Basics of Oil Hydraulics

Oil hydraulics refer to a group of devices or a system that drives a hydraulic pump with power sources, such as engines and electric motors, to transform mechanical energy to fluid energy in order to produce mechanical movement using an actuator like a cylinder while controlling energy output.

What is oil hydraulics?

Products for Each Machine (examples)

Hydraulic Equipment for Excavators and Mini-excavators

Hydraulic Equipment for Forklift Truck

Hydraulic Equipment for Combines
This catalog provides detailed information on hydraulic pumps, motors, integrated HSTs, cylinders, and valves for vehicles such as excavators, mini-excavators, loaders, forklift trucks, and agricultural machines. As for information on some products not included in this catalog, please contact KYB Hydraulic Sales Department.

Some products require prototype tests based on the specifications of customer machines so as to secure their on-site fine tuning. In some cases, new functions need to be added to our products to meet customer requirements.

The catalog makes general suggestions for product selection, handling precautions, and basic dimensions. Confirmation on detailed specifications may be necessary for actual use. Please contact KYB Sales Department for clarification of details. (Refer to Page 66 and to the back cover of the catalog for the contact details of Sales Department.)

### Basics of Oil Hydraulics

**What is oil hydraulics?**

Oil hydraulics refer to a group of devices or a system that drives a hydraulic pump with power sources, such as engines and electric motors, to transform mechanical energy to fluid energy in order to produce mechanical movement using an actuator like a cylinder while controlling energy output.

**Unit conversion table**

<table>
<thead>
<tr>
<th>Unit</th>
<th>SI Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force</td>
<td>kgf</td>
</tr>
<tr>
<td>Torque (Moment of force)</td>
<td>kgf-cm</td>
</tr>
<tr>
<td>Pressure</td>
<td>kgf/cm²</td>
</tr>
<tr>
<td></td>
<td>psi (psi)</td>
</tr>
<tr>
<td>Power</td>
<td>kgf-m/s</td>
</tr>
<tr>
<td></td>
<td>PS</td>
</tr>
<tr>
<td>Energy</td>
<td>kgf·m</td>
</tr>
<tr>
<td>Viscosity</td>
<td>kgf·s/cm³</td>
</tr>
<tr>
<td>Kinetic viscosity</td>
<td>kgf·s/cm³</td>
</tr>
</tbody>
</table>

**Pascal’s Law**

The law states the relationship between pressure and area through the medium of fluid (eg, oil).

- Pressing down by 10cm with a small force (10 kgf) results in lifting a heavy load (100 kgf) by 1 cm (100 cm³ volume of oil moves).

With a pipe connecting the two parts, the system is easily remotely controlled.

- Flexibility is enhanced in vehicle designing.

- In the hydraulic system, the (mechanical) power source rotates the hydraulic pump, by which the oil is drawn from the reservoir. The oil flows into the hydraulic actuator via the hydraulic valve. The actuator transmits generated power to the machine and activates it.

### Products for Each Machine (examples)

**Hydraulic Equipment for Excavators and Mini-excavators**

- Cylinder (CYL) – double-acting type
- Lift Cylinder – single-acting type
- Swivel Motor (with reduction gear)
- Swing Motor (with reduction gear)

**Hydraulic Equipment for Forklift Truck**

- Lift Cylinder – single-acting type
- Control Valve
- Semi-monoblock Valve (for Forklift)
- Gear Pump (GP): fixed displacement type

**Hydraulic Equipment for Combines**

- Gear Pump (GP): fixed displacement type
- HST for Travelling
Caution regarding this Product Brochure

Definition of Alert Marks
In this brochure, the “Danger”, “Warning”, and “Caution” signs are defined as follows.

● These warning signs are very important for the operator’s safety. Understand them before using the products.

Improper handling will result in an imminently dangerous situation such as death or serious injury.

Improper handling may potentially risk death or serious injury.

Improper handling may result in slight to moderate injury or damage.

