Operating Fluid

Operating fluid is liquid inside of a hydraulic device that acts as a medium to transmit power. In addition to its operational task, hydraulic operating fluid also performs such tasks as lubrication, rust prevention, sealing, and cooling. Because of the vital contributions hydraulic operating fluid makes to the operation, efficiency, and reliability of hydraulic equipment, it is important to exercise sufficient care when selecting the correct type for your needs and when storing fluid.

● Oil-based operating fluid

The most commonly used mineral oil hydraulic fluids are general operating fluid and anti-wear operating fluid.

General operating fluid is called "R&O type." It is made by adding oxidation inhibitors, rust inhibitors, foam inhibitors, and other additives to a highly refined paraffin base oil to enhance its characteristics.

Anti-wear operating fluid contains extreme pressure additives that enhances the extreme pressure characteristics required for high-pressure, high-speed hydraulic operations.

These oil-based operating fluid have a very wide range of application in hydraulic equipment, and account for most hydraulic operation fluid in use today.

● Fire-resistant Hydraulic Fluid

Fire-resistant hydraulic fluid (FRHF) is used in fire fighting equipment and in hydraulic equipment in applications where there is the danger of fire. There are two types of FRHF: water-containing and synthetic.

The common types are water-glycol type and water in oil emulsion type for water-containing FRHF, and phosphate ester type and fatty acid ester type for synthetic FRHF.

Care is required when using an FRHF concerning seal material, paint and metal compatibility (see table below), and because their lubrication characteristics are different from those of mineral oil.

◉See the pages for each hydraulic device or contact your agent to find out if a fire-resistant hydraulic fluid can be used with a particular device.

Fire-resistant Hydraulic Fluid Seal Material Compatibility

Fluid / Sea Material	Water In Oil Emulsion	Water-glycol	Phosphate Ester	Fatty Acid Ester
Nitril Rubber	○	○	×	○
E . P . R .	×	○	○	○
Fluro Rubber	○	×	○	○
Teflon	○	○	○	○
Butyl Rubber	×	○	△	×
Urethane Rubber	×	×	×	○
Silicon Rubber	×	×	○	○
Leather (Wax Sealed)	×	×	○	○
Beech N	○	○	×	○
Beech S	○	○	×	○

Fire-resistant Hydraulic Fluid Paint Compatibility

Fluid / Paint	Water In Oil Emulsion	Water-glycol	Phosphate Ester	Fatty Acid Ester
Epoxy Resin	×	×	×	○
Vinyl Resin	×	×	×	○
Urethane Resin	×	×	×	○
Phtalic Resin	×	×	×	×
Phenolic Resin	×	×	×	×

Fire-resistant Hydraulic Fluid Metal Compa-tibility (△ indicates partial problem.)

Fluid / Metal	Water In Oil Emulsion	Water-glycol	Phosphate Ester	Fatty Acid Ester
Aluminum	○	×	△	○
Cast Iron	○	○	○	○
Steel	○	○	○	○
Brass	○	○	○	○
Copper	△	○	○	○
Magnesium	○	×	△	○
Cadmium	△	×	△	△
Zinc	△	×	○	△

Note) The △ symbol indicates items that may have problems. For details, consult your agent or a hydraulic operating fluid manufacturer.
○ symbol indicates items that may be used. × symbol indicates not ok.

● General Properties of Hydraulic Fluid (Typical)

