Hydraulic Fluids Information

For Piston, Vane, and Valve Products

DENISON Hydraulics

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General Discussion

The purpose of this bulletin is to present general information concerning hydraulic fluids and their use in hydraulic systems. Denison Hydraulics, Inc. does not sell these fluids, but recognizes that customers must use them in hydraulic systems. The information presented herein is not intended to be used as a specific recommendation, but as a general guideline. For specific recommendations or warranties concerning the use of specific hydraulic fluids, please, contact the manufacturer of that fluid.

This bulletin assumes the reader has a basic knowledge of hydraulic fluids so that a "definition of terms" is not necessary.

Our past experience with fluids has shown that some fluid types work better than others in Denison Hydraulics, Inc. pumps and motors. Due to the enormous number of fluids and fluid types available today, it is impossible for us to test our products on each and every one. Because of the vast number of fluids available, Denison Hydraulics, Inc. has written hydraulic fluid standards HF-0 through HF-5, which describe characteristics of some of the different fluids. These standards have been sent to many of the hydraulic fluids manufacturers, and they have tested many of their fluids to these specifications. The manufacturers of these fluids can make the results of these tests available. The new generation of environmentally acceptable hydraulic fluids, also called biodegradable fluids, can be used with Denison Hydraulics, Inc. pumps, motors, and valves. Those fluids and recommendations are included in the Denison Hydraulics, Inc. SK-30320 specification.

General Recommendations

Viscosity Limits (piston and vane only)

Viscosity - SUS (cSt)		
	Piston	Vane
Maximum at cold start*	7500 (1618)	4000 (862)
Maximum at full power	750 (162)	500 (108)
Optimum at operating temperature	140 (30)	140 (30)
Minimum at full power**	60 (10)	60 (10)

* Cold start is defined as the lowest temperature the oil will see prior to the startup of the equipment. At cold start we recommend operating at low pressure, low volume, and low speed, until the fluid warms up to where the maximum viscosity at full power will not be exceeded. Too high viscosity grade fluid and medium temperature can cause fluid aeration or cavitation, which leads to pump damage.

** Consult Denison Hydraulics, Inc. for applications where fluid viscosity at full power is less than these figures.

Viscosity Index

Viscosity index (V.I.) is a measure of a fluid's viscosity change with changes in temperature. The higher the index the smaller the change in viscosity with a given temperature change. Denison Hydraulics, Inc. requires a minimum V.I. of 90 for all fluids. Higher values extend the range of operating temperature but may reduce the life of the fluid.

Temperature Limits

Temperature limits for each product line are listed in the individual product bulletins. Temperature range is a function of fluid viscosity, fluid type, and seal limitations. Rapeseed based oil minimum temperature should not be below –4 degrees Fahrenheit (-20 degrees Celsius).

Cold Weather Applications

Operating hydraulic equipment in cold climates requires special considerations. If suitable multi-viscosity fluids are not available, it may be necessary to either change fluids so that the appropriate viscosity limits are maintained or modify the system to maintain viscosity within appropriate limits.

Fluid Type	**Piston/Vane/Valve Products**
Antiwear fluids covered by HF-0 standard	Fluids of this type generally have antiwear additives, but the quantity and chemistry is such that the equipment can be used at the full catalog ratings.
Non-antiwear R & O fluids covered by HF-1 standard	These are the preferred fluids for our piston equipment. All catalog ratings and performance data are based on operation with this type of fluid. Full catalog performance capability and maximum life can be expected.
Antiwear fluids covered by HF-2 standard	The fluids meeting this specification are compatible with vane products, and can be used at maximum catalog ratings. Some of these fluids may not be suitable for use with piston equipment. Consult fluid's manufacturer for specific fluid recommendations.

