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: watercontaining 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

Sea Material \ Fluid	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

Paint \ Fluid	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 Compatibility
(Δ indicates partial problem.)

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

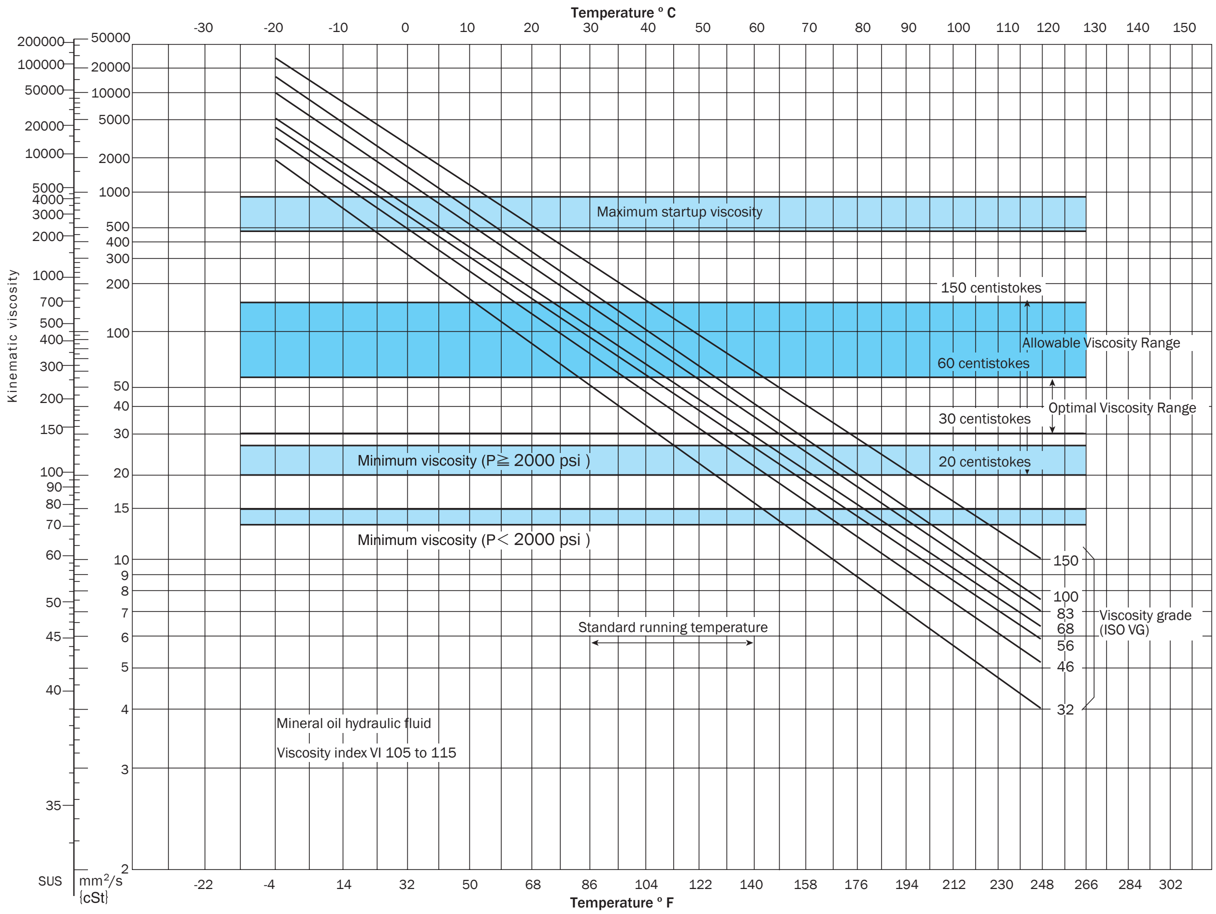
Note: The ▲ symbol indicates items that may have problems. For details, consult your agent or a hydraulic operating fluid manufacturer.
○ symbol indicates items that may be used. × symbol indicates not ok.

