

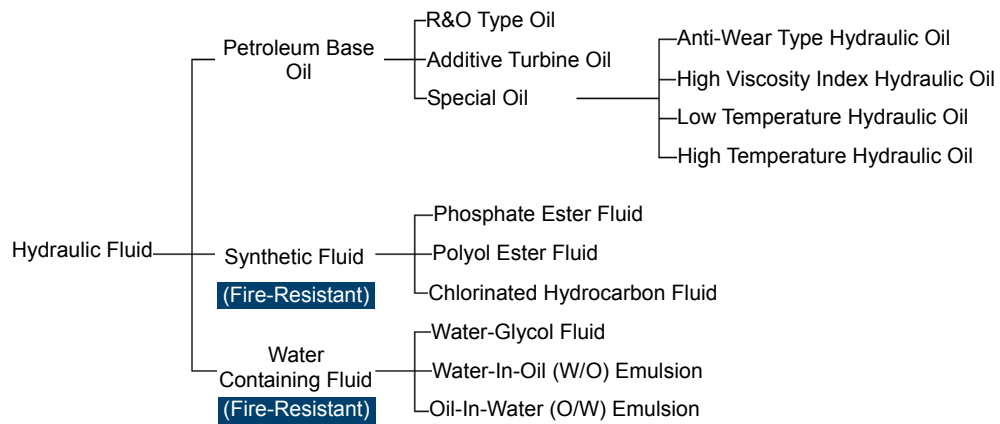
■ Requirements

Hydraulic pumps, control valves, and hydraulic cylinders operate at high pressure and high speed; they are also constructed of a variety of materials. Considering these facts as well as fluid temperature and ambient conditions during operation, the following requirements for hydraulic fluids must be met.

- Maintaining proper viscosity as temperature changes
- Flowable at low temperature
- Resistant to high temperature degradation
- Providing high lubricity and wear resistance
- Highly oxidation stable
- Highly shear stable
- Non-corrosive to metal
- Exhibiting good demulsibility/water separation when mixed with water
- Rust-preventive
- Non-compressible
- Providing good defoaming performance
- Fire-resistant

■ Classification

JIS standards for hydraulic fluids do not currently exist, and fluids that meet the above requirements and have a viscosity equivalent to that of petroleum based turbine oils (JIS K 2213) are used. Turbine oils are classified into two types: Type 1 (without additives) and Type 2 (with additives). Type 2 turbine oils contain antirust, antioxidant, and other additives. JIS K 2213 Type 2 turbine oils and special oils with a viscosity grade of ISO VG 32, 46, or 68 are widely used. If there is a risk of fire in the event of fluid leakage or blowout from hydraulic systems, fire-resistant synthetic or water containing fluids are employed. These fire-resistant fluids have different properties from petroleum base oils and must be handled carefully in practical applications. Chlorinated hydrocarbon fluids are rarely used for industrial purposes in Japan, since they become highly toxic and corrosive when decomposed. While other fluids are also available, fluids used for general industrial purposes are largely categorized as follows.



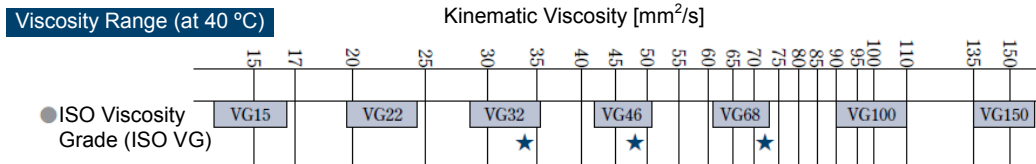
■ Properties (Example)

Hydraulic Fluid Item	Petroleum Base Oil (Type 2 Turbine Oil Equivalent to ISO VG 32)	Phosphate Ester Fluid	Polyol Ester Fluid	Water-Glycol Fluid	W/O Emulsion	O/W Emulsion	
Specific Gravity (15/4 °C)	0.87	1.13	0.93	1.04 - 1.07	0.93	1.00	
Viscosity (mm ² /s)	40 °C	32.0	41.8	40.3	38.0	95.1	0.7
	100 °C	5.4	5.2	8.1	7.7	-	-
Viscosity Index (VI)	100	20	160	146	140	-	
Max. Operating Temp. (°C)	70	100	100	50	50	50	
Min. Operating Temp. (°C)	-10	-20	-5	-30	0	0	
Strainer Resistance	1.0	1.03	1.0	1.2	0.7 - 0.8	(Same As Water)	

■ **Viscosity**

The viscosity of industrial lubricants, including hydraulic fluids, is measured by kinematic viscosity ν [mm²/s], which is obtained by dividing absolute viscosity by density. It is typically expressed in units of square millimeters per second (mm²/s). For viscosity measurement, a capillary viscometer is used to determine kinematic viscosity (mm²/s) as per JIS K 2283 "Crude petroleum and petroleum products - Determination of kinematic viscosity and calculation of viscosity index from kinematic viscosity". Hydraulic fluid viscosity critically affects the performance of hydraulic systems. System operation with a hydraulic fluid viscosity outside the specified range may result in pump suction failure, internal leakage, poor lubrication, valve malfunction, or heat generation in the circuit, shortening the life of equipment or causing a major accident.

