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

Aviation Oil Formulations

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 **20weight oil + 2%VM=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

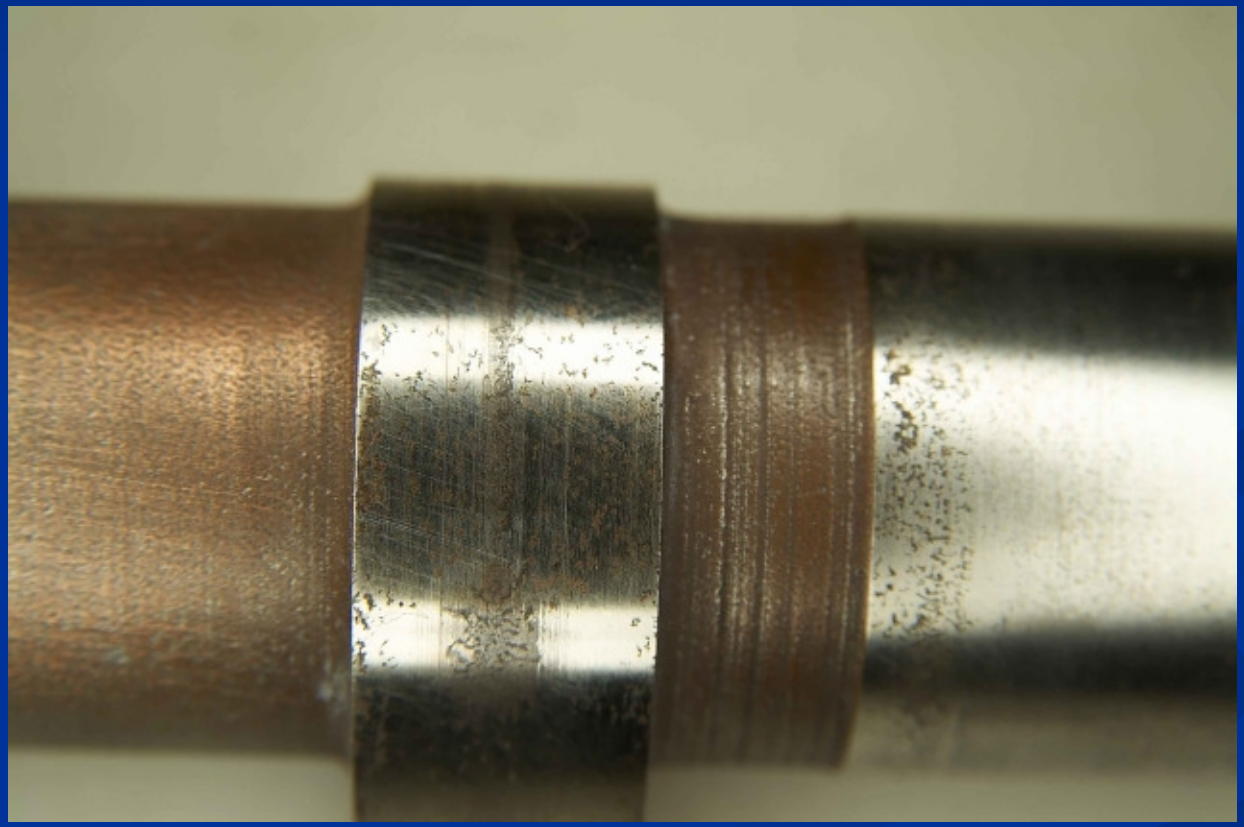
Major Obstacles to Making TBO

- ***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

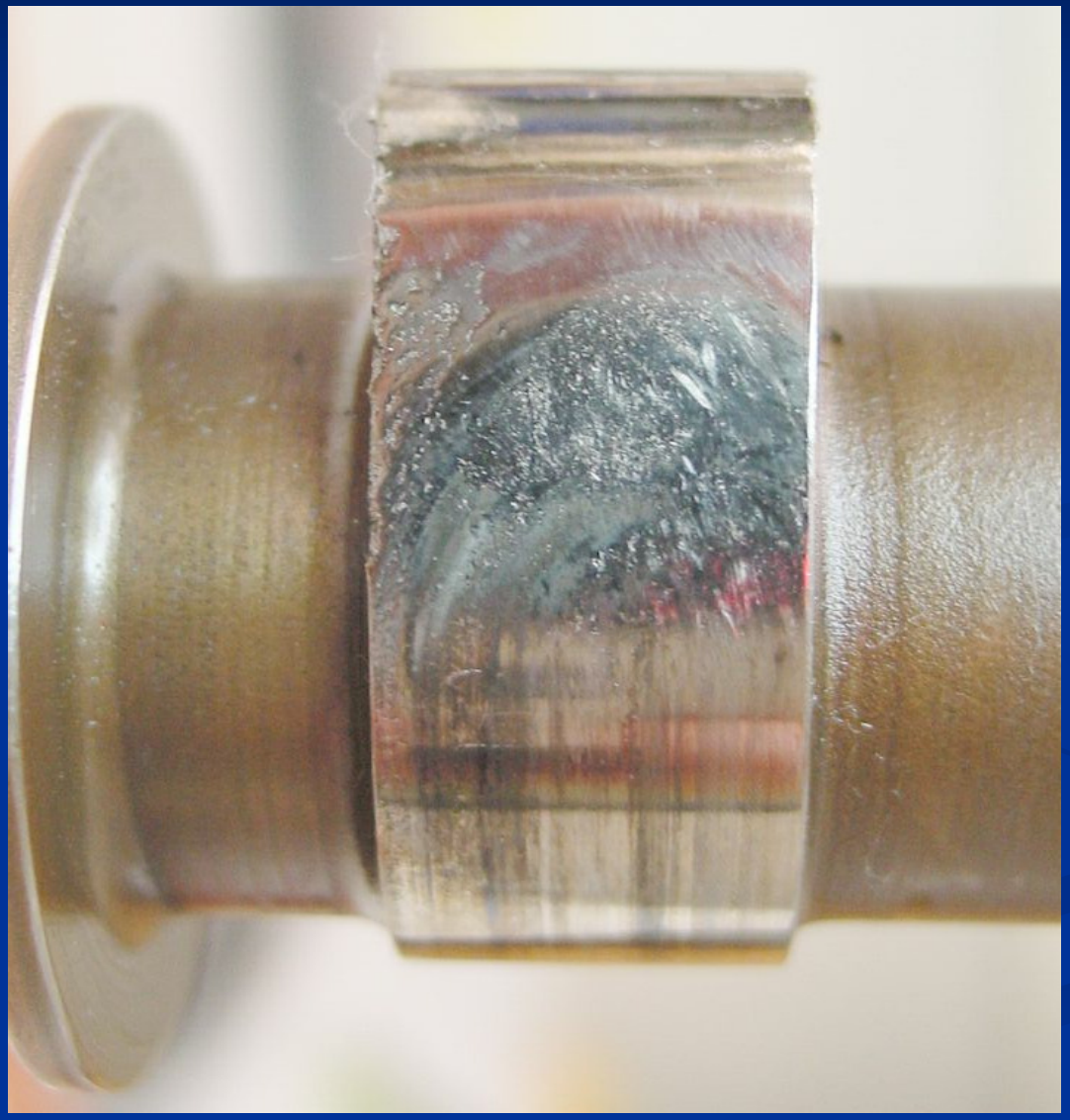
Camshaft
Hard Surface Pitting



