

Monsanto

FROM NAME & LOCATION: D. R. Pogue - St. Louis General Offices

DATE August 31, 1970

cc L. R. Stark - LSTAR
NTJ/DFS/DAH

SUBJECT TURBINOL BULLETIN

REFERENCE

TO : C. L. Curtis
CCURT

Attached is the final copy for the Turbinol bulletin. The physical properties section has been changed as suggested by Texas Eastern to include:

- 1) Specific gravities and viscosities with variation in temperature.
- 2) Heat transfer data and electrical properties data are reported on a separate page. They should be incorporated in the bulletin under separate headings as originally planned.

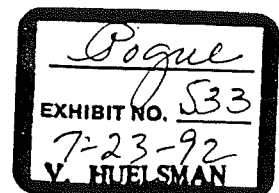
Hold printing until we get approval from Texas Eastern and Andy Smith, ASLE, to use Earl Farmer's comments. Thanks.

Don^{6b}
D. R. Pogue

1b

P.S. TITLE: FACTS ABOUT FIRE RESISTANT LUBRICANTS

SCAL 000155



- 1) Work in the remote station behind turbine for comparison. Also turbine so can't identify it as a GE unit
- 2) Eliminate "New Facts About" fr. Title.
- 3) Physical Properties Section (similar to Pydraul. list)

add

Appearance: Clear, amber colored x
oily liquid'

• Specific Gravity 1.34
25/25°C

• Neutralization No (Acidity) 0.02-0.1
(mg KOH/gm)

• Moisture (max) 0.15%

• Viscosity, Saybols
(Curve below)

② 210°F 37.1

② 100°F 108

② 40°F 2,160

Vapor Pressure 0.025 x
mm Hg @ 200°F

• Pour Point 0°F

Boiling Point 625°F x

• Secant Bulk Modulus γ
(psi) @ 100°F 412,000

Coefficient of Thermal Expansion 0.00037
cc/cc/°F

Specific Heat BTU/lb/°F
② 77°F 0.30

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Thermal Conductivity
BTU/hr/ft/°F

0.058

Stabilizing In Water

Negligible

4) Stabilizing & Corrosion Section

Use Typical Premium R-6 Turbine
oil Comparative Values for
Test

5) Use explanations below Test description
and general setup like found in
Hydraulic Selector

Add -

Low Pressure Spray Test

"Slight increase in flame intensity"

6) ~~Delete~~ Electrical properties

SCAL 000157

FIRE RESISTANT LUBRICANTS IN GAS TURBINES

By

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Presented during annual meeting of American Society
of Lubrication Engineers, Power Generation Council
Technical Session, Chicago, Illinois on May 4-7, 1970.

Paper submitted for publication in future issue of
Lubrication Engineer, official technical magazine
of A. S. L. E.

SCAL 000158

ABSTRACT

The following paper is a brief resume of our operating experience using fire resistant lubricants in industrial type gas turbines.

Basically, this article presents the reasons behind our decision to use the fire-resistant lubricants, a brief outline of the physical properties of the lubricants, and a general resume of our twelve years of operating experience while using the fire resistant lubricant.

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FIRE RESISTANT LUBRICANTS IN GAS TURBINES

The potential hazards inherent in using petroleum lubricating oils in high speed, high temperature gas turbine installations prompted Texas Eastern to investigate the applications of fire-resistant lubricants in our gas turbine installations. From our experiences, several potentially disastrous lube oil fires were prevented by alert operators who happened to be in the right place when turbine failures occurred. In another case, a turbine failure caused a lube oil fire, resulting in a complete station outage. A load compressor failure was responsible for another lube oil fire, which resulted in damages far more critical in the station operation than the compressor failure.

Still another hazard exists in the use of centrifugal pipe line compressors. These units require high-pressure seal oil systems with considerable external piping and controls. Even minor control and piping failures initiate emergency shut-down conditions, which, when using petroleum oil, necessitate the immediate shut-down of oil pumps to prevent feeding of possible fires. This means the high speed rotating elements must coast down with no lubrication, resulting in the strong possibility of wiped bearings. If the bearings are wiped badly, additional internal damage to the rotating elements and seals can result. Thus a minor failure can lead to a major station outage.

