Welcome to the Presentation on

**Fire Resistant Fluid: A Study on Deterioration of Physico-chemical Properties on Lube Oil Mixing**

Presented By:
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MAJOR ROLE OF TURBINE GOVERNING SYSTEM

• To control the speed of Turbo-generator during initial run & synchronization.

• To control the power generation through precise control of steam governing valve.

• To limit the over-speeding / speed rise upto acceptable limit upon load rejection.

High Pressure & Temperature of steam in Steam turbine dictates the use of Fire Resistant Fluid to mitigate the possibility / potentiality of dangerous & expensive fire hazards
FUNCTION AS CONTROL FLUID / EHC FLUID / HYDRAULIC FLUID / LUBRICANT

- ACTS AS PRESSURE TRANSMITTING MEDIA.
- LUBRICATES EVEN UNDER EXTREME PRESSURE.
- PLAYS CRUCIAL ROLE IN RAPID & PRECISE CONTROL OF VALVES IN GOVERNING SYSTEM.

SUPERIORITY

- HIGH FLASH POINT / FIRE POINT – SAFETY.
- FIRE RESISTANT & SELF EXTINGUISH
- REQUIRES NO ANTI-OXIDANT.- STABILITY.
- LONG SERVICE LIFE – IF PROPERLY MAINTAINED.
SPECIAL PERFORMANCE RELATED PROPERTIES OF EHC FLUID (FIRE RESISTANT FLUID / TXP)

- **FLASH POINT / B.P. / AUTO-IGNITION**: 245 / 394 / >550°C
- **SPECIFIC RESISTANCE**: $12 \times 10^9$ ohm-cm

**FALEX LUBRICATION TEST (ASTM D 2625):**

(i) **WEAR TEST (ASTM D 2670)**: 0.25 mm scar width.

(ii) **EXTREME PRESSURE TEST (ASTM D 2625):**
   - Transition Load: 1500 lbs (678 kg)
   - Transition pressure: 101000 psi.

**TIMKEN LUBRICATION TEST (ASTM D 2714):**

(i) **WEAR TEST**: 1.25 mm scar diameter

(ii) **EXTREME PRESSURE TEST**:
   - O.K. Load: 55 lbs (24.8 kg)
   - Pressure at O.K. Load: 26250 psi
WHAT IS FRF?

Fire Resistant Fluid (EHC):
The Molecule of Concern to Power Plants

Supresta; USA
Fyrquel-EHC-N

Kemture corp. / ICL; USA
Reolube: Turbofluid 46xC
KEY MOLECULAR ZONES OF CONTROL FLUID

FIRE RESISTANT PROPERTY

HYDROLYTIC STABILITY

AIR RELEASE VALUE / FOAMING
Tri-xylenyl Phosphate ester:
Usage area: Power Industry

BEST HYDROLYTIC STABILITY
&
LOW AIR RELEASE VALUE
PHOSPHATE ZONE: THE ENERGY BLACK HOLE IN FRF MOLECULE

FIRE RESISTANT PROPERTY

<table>
<thead>
<tr>
<th>BOND TYPE (Single Bond)</th>
<th>BOND DISSOCIATION ENERGY (KJ/mole)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N - O</td>
<td>222</td>
</tr>
<tr>
<td>P - O</td>
<td>419</td>
</tr>
<tr>
<td>C - O</td>
<td>352</td>
</tr>
<tr>
<td>Si - O</td>
<td>369</td>
</tr>
<tr>
<td>S - O</td>
<td>98</td>
</tr>
</tbody>
</table>

BIOLOGICAL SYSTEM

ADP + Phosphate + energy ➔ ATP

ATP ➔ ADP + Phosphate + energy

(P – O - ) BONDING PLAYS KEY ROLE
FIRE RESISTANT FLUID Vs. MINERAL (LUBE) OIL
– A Comparison at Molecular Level

Fire Resistant Fluid
VI = 0

Mineral oil / Lube oil
VI > 95
VISCOSITY INDEX OF FRF IS ZERO

KINEMATIC VISCOSITY at 0 / 40 / 80 / 100 deg.C are: 2000 / 45 / 9.5 / 5.27 cst
And VISCOSITY INDEX = 0
KEY MOLECULAR ZONES CONTROL FLUID

USED IN:
- LANDING GEAR
- BREAKING SYSTEM
- FLIGHT CONTROL SYSTEM

Tri-butyl Phosphate ester:

Usage area: Aviation Industry

- FIRE RESISTANCE PROPERTY
- BULK OXIDATION RESISTANCE PROPERTY
- HIGH VISCOSITY INDEX

Chemical structure of Tri-butyl Phosphate ester:
VISCOSITY INDEX IMPROVER

Mechanism of Action of VI Improver

**POLY METHACRYLATE**

**Figure 1.** Star or radial architecture of Lubrizol's Asteric PMA polymers.

**Figure 2.** Linear architecture common to all other PMA polymers.

Temperature increases

Temperature decreases

Coiled form at Low temperature

Un-coiled form At High Temperature
ENTRY OF TURBINE OIL TO CONTROL FLUID (FRF) CHAMBER
A MATTER OF CONCERN ....

