Service Information Letter 781

This Service Information Letter is prepared in support of ATA Specification No. 100. If any questions arise regarding this data, please contact your Collins Aerospace Representative or the Collins Aerospace Customer Response Center (CRC) at 1-877-808-7575.

APPLICATION:	Operators of Collins Aerospace Electric Power Machines Using Turbine Oil For Lubrication And Cooling
ATA CHAPTER:	24
TITLE:	Turbine Oil Topics For Electric Power Machines
REFERENCE:	Standard Practice Manual 24-10-00, SIL 327, SIL 340, SIL 621
EXPIRATION DATE:	N/A
REVISION(S):	1

Revision 0:

Original

Revision 1:

The following items have been modified in this SIL: 1) Update "Copper Chelation and Filter Plugging" section to include recommendation to to discuss oil chelation factors with oil manufacturers, 2) Updated branding, and 3) Included a section on Zinc Carboxylate and Disconnect Solenoid Actuation.

NOTE: The material in this Service Information Letter (SIL) is informational only. It does not supersede or amend any aircraft or component maintenance documents.

U.S. Export Classification

This document does not contain any export controlled technical data.

Contents

Oil Evolution and Formulations

The aerospace lubricant industry continues to develop advanced turbine oils for jet engines that operate with ever hotter turbine oil temperatures. The technological advances of ester based synthetic oils has provided unprecedented improvements in service temperature limits, oxidation stability that greatly extends oil change intervals, reduction of oil deposits, compatibility with evolving engine and component materials, and high load capability demands of bearings and gear mechanisms.

Testing and approval of new oil formulations is a joint effort among the oil developers, the engine and component manufacturers, and various industry specifications and standards committees. Analysis begins in the laboratories and advances to engine and component tests before starting controlled flight evaluations. The approval process can stretch over a period of several years. Collins Aerospace provides an approved oils list and oil condition information such as contamination limits in the TESTING section of Standard Practices Manual (SPM) 24-10-00.

Collins has decades of experience designing and producing electric power machines (CSD, IDG, Generators, VFSG, VFG, etc.) that use turbine oil for lubrication, cooling, and hydraulic power conversion. As turbine oils evolve and problems surface, Collins responds with product improvements and technical information such as this document to provide owners and operators with resources needed to maintain reliable operation of electric power equipment in their fleets.

Oil Filters and Filter Plugging

Electric power machines generate metallic and non-metallic wear particles throughout their operation. The presence of wear particles in their oil system will further increase wear and damage within a unit. In addition to the mechanical damaging effects, wear debris acts as a catalyst for lubricant degradation. Control of wear debris is provided by filters in the oil circuit to capture wear particles for removal when the filter is changed.

Particles visible on the filter folded pleats do not add any appreciable restriction to oil flow through the filter but very fine particles (undetectable to the naked eye) trapped within the pores of the filter fibers can restrict flow through the filter and result in a Differential Pressure Indicator (DPI) extension or "pop out". Because the particulate holding capacity of filters is relatively large, filters plugged from particulate debris are typically only observed as a result of a hardware failure within the electric power machine.

Figure 1 – Generator Filter

Nonetheless, operators may experience DPI pops and filter plugging within their fleet even in the absence of hardware failures. Oil degradation and copper chelation are two chemical reactions that are frequently responsible for plugged filters. The first, oil degradation, may result in a metallic soap that plugs the filter. The second, copper chelation, is a chemical reaction that may result in a filter-plugging gel from a reaction between microscopic copper particles and oil additives.

Oil Degradation and Metallic Soap Formation

Thermal breakdown of oil may be seen as soot deposits on hot metal parts. Temperatures at which soot deposits develop are not normally observed in electric power units.

At more moderate temperatures, oxidation of oil will result in varnish and sludge formations of congealed wear debris. Oils are formulated with sacrificial additives to delay the formation of sludge and varnish until the additives have been consumed. Such oxidative degradation is minimal due to the relative low operating temperatures of electric power machines, but it must be noted that the rate of degradation is a function of oil temperature, increasing dramatically the oil degradation with relatively small increases in temperature.

Current aircraft turbine oils are formulated from polyol ester base stocks which have excellent thermal properties but lack good hydrolytic stability, which is the ability to resist decomposition in the presence of water. Water content should not exceed the limits in the SPM 24-10-00. Water exceeding this limit will accelerate hydrolytic degradation with a resultant increase in organic acid formation.

Hydrolysis is the degradation of oil due to the presence of water and is the primary mechanism of oil degradation in electric power machines. Current turbine oils are hydroscopic, meaning they will readily absorb water from the environment. Oil manufacturers incorporate specific additives into the oil to reduce or delay oil degradation, but exposure to water, temperature, and time will ultimately lead to chemical changes in the oil including carboxylic acid formation as indicated by Total Acid Number (TAN) measurements.

