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Grammatical Corrections Only

GE Energy

Steam Turbine-Generator
EHC Fluid Specification and Maintenance

The following notices will be found throughout this publication. It is important that the significance of each is thoroughly understood by those using this document. The definitions are as follows:

NOTE

Highlights an essential element of a procedure to assure correctness.

CAUTION

Indicates a potentially hazardous situation, which, if not avoided, could result in minor or moderate injury or equipment damage.

WARNING

INDICATES A POTENTIALLY HAZARDOUS SITUATION, WHICH, IF NOT AVOIDED, COULD RESULT IN DEATH OR SERIOUS INJURY

*****DANGER*****

INDICATES AN IMMINENTLY HAZARDOUS SITUATION, WHICH, IF NOT AVOIDED WILL RESULT IN DEATH OR SERIOUS INJURY.

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I. INTRODUCTION

The EHC high pressure hydraulic system provides accurate steam valve control, overspeed protection, and safety against fires through the use of a synthetic phosphate ester fluid as a working medium. This document is applicable to tri-aryl phosphate ester fluids and might not be suitable in all regards to other fluid types. The fluid is a non-blended substance that looks and feels like a light mineral oil, with good lubricating properties and excellent stability. It is not to be confused with petroleum based hydraulic fluids and requires certain particular safeguards and procedures to maintain the desired degree of system reliability.

This write-up, in conjunction with other material included in the Instruction Book, is intended to supply the necessary information needed for purchasing and maintaining the EHC hydraulic fluid. Page 2 gives fluid specifications.

II. PURCHASING DATA

All fluid should be ordered to meet the requirements stated in section III.

Table 1. Ordering Information

GE Ordering Information	SUPPLIER	SUPPLIER'S DESIGNATION
302A9094P0001-4	ICL Industrial Products	Fyrquel EHC Fyrquel ECH+ Fyrquel EHC-S Fyrquel EHC-N
302A9094P0005-6	Forsythe Lubrication Associates Ltd.	Reolube Turbofluid 46XC Reolube Turbofluid 46B
302A9094P0005-6	Chemtura Corporation	Reolube Turbofluid 46XC Reolube Turbofluid 46B

The fluid can be purchased directly from the listed suppliers or can be placed through GE using the ordering information shown in Table 1. Flushing fluid and testing per table 2 can also be order through GE using ordering drawing 302A9094.

These products have shown the capability to meet the requirements of the specification through laboratory screening and field tests. It is the responsibility of the purchaser/supplier, however, to ensure that the fluid used meets the requirements of the specification.

A. Packing, Marking and Shipping

This material shall be packaged and shipped in sealed steel drums suitably lined (such as synthesize) to avoid contamination of the fluids. Drums shall be 55 US gallon [208 liter] capacity and shall meet ICC and carriers' regulations.

Each drum shall be plainly marked with the manufacturer's name or trade name, the batch number and the GE material designation in letters at least one inch high.

III. EHC FLUID SPECIFICATIONS

NEW FLUID (ORDERING DATA)

COLOR, ASTM, max	1.5
SPECIFIC GRAVITY, @ 60-68°F [15.5-20°C]	1.13-1.155
ISO VISCOCITY RANGE at 104°F [40°C], SUS [cST] for ISO 46 Grade	192-233 [41.4-50.6]
POUR POINT, max temp	0°F [–17.8°C]
WATER CONTENT, vol., %, max	0.10
ACID NUMBER, mg KOH/g, max	0.10
CHLORINE CONTENT, ppm, max	50
FLASH POINT, min	455°F [235°C]
FIRE POINT, min	665°F [352°C]
AUTO–IGNITION TEMPERATURE, min	1050°F [566°C]
RESISTIVITY[1], min, at 20°C	100 MΩm [$10x10^{7}$ Ω •m]
CONDUCTIVITY[1], max, at 20°C	$1x10^{-9}$ mhos/cm [$1x10^{-9}$ S/cm]
CONTAMINATION[2] (per 1 ml Fluid)	-/15/12

OPERATING FLUID

COLOR, ASTM, max	2.5-3.0
SPECIFIC GRAVITY, 60-68°F [15.5-20°C]	1.13-1.155
ISO VISCOCITY RANGE at 104°F [40°C], SUS [cST] for ISO 46 Grade	193-233[41.4-50.6]
POUR POINT, max temp	0°F [–17.8°C]
WATER CONTENT, vol., %, max	0.10
ACID NUMBER, mg KOH/g, max	0.20
CHLORINE CONTENT, ppm, max	50
FLASH POINT, min	455°F [235°C]
FIRE POINT, min	665°F [352°C]
AUTO–IGNITION TEMPERATURE, min	1050°F [566°C]
RESISTIVITY[1], min, at 20°C	100 MΩm [$10x10^{7}$ Ω •m]
CONDUCTIVITY[1], max, at 20°C	$1x10^{-9}$ mhos/cm [$1x10^{-9}$ S/cm]
CONTAMINATION[2] (per 1 ml Fluid)	-/15/12

1. Fluid shall only meet either resistivity or conductivity, not both.

2. The cleanliness limit of a representative fluid sample shall not exceed the maximum contamination limits listed herein. Refer to procedures ISO 11500 & ISO 4406.