Advancing technology combined with rising operating costs led to the development and rapidly increasing use of automatic, remotely controlled, unmanned pipeline compressor stations. Obviously, this type of installation becomes most vulnerable to the potential hazards of lube oil fires. The obvious solution to these potential hazards is the use of fire resistant lubricants.

Early in 1958, Texas Eastern initiated a program to investigate the possible application of fire-resistant lubricants in our large gas turbines. Many articles had been published covering years of development and laboratory testing of fire resistant fluids. However, these fluids had not been applied in lubricating systems in any major turbine, gas or steam.

Fire resistant fluids were developed initially for hydraulic systems. As the problems of air compressor fouling and resulting fires became more prominent, fluids were developed that successfully eliminated this

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problem. With the progress and acceptance of the hydraulic and air compressor applications, the fluid manufacturers began to investigate potential applications in the steam turbine lubricating field.

At this time, fire resistant fluids offered for turbine application were divided, on the basis of formulation, into five general groups:

1. Pure Phosphate Esters.
2. Phosphate Ester Based.
3. Halogenated Mixtures.
4. Water and Glycol Mixtures.
5. Water and Oil Emulsions.

Of the five groups, the pure esters and the ester based fluids had shown the most promise, both in the laboratory and on paper; therefore, most of the small scale field tests recorded had been limited to these two groups. Our investigations were limited primarily to these two groups.

For evaluating the various fluids for our specific application, the following items were considered most important:

1. Viscosity.
2. Fire Resistance.
3. Lubricity.
4. Oxidation Resistance.
5. Field Performance Tests.

As to viscosity, the essential criteria was that the absolute viscosity of the fluid should match that of a 150 SSU @ 100°F. petroleum turbine oil at the maximum operating oil temperature of 180°F. Also, it is desirable for the viscosity curve to approximate the petroleum oil curve down to the lower operating temperature of 110°F. Finally, the fluid must exhibit comparable viscosity stability after many hours of severe service.

The fire resistant and lubricity properties of both the esters and ester based compounds are satisfactory. The fire resistant properties of these fluids have been published numerous times and are readily available from any of the fluid manufacturers. Among all fluid properties, fire resistance is the most difficult to measure and the most controversial. There have been many attempts to standardize fire test methods, and, although several similar test types have emerged from these attempts, there is still essentially no standardization. The fire resistant rating of a fluid can not be established by one or two tests alone, but must be evaluated from all the possible tests that are usually run. For example, the AIT (Autogenous Ignition Temperature) for our fire resistant fluid is 1130°F., while the AIT for Benzene is 1200°F. Obviously, Benzene is not a fire resistant fluid, but actually a specialized fuel. The major desirable fire resistant properties are the high Autogenous Ignition Temperature

in excess of 1100°F. and, because of their endothermic nature (verified by the Hot Manifold Test), the ability of the fluids to retard flame propagation. Laboratory testing for lubricity, wear, and sheer stability indicated that the lubricating properties of these fluids were adequate. These tests and tests on the fluid stability, foaming, oxidation, and corrosive characteristics of the pure esters and ester based fluids established that these fluids closely matched the desired qualities of a top grade petroleum turbine lubricant.

Besides meeting all requirements for satisfactory lubrication of the gas turbine and natural gas compressor rotating elements, those synthetics must also function as a seal oil in the gas compressor. Additional tests were conducted to determine the solubility characteristics of the synthetics when exposed to 1,000psi natural gas. Both esters reacted favorably in these tests.

Because of incompatibility with some types of materials normally used in gaskets, packings, seals, O-ring, paints, and electrical insulations, all five groups of the fire resistant fluids presented problems. The natural rubbers, Buna N, and Neoprene materials are generally unsuitable and should be replaced with compatible materials such as butyl, Viton A, nylon, silicone and Teflon. Most paints are not compatible with these fluids, therefore, surfaces normally in contact with the fluid must remain unpainted.

