# Aircraft Engine Life

## The Reasons CamGuard was Created

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*Research Director ASL*

# Background

- Research Director - ***Aircraft Specialties Lubricants***
  Manufacturers of ***"CamGuard"***
- Exxon Research and Engineering

  *Director of the Engine Research Laboratory*

  *Advanced Fuels and Lubricants Group*

  *Initial research on "Elite"*
- General Motors Research

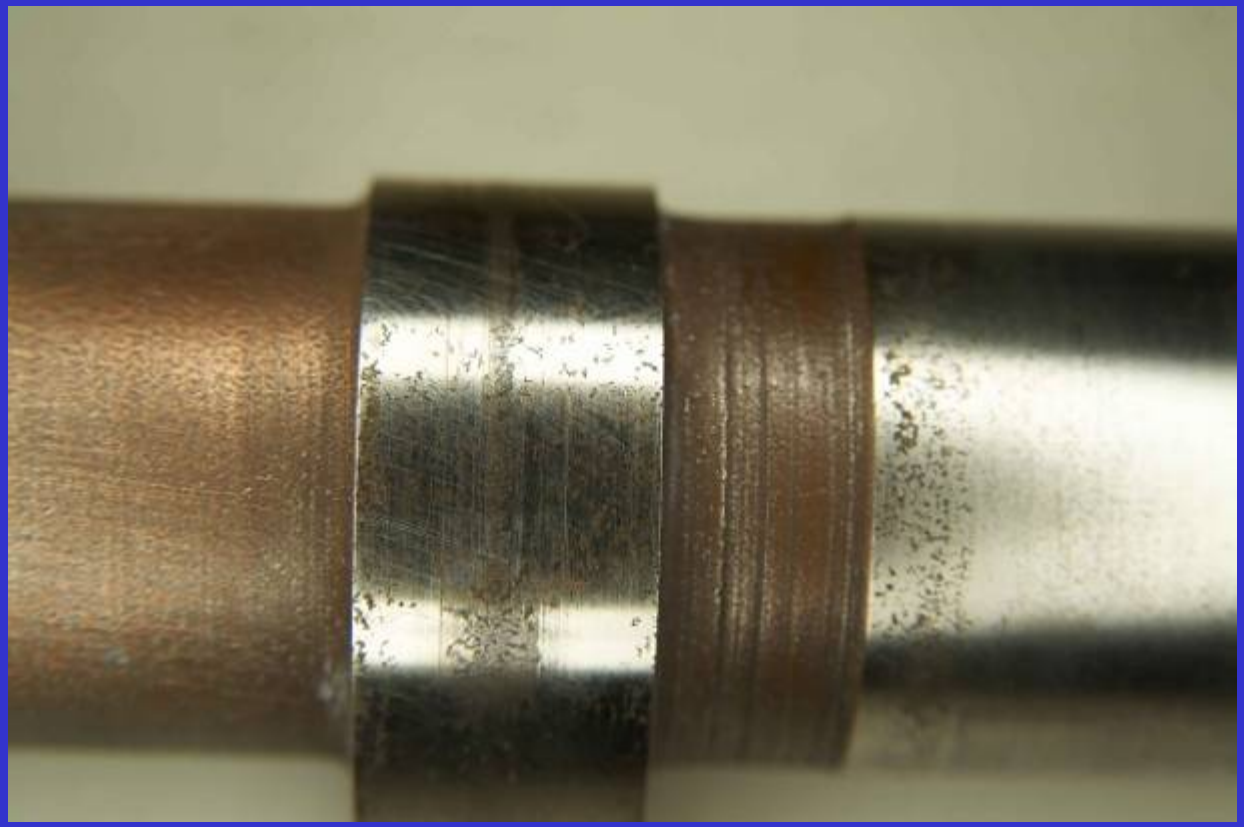
# Major Obstacles to Making **TBO**

- ***Lack Of Use*** - Average Use <100 hours/year
  - Time Sitting >8660 hours/year
- **Blow-by**
  - Highly reactive & corrosive
  - Ring groove & valve guide deposits
    - Sticking parts cause excessive wear & “morning sickness”
  - >0.1 gallons of fuel per hour into and through crankcase
  - >0.1 gallons of water from combustion /hour through crankcase
    - Combustion makes ≈ 1.2 gallons water per gallon of fuel
- **Temperature (power) management**
  - Rapid temperature changes - scuffing - cumulative effect
  - Cold temperatures - Use multi-weight oils & preheat below 40 ° F