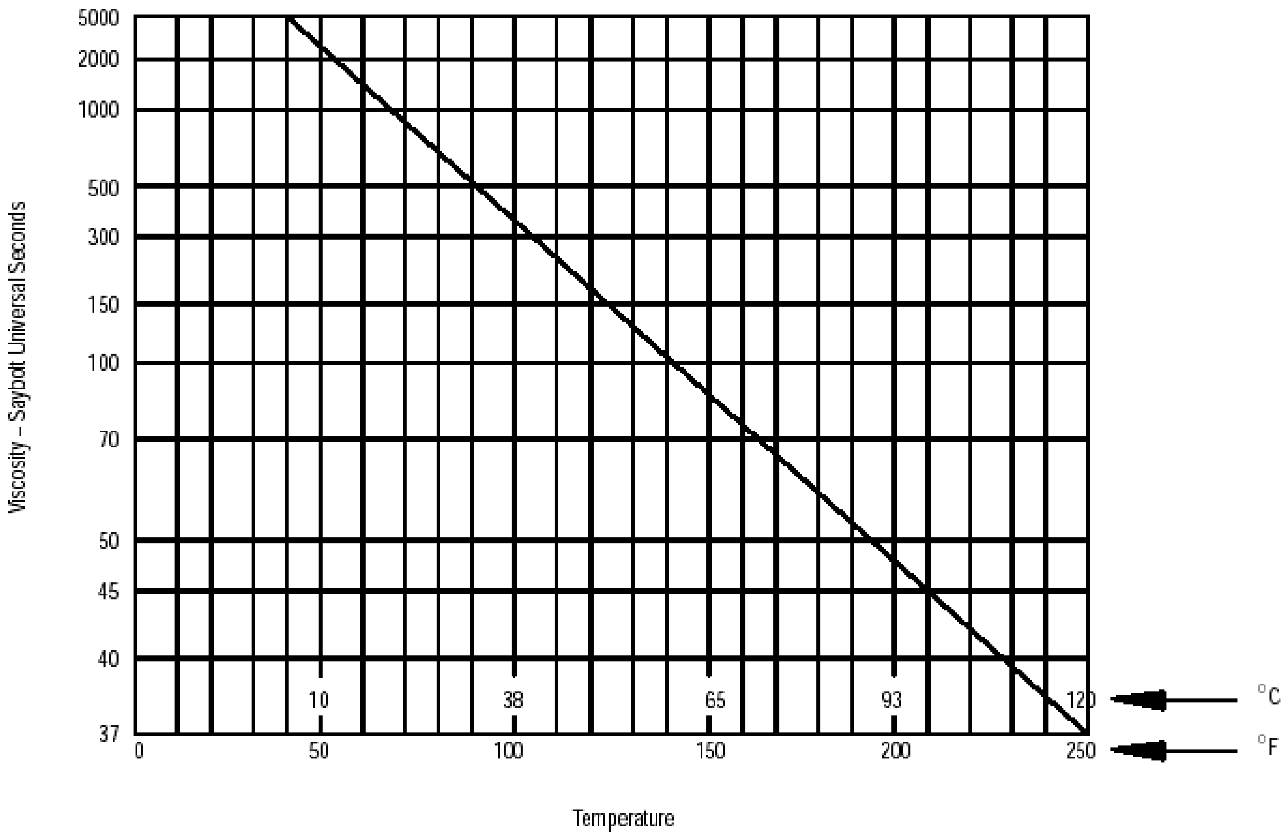

Figure 1. Viscosity - Temperature Chart

IV. FREQUENCY OF TESTING

The recommended periodic testing, warning limits and action steps are described in table 2.

Table 2. The Recommended Test Method, Limits, Frequency, Guide and Actions

Test	Warning limit	Frequency	Interpretation	Action steps
Appearance/Color -Visual/ISO 2049	Rapid Darkening	Every month	A slow darkening of the oil, while a sign of deterioration, is normal. A rapid darkening is not.	When color is >4 and acidity difficult to control at a low value, treatment with ion exchange resins may assist. Contact the filter manufacturer.
Acid number increase between consecutive analyses (mg KOH/g) -ISO 6619	0.1	Every month	Hydrolysis or oxidation taking place	Change the acid treatment cartridges. Check water levels and dry fluid if necessary. Take samples every 48 h until return to normal.
Water content (% m/m) -ISO 760/ISO 20764	0.1	Every month	Contamination	Check air breather and heat exchangers for proper installation, leaks or desiccant element condition. If Ion Exchange resin is used there may be a short period (1-4 weeks) when the water content is above the warning limit, it should be worthwhile to monitor the fluid in this scenario before any action is taken.
Cleanliness[1] -ISO 11500/4406	-/15/12 max	Every month	External (via tank) or internal contamination (fluid degradation/wear/filter malfunction etc.)	Check filtration system, tightness of reservoir covers; whether breather fitted correctly.
Mineral oil content (%)	0.5 max	Every 3 months	Contamination	Consider fluid change.
Mineral oil content -increase between consecutive analyses (%)	0.2	Every 3 months	Contamination	Review top-up procedures and possibility of cross contamination at valves.