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

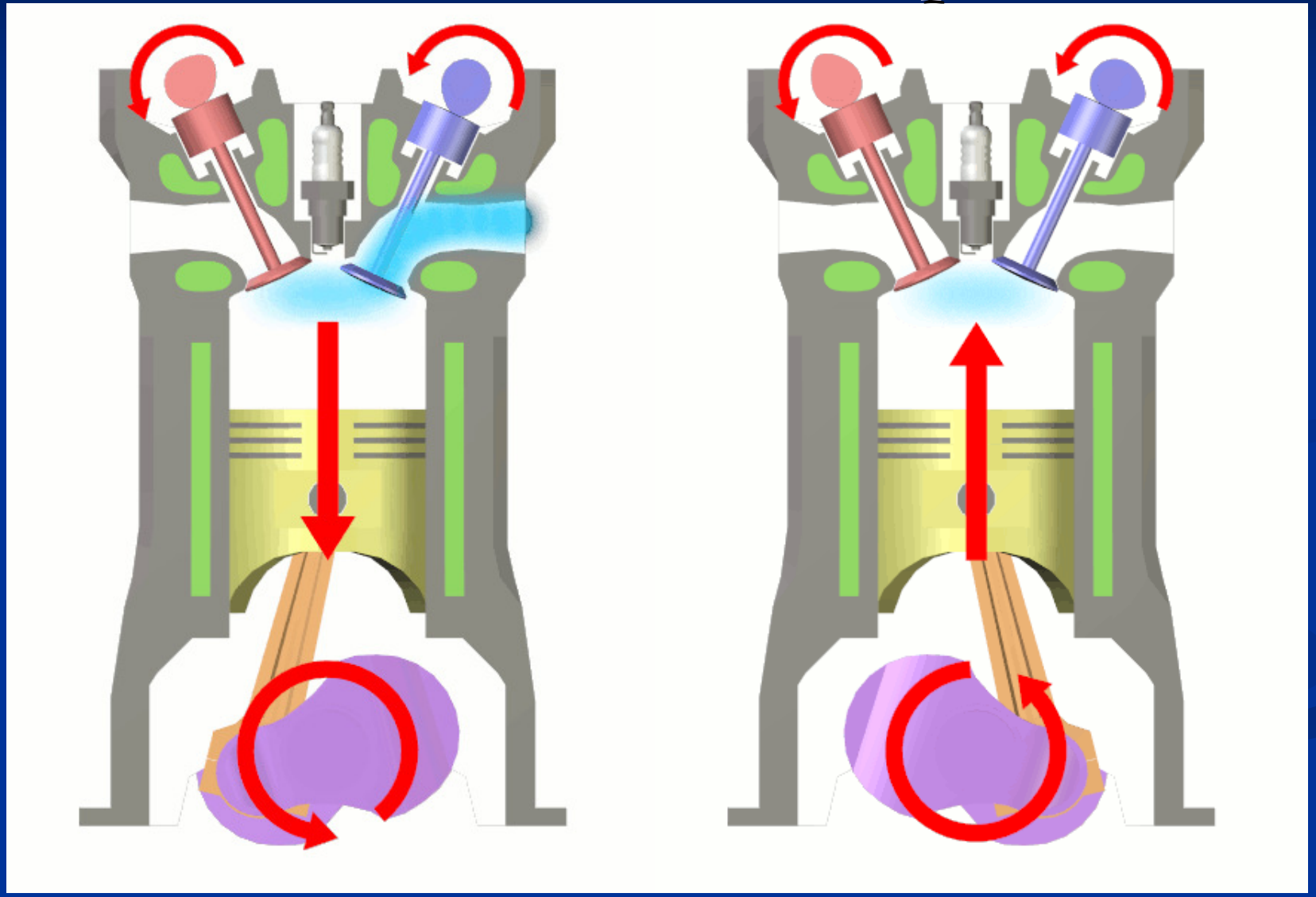
Major Obstacles to Making TBO

- ***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