In addition to carboxylic acid, the presence of chlorine will react with water to form hydrochloric acid. Reactive metals, such as magnesium, copper, aluminum and iron will corrode and be dissolved in the presence of acids to form a metallic soap which may agglomerate and plug filters.

Collins & Operator Actions

Case Vent (also known as a vacuum break valve)
In 1992, Hamilton Sundstrand introduced a case venting system into some IDG models. Case vent allows a flow of dry air (at altitude) to pass through the IDG and carry away moisture from the IDG turbine oil. Keeping moisture out of the IDG oil is desired to delay oil breakdown, acid formation and subsequent filter plugging. Extended intervals between oil and filter changes were envisioned with case vent but rarely implemented

as operator fleets often included both case vent and non-case vent units. Inclusion of case vent introduced additional leakage sources and additional costs to maintain case vent hardware. Thus, case vent was discontinued in production units as other means became available to control oil hydrolysis.

SEC Filters

Service Extender Concentrate (SEC) is a proprietary oil additive that chemically neutralizes the acids that form in turbine oil and/or from chemical contamination (most commonly water or chlorinated solvents). Acid elimination by SEC slows or stops the follow-on formation of soap or oxide that can plug the fine inner fibrous material of the filter; thus increasing oil and filter service life and reducing the damaging effects of acids on the internal machine hardware.

SEC is introduced into the IDG oil circuit by means of a pre-soaked oil filter element. When SEC filters are available for a particular electric power machine, they are listed in the illustrated parts list of the appropriate maintenance manual.

Copper Chelation and Filter Plugging

Chelate formation is a reaction between dissolved and suspended metallic wear debris and sacrificial oil additives. In electric power machines, the predominate reaction is between microscopic copper or bronze wear particles generated during normal operation and metal deactivating agents (MDA) present in turbine oils. Metal deactivating agents protect the oil from oxidative degradation thereby prolonging oil life. MDAs form a multilayer, passivating coating on reactive metals, such as copper or bronze, and in the process, increase a micro-particle to a size that will be trapped in the filter.

Large amounts of these particles form micro-particle gels. The filter fibers become coated with gel reducing the effective area of the filter and increasing the pressure drop. Increasing pressure across the filter will cause the filter differential pressure indicator (DPI) to pop out. (See Photo)

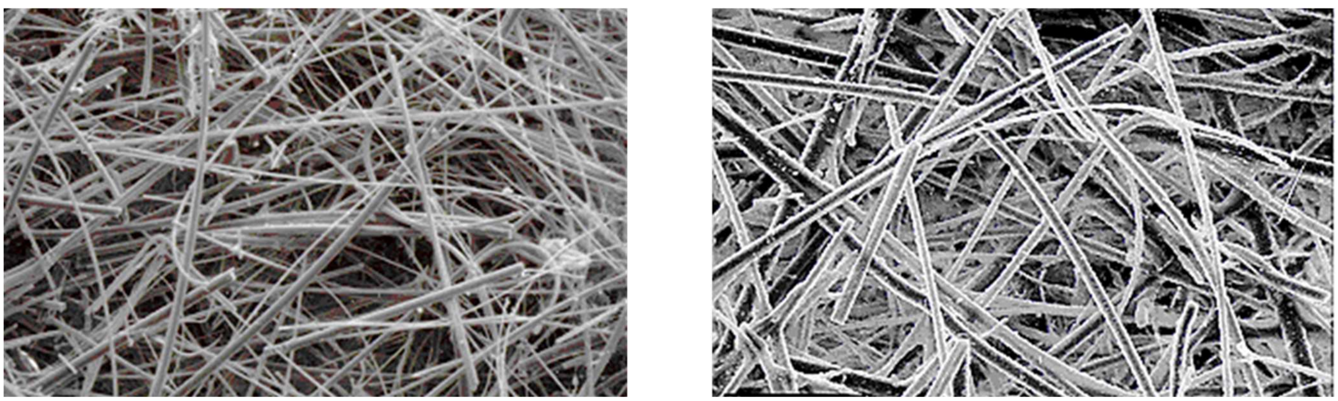

Figure 2 - SIL781 (Left: Clean Filter and Right: Filter with Chelation)

In a CSD or IDG, the largest source of bronze particles are the bronze bores of cylinder blocks used in the hydraulic pump and motor units. When coated by a MDA, particles that formerly passed through the IDG filter are now larger and accumulate in the pleats of the filter until the filter becomes plugged.

