Proper Selection of Metal-to-Metal Sealing Plugs for Drilled Holes



SFC KOENIG

Leader in
Sealing & Flow Control
Technology

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List of Contents **Page**

Introduction: The Importance of the Proper Sealing Plug	3
Design Considerations That Affect Sealing Plug Selection	3
Hole Considerations That Affect Sealing Plug Selection	4
Quality and Cost Considerations That Affect Sealing Plug Selection	5
Why Many Common Sealing Solutions Don't Work	5
Improved Options with Expansion Seals, Though Design is Critical to Success	6
Proven Effectiveness with SFC KOENIG EXPANDER® Expansion-Style Plugs	7
No Contaminants, Easy Installation & Design Flexibility of KOENIG EXPANDER Plugs	8
Summary	9
About SFC KOENIG®	11

Introduction: The Importance of the Proper Sealing Plug

Proper sealing plug selection is critical to the operation, performance and lifecycle of many designs. The right seal will prevent equipment damage, prevent fluid leakage, reduce energy consumption, save money and ensure proper system operation.

Across industries such as transportation, fluid power, aerospace, medical and energy exploration, metal-to-metal sealing plugs fulfill mission critical functions. Whether in a hydraulic manifold, or in automotive applications, such as engine blocks, engine components, pumps and transmissions, these sealing plugs are widely utilized. Many fluid system components are often constructed from a solid metal block, with channels that have been cast and drilled for fluid conveyance. Often, the block contains two ports that must be connected to allow for fluid flow. To connect the ports a channel is typically cross-drilled, which creates an open hole where the drill was inserted, that must be sealed. (see Figure 1).

When selecting which metal-to-metal seal option is best suited for an application, the engineer should consider much more than the cost per-piece. Factors including design, installation,

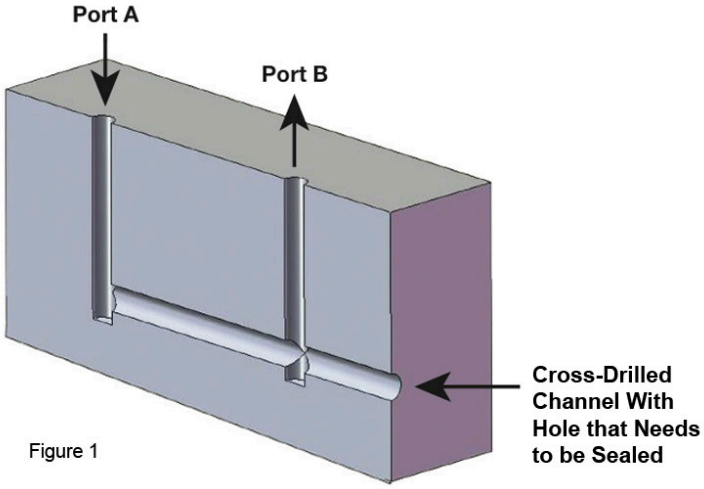


Figure 1

contamination, leakage, failure rates and more should be evaluated to determine the total cost of usage as well as which seal option will perform best.

Design Considerations That Affect Sealing Plug Selection

Before a port is sealed, it is important to account for physical properties that can affect a sealing plug's performance, such as the base material's hardness, strength, and the type of metal. The wall thickness around the hole must also have the strength to withstand installation stresses, especially if it is close to the edge or close to another port.

Corrosion can also reduce a sealing plug's performance and ability to prevent leakage. Many common sealing solutions are available in limited material options, which may cause the engineer to select a plug that will react with the base material or the fluid being sealed. Particles of corroded metal can infiltrate the fluid, block channels and restrict fluid orifices, resulting in reduced performance and even failure.

The sealing solution must also be able to withstand high and low operating temperatures, and the working pressure the seal will be exposed to during normal conditions. Many industry professionals recommend that a seal be rated for four times the designed system pressure. Occasional pressure spikes in the system should also be considered and compared to the plug's proof pressure rating.

Physical concerns, corrosion and inability to withstand operating conditions can all lead to contamination. Any contaminant which breaches the seal, and enters the channel or the sealed fluid, can negatively impact system performance and lead to catastrophic results.