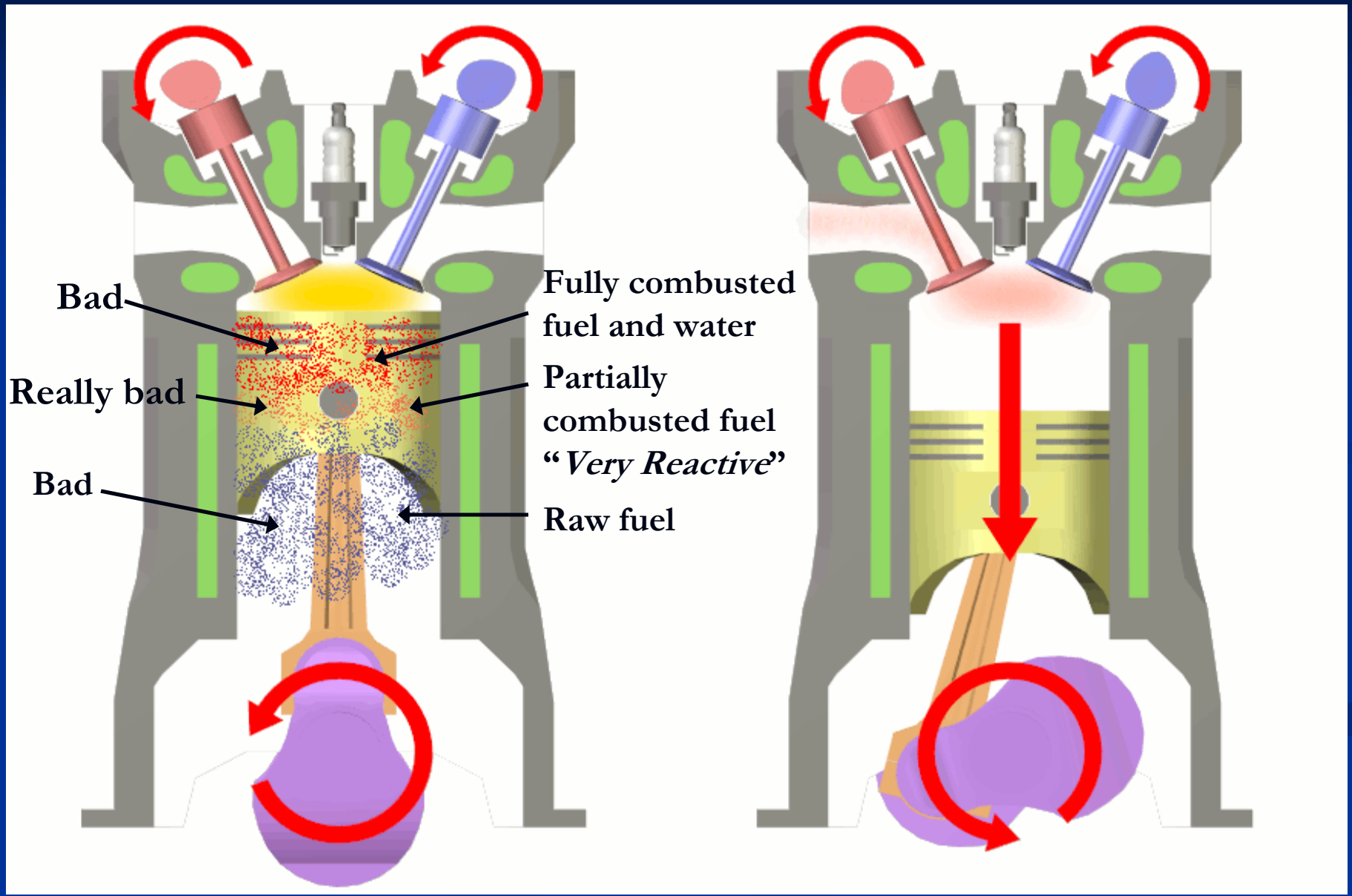
Intake

Compression



Ignition

Power



Piston Deposits

Reduce Heat Transfer/Pistons get Hotter & Hotter

400 Hours

Deposits › › › Stuck Rings

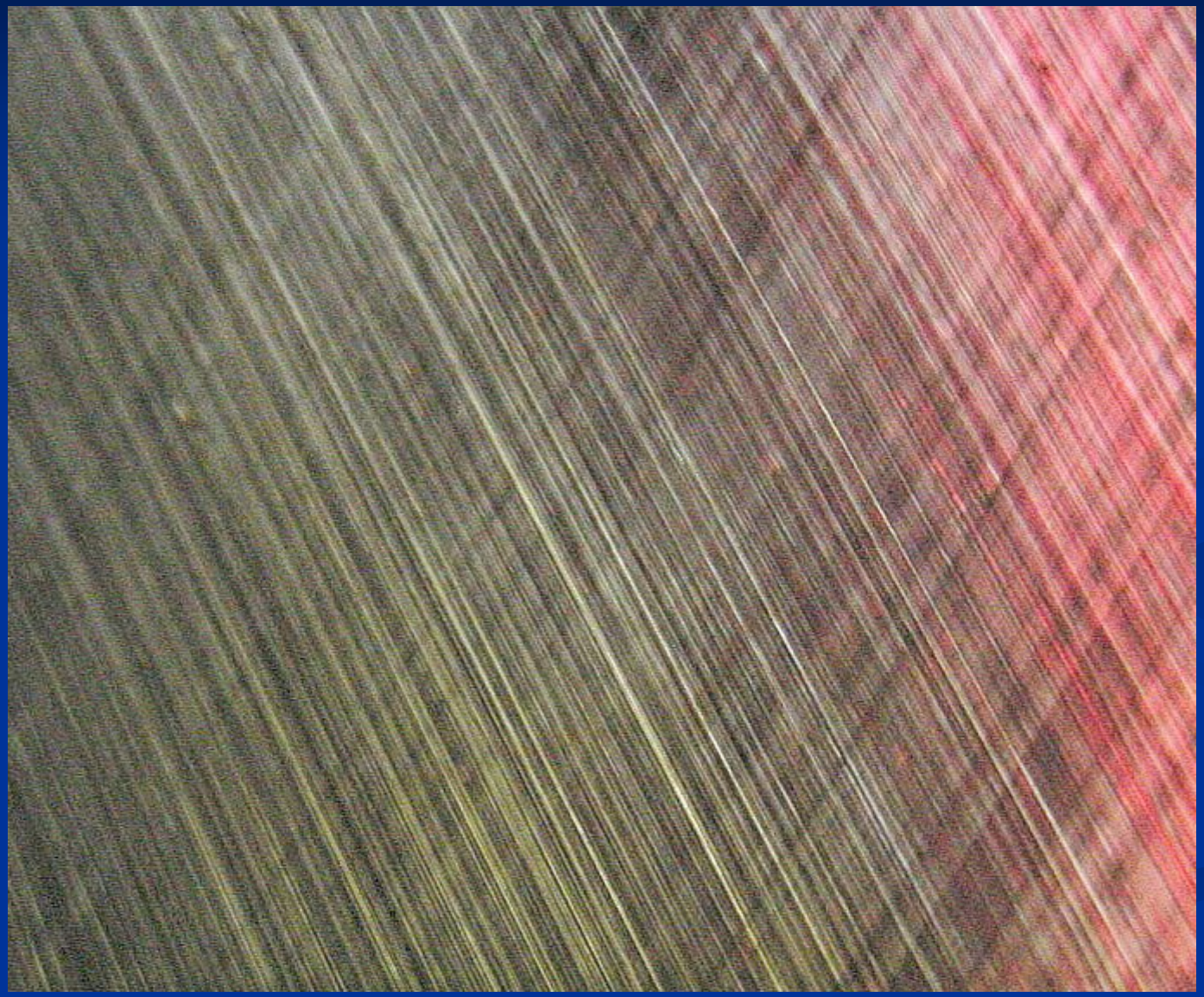