• 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 ℃		0.874	1.072	0.890	1.152	0.900
Fire Point° F		435	None	None	503	494
Viscosity centistokes	40° C 100° F	59.8	45.5	67.9	36.4	43.6
	100° C 212° F	8.09	9.09	12.0	4.72	8.00
Viscosity index		113	206	146	110	165
Pour Point° C (F)		−25 (-13)	−40 (F/C)	−12.5 (9.5)	−20 (-4)	−10 (14) 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/mr
Larger than 6µm (C) 300 particles/mr
Larger than 14µm (C) 40 particles/mr

The cleanliness code looks like: 17/15/12

Allowable Number of Particles in Hydraulic Fluid - NAS-1638 (100 m ℓ ; 6.1 in³)

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		From nominal 0.8 µm	
6	16,000	2,850	506	90	16		← to absolute 3 µm	
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 10 µm	↕NC hydraulic fluid
9	128,000	22,800	4,050	720	128	↕Electric –Hydraulic Pulse Motor	← to absolute 40 µm	↕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 (6.1 in³) 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

Subplate/Conversion Chart

Hydraulic Component for use with Water - Glycol

Pump Specifications for Water - Glycol Oil

VDR22 Design Series Variable Vane Pump

Pump Model for W/G	Rated Pressure psi	Max. Pressure psi	Max. Drive Speed rpm	Suction Pressure psi
W-VDR-1 * - 1A2-(E)22	500	500	1800	-2.1 to 4.3
1A3	1000	1000		
2A2	500	500		
2A3	714	714		

VDC Series Variable Vane Pump

Pump Model for W/G	Rated Pressure psi	Max. Pressure psi	Max. Drive Speed rpm	Suction Pressure psi
W-VDC-1 * - 1A2-20, (E)35	500	500	1800	-2.1 to 4.3
1A3	1000	1000		
2A2	500	500		
2A3	714	714		
W-VDC-2 * - 1A2-20, (E)35	500	500	1800	-2.1 to 4.3
1A3	1000	1000		
2A2	500	500		
2A3	714	714		
W-VDC-3 * - 1A2- (E)35	500	500	1800	-2.1 to 4.3
1A3	1000	1000		

IPH Series Internal Gear Pump

Pump Model for W/G	Rated Pressure psi	Max. Pressure psi	Max. Drive Speed rpm	Suction Pressure psi
W-IPH-2 * - * - 11	3000	3571	1200	-2.1 to 4.3
W-IPH-3 * - * - 20				
W-IPH-4 * - * - 20				
W-IPH-5 * - * - 21(11)				
W-IPH-6 * - * - 21(11)				

PVS, PZS Series Variable Piston Pump

Pump Model for W/G	Rated Pressure psi	Max. Pressure psi	Max. Drive Speed rpm	Suction Pressure psi
W-PVS-0B- 8N *- (E)30	2000	2000	1200	-2.1 to 4.3
W-PVS-1B- 16N *- 11, E12	2000	2000	1200	-2.1 to 4.3
22N *	1500	1500		
W-PVS-2B- 35N *- 11, E12	2000	2000	1200	-2.1 to 4.3
45N *	1500	1500		
W-PZS-3B- 70N *- (E)10	2000	2000	1200	-2.1 to 4.3
W-PZS-4B- 100N *- (E)10				
W-PZS-5B- 130N *- (E)10				

