Aircraft Engine Lubrication

What You Should Know

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Background

- Technical Director - Aircraft Specialties Lubricants
  *Creator of “CamGuard”*

- Exxon Research and Engineering
  - Director of the engine research for the Advanced Fuels and Lubricants Group
  - Initial research on “Exxon Elite” aviation oil

- General Motors Research
Lubricant Functions

- **Lubrication**
  - Boundary (metal/metal) – Cam/lifters – Cylinders/rings
  - Hydrodynamic Film (oil wedge) – Crankshaft/main bearings, rod bearings, cam bosses

- **Cooling** – Heat transfer medium

- **Sealing** – Piston rings & elastomer seals

- **Cleaning and suspending** – Blow-by, lead & dirt
Simple Formulations

- **Base stock** – 90+% Mineral, Synthetic or blend
- **Dispersant** – 3% Keep clean by suspending deposit precursors
- **Viscosity Modifier (VM)** – 2% Changes straight weight to multi-weight
  
  \[ \text{20weight oil} + 2\% \text{VM} = \text{20W-50 multi-grade oil} \]
- **Antiwear** – 1% Cam/lifters rings/cylinders valves/guides
- **Antioxidant** – 0.5% Prevent oxidation leading to deposits
- **Corrosion inhibitors** – 0.05% Ferrous & non-ferrous metals
- **Antifoam** – 20ppm - Foam is terrible for heat transfer & lubrication
Major Obstacles to Making TBO

- ***Lack Of Use*** - Average Use <100 hours/year
  - Time Sitting >8660 hours/year
Pitting Corrosion

Valve Lifter Face
196 Hours in 4 years
25 Hour oil changes
Camshaft

Hard Surface Pitting

Cam lobe and bearing surfaces
200 hours
Spalled Cam Lobe

Pitting leads to catastrophic cam failure

250 Hours
Roller Cam Surface Pitting

Rust affects all steel parts.

300 Hours

Not the solution to Lycoming cam problems.
Major Obstacles to Making TBO

- ***Lack Of Use*** - Average Use <100 hours/year
  - Time Sitting >8660 hours/year

- **Blow-by**
  - Highly reactive & corrosive “Reactive Deposit Precursors”
  - >0.1 gallons of fuel per hour through crankcase
  - Combustion of hydrocarbons produces water
    - 1 gallon water produced per gallon of fuel burned
    - A lot of water in the crankcase
What is blow-by

Intake

Compression
Ignition

Bad

Really bad

Bad

Power

Fully combusted fuel and water

Partially combusted fuel “Very Reactive”

Raw fuel
Piston Deposits

Reduce Heat Transfer/Pistons get Hotter & Hotter

400 Hours
Deposits ≫ ≫ ≫ Stuck Rings

Stuck Ring
Rusty Ring
Sludge
Scuffing
New Steel Cylinder

Crosshatching surface finish holds oil on cylinder surface
Cylinder Wear - Bore Polish

740 Hours
Worn Out
Continental IO-520
Rust / Polish Pattern
Major Obstacles to Making TBO

- **Lack Of Use** - Average Use <100 hours/year
  - Time Sitting >8660 hours/year

- **Blow-by**
  - Highly reactive & corrosive
  - DEPOSITS ring groove & valve guide
    - Sticking parts cause excessive wear & “morning sickness”
  - >0.1 gallons of fuel per hour through crankcase
  - >0.1 gallons of water from combustion /hour through crankcase
    - Combustion makes ≈ 1 gallon water per gallon of fuel

Temperature (power) management

- Rapid temperature changes - scuffing - cumulative effect
- Cold temperatures - Use multi-weight oils & preheat below 40 °F
Piston Skirt Scuffing

400 Hours
Minimizing the Problems

Corrosion – **PREVENTION** is the only option

- Change oil often - 25 to 35 hours or quarterly
- DO NOT leave dirty oil sitting in engine - 15 Hour oil is **CORROSIVE**
  - Water contaminated with acids
- Use corrosion inhibiting oils or additives such as CamGuard