Stuck Ring

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

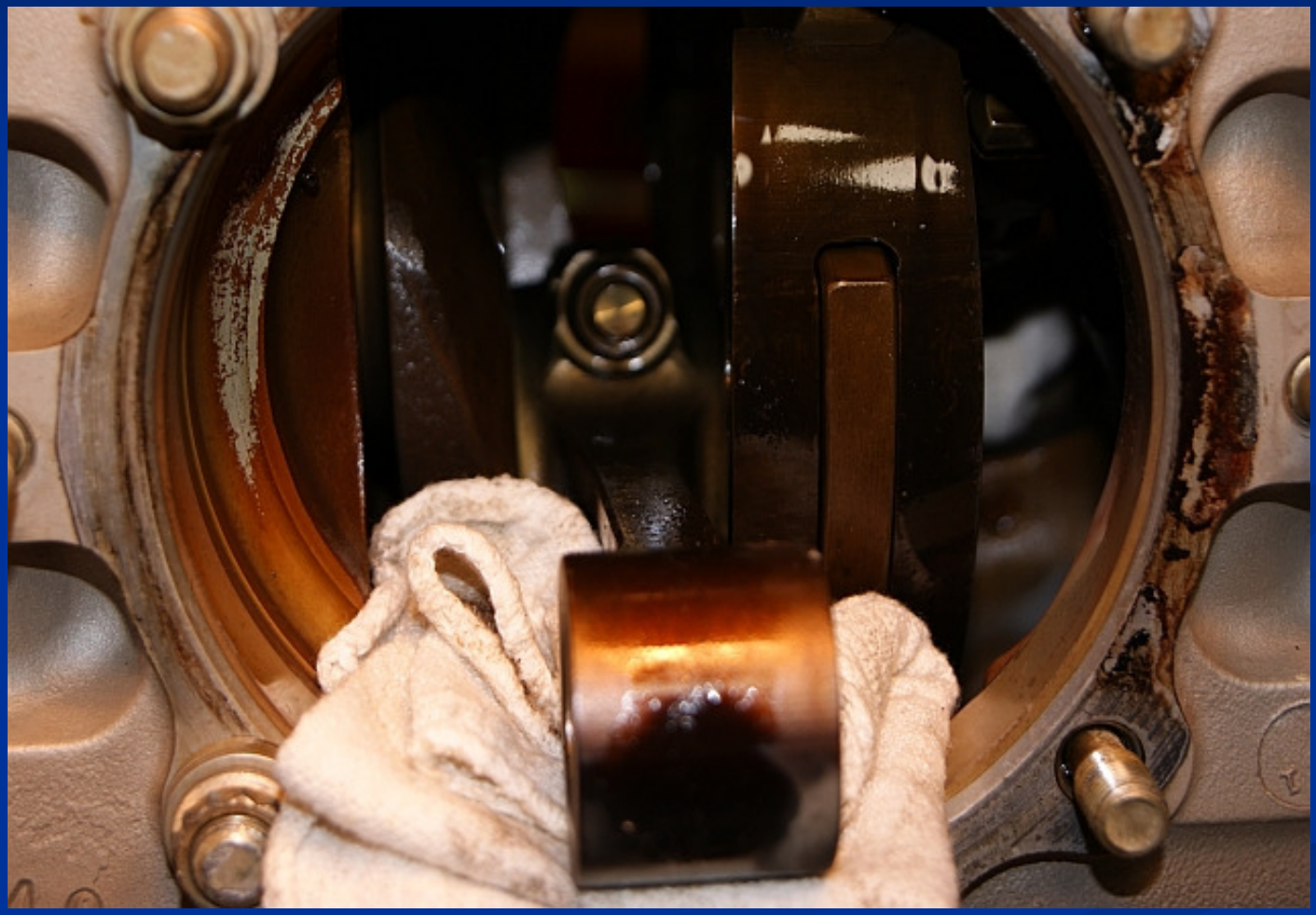
What the Oil Sees - 0 to 15 Hours

- 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