According to JIS K 2001 "Industrial liquid lubricants - ISO viscosity classification", 20 viscosity grades are available ranging from ISO VG 2 to 3200. The figure below shows the viscosity range associated with the operation of hydraulic systems. For details, see "Viscosity vs. Temperature" on page 862.



★ For JIS K 2213 Type 2 (with additives), three grades ISO VG 32, 46, and 68 are available.

■ **Contamination control**

● **Cleanliness**

Hydraulic fluid replacement is required in the following three cases.

- (a) Deterioration or degradation of the fluid
- (b) Particulate contamination of the fluid
- (c) Water contamination of the fluid

While Table 3 provides guidelines for (a), the necessity of hydraulic fluid replacement is caused by (b) and (c) in most cases. Particulate contamination of hydraulic fluids may result in pump wear or valve malfunction. In particular, the performance of systems equipped with precision valves (e.g. electro-hydraulic servo valves) and actuators is adversely affected by fine particles of a few micrometers to a few tens of micrometers. Thus, it is necessary to control the level of contamination properly by measuring the size and number of particles in the fluid with a microscope or by measuring the mass of particles per unit volume of the fluid. For the determination of the fluid cleanliness level, filter 100 ml of the fluid through a filtration device and collect particles on a millipore filter (a filter with fine pores of 1/1000 mm). Measure the number and size of the collected particles for classification as shown in Table 1. For highly contaminated fluids, determine the cleanliness level based on the mass of particles collected on the millipore filter, as shown in Table 2. Unused R&O type oils have a cleanliness level of Class 6 to 8 shown in Table 1.

Table 1 NAS Cleanliness Level Based on Particle Counting

Number of particles per 100 ml

Size (μm)	Class (NAS 1638)													
	00	0	1	2	3	4	5	6	7	8	9	10	11	12
5 - 15	125	250	500	1,000	2,000	4,000	8,000	16,000	32,000	64,000	128,000	256,000	512,000	1,024,000
15 - 25	22	44	89	178	356	712	1,425	2,850	5,700	11,400	22,800	45,600	91,000	182,400
25 - 50	4	8	16	32	63	126	253	506	1,012	2,025	4,050	8,100	16,200	32,400
50 - 100	1	2	3	6	11	22	45	90	180	360	720	1,440	2,880	5,760
More than 100	0	0	1	1	2	4	8	16	32	64	128	256	512	1,024

NAS: National Aerospace Standard ISO: International Organization for Standardization

Table 2 Classification Based on the Gravimetric Method

NAS	Class	100	101	102	103	104	105	106	107	108
	mg/100 ml	0.02	0.05	0.10	0.3	0.5	0.7	1.0	2.0	4.0
MIL	Class	A	B	C	D	E	F	G	H	I
	mg/100 ml	Less than 1.0	1.0 - 2.0	2.0 - 3.0	3.0 - 4.0	4.0 - 5.0	5.0 - 7.0	7.0 - 10.0	10.0 - 15.0	15.0 - 25.0

MIL: Military Specifications and Standards

• Service limit

Unused R&O type oils contain 50 to 80 ppm (0.005 to 0.008%) of water, but the water content increases due to entry of atmospheric moisture through the actuator or air breather. Water may cause rust on the inside of hydraulic equipment, poor lubrication, or accelerated degradation of the hydraulic fluid. The water content of the fluid is measured by Karl Fischer titration (based on the quantitative reaction of the reagent with water) with a sensitivity of 10 ppm. The particulate/water contamination tolerance of hydraulic fluids varies depending on the system configuration as outlined in Tables 4 and 5.