# Pitting Corrosion
## 196 Hours in 4 Years

25 hour oil changes

# Camshaft - Pitting Corrosion



200 hours

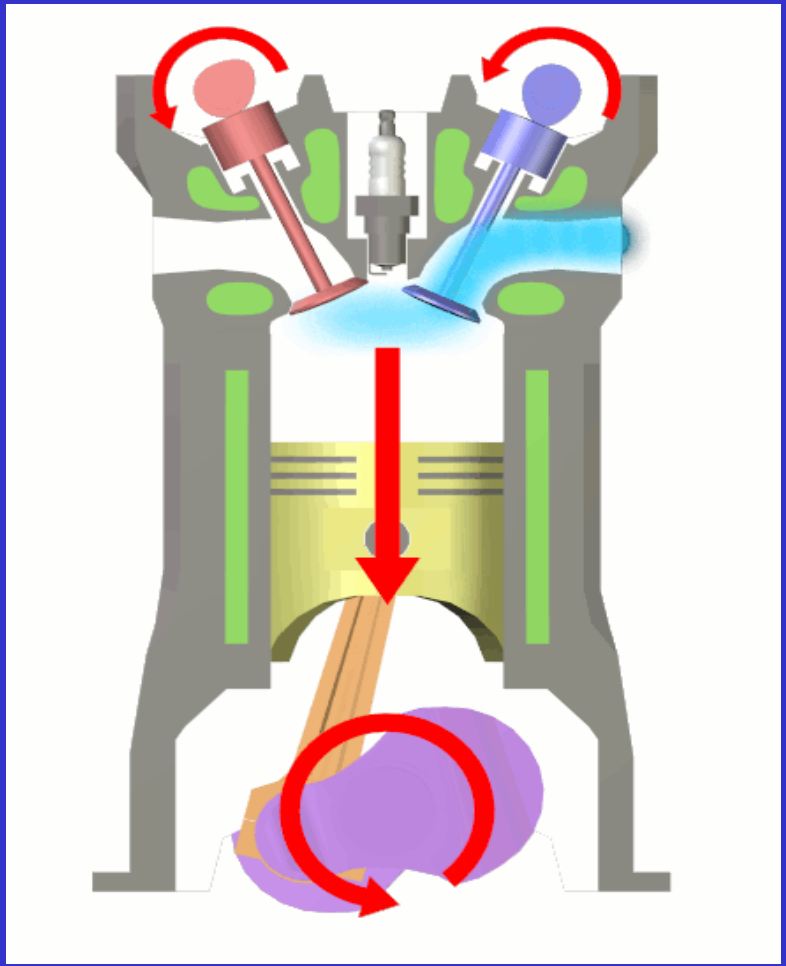
# Spalled Cam and Lifter

## Failure due to corrosion

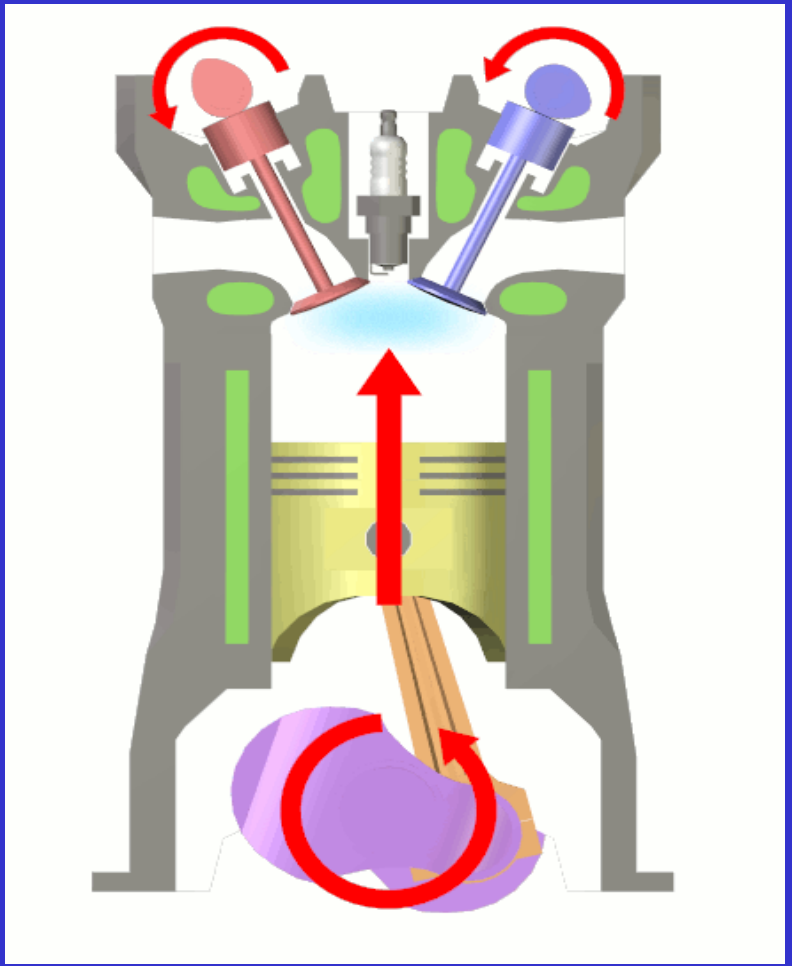

