



# **General Electric Steam Turbine EHC Fluids – Lessons Learnt**

**Ken Brown  
February 18, 2021  
Canoil Canada Ltd.**

# CANOIL CANADA LTD



- Canoil is owned by 3 partners that have been in the chemical and lubrication business for more than 35+ years each.
- Canoil Canada Ltd was established in 2002 with the acquisition of Canoil/Cortek Ltd (1985-2002). Canoil has grown to be a global supplier of grease and lubricant products.
- Canoil is ISO 9001:2015 & Z299.3 certified.
- Canoil has the rights to MOV LONG LIFE® grease used in nuclear safety related equipment. Also MOV EXTRA® is used in industrial and commercial related equipment.
- Canoil has the rights to VSG® 'The Green Grease' used at hydro dams throughout the world. Canola oil based and specifically designed to lubricate wicket gates.



- Canoil Canada Ltd has a dedicated packaging plant that packages grease & lubricants in various containers for many of the major oil manufactures.
- The packaging plant is certified under Halal, Kosher, and NSF H1

# CANOIL CANADA LTD



What does Canoil Canada have to offer?

- North American distributor of the Reolube Brand – product is in stock and warehoused in Toronto – product can normally ship out within 24 hours and be delivered anywhere in North America in 2-5 business days. Plus. some stocking in the US.
- Can provide fluid analysis and in-depth reporting with comments.
- Can provide technical assistant with the fluid monitoring.
- **Our goal is to help increase the longevity and improve the condition of your fluid. Having to change out the fluid should not be required.**



# BIOGRAPHY

## KEN BROWN



Ken is a P.Eng. with a BASc and MASc in Mechanical Engineering from the University of Waterloo. He is an active member of STLE (has his CLS) and ASTM D2. From 1976-1993 he was with Ontario Hydro's (now OPG) Power Equipment Department of D&D working on bearings, lubes, seals and EHC fluids for new and existing fossil and nuclear power stations.

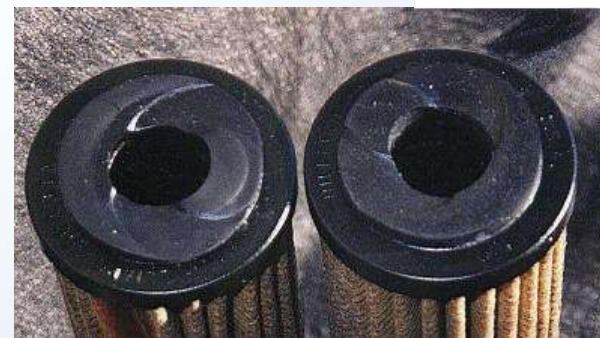
For EPRI, Ken has contributed to several lube notes and was the main contractor for their EHC fluid maintenance and the EHC fluid compatibility guides. He continues to provide day to day technical support to Canoil and others as well as being a repeated speaker at EPRI TGUG and CBM workshops.

# TOPICS



- Introductions
- Why Phosphate Esters
- What Are Phosphate Esters
- GE Legacy EHC Skids
- Fluid Testing
- Lessons Learnt
  - Dark Fluid
  - High Acid Number
  - High Particle Count
  - Low Resistivity
  - High Water Content
  - MPC and Phenols
- Questions

# WHAT WE WANT TO HELP PREVENT...



# PHOSPHATE ESTER **EHC** FLUIDS

ICL	LANXESS		
Fyrquel EHC-N (was EHC)	Turbofluid 46XC, 46SJ and Reolube 46RS (was OMTI)	Trixylenyl Phosphate Ester (TXP)	Lowest air release times and good hydrolytic stability
Fyrquel EHC-S <b>EHC Plus</b>	<b>Turbofluid 46B</b> (Durad EHB)	Butylated Phenol Phosphate Ester (TBPP)	Good oxidation resistance
Fyrquel EHC	-	Blend of butylated phenol and trixylenyl phosphate ester	Compromise of the natural and synthetic



# DIFFERENCES FROM MINERAL OILS



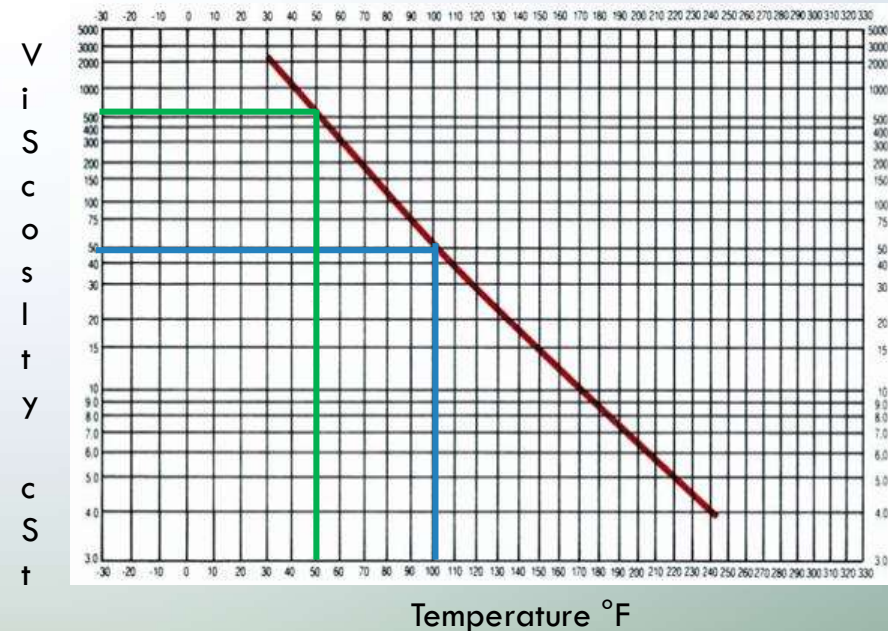
- Higher specific gravity – 1.13 vs 0.86
- Lower viscosity index – 20 vs 90 or more
- Good wear protection without additives
- Good oxidation resistance but can have poor hydrolytic stability
- Much more fire resistant!
- Good plasticizers so different elastomer compatibilities

# EHC FLUID VISCOSITY - TEMPERATURE



Triaryl phosphate ester fluids like those used in EHC systems have a very low Viscosity Index (VI). This means that the viscosity really increases as the temperature drops and really decreases as it rises.

This is not normally an issue during operation but must be considered when adding cold fluid from a drum or starting a unit. The turbine OEMS usually have minimum fluid temperatures before running pumps or other equipment.



ISO 46 @40C (104F)

**Note:** If the fluid is cold before adding any fluid take the drum up to the turbine deck or some warm place to let it warm up. This might take a day. You can also get strap-on drum heaters and drum heater enclosures.