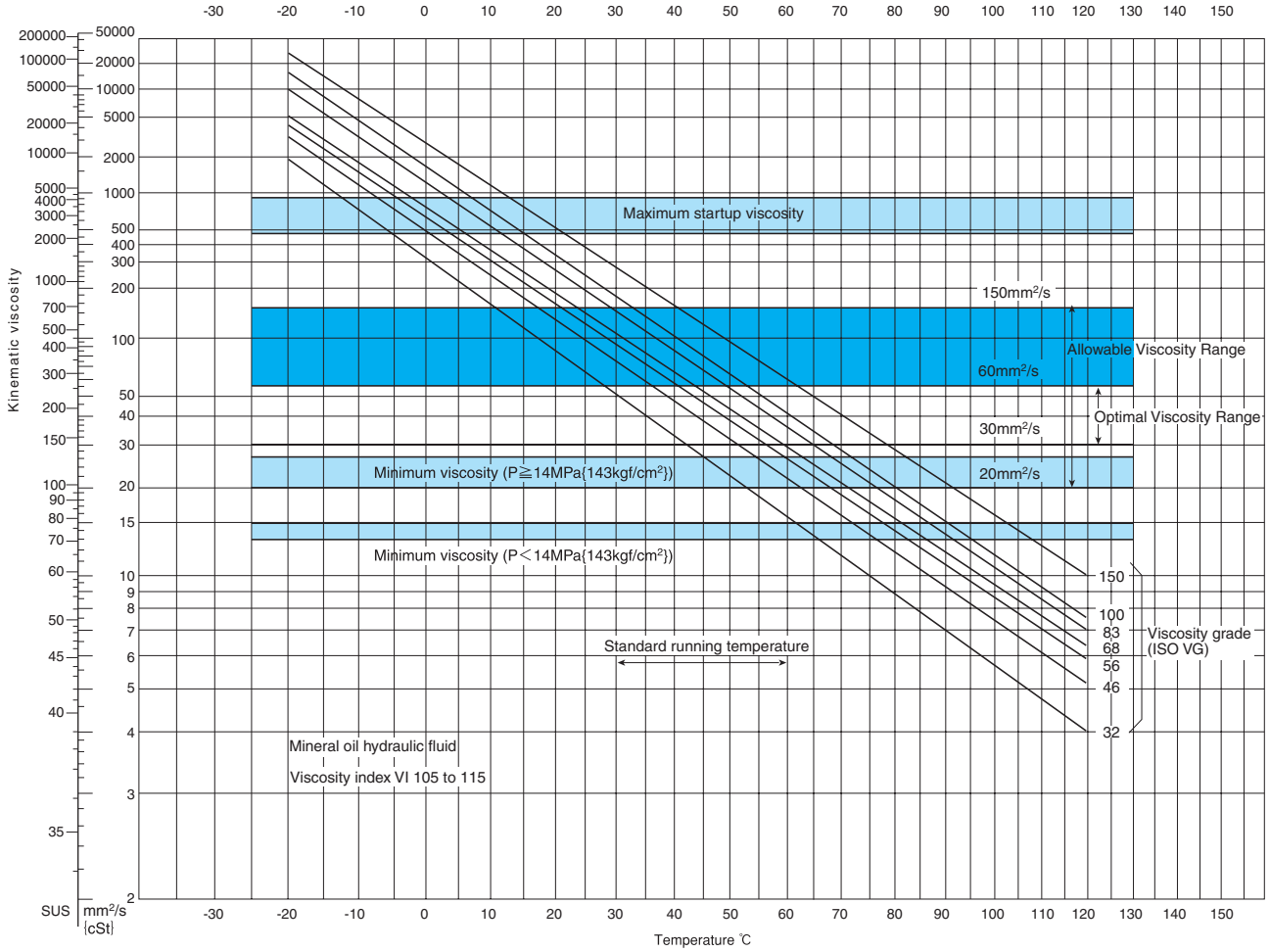
Item / Type		Oil-based operating fluid	Water-glycol	Water In Oil Emulsion	Phosphate Ester	Fatty Acid Ester
Specific Gravity 15/4°C		0.874	1.072	0.890	1.152	0.900
Fire Point °C		224	None	None	262	257
Viscosity mm²/s	40°C	59.8	45.5	67.9	36.4	43.6
	100°C	8.09	9.09	12.0	4.72	8.00
Viscosity index		113	206	146	110	165
Pour Point °C		–25	–40	–12.5	–20	–10 or less

● Viscosity–Temperature Characteristics (Oil-based operating fluid)

Viscosity is the most important factor to consider when selecting hydraulic operating fluid. Viscosity has a major effect on a variety of characteristics, including the volumetric efficiency, mechanical efficiency, and pipe resistance, valve leakage, operational characteristics, etc.