NON-COMPATIBILITY AND PERFORMANCE / PROPERTY DETERIORATION
SECTIONS OF TURBINE GOVERNING SYSTEM WHERE CONTOL FLUID PLAYS....

- SPEEDER GEAR & STARTING DEVICE.
- HYDRAULIC AMPLIFIER WITH SET OF FOLLOW UP PISTONS.
- ELECTRO-HYDRAULIC CONTROLLER WITH SET OF FOLLOW UP PISTONS.
- TRIPING DEVICE & EMERGENCY TRIP VALVE.
- SET OF SOLINOIDS FOR ATT OPERATION.
Hydraulic Amplifier

- Secondary Fluid (CF)
- Aux. Secondary Fluid (CF)
- Return Fluid (CF)

KWU

Control Fluid - INLET

Return Fluid (CF) - OUTLET

1. Amplifier piston
2. Follow-up piston
3. Sleeve
4. Shaft
5. Lever
6. Feedback lever
7. Pilot valve
8. Compression spring
9. Adjusting screw
a. Control fluid
b. Secondary fluid
b1. Auxiliary secondary fluid
c. Return fluid
HP CONTROL VALVE SERVO MOTOR : 500 MW

Control fluid pressure : 5-8 kg/cm² (max.)
Control fluid pressure to Control valve : 32 kg/cm² (max.)
Hydraulic amplifier and follow up pistons
ELECTRO HYDRAULIC CONVERTOR

Moving Coil System (0-10 V)

1. Differential transformer
2. Amplifier casing
3. Amplifier piston
4. Piston rod
5. Valve bushing
6. Pilot valve
7. Grooved ball bearing
8. Spring disc
9. Compression spring
10. Sleeve
11. Casing support
12. Moving coil system

a. Control fluid
x. Trip fluid

CF-(IN)
Trip Fluid-(IN / Out)
SPEEDER GEAR AND STARTING DEVICE

Motor for starting & load limiting device

Aux. Sec CF

KWU

Aux. Starting Fluid

CF-IN

Leakage Fluid

Primary Oil (MOT)

Return CF- (Outlet)

1. Push rod
2. Set screw
3. Tension spring
4. Follow-up piston
5. Sleeve
6. Lever
7. Pin
8. Governor bellows
9. Bellows
10. Push rod
11. Link
12. Trip test lever
13. Speed setting spring
14. Scale
15. Differential transformer
16. Speed setting device
17. Electric position transmitter
18. Limit switch for position indication
19. Handwheel
20. Motor for starting and load limiting device
21. Valve
22. Limit switch for position indication

a. Control fluid
b. Auxiliary secondary fluid
c. Return fluid
c1. Leakage fluid
c2. Ventilation
u. Starting fluid
u1. Auxiliary starting fluid
LUBE OIL MIXING POSSIBILITIES

- **NORMAL ROUTE**: LEAKAGE THROUGH GOVERNOR BELLOW / O-RING PART OF SPEEDER GEAR AT JUNCTION OF PRIMARY OIL (LUBE OIL) & CONTROL FLUID (FRF) .... (common case).
- **MISTAKE**: WRONG OIL TOP UP...(rare case).
- **CRISIS**: LOW LEVEL OF FRF / DRAINAGE OF FRF- URGENT TOP UP / NON-AVAILABILITY OF FRF IN STOCK ....(rare case).
HOW TURBINE OIL AFFECTS THE CONTROL FLUID (FRF)?
DETERIORATION IN PROPERTIES OF FRF(TXP)

- EMULSION FORMATION (Hazy appearance)
- DENSITY DECREASES
- KINEMATIC VISCOSITY INCREASES (*)
- FLASH POINT DECREASES (*)
- ACIDITY INCREASES (*)
- NAS-1638 LEVEL INCREASES (*)
- EP LUBRICATION CHARACTER DETERIORATES (*)
- DETERIORATION IN PRESSURE TRANSMITANCE (*)
VARIATION IN APPEARANCE OF FRF & LUBE OIL

NEW FRF (100%)

USED MOT (100%)

Layer separation

Hazy oil

NEW FRF

NEW MIXED OIL (80 : 20)
TOLERANCE OF LUBE OIL MIXING WITH FRF

BEFORE SHAKING

FRF & LUBE OIL IN DIFFERENT PROPORTION

100%  (99 : 1)  (98 : 2)  (97.5 : 2.5)  (97 : 3)  (96 : 4)  (95 : 5)

HAZY
POLARITY EFFECT:
MIXING OF LUBE OIL WITH CONTROL FLUID

FRF & LUBE OIL IN DIFFERENT PROPORTION

BEFORE SHAKING / MIXING

MOT
FRF

AFTER SHAKING / MIXING
VARIATION IN KINEMATIC VISCOSITY OF FRF ON LUBE OIL MIXING
VARIATION IN FLASH POINT OF FRF ON LUBE OIL MIXING

- Flash point (°C) vs. Percent Lube oil in FRF

- The graph shows a decreasing trend in flash point with increasing lube oil mixing percentage.