Instruction Manual
The cautions and notices described in this manual are intended to help select products. Please read the manuals of the selected products and fully understand the properties of the selected products before using them.

Regulations and Standards
Please observe the warnings and cautions described in this manual and the following regulations and standards for the selected products.
[Safety related regulations and standards]
1) High Pressure Gas Safety Law, 2) Industrial Safety and Health Law, 3) Fire Service Law, 4) Explosion Protection Classes,
5) Construction of Pressure Vessels (JIS B 8243), and 6) General Rules for Hydraulic Systems (JIS B 3851)

Safety Precautions

(1) On Product Handling
● Always be aware of the warning signs defined in this manual.
● Be aware of the factors that could cause personal injury or damage to property.

(2) On Mounting and Dismounting products
● Mounting, dismounting, piping, and wiring should be performed only by a qualified engineer (preferably one who has been trained by KYB) with the required knowledge.

(3) On Operation
● Use only explosion- or combustion-proof products in a explosive or combustible state.

(4) On Maintenance and Storage
● Any alteration or modification of the product by a customer is strictly prohibited.

Precautions on the Use of Hydraulic Equipment

All Hydraulic Circuits
- When selecting hydraulic components, contact each manufacturer for the characteristics of hydraulic equipment such as piping, joints, filters, and oil reservoirs manufactured by other manufacturers.
- Pressure drop: Pressure drop is proportional to the square of the flow rate. Because the loss may increase depending on the specific equipment and the size and/or length of joints, the normal flow rate and the maximum flow rate being used also should be taken into account.
- Circuit temperature control: The temperature of the hydraulic fluid in the entire circuit may rise because of the operation frequency and/or pressure drop. Consult the component manufacturer to make sure the reservoir and cooler capacity is sufficient.

Hydraulic Fluids

<table>
<thead>
<tr>
<th>Cold regions</th>
<th>Warm regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO VG 32</td>
<td>ISO VG 46</td>
</tr>
<tr>
<td>Outside air temperature</td>
<td>10 - 25℃</td>
</tr>
<tr>
<td>Inside air temperature</td>
<td>0 - 25℃</td>
</tr>
</tbody>
</table>

Proper range 25 - 100 ℃
Practical range 15 - 500 ℃

Strainers and Filters
Apply a 150 mesh strainer to the suction line from a reservoir and a 10 μm filter to the return line to the reservoir.

Select a shaft end configuration appropriate for the driving system based on the following pump and motor requirements.

Suitable for a continuous operation.

Mounting
- In general, the pump/motor can be mounted in any direction. But the drain piping should be connected to the reservoir at a point lower than the oil level after it is taken out from the upper surface of the pump/motor housing. This is to lubricate the reduction gears. Please note that the travel motor and the swing motor are to be mounted in the specified direction.
- Make sure that the rotating direction is correct for both pump and motor.
- Make sure there is some allowance between the pump shaft and driving shaft (with a motor or engine), and between the motor shaft and driven shaft (on the load side), in either case in the radial direction. Avoid applying thrust load to the pump or motor shaft.
- Maintain the center dislocation between the pump and driving shafts, and between the motor and driving shafts within 0.1 mm on the shaft (for axial reading).

Selecting Shaft End Configuration
Select a shaft end configuration appropriate for the driving system based on the following pump and motor requirements.

Direct driving: When it is difficult to give some allowance in the radial direction, use a spline shaft. Make sure to apply lubricant and dust-protection to the spline. Selecting a counterpart spline with the surface hardness over HRC 50 and the surface roughness below 32μ is recommended.

Couppling driving: When using a flexible coupling, select one with a straight shaft and assemble it in such a way that no thrust load is applied to the pump motor shaft. (See Fig. 2 below.)

Applicable shaft configurations vary depending on the product. Please contact us for details.

