



May 20, 2015

Electro-Static Discharge (ESD) in Turbine Oils

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Agenda

ESD defined

Lube oil conductivity

ESD test rig evaluations

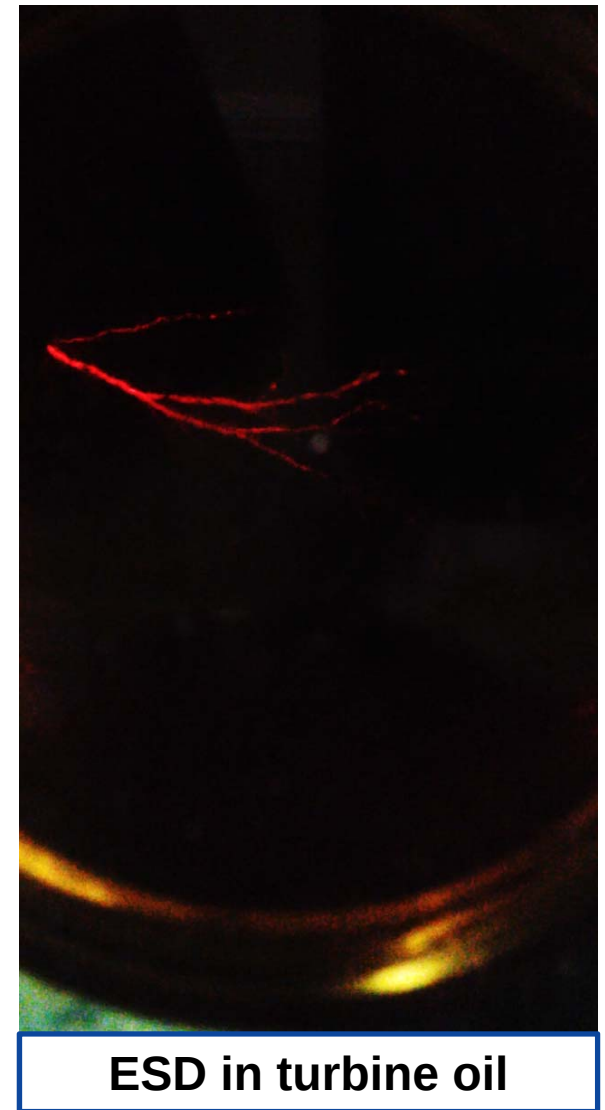
Field & test stand performance examples

Conclusions

ESD - Hydrocarbons Charging

- Accumulated charge in fluid can discharge to conductive part of circulation system
- Nonconductive filter material may acquire a charge acting like a capacitor until the voltage is great enough to overcome gap and discharge to lower potential component of system
- A clicking or rattling sound in the circulation system caused by sparking indicates this cycle of charging and discharging
- Can be a safety concern – ie. Hydrogen compressors
- Can create holes in filters, decreasing contaminant removal
- “May” accelerate oxidation and deposits

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ESD in turbine oil

API RP 2003 - Influence of Conductivity

- API RP 2003, Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents

“Generally, liquids with conductivity greater than 50 picosiemens / meter (pS/m) do not accumulate static charges...”

Low Conductivity < 50 pS/m

High Conductivity > 50 pS/m

- There are other conductivity guidelines referenced in related industry articles

Base Oil and Additive Influence on Conductivity

- Minimal base oil influence - it's the **additives**
- Non zinc hydraulic oils can be high conductive

ISO 46 Hydraulic Oil – Primary base oil and AW package	pS/m ASTM D 4308
ZDDP in Group I	226
Non zinc - Group III	119

ISO 32 Turbine Oil - Primary base oil API group	pS/m ASTM D 4308
Oil B - Group I	4
Oil F - Group II	12
Oil E - Group II	4
Oil D - Group II	5
Oil I - Group II	16
Oil C - Group II	17
Oil A - Group II	21
Oil G - Group II	286
Oil H - Group III	24
Oil K - Group III	111
Oil J - Group IV (PAO)	6

ESD Test Rig



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Low Conductive Turbine Oil Reaches 50K Service Hours