400 Hours

# What is Blow-by

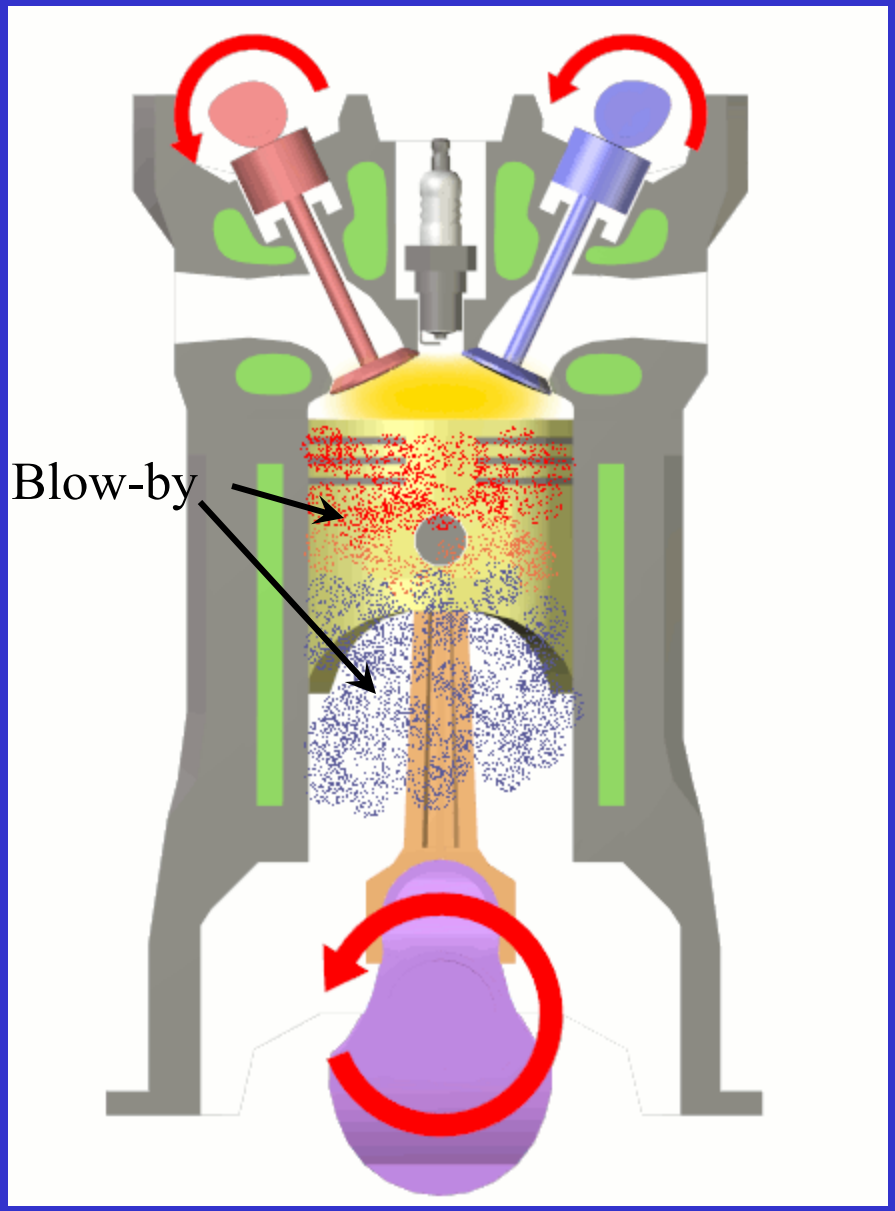
Intake



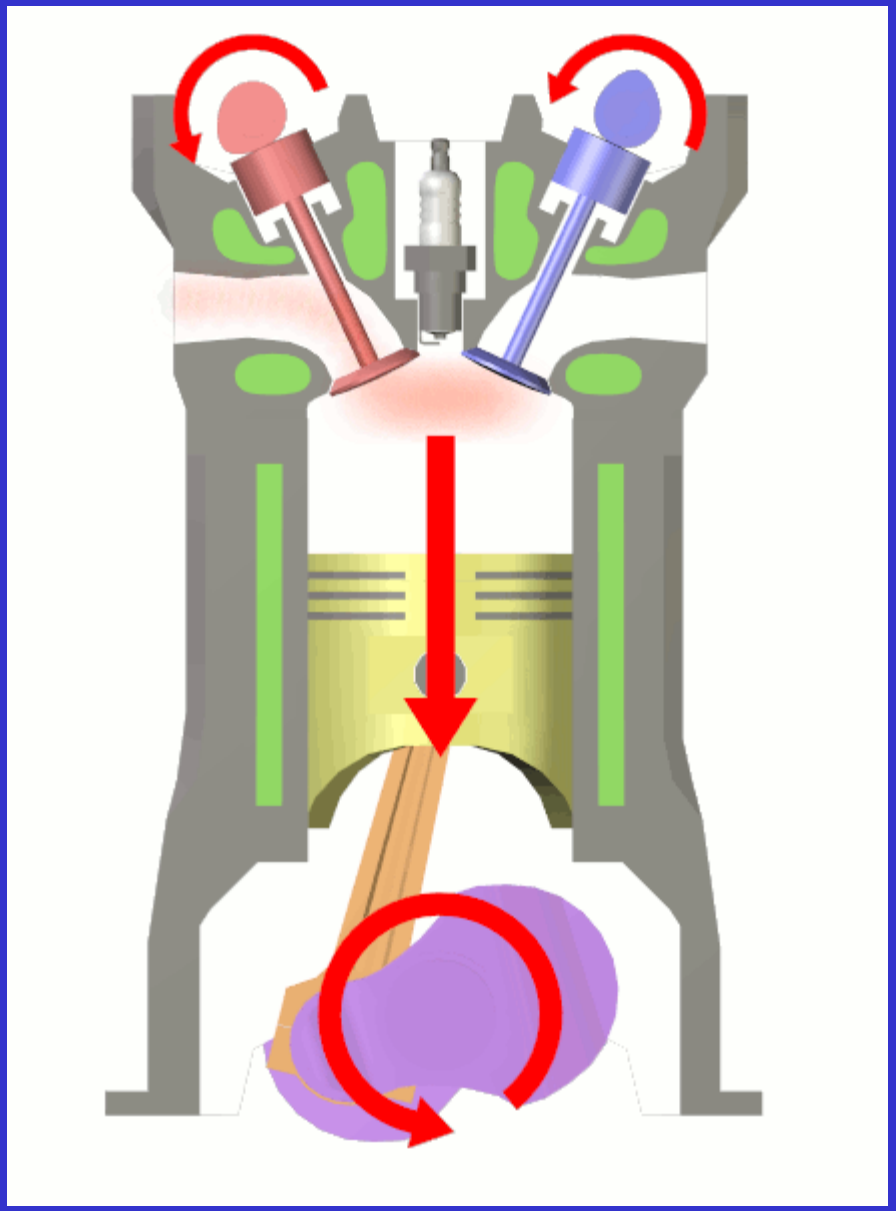
Compression



# Ignition




# Power



# Piston Skirt Scuffing

## Power Mismanagement?


400 Hours

# 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 & other contamination

# Aviation Oils vs Automotive Oils

- Major Differences
  - Automotive and Heavy Duty Motor Oils
    - Ash forming metallic detergents
    - ZDDP "Zinc" antiwear
- Aviation Oils - Simple formulations