Subplate/Conversion Chart
Valve Specifications for Water - Glycol

Pressure Control Valve

Valve Name	Valve Model for W/G	Specifications	
		Max. Pressure psi	Max. Flow gpm
Relief Valve	R- * 03 - * - 11	3000	7.9 (5.3) Note
	R- * 06 - * - (E)20		39.7
	R- * 10 - * - (E)20		89.9
Relief Valve	RI- * G03 - * - (E)10	3000	22.5 (5.3) Note
	RI- * G06 - * - (E)10		44.9
Direct Type Relief Valve	RD- * G03 - * - 11	3000	11.9
	RD- * G06 - * - 11		19.8
Relief Valve for Remote Control	RCD- T02 - * - 11	3000	4.0
	RC- T02 - * - 12		0.5
	RC- G02 - * - 21		0.5
Solenoid Control Relief Valve	RSA- * 03 - *** - ** - 13	3000	7.9
	RSA- * 06 - *** - ** - 22		39.7
	RSA- * 10 - *** - ** - 22		89.9
	RSS- * 03 - *** - ** - 13		7.9
	RSS- * 06 - *** - ** - (E)22		39.7
	RSS- * 10 - *** - ** - (E)22		89.9
Solenoid Control Relief Valve	RIS- G03 - *** - ** - 11	3000	22.5
	RIS- G06 - *** - ** - 11		44.9
Reducing Valve	W-(C)G - * 03 - * - 21	3000	10.6 (5.3) Note
	W-(C)G - * 06 - * - 21		26.4
	W-(C)G - * 10 - * - 21		66.1
Balancing Valve	GR- G01 - A * - 20	2000	5.3
	GR- G03 - A * (B) - 20		10.6
Pressure Control Valve	(C)G - * 03 - * * - 21	3000	10.6
	(C)G - * 06 - * * - 21		26.4
	(C)G - * 10 - * * - 21		66.1

Note: ( ) value is for pressure range “A”, “B” and “C”.

Directional Control Valve

Valve Name	Valve Model for W/G	Specifications	
		Max. Pressure psi	Max. Flow gpm
Right Angle Check Valve	CA- * 03 - * - 20	3000	10.6
	CA- * 06 - * - 20		29.1
	CA- * 10 - * - 20		84.6
Inline Check Valve	W-CN - T03 - * - 10	3000	7.9
	W-CN - T06 - * - 10		19.8
	W-CN - T10 - * - 10		50.2
Pilot Check Valve	CP- * 03 - * - 20	3000	10.6
	CP- * 06 - * - 20		29.1
	CP- * 10 - * - 20		84.6
DMA Type Manual Valve	W-DMA- G01 - *** - (E)20	3000	9.3
	W-DMA- G03 - *** - (E)10		17.2
Manual Valve	W-DM- T03 - *** - (B)-10	3000	11.9
	W-DM- T06 - *** - (B)-10		26.4
SA Type Solenoid Valve	SA- G01 - ** - ** - (E)30	4000	Note. 22.5
	DSA- G04 - ** - ** - (E)21		66.1
	DSA- G06 - ** - ** - (E)21		132.2
SS Type Solenoid Valve	SS- G01 - ** - ** - (E)30	4000	Note. 22.5
	SS- G03 - ** - ** - (E)20		24.1
	DSS- G04 - ** - ** - (E)21		66.1
	DSS- G06 - ** - ** - (E)21		132.2
	SS- G01 - ** - FR - ** - (E)30	3000	Note. 11.9
	SS- G03 - ** - FR - ** - (E)20		17.2
	SS- G03 - ** - ** - (E)10		18.5
Fine Solenoid Valve	SF- G01 - ** - ** - 10 - (E)10	2000	Note. 9.0
Non Leak Type Solenoid Valve	SNH- G01 - ** - ** - 10	4500	Note. 4.5
	SNH- G03 - ** - ** - 10		9.0
	SNH- G04 - ** - ** - 10		13.2
	SNH- G06 - ** - ** - 10		22.5
Gauge Valve	W- K - * ** - 10	5000	--
	K2- * 02 - 10	3000	--
	K2- * 03/04 - 10	6000	--

Note: Max. flow capacity changes depending on spool type. Flow rating is 85% of standard max. oil flow.

Subplate/Conversion Chart
Valve Specifications for Water - Glycol

Flow Control Valve

Valve Name	Valve Model for W/G	Specifications	
		Max. Pressure psi	Max. Flow gpm
Flow Regulator	R- * 03 - * - 11	3000	7.9
	R- * 06 - * - (E)20		19.8
	R- * 10 - * - (E)20		50.2
FT Type Flow Control Valve	RI- * G03 - * - (E)10	3000	Note.
	RI- * G06 - * - (E)10		
F Type Flow Control Valve	RD- * G03 - * - 11	3000	
TN Type Flow Control Valve	RD- * G06 - * - 11	1500	
	RCD- T02 - * - 11		
TS Type Flow Control Valve	RC- T02 - * - 12	1500	
TL (TLT) Type Feed Control Valve	RC- G02 - * - 21	1000	
	RSA- * 03 - *** - ** - 13		
	RSA- * 06 - *** - ** - 22		

Note: Flow rating is 85% of standard max. oil flow.

