUWER.
Equipment Owner	The organisation who has purchased the Mechanical Connector for use on their site.
Third Party	Independent body engaged by either the OEM or the User to provide impartial inspection, certification, or assurance on the quality of goods or services.
Technical Authority	Position within the User's organisation who has responsibility for the assurance and technical suitability of equipment within their discipline.
Fluid Category	Category M fluids are defined as (1) the fluid is so highly toxic that a single exposure to a very small quantity of the fluid, caused by leakage, can produce serious irreversible harm to persons on breathing or bodily contact, even when prompt restorative measures are taken and (2) after consideration of piping design, experience, service conditions, and location, the owner determines that the requirements for Normal Fluid Service do not sufficiently provide the leak tightness required to protect personnel from exposure Category D fluids are defined as (1) the fluid handled is non-flammable, nontoxic, and not damaging to human tissues as defined in para. 300.2. and (2) the design gage pressure does not exceed 1 035 kPa (150 psi) and (3) the design temperature is not greater than 186°C (366°F) and (4) the fluid temperature caused by anything other than atmospheric conditions is not less than -29°C (-20°F). Normal Service fluids are those which are not classified as either M or D.
Safety Critical	The term safety critical is used in this document to describe equipment with a a high consequence of failure associated with failure to perform it's primary function e.g. piping on an emergency de-pressurization system.
Written Scheme of Examination (WSE)	A WSE is the typical term used to describe the formal (and often regulatory) inspection programme / scope of work for equipment. Recognizing that this document may be utilized globally, other terms may be interchanged with WSE to describe the inspection programme / scope of work.

3 Description of Connector Types

Due to the great variations in design and configuration of mechanical joints, no specific recommendation regarding calculation method for theoretical strength calculations is given in these requirements. These requirements are applicable to pipe unions, compression couplings and slip-on joints as discussed below. Similar joints complying with these requirements may be acceptable. This is not an exhaustive list but is considered to address the more commonly used connector types with in the Upstream and Downstream Oil & Gas and Chemical industries.

3.1 Grooved Flange Type

A Grooved Flange Type connector is similar to a standard slip-on flange that might be welded onto the end of a pipe, except that it has a number of full circumferential grooves on the inner diameter of the flange bore. The flange is slid over the end of a plain end cut pipe, and a hydraulic tool is used to apply an outward radial force to plastically deform the wall of the pipe into the two grooves. This creates a gas tight joint without the need for elastomeric seals or welding. Each patented design is engineered and the OEM should be able to provide an engineering design document with test results and any applicable Type Approval demonstrating compliance with various industry codes and/or international standards. See Appendix 1 for more details on the use of the Grooved Flange Type connector.



Figure 1 – Grooved Flange Connector

3.2 Elastic Strain Preload Type

The Elastic-Strain Preload (ESP) design of mechanical connector uses a hydraulic method of sliding a drive ring over the body of the connector, which elastically deforms the body of the coupling, pressing the coupling onto the parent pipe. This compression results in elastic deformation of the pipe and provides a friction preventing longitudinal slip and pull-out. The pipe is compressed, first elastically and then plastically, by the swaging action during installation, circumferential sealing lands machined in the bore of the fitting body grip and seal on the pipe OD, forming a gas-tight, metal-to-metal seal without O-rings or other elastomeric seals. Each patented design is engineered and the OEM should be able to provide an engineering design document with test results along with any applicable Type Approval proving compliance to international codes and standards. In addition to straight pipe to pipe couplings they can typically be provided as fittings e.g. elbows or tees and also with integral flanged ends. See Appendix 2 for more details on the use of the Elastic Strain Preload Type connector.

