Introduction to OCTG
Premium Connections
Connectors
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Handout 08
There are no standard designs for Premium Connections. Manufacturers have their own preferences so they design different types of threads. The main characteristics of proprietary connections are:

**The thread geometry:** this is related to the taper, the stab flank, the load flank, the threads per inch, the stand-off, etc.

**The thread profiles:** they vary according to the application and the well design. Based on this, there are different shapes of threads. Some of these profiles are:

- Flank to flank
- Crest to root
- Hooked thread
- Dovetail

**Seal designs:** as well as the threads, metal-to-metal seals come in a wide range of shapes which provide different pin-box contact pressures, such as:

- Cone-Cone
- Cone-Spheric
- Cone-Multi Tapered

**Sliding distance:** this is the distance from the first point of the pin-box seal contact until it reaches the final make up position. In general terms, the shorter the sliding distance, the lower risk of galling on the seal.
Threaded and Coupled Connections

The most typical connections used in oil and gas wells are threaded and coupled connections, where two pipes are made up together through a third element known as a coupling. Threaded and coupled connections are available in different types, such as:

- Standard Coupling which has the OD specified by the manufacturer.
- Special Clearance Coupling which has a reduced OD for higher clearance in the well but results in reduced tension efficiency.
- Matched Strength Coupling which has a reduced OD and the same tension resistance as the pipe body.
- Special Beveled Couplings where their faces have been chamfered to be used in dual completions or horizontal wells to minimize drag forces.

Integral Connections

They join two pipes without a third element or coupling. Integral Connections can be classified as:

- Integral flush connections where the OD of the connection is the same as the OD of the pipe, so the entire string has a continuous and equal outside diameter. These connections are used in wells in which clearance between pipe and pipe or pipe and hole is critical.
- Then we have Integral semi flush or near flush connections which have an OD slightly larger than the OD of the pipe body, generally from 2 to 5%. Near flush connections allow the cutting of a seal with a homogeneous thickness. Integral semi flush connections are also used in wells with restrictions in the clearance between strings. Their tension resistance is higher than the resistance presented by integral flush connections but lower than that of threaded and coupled connections.
Wedge Connections

They use a dovetailed-wedge thread form, a unique design that creates the largest possible contact surface area at make-up to provide superior compression and several times the torque strength of most competing technologies.

These premium connections have a progressive thread width as it moves helically around the pipe. The mechanical strength of the connection comes from the large contact area as the flanks come into contact. As torque increases, more pressure is put on the flanks due to the wedge effect absorbing the torque.

A series of geometric elements characterize Wedge Series connections:

- Dovetail: the dovetail profile helps mechanically lock the pin and box together, creating a more rigid connection.
- Internal metal-to-metal seal: most Wedge metal-to-metal seal products are pressure energizing. As internal pressure is applied, contact pressure becomes higher.
- Seal saver: the seal saver is located at the end of the pin on some connections of the series. It acts as a bumper to isolate the seal surface from handling and stabbing damage.
- Make-up band: this is an external visual confirmation of make-up. After a proper make-up, the box end must reach the make-up band.
Their helical surface contact area, generated by the wedge effect of the thread, ensures higher compression capacity. Bending capacity is a function of either the tension or compression capacity, whichever is weaker. Bending loads produce axial tensile and compressive stresses on opposing sides of the connection. The bending efficiency of Wedge connections is equal to their tensile efficiency, which is almost 30% more than a standard shouldered integral connection.

This bending efficiency combined with the superior structural capability provided by the interlocking dovetail wedge thread makes this technology ideal for deviated applications.

The structural collapse performance of these connections is rated at 100% of the pipe body performance. When it comes to internal yield, some types of Wedge connections meet the pipe body yield performance while others are limited to low-moderate pressure services.

An extremely important feature of Wedge connections is their superior torque strength, which makes them useful for applications such as work strings, rotating liners during cementing, drilling with casing and tubing. This extra torque capability provides a greater safety margin against the unpredictable downhole torque.

**Connectors**

Connectors are used on pipes with large ODs, generally of 20” and above. For this reason, they are mostly used in surface and conductor casing strings in deep and offshore wells.

An advantage offered by connectors when they are run from barges or floating platforms which move with the sea tides and waves, is the fast and safe make-up which helps to avoid cross threading during running.

To achieve this, the design of some types of connectors includes multi-starting threads that allow the make-up of two joints in less than one turn of the pipe. Easy and reliable running is achieved through a deep stabbing provided by a fast thread taper and high stabbing flank angle.
An additional aspect to be considered in these quick connectors is their ability to avoid any back-off after the running. Different anti back-off devices have been designed for this purpose, such as the anti-rotational keys (ARK).

**Finite Element Analysis**

Finite element analysis (FEA) is a numerical method based on the discretization of the connection into small elements known as ‘nodes’. These nodes constitute a net and are linked by mathematical functions. The smaller the nodes, the higher the precision of the method. Through FEA the behavior of the connection and the seal under different load conditions can be evaluated. And to properly evaluate a connection design, all the extreme combinations of tension, compression, bending and internal/external pressure must be considered.

In the past, connections were mainly tested according to API RP 5C5 (Recommended Practice for Evaluation Procedures for Casing and Tubing Connections). In addition, some major operators used their own criteria to evaluate premium connections. However, since 2002, most companies have migrated and adopted the ISO protocol, which has been established in the ISO 13679 standard (Petroleum and natural gas industries, Procedures for testing casing and tubing connections). This standard presents four Connection Application Levels (CAL) where CAL IV represents the most demanding level and it is associated with the severity of the intended use.

In order to comply with the ISO 13679 testing protocol, several samples must be tested. These samples produced in extreme values of manufacturing tolerances in terms of both threads and seals, are subject to three different types of tests:

**Galling Resistance:** several make-and-break operations are performed under different conditions. Once done, samples are baked to eliminate the thread compound used during the galling resistance test. With this procedure, we ensure that the sealability of the connection is achieved only through the metal-to-metal seal and not through the thread compound.

**Sealability:** samples are subject to combined loads such as tension, internal pressure, bending, thermal cycling, and so on, to confirm the connection sealability with gas.
Failure tests: in these tests the samples are subject to extreme loads until they break or fail. The criteria to accept a connection as good is if the samples break beyond their declared mechanical limits.

The results of these ISO 13679 Full Scale Tests are represented in the von Mises ellipse and the “service envelope” of the connection is obtained. The ISO standard is the proper way to compare connections from different manufacturers, as their performance can be seen through their envelopes. The bigger the envelope is, the closer to the pipe performance. And actually, this is what the designers look for, to get the connection service envelope as close as possible to the pipe body envelope.