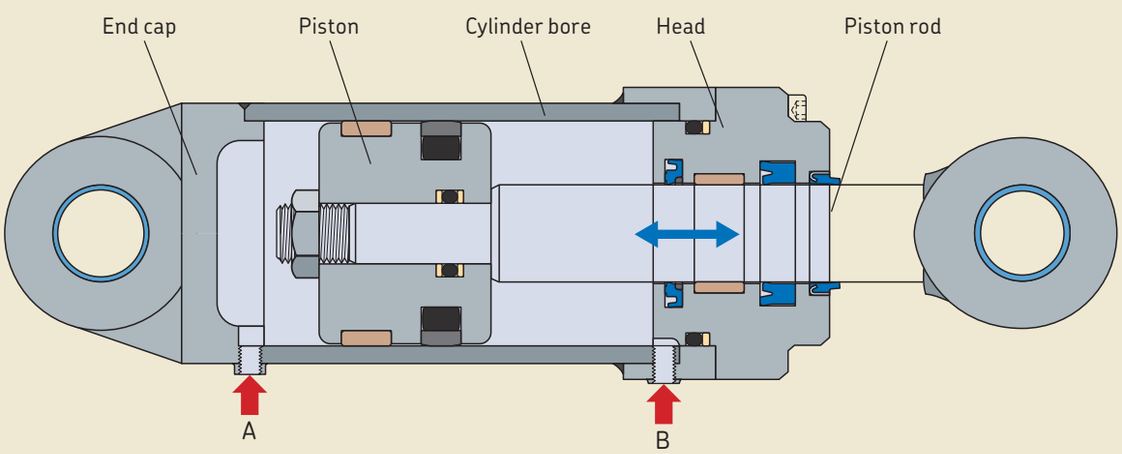
Introduction to fluid power

Fluid power systems transfer and utilize mechanical power through a working fluid. Energy is transmitted, stored and used through the transfer and pressure of fluids. There are two main types of fluid power system:

- hydraulic – using liquid, such as oil, for the working fluid
- pneumatic – using gas, such as air, for the working fluid

Fig. 1

Double-acting hydraulic cylinder



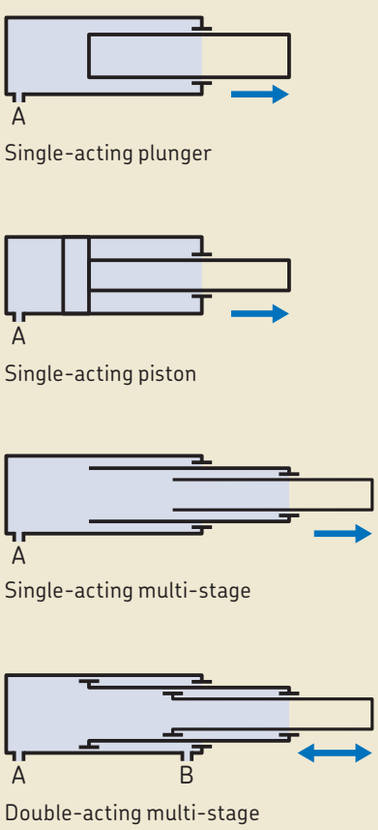
Hydraulic cylinders

A hydraulic cylinder is a linear actuator used to push or pull a load, or to selectively resist motion under load, by means of fluid pressure. Double-acting cylinders, the most common type, are able to push and pull (→ **fig. 1**). High pressure fluid pumped into the extend chamber (port "A") acts on the piston to push the piston rod out, thereby extending the length of the cylinder. Inversely, to retract the piston rod and reduce the length of the assembly, high pressure fluid is pumped into the retract chamber (port "B") and acts on the opposite side of the piston.

Other cylinder types are shown in **figure 2**. A cylinder which can only push but not pull is referred to as a single-acting cylinder. High pressure fluid is pumped into the extend chamber (port "A") and acts on the piston to push the piston rod out. An external force is required to return the cylinder to the retracted position. A typical application for a single-acting cylinder is a lift truck, where the load of the fork pushes the cylinder back. Multi-stage cylinders (also referred to as telescoping cylinders) have two or more piston rods in a coaxial arrangement to achieve greater extended length compared to the retracted length.

Fig. 2

Cylinder types



Cylinder classification

The type of cylinder and the application in which it is used are two of the main criteria when selecting the appropriate seals and guides. Applications are referred to as light duty, medium duty or heavy duty applications. These classifications are somewhat subjective but the duty levels are typically characterized by the following criteria.

