

Whitepaper

ENGINEERING
TOMORROW

Danfoss

Danfoss Hansen® **Flat Face coupling series**
improves fuel efficiency and increases product life
while offering higher pressure resistance



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Authors



Christian Kuenstel

Global Product Management
Leader, Connectors Business



Atul Puranik

Lead Engineer, EMEA, Danfoss
Power Solutions II



Sebastien Lafond

Global Engineering Leader,
Connectors Business

Executive summary

Danfoss has enhanced its flat face series quick disconnect coupling with several technical developments in order to offer 60% higher operating pressure and up to 74% higher flow rates compared to ISO 16028 specification. Danfoss' Dura-Kote plating significantly extends the service life of the products with corrosion resistance and connect under pressure plug capability. The enhanced design of the coupling features higher flow rates and higher operating pressure at the same time!

A flat face quick disconnect coupling is a double shut-off style high performance quick disconnect coupling (QDC), where valving on both halves of the coupling are flush facing with body. This capability reduces spillage and air inclusion compared to traditional poppet style coupling. Quick disconnect couplings are used in a variety of industries such as oil and gas drilling, agriculture, construction, mining equipment, and heavy machinery, amongst others.

In most of these industries, quick disconnect couplings are used in machinery and equipment where frequent connection and disconnection of hydraulic lines is necessary. This is where easy and quick connection of coupling without any special tools becomes valuable for the customer. Flat face coupling offers this with an added advantage of minimum fluid loss (spillage) and air inclusion in the system per connection / disconnection.

Over the past few years, industry trend has been to offer compact machines, but with the same power and operating capabilities of their larger equivalents. In turn, this demands higher pressure resistance capability from hydraulic system components, which essentially means higher force and torque is available from smaller equipment. Parallely, with the cost of fuel being high in the twenty-first century, it is essential and of operator importance to ensure that fuel economy is optimized and maintained. Whilst there are many factors that contribute to the amount of fuel consumed, one such area that can dramatically affect a mobile machines performance is hydraulic pressure. In context of couplings, it is essential that the coupling lets more fluid through. If the coupling cannot deliver enough flow, then the pump for the hydraulic oil will have to compensate.

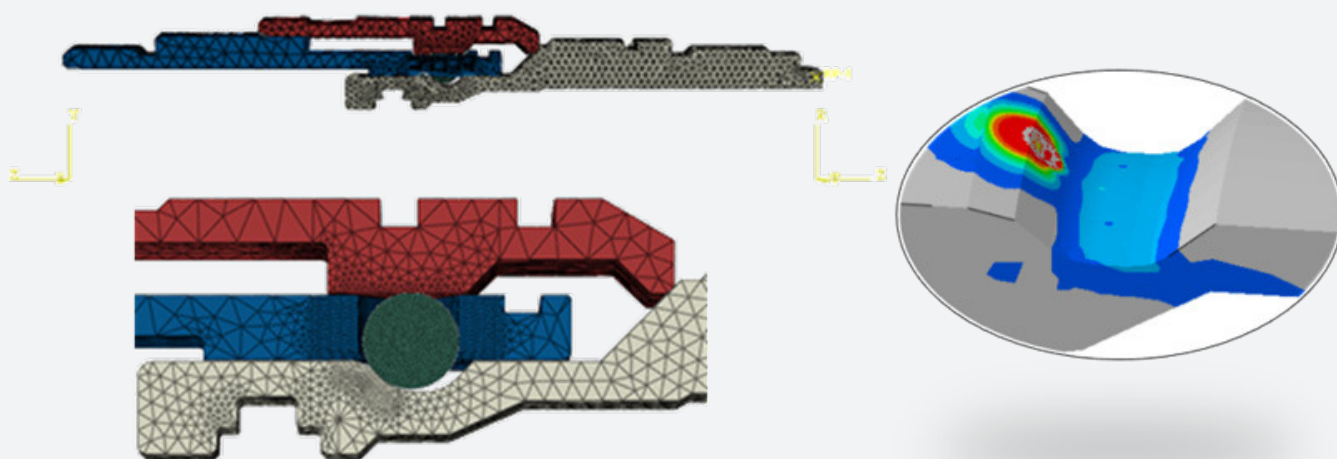
This means that the amount of energy drawn from the ICE (internal combustion engine) is greater, thus the amount of fuel utilized for this compensation is increased.