Considering the reluctance of turbine manufacturers to use unpainted oil reservoirs, the oxidation resistance of the fire resistant fluids becomes most important. It was decided that the ASTM oxidation test would give a good indication of what could be expected in an unpainted oil reservoir. Laboratory tests determined that some of the ester based fluids could pass the required 1,000 hour ASTM oxidation test required of the premium petroleum turbine oils. One specific fluid was on specification after 7,000 hours.

After reviewing all the literature and data available on the fire resistant fluids, it was decided that one of the phosphate ester based fluids met all our requirements. The physical properties of this fluid are tabulated in Table I, along with the properties of a typical petroleum oil and another fire resistant fluid, which will be discussed later.

SCAL 000162

TABLE I
PHYSICAL PROPERTIES OF TURBINE LUBRICANTS

<u>Property</u>	<u>Petroleum Oil</u>	<u>Phosphate Ester Base</u>	<u>Chlorinated Polyphenyl Ester Base</u>
Specific Gravity @ 77°F.	.871	1.40	1.335
@ 210°F.	.830	1.33	1.268
Flash Point, COC, (°F.)	340	385	360
Fire Point, (°F.)	455	660	560
Autogenous Ignition Temp., (°F.)	700	1160	1130
Neut. No. (mg KOH/gr)	0.14	0.07	0.05
Pour Point, (°F.)	0	15	0
Specific Heat, (BTU/#-°F.)			
@ 100°F.	.47	.319	.304
@ 150°F.	.50	.340	.318
@ 200°F.	.53	.360	.327
Viscosity, SSU			
@ 100°F.	155	166	108
@ 130°F.	86	70.5	65
@ 210°F.	43	37	37.1
Absolute Viscosity Centipose			
@ 100°F.	28.9	49.1	30
@ 130°F.	14.6	18.2	14
@ 210°F.	4.34	4.27	4.3
Oxidation Test	2000 HR	3000 HR	3000 HR

In 1958, Texas Eastern pioneered the use of fire-resistant lubricants in large, industrial gas turbines when we installed four 13,400 HP @ 80°F. units with the phosphate ester based fluid as the only lubricant. These units were installed in four isolated, unattended, remotely controlled stations that are used primarily for increasing gas deliveries during the winter months. These simple cycle, single shaft, two stage gas turbines operate at 4860 RPM and drive a two stage 30 inch by 30 inch pipe line booster compressor. Both the turbine and the load compressor are served by a common lube oil system built around the 2000 gallon turbine reservoir. The oil is pumped from the reservoir through a cooler and through a series filter system consisting of standard magnetic, knife edge, and full flow filters. The oil then flows from the filters into the various bearing systems and is returned to the reservoir. Basically, the oil systems operate with a normal bearing oil supply temperature between 110°F. and 130°F. and a bearing drain temperature of 175°F.

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The load compressor seal oil system is supplied by a positive displacement pump taking suction from the turbine lube oil header and discharging through a small filter bank to the seal oil control system. The seal oil is delivered at about 1000 psi to the compressor seals and the emergency seal oil tank. The return seal oil from the compressor is passed through a separator-accumulator to remove the entrained natural gas before returning to the reservoir.

Low pressure control oil is taken from the main lube oil header ahead of the system filters and passed through a small bank of micron filters before being fed to the control oil system.

Because of the high pour point and high viscosity at low temperatures, it is necessary to insulate outside storage tanks and related oil transfer piping. An immersion heater in conjunction with a small circulating transfer pump and a circulating loop maintains the storage system oil at a pumping temperature. These precautions are essential in our systems because make-up oil is automatically added. At some of our more recent stations, which are remotely controlled outdoors installations, reservoir heaters and heat tracing of oil lines was required to maintain the oil system at pumping conditions during down time.

Initial start-up of the first of these four units was a time anxiety over numerous unknowns. The turbine and gas compressor were the largest ever applied to pipeline operation and the compressor was a new design. The use of the fire resistant fluid as the only lubricant was a radical departure. Considering the lubricant as an unknown element, certain functions were observed closely to determine the action of the fire resistant lube oil in the system. Clear plastic cover plates were installed in the reservoir taps to observe any foaming tendencies. Further, oil temperatures and pressures were recorded frequently; bearing temperature differentials and vibrations were recorded at two to three minute intervals. Filter pressure drops were frequently checked for signs of filter clogging.