Light duty cylinders

Light duty cylinders, e.g. cylinders used for stationary equipment indoor in a factory environment, may be characterized by:

- system pressures up to 160 bar *(2 300 psi)*
- temperatures up to 70 °C *(160 °F)*
- rare pressure peaks in excess of system pressure
- minimal side loads acting on guides
- environment with moderate temperature fluctuations and relatively free of contaminants

Medium duty cylinders

Medium duty cylinders, e.g. cylinders in agriculture off-highway equipment, may be characterized by:

- system pressures up to 250 bar *(3 625 psi)*
- temperatures up to 90 °C *(195 °F)*
- moderate pressure peaks in excess of system pressure
- moderate side loads acting on guides
- environment with temperature fluctuations and typical external contaminants such as dust and moisture

Heavy duty cylinders

Heavy duty cylinders, e.g. cylinders in off-highway earthmoving or forestry equipment, may be characterized by:

- system pressures of 400 bar *(5 800 psi)* or more
- temperatures exceeding 90 °C *(195 °F)* with peaks in excess of 110 °C *(230 °F)*
- regular pressure peaks in excess of system pressure
- heavy side loads acting on guides, usually due to heavy components and/or high accelerations
- tough environment with wide temperature fluctuations and typical harsh external contaminants

Hydraulic seals and guides

Hydraulic cylinder seals are used to seal the opening between various components in the hydraulic cylinder. **Figure 3** shows an example of the seal and guide components of a heavy duty cylinder. There are two main types of hydraulic seals in the system:

- Dynamic seals
  They seal between components in relative motion. In a hydraulic cylinder the rod sealing system seals dynamic reciprocating motion between the piston rod and head, while the piston sealing system seals dynamic reciprocating motion between the piston and cylinder bore.
- Static seals
  They seal between components fixed together without relative motion. Hydraulic cylinders use static seals in various locations depending on the design and construction. The most common are static seals between the piston and piston rod and between the head and cylinder bore tube.

Each dynamic seal in a hydraulic cylinder has a special function to contribute to the performance of the system:

Piston seal functions

- act as pressure barrier and prevent fluid passing the piston – important for controlling the cylinder motion or maintaining the position when at rest

Rod seal functions

- act as pressure barrier and keep the operating fluid inside the cylinder
- regulate the fluid film which extends with the surface of the piston rod – important to inhibit rod corrosion and to lubricate the wiper seal and the rod seal itself
- accept the lubrication film back into the cylinder when the rod retracts

Buffer seal functions

- protect the rod seal from fluid pressure peaks in excess of system pressure
- attenuate the fluctuations in system pressure, thereby improving rod seal performance by allowing the rod seal to deal with more constant or gradually changing pressure
- act as an internal excluder to keep system contaminants, such as metal particles, from damaging the rod seal

Wiper seal functions

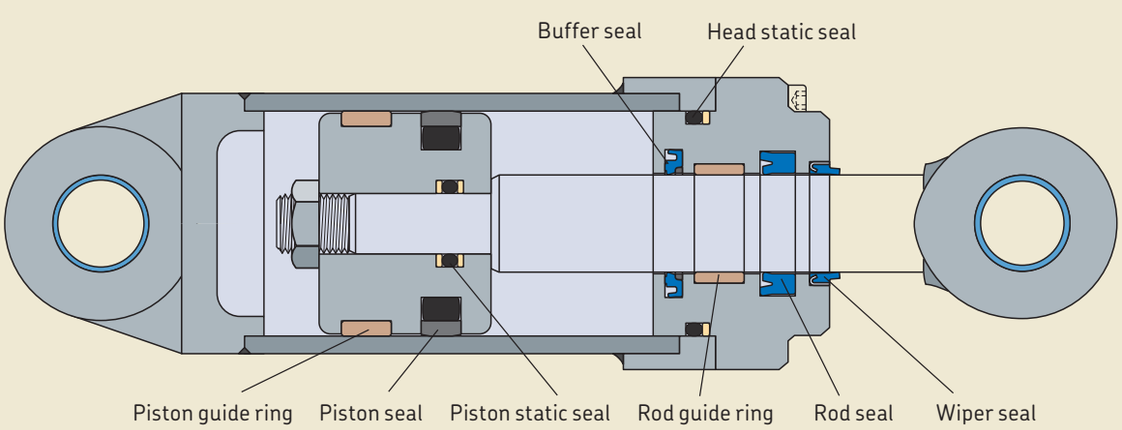
- exclude external contaminants from entering the cylinder assembly and the hydraulic system
- accept the lubrication film back into the cylinder when the rod retracts

Guide rings (rod and piston) functions

- prevent metal-to-metal contact between components
- react the radial load caused by side loads on the cylinder assembly
- keep the piston rod and piston accurately centred in the cylinder assembly – important for performance of the rod sealing system and piston sealing system

The subsequent chapters contain additional information regarding the function of each seal or guide in the system and the selection of them.

