General Service Bulletin (GSB):	Engine Failure Analysis and Tips
GSB Overview:	This bulletin provides tips to assist the dealership when performing engine diagnostics and root cause determination.
NOTE: This information is not intended to replace or supersede any warranty, parts and service policy, Work Shop Manual (WSM) procedures, PC/ED procedures or technical training or wiring diagram information.	

READ THIS TO HELP PREVENT NON-WARRANTABLE REPAIRS

BEFORE ENGINE IS REPLACED AND VEHICLE STARTED

Engine Failure Analysis and Tips Job Aid

Guide to Engine Analysis and Preventing Repeat Engine Failures

Overview, Section 1

Guide to Engine Analysis—Normal vs. Problem

NORMAL

OFTEN mistaken for engine failure

PROBLEM

Root cause determination, and the extent of damage, is necessary during engine assessment.

Some inspection areas include:

- Metal in the oil filter
- Metal found in the oil pan
- Cylinder head cam bore
- Camshaft journals and lobes
- Cylinder wall
- Rod and main bearing condition
- Crankshaft journals

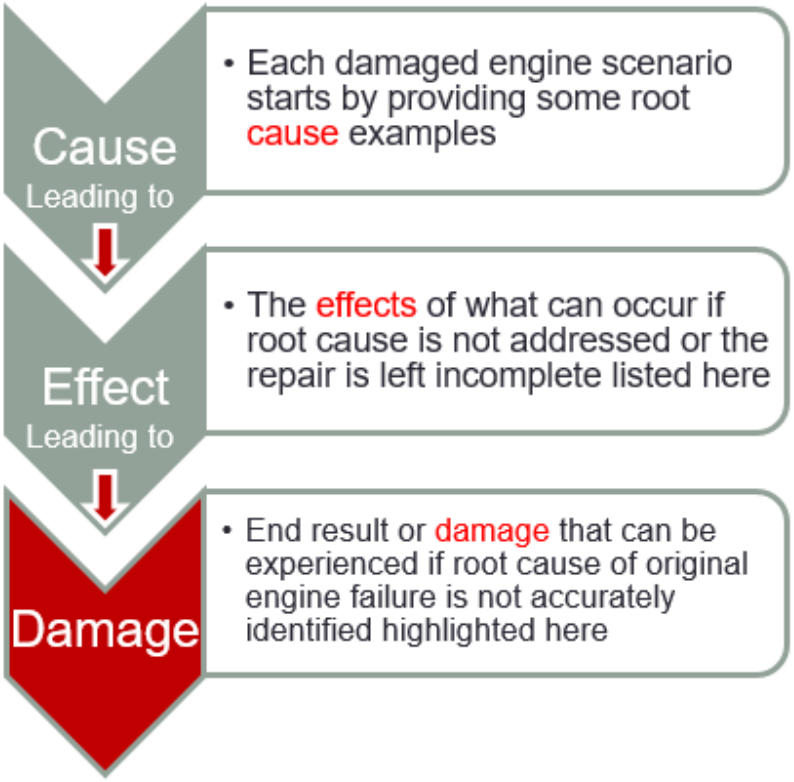
Understanding normal engine observations / findings vs. actual damage that is the source of a concern can increase the accuracy of a assessment.

This section of the Job Aid targets some normal engine characteristics mistaken for engine failures.

Overview, Section 2

Guide to Preventing Repeat Engine Failures

Progression List



In situations where partial diagnosis suggests engine replacement may be necessary, such as:

- Bearing damage
- Engine noise
- Cylinder misfire
- Loss of compression
- Metal contamination
- Undetermined oil consumption

If the true root cause is not identified (with visual confirmation to the extent of total damage), an over repair or an incomplete repair leading to repeat engine failure may result.

This section of the Job Aid targets specific gas engine failure modes and includes a progression list highlighting:

- Cause
- Effect
- Damage

The progression list assists in identifying certain common operational concerns, overlooked contamination scenarios, and incomplete repair possibilities (see example on left).

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Engine Analysis

Crankshaft Bearing Condition
Page 11

Crankshaft Journals
Page 14

Cylinder Head Cam Bore
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Camshaft Journals and Lobes
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Cylinder Wall and Piston Skirt Page 23

Metal in the Oil Pan, Filter, or Screens Page 28

Head and Block Deck Surface

Page 33

Guide to Engine Analysis

Section 1

Engine Noise + Non-related Blemishes: NOT Root Cause

NORMAL

This will **NOT** cause engine noise or head gasket leaks—nowhere near a sealing bead!

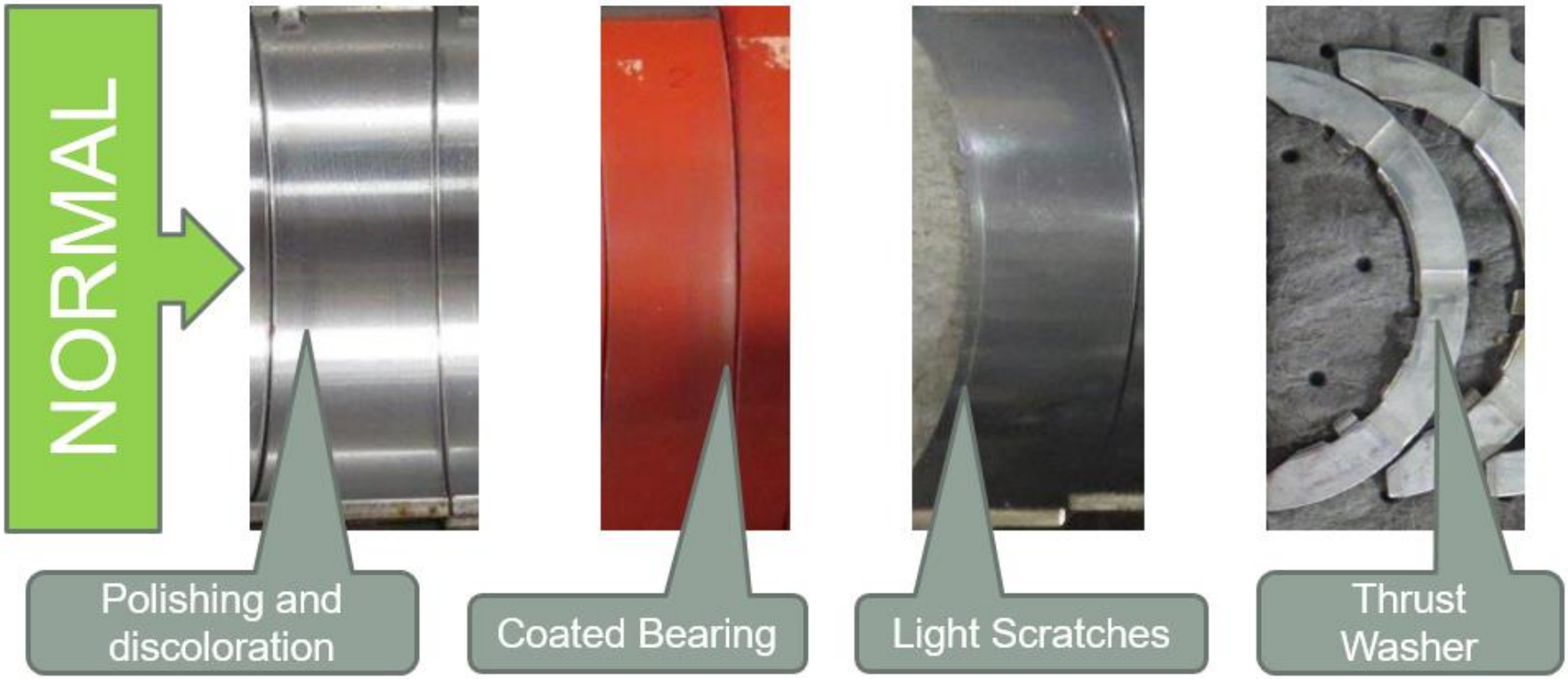
If a vehicle comes in for service with an engine noise complaint, and a cosmetic variation is seen on the head surface during root cause analysis (with no coolant or oil consumption), this has **NO** relation to the complaint.