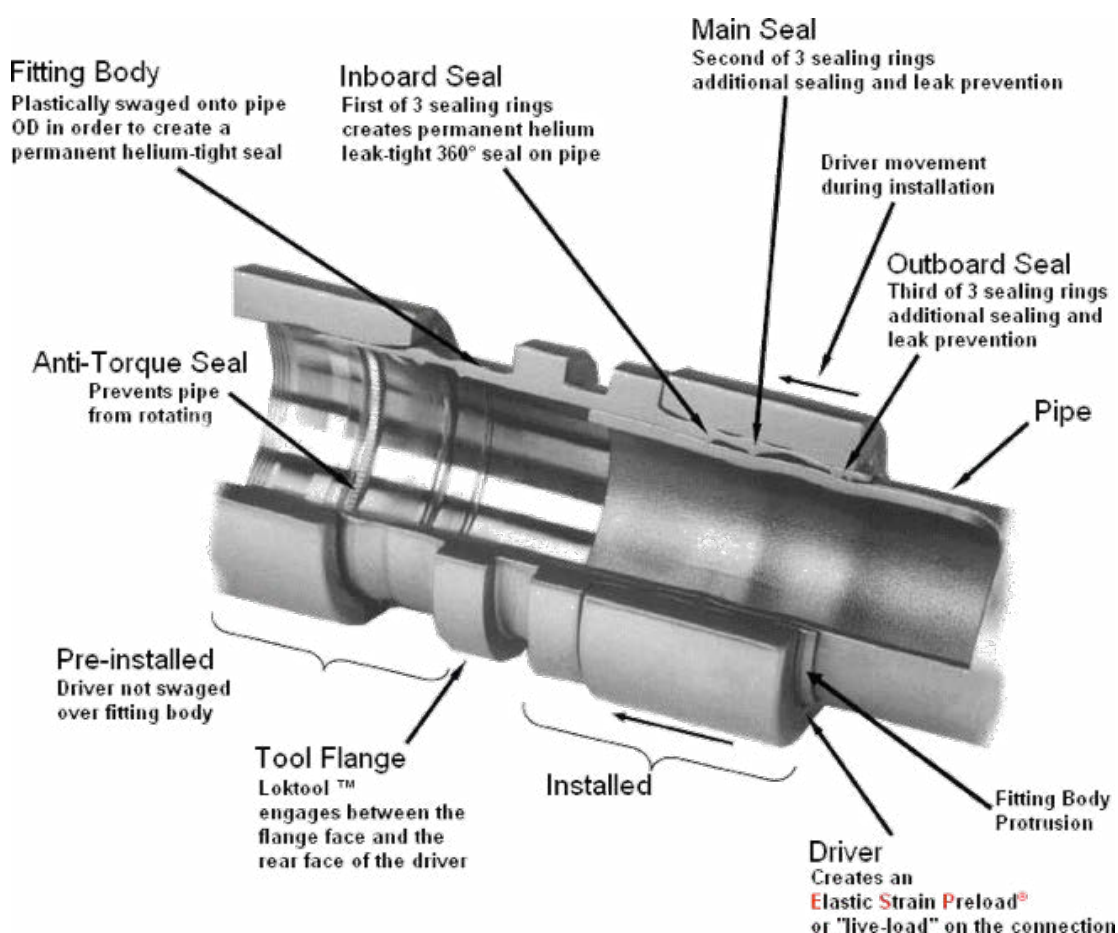


Figure 2 – Elastic Strain Preload Connector

3.3 Tapered Locking System Type

Mechanical connectors that employ the Tapered Locking System design are generally referred to as those which use a series of ball bearings or wedges which are compressed radially around the outside circumference of a pipe upon the application of an axial force. The axial force causes the balls or wedges under a tapered mating surface in the body of the clamp, thus forcing them onto the outside of the pipe. The number of balls or wedges used should ensure that the pipe is evenly compressed and hence not at risk of collapse. The locking system itself will only provide the mechanical connection between the pipe and the clamp body; it will not provide a leak tight fluid seal. For this reason, such connectors will also employ at least one compressible seal between the pipe and the clamp body per length of pipe to be joined. Such seals are typically energised simultaneously with the locking system. Many designs use a dual seal arrangement such that there is 100% redundancy in seals, and so that the seal integrity can be tested by carrying out a pressure test to the annulus space between the two seals. It is good practice for connector manufacturers to employ anti-extrusion rings on either side of the compressible seals. See Appendix 3 for more details on the use of the Tapered Locking System Type connector.