Higher pressure resistance, higher flow rates (low pressure drop), and reliable product for longer life are industry needs from quick disconnect coupling. Danfoss Hansen Flat Face (FF) series coupling caters to the requirements for these industry trends and offers following salient features to meet the application demand.

Pressure resistance - 60% higher operating pressure than ISO 16028 specification

With industry interchange design, engineers have a very fine margin to play with and because of this typically higher-pressure resistance comes with the cost of reduced flow rate (rate of fluid flow at 1 bar pressure drop). However, with use of superior high strength materials and design optimization efforts, Flat Face (FF) series coupling can withstand up to 400 bar (5800 psi) working pressure for static, non-pulsating applications, across 6 sizes. For applications causing pressure pulsations, this coupling is recommended to use up to 350 bar (5075 psi). Even with such higher working pressure, safety has not been compromised, and FF series coupling is designed to withstand 1400 bar (20300 psi) static pressure before fracture occurs. It is also ensured that there is no plastic deformation of metal components, or any sealing, is not compromised for pressure up to 600 bar (8700 psi), for safety against intermittent and sudden short term rise in system pressure.

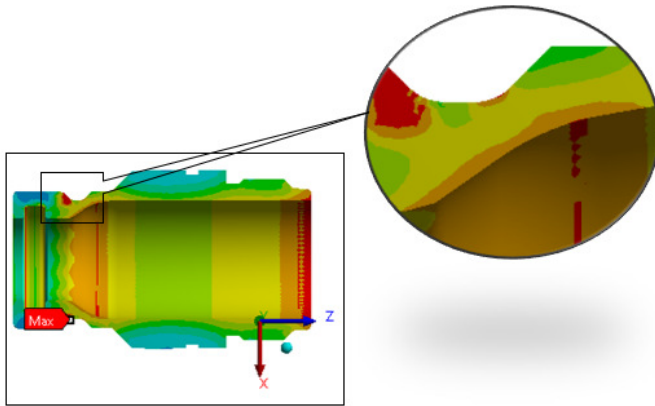
Danfoss Hansen Flat Face series coupling is qualified for one million impulse cycles. With a safety factor of 1.33 pulsating pressure, the couplings ensure resistance to fatigue failure caused by hydraulic shocks. Often in products with ball latch mechanism, there is a probability of indentation in the latching region, which can cause coupling to get locked in a connected state. To prevent this phenomenon, an FF series coupling plug is heat-treated to increase hardness in this region of the plug body. With increased hardness, FEA simulation is leveraged to optimize the material thickness of the plug body to maintain the brinelling.



Thanks to Danfoss' finite element analysis capabilities, each component in the FF series coupling has been optimized. With FEA simulations, followed by rigorous testing, it is ensured that the coupling meets the pressure resistance requirements, but components are not overdesigned as well. These optimization efforts help in complimenting the flow performance. All critical locations in assembly for stress concentration have been improved by adding stress relieving

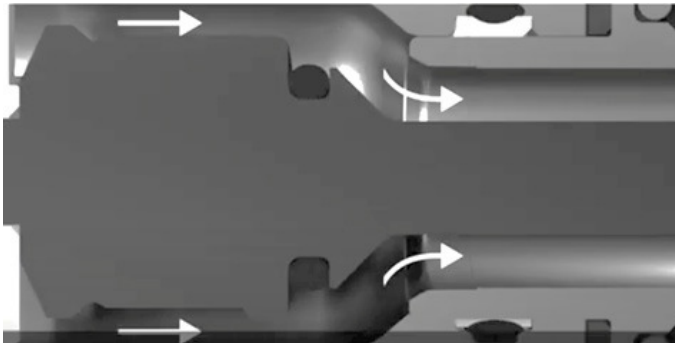
features. For example, the images highlight the most critical region in FF coupling (near ball latch groove) for strength as well as flow performance, and how it was optimized to meet both requirements.