Hole Considerations That Affect Sealing Plug Selection

The hole size is one of the most critical factors that impacts sealing plug choice. Not only must a plug's tolerance match the hole's diameter and allow the plug to form a tight seal, but size tolerances can contribute to system performance in some instances. While a generous plug size tolerance may accommodate large manufacturing variances, often the plug's fit is less precise leading to leakage and pressure losses which increase energy usage, reduce system output and strain system operations, finally increasing failure rates and waste. Conversely, tight hole tolerances may require the use of special installation tools, which increases labor and slows production, increasing costs.

In some applications, reaming (a secondary machining operation) is used after the initial drilling operation to produce a more precise hole diameter and smoother finish, which can allow for better sealing plug fit. However, reaming increases the cost and effort required in production.

Many seal types create contamination problems simply through their installation. Metal chips that result from the insertion process can block fluid circulation and cause catastrophic failure. These seals also typically require an added sealing compound, which – when applied in excess – creates additional debris, contamination and cost.

Some non-engineered seal options – such as balls, screws and caps – pose a greater risk of creating cracks during installation. If the base metal surrounding a port is not thick enough, or the base material strength is insufficient, cracks can occur. These cracks, which can be visible or micro-sized, can become a source of leakage and pressure loss.

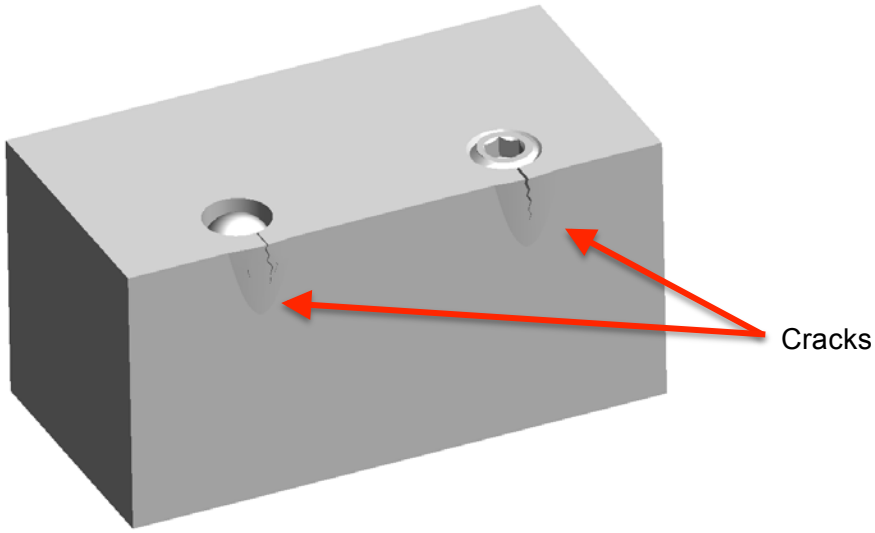


Figure 2

Hole orientation and location are other key considerations, since angled ports may require complicated fixtures, and plugs located deep inside a port can create dead space where air pockets might form in fluid passages affecting system dynamics and performance. The engineer must also consider the cross port position and the plug height to ensure the plug will not obstruct the fluid channel.