Pump Suction Pressure and Piping
During a normal pump operation, maintain pressure on the pump suction port (less than 30 mm from the port surface) above -0.02 MPa. Pressure may come down as low as -0.05 MPa for a short while on a cold start, but air suction from the piping should be strictly avoided. For the suction side piping, use pipes with a diameter equal to or larger than the diameter of the pump suction port and try to keep the length as straight and short as possible.

Pump/Motor Shaft Driving System

[Fig. 1 Example of Direct Driving]
[Fig. 2 Example of Coupling Driving]
Definition of Alert Marks

In this brochure, the "Danger", "Warning", and "Caution" signs are defined as follows.

- **Danger**: Improper handling may result in an immediately dangerous situation such as death or serious injury.
- **Warning**: Improper handling may potentially risk death or serious injury.
- **Caution**: Improper handling may result in slight to moderate injury or damage.

Instruction Manual

The cautions and notices described in this manual are intended to help select products. Please read the manuals of the selected products and fully understand the properties of the selected products before using them.

Regulations and Standards

Please observe the warnings and cautions described in this manual and the following regulations and standards for the use of products.

- Safety related regulations and standards
- High Pressure Gas Safety Law
- Industrial Safety and Health Law
- Fire Service Law
- Explosion Protection Classes
- Construction of Pressure Vessels (JIS B 8243)
- General Rules for Hydraulic Systems (JIS B 3861)

Safety Precautions

(1) On Product Handling
- **DANGER**: Always be alert to avoid getting your hand pinched or suffering a backache from an unnatural operating posture or overload when handling the product.
- **WARNING**: Do not step on, strike, drop, or apply stress to the product. Such an act may cause malfunction, damage, or oil leakage.
- **CAUTION**: Oil on a product or the floor makes it slippery and dangerous. When you find the hydraulic fluid on the product or the floor, wipe it off immediately.

(2) On Mounting and Dismounting products
- **DANGER**: Mounting, dismantling, piping, and wiring should be performed only by a qualified engineer (preferably one who has been trained by KYB) with the required knowledge.
- **WARNING**: Before starting such work, make sure that the machine is turned off, the motor or engine is not in motion, and pressure inside the hydraulic piping is zero.
- **CAUTION**: Turn off the power supply before doing wiring work. A failure to do so may cause an electric shock.
- **CAUTION**: Keep the mounting holes and surfaces of the product clean. A loose bolt or broken seal may cause damages or oil leakage.
- **CAUTION**: When mounting the product, use specified bolts only and tighten them with the specified torque. A failure to do so may cause malfunction, damage, or oil leakage.

(3) On Operation
- **WARNING**: Use only explosion- or combustion-proofed products in a explosive or combustible state.
- **CAUTION**: Apply a protection cover on the rotation shaft of the pump and motor to avoid your hand or clothing being caught in the machine.
- **CAUTION**: If you find something wrong, such as strange sound, oil leakage and smoke, stop the operation immediately and take necessary action. A failure to do so may cause damage, fire, or injuries.
- **CAUTION**: Make sure that the hydraulic circuits and wiring are properly connected with no loose connections before the initial operation.
- **WARNING**: Use the product only according to the specifications described in the catalog and drawings, and the specifications provided by KYB.
- **CAUTION**: The product becomes very hot during operation because of a rise in the temperature at the circuit oil and the solenoid valve. Make sure that the operator’s hand or another part of his body does not touch such heated parts. A failure to do so may cause burns.
- **CAUTION**: Use the specified or proper hydraulic fluid and keep the contamination level within the recommended range. A failure to do so may cause malfunction or damage.

(4) On Maintenance and Storage
- **DANGER**: Any alteration or modification of the product by a customer is strictly prohibited.
- **DANGER**: Do not disassemble and reassemble the product without permission of KYB or its authorized agency. A violation may cause poor performance, damage, or an accident.
- **CAUTION**: Transport or store the product in a proper environment at a proper temperature and humidity with proper dust- and rust-preventative measures in place.
- **CAUTION**: Replacing seals may be necessary after storing the product for a long period.