Pressure drop - superior flow rate up to 74% higher than ISO 16028 specification



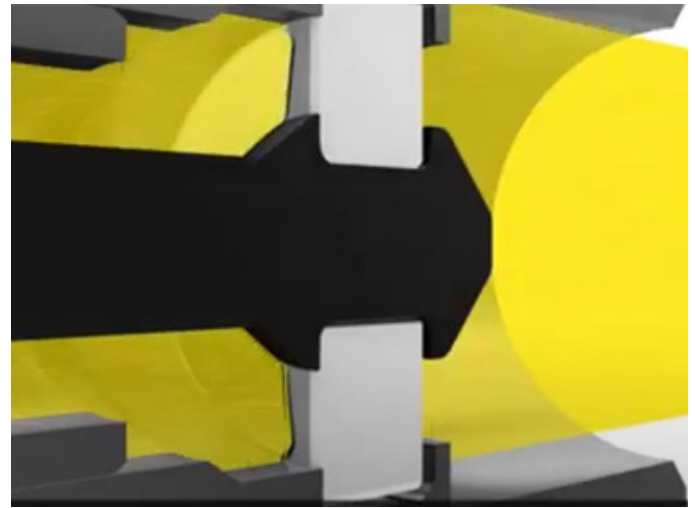
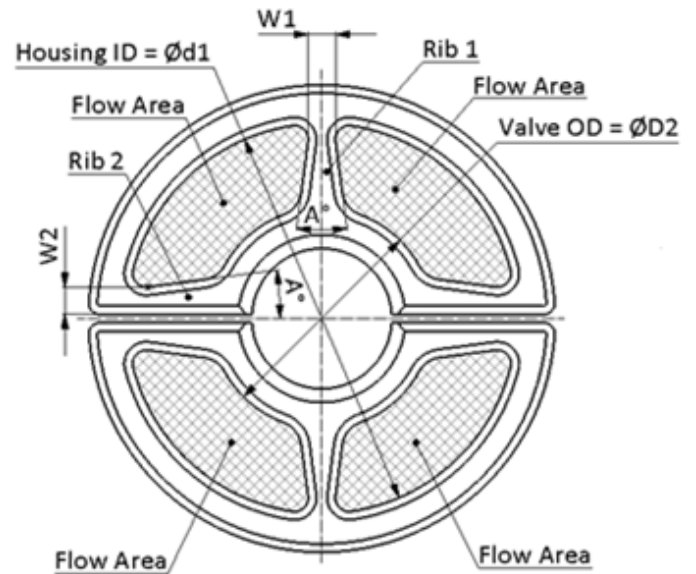
Hydraulic pressure drop is directly linked to energy loss for equipment resulting in higher fuel consumption. In the world of quick disconnect coupling, pressure drop performance is measured in terms of rate of fluid flow possible through the coupling at a pressure drop of one bar— meaning higher the flow rate, the better the product is for pressure drop performance. Some of the key factors for lower pressure drop are:

- Uniform flow area across length
- Low frictional losses
- Smooth transition of flow at junction

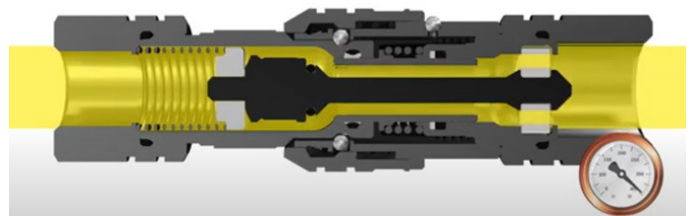


While upgrading the FF series coupling, Danfoss engineers ensured that fluid flow path is smoother across the length. There is no boundary layer separation of fluid, which in turn helps reduce eddy formation and minimize the pressure drop. Flow path at critical fluid transition areas like at plug and socket valve mating junction, have been made smoother to reduce the losses. Our world class manufacturing processes ensures that components in fluid flow path have a superior surface finish, resulting in lower frictional losses of pressure.

This valve holder design on socket side with kidney port flow passage helps in providing uniform flow area at this section, and improves pressure drop performance over previous design of drilled holes. The valve holder and its kidney ports are optimized using full factorial DOE. By using factors like rib widths and component thickness, the maximum area is available for fluid flow while meeting strength requirements.