Metal content (ppm) -ASTM D 5185/6595	10 max	Every 3 months	Contamination, corrosion, wear and adsorbent solids	Identify source and remove e.g. by resin treatment, fine particle filtration etc.
Resistivity at 20°C (MΩ.m) -IEC 60247	50 max	Every 3 months	Contamination (water/dirt), fluid ageing (acid)	Check top-up fluid. Correct water leakage. Change adsorption filters and take samples every 48 h until return to normal.
Air release at 50°C -ISO 9120	10 max	Every 6 months	Contamination or fluid ageing.	Investigate and correct any contamination. Consider fluid change
Kinematic viscosity at 40°C (mm^2/s) -ISO 3104	< ± 5 % of the initial value	Every 6 months	Cross contamination by a fluid of either lower or higher viscosity.	Check nature of contaminant and reduce /eliminate if possible. Identify source and/or ensure top up procedure is correct. If contaminant cannot be removed, consider fluid change.
Chlorine content (mg/kg) -NF EN 14077	50 max	Every 6 months	Contamination	If sea water contamination is suspected, checks leaks; change adsorption filters and take samples every 48 h until return to normal.
Foaming: Sequence 1 at 24°C (ml) -ISO 6247	200/0 max	Every 12 months	Pollution – ageing.	Check for presence of foam in the tank. Check contamination by dirt, water, metal soaps and correct.
(1) Cleanliness testing frequency and limit will depend on the system pressure and the presence of servo-valves.				

NOTE

Table 2 details the minimum recommended requirements for the frequency of testing of EHC fluids. In addition to these afore mentioned tests, other industry approved applicable frequency of testing could be carried out.

A. Reference Test Methods

Where possible it is recommended to use ISO test methods as mentioned in table 2; however other similar test methods are available and can be utilized at the sites or testing facilities agreement and discretion.

Table 1. Reference Test Methods

Property	ASTM/Other Test Method	DIN/IEC/IP	ISO Test Method
Color	ASTM D 1500	-	**ISO 2049**
Specific Gravity	ASTM D 1298	-	**ISO 12185**
Viscosity	ASTM D 445	-	**ISO 3104**
Pour Point	ASTM D 97	-	**ISO 3016**
Water Content	ASTM D 1744[1]	IEC 814	**ISO 760**
Acid Number	ASTM D 974/664[2]	DIN 51558/ IP 177	**ISO 6619**
Flash/Fire Point	ASTM D 92	-	**ISO 2592**
Auto ignition Temperature	ASTM D 286[1]/E 659/D 2155	DIN 51794	-
Contamination (Classification)	ARP 598/SAE 749[3]/ NAS 1638[3]	-	**ISO 11500/4406**
Chlorine Content	NF EN 14077	IP 510	**ISO 15597**
Resistivity	ASTM D 1169	IEC 60247	-
Conductivity	ASTM D 1125 (mod)[4]	-	-
Metal Content	Atomic absorption method	-	-
Flammability	-	-	**ISO 14935/ISO 20823**
Foaming Characteristics	ASTM D 892		**ISO 6247**
Air Release	ASTM D 3427	DIN 51381	**ISO 9120**

1. Not in the current ASTM handbook of standards.
2. ASTM D 974 is the colorimetric method. ASTM D 664 is the potentiometric method.
3. SAE and NAS Contamination methods are obsolete.
4. See section XIV part G. Note results from method may not equal IEC 60247 results.

NOTE

GE recommends using ISO test methods whenever possible. If the testing is not done at the power plants own laboratory the plant should provide the testing entity with a test sample with the following data: Plant identification, Fluid Brand/Trade Mark, Date and Operation time of fluid in use.

V. FLUID ANALYSIS

EHC Fluid Analysis may be arranged with any of the approved suppliers, all of who provide testing services.

VI. MOTOR CURRENT

A gradual rise of motor phase current over a period of time indicates normal servo valve wear accompanied by slowly increasing leakage; i.e., as more fluid is required, motor load will also increase. Motor current should be measured weekly.

The maximum recommended pump output for the turbine in steady–state condition is around half of rated pump capacity. If this level of current is exceeded, investigate and correct the cause of the high pump flow. Test the fluid for contaminants and neutralization number as recommended in this section. Most likely, worn control edges on the servo valves caused by a change in the fluid will prove to be the trouble. When such is the case, check all filters for cleanliness and, if necessary, change the filters in the auxiliary filter system.

VII. FLUID HANDLING AND SAFETY

A. Handling and Storage

The hydraulic fluid is supplied and shipped in sealed steel drums of 55 US gallon [208 liter] capacity or 46 Imperial gallon [210 liters], suitably lined (such as synthezine) to avoid contamination. Upon receipt they should be handled with sufficient care to avoid dropping or denting the barrels to prevent rupture of the lining.

Storage shall be inside in a dry location relatively free of dust and dirt. Ensure that each drum is tightly sealed.

NOTE

> Before uncapping the drums to add fluid to the hydraulic power unit reservoir, thoroughly clean the drum tops and caps with a suitable solvent (non-chlorinated) to prevent inducing contamination into the hydraulic system. Site should always fill system with provided fill hose via the TAFM/S system.

Reseal and store empty drums for future use in the event the HPU reservoir needs draining.

VIII. PHYSIOLOGICAL EFFECTS

The phosphate ester fluid exhibits excellent stability and under normal operating temperatures emits no harmful vapors. There have been no reports of toxic effects through continued exposure, provided certain guidelines are adhered to. For details of the physiological effects refer to the Material Safety Data Sheet of the supplier. Some general comments are provided here.