Table 4 Recommended Control Level of Fluid Contamination

System Configuration	Class	
	JIS B 9933 (ISO 4406)	NAS
System with Servo Valve	18/16/13	7
System with Piston Pump	20/18/14	9
System with Proportional Electro-Hydraulic Control Valve	20/18/14	9
System Operating at Pressures Higher than 21 MPa	20/18/14	9
System Operating at Pressures of 14 to 21 MPa	21/19/15	10
General Low Pressure Hydraulic System	21/20/16	11

★ Comparison of JIS B 9933 (ISO 4406) and NAS for reference

Table 3 Criteria for Hydraulic Fluid Replacement (Example)

Fluid Type / Test Item	Petroleum Base Oil		Water-Glycol Fluid
	R&O	Anti-Wear	
Kinematic Viscosity (40 °C)* mm ² /s	±10%		±10%
Total Acid Number* mgKOH/g	0.25	a*	0.25
		b*	±40%

★: Variation in kinematic viscosity

☆: Additive type (a: Non-zinc based, b: Zinc based)

Table 3 provides guidelines for hydraulic fluid replacement. Detailed specifications vary depending on the manufacturer, and additional control requirements may be applied. Contacting the fluid manufacturer is recommended.

For example, the total acid number (or acid number) is a measure of fluid degradation and affected by the additive type and level. For water-glycol fluids, the pH value is also controlled.

Table 5 Water Contamination Tolerance of R&O Type Oils

1 ppm = 1/1000000

System Conditions	Service Limit
The hydraulic fluid is cloudy with water.	To be immediately replaced
The system has a circuit for circulating the hydraulic fluid back to the oil tank and operates without long-term shutdown.	500 ppm
The piping length of the system is long, and the hydraulic fluid does not fully circulate in the circuit.	300 ppm
The system remains out of service for a long period (safety system), has a circuit in which the hydraulic fluid hardly moves, or is designed to provide precision control.	200 ppm

• Portable Fluid Contamination Measuring Instrument

YUKEN CONTAMI-KIT

Model Number: YC-100-22

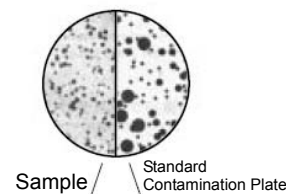
YUKEN's CONTAMI-KIT is a fluid contamination measuring instrument that samples hydraulic fluids and microscopically measures the distribution of particles collected on a membrane filter as per JIS B 9930 or SAE ARP 598 A.

■ Specifications

- 1) Power supply: Both AC and DC power supplies supported (100 V AC/6 V DC)
- 2) Microscope magnification: 100 times (40 times: Option for KYC-100-L-20)
- 3) Applicable fluids: Petroleum base oil, polyol ester fluid, and water-glycol fluid (optional)
- 4) Case dimensions: L 600 × W 240 × H 360 mm
- 5) Total mass: Approximately 9 kg

■ Features of CONTAMI-KIT

- 1) Usable everywhere
Portable and supports both AC and DC power supplies (switchable).
- 2) User-friendly
Requires no skills and involves only comparing the results with the standard contamination plate.
- 3) Time-efficient
Takes only about 10 minutes for each measurement.
- 4) Supporting photo taking
Allows photo taking with a single-lens reflex camera for recording.



Hydraulic equipment is affected differently depending on the fluid type; special care should be taken when selecting the equipment. The table below shows YUKEN's hydraulic equipment available for each fluid type. For details, see the relevant pages.

Hydraulic Fluid Equipment		Petroleum Base Oil (Equivalent to JIS K 2213 Type 2)	Phosphate Ester Fluid	Polyol Ester Fluid
A Series Variable Displacement Piston Pump		Standard	Custom: Z6 Seal: Fluororubber	Consult us.
Fixed Displacement Vane Pump		Standard	"F-" + Standard Model Seal: Fluororubber	Standard
Pressure Control Valve		Standard	"F-" + Standard Model Seal: Fluororubber	Standard
Flow Control Valve		Standard	"F-" + Standard Model Seal: Fluororubber	Standard
Directional Control Valve		Standard	"F-" + Standard Model Seal: Fluororubber	Standard
Modular Valve		Standard	"F-" + Standard Model Seal: Fluororubber	Standard
Logic Valve		Standard	"F-" + Standard Model Seal: Fluororubber	Standard
Proportional Electro-Hydraulic Control valve		Standard	"F-" + Standard Model* ¹ Seal: Fluororubber	Standard* ²
Servo Valve		Standard	"F-" + Standard Model Seal: Fluororubber	Standard
Cylinder	CJT Series	Standard	"F-" + Standard Model Seal: Fluororubber	Standard
	CBY14 Series	Standard Packing Material: 6 (HNBR)	Semi-Standard Packing Material: 3 (Fluororubber)	Standard Packing Material: 6 (HNBR)
Accumulator		Standard/ Commercially Available Product	Butyl Rubber Diaphragm Type/ Piston Type (Except for Aluminum) Permitted	Butyl Rubber Diaphragm Type Prohibited
Needle Valve		Standard	"F-" + Standard Model Seal: Fluororubber	Standard
Tank Filter		Aluminum	Aluminum	Aluminum
Oil Level Gauge		Direct Reading Type	Remote Reading Type	Direct Reading Type
Rubber Tube		Nitrile Rubber	Butyl Rubber	Nitrile Rubber
Inside Coating of Oil Tank		Epoxy/Phenolic Coating Permitted	Inside Coating Prohibited (Chemical Conversion Coating Permitted)	Phenolic Coating Prohibited
Effect on Metals		None	Aluminum Sliding Parts Prohibited	None
Seal	Nitrile Rubber	Permitted	Prohibited	Permitted
	Fluororubber	Permitted	Permitted	Permitted
	Silicone Rubber	Prohibited	Permitted	Permitted
	Butyl Rubber	Prohibited	Permitted	Prohibited
	Ethylene Propylene Rubber	Prohibited	Permitted	Permitted
	Urethane Rubber	Permitted	Prohibited	Permitted
	Fluoro-resin	Permitted	Permitted	Permitted
	Chloroprene	Permitted	Prohibited	Permitted
Leather		Permitted	Permitted	Permitted
Other		-	Protect electrical wiring by applying oil resistant coating or by running it in conduits.	-