Precautions on the Use of Hydraulic Equipment

All Hydraulic Circuits

- When selecting hydraulic components, contact each manufacturer for the characteristics of hydraulic equipment such as piping, joints, filters, and oil reservoirs manufactured by other manufacturers.
- Pressure drop: Pressure drop is proportional to the square of the flow rate. Because the loss may increase depending on the specific equipment and the size and/or length of joints, the normal flow rate and the maximum flow rate being used also should be taken into account.
- Circuit temperature control: The temperature of the hydraulic fluid in the entire circuit may rise because of the operation frequency and/or pressure drop. Consult the component manufacturer to make sure the reservoir and cooler capacity is sufficient.

Hydraulic Fluids

<table>
<thead>
<tr>
<th>Applicable hydraulic fluids</th>
<th>Applicable hydraulic fluids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold regions</td>
<td>Warm regions</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>IS0 VG 32</td>
<td>IS0 VG 46</td>
</tr>
<tr>
<td>Outside air temperature</td>
<td>Outside air temperature</td>
</tr>
<tr>
<td>10 - 25℃</td>
<td>0 - 25℃</td>
</tr>
</tbody>
</table>

- Strainers and Filters
  Apply a 150 mesh strainer to the suction line from a reservoir and a 10μm filter to the return line to the reservoir. Determine the capacity based on the pump flow rate on the maximum input rotation and maintain the pressure drop below 0.03 MPa.

- Hydraulic fluid contamination level control
  It is recommended to maintain hydraulic fluid contamination within the NAS 9 class range.

Circuit Oil Temperature

Permissible oil temperature ranges: -20℃ (starting temperature) up to 100℃ (total 100 hours), and between 20℃ and 80℃ for a continuous operation.

Please contact us when you plan to use the equipment outside the permissible oil temperature range.

Precautions on Handling Pump/Motor

Mounting

- **DANGER**: In general, the pump/motor can be mounted in any direction. But the drain oil should be connected to the reservoir at a point lower than the oil level after it is taken out from the upper surface of the pump/motor housing. This is to lubricate the reduction gears. Please note that the travel motor and the swing motor are to be mounted in the specified direction.
- **WARNING**: Make sure that the rotating direction is correct for both pump and motor.
- **CAUTION**: Make sure there is some allowance between the pump shaft and driving shaft (with a motor or engine), and between the motor shaft and driven shaft (on the load side), in either case in the radial direction. Avoid applying thrust load to the pump or motor shaft.
- **CAUTION**: Maintain the center dislocation between the pump and driving shafts, and between the motor and driving shafts within 0.1 mm on Fir (Full Indicator Reading).

Selecting Shaft End Configuration

Select a shaft end configuration appropriate for the driving system based on the following pump and motor requirements.

- **DANGER**: Direct driving: When it is difficult to give some allowance in the radial direction, use a spline shaft. Make sure to apply thrust load to the pump motor shaft. (See Fig. 2 below.)
- **CAUTION**: Coupling driving: When using a flexible coupling, select one with a straight shaft and assemble it in such a way that no thrust load is applied to the pump motor shaft. (See Fig. 2 below.)
- **CAUTION**: Applicable shaft configurations vary depending on the product. Please contact us for details.

Pump/Motor Shaft Driving System

Pump Suction Pressure and Piping

During a normal pump operation, maintain pressure on the pump suction port (less than 30 mm from the port surface) above -0.02 MPa. Pressure may come down as low as -0.05 MPa for a short while on a cold start, but air suction from the piping should be strictly avoided. For the suction side piping, use pipes with a diameter equal to or larger than the diameter of the pump suction port and try to keep the length as straight and short as possible.
Piston Pumps and Motors with reFlow control valve (FC)
Pumps
When leaving the rod extended after the cylinder is mounted on the equipment, apply grease to the exposed rod.