A. Oral Ingestion

Accidental swallowing or inhalation of mists is the chief potential sources of entry into the body and harmful effects can result. In the event of ingestion, seek medical attention immediately.

B. Eye Contact

Accidental eye contact can result in harmful effects. Seek medical attention immediately.

C. Skin Absorption

Exposure to the skin represents a very minimal hazard and standard sanitary practices will prevent any adverse health effects. No ill effects have been reported from occasional accidental intense skin exposure. Particular attention should be paid to thorough cleaning of the skin and removal of any soiled clothing if extensive and prolonged contact occurs.

WARNING

THE FLUID CAN BE HARMFUL. NO EATING OR SMOKING SHOULD BE ALLOWED WHILE WORKING WITH OR NEAR THIS MATERIAL AND PERSONAL CLEANLINESS SHOULD BE INSISTED ON.

IX. MATERIAL COMPATIBILITY

Most seal materials, paints, and packings commonly found in hydraulic systems using petroleum based fluids are NOT compatible with the phosphate ester fluid used in EHC high pressure hydraulic system.

CAUTION

Some commercial bulletins and catalogs list standard seals only and make no reference to seal materials for phosphate ester fluids. If there is any doubt concerning replacement seals for the hydraulic system, consult the GE Company. Control system malfunction or failure can result from the use of incorrect materials.

Material compatibility determinations for seals and packings are based on no more than 15% swell and less than 5% shrinkage. The test parameters are immersion in phosphate ester fluid at 140°F [60°C] for 168 hours.

Improper use of seals and packings can result in swelled or eroded materials, which can lead to fluid leaks or binding in moving parts.

All painted surfaces require special phosphate ester resistant paints and coatings. Standard coatings will soften and peel with a possible result of a system malfunction.

Packings, seals and coatings used in the high pressure hydraulic system along with acceptable substitutes are listed in the table below.

RECOMMENDED SEALS, PACKINGS, AND SURFACE COATINGS HIGH PRESSURE HYDRAULIC SYSTEM

Table 4. Material Selections

Seal	Material	Substitute Material
Accumulator Bladder	Viton, EPDM	Butyl rubber
Reservoir end – cover gasket	Fiber Sheet	None
Hydraulic cylinder rod seals, and wipers	Teflon, EPDM	None
O–Rings	Viton	EPDM, Butyl Rubber
Pipe–thread compound	Teflon	None
Paints and coatings	Amine–cured epoxy	None

A. Effect On Electrical Wire Insulation

EHC fluid will soften and eventually decompose some insulation materials. For example, polyvinyl chloride (PVC) may be made with phosphate esters as a plasticizer; therefore, soaking in EHC fluid will soften PVC. Insulated wire used in areas where the insulation may come in contact with EHC fluid requires an outer coating of material resistant to the fluid. The EHC fluid manufacturer recommends, Teflon, EPDM, nylon, polyethylene or polypropylene, but suggests that suppliers of the wire be contacted for specific cases as a multitude of insulation materials and grades are in use. In general, insulation containing PVC should be avoided in areas of possible EHC leaks. Wiring provided on EHC components likely to come in contact with EHC fluids is made with insulation impervious to EHC fluid, mainly GE Vulkene or Vulkaflex, and on more recent units, extruded Tefzel supplied by Quirk Wire Co.

The best prevention of trouble is obviously to avoid spills of EHC fluid onto electrical wiring insulation of unknown composition. In areas where spills onto wiring may occur (for example during maintenance) shielding of the wiring should be provided.

If wiring insulation of unknown composition has been accidentally wetted with EHC fluid it should be wiped clean with rags preferably wetted in a solvent that will remove EHC fluid and not harm the insulation.

Thereafter, the cables should be inspected periodically to determine if they are suffering slow deterioration.

WARNING

DO NOT USE INSULATION MATERIAL THAT WILL BE DECOMPOSED BY THE EHC FLUID.

X. FIRE RESISTANCE

General Electric’s definition of an EHC self-extinguishing fire resistant fluid is: a self-extinguishable (non-continuous burning) Class E fluid (See ISO 15029).

NOTE

Classification per ISO/DIS 15029-2 and continuous burning properties per ISO 14935, continuous burning means ignition persists longer than 60 seconds and/or if the test is not manually terminated, combustion continues until all fluid is exhausted

EHC fluid is a phosphate ester which is described as fire resistant but in no way can it be considered nonflammable.

If EHC fluid is allowed to leak out of the hydraulic system, it may in some areas be soaked up by the heat retention material on nearby components. The EHC fluid will then decompose when subjected to heat and the fragments may smolder which can lead to heavy smoke and causing further degradation.

The best method of avoiding fire hazards is to prevent EHC fluid leaks from occurring by following the operating and maintenance instructions and recommendations, and keeping the related equipment in a good state of repair at all times. In areas where the customer’s operating experience has shown that leaks may develop, the following is recommended to obtain additional protection.

- *Seal lagging material that could be exposed to leaking EHC fluid with finishing cement to provide a nonporous surface.*
- *Cover exposed lagging with aluminum sleeves to prevent entry of EHC fluid at the surface.*
- *Provide metal shields to drain spilled fluid away from lagging to collection points.*

WARNING

FIRE EXTINGUISHING PROCEDURES SHOULD BE FOLLOWED. EMPLOYEES SHOULD BE PROVIDED WITH PROPER PPE AND TRAINED TO HANDLE THE PPE.