Bearing Condition

Bearing--Acceptable Wear / Conditions

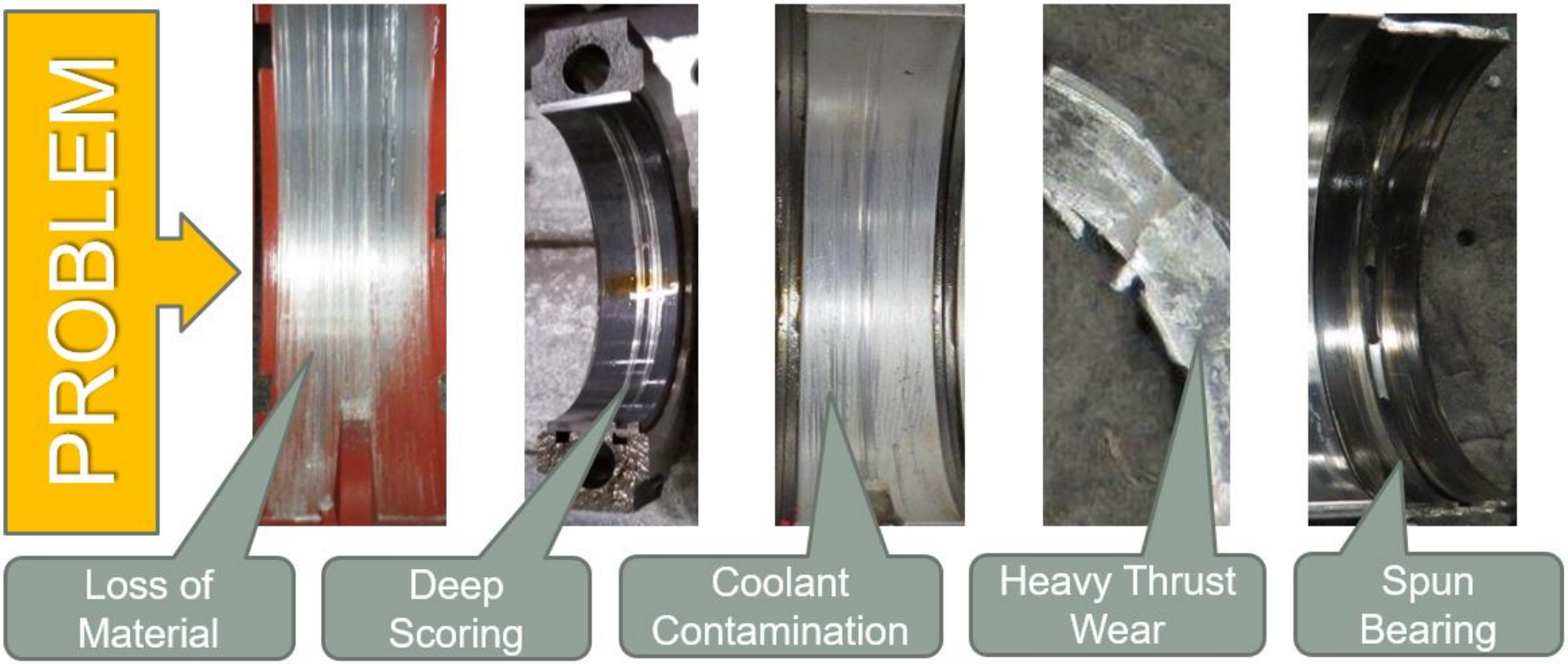
- Polishing
- Discoloration
- Light contact with the red coating
- Light scoring

NOTE. Bearings are designed to manage some debris; therefore, some light scoring found on the bearing surface is not necessarily an indication of engine failure or root cause determination.



Bearing—Unacceptable Wear

- Metal transfer
- Erosion
- Significant loss of material--excessive clearance
- Coolant contamination
- Deep scoring or Cracking
- Spun bearing



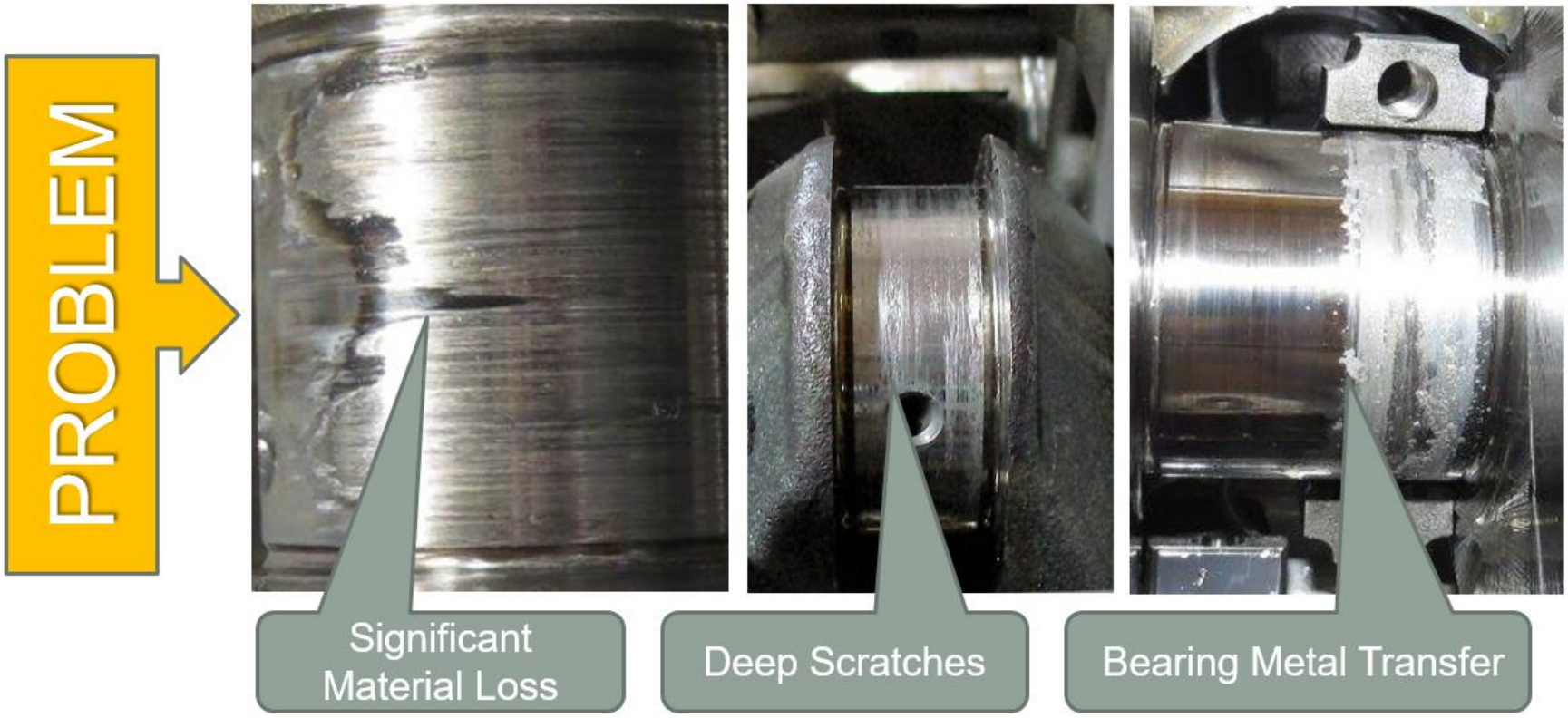

Crankshaft Journals

Crankshaft—Acceptable Wear / Conditions

- Polishing
- Discoloration
- Light scratches--felt with a fingernail

Crankshaft—Unacceptable Wear

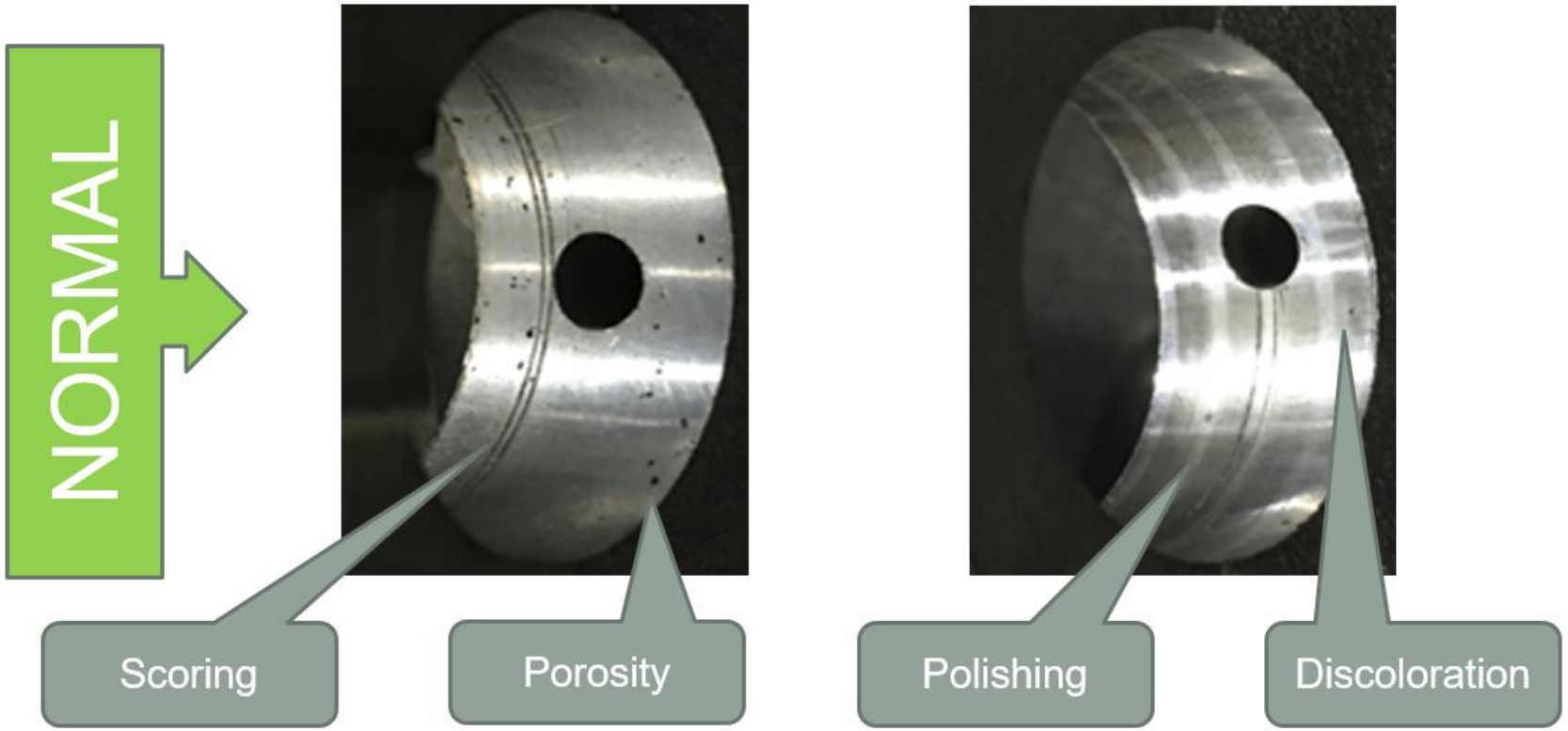
- Significant material loss
- Metal transfer
- Deep scratches
- Gouges
- Bluing: lack of proper lubrication
- Cracking