Water-in-oil invert emulsion covered by HF-3 standard	The fluids meeting this specification are acceptable for use with the following limitations: Due to the higher specific gravity of these fluids, catalog absolute inlet ratings must be raised 25%; in no case, however, should the pump inlet pressure be less than 13.0 psia (approximately 3 in. –Hg vacuum at sea level) as cavitation may occur due to the low vapor pressure of the water in the fluid. Since these fluids have less lubricity than petroleum fluids, piston equipment should be operated at no more than 3,500 psi (2,000 psi on PV6 through PV29 units). Consult Denison Hydraulics, Inc. for operation above 3,500 psi. Maximum speed is 1,800 rpm.
Water glycol solution covered by HF-4 standard	The fluids meeting this specification are acceptable for use with the following limitations: Due to the higher specific gravity of these fluids, catalog absolute inlet ratings must be raised 25%; in no case, however, should the pump inlet pressure be less than 13.0 psia (approximately 3 in. –Hg vacuum at sea level) as cavitation may occur due to the low vapor pressure of the water in the fluid. Since these fluids have less lubricity than petroleum fluids, piston equipment should be operated at no more than 3,500 psi (2,000 psi on PV6 through PV29 units). Consult Denison Hydraulics, Inc. for operation above 3,500 psi. Maximum speed is 1,800 rpm.
Phosphate ester fluids covered by HF-5 standard	Use of these fluids requires the catalog absolute inlet rating be raised 35% to assure that cavitation does not occur. Lubricating properties of these fluids are generally comparable to petroleum fluids; so, catalog speed and pressure ratings still apply.
Biodegradable fluids covered by SK-30320 specification	Fluids of either ester base, rapeseed base, or polyglycol base can be used at full catalog pressure. Catalog ratings per HF-0, HF-1, & HF-2. Speed limits should be determined by using catalog absolute inlet ratings raised by 10%. Since water contamination has affected thermal stability, a water decantation fitting should be installed in the circuit.

Comparison of Solid Contamination Classification Systems (refer to "Particle Contamination" on page 5)

National Aerospace Standard (NAS) 1638															
Class															
		00	0	1	2	3	4	5	6	7	8	9	10	11	12
Particle Size Range	5-15 · m	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 · m	22	44	89	178	356	712	1,425	2,850	5,700	11,400	22,800	45,600	91,200	182,400
	25-50 · m	4	3	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
	>100 · m	0	0	1	1	2	4	8	16	32	64	128	256	512	1,024
Maximum Particles	>5 · m	152	304	609	1,217	2,432	4,864	9,731	19,462	38,924	77,849	155,698	311,396	622,792	1,245,584
	>15 · m	27	54	109	217	432	864	1,731	3,462	6,924	13,849	27,698	55,396	110,792	221,584

ISO: DIS 4406; SAE J1165																
ISO Solid Contaminant Code																
		8/5	9/6	10/7	11/8	12/9	13/10	14/11	15/12	16/13	17/14	18/15	19/16	20/17	21/18	22/19
Maximum Particles	>5 · m	250	500	1,000	2,000	4,000	8,000	16,000	32,000	64,000	130,000	250,000	500,000	1,000,000	2,000,000	4,000,000
	>15	32	64	130	250	500	1,000	2,000	4,000	8,000	16,000	32,000	64,000	130,000	250,000	500,000

Note: All measurements are for a 100 ml sample size.

Fluid Type	General Comments
Antiwear fluids covered by HF-0 standard	These types of fluids are intended for systems in which both piston and vane products are used, as both products can be operated at full catalog ratings. Recommended seals: Nitrile (Buna N)(Denison Hydraulics, Inc. S-1) Alternate seals: Fluorocarbon (Viton) (Denison Hydraulics, Inc. S-5) Temperature range: see product bulletin*

Non-antiwear R & O fluids covered by HF-1 standard	A typical example of this type of fluid is turbine oil. Recommended seals: Nitrile (Buna N)(Denison Hydraulics, Inc. S-1) Alternate seals: Fluorocarbon (Viton) (Denison Hydraulics, Inc. S-5) Temperature range: see product bulletin*
Water-in-oil invert emulsion covered by HF-3 standard (45% maximum water content) (95-5 fluids are not acceptable)	In general, this fluid is equal in performance to water glycol fluid. Recommended seals: Nitrile (Buna N)(Denison Hydraulics, Inc. S-1). Fluorocarbon seals are recommended for use with polyglycol base fluids. Alternate seals: Fluorocarbon (Viton) (Denison Hydraulics, Inc. S-5) Temperature range: see product bulletin*
Water glycol solution covered by HF-4 standard	In general, this fluid is equal in performance to water-in-oil invert emulsion. Recommended seals: Nitrile (Buna N)(Denison Hydraulics, Inc. S-1). Fluorocarbon seals are recommended for use with polyglycol base fluids. Alternate seals: Fluorocarbon (Viton) (Denison Hydraulics, Inc. S-5) Temperature range: see product bulletin*
Phosphate ester fluids covered by HF-5 standard	Because of the variety of phosphate ester fluids available, each application should be considered individually. Consult Denison Hydraulics, Inc. for information. Recommended seals: Fluorocarbon (Viton)(Denison Hydraulics, Inc. S-5). Some exceptions known to be incompatible with fluorocarbon are: Monsanto, Stauffer Blend G, Skydrol 500B, Skydrol 500C, Skydrol 7000, Skydrol LD, Pydraul 60, Pydraul 10E, and Pyrogard 53. These fluids require EPR seals (Denison Hydraulics, Inc. S-4). For other phosphate ester fluids, check with the fluid's manufacturer for seal compatibility. Temperature range: see product bulletin*
Biodegradable fluids covered by SK-30320 specification	Recommended seals: Nitrile (Buna N)(Denison Hydraulics, Inc. S-1) for ester and rapeseed base fluids. Fluorocarbon (Viton) (Denison Hydraulics, Inc. S-5) for polyglycol base fluids.