Modular Valve

Valve Name	Valve Model for W/G	Specifications	
		Max. Pressure psi	Max. Flow gpm
Relief Valve	OR- G01 - ** - 20 (21)	3000	7.9
	OR- G03 - ** - (E)50		17.2
	OR- G06 - ** - (E)10		31.7
Brake Valve	ORO- G01 - ** - 20	3000	5.3
	ORO- G03 - ** - (J)50		7.9
Direct Type Relief Valve	ORD- G01 - ** - 20	3000	5.3
	ORD- G03 - ** - (J)50		7.9
Reducing Valve	OG- G01 - P * - (E)20	3000	7.9
	OGB- G01 - P * - 20		7.9
	W-OG- G03 - P * - (E)50		17.2
	W-OG- G06 - P * - (E)12		31.7
	OGS- G01 - P * C - 20	1000	7.9
	OGC- G01 - P * - (E)12		4.0
Reducing Valve	OG- G01 - * * - (E)20	3000	7.9
	OGB- G01 - * * - 20		7.9
	W-OG- G03 - * * - (E)50		17.2
	W-OG- G06 - * * - (E)12		31.7
Sequence Valve	OCQ- G01 - P2 - 20	3000	7.9
	OCQ- G03 - P2 * - (J)50		17.2
	OCQ- G06 - P2 * - (E)11		31.7
Counter Balance Valve	OCQ- G01 - * 1 * - 20	3000	7.9
	OCQ- G03 - * 1 * - (J)50		17.2
	OCQ- G06 - * 1 * - (E)11		31.7
Pressure Switch	OW- G01 - ** - 20	3000	7.9
Flow Regulator	OY- G01 - * - 20	3000	7.9
	OCY- G01 - P - 20		7.9
	OCY- G03 - P - (J)50		22.5
	OCY- G06 - P - 10		31.7
	OCY- G01 - * - X/Y - 20		7.9
	OCY- G03 - * - X/Y - (J)50		22.5
	OCY- G06 - * - X/Y - 11		31.7
Flow Control Valve	OF- G01 - P20 - 20	3000	Note.
	OF- G03 - P60 - J50		
	OCF- G01 - * 40 - X/Y - 30		
	OCF- G03 - * 60 - X/Y - (J)50		
Check Valve	OC- G01 - ** - 20	3000	7.9
	OC- G03 - ** - (J)50		22.5
	OC- G06 - ** - 10		31.7
Vacuum Check Valve	OCV- G01 - W - 20	3000	7.9
	OCV- G03 - W - (J)50		17.2
Pilot Check Valve	OCP- G01 - ** - (F) - 21	3000	7.9
	OCP- G03 - ** - (J)50		22.5
	OCP- G06 - ** - 11		31.7
D07 Relief Valve	ORH- G04 - P * - 10	4500	66.1
D07 Direct Type Relief Valve	ORH- G04 - D * - 10	4500	10.6
D07 Reducing Valve	OGH- G04 - * * - 10	4500	66.1
D07 Counter Balance Valve	OQH- G04 - * * - 10	4500	66.1
D07 Flow Regulator	OYH- G04 - * * - 10	4500	66.1
D07 Flow Control Valve	OFH- G04 - * 200 - X/Y - 10	4500	Note.
D07 Check Valve	OCH- G04 - * * - 10	4500	66.1
D07 Vacuum Check Valve	OVH- G04 - W - 10	4500	66.1
D07 Pilot Check Valve	OPH- G04 - * * - 10	4500	66.1

Note: Flow rating is 85% of standard max. oil flow.