Cylinder Head Cam Bore

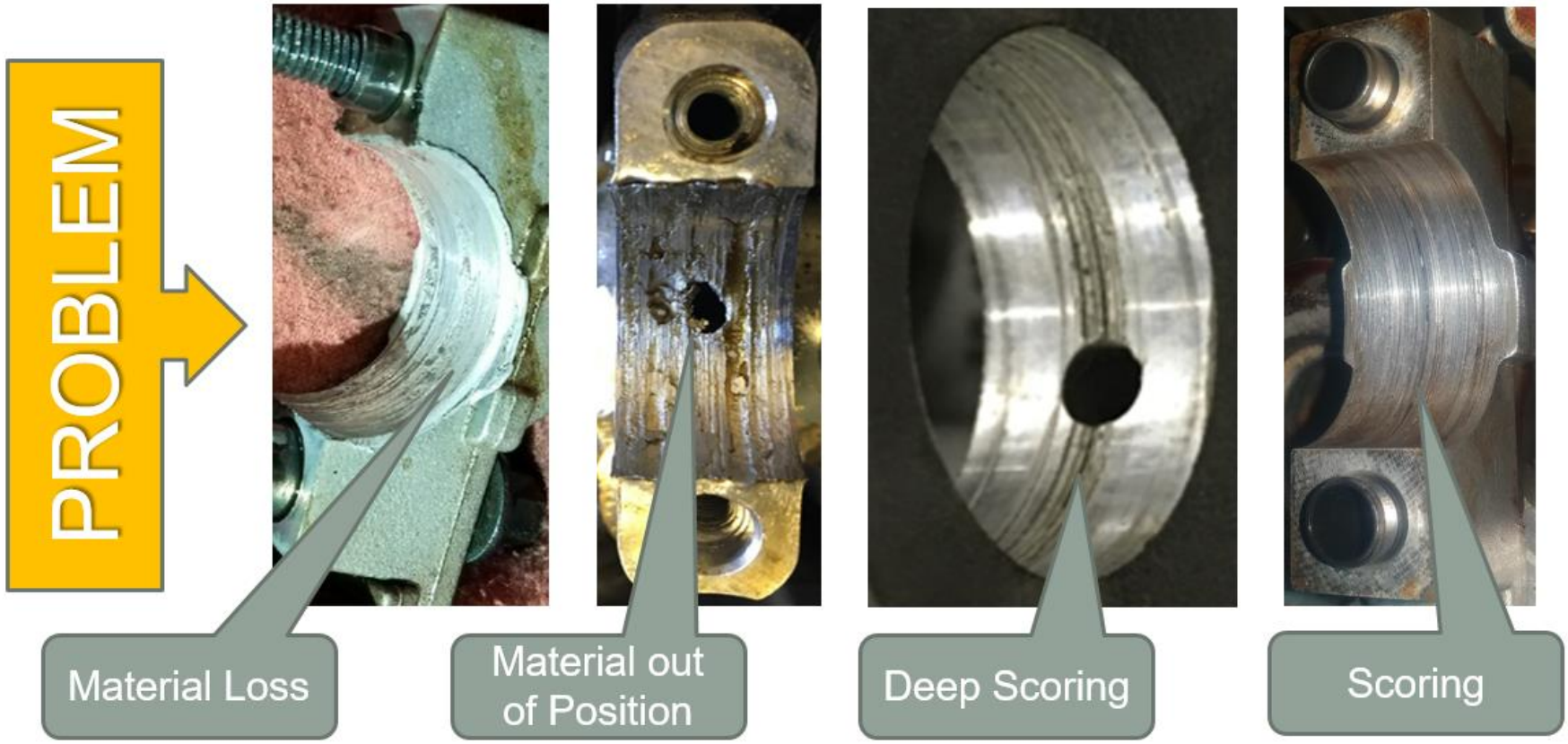
Cam Bore—Acceptable Wear / Conditions

- Polishing
- Discoloration
- Some porosity
- Uniform or symmetrical score felt with a fingernail is OK—just holds more oil



Cam Bore—Unacceptable Wear

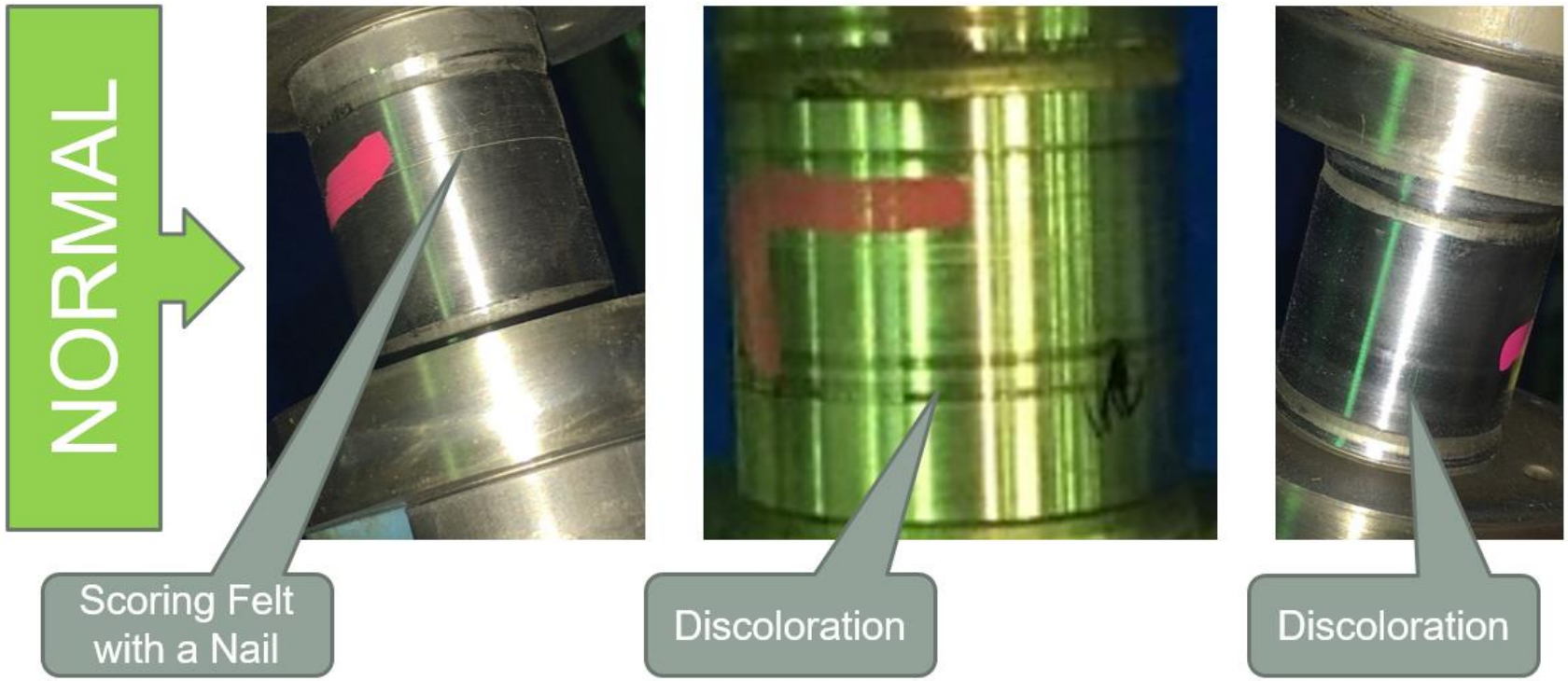
- Metal transfer or loss of material
- Material out of position
- Excessive Clearance
- Heavy Scoring