The time needed to plug a filter in this manner is influenced by several factors:

- 1) Amount of bronze particles dissolved or suspended in oil
  - Bronze wear is higher in newly installed cylinder blocks and decreases as clearances between pistons and bore walls increase
  - Bore wear is higher in fixed unit cylinder blocks when the IDG is operating near straight-through speeds.

- 2) Oil Temperature
  - Drives chemical reaction, a small increase can make a significant difference
  - Engine manufacturers control electric power machine oil temperatures; hotter oil temperatures generate more frequent filter plugging.

- 3) Oil formulation
  - Filter plugging mechanism is dependent upon turbine oil formulation.
  - Proprietary additive packages are controlled by the oil manufacturers.

When selecting or changing an approved oil, Collins recommends discussing copper chelate formation with the specific oil manufacturer. The impact of copper chelation on aggregate fleet IDG maintenance is dependent on the factors noted above. The relative value of factors 1) and 2) are specific to a given fleet and should be accounted for prior to selecting or changing an approved oil (factor 3).

Collins & Operator Actions

Alternate DPI Procedure

Alternate DPI procedures may be available in AMMs to provide line maintenance options in case of premature filter plugging, as indicated by a DPI extension. If criteria are met, the IDG may remain on-wing after changing oil and filters, and resetting the DPI. Upon the fourth DPI extension, the IDG must be removed for shop inspection of the cylinder blocks. It is important to fully understand the criteria before implementing this procedure and following it properly. Refer to Service Information Letter 327, SIL 340, and SIL 621 as applicable.

Using the alternate DPI procedure may not preclude future removals of the IDG if new bronze cylinder blocks are installed at repair, with the same oil temperatures and oil brand.

Bare Bore Blocks

Collins developed Bare Bore Blocks as an alternative to bronze bore cylinder blocks to eliminate copper particle wear debris from IDG hydraulic pump and motor cylinder block bores. Reducing copper wear particles in the IDG minimizes filter plugging from copper chelation. The special finish of the steel bores and matched piston/slipper assemblies eliminate bore wear and offer longer service life than bronze bore cylinder blocks.

Charge Pressure Switch Contamination

Chelation is not limited to reactions containing copper particles. Some metal deactivating agents in turbine oils also chemically react with microscopic silver ions in the microswitch of the charge pressure switch (CPS) assembly. During normal switch operation, the interruption of electrical current by the microswitch contacts releases silver particles which are largely retained in the microswitch cavity. Non-hermetic switch designs do not prevent oil from reaching the microswitch cavity and reacting with the silver particles. Chelate formed in the microswitch will deposit on the electrical contacts making them non-conductive. These oil deposits in the microswitch do not allow a cockpit indication of low oil pressure when the engine is shut down and will require removal of the associated electric power machine for CPS repair or replacement.

As described in the copper chelation section, the rate of chelation is influenced by the amount of particles present, the temperature, and the particular oil formulation.

- Since silver ions are liberated with each electrical actuation, high-time and/or high-cycled CPS will have more metal ions. An IDG that is leaking or operated with a low oil condition could rapidly cycle the CPS.
- Higher oil temperatures increase chelation rate
- Some oil formulations react more aggressively with silver particles

Collins & Operator Actions

Time-based Replacements

When returning hardware, some operators have reportedly instituted a maintenance program to replace the non-hermetic CPS based on their fleet's historical experience in flight hours. Additionally, a CPS with fewer hours can be functionally checked for closed contact voltage drop values using the INSPECTION/CHECK procedure of Hamilton Sundstrand Standard Practices Manual 24-10-00 for both new and used switches.

Hermetic CPS Design

Collins has developed a charge pressure switch assembly that packages the microswitch in a sealed cavity. Preventing oil from reaching the electrical contacts precludes chelate formation and contamination of the electrical contacts. Operators experiencing non-hermetic CPS failures should consider incorporation of this design improvement when available as an option in component manuals.

Elastomer Compatibility with HTS Oils

Evolution of jet powerplant designs has resulted in engines with higher efficiency, higher reliability, and higher operating temperatures. These higher operating temperatures have demanded concurrent advances in turbine oil formulations with higher thermal-oxidative stability (HTS) to realize the advantages of higher engine reliability and longer time on wing. However, the oil additive packages of some HTS oils have been found to be more aggressive toward the standard fluorocarbon elastomers (identified by M83248/1, AS3208, or AS3209 part numbers) commonly found in o-rings and seals of electric power machines. Exposure to some HTS oils can change standard o-ring physical properties and result in unacceptable swelling, loss of elasticity, cracking, and possible oil leakage.