Though the overall efficiency and characteristics of the hydraulic device should be considered when determining the proper viscosity of the fluid, the main consideration should be the needs of the hydraulic pump at the heart of the hydraulic system.

The following pages show typical Viscosity–Temperature characteristics for oil-based operating fluid with viscosity indexes from 105 to 115, as well as ASTM Viscosity Index–Temperature tables with information about suitable and optimal viscosity ranges for hydraulic pumps.



● Fluid Cleanliness Levels

Today's high-pressure, high-speed, high-precision control hydraulic equipment is more susceptible than ever before to problems caused by hydraulic fluid contaminants. Fluid contaminants can cause a loss of machine performance, shorten machine life, and even lead to equipment malfunction.
Because of this, the U.S. has taken the lead in defining numeric contamination limits to govern cleanliness levels for hydraulic operating fluid.
Japan also applies the same standards (normally, NAS-1638) to classify fluid contamination limits.
In the future, the world standard ISO cleanliness codes (ISO 4406) will use a range code to define the cumulative number of particles by diameter per milliliter. The range codes are separated by a slash in order of the diameter of the particle: larger than 4 μm (C), larger than 6 μm (C), and larger than 14 μm (C).
For example

Larger than 4μm (C) 1200 particles/m ℓ
Larger than 6μm (C) 300 particles/m ℓ
Larger than 14μm (C) 40 particles/m ℓ

The cleanliness code looks like: 17/15/12

Allowable Number of Particles in Hydraulic Fluid–NAS-1638 (100m ℓ)

Particle Size / Class	5 to 15μm	15 to 25μm	25 to 50μm	50 to 100 μm	100 μm or larger	Device	Filter	Remarks
00	125	22	4	1	0			
0	250	44	8	2	0			
1	500	89	16	3	1			
2	1,000	178	32	6	1			
3	2,000	356	63	11	2			
4	4,000	712	126	22	4			
5	8,000	1,425	253	45	8			
6	16,000	2,850	506	90	16		From nominal 0.8μm ← to absolute 3μm	
7	32,000	5,700	1,012	180	32	↕Electric–Hydraulic Servo Device		↕Clean oil
8	64,000	11,400	2,025	360	64		From nominal 10μm ← to absolute 40μm	↕NC hydraulic fluid
9	128,000	22,800	4,050	720	128	↕Electric–Hydraulic Pulse Motor		↕In drum General hydraulic fluid (new)
10	256,000	45,600	8,100	1,440	256			
11	512,000	91,200	16,200	2,880	512			
12	1,024,000	182,400	32,400	5,760	1,024	↕General Industrial Hydraulic Device		

Weight of Contaminants Per 100 m ℓ of Hydraulic Fluid–NAS-1638

Class	100	101	102	103	104	105	106	107	108
Weight mg	0.02	0.05	0.01	0.30	0.50	0.70	1.0	2.0	4.0

ISO Contamination Limit Equivalents (ISO 4406:1999)Number of particles show upper limit values for each scale number.

Number of Particles (Particles/m ℓ)	Scale Number	Number of Particles (Particles/m ℓ)	Scale Number	Number of Particles (Particles/m ℓ)	Scale Number
2,500,000 +	>28	5,000	19	5	9
2,500,000	28	2,500	18	2.25	8
1,300,000	27	1,300	17	1.3	7
640,000	26	640	16	0.64	6
320,000	25	320	15	0.32	5
160,000	24	160	14	0.16	4
80,000	23	80	13	0.08	3
40,000	22	40	12	0.04	2
20,000	21	20	11	0.02	1
10,000	20	10	10	0.01 or less	0