Low conductive oil (16 pS/m) in two GE Frame 7FA's

- Both turbines with servo valve varnish issues starting at approx. 20,000 service hours using a well known API Group I turbine oil (4 pS/m)
- Both turbines now above 50,000 service hours without issue
- No audible or visual signs in filters of ESD
- Oil analysis and visual inspections are very good

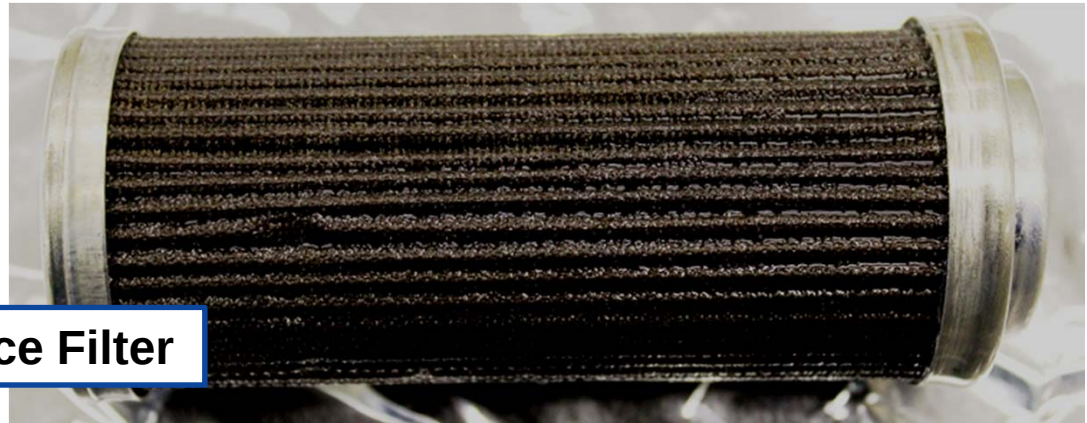
**Clean Pencil Filter
& Valve Spool**



High Conductive Turbine Oil - Deposits Found

High conductive oil (286 pS/m) in GE Frame 7FA

- Filter media removed and deposits extracted using toluene, yielding 13.9g deposit - 58% soluble /42% insoluble material
- No signs of ESD

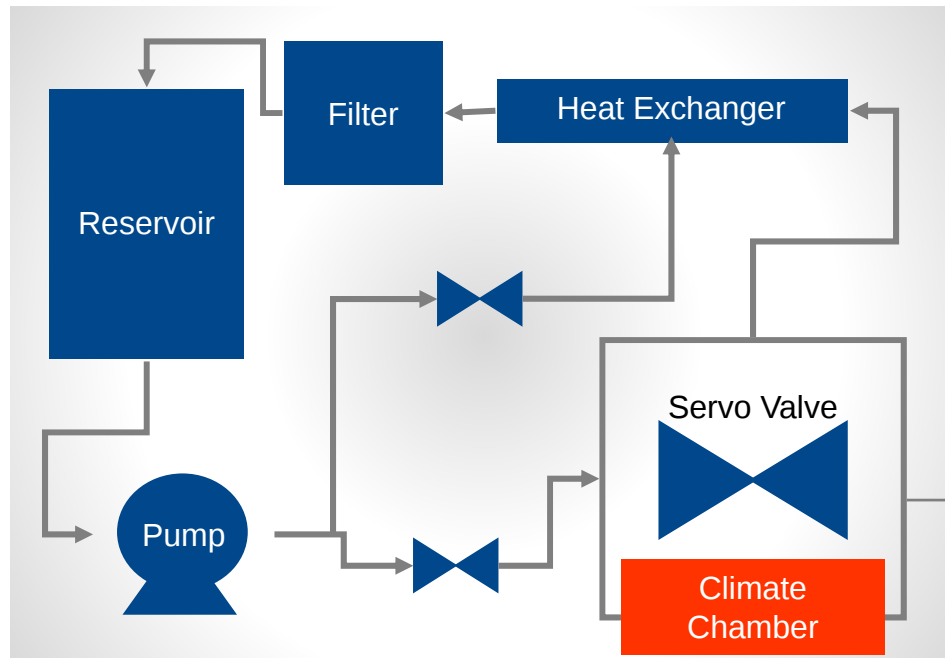


Fouled Last Chance Filter



Varnished Servo Valve

Proprietary Valve Varnish Rig Test to Create Varnish



Valve Varnish Rig Test:

- Evaluates Varnish Control
- Rig Configuration
 - Oil circulation system containing a reservoir, pump, heat exchanger, filter, and control valves
 - Utilizes cyclic on / off operation to simulate real world conditions

This rig test is a turbine oil performance test that:

- Helps develop high-performing turbine oils
- Replicates real world conditions, hence more relevant than glassware tests

Servo Valve Components



Valve Varnish Rig Test – No Signs of ESD

Additional Monitoring Parameters:

System cleanliness merit ratings:

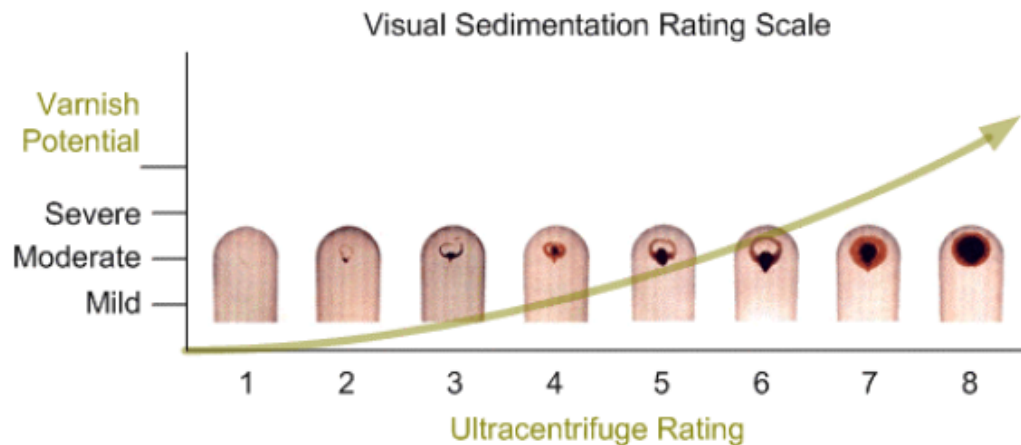
- 10 (Clean) – 0 (Dirty)
- Filter cleanliness at EOT
- Reservoir cleanliness at EOT

In-service oil condition monitoring analysis:

- Including ultra centrifuge deposit rating



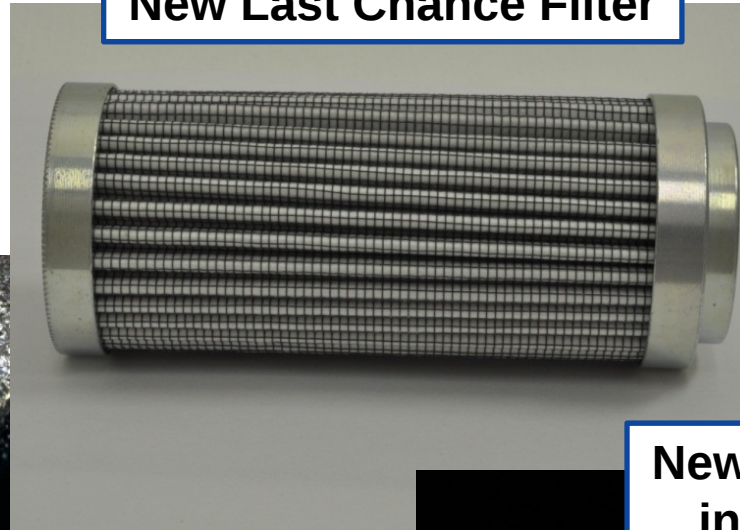
Filters: New and Used



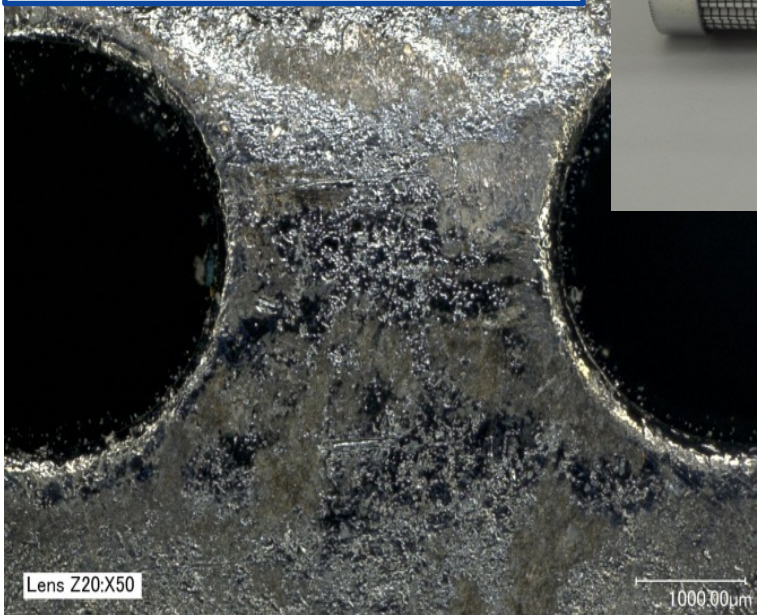
Reservoirs: New and Used

GE Gas Turbine Last Chance Filter - New

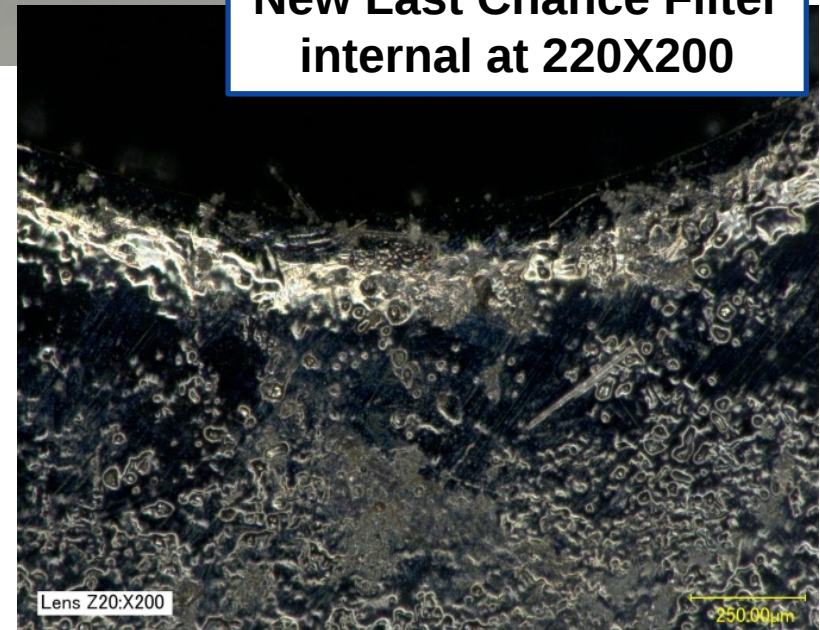
New Last Chance Filter



New Last Chance Filter
internal at 220X30



New Last Chance Filter
internal at 220X200



ESD – Our Experience

- Not seen as a leading contributor to varnish deposits
- May impact turbine oil service life with extended active ESD
 - Below 70F (21C) and low micron, ungrounded filters
- May be a safety consideration
- May impact filter life and effectiveness

ESD – Mitigation, if needed

- System grounding (filtration system, piping, reservoir)
- Minimize cold oil circulation
- Minimize entrained air
- Increase oil relaxation time
- Use low flow density and anti-spark filters
- Use high conductivity lubricants

Concussions

Much is being said about ESD but full effects are not fully understood

Additive chemistry has the major influence on conductivity

High and low conductivity turbine oils have been rig tested to demonstrate ESD

Field and test stand experience show no correlation between ESD and varnish

If needed, ESD mitigation is available