MSF Series (motor unit)
On Operation
KVS and KVM Series
Caution on the Use of the Unit
Dimensions, performance curves, specific functions and characteristics, precautions, etc.

…………17
PSV Series (Closed circuit)
…………17
PSDV Series (Open circuit)
…………17
PSVL Series (Open circuit, load sensing type)
…………17

HVFD Series
…………23

Principle Formulas
…………64

HST (General)
…………61

Hose rupture valve (HRV)
…………61

KCH, KCM, and KCFL Series
Multiple Control
…………49

KFP Series (Tandem)
…………49

KFP, KFS Series (Single)
…………49

PSV Series (Open circuit)
…………49

KFP Series (Tandem)
…………49

Precautionary Cylinder Handling
Initial Unpacking
Do not remove the plug placed on the cylinder port until you start assembling the unit. Mount the cylinder on the prepared equipment right after unplugging it, and fill the cylinder with oil.

Rust Protection
When leaving the rod extended after the cylinder is mounted on the equipment, apply grease to the exposed rod surface once a month.

Precautions on Valve Handling
On Assembly
Do not remove the plug placed on each port until it is connected to the piping.

On Operation
Set the valve lever at the neutral position when starting an operation. Otherwise, it may cause the actuator to start running unexpectedly.

Allowable maximum backpressure: The figure in the specifications includes a peak value at the tank port of the motor, and excessive back pressure may damage the motor at an early stage of its life. Contact us for permissible maximum back pressure for each product.

Piston Motor Back Pressure
If the output port of a motor in a series- or meter-out circuit is pressurized highly and constantly, the product life shortens and excessive back pressure may damage the motor at an early stage of its life. Contact us for permissible maximum back pressure for each product.

Piston Motor Cavitation Prevention
With a motor used in an open circuit, cavitation may occur at a low-pressure area when the motor stops running. Install a cavitation preventive function in the circuit to avoid such damage.

Precautionary Cylinder Handling
Initial Unpacking
Do not remove the plug placed on the cylinder port until you start assembling the unit. Mount the cylinder on the prepared equipment right after unplugging it, and fill the cylinder with oil.

Rust Protection
When leaving the rod extended after the cylinder is mounted on the equipment, apply grease to the exposed rod surface once a month.

Precautions on Valve Handling
On Assembly
Do not remove the plug placed on each port until it is connected to the piping.

On Operation
Set the valve lever at the neutral position when starting an operation. Otherwise, it may cause the actuator to start running unexpectedly.

Allowable maximum backpressure: The figure in the specifications includes a peak value at the tank port of the motor, and excessive back pressure may damage the motor at an early stage of its life. Contact us for permissible maximum back pressure for each product.

Piston Motor Back Pressure
If the output port of a motor in a series- or meter-out circuit is pressurized highly and constantly, the product life shortens and excessive back pressure may damage the motor at an early stage of its life. Contact us for permissible maximum back pressure for each product.

Piston Motor Cavitation Prevention
With a motor used in an open circuit, cavitation may occur at a low-pressure area when the motor stops running. Install a cavitation preventive function in the circuit to avoid such damage.

Definition of terms frequently used with hydraulic circuit trouble

<table>
<thead>
<tr>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil hammer</td>
</tr>
<tr>
<td>Chattering</td>
</tr>
<tr>
<td>Aeration</td>
</tr>
<tr>
<td>Hunting</td>
</tr>
<tr>
<td>Cavitation</td>
</tr>
<tr>
<td>Hydraulic lock</td>
</tr>
<tr>
<td>Erosion</td>
</tr>
<tr>
<td>Flow force</td>
</tr>
<tr>
<td>Contamination</td>
</tr>
<tr>
<td>External leak</td>
</tr>
<tr>
<td>Flushing</td>
</tr>
<tr>
<td>Internal leak</td>
</tr>
<tr>
<td>Heat shock</td>
</tr>
<tr>
<td>Check (Gust)</td>
</tr>
</tbody>
</table>