Camshaft Journals and Lobes

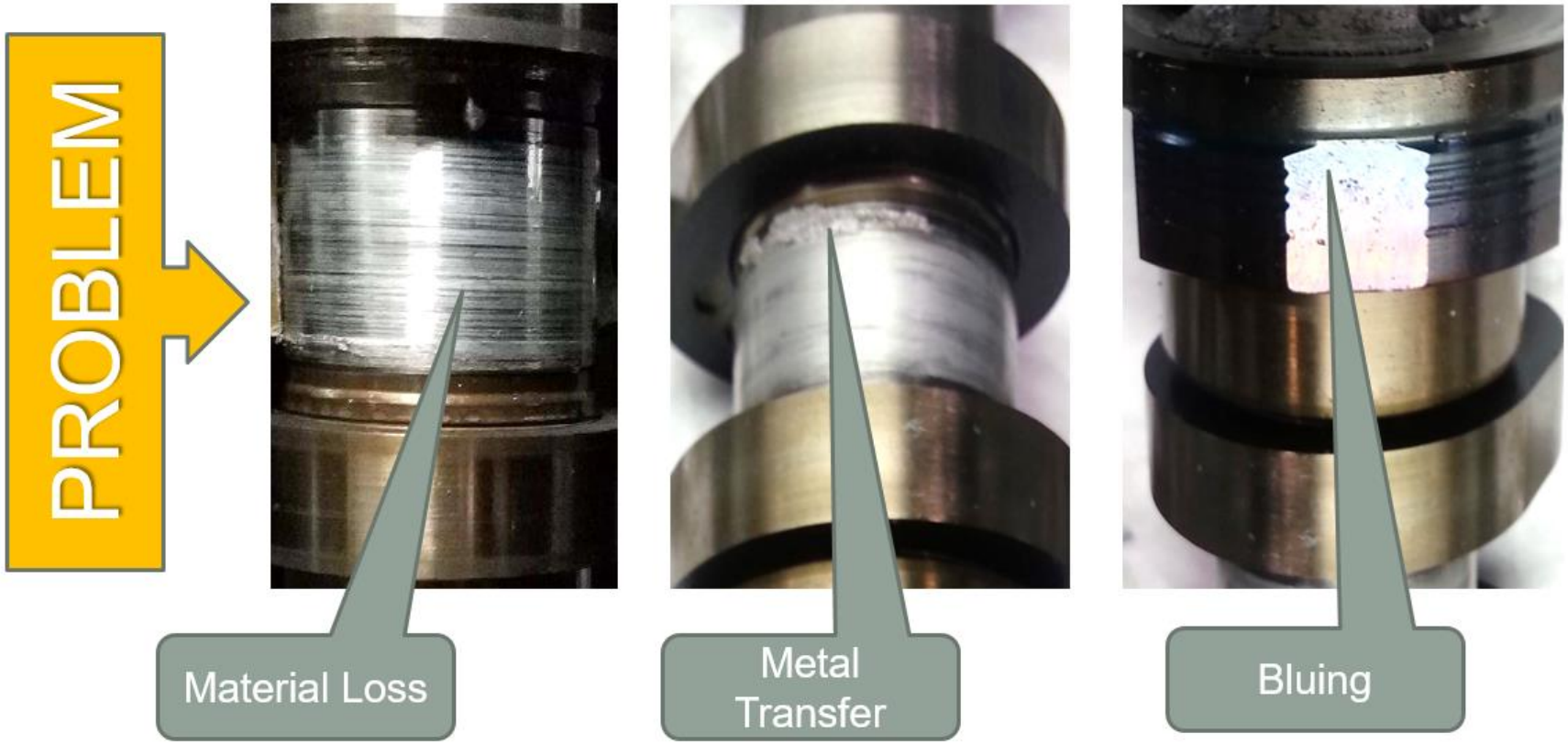
Cam Journal—Acceptable Wear / Conditions

- Polishing
- Discoloration
- Uniform or symmetrical score felt with a fingernail is OK—just holds more oil



Cam Journal—Unacceptable Wear

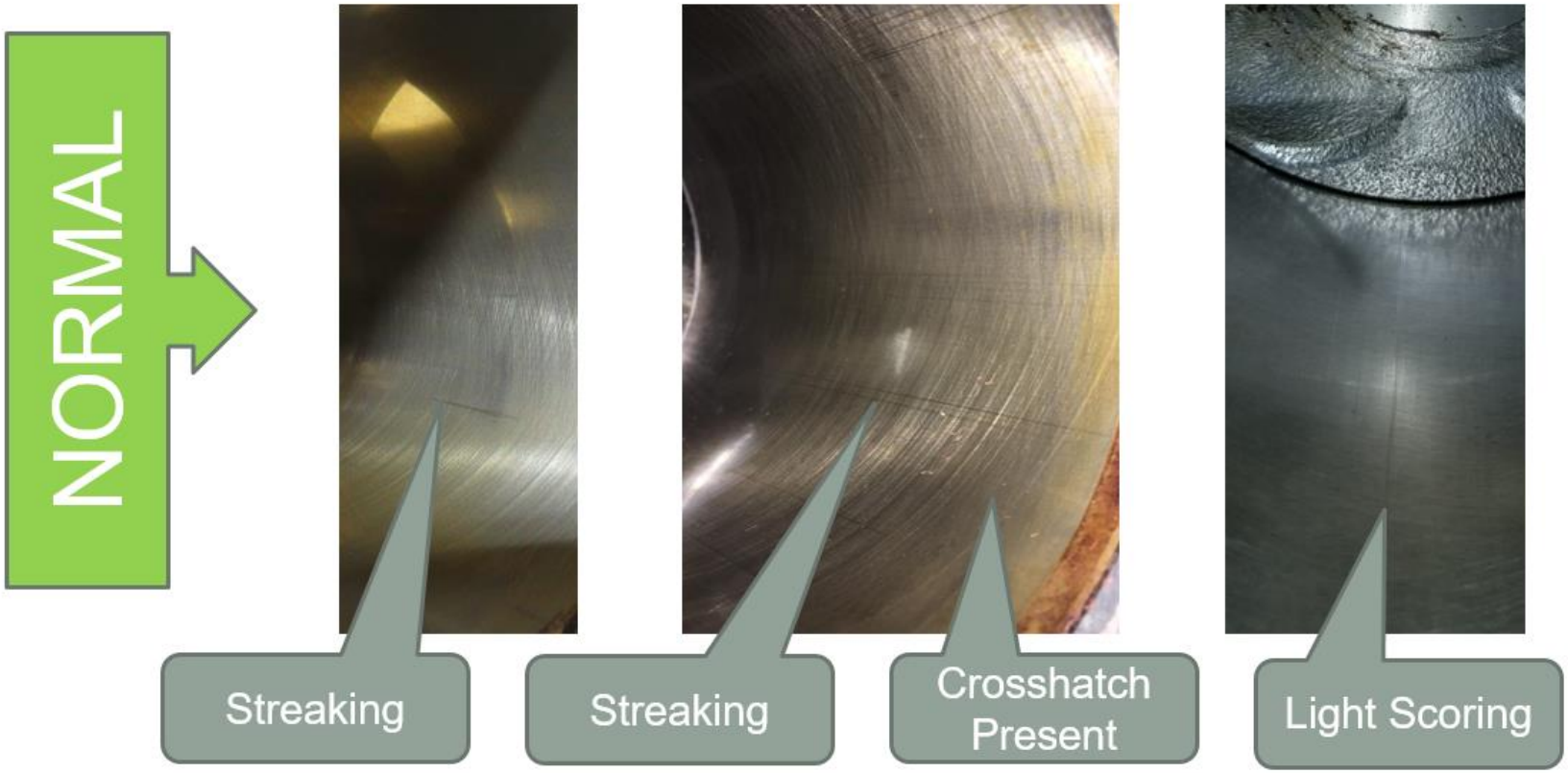
- Metal transfer or material loss—Excessive Clearance
- Deep scoring
- Bluing
- Cracking



Cylinder Wall and Piston Skirt

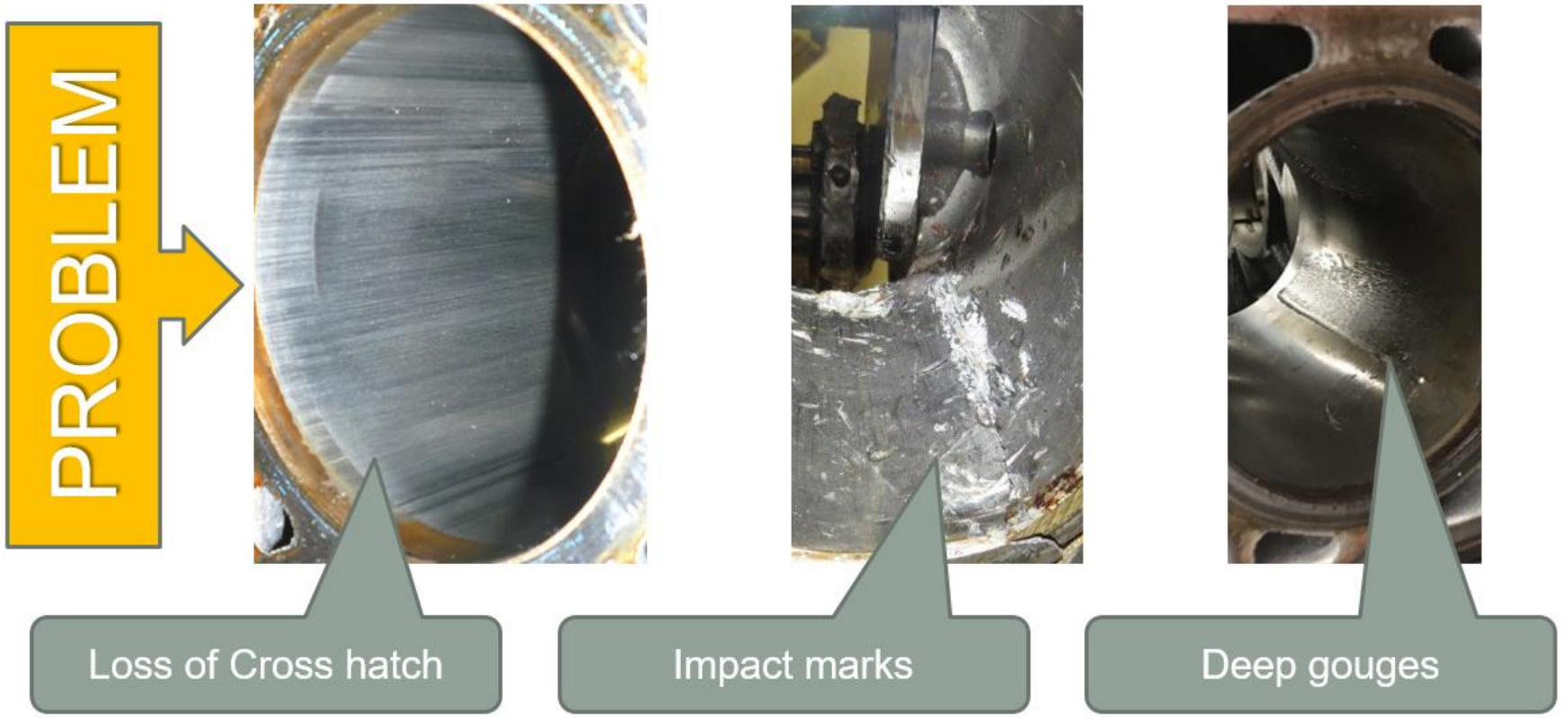
Cylinder Wall-Acceptable Wear / Conditions