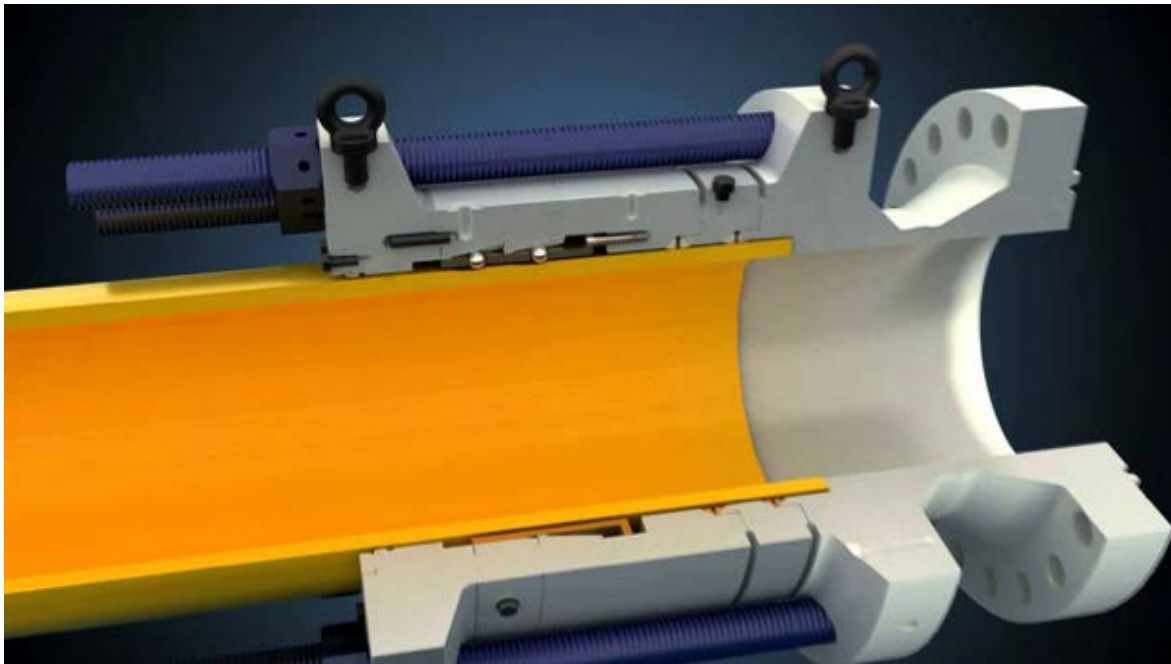


Figure 3 – Tapered Locking Flange

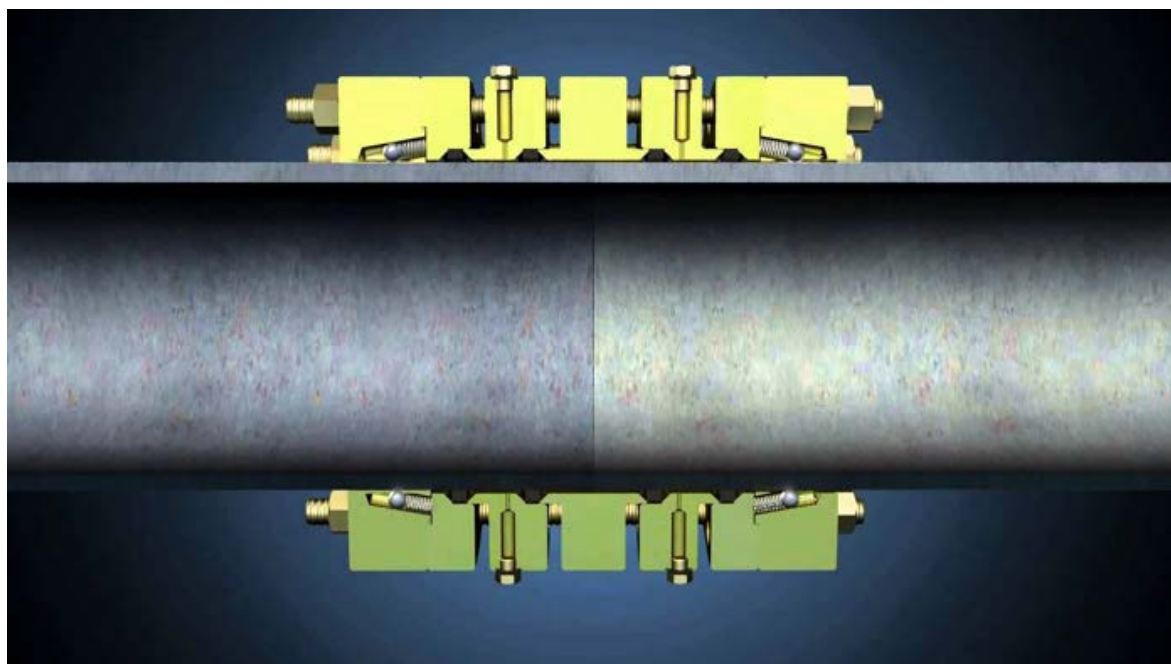


Figure 4 – Tapered Locking Connector/Coupling

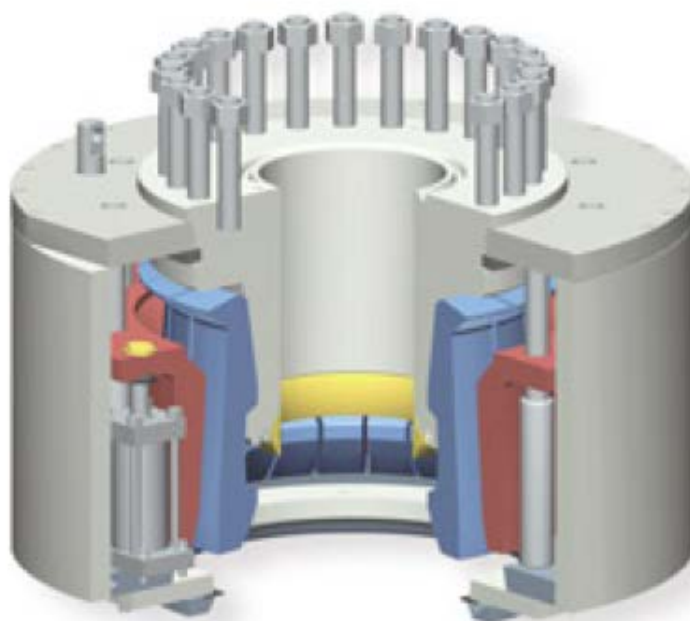


Figure 5 – High Pressure Tapered Collet Connector

3.4 Grip and Seal Type

A Grip & Seal type mechanical connector will employ a means of applying a circumferential load between the connector and the pipes to be joined. This load will be used to energise a seal to prevent leakage. The circumferential load is typically applied via a bolt load which brings together two halves of a casing in which the seal / gasket is located. These types of connectors can be provided with axial grips to prevent axial loads from internal pressure end load or externally applied axial loads from pulling the pipe out from the coupling. Typically, only available as a straight pipe to pipe coupling. See Appendix 4 for more details on the use of the Grip and Seal Type connector.



Figure 6 – Axial Grip & Non-Grip Type Couplings



Figure 7 – Axial Grip & Seal Connector

3.5 Flared Type

A flared type pipe connection requires the mechanical cold-working (i.e. forming) of each pipe end to create a sealing face for a gasket, and a reaction face for which a backing flange is used to mechanically secure each side of the connection. Flared Type flange connectors come with different flare angles and typically the flatter the angle e.g. a 90° flare the lower the pressure rating.

Flatter angled Flared Type Flange System, (typically a 90° flare is made), are generally used on utility systems for the Marine, Offshore, Chemical industries for class III piping with a maximum allowable working pressure of 16 bar. This Flare Flange Jointing method is suitable for low pressure piping systems in a wide range of different materials ranging from mild steel to super duplex and on pipe sizes up to 24" NB. To make up a joint using this system the end of the tube is clamped into a flaring machine where a conical rotating tool flares the pipe end into a die. A seal is placed between the pipe ends and the flanges are then tightened together to complete the connection.



Figure 8 – 90° Flared Connector

Shallow angled Flared Type flange connectors can be used in a broad range of high and medium pressure applications in a wide variety of services ranging from Marine and Offshore to Chemical and other light industrial applications. They are typically used for piping systems with a maximum allowable working pressure of up to 400 bar. On larger pipe sizes up to 10" NB the pressure can be limited to closer to 50 bar. In this connector the end of the tube is clamped into a propriety flaring machine where a conical rotating tool flares the pipe end into a die to the required angle. An insert is placed in each pipe end with a seal in between and the flanges are then tightened together. See Appendix 5 for more details on the use of the Flared Type connector.