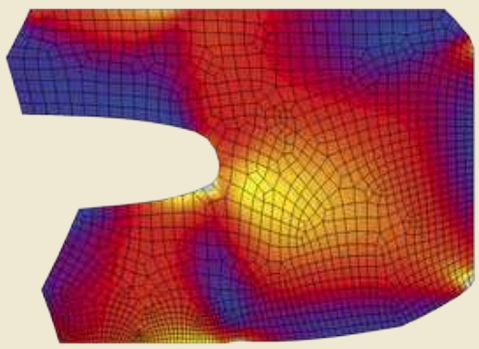
Fig. 3



SKF hydraulic seals and guides capabilities

The SKF assortment of hydraulic seals comprises hundreds of different designs and material combinations. The products shown in this catalogue are the more commonly used seal profiles and sizes for hydraulic cylinders. The flexible SKF manufacturing systems and processes, combined with the industry's most agile and comprehensive design and engineering capability, allow additional profiles and sizes to be added on a daily basis. If application requirements are not served by the common profiles or sizes in this catalogue, contact SKF to provide a specific offer.

Fig. 4



Customized sealing solutions

In addition to the standard assortment of series-produced seals and sizes listed in this catalogue, SKF designs and manufactures hydraulic seals customized for virtually any requirements.

The design and development of high performance materials combined with testing and failure analysis are vital elements for successful seal development. SKF combines these elements with its extensive application knowledge, to offer solutions that are based on an understanding of sealing systems under various real conditions. SKF continuously develops new customized materials and designs and operates its own testing facilities around the world to provide optimized sealing solutions that meet the sophisticated demands of many industries.

Finite element analysis (FEA)

FEA is used to simulate the impact of operating conditions, material selection and seal design on seal behaviour (→ **fig. 4**).

SKF SEAL JET system

With the innovative production system SKF SEAL JET virtually any kind of seal for any conceivable application can be manufactured in any dimension and design. SKF operates more than 200 machining centres worldwide and aims to be located as close to the customer as possible. This reduces manufacturing and dispatch time to a minimum. With local and global application engineering teams supported by research and development centres, machined seals (→ **fig. 5**) produced with SKF SEAL JET machines (→ **fig. 6**) can be customized to meet the most stringent sealing requirements of many industries. Key factors of the SKF SEAL JET systems (→ **fig. 7**) are:

- partnership with customers from the design phase to serial production with customized solutions
- prompt manufacturing of seals and components up to 4 000 mm *(157 in.)* in diameter as one piece and larger with short delivery times
- diameters up to 10 000 mm *(395 in.)* and larger by using a special welding technique
- virtually unlimited seal designs
- extensive range of sealing materials including materials certified to or complying with a broad range of industry standards and regulations (FDA, NSF, KTW, NORSOK, NACE, etc.)

Fig. 5

Machined seals

Fig. 6

SKF SEAL JET machine

Fig. 7

SKF SEAL JET system

Criteria for seal selection

The selection of the right seal profile and material for a given application requires consideration of many factors. This catalogue supports the selection of the right seal for typical hydraulic seal applications and existing cylinder designs. For any application factors outside of the ordinary, or to specify sealing systems in new hydraulic cylinder designs, a certain amount of expertise, beyond the content of this catalogue, may be required. The hydraulic seal experts at SKF can assist in selecting the right sealing system for new cylinder designs.

Before seals can be selected certain application parameters and information should be collected. The following most common application considerations are nearly always required when selecting hydraulic seals:

- fluid pressure range,
  the range of operating fluid system pressure, as well as frequency and severity of pressure peaks
- temperature range,
  the range of the fluid and cylinder assembly, both when operating and at rest
- speed,
  the stroking speed of the reciprocating piston rod
- fluid media,
  the type and viscosity of fluid used in the system
- hardware dimensions,
  the rod and bore diameters, seal groove dimensions and gaps (if already specified), cylinder overall length and stroke length as well as surface finish specifications (if already specified)
- application of the cylinder,
  the type of equipment the cylinder will be used on and how the cylinder will operate in the equipment as well as installation, duty cycles and environmental factors (external temperature, contaminants)