**NO ADDITIVE CAN CURE EFFECTS OF RUST**

Deposits – Lead to Sticking Parts and Excessive Wear

- Fuel components in blow-by **IS the CAUSE of DEPOSITS**
  - Lean aggressively on the ground & below 65% power (POH)
  - Multi-probe engine analyzers allow more aggressive leaning
  - LOP – ROP debate
  - Use deposit inhibiting additives such as CamGuard
What the Oil Sees - 0 to 15 Hours

- Dispersant bonds to “Deposit Precursors”
  - “Keep Clean” by suspension
- Combustion water reaches equilibrium
  - 100-1000ppm – Oil temperature dependent
- IMPORTANT to have ENOUGH oil consumption
  - 1 qt in 4-20 hours
- Oil consumption increases as oil becomes “stickier”
  - Heavy oxidized FUEL components collecting
Oil 15-30 Hours

- Makeup oil 1 to 3 quarts
  - shot of dispersant and A/O
- Deposit Precursors from blow-by
  overwhelming dispersant start to form:
  - Lacquer > varnish > hard carbon deposits
  - Combustion water becoming “Acidified” and corrosive
- Sludge - combination of lead particles (from leaded avgas) and resinous lacquer
  - Can bake into heavy carbonaceous deposits
Engine “Painted” with Varnish

800 Hours
Small sump
Cirrus
50 hour oil changes
Lead Sludge Buildup - Crankshaft

Lead bromide + oxidized Fuel
2000 Hours
Dispersant
Cannot suspend lead particles
Oil 25-35 Hours

Recommended Oil Change Interval

- Recommended for most aircraft
- Engine should be warmed up to operating temps by FLYING
  - Cut filter to look for metal, carbon & other stuff
- Organic acids & water in the oil are very corrosive
  - 0.1-2 ounces of water in crankcase – Ground running increases water and NOT recommended
  - Minimal neutralization of acids in ashless oils
  - Neither water or acids can be filtered out of oil
- Regular oil analysis - Establish a trend for engine
Frequency of Use Impact

- **Frequent Use**
  - Low wear rates reflected in Oil Analysis
  - Carbon Deposits formed are softer and easily displaced

- **Infrequent Use**
  - Corrosive environment
  - Real Startup Wear (RUST)
    - Cylinders
      - Rust/Polish pattern
      - Dimensional change
    - Cam lobes & lifters
      - Pitting and spalling
  - Oil analysis erratic values
When To Overhaul

- **Low compression - Valve leakage or ring wear**
  - Boroscope cylinders
    - Treat cylinders as accessory's & repair as required

- **Excessive oil consumption**
  - Stuck or worn oil control rings

- **Making metal**
  - Determine source and extent of engine contamination
Conclusions & Recommendations

- Fly Frequently – as frequently as possible
- Frequent oil changes (25-35) hours or quarterly
- Power/temperature management
- Anti-corrosion oils or additives “CamGuard”
- Why Camguard was created
  - Corrosion
  - Deposits
  - Wear
  - Seals
The Following Information is from the CamGuard Certification Effort

Pictorial of 500 Hour Engine Test Results

Skybolt Aerobatic Aircraft

Lycoming IO-540 300 HP

531.5 Hours TT

Flown By Randy Harris

Photos as engine was disassembled

with 54 hour oil on parts

Nothing was wiped down or solvent washed
Pistons Clean With Camguard
Deposits › › › Stuck Rings

No Camguard
Stuck Ring
Rusty Ring
Sludge
Scuffing
Deposit Free Ring Zone and Skirt

No deposits in the oil wetted areas with Camguard
Ring Groove Close-up

No Deposit Buildup With Camguard
Parts Varnish and Deposit Free
Exhaust Valve Guides

Zero Deposits – Zero wear typical
No Deposits or Sludge with Camguard
Piston Pin Free & Easily Removed
Lifter Faces

No Wear – No Corrosion*

*Plane sat idle for almost 4 months
Cam Lobe-No Wear-No Corrosion*

*Plane sat idle for almost 4 months
Flight Testing CamGuard

• Oil additives are approved by testing in accordance with Advisory Circular 20-24B

• CamGuard was tested beyond the ‘typical operational environment’

• No other operation is as abusive on an aircraft engine as demonstration flying.
Conclusions

- CamGuard first real alternative to marginal commercial oils
- Single package demonstrates multiple benefits
  - Corrosion
  - Deposits
  - Wear
  - Seal issues
- Addresses SB’s and SI’s