# ELASTOMER COMPATIBILITY CHART



MATERIAL	SEALS, HOSES, AND BLADDERS	WIRE AND CABLE INSULATION	PAINTS
ACRYLONITRILE BUTADIENE STYRENE (ABS)	U		
ACRYLIC			U
ALKYD PAINT (STOVED/BAKED)			S
BUTYL RUBBER	R		
ETHYLENE PROPYLENE RUBBER (EPR & EPDM)	S		
EPOXY PAINT (CURED)			R
NATURAL RUBBER (NR)	U		
CHLOROPRENE RUBBER (CR) NEOPRENE	U		
NITROCELLULOSE			U
NITRILE BUTADIENE RUBBER (NBR) BUNA N	U		
NYLON (PA66)	R	R	
PHENOLIC RESINS			U <sup>2</sup>
POLYETHYLENE (PE)		A	
CHLORINATED POLYETHYLENE	S <sup>1</sup>		
POLYPROPYLENE (PP)		A	
POLYURETHANE			S
POLYVINYL CHLORIDE (PVC)	U		
SILICONE RUBBER (VMQ)	S <sup>1</sup>	A	
POLYTETRAFLUORETHYLENE (PTFE) TEFLON	R	R	
FLUOROCARBON RUBBER (FPM) VITON	R		

**Do not  
use  
Buna N**

Many are  
okay.

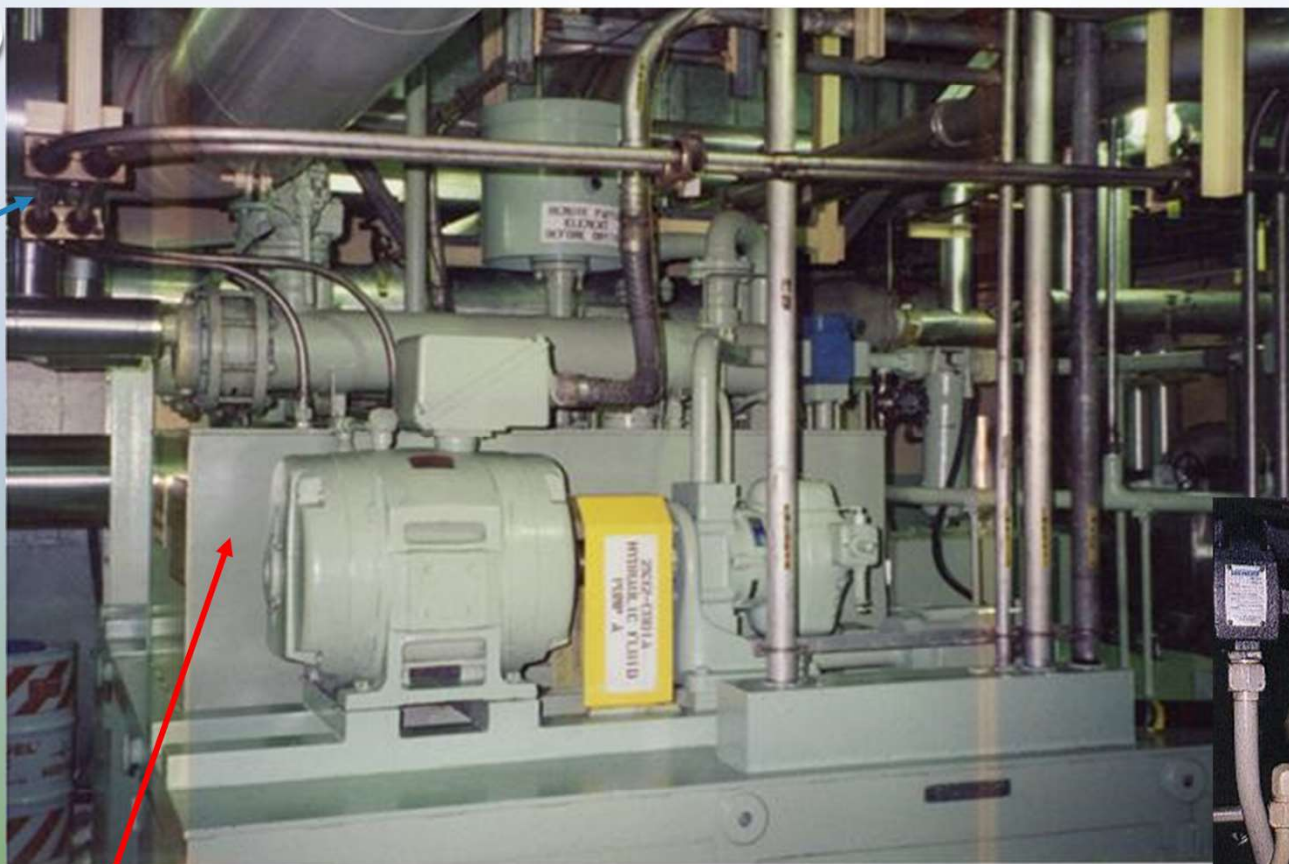
Specify  
what you  
want.

There are  
many  
versions of  
Viton

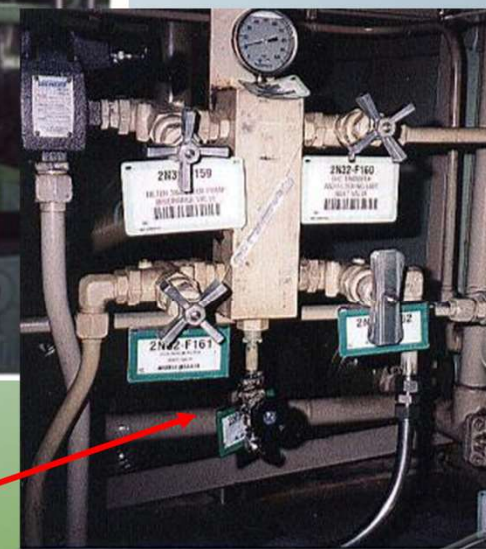
**Note 1;  
Compatible  
but can  
affect fluid**



# GE EHC HYDRAULIC SKID



800 Gallon Reservoir



Sample valve





Canoil Canada Ltd.