Typical Piston with Deposits

400 hours

No Camguard

Pistons Clean With Camguard

Deposits › › › Stuck Rings

No Camguard

Stuck Ring

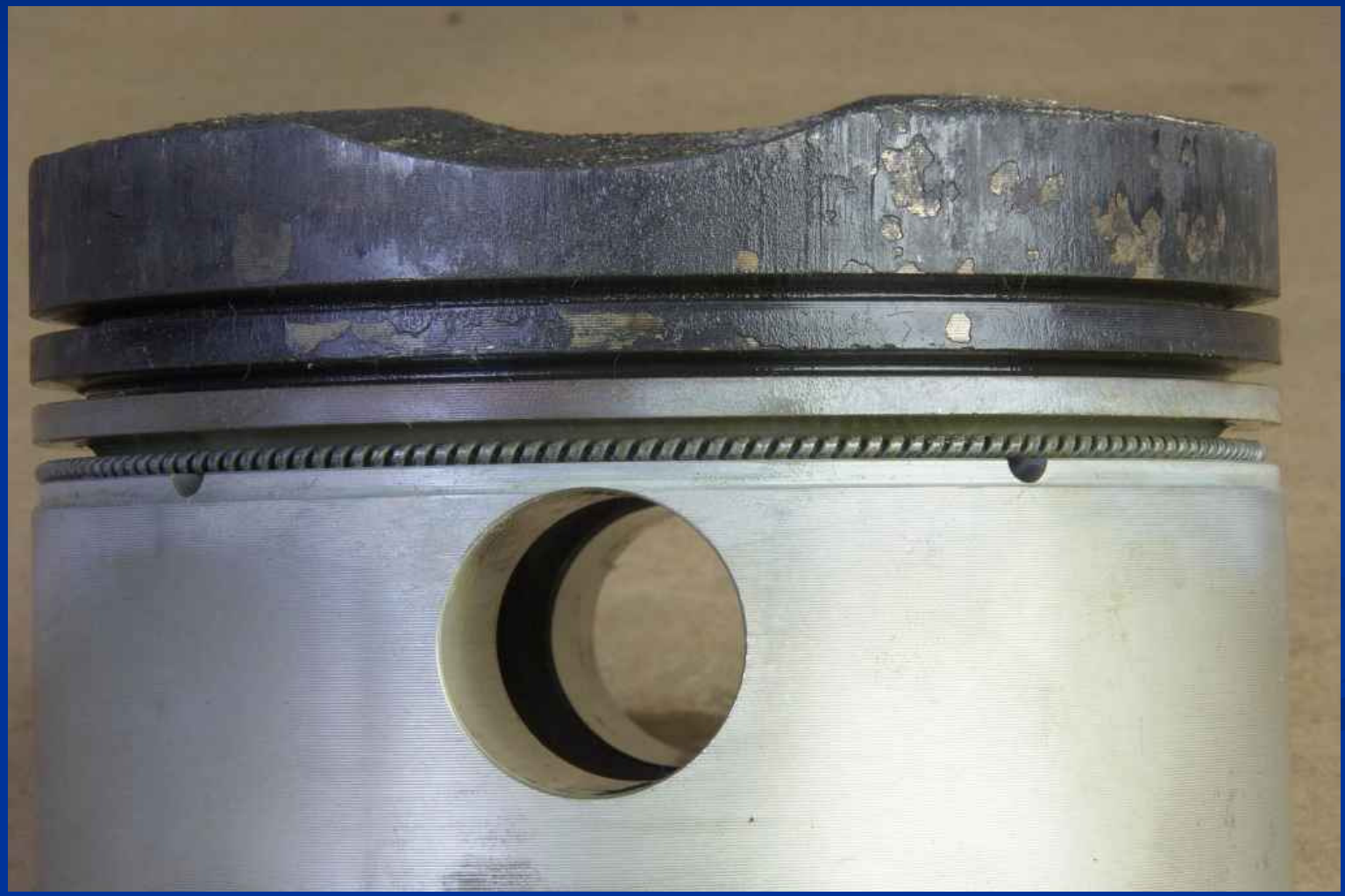
Rusty Ring

Sludge

Scuffing