* Refer to "Temperature Limits" on page 2 and "Oxidation" on page 5, as well as the product bulletins. Contact Denison Hydraulics, Inc. for fluids not listed in this bulletin.

Fluid Maintenance

Optimum life from Denison Hydraulics, Inc. equipment can only be obtained with proper hydraulic fluid maintenance. This includes checking the fluid at the time of installation and an average of every three to six months, thereafter. The fluid should be checked for viscosity, oxidation, water content, additive depletion, and contamination. A record should be kept of each check to detect signs of progressive deterioration. For best results, fluid samples should be taken with the system operating at normal operating temperature. Most fluid suppliers will provide assistance in analyzing your fluid sample.

Viscosity

Many hydraulic fluids will shear or thin out with use. The viscosity at each check should be compared to the viscosity when new. At no time should the viscosity be outside the minimum and maximum operating limits. Check the specific product bulletin for these viscosity limits. If viscosity is outside these limits, proper corrective action should be taken. High VI improved fluids are particularly susceptible to viscosity breakdown, and should be checked more frequently. Consult your fluid supplier for a recommendation.

Oxidation

Fluid oxidation will occur with temperature changes and use, and is evidenced by a change in color and/or odor, increased acidity, formation of sludge, formation of gum, or formation of varnish in the system. The rate of oxidation increases significantly with operation at temperatures over 140-degrees Fahrenheit (60- degrees Celsius). The fluid should be checked more often if operation is at high temperatures. The oxidation process increases the acidity of a fluid, and is measured by a neutralization number. The oxidation process is typically slow at first, and then increases sharply in the final stages of complete oxidation. A sharp increase (by a factor of 2-3) in the neutralization number is a good indication the fluid is reaching the limit of its oxidation life, and should be replaced.

Water Content

Contamination of petroleum, biodegradable, and synthetic fluids by water can usually be detected by sampling the fluid at the bottom of the reservoir. Most hydraulic fluids readily separate the water, which will settle to the bottom of the reservoir. For biodegradable fluids, a water drain -off fitting is recommended to be installed at the lowest decantation point of the circuit. This water should be drained. Certain fluids (crankcase oil, transmission fluid, etc.) emulsify the water, but there is usually a detectable reaction such as coating on filters, a color change in the fluid, or some formation of particulate matter. Consult your fluid supplier for the proper corrective action in this case. For water-in-oil emulsions and water glycol solutions, it is essential that the proper percentage of water be maintained. With these fluids, the water can evaporate, with a resultant reduction in fire resistant properties. If the water content increases through condensation or other means, the fluid's lubrication properties are diminished. The fluid viscosity will usually change with a change in water content. A viscosity check of these fluids is a good way of detecting a change in water content. Consult your fluid supplier for the acceptable limits on water content, and the necessary corrective action, if needed, for your particular fluid.

Additive Depletion

Most hydraulic fluids contain additives to give better performance properties. These additives are used up in the system with use. Thus, the presence of adequate amounts of the necessary additives should be checked regularly, especially after repair or replacement of a component. Your fluid supplier should be consulted for information on maintaining the proper additive level.

Fluid De-aeration Properties

When pumps are operated at high working pressure with fast pressure cycle change, it is recommended to select fluids having the best de -aeration properties. Air in oil generates circuit temperature increase, pressure spikes, accelerated fluid aging, and component wear.

Particle Contamination

The NAS 1638 Class 8 specification defines the maximum contamination level recommended by Denison Hydraulics, Inc. for its equipment. This corresponds approximately to ISO 17/14. Refer to the NAS/ISO chart on page 3. Component life will be improved if you maintain an even cleaner system.

In most applications, a filter with a 10-micron (nominal) rating is adequate. It will not, however, guarantee the above standards for particle sizes smaller than 25-micron, due to the difference between nominal and absolute ratings. Applications with a highly contaminated environment may require the use of absolute ratings rather than nominal ratings on the filters. New hydraulic fluid, as received by the user, is generally not in a satisfactory cleanliness condition for long component life. The fluid should be filtered through a 10-micron (nominal) filter prior to it entering the hydraulic system. System filters should be checked on a regular basis, and elements changed as required. Filters with a dirt alarm are recommended. Inspect filter elements that have been removed for evidence of fluid deterioration and metallic deposits, indicating excessive component wear. Do not return system fluid that has leaked out.