**DO NOT USE AUTO OILS IN AIRCRAFT**

# Aviation Oil Additives
## Most Current Oil is1980's Technology

- Base stock - Mineral, Synthetic or blend
- Dispersant - Keep clean by suspending deposit precursors
- Viscosity modifier - Changes straight weight to multi-weight
  - Multi-weight vs. straight-weight debate
- Corrosion inhibitors - Ferrous & non-ferrous metals
- Antiwear - Cam / lifters  rings / cylinders  valves / guides
- Antioxidant - Prevent oxidation leading to deposits
- Antifoam - Foam is poor for heat transfer & lubrication

# **YOU** Can Minimize 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 - 10 Hour oil is **CORROSIVE**
  - Water contaminated with acids, salts, etc.
- Use corrosion inhibiting oils or additives (CamGuard)

NO ADDITIVE CAN CURE EFFECTS OF RUST

## **Deposits** – Lead to Excessive Wear

- Liquid fuel component 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

# What the Oil Sees - 0 to 20 Hours

- Dispersant bonds to leftover “Deposit Precursors”
  - “Keep Clean” by suspension
- Oil/ AO in the ring belt is severely stressed due to small amount circulation & presence of highly reactive blow-by gas
- Oil consumption increases as oil becomes “stickier”
  - Heavy oxidized FUEL components collecting
- IMPORTANT to have ENOUGH oil consumption
  - 1 qt in 4-20 hours
- Lightest components of lube & many aftermarket additives evaporate

# What the Oil Sees - 20 to 35 Hours

- Makeup oil 1 to 3 quarts
  - shot of dispersant and A/O
- Deposit precursors from fuel overwhelming dispersant start to form:
  - Lacquer >varnish >hard carbon deposits
  - Sludge - combination of lead particles and lacquer can bake into heavy thick carbonaceous deposits

# Piston Deposits

## Reduce Heat Transfer/Pistons get Hotter


400 Hours

# Deposits › ›Stuck Rings › ›Wear

Stuck Ring

Rusty Ring

Sludge

Scuffing

# Lead Sludge Buildup - Crankshaft


2000 Hours

# Oil 25-35 Hours
# Recommended Oil Change Interval

- Engine should be warmed up to operating temps by FLYING the Aircraft
  - Cut filter to look for metal, carbon particles & other stuff
- Acids & water in the oil are VERY corrosive
  - Minimal neutralization of acids in ashless oils
  - Cannot be filtered out of oil
- Regular oil analysis - Establish a trend for your engine