Incidents noted during start-up were control malfunctions, slight scoring of a major bearing, several worm gear failures, and hot bearings first at one location, then another. Each time, the initial blame was placed on the lubricant. However, in each case, other causes were established for each incident and when time came for start-up of the third and fourth units, the fire resistant fluid was no longer considered the unknown. In reviewing the start-up data, it was noted that all the lube oil systems operated as calculated. Oil foaming in the reservoirs was found to be less than normally experienced with petroleum oils. Filters reacted normally with a 4 to 6 psi pressure drop and normal build up rates. Seal and control oil systems, pumps and heat exchange equipment all reacted as designed.

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The temperature rises across individual bearings were observed closely as an indication of bearing action with the synthetic oil. Data indicated that the bearing temperature rises were some 2°F. to 7°F. higher using the synthetic fluid as compared to a petroleum oil. Vibration levels appeared to be lower with the synthetic fluid.

The quality of the synthetic oil was checked carefully twice per week during start-up operations. These quality control tests indicated that the oil was completely stable and remained on specifications. After the fourth station was completed and placed into service, all indications were that the fire resistant fluid had not all criteria for use in large industrial gas turbines.

To date, these four stations, with a total of 53,600 HP installed have operated for 86,000 hours without any problems associated with the fire resistant fluid. One of these units has operated in excess of 31,000 hours. Normally, these units are operated only during the severe winter months when our system is at its peak loads and are idle during the off load seasons. This intermittent service with long downtimes can be more severe on the oil than continual operation. This fire resistant fluid has proven excellent oxidation and thermal stability. To date, we have not experienced a single oil change caused by excessive oxidation in these four original installations.

Today, we have twenty industrial type gas turbines in service using the fire resistant fluid in the oil systems. These twenty units, with a total of 323,800 HP have operated in excess of 410,000 hours without any failures attributed to the fire resistant fluid. These units which have been installed during the past twelve years, consist of nine 19,800 HP units, three 18,500 HP units, four 13,400 HP units, three 8,000 HP units, and one 12,500 HP unit. Two of these units have logged over 67,000 hours of service each and two other units have operated in excess of 50,000 hours each.

As noted in Table I, the physical properties of a second fire resistant fluid were given. This fluid, our present gas turbine lubricant standard, is formulated with a chlorinated polyphenyl and a phosphate ester. Phosphate ester exhibit excellent lubricating properties in film lubrication, good viscosity-temperature characteristics and excellent fire-resistivity. the chlorinated polyphenyls exhibit poor viscosity-temperature characteristics, excellent fire resistivity, and excellent EPL or boundary lubrication. Therefore, the proper formulation of these two fluids has created a superior lubricant exhibiting the desired properties of both fluids. Since this formulation was introduced in the early sixties, we have phased out the original phosphate ester based fluid and now use this formulation exclusively.

SCAL 000165

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Our operating experience over the past twelve years has proven the fire resistant fluid used in our gas turbines to be extremely stable, both thermally and oxidatively. None of the units using this lubricant have experienced an oil change because of excessive oxidation. Periodic tests have indicated little change in the neutralization number. A coupling guard leakage at one station provided a practical test of the oil's fire resistance by spraying oil against a 700°F. exhaust housing with no fire resulting. Modifications and repairs by welding on oil piping within the oil tanks further demonstrated fire resistance.

Because of the added safety factor and the proven reliability and stability of the fire resistant fluid, it has become the standard lubricant in all our industrial type gas turbine installations placed in service since 1958.

SCAL 000166

FIRE RESISTANCE PROPERTIES

· High-Pressure Spray Test
(AMS 3150-C and Federal
Test Method Std. 791)

Localized flashing in contact with flame but self-extinguishing.

Low Pressure Spray
Test

Slight increase in flame intensity.