- Some polishing and discoloration
- Vertical streaking
- Some light scoring felt with a fingernail
- Cross hatch is visually present
- Light staining / spots
- Light piston slap contact



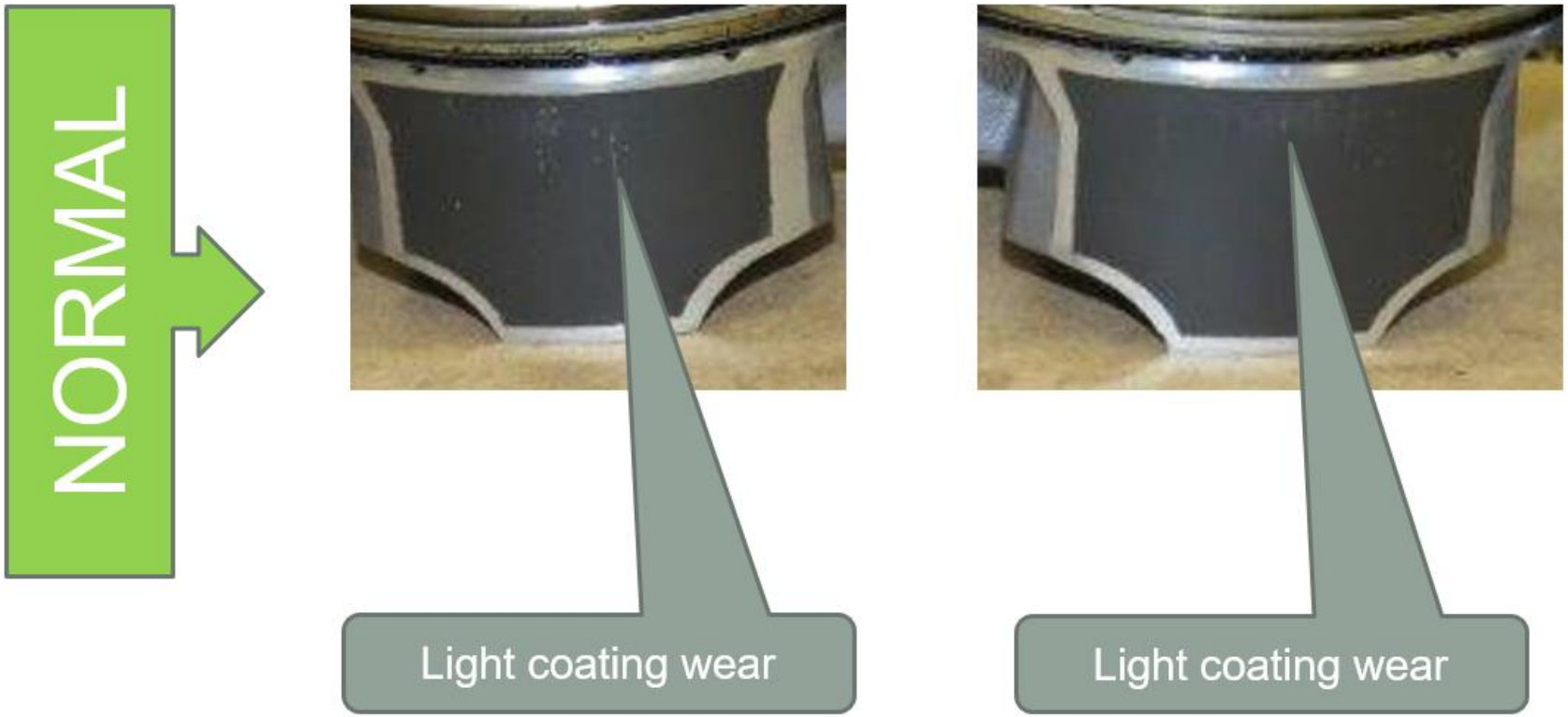
Cylinder Wall-Unacceptable Wear

- Deep gouges or impact marks
- Loss of cross hatch
- Cracks



Piston Skirt-Acceptable Wear / Conditions

- Light coating wear



Piston Skirt-Unacceptable Wear

- Heavy coating wear

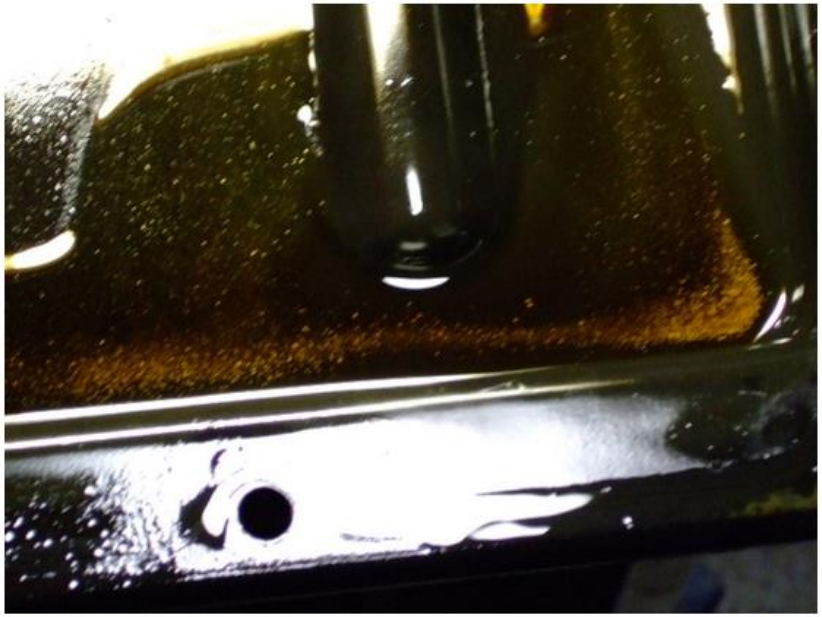
PROBLEM

Metal in the Oil Pan, Filter, or Screens

Metal in the Oil Pan-Acceptable Conditions

- Some metal found in the oil pan is expected and considered normal

NORMAL

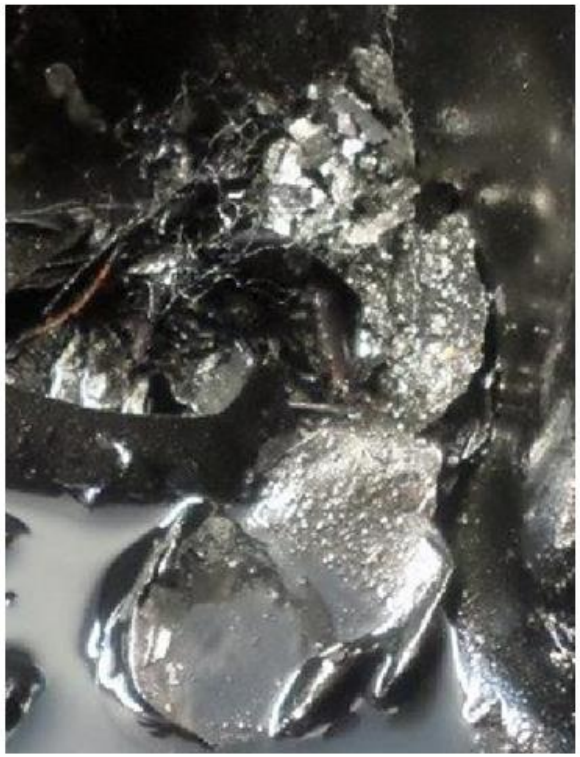


Some metal shavings are not a concern

Metal in the Oil Pan-Unacceptable Conditions

- Large quantities of metal
- Heavy accumulation in the oil filter pleats

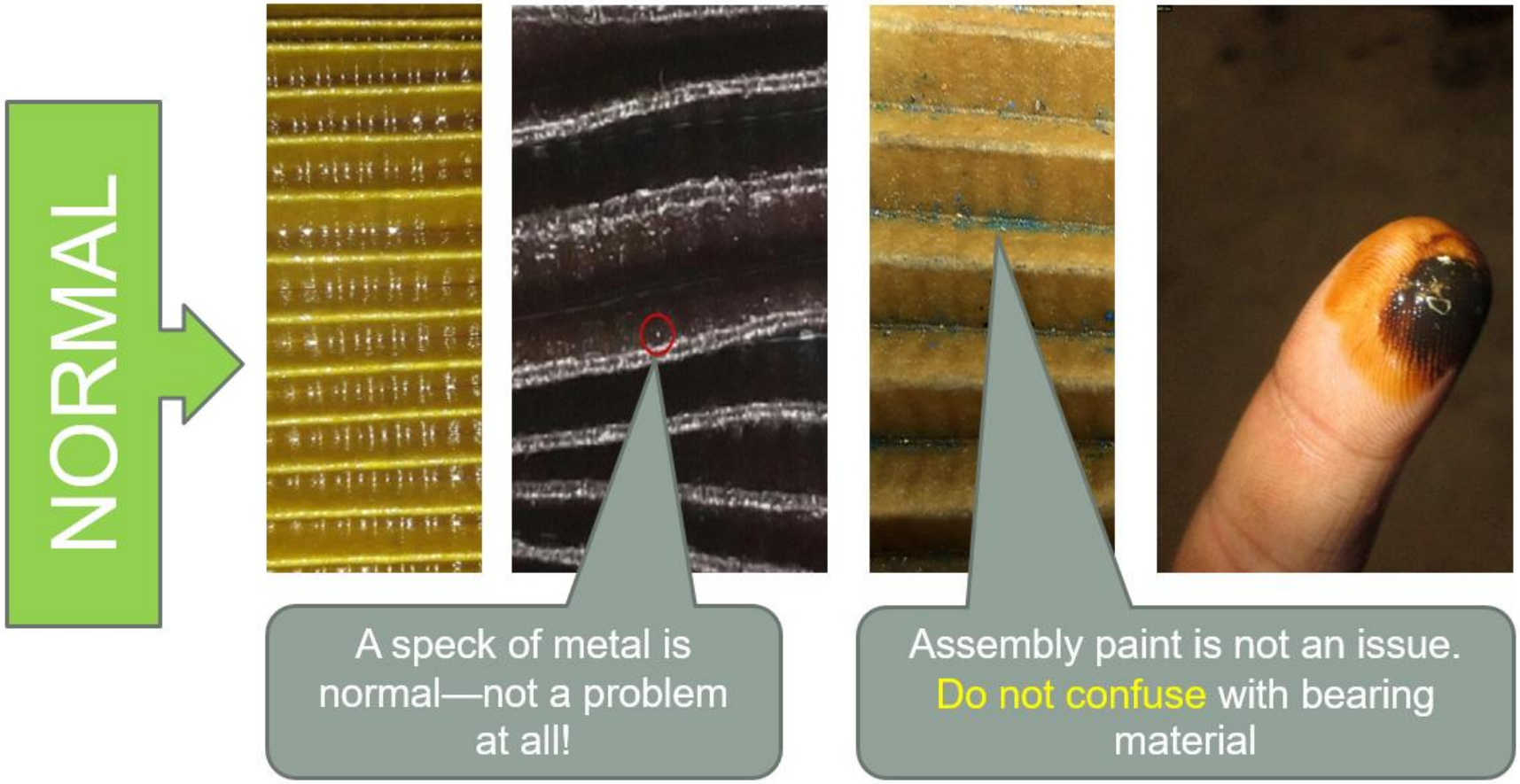
PROBLEM



Very large chunks merit further root cause investigation

Metal in the Oil Filter-Acceptable Conditions

- Colored paint flakes
- Some metal



Metal in the Oil Filter-Unacceptable Conditions

- Excessive metal = further root cause research

PROBLEM

Head and Block Deck Surface

Head and Block Deck Surface-Acceptable in Non-critical Areas

- Porosity
- Gasket sealing bead discoloration
- Scratches
- Gouges

NORMAL

Non-critical area

Discoloration or impressions from a head gasket are **NOT** necessarily defects.

NO indication of leaks (e.g. coolant, etc.) into the combustion chamber

Head and Block Deck Surface-Unacceptable in Critical Areas

Handling damage and defects in critical areas, include:

- Scratches
- Gouges
- Porosity
- Warpage

PROBLEM

Section Two
Preventing Repeat Engine Failures

Piston Damage

Pre-ignition
Excessive Levels of Detonation
Engine Performance Modifications
Aftermarket Fuel System Modifications

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Misfire from Valve Leakage

Excessively Lean Conditions
Excessively High Cylinder Temperatures