A. Extinguishing of Lagging Fires

Should EHC fluid ever leak into lagging and be ignited as described above, the fires can be extinguished with foam, powder, carbon dioxide and even water; however, water is likely to cause very rapid cooling of hot steel parts and can lead to serve distortions or cracking. Use of water is, therefore, not recommended and one or more of the other extinguishing methods should be provided. If lagging must be cut away, it should be dropped into a container with a cover to stop further smoldering, decomposition and the emission of the smoke to the surrounding atmosphere. Handling of smoldering lagging requires that protective gloves and clothing be worn.

Combustion products from a smoldering EHC fluid flame are irritating and may be mildly toxic to people. In addition to carbon dioxide, carbon monoxide, water vapor and organic gases, phosphorous pentoxide can be formed. In the presence of moisture (for example, inside lungs), this can form phosphoric acid. People should be protected against prolonged exposure to these fumes. Firemen should be equipped with self–contained breathing apparatus, which effectively prevents inhaling of fumes.

WARNING

PROPER PPE AND TRAINING SHOULD BE PROVIDED. EMPLOYEES SHOULD BE TRAINED TO HANDLE THE SITUATIONS ARISING DUE TO THE RELEASE OF ECH FLUID. IN THE AREAS OF A POTENTIAL LEAK, IGNITION SOURCES AND HOT SURFACES SHOULD BE MINIMIZED AS MUCH AS POSSIBLE.

B. Recommendations

1. At least annually and more often if experience so indicates, review the EHC hydraulic system for fire resistant fluid leaks or potential leaks onto lagging and take the “Preventive Measures” described.

2. If risk of ignition of fire resistant fluid exists, instruct your maintenance and firefighting personnel about “Extinguishing of Lagging Fires.”

3. Review the electrical system in the neighborhood of the EHC hydraulic system and follow measures described.

XI. TROUBLESHOOTING UNACCEPTABLE FLUID

A major cause of contaminated EHC fluid is the addition of fluid from contaminated drums or totally foreign fluid to the reservoir. For this reason, many utilities now allow only factory sealed drums to be added to the reservoir. Details of how to add fluid to the system can be found in the hydraulic pumping unit instruction book article.

NOTE

If problems persist or additional information is required, contact the GE Company.

Table 5. Troubleshooting Methods

VARIABLE OUT OF SPEC	SOURCE	ACTION INDICATED
WATER CONTENT	Air Dryer	Ensure that there are no leaks past the Air Dryer.
	Air Breather	Investigate and replace the desiccant if necessary.
	Fluid Coolers	Leak test the fluid coolers. If leaks are discovered, the GE Company should be consulted for repair procedures.
	Acid Control Media	Change the acid control media and sample for water every 48 hours until the fluid water content returns to normal. Water content in the Ion Exchange Resin cartridges is normally high. After a change out, one should expect the water content to increase significantly. The plant should allow the level to fall naturally over 2-3 weeks before any actions are taken. If the level remains high the plant can utilize vacuum dehydration which rapidly removes the water (and any gases in the fluid) or by using the Stealth drying unit which acts fairly quickly and is much cheaper but does not remove dissolved gases from the fluid. Among these, Stealth drying is recommended. The Stealth air dryer can be purchased through GE and requires a hook up to the plants station air supply.

PARTICLE COUNT	External Contamination Entering System	Ensure that any make–up fluid added to the system meets GE specifications for new fluid. Check the reservoir to ensure all cover plates are in place and the system is sealed. When performing maintenance on the system, observe the utmost in cleanliness procedures. Change filters and strainers as required. Look for increase in motor current as evidence of a problem within the main pump or of increased flow due to high leakage. Potential problem areas include servo valves, solenoid valves, front standard trip valves, and pump or accumulator parts.
	Extreme Wear Rate in Portion of System	Remove a main pump suction strainer and check for large chips of steel or brass which would tend to indicate failed pump bearings or parts. Change filters and strainers as required. Ensure that high pressure fluid filters are operating effectively.
	Faulty high pressure filters	Indicated when sample taken from the system and reservoir are above recommended specifications for particulates and approximately equal (M + 10%). Investigate for missing or damaged O–rings or a ruptured element.

CHLORINE CONTENT	Chlorinated Solvents used during Maintenance Water Leaks	Discontinue the use of chlorinated solvents around the hydraulic system. Change acid control media cartridges and samples every 48 hours until chlorine level returns to normal. Investigate coolers for leaks. Change acid control media and take fluid samples every 48 hours until chlorine returns to normal.
ACID NUMBER	Fluid–Water Interactions	Investigate and correct any water leaks. Change acid control media cartridges and take fluid samples every 48 hours until acid number returns to normal.
MINERAL OIL	Addition of Petroleum–Based Fluids	Mineral oil content will lower the specific gravity and result in a decrease in the effectiveness of the fluid flammability characteristics. It can also result in increased foaming and greater air retention. It may be necessary to drain the reservoir completely. Use only GE recommended fluids as make–up. Contact the GE Company for specific recommendations.

XII. HIGH WATER CONTENT

High concentration of water in the EHC fluid can create serious control system problems. For this reason the following information is presented.

A. Fluid Dehydration Units

Where a charge of fluid is badly contaminated with water, a vacuum dehydration unit is the quickest way to dry the fluid.