# KNOW YOUR SYSTEM

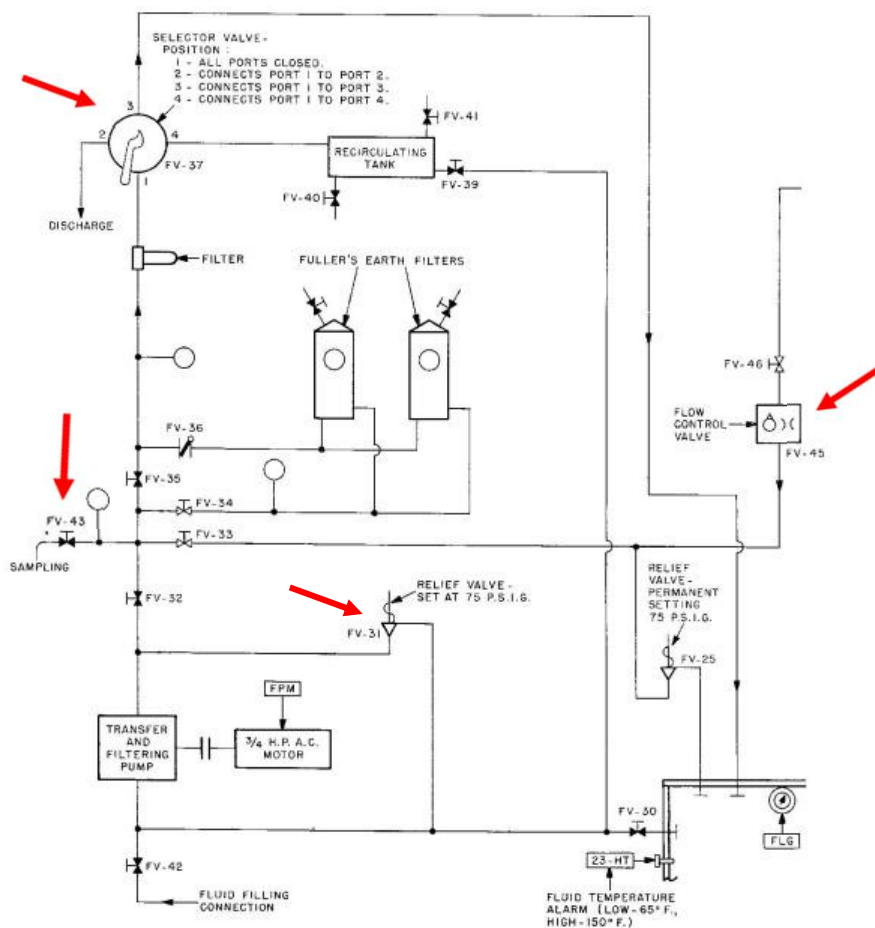
GEK 46355F



Canoil Canada Ltd.

Old

EHC FLUID SPECIFICATIONS AND MAINTENANCE GEK-46357



Water-Cooled Hydraulic Power Unit

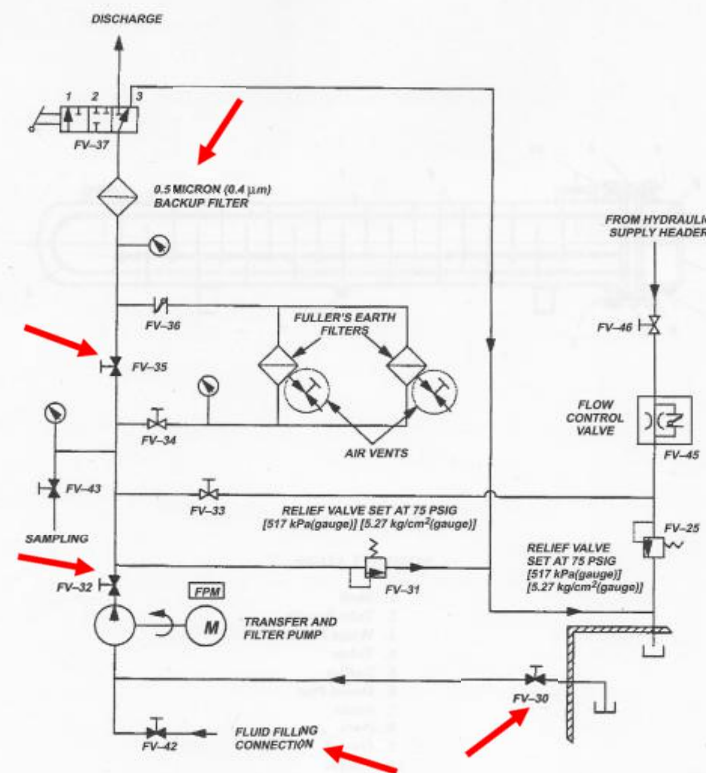


Figure 5a. Fluid Transfer and Filtering Unit (TAFEFU)  
Main Hydraulic System Pressurized Valves Shown in On-line Filtering Mode

# EHC FLUID TESTING



First do not assume that the current fluid test program is right or that the tests are being done properly.

The tests being done should be compared against those recommended in the EPRI reports, against the **current** turbine and fluid supplier recommendations and against those tests required to address any specific local problems.

Fortunately for EHC fluids in North America, routine fluid testing can be included in the cost of the fluid.

# NEW TESTING GEK 46357H



Canoil Canada Ltd.

Color	monthly
Water Content	"
Neutralization Number	"
Particulates	"
Resistivity	3 months
Mineral Oil Content	"
Metal Content	"
Viscosity	6 months
Air Release	"
Chlorine Content	"
Foaming	12 months
Specific Gravity	?
Pour Point	?
Flash Point	?
Fire Point	?
Autoignition Temperature	?
Fire Resistance	?

***New test requirements in blue.*** First given in Rev F 2012

## Canoil Generic GE EHC Test Program



Frequency Test	Monthly or Bimonthly	Quarterly	Semi-annually	Annually or Before Outage
Appearance	✓	✓	✓	✓
Acid Number	✓	✓	✓	✓
Color	✓	✓	✓	✓
Particle Count	✓	✓	✓	✓
Resistivity	✓	✓	✓	✓
Water	✓	✓	✓	✓
Chlorine	Do if Resistivity low	Do if Resistivity low	(✓)	✓
Mineral Oil	Do if Appearance, Color or Viscosity odd	Do if Appearance, Color or Viscosity odd	✓	✓
Viscosity	If fluid contamination suspected	If fluid contamination suspected	✓	✓
Metals (by ICP)	If Acid or Particles high or if deposits	Do if Acid or Particles high or if deposits	✓	✓
MPC	(✓)	✓	✓	✓
Phenols	(✓)	✓	✓	✓
Air Release	Do if Metals high or if deposits	Do if Metals high or if deposits	Do if Metals high or if deposits	✓
Foaming	Do if Metals high or if deposits	Do if Metals high or if deposits	Do if Metals high or if deposits	✓
Other As Required	✓	✓	✓	✓

Canoil  
has  
more  
info on  
the  
tests.  
Contact  
us.



# LESSONS LEARNT - COLOUR



New fluid  
0.5-1.0

3.0 – 4.0 typical  
for in-service GE

7.0 – 8.0

Know what is normal and watch for it.

# CAUSES OF DARK FLUID

Dark fluid is usually the result of oxidation as a consequence of very high temperatures.

- Hot spots can be from missing insulation or heat shields up at the steam valves or from fluid supply lines or accumulators not protected and/or fluid lines lagged in with a steam line.
- A low fluid level will also tend to help degrade the remaining fluid faster, lower the reservoir retention time and decrease the pump suction head. With the original horizontal mounted pumps the reservoir fluid level can be critical.
- Heaters being left on or too high a watt density and/or low heater flow can also degrade the fluid.
- Running the transfer pump with a restricted suction or in bypass mode and also cause overheating of the fluid.