Additional Information

Definition of terms frequently used with hydraulic circuit trouble

<table>
<thead>
<tr>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil hammer</td>
</tr>
<tr>
<td>Chattering</td>
</tr>
<tr>
<td>Aeration</td>
</tr>
<tr>
<td>Hunting</td>
</tr>
<tr>
<td>Cavitation</td>
</tr>
<tr>
<td>Hydraulic lock</td>
</tr>
<tr>
<td>Erosion</td>
</tr>
<tr>
<td>Flow force</td>
</tr>
<tr>
<td>Contamination</td>
</tr>
<tr>
<td>External leak</td>
</tr>
<tr>
<td>Flushing</td>
</tr>
<tr>
<td>Internal leak</td>
</tr>
<tr>
<td>Heat shock</td>
</tr>
<tr>
<td>Check (Gust)</td>
</tr>
</tbody>
</table>

<Main contents of this product guidance>

Products are explained in the following order.

Category (Pumps, Motors, HSTs, Cylinders, and Valves): General categorization of KYB products

Equipment (Gear Pumps, Piston Pumps, etc.): Each product line

Features (characteristics), basic structure, mechanisms, circuits, functions, specifications, applications, model names, etc.

Series: Each model
Dimensions, performance curves, specific functions and characteristics, precautions, etc.
1. Main Formulas (Source: Extracted from the Practical Hydraulic System Pocket Book published by the Japan Fluid Power Association)

Additional Data

1. Main Formulas

**<Cylinder related formulas>**

- **Reciprocity load and cylinder selection**
- A double acting cylinder is considered to generate the following loads.

- **Static friction load** $F_s = \mu_s \cdot m \cdot g \cdot N$ (N)
- **Dynamic friction load** $F_d = \mu_d \cdot m \cdot g \cdot N$
- **Inertia load** $F_i = m \cdot a = m \cdot \omega^2 \cdot N$
- **Electricity load** $F_e = k \cdot x \cdot N$

Where,
- $\mu_s$: Moving angle static friction coefficient
- $\mu_d$: Moving surface dynamic friction coefficient
- $\omega$: Revolution angular velocity $\text{rad/s}$
- $v$: Volumetric efficiency of a hydraulic motor
- $P$: Effective pressure of a hydraulic motor $\text{MPa}$
- $D$: Displacement volume of a hydraulic motor $\text{cm}^3$

**<Valve related formulas>**

- **(1) Pressure and flow rate Q before and after throttle**
  
  $Q = 60 \frac{A}{\sqrt{P}} \text{L/min}$

  Where,
  - $Q$: Flow rate $\text{L/min}$
  - $A$: Throttle area (opening) $\text{mm}^2$
  - $P$: Working pressure $\text{MPa}$

- **(2) G O-ring boss joint**
  
  Unit: $N \cdot m$ (kgf \cdot m)

- **(3) Unified O-ring boss joint**
  
  Unit: $N \cdot m$ (kgf \cdot m)

**<Working oil viscosity - Temperature graphs>**

- **Use hydraulic oil ISO VG 32 in cold areas and ISO VG 46 in warm areas.**

2. Tightening Torque for Piping (Reference data)

Note: The tightening torque may vary depending on various conditions such as material, specifications, tightening methods, etc. The following figures represent hypothetical conditions:

![Image of tightening torque](image)

(1) **Metric screw**

<table>
<thead>
<tr>
<th>Coarse pitch strength grade II</th>
<th>Unit: N \cdot m (kgf \cdot m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M6</td>
<td>M8 x 1.25</td>
</tr>
<tr>
<td>6.7</td>
<td>14.3</td>
</tr>
<tr>
<td>8.8</td>
<td>17.8</td>
</tr>
<tr>
<td>11.0</td>
<td>20.9</td>
</tr>
<tr>
<td>13.0</td>
<td>24.7</td>
</tr>
<tr>
<td>15.0</td>
<td>28.5</td>
</tr>
</tbody>
</table>