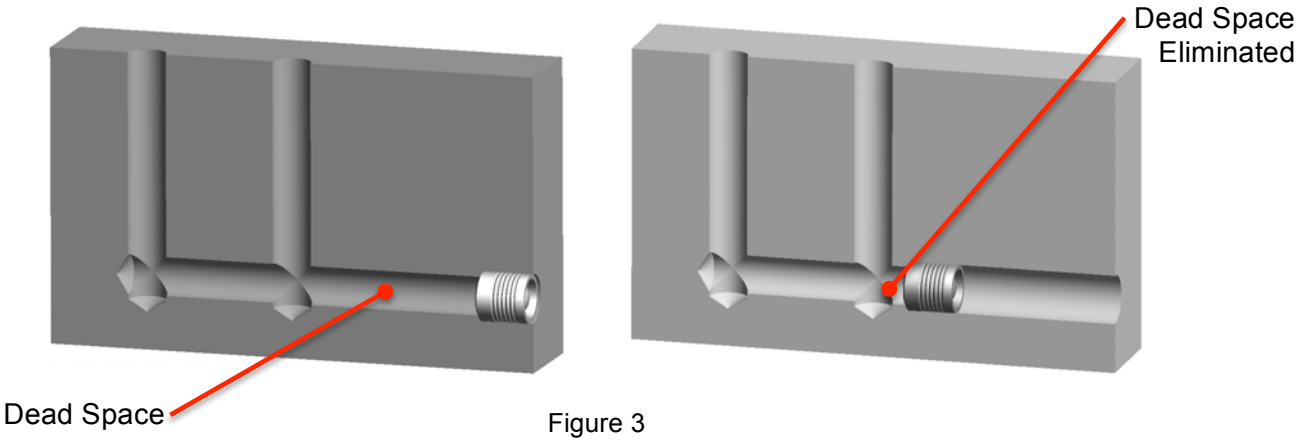


Figure 3

Quality and Cost Considerations That Affect Sealing Plug Selection

Production methods, such as the degree of automation needed in one's manufacturing processes, should also be considered in the design stage. Some sealing plugs are provided to the customer in a two-piece package and require assembly increasing labor requirements and reducing production speeds.

Certain plugs are also widely recognized to have high scrap and rework rates. While the per-piece price may be lower than other sealing solutions, the total installed cost can often be many times more.

The total cost of a sealing plug should be determined when selecting which option best suits the needs of an application. Labor, production, capital, and quality - not just the price per piece - should also be considered.

Why Many Common Sealing Solutions Don't Work

Common sealing solutions include threaded plugs, port plugs with O-rings, sealing balls and sealing pins. While these solutions have some benefits, such as low per-piece purchase cost and easy availability, they are often difficult to assemble and install, and their use can result in significant long-term problems including leakage and system failure.

Threaded Pipe Plugs
A threaded pipe plug is essentially a fastening screw that is used to fill a hole. These plugs require the use of a tap to cut threads into the interior of the hole, which often creates metal filing contaminants. Additionally, sealing compound or tape may be required to create a leak-proof fit. Excess thread compound sealant can drip into the port, blocking passages or contaminating fluid. Conversely, too little sealant may not adequately seal the hole, and will result in leakage. The installer must also ensure the plug's threads properly align with the port's threads when inserting the plug to avoid cross threading and expensive re-work. These multiple installation steps typically require extensive time and effort and make automated assembly difficult.

Port Plugs with O-Rings
A port plug with an O-ring is simple to install, however, the O-ring is the only sealing element in this plug design, which may cause problems. Low temperatures can cause O-rings to become brittle and fail, while high temperatures can cause them to decompose. In addition, damage, swelling and corrosion often occurs when an O-ring is exposed to chemicals. These plugs are also prone to having the incorrect O-ring size or contact pressure for the needs of an application, which can also lead to failure. Total costs for these port plugs also increases when one accounts for the expensive torque wrenches which are needed for proper installation.

Sealing Balls and Sealing Pins
Although a sealing ball can be simple to insert, it only forms a single point of contact with the hole, so it must create a tight seal where the ball meets the hole wall or leakage will occur. This is achieved during the insertion process, with high levels of force that push the ball into the port. However, these high forces create metal debris and contamination, and also may crack the base material. To create an effective seal with a ball the hole must be precisely controlled with very tight tolerance requirements, which adds cost and introduces quality control risk.

Sealing pins have greater contact with the hole than sealing balls but are subject to similar installation problems, including high insertion forces and excessive stress on the base material. In addition, since both the pin and the port are cylindrical in shape, the hole may leak or contaminants may enter the channel. Sealing pins also require an extremely tight hole tolerance, which may require reaming or additional production effort.

Improved Options with Expansion Seals, Though Design is Critical to Success

Expansion-style plugs are inserted into a hole and expand to engage the housing, typically utilizing a serrated exterior that digs into the wall of the hole. Expansion plugs usually offer the most space efficient solution for sealing ports, allowing designers to design smaller and lighter systems. While expansion plugs are often viewed as a preferred sealing solution, it is important to consider the type and design of the expansion plug when selecting the proper seal for your application.

Two-Piece Expansion Plugs
These metal-to-metal sealing plugs are shipped in two-pieces and require assembly, which is time consuming and increases the likelihood of incorrect installation - causing damage and increasing scrap rates. Automated assembly is often not realistic, and assembly must occur manually, which greatly increases labor, reduces turnaround time and increases the total cost of production.