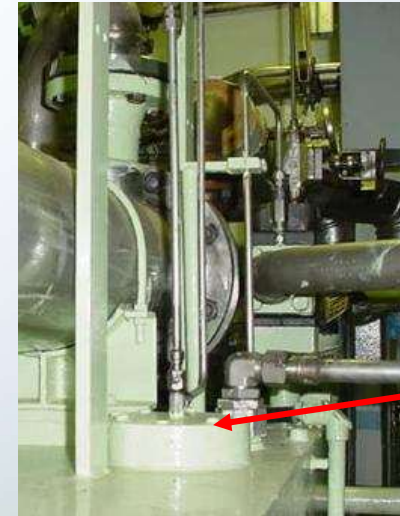
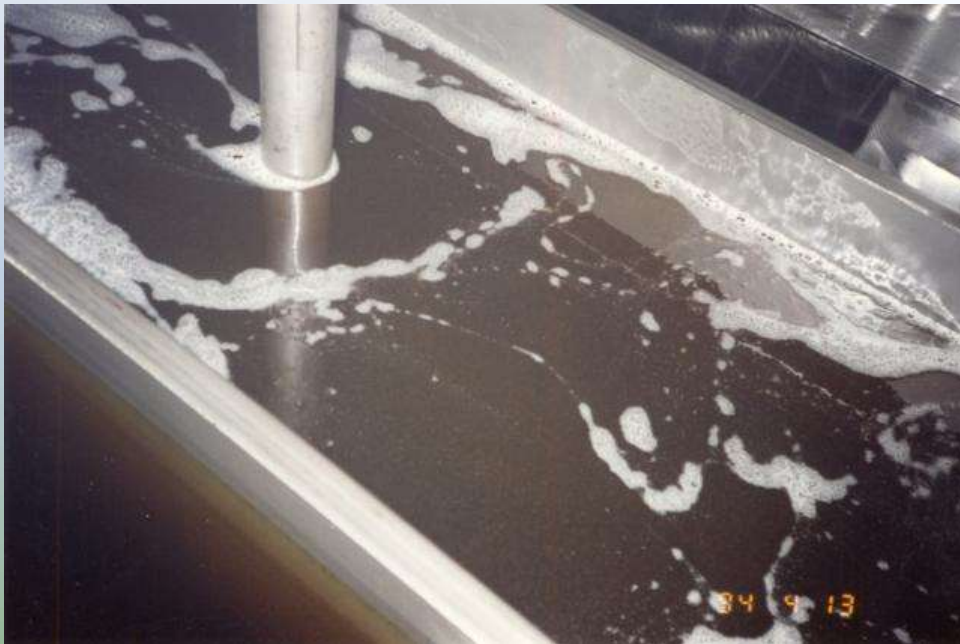
## CAUSES OF DARK FLUID CONT'D

In addition, high temperatures and dark fluid can result from the compression of air bubbles. This causes very high local temperatures that will not be seen as a bulk fluid temperature rise. But it can be hot enough to actually burn the fluid. One result can be coke particles which are black. These are too fine to be caught by the OEM filters.

- Mechanical causes of bubbles are usually plunging return lines from any added rigs, or OEM return lines too high and/or too close to the pump suction. The latter can be main returns or PRV returns.
- Fluid causes can include, high foaming tendencies, and/or long air release times.
- Operational causes can include low fluid level, **running both pumps for too long**, passing bypass valve, and/or passing pressure relief valves.
- Maintenance causes can include plugged reservoir breather, blocked suction strainer and/or worn suction strainer O-ring.

***NB: Fluid levels, plunging returns and excessive foam can be checked by opening the inspection port.***

# GE 800 GALLON RESERVOIR



Inspection port

**Know what is normal!**



## HIGH ACID NUMBER ACIDITY (NOT REALLY)

As fluid is used, acid like compounds can be formed.

*A good target is  $<0.1$  mgKOH/g. Possible with correct changes of the right purification media.*

**Caution:** too high at any time can lead to later problems and shortened fluid life. As acid number gets higher, the degradation rate can increase. Also, if too high often the fluid charge **cannot be saved** with traditional means.

# HIGH ACID NUMBER



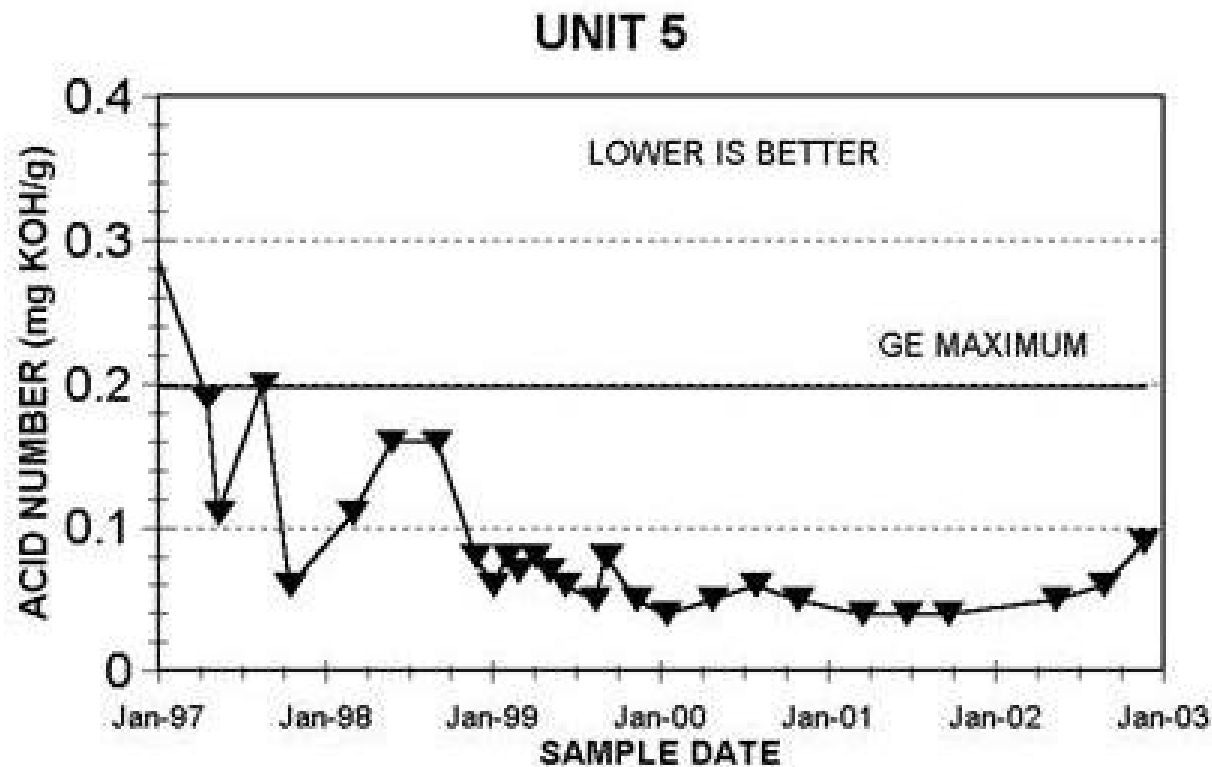
**One or more**, of the following;

- 1. Purification media not changed soon enough.**
- 2. Purification flowrate is wrong.**
- 3. Purification media is wet or dry and/or fouled.**
- 4. Purification housings are air bound.**
- 5. Defective valves.**
- 6. Wrong purification media.**
7. Wrong fluid is being used.
8. Overstressed fluid (hot spots, low levels, etc.)
9. Material incompatibility
10. Other: Design, maintenance, substitutions, operations, and/or flush issues.