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An improved o-ring material is available that provides superior performance and compatibility with HTS oils. Collins has incorporated HTS compatible o-rings, identified in AS83458 by M83485/1 part numbers into repair manuals. These M83485/1 o-rings are suitable for use with both standard and HTS oils. Operators may specify their repair provider use M83485/1 o-rings throughout the electric power machine. The HTS compatible o-rings are recommended on the input shafts of electric power machines to ensure containment of engine oil supplied by the accessory gearbox to the electric power machine input shaft splines.

Oil Conductivity and Static Charge Generation

Turbine oils used for efficient cooling of electric power machines have low electrical conductivity. Internal oil flows are designed to maintain generator electrical windings and rotor rectifying diode temperatures within thermal limits. The hot oil leaves the electrical power machine to be cooled by an external heat exchanger before returning again to the electrical power machine.

Electrical conductivity of oil within an electric power machine is not a stationary parameter; conductivity will change with oil temperature, oil additive reactions, and the presence of wear debris, water, and oil oxidation products. The oil conductivity is typically lowest when the oil is new and increases as the oil accumulates operational hours.

One undesirable characteristic of low conductivity turbine oil is the ability to generate an electrical charge within the oil due to molecular friction between the flowing fluid and material surfaces in contact with the oil.

As oil flows through the spinning rotor of the generator to provide cooling and lubrication, electrostatic charge accumulation may reach levels sufficient to damage electrical wire insulation and damage rectifying diodes in the generator.

FACTORS WHICH INCREASE ELECTRICAL CHARGE ACCUMULATION
• Low electrical conductivity of the oil
• High oil flow velocities
• High oil viscosity
• Low oil temperature
• Large surface area in contact with flowing oil
• Low moisture content of oil
• Clean oil, absent of metallic wear particles

Turbine oils are manufactured and tested to conform to several international specifications that define chemical and physical properties of the oil. However, at the time of this paper, the conductivity of the oil is not a controlled parameter and will vary among oil brands and formulations. Oils with low conductivity values may be more susceptible to electrostatic charge generation.

Reductions in static charge accumulation could be achieved by changing the materials used in constructing electric power machines and by increasing the electrical conductivity of turbine oils. Both of these avenues, however, will require extensive new research and testing and will not be readily applicable to current electrical machine designs. Further, neither operators nor Collins has control of all the factors influencing oil electrical conductivity.

Operators experiencing diode failures induced by static discharge may note an increase in failures during colder, drier seasons as higher viscosity oil and absence of moisture favor electrical charge accumulation. Diode failures may also be noted to increase following oil and filter changes as clean, dry oil can have lower conductivity.

Collins & Operator Actions

Operators should discuss their experience with the technical staff of their oil provider for oil selections to mitigate static charge conditions including the properties of oil conductivity. A common measurement of oil conductivity is reported in pico-Siemens per meter (pS/m).

Collins has incorporated a means to prevent electrical discharge damage to the rotor circuit for new designs and as a retrofit for some existing IDG programs. Incorporation of a grounded diode pack provides an electrical path for accumulated charges on the rotor to dissipate through an oil transfer tube and provides protection to the rotating diodes in the rotor. As improved diode pack designs are developed and tested, service bulletins will be released to incorporate grounded diode packs into specific applications. Operators are encouraged to review their fleet experience with diode failures and consider incorporation of these service bulletins.

Zinc Carboxylate and Disconnect Solenoid Actuation

Collins Aerospace has noted an issue that can affect the disconnect function of an IDG or VF generator. The issue involves the collection of zinc carboxylate deposits within the disconnect solenoid. In some cases, the deposits have been sufficient to prevent actuation of the disconnect solenoid, and thus interfere with the ability to disconnect (either manually or thermally) the IDG or VF generator. Although the quantity of units which have experienced disabled disconnect is relatively small, the potential effect of a disabled disconnect is significant, and thus warrants this informational note.

The zinc carboxylate deposits are byproducts of a chemical reaction between highly acidic turbine oil and the eutectic solder pellet within the disconnect solenoid. Lab tests have produced zinc carboxylate deposits with several different oil brands. However, the formation of significant zinc carboxylate deposits in the disconnect solenoid during field use has only been observed when using ASTO 560 turbine oil.

Collins & Operator Actions

Lab testing has indicated that acidification (ageing) of the turbine oil plays a role in this chemical reaction. This means that oil maintenance practices and operational conditions can influence this behavior. Also, as with most chemical reactions, temperature plays a key role. Operating oil temps vary among aircraft types, engine types, and operator's locations; therefore, Collins would expect operator's experience with this issue to vary. Collins recommends that operators currently using ASTO 560 turbine oil contact their maintenance provider to determine if this issue has been observed in their IDGs or VF generators. If this issue has been observed, Collins recommends that operators discuss this behavior with their oil provider to determine an appropriate action.