Aftermarket Induction Modifications

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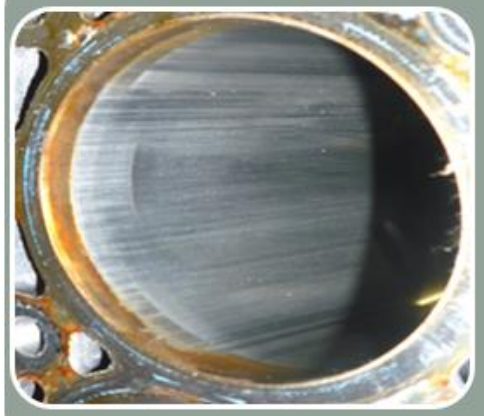

Cylinder Wall Scuffing & Scoring

Catalyst Material Ingestion

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Piston and Valve Damage

Foreign Object Debris or F.O.D.

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Severe Oil Consumption

Open Breather Tube Fitting in Place of PCV Valve on 2v Modular V8 & V10

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Bent Connecting Rod

Hydrolock
Injector Failure
External Water Ingestion

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Piston Damage

Pre-ignition
Excessive Levels of Detonation
Aftermarket Modifications and Lean Conditions

Piston Damage

Pre-ignition, Detonation, and Lean Conditions

Lean or Modifications

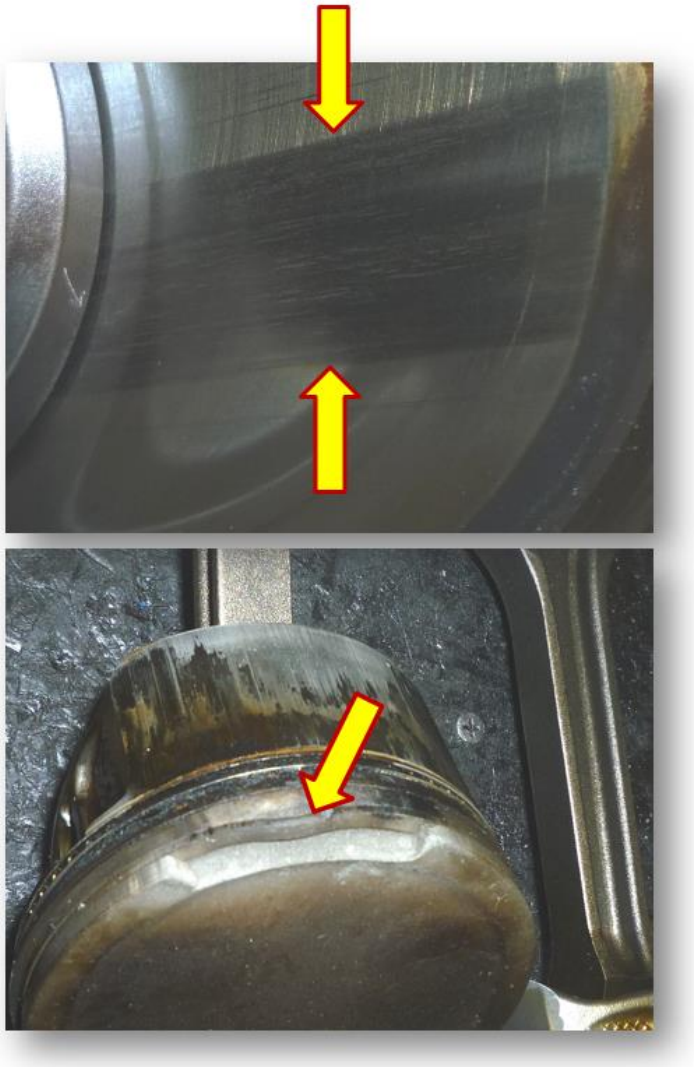
- Modifications (timing, CNG, incorrect spark plug)
  - Overboost (Supercharger / Turbocharger)
  - PCM Performance Chip / Programmer
- Lean conditions
  - Mass Air Flow (MAF) sensor failure
  - Damaged air inlet (MAF sensor turbulence)

High Cylinder Pressure or Spark Knock

- Excessively high combustion temperatures
- Excessive cylinder pressure
- Pre-ignition
- Excessive levels of detonation (fuel quality / low octane, etc.)

Damage

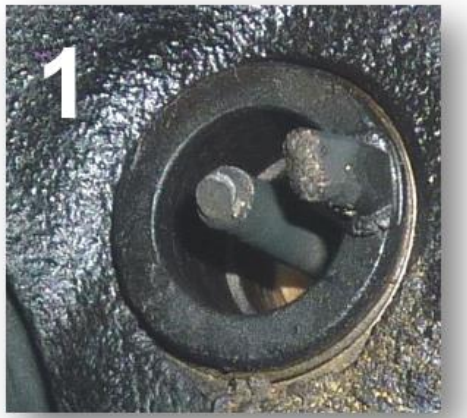
- Spark plug electrode damage
- Hole in center of piston (pre-ignition)
- Piston ring land damage (detonation)
- Pitted piston tops
- Cylinder wall scoring

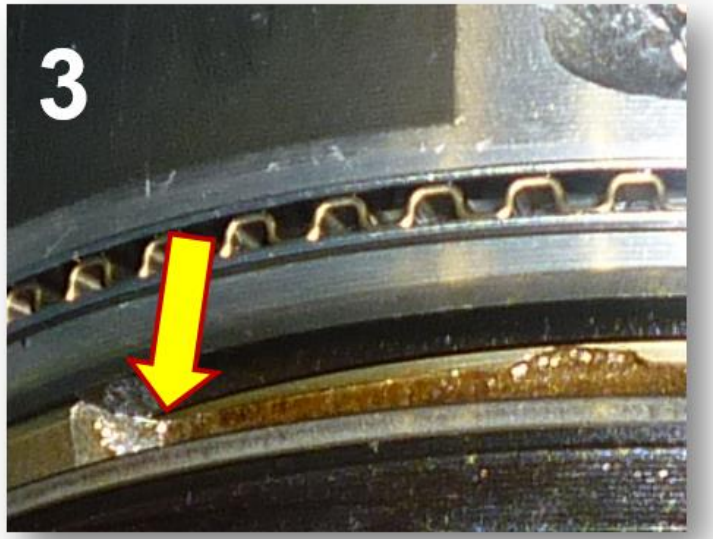


Piston Damage

Pre-ignition, Detonation, and Lean Conditions

1. Spark plug damage (porcelain fractured or electrode melted off) is an indication of excessive detonation.
2. Heat generated from friction caused cylinder wall to crack (note upper ring land damage).
3. Excessive levels of detonation cause excessive cylinder pressure spikes leading to piston ring land fractures. In this instance, the less obvious second ring land is damaged.