- Key points:
  - Flash point at 0% lube oil: 280°C
  - Flash point at 50% lube oil: 248°C
  - Flash point at 100% lube oil: 220°C
WHAT IS ESSENTIAL TO KNOW ABOUT THE FRF (TXP) IN GOVERNING SYSTEM ???

- MOISTURE ?
- ACIDITY ?
- NAS-1638 / CONTAMINATION CODE ?
- LUBRICITY DATA - (FALEX / TIMKEN TEST) ?
- % OF LUBE OIL IN FRF ?
- PURITY LEVEL / % OF ACTUAL ACTIVE MOLECULES ?

HEALTH OF PURIFICATION UNIT
### TESTING REQUIREMENT FOR IN-SERVICE CONTROL FLUIDS

<table>
<thead>
<tr>
<th>SERIAL</th>
<th>PARAMETER</th>
<th>TEST METHOD</th>
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<tbody>
<tr>
<td>01</td>
<td>APPEARANCE &amp; COLOUR</td>
<td>ASTM D1500</td>
</tr>
<tr>
<td>02</td>
<td>MOISTURE CONTENT</td>
<td>IS- 13567</td>
</tr>
<tr>
<td>03</td>
<td>ACIDITY (TAN)</td>
<td>IS-1448 (P-2)</td>
</tr>
<tr>
<td>04</td>
<td>ISO CONTAMN. CODE</td>
<td>ISO-4406</td>
</tr>
<tr>
<td>05</td>
<td>DENSITY AT 27 DEG.C</td>
<td>*</td>
</tr>
<tr>
<td>06</td>
<td>FLASH POINT</td>
<td>IS- 1448 (P-21)</td>
</tr>
<tr>
<td>07</td>
<td>PURITY LEVEL / ACTIVE CONTENT</td>
<td>*</td>
</tr>
<tr>
<td>08</td>
<td>LUBE OIL MIXING</td>
<td>*</td>
</tr>
<tr>
<td>09</td>
<td>LUBRICITY TEST (FALEX / TIMKEN)</td>
<td>ASTM D 2625/2714/2783</td>
</tr>
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</table>
## IN-SERVICE PROPERTY REQUIREMENTS FOR FIRE RESISTANT FLUID

<table>
<thead>
<tr>
<th>SL</th>
<th>PARAMETERS</th>
<th>UNIT</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Appearance</td>
<td>*</td>
<td>Clear</td>
</tr>
<tr>
<td>02</td>
<td>Water content</td>
<td>ppm</td>
<td>1000 (max.)</td>
</tr>
<tr>
<td>03</td>
<td>Kin. Viscosity at 40 °C</td>
<td>cSt</td>
<td>41-45</td>
</tr>
<tr>
<td>04</td>
<td>Acidity (TAN)</td>
<td>mg KOH/gm oil</td>
<td>&lt;0.2</td>
</tr>
<tr>
<td>05</td>
<td>Particle contamination code</td>
<td>*</td>
<td>19/17/14 (max)</td>
</tr>
<tr>
<td>06</td>
<td>Cleanliness code (NAS-1638)</td>
<td>*</td>
<td>8 (max.)</td>
</tr>
<tr>
<td>07</td>
<td>Mineral oil content (if mixed)</td>
<td>% by volume</td>
<td>&lt; 3</td>
</tr>
<tr>
<td>08</td>
<td>Purity index</td>
<td>%</td>
<td>&gt;80</td>
</tr>
</tbody>
</table>
# REJECTION CRITERIA FOR CONTROL FLUID (FRF) UNACCEPTABLE PARAMETERS

<table>
<thead>
<tr>
<th>SL</th>
<th>PARAMETERS</th>
<th>UNIT</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Moisture</td>
<td>%</td>
<td>≥ 0.2</td>
</tr>
<tr>
<td>02</td>
<td>Particle contamination code</td>
<td>*</td>
<td>&gt; 19/17/14</td>
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<tr>
<td>03</td>
<td>Cleanliness code (NAS-1638)</td>
<td>*</td>
<td>≥ 10</td>
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<tr>
<td>04</td>
<td>Appearance &amp; Colour</td>
<td>* / ASTM Color Code</td>
<td>Hazy / Dark brown / &gt; 3</td>
</tr>
<tr>
<td>05</td>
<td>Acidity (TAN)</td>
<td>mg KOH/gm oil</td>
<td>&gt; 0.5</td>
</tr>
<tr>
<td>06</td>
<td>Lube oil content</td>
<td>%</td>
<td>?</td>
</tr>
<tr>
<td>07</td>
<td>Purity Level</td>
<td>%</td>
<td>?</td>
</tr>
</tbody>
</table>
ANY QUESTION PLEASE?