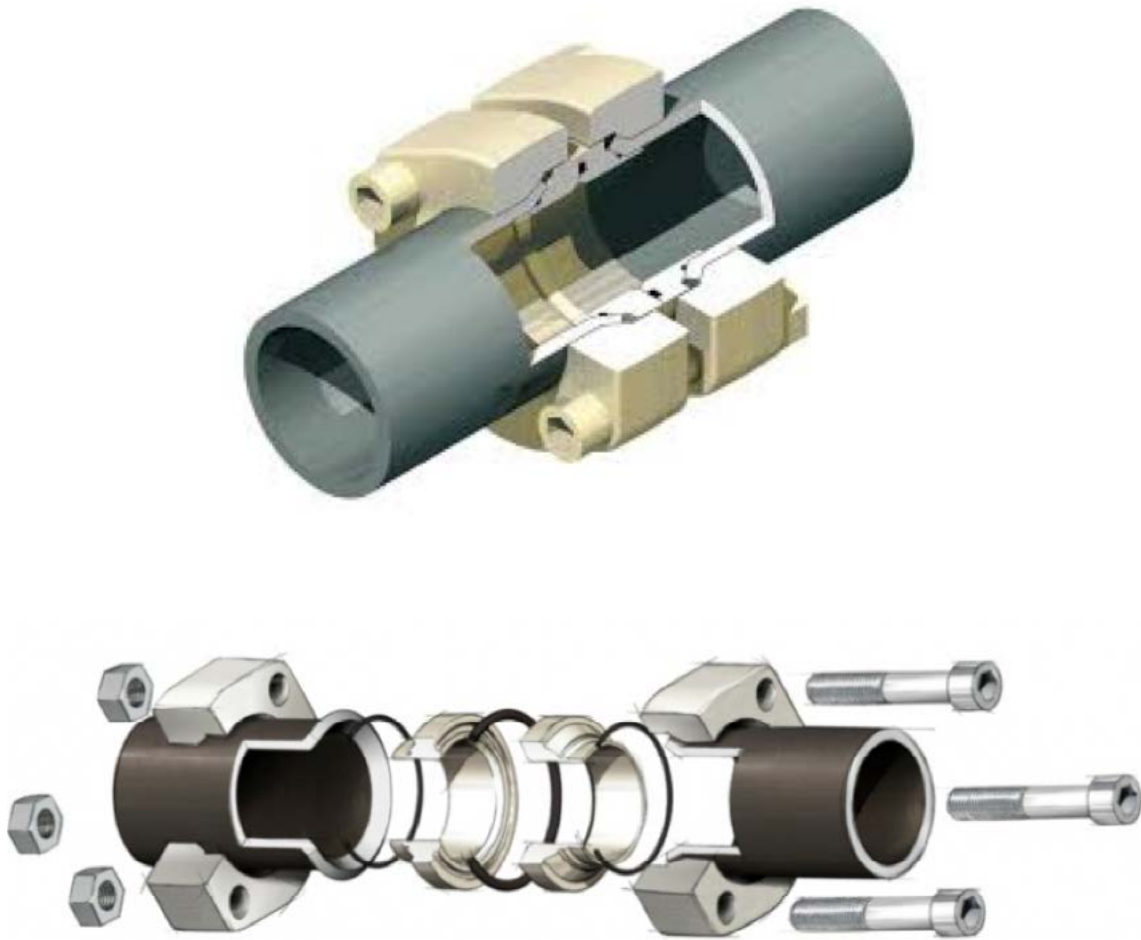


Figure 9 – Assembled & Exploded view of 37° Tapered Flared Connector

3.6 Machined Pipe Groove Type

Machined Pipe Grooved type connectors consist of a combination of four key components:

- the grooved pipe,
- the gasket or seal ring,
- the flanges or housings (can be axially or radially split) which locates into the pipe groove,
- the fasteners.