Misfire from Valve Leakage

Excessively Lean Conditions
Excessively High Cylinder Temperatures
Aftermarket Induction Modifications

Valve "Tuliping"

Misfire from Valve Leakage

Valve Tuliping

Lean

- Induction modifications
- Mass Air Flow (MAF) sensor failure
- Damaged air inlet affecting MAF performance
- Incorrect air/fuel mixture

Lacks Power

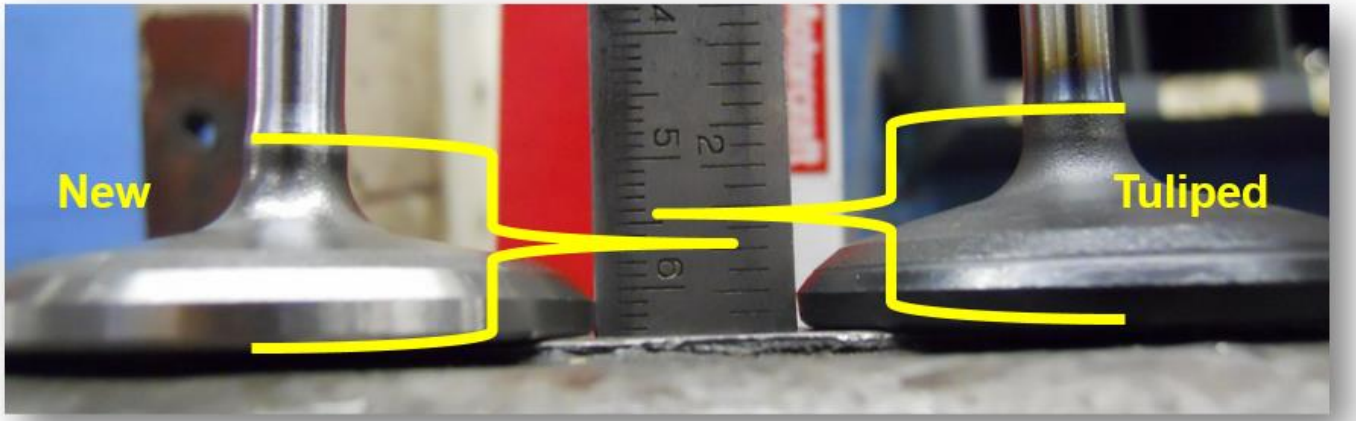
- Excessively high combustion chamber temperatures
- Lean running engine = HOT

Damage

- Valve tuliping
- Valve seat recession

Misfire from Valve Leakage

Valve Tuliping



If cylinder leakage is present past the valves:

- Check for valvetrain components out of position that could hold the valve open
- Check if the valve stem is sticking in the valve guide
- Inspect for possible debris preventing the valve from contacting the valve seat

Excessively lean conditions can cause valves to overheat. As an overheated, softened valve opens and closes on the valve seat, it will deform. The valve will no longer seal on the valve seat as it stretches or "tulips" causing leakage and a misfire.

Comparing total valve height of the suspect valve to a known good valve can help identify issues. A height difference in the suspect valve is an indication of valve tuliping.

Remember: Valve tuliping is the effect, not root cause of the concern.

Cylinder Wall Scuffing & Scoring

Catalyst Material Ingestion

Cylinder Wall Scuffing & Scoring

Catalyst Material Ingestion

Mixture Issues

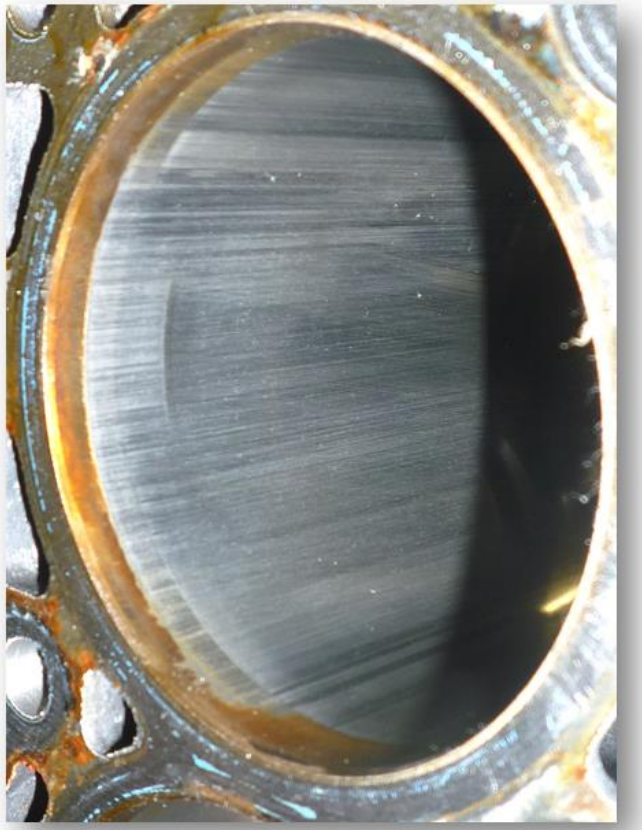
- Excessive Oil consumption
- Lean conditions
- Rich conditions
- Cylinder Misfire

Deterioration

- Catalyst material begins to dust or flake
- Catalyst dust or “sand” is pulled back into engine

Damage

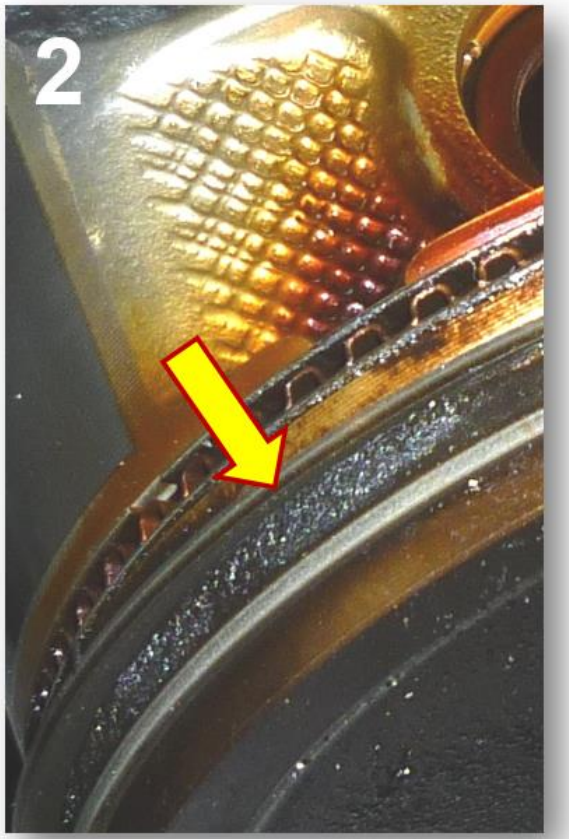
- Cross hatch is scraped/polished off cylinder walls. Bearing surfaces can be damaged if material is pushed past piston rings into the engine oil



Cylinder Wall Scuffing & Scoring

Catalyst Material Ingestion

1. Inspection alone may not reveal deterioration. Tip the exhaust and check for debris falling out.
2. Catalyst material can collect on the sides of the piston damaging cylinder wall surfaces.



Foreign Object Debris

Piston and Valve Damage from Contamination Transfer

Foreign Object Debris (FOD)

Contamination

Engine Failure

- Catastrophic combustion chamber damage
  - Broken pistons or rings
  - Broken valves
  - Dropped valve seats

Debris Transfer

- Original intake manifold transferred to the new engine
- Warning: Intake manifolds CANNOT be cleaned effectively in these instances!

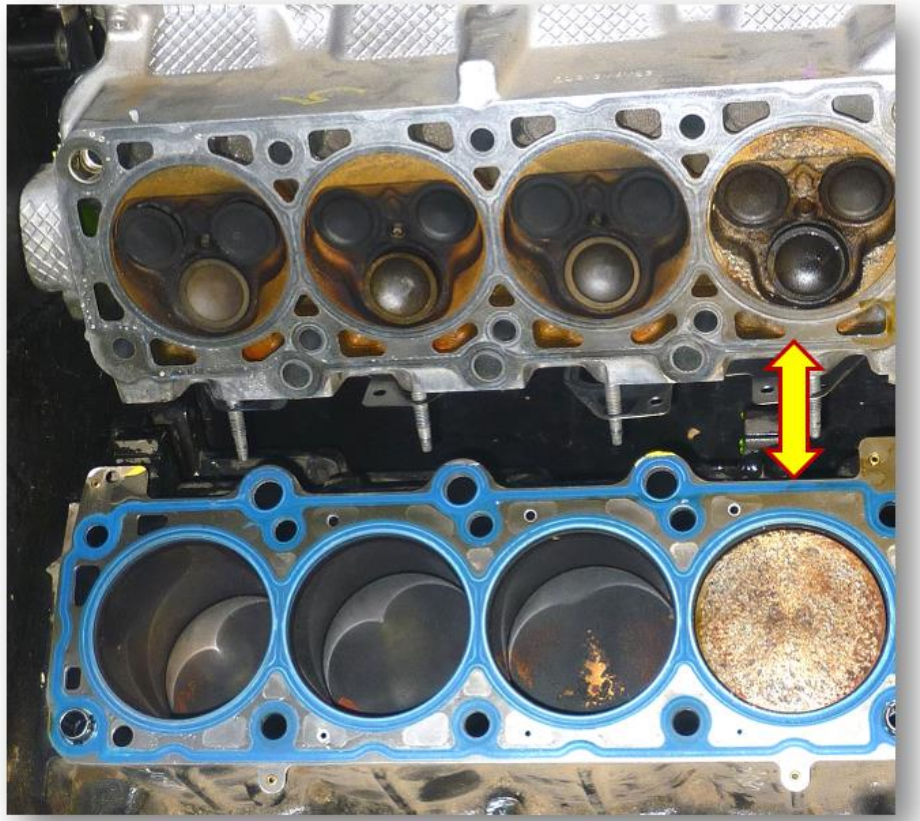
Damage

- Engine vacuum dislodges debris trapped in intake manifold. This can damage multiple engines if the intake manifold is not replaced.