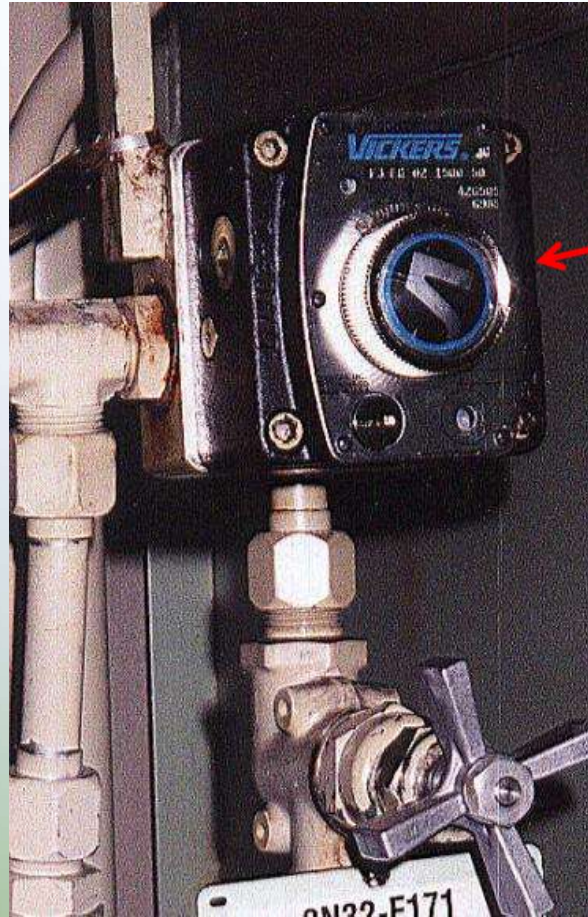
*Much better  
with more FE  
changes  
and dry media*

Caution: fluid  
issue can  
have more  
than one  
cause. In this  
case there  
were 14 other  
improvements  
mainly re  
procedures.



## ACID NUMBER – GE FOSSIL

# CHECK THE FLOW RATE



VICKERS FLOW CONTROL VALVE – THEY FAIL!



# GE FLUID PURIFICATION HOUSINGS



CAP  
NUT

TIL 877  
Figure 2

Leaks



ONE CARTRIDGE HIGH

'1' GPM



VENT

TWO CARTRIDGES HIGH

'2' GPM

NOTE: VENT HOUSINGS AFTER INSTALLATION AND AS REQUIRED.



## HIGH PARTICLE COUNT

Too high can lead to shorter fluid lives, to servo and or solenoid valve problems with sticking and to screen/filter blockage. Resample and determine the **source** if still high.

**NB:** A high particle count should always be investigated and corrected. This is in case a pump is in distress, contaminated fluid was added and/or a filter is bypassing. The goal is to prevent compromising the system.

**ISO 4406 is only the method of reporting the counts not the procedure.**

Particles counts  
>X microns  
i.e. 17/15/12

>4, >6, >14  
microns

Counts can also be reported for other sizes.

**With servo valves target 17/15/12 or lower.**

ISO 4406:1999 Scale Number Table		
Number of particles per millilitre		Scale number
More than	Up to and including	
2 500 000		> 28
1 300 000	2 500 000	28
640 000	1 300 000	27
320 000	640 000	26
160 000	320 000	25
80 000	160 000	24
40 000	80 000	23
20 000	40 000	22
10 000	20 000	21
5 000	10 000	20
2 500	5 000	19
1 300	2 500	18
640	1 300	17
320	640	16
160	320	15
80	160	14
40	80	13
20	40	12
10	20	11
5	10	10
2.5	5	9
1.3	2.5	8
0.64	1.3	7
0.32	0.64	6
0.16	0.32	5
0.08	0.16	4
0.04	0.08	3
0.02	0.04	2
0.01	0.02	1
0	0.01	0

# HIGH PARTICLE COUNT



The most common reason is improper sampling.

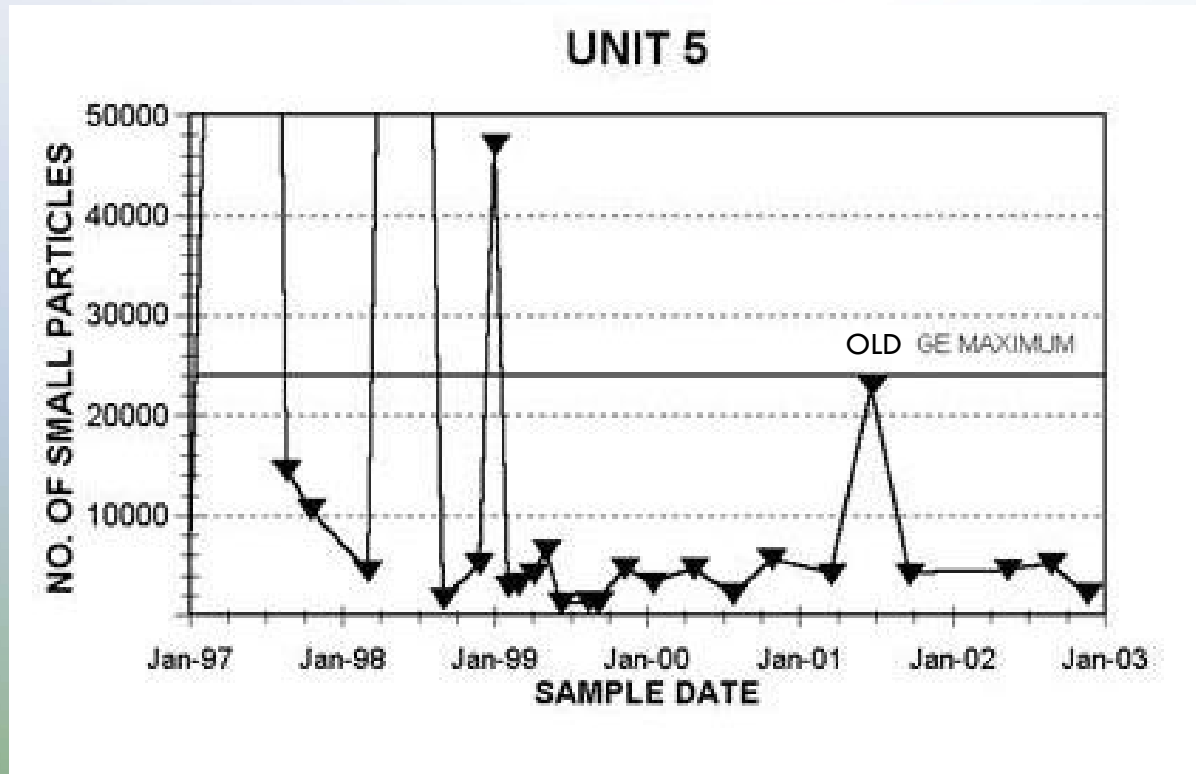
It is very important to flush out enough fluid so to get a representative sample, to use a flush container, to use a clean sample bottle and to not touch the sample valve when the sample bottle is in position.

GE has a dedicated sample valve on bottom of the TAFEFU low pressure manifold.