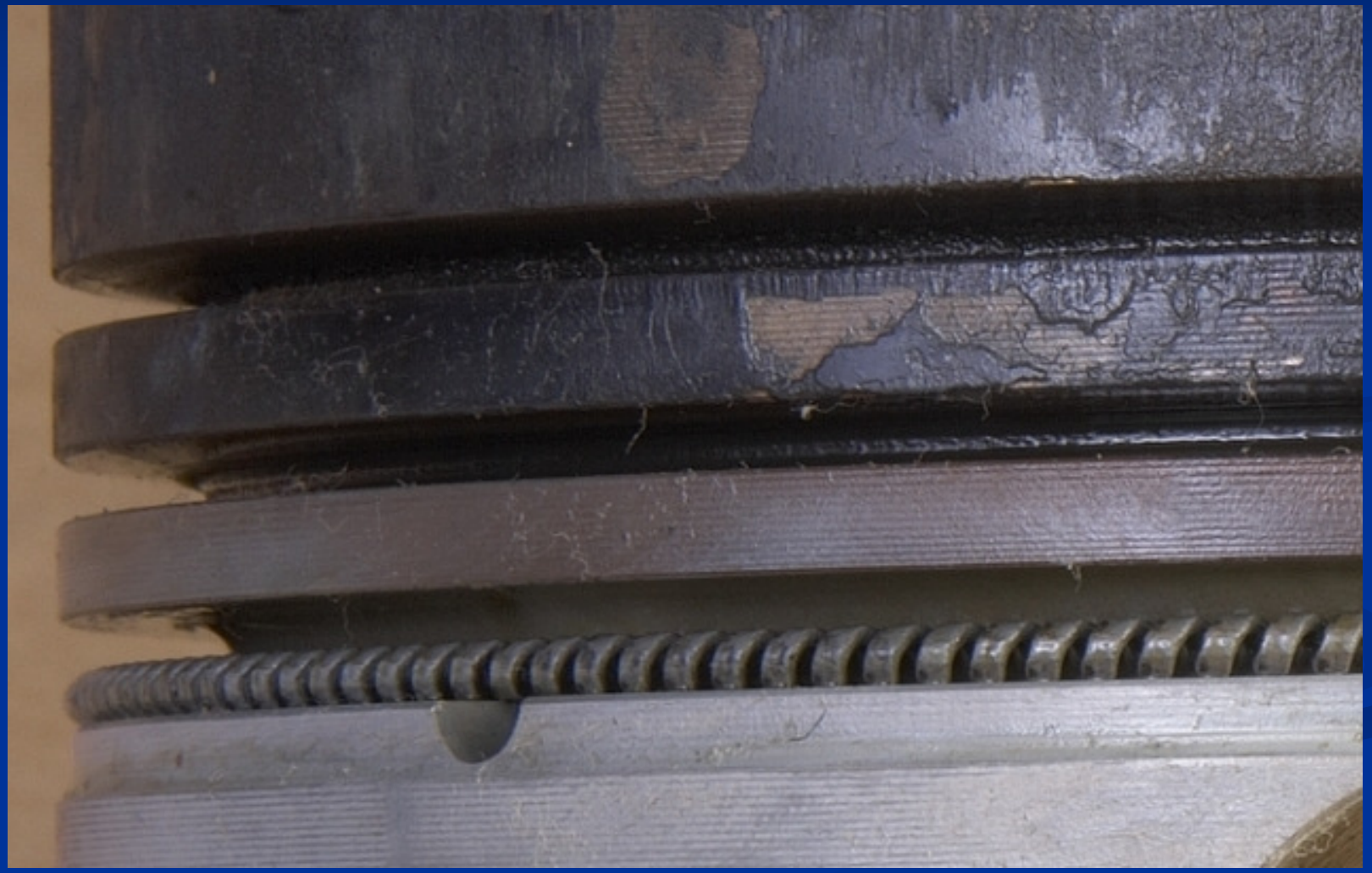
Deposit Free Ring Zone and Skirt

No deposits in the oil wetted areas with Camguard



Ring Groove Close-up

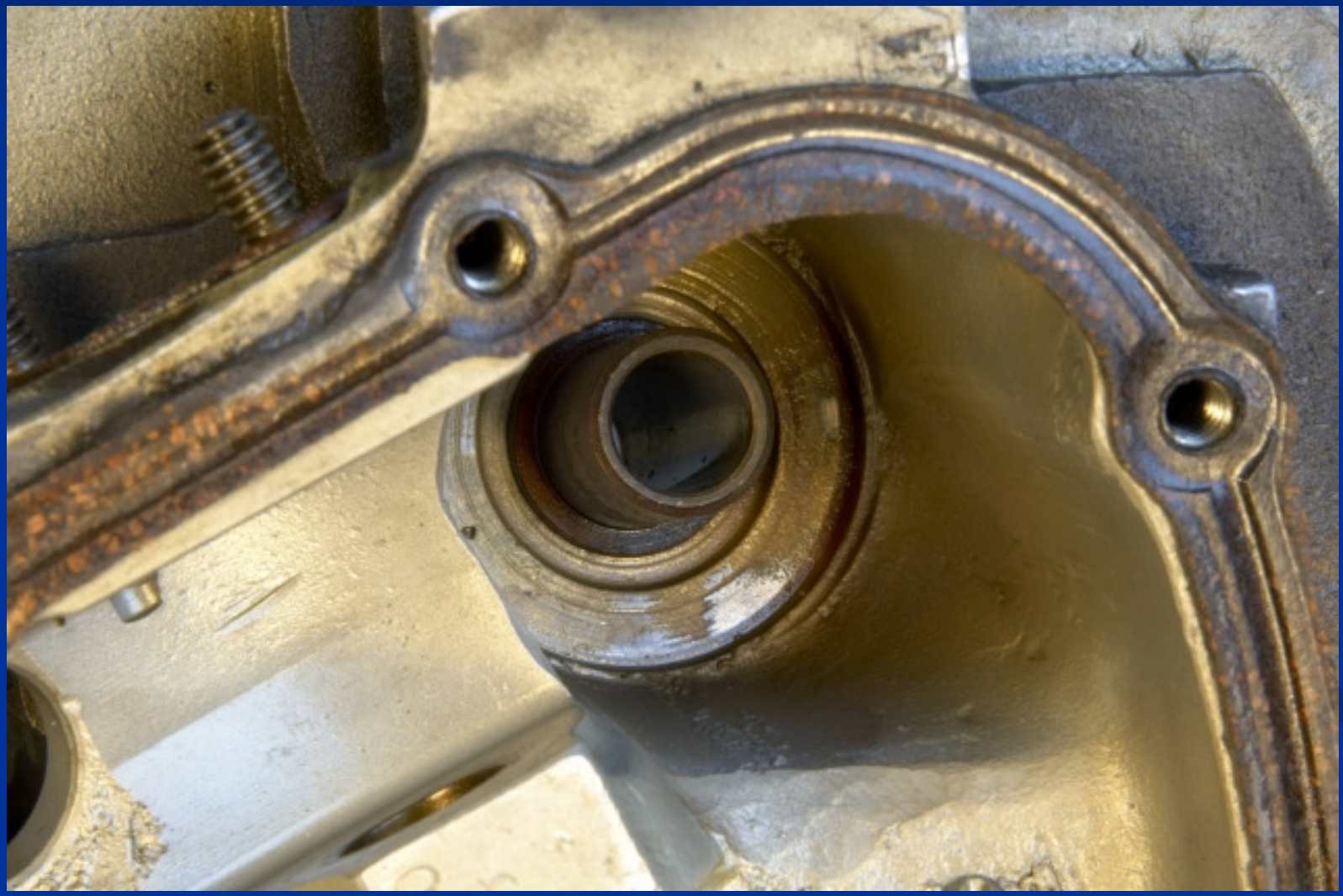