Foreign Object Debris (FOD)

Contamination

- Intake manifold must be replaced in these instances.
- Hot metal can adhere itself to the intake. Engine vacuum over time will dislodge debris damaging new engines.
- Understanding the extent of damage can help provide a complete estimate for the customer (i.e. engine + intake manifold).



Severe Oil Consumption

Repeat Bearing Failure

Severe Oil Consumption

Repeat Bearing Failure

PCV not Replaced

- Lack of maintenance
- Open breather tube fitting installed where PCV valve should be located

Oil Consumption

- Since no metering orifice is present in the fitting, engine oil is pulled through breather tube and burned off by the engine

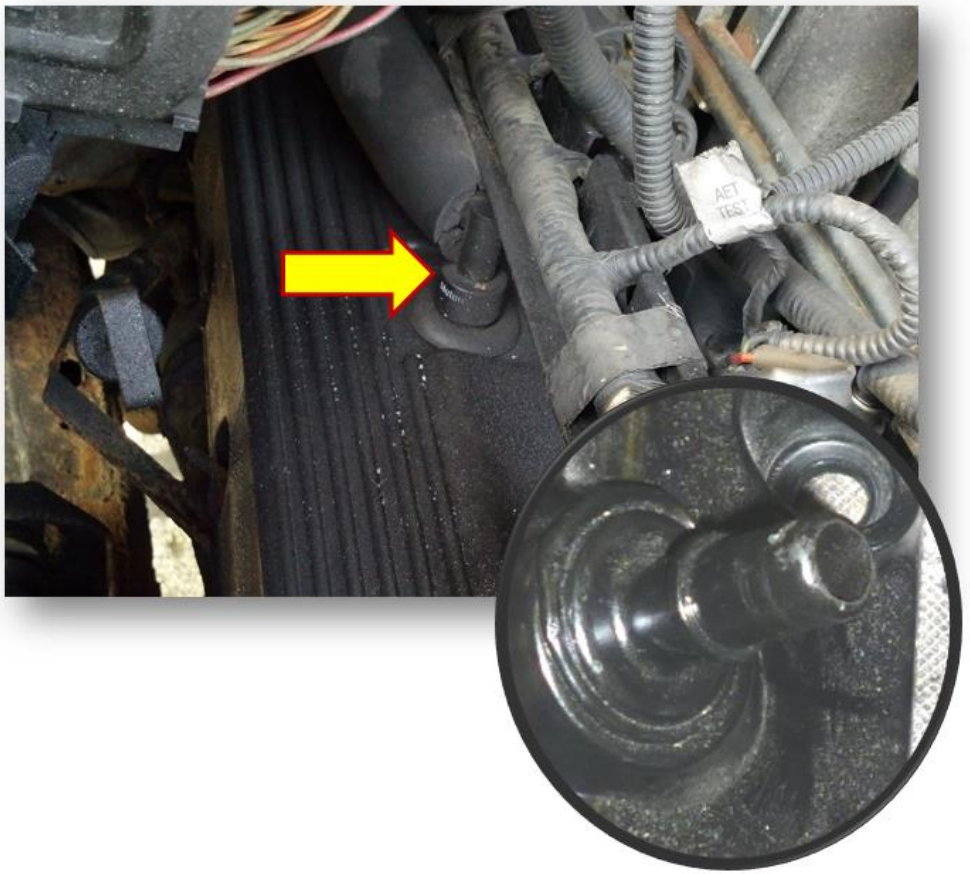
Damage

- Severe bearing and journal damage from lack of lubrication

Severe Oil Consumption

Open breather tube fitting in place of PCV valve

- Warning: On multiple/chain engine replacements, an open breather tube fitting (mistaken for a PCV valve) could be transferred from engine to engine causing bearing failure.
- Remanufactured Modular 2v V8 and V10 engines NEVER come with a PCV valve installed.
- If a PCV valve appears to be in place on a newly-installed Remanufactured 2v V8 or V10 engine, REPLACE it.



Bent Connecting Rod

Hydrolock

Bent Connecting Rod

Hydrolock

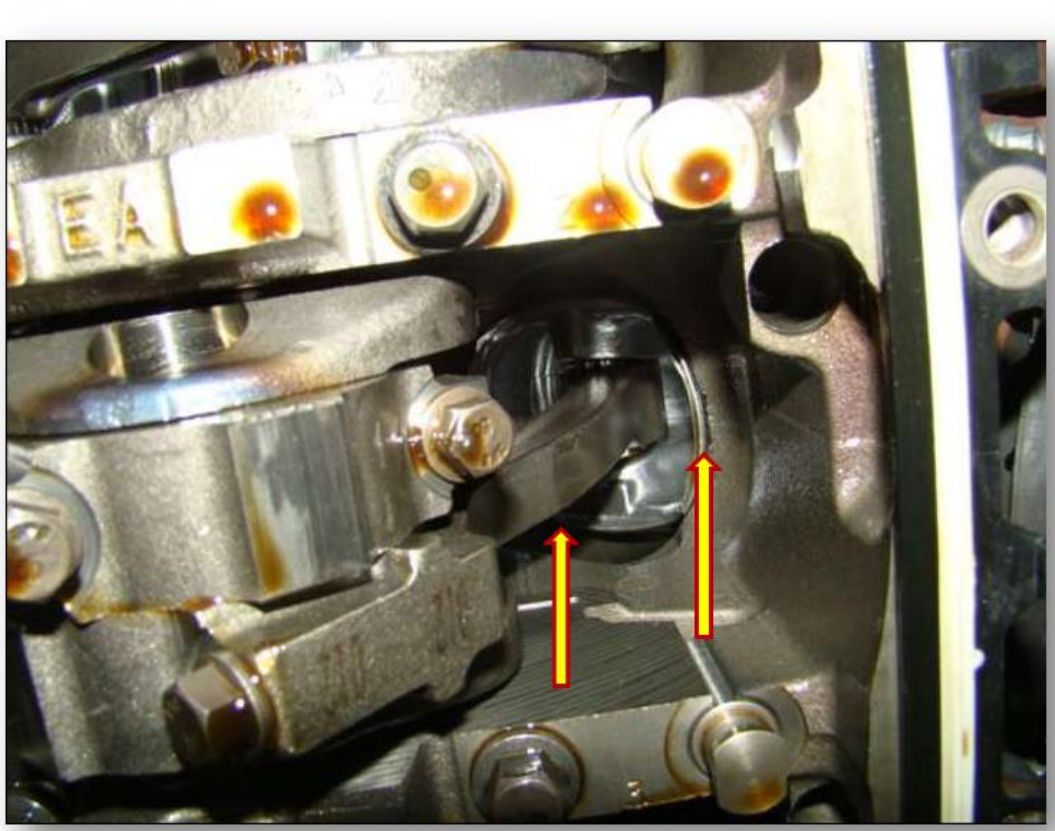
Liquid Ingested
- Stuck open or leaking fuel injector
- Water ingestion through air inlet
  - Note: Air filter may appear water-damaged or warped

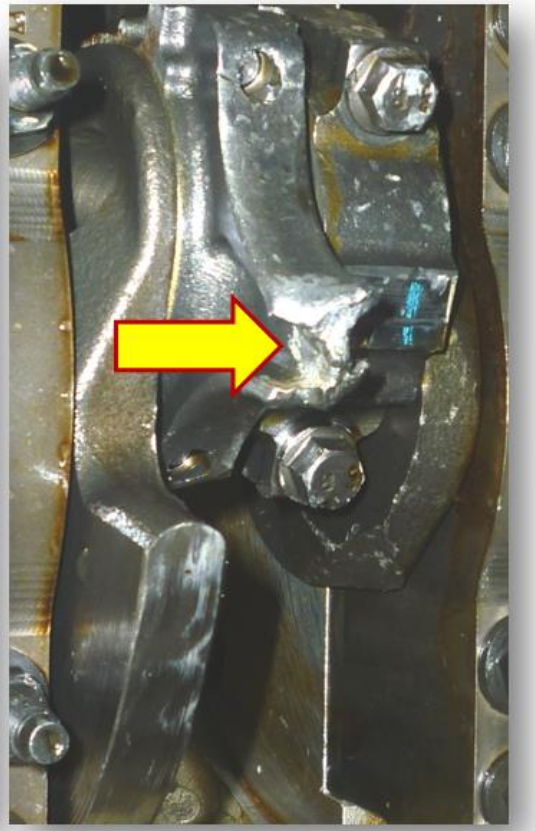
Hydrolock
- Liquid cannot be compressed

Damage
- Connecting rod bends or breaks

Bent Connecting Rod

Hydrolock





Since fluids cannot be compressed, the connecting rod typically suffers from a hydrolock event.