The pipe groove is made by forming or machining an actual groove into the ends of two pipes. A gasket or seal ring can be wrapped around the pipe, located between the pipe ends or installed between the pipe and a connector piece. Where a housing is used it locates into the grooves to provide the connection between the two section of pipe, where a flange is utilised then a retaining ring is fitted into the groove and reacts with the flange to provide the connection. For some connector types the same fasteners are used to provide both the connection load and the gasket sealing load. Other designs utilise separate fasteners for both the connection load and the sealing load. See Appendix 6 for more details on the use of the Machined Pipe Groove Type connector.

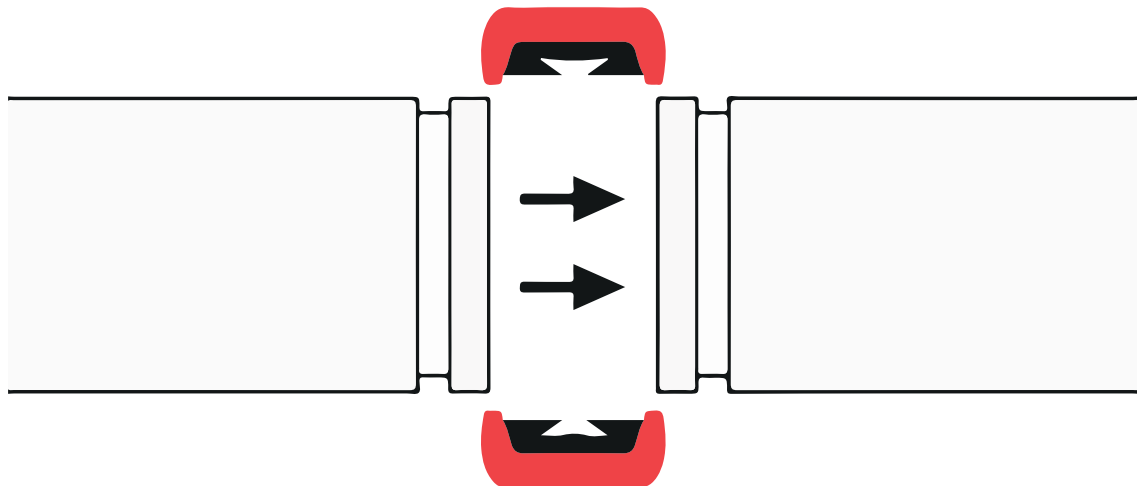


Figure 10 – Schematic of Machined Pipe Grooved Coupling



Figure 11 – Exploded view of Machined Pipe Grooved Mechanical Connector

3.7 Miscellaneous Pipe Connectors and Flange Adaptors

There are many other types of Flange Adaptors and Pipe Connectors which are not addressed specifically within this guidance document. In general, where the principles of this document are followed and the user takes into consideration the design limits, type approval and life cycle guidance discussed for the above connector types then it is considered that those connector types can be equally suitable for appropriate applications.

4 Local Law and Regulatory Requirements

It is the User's responsibility to ensure compliance to local law and regulations. This document is intended to provide technical information for selection and use of mechanical connectors but does not offer approval or consent in the application of their use. The list of regulations below are applicable to the UK, however it is recognised that Operators and Users of pressure equipment do so in other countries where other legislation and local laws will govern or take precedence over anything stated or implied within this document and it is the responsibility of the equipment user to ensure that the appropriate laws are fully adhered to.

Applicable regulations:

- Health and Safety at Work etc. Act, 1974
- Control of Major Accident Hazard Regulations, 2015 (Onshore only)
- Offshore Installation (Safety Case) regulations (OSCR), 2005 (Offshore only)
- Pressure System Safety Regulations (PSSR), 2000 (Onshore only)
- Pressure Equipment (Safety) Regulations (PER), 2016
- Prevention of Fire & Explosion and Emergency Response Regulations, 1995 (Offshore only)
- The Management of Health and Safety at Work Regulations, 1999
- The Offshore Installation and Wells (Design and Construction etc.) Regulations (DCR), 1996
- The Provision and Use of Work Equipment Regulations (PUWER), 1998

The above list of regulations are latest at time of issue. It is the user's responsibility to verify that the most up to date issue plus any amendments are followed to ensure regulatory compliance