Hot Manifold Test
(Federal Test Method
Std. 791)

1300°F. Tube

Intermittent flashing on tube. Does not propagate flame to pan below.

950°F. Tube

Does not flash.

Molten Metal Ignition
(Aluminum alloy @ 1200°F.)

Does not ignite spontaneously. Flashes intermittently with ignition source, but self-extinguishes.

SCAL 000167

LUBRICATION PROPERTIES

	<u>Turbinol 153</u>	<u>Typical Premium R&O Turbine Oil</u>
<u>Four-Ball Wear Test</u>		
(mm scar diameter)		
620 rpm, 167 F., 1 hr.		
Steel/steel 10 kg	0.23	--
40 kg	0.53	0.6 to 1.0
Steel/bronze 10 kg	0.92	2.0 to 3.0
<u>Timken Test</u>		
Passing Load, lbs.	40	15
<u>Falex Load</u>		
Jaw Load, lbs.		
Torque, lb. inches		

SCAL C00168

ALCOR DEPOSITION TEST

48 hours, 250°F. fluid, 1000 ml/min. air flow @ 400°-475°F.
tube temperature.

	<u>Turbinol 153</u>	<u>Petroleum Oil</u>
Total Deposit Rating	10.5	10.5
Filter, mg.	10	13
Acidity, TAN Change	+ 0.03	+ 0.02
Viscosity % Change, 100°F.	15.6	5.8

SCAL 000169

STABILITY AND CORROSION PROPERTIES

	<u>Turbinol 153</u>	<u>Typical Premium R&O Turbine Oil</u>
<u>ASTM Rust Test D-665</u> 140°F. Distilled Water	Pass	Pass
<u>ASTM Emulsion Test D-1401</u> ml Emulsion after 30 minutes	0	0
<u>ASTM Foam Test D-892</u> Sequence 1	Pass	Pass
Sequence 2	Pass	Pass
Sequence 3	Pass	Pass
<u>ASTM Turbine Oil Stability Test D-943 (Modified^a)</u> Hrs. to reach 2.0 mg KOH/g	>2000	2000
<u>Hydrolytic Stability Test (MILH 19457 - Beverage Bottle Test)</u> 200°F. water, 48 hrs., Cu strip	Pass	Pass
<u>Oxidation/Corrosion Test</u> 168 hrs., 250°F., air		
<u>Metal Attack, mg/cm²</u> Al	-0.01	
Mg	-0.01	
Cu	-0.04	
Fe	0.0	
Cd	-0.01	
<u>Viscosity</u> % Change, 100°F.	+8.5	
% Change, 210°F.	+0.6	
<u>Acidity, TAN</u> Change	+0.02	

^aBecause of the higher specific gravity of these fluids, water used in the test would not settle to the bottom of the test cylinder. Hence, oxygen stream was saturated with water before being bubbled through the test fluid.

SCAL 000170

PHYSICAL PROPERTIES

Appearance	Clear, amber colored oily liquid
Specific Gravity 25/25°C	1.34
Neutralization Number (Acidity)(Mg KOH/gm)	0.02-0.1
Moisture (Max.)	0.15%
Viscosity, Saybolts (see p.2)	
@ 210°F.	37.1
@ 100°F.	108
@ 40°F.	2,160
Vapor Pressure (mm Hg @ 200°F.)	0.025
Pour Point	0°F.
Boiling Point	625°F.
Secant Bulk Modulus (psi) @ 100°F.	412,000
Coefficient of Thermal Expansion cc/cc/°F.	0.00037
Specific Heat BTU/lb./°F. @77°F.	0.30
Thermal Conductivity BTU/hr./ft./ °F.	0.058
Solubility In Water	Negligible

SCAL 000171

Solubility with Other Fluids

Other Phosphate Esters and
Phosphate-Ester Base

Soluble in all
proportions

Petroleum Oils

Soluble in all
proportions, but
petroleum oil can
reduce the viscosity
five times.