Possible actions: Ask lab to identify particles, resample, check filter differentials pressures (**re too high or too low**), check pumps, determine recent activities. Later review sampling procedures, containers, training and if filter elements different.

***NB: Canoil has a generic procedure if required.***

# PARTICLE COUNT



*Can depend on the sampling point but there should not be great spikes. Check sampling procedure and compliance.*

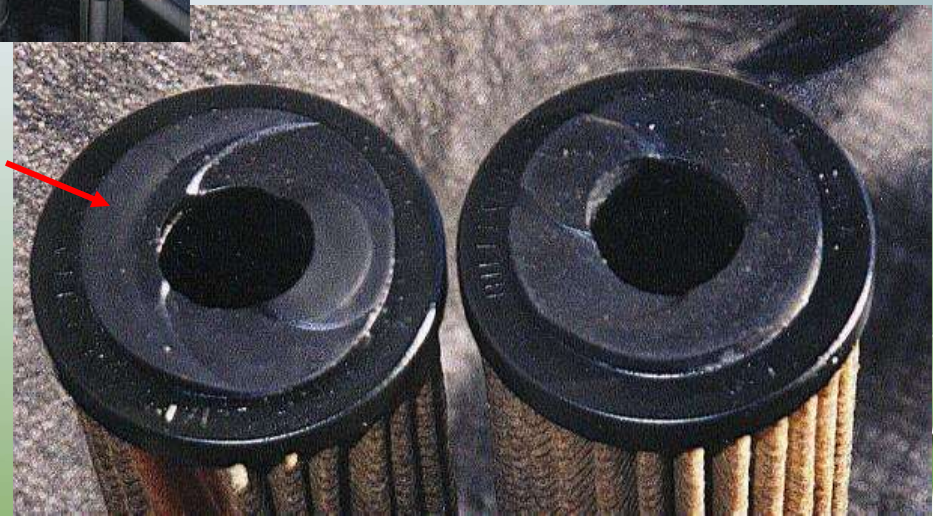
**KNOW WHO TOOK THE SAMPLE – AND HOW**



# TRAP FILTER ISSUES



TIL 759  
TIL 877



# FLUID MAKE-UP

- **CLEAN FLUID AND USE GOOD NEW FLUID.**

DO NOT ASSUME IT IS BEING FILTERED PROPERLY.





# FILTRATION SYSTEMS - UPGRADES

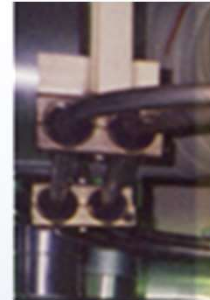


Check

Better



GE Exelon  
✓ Duplex with switchover



GE COGEN 8" to 16"



GE Double  
✓ Plus insulating valves.



Westinghouse

✓ Get Longer Cans

## LOW RESISTIVITY



Keep high to prevent electrokinetic wear of servo-valve internals such as the spools and flappers. Also called streaming currents.

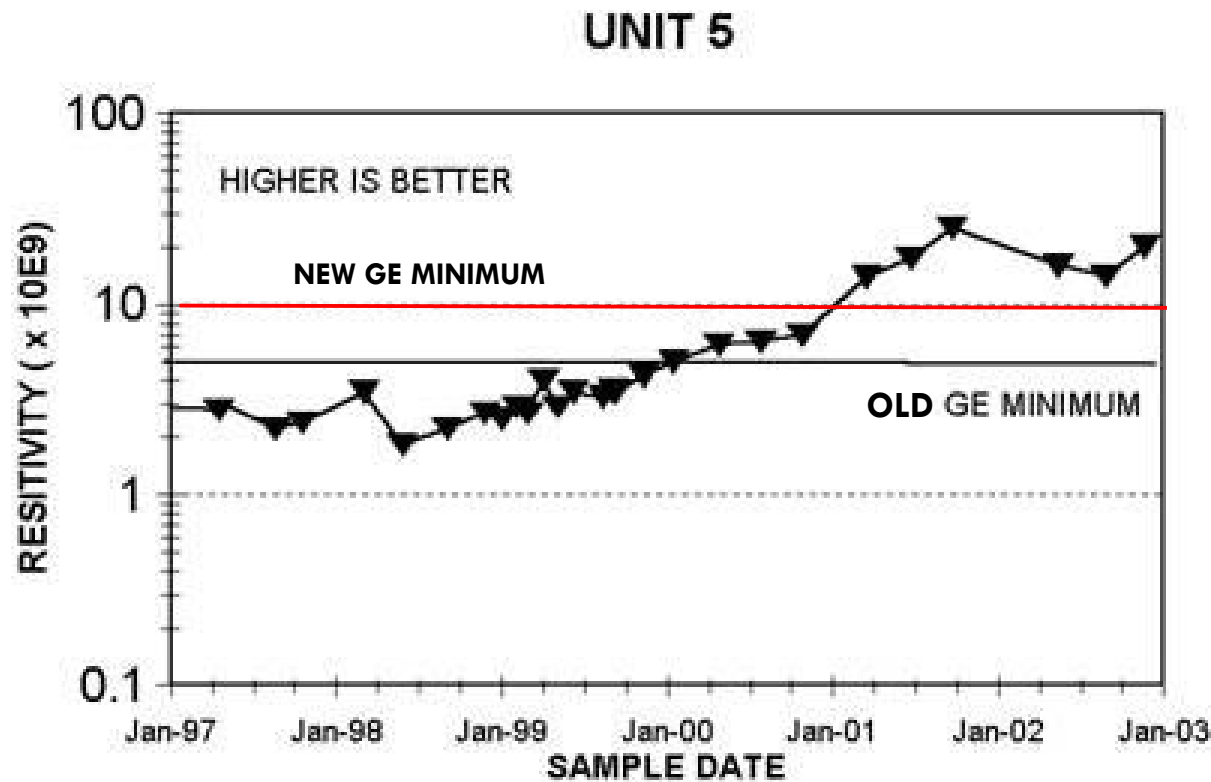
Normally controlled by fuller's earth, Selexsorb and some IX purification media.

**Caution:** Can also affect other close clearance components with pressure drops including pressure control and relief valves.

**Caution:** Some servo-valve designs can be more tolerant than others.



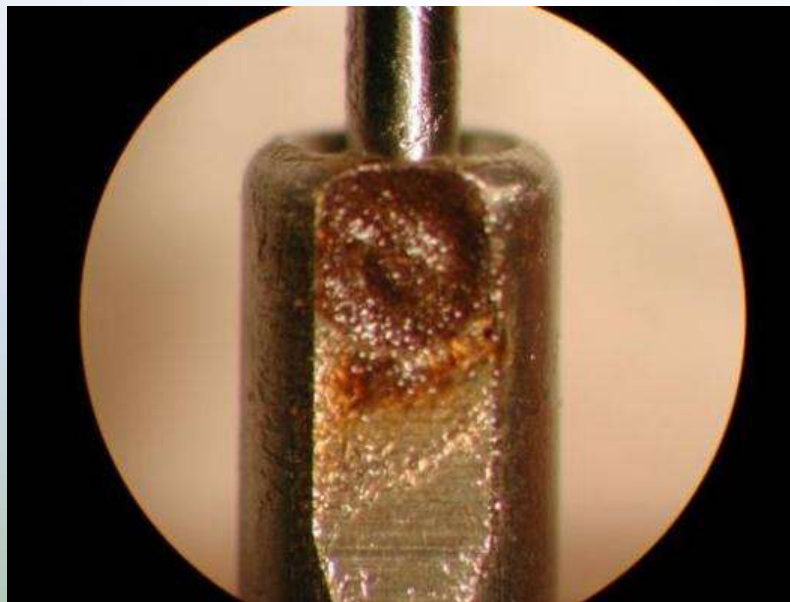
# RESISTIVITY



Important to trend and to determine if too low is a real issue.