Expansion Plugs for Tapered Holes
Some expansion style sealing plugs require that the hole be tapered to form an effective seal. Often tapering the port requires an additional production process, first drilling the channel to connect the ports, and then drilling a second hole that is tapered for the sealing plug. This additional drilling process can increase labor efforts and production costs. In addition, the tapering of the port must precisely meet the expansion plug's tolerances, or the potential for leaks will increase. Because of this tolerance requirement, many engineers choose to ream the second, tapered hole. However, reaming can introduce additional contaminants and also adds cost to production processes.

Expansion Plug Material
The engineer must also consider the expansion plug material, the base material and the fluid that will be sealed when selection an expansion plug. Some expansion-style plugs models are available in very limited material options. While the expansion plug may create a tight seal when first installed, field usage will lead to corrosion, creating debris and contamination in the fluid, and will likely damage the plug itself. Corrosion may also cause leakage and seal failure, which at high-pressures, raises a significant concern for risk and damage.

Proven Effectiveness with SFC KOENIG EXPANDER® Expansion-Style Plugs

With over 3 billion parts installed and a lifetime field failure rate less than 1 PPM (parts per million) the SFC KOENIG EXPANDER provides an industry-leading metal-to-metal sealing plug solution. Already pre-assembled, these expansion-style plugs have been proven to offer easy installation, reduced contamination risk, increased performance reliability, and peace of mind when designed into safety critical applications. Compared to many sealing plug options, KOENIG EXPANDERS provide the best solution with the lowest total cost.

KOENIG EXPANDERS differ from other expansion-style plugs in their design, in that they utilize both a serrated shell expansion element and a precisely fitted ball (see Figure 2). This configuration capitalizes on the benefits of expansion-style plugs and sealing balls in one easy-to-install unit.

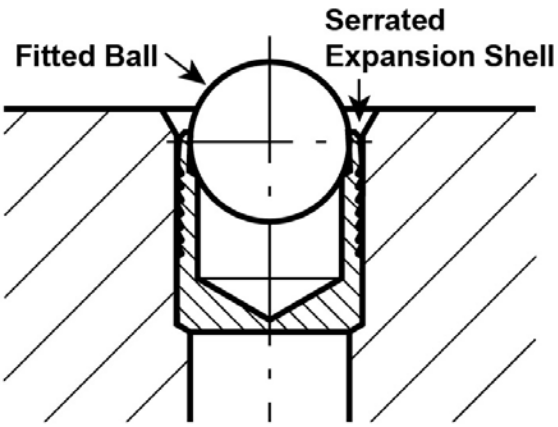


Figure 2

Two KOENIG EXPANDER plug models are available: a push style and a pull style. The difference between the two largely relates to installation method.

For push-style KOENIG EXPANDER plugs, the port connecting the fluid channels must be drilled with a step-type drill bit to create a counter bore. The plug is dropped into the hole up to the counter bore (see Figure 3). The ball is then pressed into the seated shell (see Figure 4), which causes serrated grooves to expand and “bite” into the base material creating a tight, metal-to-metal seal.