(2) **G O-ring boss joint**

<table>
<thead>
<tr>
<th>Size</th>
<th>Unit: N \cdot m (kgf \cdot m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1/8</td>
<td>11.8</td>
</tr>
<tr>
<td>Q1/4</td>
<td>16.7</td>
</tr>
<tr>
<td>Q3/8</td>
<td>21.6</td>
</tr>
<tr>
<td>Q1/2</td>
<td>26.5</td>
</tr>
<tr>
<td>Q2/4</td>
<td>31.4</td>
</tr>
</tbody>
</table>

3. Working oil viscosity - Temperature graphs

4. Throttle pressure - Flow characteristic

**Legend:**

- **Recommended operating viscosity grade and applicable viscosity range**

**Flow rate Q [L/min]**

- **Throttle hole diameter mm**

Use hydraulic oil ISO VG 30 in cold areas and ISO VG 46 in warm areas.
### 1. Main Formulas (Source: Extracted from the Practical Hydraulic System Pocket Book published by the Japan Fluid Power Association)

#### Cylinder related formulas

- **Reciprocation load and cylinder selection**
  - A double-acting cylinder is considered to generate the following loads.
  - **Static friction load** \( P_f = \mu \cdot D \cdot g \) (N)
  - **Dynamic friction load** \( P_d = \mu \cdot D \cdot v \) (N)
  - **Inertia load** \( P_i = m \cdot a \) (N)
  - Elasticity load \( P_e = k \cdot x \) (N)

- **Flow rate** \( Q = \frac{\pi \cdot D^2 \cdot V}{4} \) (L/min)

- **Torque** \( T = \pi \cdot D^2 \cdot \eta \) (N-m)

- **Volume efficiency** \( \eta_v = \frac{1}{1 - \eta_d} \)

### 2. Tightening Torque for Piping (Reference data)

#### Metric screw

<table>
<thead>
<tr>
<th>Size</th>
<th>Coarse pitch strength grade II</th>
<th>Fine pitch strength grade II</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unit: N-m (kgf-m)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M6 x 0.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M6 x 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M6 x 1.25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M8 x 1.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M8 x 1.75</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M8 x 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M10 x 2.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M12 x 2.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M16 x 2.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M16 x 2.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M20 x 2.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M22 x 2.5</td>
<td></td>
</tr>
</tbody>
</table>

#### (G) O-ring boss joint

- **Working pressure**
  - Unit: MPa
  - Size: Q1/8: 10.0 MPa, Q1/4: 15.0 MPa, Q3/8: 30.0 MPa, Q1/2: 50.0 MPa, Q3/4: 70.0 MPa

#### (3) Unified O-ring boss joint

- **Working pressure**
  - Unit: MPa
  - Size: Q1/8: 10.0 MPa, Q1/4: 15.0 MPa, Q3/8: 30.0 MPa, Q1/2: 50.0 MPa, Q3/4: 70.0 MPa

### 3. Working oil viscosity - Temperature graphs

[Table: Recommended working viscosity grade and applicable viscosity range]

### 4. Throttle pressure - Flow characteristic

[Graph: Flow rate Q (L/min.) vs. Throttle hole diameter]
Typical Applications and Products

- Pumps, valves, motor, and cylinders for excavators and mini-excavators
- Pumps, valves, and motors for wheel loaders and skid-steer loaders
- Pumps, valves, and cylinders for forklift trucks
- Pumps, valves, HSTs, and MMTs for agricultural equipment

Major business locations

Domestic manufacturing plant

- **Sagami Plant**
  1-12-1, Asamizodai, Minami-ku, Sagamihara-shi, Kanagawa, Japan
  - About fifteen minutes by taxi from Sagami-Ono station on the Odakyu Line
  - About ten minutes by taxi from Kobuchi station on the JR Yokohama Line