Subplate/Conversion Chart
Valve Specifications for Water - Glycol

Proportional Valve

Valve Name	Valve Model for W/G	Specifications	
		Max. Pressure psi	Max. Flow gpm
Pilot Relief Valve	EPR- G01 - * - (E)11	4000	0.3
Relief Valve	ER- G03 - * - (E)10	3571	10.6
	ER- G06 - * - (E)10		39.7
Reducing Valve	W-EBG- G03 - * - (E)10	3571	10.6
	W-EBG- G06 - * - (E)10		21.2
Flow Control Valve	(O)ES- G02 - * - (F) - (E)11	3000	Note.
	ES- G03 - * - (F) - (E)11		
	(C)ES- G06 - 250 - (E)10		
	ES- G10 - 500 - (F) - (E)10		
Load Sensing Type Flow Control Valve	ESR- G03 - 125 - (E)11	3571	Note.
	ESR- G03 - 125R * - (E)11		
	ESR- G06 - 250 - (E)11		
	ESR- G06 - 250R * - (E)11		
	ESR- G10 - 500 - (E)11		
	ESR- G10 - 500R * - (E)11		
Directional and Flow Control Valve	ESD- G01 - *** - (E)11	3571	Note.
	ESD- G03 - *** - (E)11		
	ESD- G06 - *** - (E)11		
Modular Type Reducing Valve	EOG- G01 - P * - 10	3571	6.6
Modular Type Flow Control Valve	EOF- G01 - * 25 - 10	3000	Note.

Note: Flow rating is 85% of standard max. oil flow.

N

Technical Data

NACHI

Conversions and Formulas

Conversions

TO CONVERT	INTO	MULTIPLY BY
Bar	PSI	14.5
cc	Cu. In.	0.06102
°C	°F	(°C x $\frac{9}{5}$) + 32
Kg	lbs.	2.205
KW	HP	1.341
Liters	Gallons	0.2642
mm	inches	0.03937
Nm	Lb. - ft.	0.7375
N	Lbs.	0.22481
Cu. In.	cc	16.39
°F	°C	(°F-32) / 1.8
Gallons	Liters	3.785
HP	KW	0.7457
Inches	mm	25.4
Lbs.	Kg	0.4535
Lb.-ft.	Nm	1.356
PSI	Bar	0.06896
In. of HG	PSI	0.4912
In. of H_2O	PSI	0.03613
Lbs.	Nm	4.4482

Formulas

CYLINDERS

- Cylinder Area = diameter^2 x .7854
- Tube Area = $\frac{\text{GPM x .3208}}{\text{oil velocity}}$
- Cylinder Force = pressure x area
- Adjust GPM on Return = $\frac{\text{cyl area x GPM}}{\text{area}}$
- Cylinder Time (in seconds) = $\frac{\text{area x stroke x .26}}{\text{GPM}}$
- Cylinder Speed (Ft/Min) = $\frac{\text{stroke x 5}}{\text{time (in secs)}}$
- Pneumatic HP = $\frac{\text{compressed CFM x PSI x 144}}{\text{33,000}}$
- Cylinder Speed (Ft/Min) = $\frac{\text{GPM x 19.25}}{\text{area}}$
- Cylinder HP = $\frac{\text{cyl speed x cyl force}}{\text{33,000}}$
- Comp CFM = $\frac{\text{area x stroke x 60}}{\text{time (in secs) x 1728}}$

PUMPS MOTORS

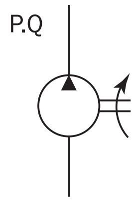
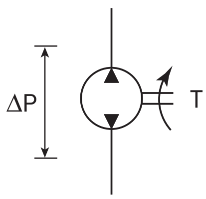
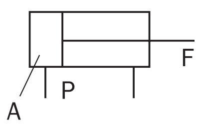
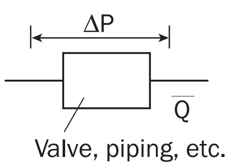
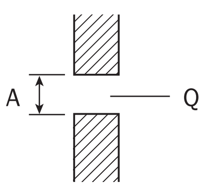
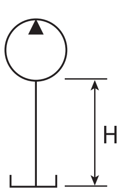
- HP Out = $\frac{\text{HP IN x overall Eff.}}{100}$
- GPM = $\frac{\text{RPM x disp. (in inches)}^3}{231}$
- Actual Torque = $\frac{\text{theo. torque x mech. eff.}}{100}$
- Hyd. HP = $\frac{\text{GPM x PSI}}{1714}$
- Actual Motor RPM = $\frac{\text{theo. RPM x vol. eff.}}{100}$
- Torque (in lbs.) = $\frac{\text{PSI x disp. (in inches)}^3}{6.28}$
- Overall Efficiency = $\frac{\text{mech. eff. x vol. eff.}}{100}$
- Torque (in lbs.) = $\frac{\text{HP x 63025}}{\text{RPM}}$
- Actual Pump GPM = $\frac{\text{theo. GPM x vol. eff.}}{100}$