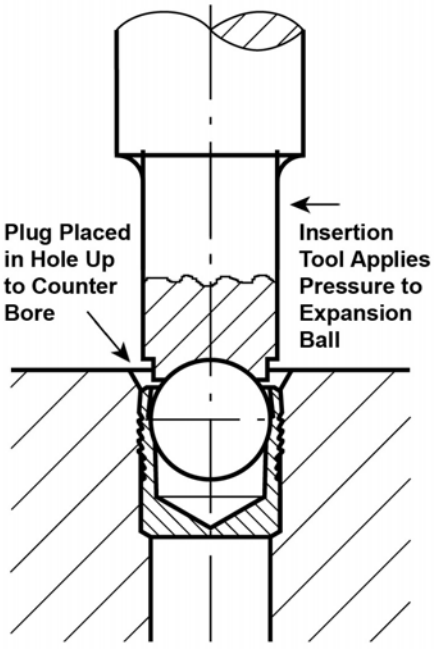


Figure 3

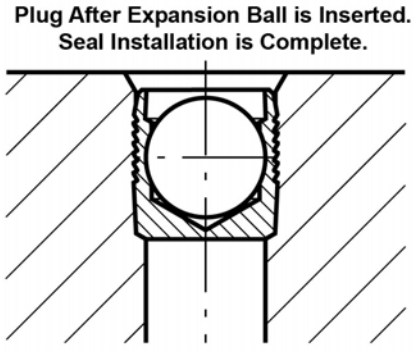


Figure 4

Pull-style KOENIG EXPANDER plugs do not require the port to be counter-bored, and instead use an integrated mandrel to insert the plug into a drilled hole (see Figure 5).

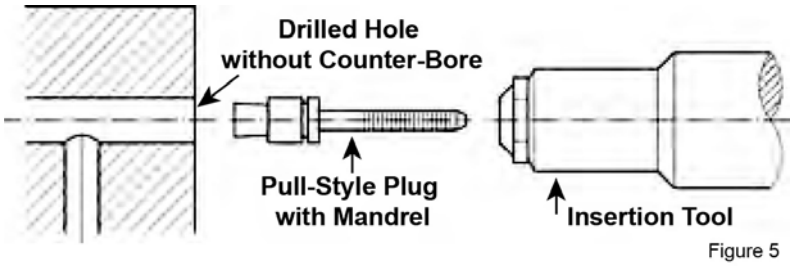


Figure 5

During installation, the mandrel extends from the top of the plug. When the plug is inserted in the hole, force applied to the mandrel will cause the plug's serrated shell to expand against the walls of the hole and produce a tight seal (see Figure 6). When the proper tension has been reached, the mandrel breaks away and is transferred to a collection bin for recycling (see Figure 7).

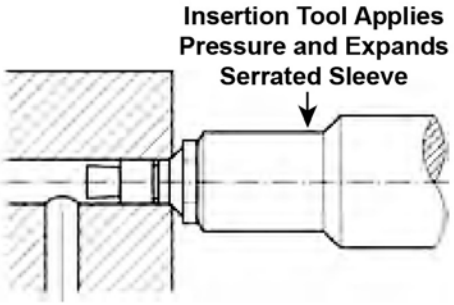


Figure 6

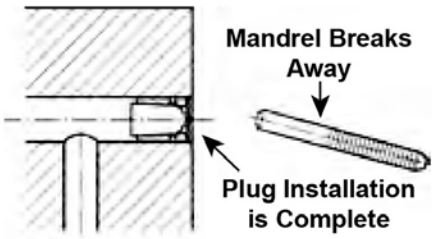


Figure 7

Since they can be easily aligned, pull-style KOENIG EXPANDER plugs are often used for angled channels. They are also well suited for applications where holes are on different faces and it is difficult to move the block for proper orientation.

No Contaminants, Easy Installation & Design Flexibility of KOENIG EXPANDER Plugs

Compared to other sealing plug options, KOENIG EXPANDER plugs have proven to be one of the most reliable and customizable metal-to-metal seal options available in the market. The plugs are available in a wide variety of sizes and materials types, allowing them to be customized to the needs of an application. The short ball style series offers an even more space efficient design option.

SFC KOENIG has performed exhaustive testing to ensure the highest levels of performance. Both the push-style and pull-style plugs can permanently resist pressures up to 500 bar, and are pressure rated with safety factors to accommodate system shocks and spikes. In addition, KOENIG EXPANDER plugs withstand one of the widest temperatures ranges of any metal-to-metal sealing option, with effective operation from -40°C to 150°C (-40°F to 302°F).

With their unique metal-to-metal, ball and sleeve seal design, KOENIG EXPANDER plugs form complete, precise contact with the hole, creating a secure, leak-proof seal.

No Contamination from Sealants or Installation Debris
KOENIG EXPANDERS have been designed to provide clean installation and reduce the risk of installation errors. The plugs' one-piece design requires no customer assembly, and no additional reaming, tapping or screwing of the port is needed, removing the potential for metal chips, debris and contamination, while also reducing production requirements.

Additionally, unlike some common sealing options, KOENIG EXPANDER plugs do not require additional sealants, which also reduces the potential for contamination. The seals' design inherently creates a reliable, secure metal-to-metal seal and a leak-proof solution.