- **Gifu East Plant**
  60 Dota, Kani-shi, Gifu, Japan
  - From Meitetsu "Meitetsu Nagoya" station the Inuyama Line Mitake-cho and Shinokari (via Inuyama towards) that starts at Meitetsu Nagoya station. (Approx: fifty minutes from Meitetsu Nagoya station in total)

- **Gifu South Plant**
  505 Dota, Kani-shi, Gifu, Japan
  - Two-minute walk from Kanigawa station on the Inuyama Line bound for Mitake-cho and Shinokari (via Inuyama towards) that starts at Meitetsu Nagoya station. (Approx: fifty minutes from Meitetsu Nagoya station in total)

Global Network

KYB’s global production system meets the needs of customers everywhere by timely providing high performance, high quality products that satisfy customer requirements.

- **Sagami Plant**
  - 1-12-1, Asamizodai, Minami-ku, Sagamihara-shi, Kanagawa, Japan
  - About fifteen minutes by taxi from Sagami-Ono station on the Odakyu Line
  - About ten minutes by taxi from Kobuchi station on the JR Yokohama Line

- **Gifu East Plant**
  - 60 Dota, Kani-shi, Gifu, Japan
  - From Meitetsu "Meitetsu Nagoya" station the Inuyama Line Mitake-cho and Shinokari (via Inuyama towards) that starts at Meitetsu Nagoya station. (Approx: fifty minutes from Meitetsu Nagoya station in total)

- **Gifu South Plant**
  - 505 Dota, Kani-shi, Gifu, Japan
  - Two-minute walk from Kanigawa station on the Inuyama Line bound for Mitake-cho and Shinokari (via Inuyama towards) that starts at Meitetsu Nagoya station. (Approx: fifty minutes from Meitetsu Nagoya station in total)

[Hyaloid equipment business locations]

Other business (automobile, motorcycle, special vehicle, etc.) locations are not indicated.

- **Sales**
  - KYB Corporation (Hydraulic Component Business Headquarters)
  - Main line of business:
    - **Hydraulics**: Sales of overall hydraulic equipment
    - **Hydraulics Sales Deep**: Sales in Japan on an OEM basis, overseas export sales
    - **Osaka Branch**: Sales in Japan on an OEM basis, overseas export sales
    - **Railway Sales Department**: Sales of railway equipment
    - **K.Y.B. America LLC (U.S.A.)**: Sales of overall hydraulic equipment in the U.S.
    - **K.Y.B. Corporation (Germany)**: Sales of overall hydraulic equipment in Europe
    - **KYB Trading (Shanghai) Co., Ltd.**: Sales of overall hydraulic equipment in China

- **Production**
  - **KYB Engineering and Service Co., Ltd.**
  - Head office (Tokyo), Office (Saitama), Sales branch (Sendai, Nagoya, Osaka, Hiroshima) Domestic After sales distributor sales, Service and OEM

- **Main plants**
  - KYB: Sagami Plant: Pumps, motors, HSTs, valves, railway equipment, shock absorbers for industrial equipment, etc.
  - Gifu South Plant: Cylinders, valves for industrial equipment, etc.

- **Main affiliated manufacturing companies**
  - KYB-YS Co., Ltd.: Valves (for compact excavators and forklift trucks), cylinders (for compact excavators), Coupling facilities for valves (for excavators) and dumpers (Nagano)
  - Takano Industries, Inc.: Piston pump and motor parts (Kyoto, U.S.A., and Vietnam)
  - KIMZ: KYB Industrial Machinery (Zhenjiang): Cylinders (for excavators) (Zhenjiang, China)

- **Technical partners**
  - HUSCO International Inc. (U.S.A., Valve)
  - Deere & Company (U.S.A., Cylinder)
  - Bortoff Transmital (Italy, Motor)
  - CNH Industrial (Italy, Cylinder)