★1. Contact us for details of EH Series High Response Directional and Flow Control Valves (EHDFG-04/06).

★2. Contact us for details of EH Series Directional and Flow Control Valves (EHDFG-03) and EH Series High Response Directional and Flow Control Valves (EHDFG-04/06).

Hydraulic Fluid Equipment		Water-Glycol Fluid	W/O Emulsion	O/W Emulsion
A Series Variable Displacement Piston Pump		Custom: Z30	Custom: Z30	Consult us.
Fixed Displacement Vane Pump		"M-" + Standard Model PV2R: Standard	Custom: Z35 ("M-" + Standard Model in some cases) PV2R: Standard	Consult us.
Pressure Control Valve		Standard	Consult us.	Consult us.
Flow Control Valve		Standard	Consult us.	Consult us.
Directional Control Valve		Standard	Standard	Consult us.
Modular Valve		Standard	Consult us.	Consult us.
Logic Valve		Standard	Consult us.	Consult us.
Proportional Electro-Hydraulic Control Valve		Standard* ¹	Consult us.	Consult us.
Servo Valve		Standard* ²	Consult us.	Consult us.
Cylinder	CJT Series	Standard Seal: Nitrile Rubber	Standard Seal: Nitrile Rubber	Custom Seal: Nitrile Rubber
	CBY14 Series	Standard Packing Material: 6 (HNBR)	Standard Packing Material: 6 (HNBR)	Standard Packing Material: 6 (HNBR)
Accumulator		Standard/ Commercially Available Product	Standard/ Commercially Available Product	Standard/ Commercially Available Product
Needle Valve		Standard	Standard	Standard
Tank Filter		Stainless Steel (Aluminum, Cadmium, or Galvanizing Prohibited)	Aluminum/Stainless Steel (Cadmium or Galvanizing Prohibited)	Stainless Steel (Aluminum Prohibited)
Oil Level Gauge		Direct Reading Type	Direct Reading Type	Direct Reading Type
Rubber Tube		Nitrile Rubber	Nitrile Rubber	Nitrile Rubber
Inside Coating of Oil Tank		Inside Coating Prohibited (Chemical Conversion Coating Permitted)	Inside Coating Prohibited (Chemical Conversion Coating Permitted)	Epoxy Coating Permitted
Effect on Metals		Aluminum, Cadmium, or Zinc Prohibited	Copper, Cadmium, or Zinc Prohibited	None
Seal	Nitrile Rubber	Permitted	Permitted	Permitted
	Fluororubber	Permitted	Permitted	Permitted
	Silicone Rubber	Prohibited	Prohibited	Prohibited
	Butyl Rubber	Permitted	Prohibited	Prohibited
	Ethylene Propylene Rubber	Permitted	Prohibited	Prohibited
	Urethane Rubber	Prohibited	Prohibited	Prohibited
	Fluororesin	Permitted	Permitted	Permitted
	Chloroprene	Permitted	Permitted	Permitted
Leather		Prohibited	Prohibited	Prohibited
Other		-	Be sure to have the oil tank bottom tilted and equipped with a drain cock.	-

★1. Contact us for details of EH Series High Response Directional and Flow Control Valves (EHDFG-04/06).

★2. Contact us for details of the following products.

- On-Board Electronics Type Linear Servo Valves without DR Port (Wet Type Pilot Valve: LSVHG-*EH*-*W)

Caution : In the case of Water Glycol fluid, a slight oil leak occurs from the shaft seal part.

(Criterion: 500 ml / 6 months of oil leakages.)

Install a tray appropriate capacity on the pump-base, please.