VEHICLE SIZING

- RPM = $\frac{\text{MPH x 168}}{\text{LR}}$
- Torque = TE x LR
- Wheel Slip Torque = WD x ADC x LR
- TE = RR + GR + DP
- RR = $\frac{\text{GVW x R}}{1000}$
- GR = $\frac{\text{\% Grade x GVW}}{100}$

LEGEND

- G = Gear Reduction Ratio
- LR = Load Radius
- TE = Tractive Effort
- WD = Weight on Drive Wheels
- ADC = Adhesion Coefficient
- RR = Rolling Resistance
- GR = Grade Resistance
- DP = Draw Bar Pull Desired
- TE = RR + GR + DP
- R = Rolling Resistance Coefficient
- GVW = Gross Vehicle Weight

Item		SI units	Power (engineering) units
Requirement		$hp=\dfrac{P \cdot Q}{1714 \times \eta}$ L : Power Requirement [hp] P : Discharge Pressure [psi] Q : Discharge Rate [gpm] η : Pump Efficiency	$hp=\dfrac{P \cdot Q}{1714 \times \eta}$ L : Power Requirement [hp] P : Discharge Pressure [psi] Q : Discharge Rate [gpm] η : Pump Efficiency
Oil Motor Output Torque		$T=\dfrac{PQ \times 36.77}{RPM}$ T : Output Torque [in lbs] P : Inlet/Outlet Pressure Differential [psi] Q : Discharge rate [gpm] η : Torque Efficiency	$T=\dfrac{\Delta P \cdot q}{200 \times \pi} \times \eta$ T : Output Torque [kgf·m] ΔP : Inlet/Outlet Pressure Differential [kgf/cm^2] q : Volume per Oil Motor Turn [cm^3] η : Torque Efficiency
Cylinder Output		$F=PA\eta$ F : Cylinder Force [lbs] P : Working Presure [psi] A : Cylinder Contact Area [in^2] η : Cylinder Efficiency	$F=P \times A \times \eta$ F : Cylinder Output [kgf] P : Working Presure [kgf/cm^2] A : Cylinder Contact Area [cm^2] η : Cylinder Efficiency
Pressur Loss Conversion Energy		$H=60 \times P \times Q$ H : Heat Release [kJ/h] P : Pressure Loss [MPa] Q : Flow Rate [ℓ /min]	$H=1.4 \times P \times Q$ H : Heat Release [kcal/h] P : Pressure Loss [kgf/cm^2] Q : Flow Rate [ℓ /min]
Orifice Flow		$Q=29.81\,CA^2\sqrt{\dfrac{\Delta P}{S}}$ Q : Flow Rate [gpm] C : Compressibile Flow Coefficient [Dimensionless] A : Passage Area [Dia. in^2] ΔP : Pressure Differential [psi] S : Sp. Gr.	$Q=CA\sqrt{\dfrac{2g \cdot \Delta P}{\gamma}} \times 0.06$ Q : Flow Rate [ℓ /min] C : Compressibile Flow Coefficient [Dimensionless] (≒0.6) A : Passage Area [cm^2] g : Gravitational Acceleration [980cm/s^2] ΔP : Pressure Differential [kg/cm^2] γ : Specific Gravity [kg/cm^3] ($\fallingdotseq 0.87 \times 10^{-3}$)
Pressure Loss		$\Delta P=\rho \times g \times H \times 10^{-6}$ ΔP : Pressure Loss [MPa] ρ : Density [kg/m^3] g : Gravitational Acceleration [9.8m/s^2] H : Height [m]	$\Delta P=\gamma \times g \times H \times 10^{-4}$ ΔP : Pressure Loss [kg/m^2] γ : Specific Gravity [kgf/cm^3] H : Height [m]

Note: When performing calculations, make sure that you first convert values correctly. Cutting off and rounding up values can cause differences in calculation results.