Extensive laboratory test work has shown that EHC fluid can absorb up to 0.50% water in solution @ 110°F [43.3°C]. The suggested maximum allowable water content in the EHC fluid is 0.20% and should be expected to rise for a short period of time after an Ion Exchange cartridge change out. Conventional filtration (Absorption/Adsorption) supplied on the EHC–HPU has been found to be only partially successful in removing water in solution. To prevent the costly expense of replacing a batch of water contaminated EHC fluid, a review and field evaluation has been made of commercially available equipment that will dehydrate EHC fluid by removing water in solution. Where Stealth Dryer units are installed vacuum dehydrators should be unnecessary.

Hilco – "Hilco Oil Reclaimer"

Model # – 02R050 or 02R100

Vendor – The Hilliard Corp. (www.hillardcorp.com +1-607-733-7121)

100 W. Fourth Ave.

Elmira, N.Y. 14901

It is important to understand that the devices described herein remove water, and to some extent, particulate contamination. They do not "recondition" (make like new) the fluid. Chlorine content, conductivity, neutralization number and other parameters determine overall fluid system compatibility, and control of these factors cannot be reliably accomplished by the devices described herein. "Reclaimed" EHC fluid should not be used unless each batch has been found to comply with all aspects of the EHC fluid specification.

Both pieces of equipment are portable and fully equipped with their own motor–driven suction, discharge and vacuum pumps. The equipment can be used to dehydrate a batch of fluid contained in the HP unit main reservoir or individual drums of water–contaminated fluid. To connect the system, all that is required is an electrical power source and pump suction, and discharge lines, for example 1, [25 mm] OD tubing from the conditioner to the fluid reservoir or drum. For drying a batch of fluid in the main reservoir, a spare connection on top of the reservoir can be used for the pump suction and the fluid discharge can be temporarily located through either an inspection cover or the mounting plate for a level gauge.

Water removal is accomplished by vacuum dehydration, and for either conditioner, 24–36 hours of continuous operation should reduce the water content below the specification requirement when treating a batch of fluid in the main reservoir.

A comprehensive set of literature covering the fluid conditioner principles of operation, etc. can be obtained from the vendors listed.

XIII. OBTAINING FLUID SAMPLES

A. Scope

The method covers the required procedure for obtaining EHC hydraulic fluid samples while the EHC system is in operation. Fluid analyses are to be performed to ascertain system fluid cleanliness levels as well as diagnose any potential malfunctions. ISO 3170 explains techniques for sampling of fluid from reservoirs and lines. If ISO 3170 is not used the site personnel at a minimum should use the following guidelines.

B. Significance

The procedure should provide samples for laboratory analysis that are representative of the fluid in the high pressure system. The use of trained or knowledgeable personnel is highly recommended as carelessness can introduce contaminants that will result in erroneous results. Samples obtained will be processed for the desired results as outlined under each respective section for Particle Count, Water Content, Chlorine Content, Acid Number, Mineral Oil Content, and Specific Gravity. Should any one sample show a large increase (25% or more), several samples show a gradually increasing trend, or maximum limits be exceeded, then corrective action should be initiated.

C. Preparation of Bottles, Test Apparatus and Reagents

1. Filter reagents such that a 100 ml sample in a blank analysis shows a particle count of not more than 10% of an acceptable fluid test.

2. Wash all apparatus thoroughly in hot water and free rinsing detergent (if possible an automatic dishwasher would be preferable).

3. Rinse twice with at least 50 ml of filtered distilled water.

4. Rinse twice with filtered isopropyl alcohol to remove the water.

5. Rinse with filtered solvent and allow a small quantity to remain in the bottle.

6. Bottles should have an inside section of plastic wrap (doubled) immediately placed over the top and the cap tightened without tearing the plastic film.

7. All sample bottles should be labeled as to customer, station, unit number, date, and location of sample (reservoir, after high pressure filters, skimmed off of top of reservoir, etc.).

D. Sampling Procedure

The hydraulic power unit should be in operation with the system at steady–state conditions (normal operating temperature and rated pressure) to ensure thorough mixing of the fluid for a representative sample. The minimum circulation time needed to accomplish this is approximately one hour.

It is recommended that for all investigations a 500 ml reservoir sample be taken for a complete fluid analysis and a separate 200 ml system sample be taken for only a particle count analysis at the fluid sample port (part of the cooling/conditioning manifold). In this way, a comparison can be made between the cleanliness of the fluid going to the system and that returning from the system.

E. Reservoir Sampling

1. Set the bypass filtration unit as follows:

   Open valves at inlet and outlet (if provided) of filter pump.

   Close valves at the inlet to the acid control media, the bypass valve around the acid control media, and the valve on the fluid fill connection (if provided).

   All other valves may remain in their normal position for bypass filtering.

2. Wash sampling valve outlet with filtered solvent from a wash bottle.

3. With the bypass filter pump running, open the sampling valve and allow between 500–1000 ml of fluid to purge the valve and lines before taking the sample. Catch the fluid in a bucket and discard.

4. Remove the cap and plastic wrap from the sample bottle and immediately fill the bottle from the flowing stream. Do not let the sample bottle and valve touch. Under no circumstances should the sampling valve be operated or any fluid lines are touched while the bottle is being filled.