No Deposit Buildup With Camguard



Parts Varnish and Deposit Free

Exhaust Valve Guides

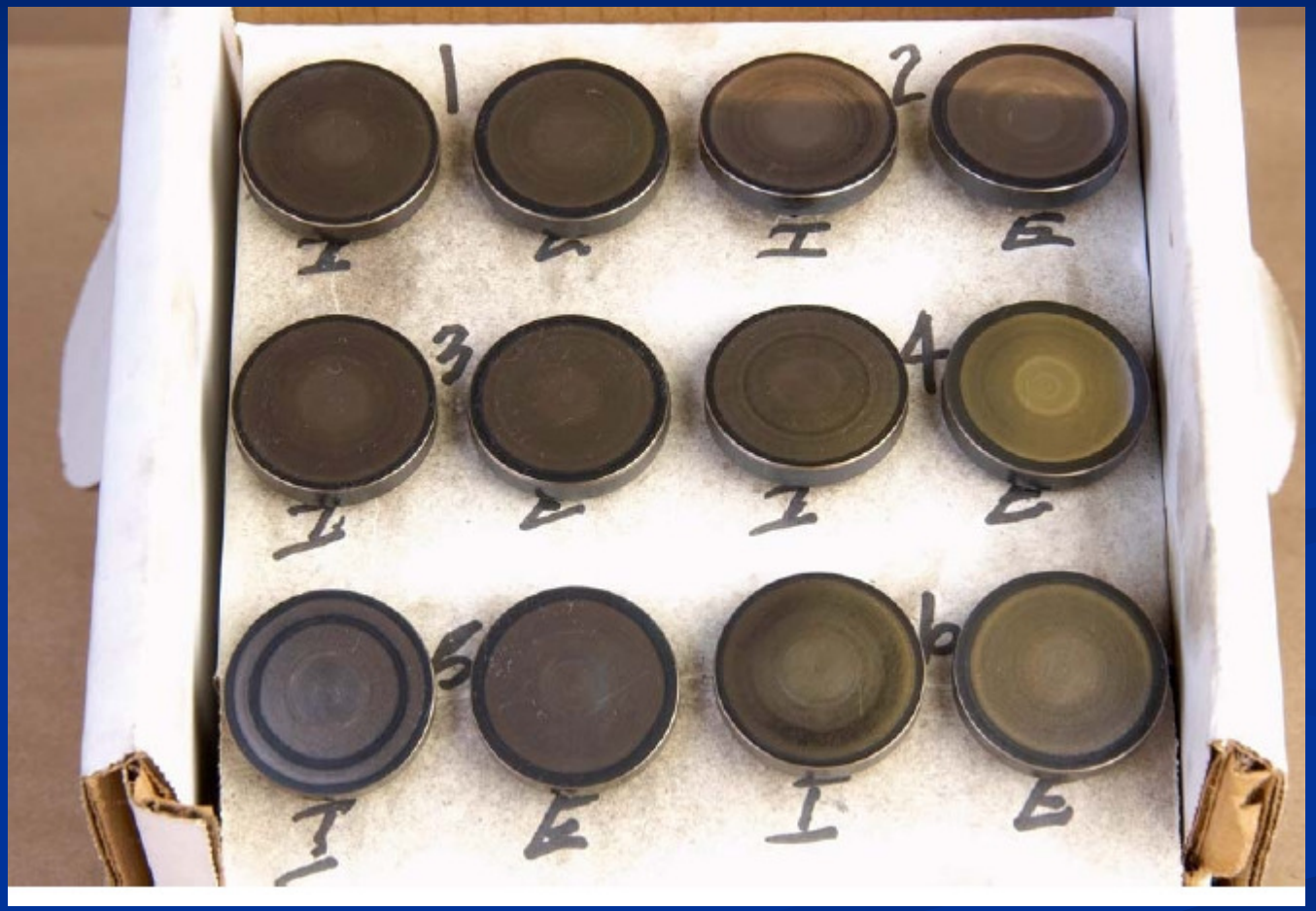
Zero Deposits – *Zero* wear typical



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