SLOWLY GETTING BETTER WITH RIGHT CHANGES AND DRY MEDIA. SHOULD GO UP WITH NEW MEDIA.

# ELECTROKINETIC WEAR



Moog flapper  
showing  
electrokinetic wear.

Also had 'wrong'  
torque motor  
showing need to  
properly inspect  
pulled servo valves.

# HIGH WATER CONTENT

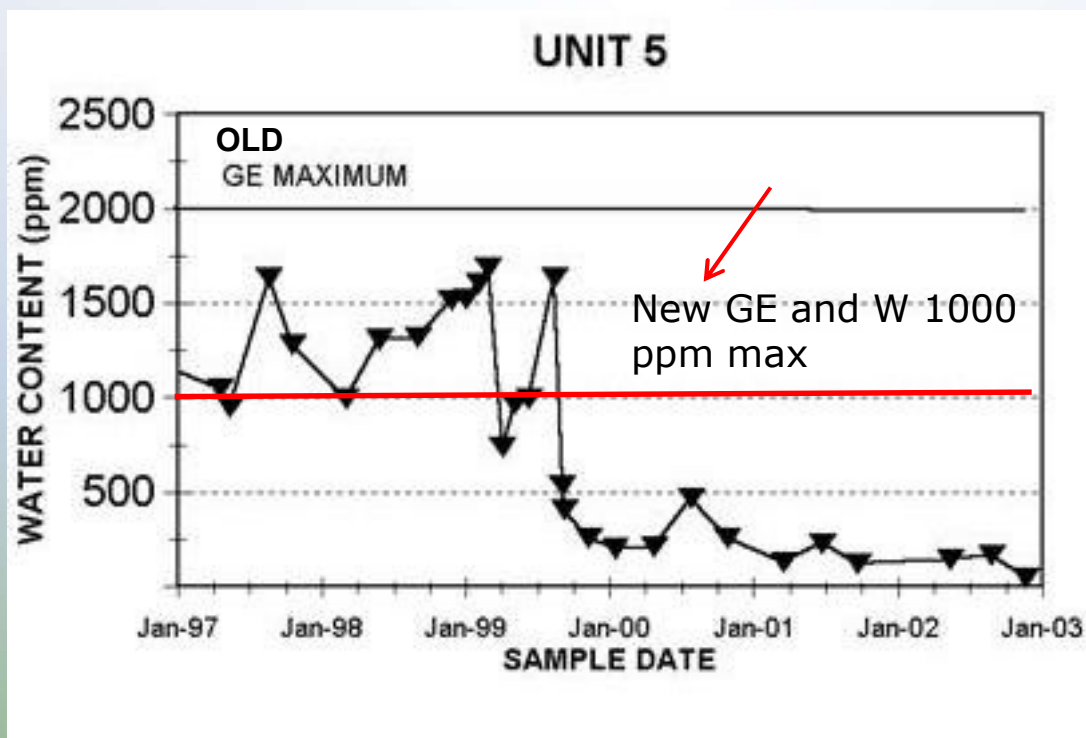


This can be an issue for numerous reasons;

- It can lead to corrosion of the ferrous components in the system.
- Solids type purification media including fuller's earth can absorb water which reduces the effectiveness for purification.
- It can affect electrostatic filters.
- Just as importantly, esters in the presence of water can undergo hydrolytic degradation.

The consequences can take many forms depending on the condition of the fluid possibly resulting in some or all of the following; higher acid numbers, lower resistivity, gels, varnish and/or foaming. A bathtub ring in the reservoir is a classic.

# WATER CONTENT



*Dryer fluid can extend fluid life and also that of some purification media, and reduce maintenance on desiccant breathers.*