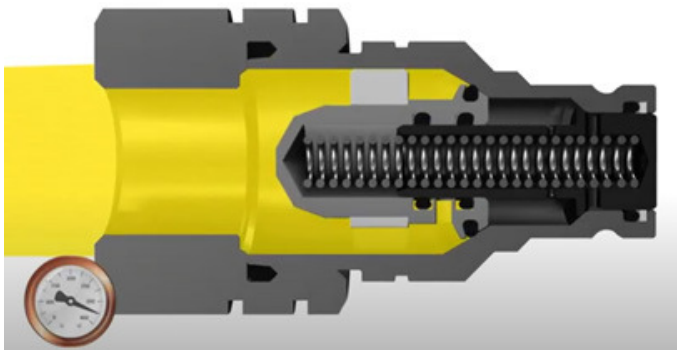
Albeit higher pressure resistance and high flow rate are opposite characteristics—like if you add material thickness to improve the mechanical strength—flow rate is compromised and vice-a-versa. However, with multi-physics simulation techniques and by maintaining uniform flow area throughout its length, we have optimized the FF series coupling such that it can withstand higher pressure and at the same time provide improved flow rate



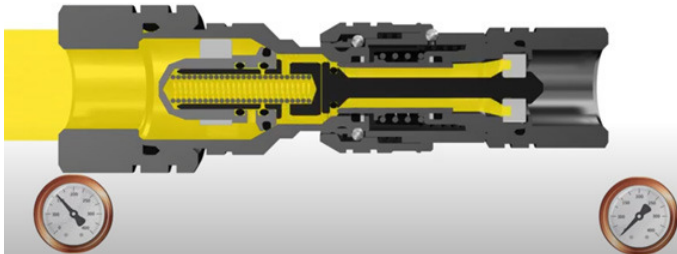
Connection under residual pressure

In certain applications, especially when equipment and attachments are stored/placed in an open environment, changes in sunlight temperature can cause residual pressure built up in hydraulic lines. In such cases, connection of quick disconnect coupling becomes difficult because the valve does not get pushed easily. Either it requires very high force, or pressure needs to be bleed off by starting an ignition and opening control valve to tank. Such forceful connection under high residual pressure can also damage internal seals permanently and can cause leakage. For such applications, Danfoss' FFCUP series plug, having patented valve mechanism is useful. In this plug, residual pressure in excess of 350 bar is bleed off internally in coupling and allows operator to connect hydraulic line under pressure without any significant effort. Below images illustrates operation of patented valve mechanism.

Alternately, standard FF series coupling is also designed such that it can be connected under residual pressure up to 50 bar, without any damage to internal seals. Special inverted PTFE seal, installed in plug, protects polymer seal from abrasion and wear damage due to connection under pressure, and maintains coupling leak-free.



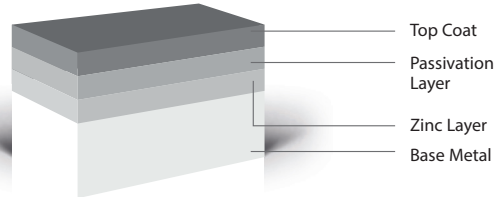
Step 1: Pressure is blocked by secondary valve mechanism



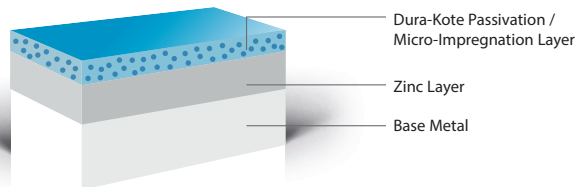
Step 2: Residual pressure is bleed off through secondary valve, and then plug valve is fully opened

Corrosion protection - extended product life

In certain markets the role that aesthetics play cannot be underestimated. Manufacturers spend millions ensuring that their products are cutting edge in terms of performance. However, there can be no doubt that aesthetics plays a huge role in brand reputation. If the couplings used are not resistant to rust, then damage to the OEM brand can be done through a negative viewpoint. However, there is an important underlying message: The OEM machines can be shipped to many different places around the world, and they have to be able to cope with the rigors of the environment. Elements such as water and salt spray (used on treated roads) can wreak havoc on system components, causing them to rust if not protected. Eventually rusty components will break down and the hydraulic fittings could leak thus causing reliability and maintenance issues.



Dura-Kote Plating



Dura-Kote coating offers three times higher corrosion resistance protection compared to traditional Zinc trivalent chromium. Danfoss guarantees a minimum 720 hours of corrosion resistance against red rust, as tested in a salt spray test lab environment per EN ISO 9227 (ASTM B117). This coating is also referred as environment friendly solution, because of its nickel and solvent free chemical composition which meets global RoHS, ELV and REACH requirements.

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Danfoss Power Solutions, Nordborgvej 81, 6430 Nordborg, Denmark, Tel. +45 74 88 22 22, Fax +45 74 65 25 80
www.danfoss.com, E-mail: info@danfoss.com

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