SCAL 000172

HARTOLDMON0042320

FIRE RESISTANCE PROPERTIESMonsanto Screening Tests

Flash Point, COC, °F

360

360

Fire Point °F

560

> 725

(none to boiling point)

Autogenous Ignition Temperature (ASTM D-2155)

1110

760

① High-Pressure Spray Test
(AMS 3150-C and Federal Test Method Std. 791)

Localized flashing in contact with flame

Intermittent flashing, but self-extinguishing.

② Low pressure spray test

but propagation < 12 inches

slight increase in flame intensity

③ Hot Manifold Test
(Federal Test Method Std. 791)
1300°F Tube

Intermittent flashing on tube. Does not carry flame to pan below.

Intermittent flashing, but does not propagate to pan below.

950°F Tube

Does not flash on tube.

Does not flash on tube.

④ Molten Metal Ignition
(Aluminum alloy @ 1200°F)
~~without spark~~

Does not ignite spontaneously. Intermittent flashing, self-extinguishing

Does not ignite spontaneously. Flashes intermittently with ignition source.

With sparking over surface

Flashes, self-extinguishing

Flashes, self-extinguishing until most of fluid vaporized; then burns to completion

page 5 cont

-continued-

SCAL 000173

FIRE RESISTANCE PROPERTIES
-continued-

U.S. Bureau of Mines'
Schedule 30 Fire
Tests: ^(a)

Minimum
Require-
ment

MCS 153

~~Pydraul~~
~~135~~ ^(b)

Pipe Cleaner Test,
Number of Cycles:

Fresh Fluid
Aged 2 hrs. @ 150°F
Aged 4 hrs. @ 150°F

24
18
12

>50
>50
>50

28
--
24

Temperature/Pressure
Spray Ignition Test:

Propane Torch
Electric Arc
{ Burning Kerosene-
Soaked Cotton

{ See
Schedule
30

Not run,
but fluid
would pass
all three
sequences

Pass
Pass
Pass

Autogenous Ignition
Temperature:

600

1130

760

^(a) Pydraul 135 meets the U.S. Bureau of Mines' fire-test requirements. It does not have official approval since required field tests in mining machinery have not been performed.

^(b) Pydraul 135 is listed with Underwriters' Laboratories, Inc.

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SCAL 000174

COMPATIBILITY CHARACTERISTICS OF PYDRAUL 135

Metals

Pydraul 135 is compatible with all common metals of construction. See Corrosion and Oxidation test results for aluminum, magnesium, copper, iron, and cadmium/iron specimens, page 8.

Packings, Seals, etc.

Viton o-rings, u-cups, chevron packings, etc. are recommended where dynamic sealing is required. Silicone, nylon and Teflon elastomers are equally compatible with Pydraul 135 for dynamic seals but these types may exhibit inadequate mechanical properties. For static seals and gaskets, butyl, Viton, asbestos, and leather are generally satisfactory. Oil-type seals (Buna N and neoprene) are sometimes used satisfactorily as static seals, but this practice is not recommended.

Hoses

Butyl-lined hoses are widely used and are recommended. Nylon and reinforced nylon hose has proved highly satisfactory with Pydraul 135 and MCS 153. Certain ethylene/propylene terpolymers (EPT or EPR types) are also satisfactory hose-liner materials. Viton- and Teflon-lined hoses are completely compatible but may be deficient in flexibility for some applications. Oil-type Buna N hoses are sometimes used but are not recommended.

Filters

Pydraul 135 can be filtered through 5 to 10 micron paper-type return-line filters without separation or other adverse effects. For fluid clean-up and/or reclamation, Fuller's earth or other active type Attapulugus earth filters are recommended. Three to five micron size filtration is recommended. Binders used with oil-type paper filters may be dissolved, however, and cured phenolic or epoxy binders are recommended.

Paints

Pydraul 135 is most commonly used in systems unpainted on the interior. Epoxy paints are compatible where painting is required.