Fast & Easy Installation for Even Unique Installations
With a variety of plug size options, ranging from 0.093 inches to 0.875 inches (3mm to 22mm) in diameter, KOENIG EXPANDER seals are designed for a wide variety of applications. They feature liberal tolerance allowances, up to +.12 mm for pull-style plugs and up to +.10 mm for push-style expanders, with proven sealing performance that affectively maintains system pressure levels. (Check the tolerance allowances of the KOENIG EXPANDER model for exact specifications).

Both pull-style and push-style KOENIG EXPANDER plugs are designed for fast installation. Insertion can be manual or completely automated and quality controls can be easily integrated into the installation process. In a typical production environment 15 to 20 EXPANDER plugs can be inserted in one minute.

Pull-style KOENIG EXPANDER plugs offer the unique benefit of easy installation in angled ports or deep inside the housing without the need for elaborate fixtures. The plugs also distribute stresses evenly, which allows them to be used for thin-wall installations.

SFC KOENIG has developed extensive testing data and reference materials that can help the engineer to determine which sealing solution best suits their application. Design charts are available that specify how to install the plugs depending on the base material's hardness, strength and metal type. Design guidelines are also provided to determine minimum wall thickness to an exterior wall or between bores for different combinations of base material and plug.

Variety of Plug Materials
Unlike many other sealing options, KOENIG EXPANDER plugs are available in a wide range of metals, including stainless steel, carbon steel, aluminum and titanium. This ensures the plug is compatible with the base material, greatly reducing the potential for damage during installation and achieving an effective, no-leak seal.

The variety of plug material options also prevents corrosion and allows for long life-cycles, as any predictable reaction with the base material or the fluid can be avoided.

SFC KOENIG has performed comprehensive testing, including corrosion and salt-spray testing, test loading, tensile strength and hardness testing, and molecular testing, which can assist the engineer in determining which KOENIG EXPANDER plug material option will best suit their needs.

Lower Total Cost of Use
Compared to many other sealing options, KOENIG EXPANDERS offer one of the lowest total cost of use, when all factors are considered. The plug's one-piece design requires no assembly, and with fast and easy installation, error, scrap and labor costs are kept at a minimum. The plugs do not create contamination from metal chips or sealants, removing the potential for debris in the fluid or the channel, which reduces failure rates and damage. When total costs are calculated, KOENIG EXPANDERS are often one of the most economical metal-to-metal seal options available.

Summary

It is important for the engineer to consider a wide variety of factors when determining which metal-to-metal sealing solution is best for their needs and application. The right sealing plug will eliminate leakage, ensure proper system pressures, eliminate contamination, and provide long life span and lower costs.

Many common sealing methods that involve screw-type designs, press-fitting pins, O-rings, sealants or welding are not dependable and cannot be reliably reproduced. Some expansion-

style plugs, while better than common sealing methods, have limited features and capabilities, and may not perform as required.

SFC KOENIG EXPANDER plugs are proven to provide secure, leak-free sealing and avoid contamination. They provide fast and easy installation for a wide variety of base materials and port configurations and often reduce labor and production costs.

Widely used in aerospace and aviation, automotive, hydraulic, medical, off-shore and marine, and transportation applications, over 3 billion SFC KOENIG parts have been installed with a field failure rate less than 1 PPM.

About SFC KOENIG®

SFC KOENIG is a worldwide supplier of sealing and flow control components, with over 85 years of history. The company offers two manufacturing locations globally - one at the organization's headquarters outside of Zurich, Switzerland, and the other in the United States located outside of New Haven, CT. SFC KOENIG also has large sales and distribution subsidiaries in Germany and China, and a vast independent distribution network covering the globe. In April of 2014 the company changed its name from KVT-Koenig to SFC KOENIG and refined its focus solely to sealing and flow control technologies.

SFC KOENIG operates with ISO/TS 16949, ISO 9001 and ISO 14001 certified standards, and is the original inventor of the one-piece, metal-to-metal sealing solution. SFC KOENIG offers the unique ability to produce customized components that increase reliability and efficiency, optimizing total customer costs while maintaining strict quality standards and an unrivaled performance.

Additional information is available at www.sfckoenig.com.