# Engine Break-in

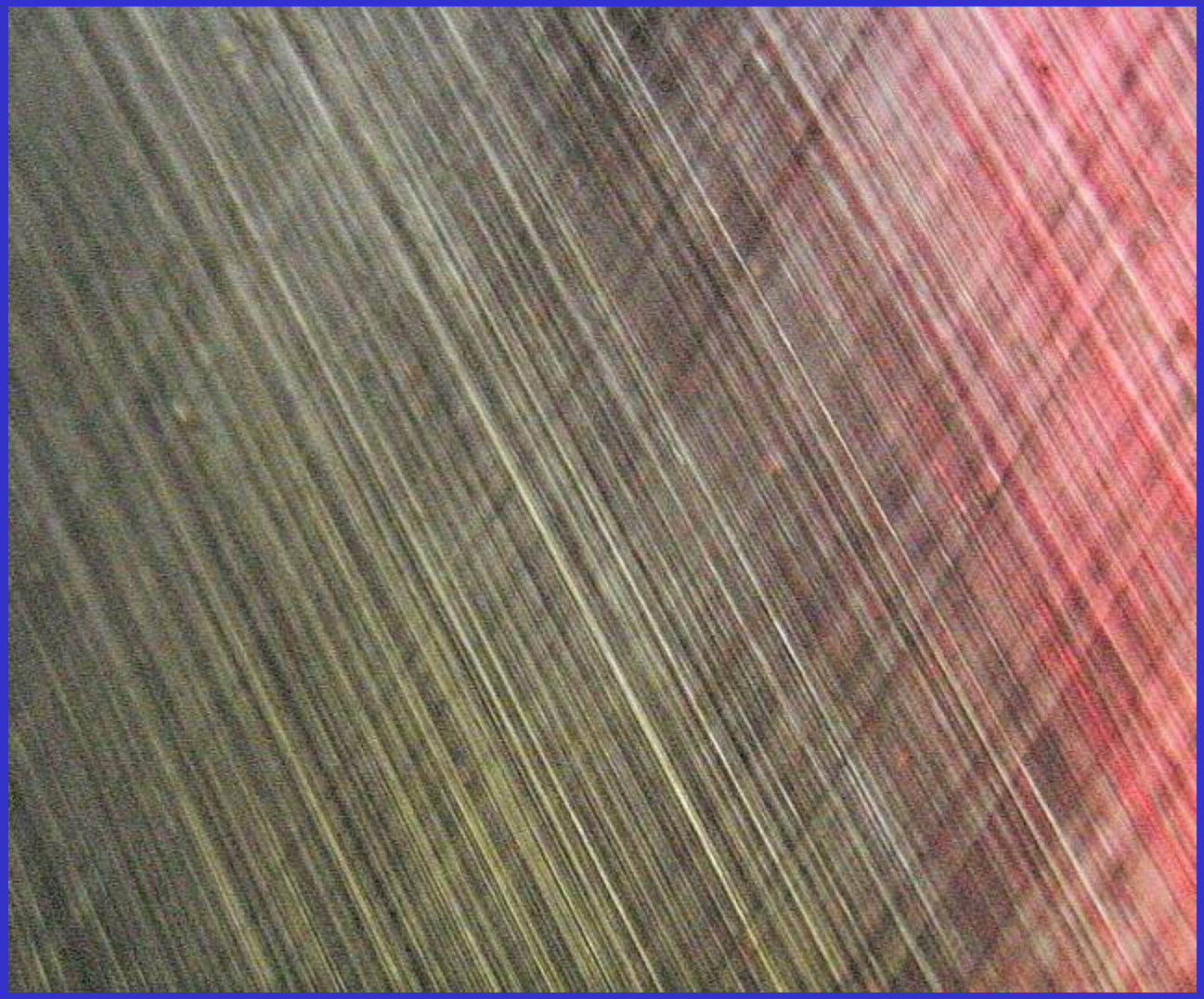
- Cylinder & valve train run-in
- Recommend multi-weight AD oil (manufacture or builder)
- Preheat engine & oil if cold
- Important to use smooth application & reduction of power
- Use high power settings - ROP
  - Careful to watch for overspeeding & high temperatures
- Use shallow climbs & descents to minimize temperature extremes
- Use power on final - **DO NOT** chop and drop

# Engine Break-in

- Components run-in
  - Cylinders most important
  - Need high cylinder pressures to push rings out
    - Minimize blow-by
    - Prevent glazing – torching of oil film
    - Steel - ridges quick break-in / Chrome - flat slow break-in
  - Cam & lifters
  - Guides & rocker arm bushings
- Engine break-in quick but first 50 hours are very important to overall engine longevity

# New Steel Cylinder

## Honed Crosshatch Pattern



# After Break-in to 100 hours

- Break-in complete
  - Temperatures stabilize – Cylinder head & Oil
  - Oil consumption stabilizes

# FREQUENCY OF USE IMPACT

- Frequent Use
  - Low wear rates reflected in Oil Analysis
  - Carbon Deposits formed are soft 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

# ENGINE PROBLEMS TYPE SPECIFIC

- Continental
  - Low compressions
    - Piston ring groove deposits
    - Loss of choke & crosshatching - bore polish
    - ring wear / annealing
    - ring reversal step wear
  - Exhaust valve guide wear
  - Early top
- Lycoming
  - Cam and lifter corrosion
    - Spalling
  - Valve guide deposits "Morning Sickness"
  - Exhaust valve guide wear
  - Early top

# ENGINE 500-1800 HOURS
# Premature Failure Modes

- Top ring & cylinder wear › › loss of compression › › early top
- Exhaust guide wear affects valve seating › › valve and seat overheat › › loss of compression › › early top
- Oil control ring wear › › floating rings with increased oil consumption › › early top

- *WHEN TO OVERHAUL*
  - Low compression - Valve leakage or ring wear
  - Excessive oil consumption
  - Making metal

# Conclusions & Recommendations

- Fly Frequently
- Break-in important
- Power / Temperature management
- Frequent oil changes (25-35) hours or quarterly
- Anti-corrosion oils or additives *"**CamGuard**"*
- Fly Frequently