5. Remove the bottle from under the flowing fluid before closing the sampling valve and immediately replace the plastic wrap over the bottle mouth and tighten the cap.

6. Return the bypass filtration unit to bypass filtering.

F. Sampling By Dipping

Whenever the water content of a sample taken by the method outlined in Steps 1 through 6 is 0.2% or larger, the probability exists for free water to be in the system. This procedure is used for investigating for free water in the reservoir.

1. Thoroughly clean the area around the reservoir top cover plate (when provided) and remove the bolts, or, if an inspection cover is not provided, remove the top–mounted level alarm.

2. Lift the cover and dip or skim a sample from the surface of the fluid using a clean bottle attached to a rod or a commercial “Grab Sampler.”

3. Check the cover gasket for damage and replace if necessary, then rebolt the cover in place.

4. Any free water will be evident on the sample as a layer floating on the surface of the hydraulic fluid.

If surface water is found in the reservoir, water is definitely entering the system and immediate action must be taken to alleviate the situation.

System Sampling – After high pressure filters (applicable to units having a cross connection from the main supply header through a flow control valve to the bypass filters).

Shut down the bypass filter pumps and set the bypass filter system as follows:

Close valves at the inlet to the fuller’s earth filter, the bypass valve around the filter, at the pump discharge (if provided) and fluid filling connection (if provided).Open valve ahead of flow control valve.

All other valves may be left in their normal position for bypass filtering.

Follow the procedures outlined in Steps 2 through 6 for taking the sample. This sample will be representative of the fluid going to the hydraulic system after passing through the high pressure filters, and as such a comparison of particle count data with that obtained by Steps 1 through 6 yields a relative effectiveness of the high pressure filters.

XIV. RECOMMENDED AND ALTERNATE TEST PROCEDURES FOR FLUID ANALYSIS

The following section describes, in detail, the procedures which must be followed to obtain a meaningful fluid analysis.

Any properly equipped chemical lab should, using the following procedures, be able to generate the data required for comparison to the specifications presented on Page 5. If such a lab is not available the fluid supplier may be contacted as a source for analysis.

A. Procedure For the Determination of Particulate Contamination

ISO 11500, Hydraulic fluid power - Determination of the particulate contamination level of a liquid sample by automatic particle counting using the light-extinction principle

B. Procedures For the Determination of Water Content

The maintenance of low levels of water quantities in the hydraulic fluid is important to prevent rusting of exposed metal parts and sludge buildup in the EHC hydraulic system. The maximum allowable water content for in–service conditions is 0.2% by volume. In accordance with this GEK, new EHC fire resistant hydraulic fluid may contain up to 0.10% water in solution.

Reservoir water content should be determined on a monthly basis and a log kept. If the water content of the fluid shows a steady increase over several months, any one sample increase by 25% over the previous or the content goes above 0.2% by volume, then water is entering the system either through the air dryer or fluid coolers and these should be investigated (Reference "Hydraulic Power Unit," elsewhere in the Instruction Book). After an Ion Exchange resin change out water content is expected to rise and should not be a cause for immediate concern.

C. Procedures For the Determination of Chlorine Content

High levels of chlorine in hydraulic systems have been associated with increased servovalve erosion and the deterioration of certain seal and gasket materials.

New fluid specifications stipulate a maximum of 50 ppm. To ensure safe levels of chlorine in the system, samples should be taken and tests conducted monthly. If the level suddenly increases by 25%, a gradually increasing trend develops, or the maximum limits are exceeded, then the minimum test frequency should be every 48 hours, accompanied with fuller's earth changes.

Chlorine can enter the system through the use of chlorinated solvents, water leaks, or other fluid interactions. In the event of difficulty, these potential sources should be investigated and the GE Company consulted.

Some of the accepted procedures for the determination of chorine in EHC fluid are: X-ray florescence (XRF), Microcoulometry and Neutron activation method. The X–ray fluorescence method, described in ISO 15597.

D. Procedure For The Determination of Acid Number

The acid number is a measure of this amount of acidic substances in the oil under the conditions of the test. The acid number is used as a guide in the quality control of hydraulic oil.

The international standard, ISO 6619: Petroleum products and lubricants – Neutralization number – Potentiometric titration method, describes a method for the determination of acidic constituents in petroleum products. This international method is the preferred one to determine acid number of phosphate ester hydraulic fluid.

E. Procedures For the Determination of Mineral Oil Content

Concentrations of mineral oil greater than 4% may attack certain seal materials in the system and will reduce the nonflammable characteristics of the hydraulic fluid. The suggested method is Thin Layer Chromatography, alternate methods are detailed below:

1. **Materials Needed**

   Mixing cylinder, 250 ml (with T stopper, graduated in 2 ml subdivisions)

   Concentrated sulfuric acid, 95–98%, 10 ml

   Test Sample, 200 ml

2. **Procedure**

WARNING

WEAR SAFETY GLASSES AND PROTECTIVE CLOTHING WHILE CONDUCTING THIS TEST.

   a. Fill graduated mixing cylinder with test sample to 200 ml mark.

   b. Add CAUTIOUSLY 10 ml concentrated sulfuric acid to test sample.

   c. Stopper and shake the graduate gently for 30 seconds. Heat generated by the solution will warm the cylinder slightly.

   d. Vent the cylinder, then stopper and shake it vigorously for 60 seconds. The fluid will take on a murky appearance.

   e. Remove the stopper, and allow the cylinder the stand for 4 days minimum.

   f. Inspect the contents after 4 days. If oil is present, a clear separation will be visible at the top of the fluid. If no oil is present, no change in appearance will be evident other than the original murky appearance described in Step d.

   g. If oil is present, record the separation volume (in ml of oil) to the nearest ml.

   h. Calculate the percent of oil present from

$$\frac{\text{Separation volume, ml}}{2}$$

3. **Alternate Procedure**

   The specific gravity of Fyrquel 220 is 1.14 at 75°F [23.9°C] and that of petroleum oil 0.86 to 0.90 at 75°F [23.9°C].