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COMPATIBILITY
-continued-

heading
Solubility with Other Fluids

Monsanto Synthetic Fluids

Turbine
Pydraul 512 and MCS 151

Non-Monsanto Phosphate Esters

Houghto-Safe and Fyrquel

Other Phosphate Esters & phosphate base

Water/Glycols and Oil-in-Water Emulsions

Petroleum Oils

Turbine

Pydraul 135

~~Soluble in all proportions.~~

Turbine
~~5% ester is soluble in Pydraul 135 at room temperature, 10% is soluble at room temperature. Conversion normally involves simply draining old fluid and filling system with Pydraul 135 without flushing.~~

Turbine
~~Pydraul 135 is essentially insoluble in water-base fluids and vice versa. Conversion normally is accomplished by draining water-base fluid completely, flushing and operating with Pydraul 135 for several hours, draining flushing fluid and filling with final operating charge of Pydraul 135. The same flushing charge can be used several times.~~

Turbine
Soluble in all proportions, but petroleum oil can reduce the fluids' fire resistancy. Recommended conversion procedure is to drain oil, flush with Pydraul 135, drain and recharge with fresh Pydraul 135 as above.

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HEAT TRANSFER PROPERTIESTurbine
MC 153
XHydraul 135Specific Heat
BTU/lb/°F

60°F	0.297
100°F	0.304
150°F	0.318
200°F	0.327

0.319
0.331
0.347
0.362

Thermal Conductivity
BTU/°F/Ft/Hr

80°F	.058
------	------

.067

ELECTRICAL PROPERTIESTurbine
MC 153
XHydraul 135Dielectric Constant @ 25°C

@ 60 cycles/sec	6.52
@ 1,000 cycles/sec	5.94

-
4.62Power Factor @ 25°C, %

@ 60 cycles/sec	52.00
@ 1,000 cycles/sec	3.45

-
15.4Specific Resistivity (ohm-cm)

@ 25°C	1.7×10^{10}
@ 100°C	2.0×10^9

 2.9×10^9
-Dielectric Strength, KV

-

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COMPARATIVE PROPERTIES OF COMMERCIAL TURBINE FLUIDS

PROPERTY	150 SSU Grades				300 SSU Grades			
	MCS 153	Hydraul 135	Typical Premium R & O Turbine Oil	Straight Phosphate Ester ^a	Hydraul 312	Typical Premium R & O Turbine Oil	Straight Phosphate Ester ^a	Straight Phosphate Ester ^a
Specific Gravity @ 25°C	1.34	1.19	0.88	1.16	1.18	0.89	1.15	1.16
Viscosity, SSU at 40°F	2160	1600	2000	1100 est.	6750	3800	3400 est.	2500 est.
100°F	108	136.9	150	150	302	300	306	220
210°F	37.1	40.8	43	40	47.8	52	45.5	42
Viscosity Index	< 0	49	95	< 0	40	95	< 0	< 0
Four Point, °F	0	-12	+10	-10	-5	+20	+5	0
Fire Resistance	Yes	Yes UL Listed	No	Yes	Yes UL Listed	No	Yes	Yes
Major Components	Chlor- inated H.C.	Chlorinated H.C.; Phos. Ester; Sel. Pet. Fraction	Oil	Phos. Ester	Chlorinated H.C.; Phos. Ester; Sel. Pet. Fraction	Oil	Phos. Ester	Phos. Ester
Four-Ball Wear Test, mm Scar (620 rpm, 160°F, 1 hour)								
Steel/Steel, 40 kg	0.53	0.43	0.6 to 1.0	0.62	0.52	0.6 to 1.0	0.55	0.54
Steel/Bronze, 10 kg	0.92	0.48	2.0 to 3.0	-	0.43	2.0 to 3.0	-	-
Timken Test Max. OK Load, lb.	40	45	~15	-	60	~15	-	-
ASTM D943 Turbine Oil Stability Test (Hrs. to reach 2.0 acid no.)	> 2000	1986	> 2000	-	1986	> 2000	-	< 432
Hyder Gear Test, lb./in.	3800 est.	3125	2800		4275	2800 ^b		

^a Data was taken from published literature except Four-Ball Wear data, which was obtained at Monsanto Laboratories.

^b Leaded industrial gear oil, 4450 lbs./in.

SCAL CO0178

APPENDIX I