**MUCH BETTER WITH RESERVOIR DRY AIR PURGE**



# WATER CONTENT CONTROL



Good



NEI Parsons



GE  
Legacy  
**Poor**



GE COGEN



Alstom

No  
moisture  
control plus  
extraction  
fan



Westinghouse

**Not so good**

Just a  
screen  
mesh

# LECTROBREATHER

TIL 877 Fig 3

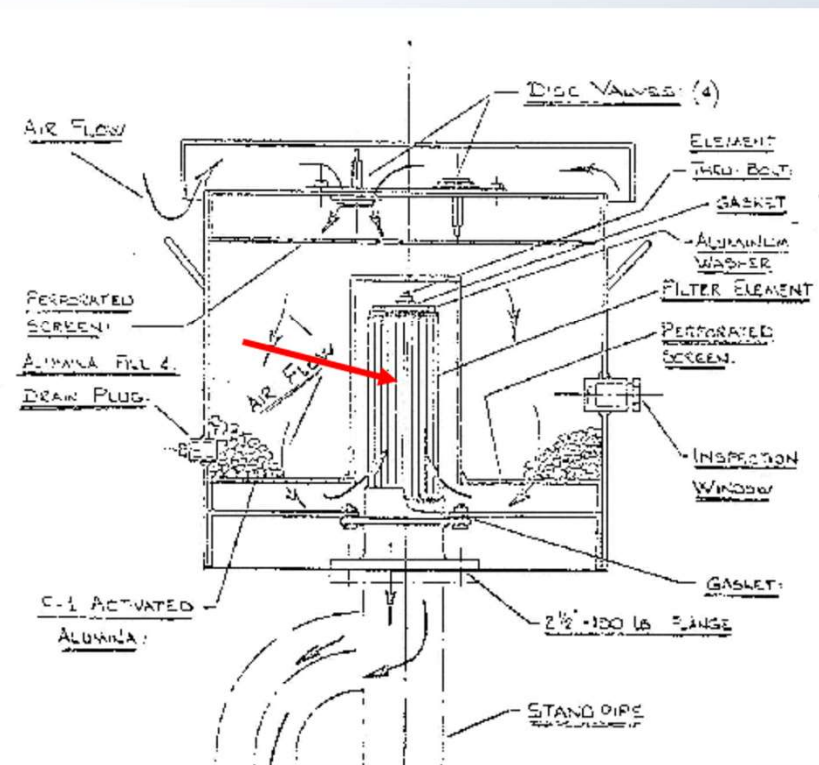


Blue – good

Purple

Lavender

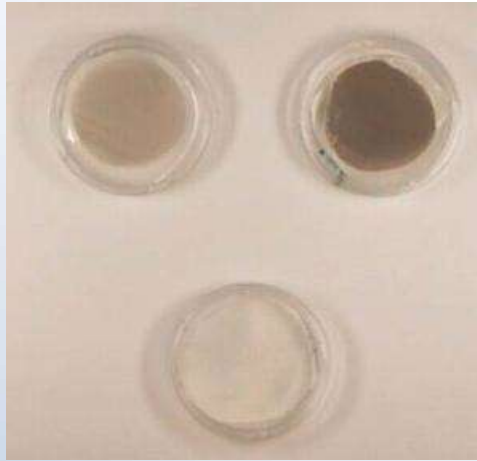
Light pink - renew



GEK 63397

Filter element – as a minimum  
replace every 6 months

## NEWER TESTS - PATCH



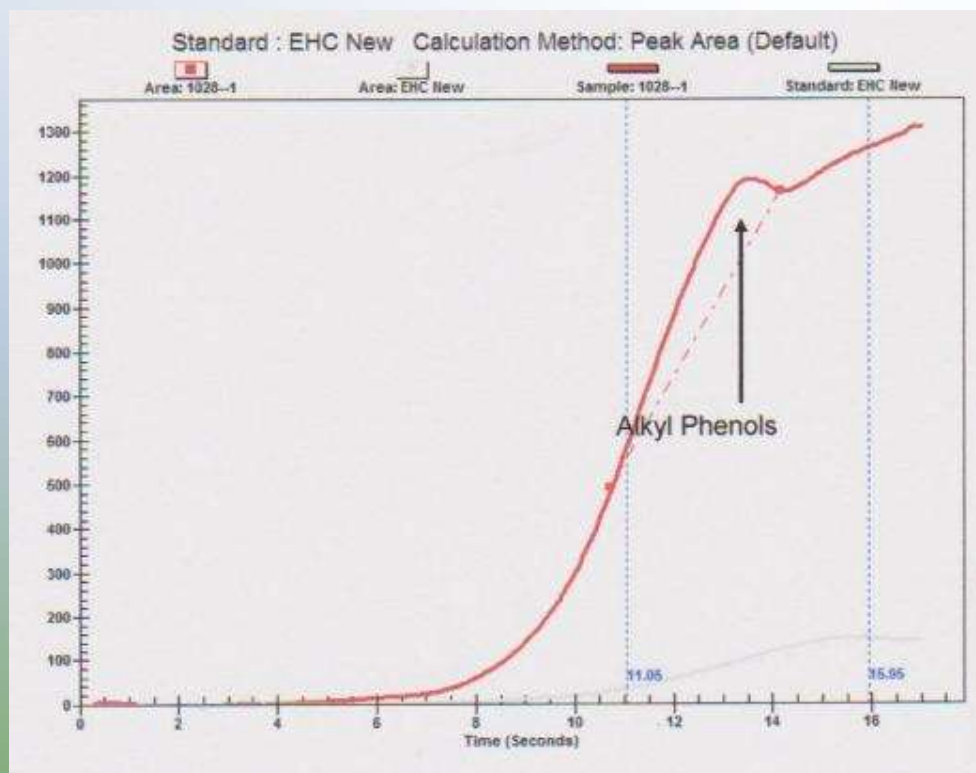
*Note: The standard ASTM MPC test needs to be modified for phosphate ester fluids as does the reporting in some cases.*

MPC (membrane patch colorimetry) uses a 0.45 micron patch. A dark patch and/or a high patch weight can indicate existing or pending varnish and/or soot problems.

MPC reported as dE or  $\Delta E$ .

Dark fluids give high values not necessarily indicative of varnish so can be reported as  $\Delta a + \Delta b$  and  $\Delta L$ .

# NEWER TESTS – RULER AREA FOR PHENOLS



To large an area under the bump can indicate phenols and fluid degradation.

Deposits and/or varnish can be more likely.

Usually done by Canoil but not by other fluid suppliers.



# TRITEK ELECTROSTATICS, IX AND

...



# ELECTROSTATICS





## LESSONS LEARNED

EHC fluids should provide decades of trouble-free service.

This only possible when;

- The fluid is being stored, added and maintained correctly.
- The EHC system is operated properly including fluid levels, cooling, filtering, purifying and testing.
- The EHC system components are purchased, stored and examined and installed properly.

## LESSONS LEARNED

In many cases the reason that the fluid is trending or has gone out of specification is that something changed or did not happen. It is seldom a fluid issue.

Verify that what is supposed to happen or used, was done. Do more tests if required and check the hydraulic package. If overheating suspected, check heater off, one pump running and walk the lines looking for for insulation or heat shield issues.

Then, check stores and maintenance practices.

# CANOIL WEBSITE WHITE PAPERS



- Canoil Turbofluid EHC Fluid Annual Testing Program
- TF Suggested Test Schedule Alstom
- TF Suggested Test Schedule May 2017 GE W NEIP
- List of GE TILs on EHC fluid and components
- List EPRI Lube Notes on EHC fluid and issues
- Q&A on EHC Fluids
- Canoil Turbofluid Testing Advantages
- Turbofluid Tests Explained
- Explaining Fire Resistance tests
- Managing the Health of Fire Resistant Steam Turbine Electrohydraulic (EHC) Control Oils
- Condition-Monitoring of Phosphate Ester Hydraulic Fluids – Machinery Lubrication





## WEBINARS

- First one was an introduction to EHC fluid maintenance and is available on the Canoil website.
- Others will be OEM specific and considered so far are GE, Westinghouse and Alstom. Others as required.

[www.canoilcanadaltld.com](http://www.canoilcanadaltld.com)

**SEE ALSO CANOIL EHC FLUID HEALTH CALCULATOR**

[www.ehcturbofluid.com/#calculator](http://www.ehcturbofluid.com/#calculator)



Canoil Canada Ltd.

ehcturbfluid.com/#calculator



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## EHC FLUID HEALTH CALCULATOR



Canoil' EHC Calculator takes your latest laboratory results from your current fluid and returns results of its current health. To use the calculator use your laboratory results and type them in the appropriate boxes and and click on Calculate. You will then be taken to a page with your results, displaying the health of each of the parameters of your fluid and whether you need to take any actions based on the results you entered.

Disclaimer

Background ▼

Viscosity cSt @ 40° C ⓘ

Total Acid/Neutralization No. (mg KOH / gm) ⓘ

Resistivity Gohm.cm ⓘ

Water Content ppm ⓘ

Calculate

## ABOUT US

At Canoil, we believe in more than just selling a product. We help you use it the

TRY IT



**Thank you, and now for Q&A items.**

**Your questions will be anonymous and can only be viewed by the moderator and the speaker.**

***You also have the option to send an e-mail or call. Include test reports if possible.***

**E-mail: [info@canoilcanadaltd.com](mailto:info@canoilcanadaltd.com)**

**Phone: 905-820-2022**

**Toll Free North America: 1-855-520-2022**

**Website: <https://canoilcanadaltd.com/>**



*The information provided in this webinar is believed to be correct and was reviewed and approved by Canoil who are solely responsible for the content. Suggestions as to root causes are based on findings at specific facilities. Because there are many variables, any actions or nonactions should be done in consultation with your subject matter experts and/or suppliers. Canoil can provide specific suggestions for fluid customers.*