   If the specific gravity of a test sample is less than 1.14 at 75°F [23.9°C], petroleum oil contamination should be suspected. The extent of contamination will depend upon the original gravity of the petroleum oil. This value must be known so that the degree of contamination can be calculated or determined by comparing it with samples of known oil content.

Using the specific gravity method, percent turbine oil is equal to

$$\frac{100C - 100M}{C - T}$$

where:

C = Specific gravity of new EHC fluid

T = Specific gravity of oil suspected as contaminant

M = Specific gravity of mixture (measured)

F. Procedures For Determination of Resistivity

IEC 60247 is the recommended procedure for determination of resistivity.

G. Procedures For AC Conductivity Measurement

For general background refer to ASTM D1125, method A, modified here for use with EHC fluid instead of water. Materials Needed

Wayne Kerr 6500B Precision Impedance Analyzers or 4300S LCR Meters or 3260B Precision Magnetics Analyzer series. (Wayne Kerr Electronics, www.waynekerrtest.com, sales@waynekerr.info, 1-800-933-9310)

Conductivity cell, flow through, with a cell constant of 0.0100/cm or less (Beckman D001 or the equivalent).

Separatory funnel or dropping funnel, 100 ml minimum volume, with stopcock.

Latex tubing (or other tubing unaffected by EHC fluid) to connect funnel to cell and cell exit to sample receiver.

Distilled water and reagent grade acetone for cleaning funnel, tubing, and conductivity cell.

4. Procedure

Null the AC bridge and attach the proper leads to the conductivity cell (see instructions with bridge). There will usually be four bridge leads; two are attached to the conductivity cell leads and the other two are connected to one another.

The EHC fluid sample of at least 100 ml should be poured into the separatory or dropping funnel with the stopcock off. The latex tubing from the funnel should drop down to the conductivity cell inlet. The cell should be adjusted so that it is tilted slightly above a horizontal position so that fluid flowing into it covers the plates and fills most of the cell before it flows out the exit tubing down to the catch bottle or container. The catch bottle should be clean and dry so that the fluid may be poured back into the dropping funnel to maintain a longer flow through the conductivity cell if needed.

Open the dropping funnel stopcock and adjust the fluid flow to a convenient rate. A steady flow, not drops, should come off the exit tube. After the conductivity cell is filled with fluid and it is flowing out of the cell, begin balancing the conductance and capacitance on the AC bridge. Once balance is achieved, stop the fluid flow, record the conductance, pour the fluid from the catch container back into the dropping funnel, and disconnect the bridge leads form the conductivity cell leads.

Null the AC bridge again. Reconnect the bridge leads, let the fluid flow again, and after it is clearly flowing out the exit tubing from the cell, balance the bridge again. This gives two conductance readings which should be averaged. If they do not agree within at least +3 digits in the second significant figure, run through the procedure again. The averaged conductance multiplied by the cell constant is then the EHC fluid conductivity. (If a bridge is used that measures resistance in ohms (Ω), then take the reciprocal of the average of a satisfactory pair of readings to obtain conductance).

After two satisfactory readings are obtained, drain the fluid out of the dropping funnel, tubing, and conductivity cell. Flush each of these items thoroughly with acetone to remove residual EHC fluid, and then flush thoroughly with distilled or doubly deionized water to remove any water soluble material. Flush once more with acetone and purge, and then blow dry with a clean stream of compressed air or nitrogen. Be sure that all water and acetone is removed from the inside of the dropping funnel, tubing, and conductivity cell. If there is any doubt about the cleanliness of the equipment, it should be cleaned in this way before use.

The AC conductivity measured in this way will usually be in the range of 2 x 10–10 to 5 x 10–10 mhos/cm [2 x 10–10 to 5 x 10–10 S/cm]. If the AC conductivity increases to 9 x 10–10 mhos/cm [9 x 10–10 S/cm], the fuller's earth filter cartridges should be changed as described in "Changing the Fuller's Earth Filter Elements." The maximum AC conductivity permitted is 1 x 10–9 mhos/cm [1 x 10–9 S/cm].

NOTE

The AC conductivity bridge used in this test must work at a minimum of 60 Hz and preferably closer to 100 Hz. It must read conductance at least to the order of 1 x 10–9 mhos [1 x 10–9 S] or resistance to at least as high as 1 x 109 ohms [1 x 109 Ω]. It is necessary, at these low conductance or high resistance levels, to have a variable capacitance in the bridge which is balanced simultaneously with conductance or resistance; a fixed capacitance will not do here as it is used in most AC bridges measuring lower resistances or higher conductances. The Wayne–Kerr B221 and B224 meet and exceed these requirements.

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