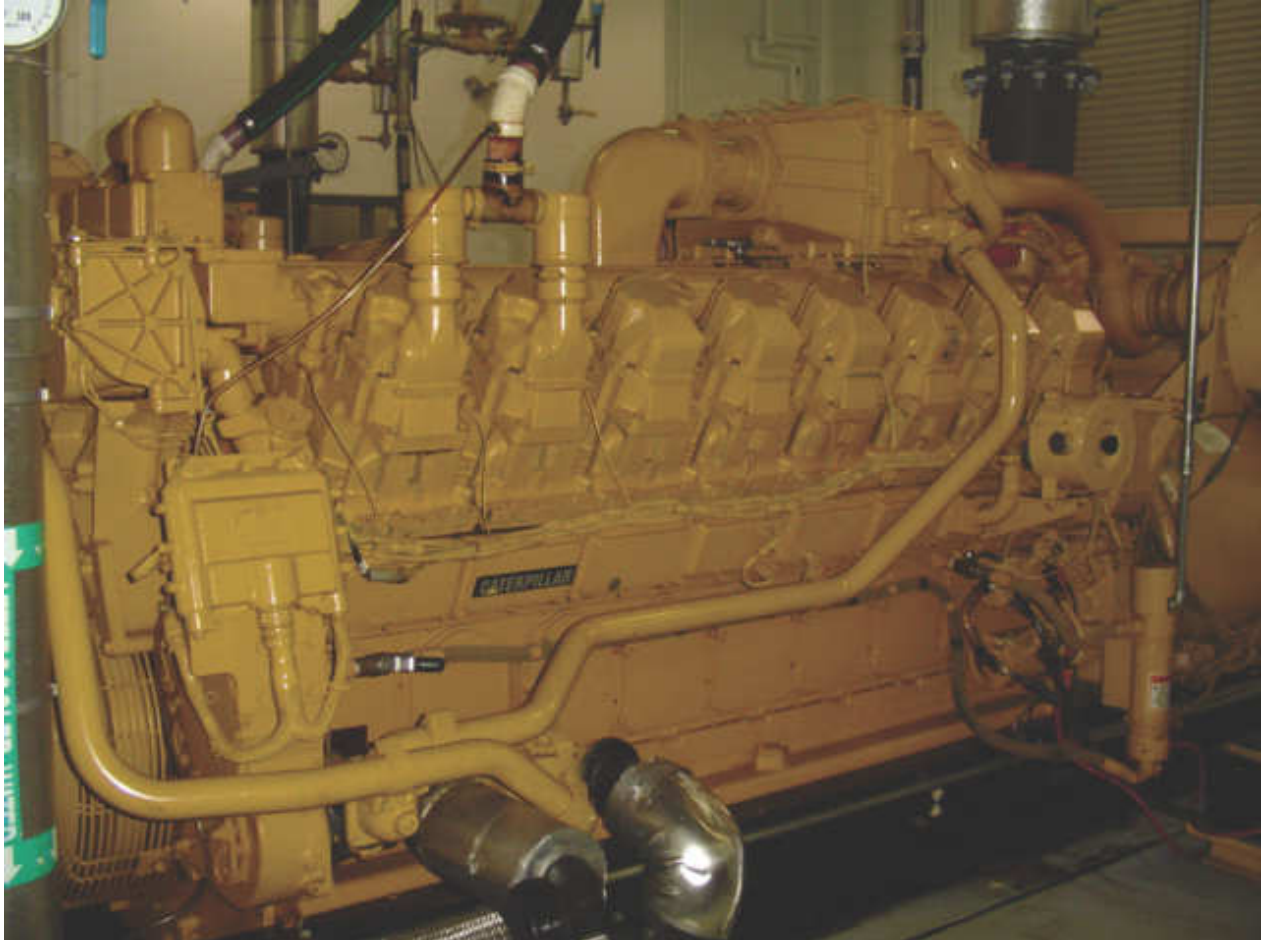


Introduction to Landfill Gas Engines



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Introduction to Landfill Gas Engines

Lubricant Standards

- Currently there is no standard classification or procedure available for gas engine oils
- Approval for a specific oil is usually granted upon completion of extensive field trial. 1000 to 7000 hours

Landfill Gas

- Landfill gas is derived from household and industrial waste
- Gas is produced by anaerobic degradation of organic compounds in the waste by micro organisms.

Landfill Gas Contains

- 40 – 60% Methane
- 20 – 40% Carbon Dioxide
- Up to 10% nitrogen or oxygen
- May also contain large amounts
- Hydrogen Sulfide
- Chlorinated hydrocarbons
- Dust particulates
- Silicon compounds
- Moisture

Methane Number

- Methane is the main component of many gaseous fuels
- Highly resistant of knock and is therefore given a MN of 100
- Hydrogen is very pro-knock and given a MN of 0
- MN is determined by the volume percentage of methane and hydrogen in the mixture.



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Properties of Gaseous Fuels

- Methane Number
- Anti-knock rating of a fuel is measure of its resistance to auto ignition or detonation.
- Higher the anti-knock rating the more resistant the fuel will be to knock

LFG Categories

- Aggressive Gas contains:
 - 500 – 1500 ppm hydrogen sulfide
 - 50 – 150 ppm chlorinated hydrocarbons
- Non-aggressive:
 - < 500 ppm Hydrogen sulfide
 - < 50 ppm Chlorinated hydrocarbons

Landfill Gas Engines Types

- Low Pressure Gas, spark ignited
- High Pressure Gas pilot fuel ignited
- Low Pressure Gas, pilot fuel ignition

LFG Engine Categories

- Stoichiometric Combustion –
- Is the ideal combustion process during which a fuel is burned completely



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Stoichiometric Combustion

- Complete combustion is a process which burns all the
- Carbon (C) to Carbon Dioxide(CO₂),
- Hydrogen (H) to Water (H₂O)
- Sulfur (S) to Sulfur Dioxide (SO₂)

LFG Engine Categories

- Lean Burn –
- Uses a pre-combustion chamber in which a rich mixture is ignited and charged into the main chamber to ignite the lean fuel/air mixture.
- Designed to meet NO_x emission requirements without an exhaust catalyst

Low Pressure Spark Ignition

- Use a spark plug instead of pilot fuel to ignite the gas/air mixture
- Commonly known a “spark ignited” engines (SI)

High Pressure Gas

- Pilot fuel ignition operate on the “gas diesel” principle.
- A charge of pilot fuel (5% of total fuel charge of a distillate fuel) is injected through a fuel valve just prior to TDC initiating combustion
- The remainder of the charge is injected into the cylinder at high pressure (3625 psi-250 bar)
- The gas ignites as it enters the cylinder allowing for a clean combustion without detonation or pre-ignition

Low Pressure Pilot Fuel Ignition



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- Known as “Dual-Fuel” engines.
- The gas is mixed with the air charge either at the inlet air manifold or in a pre-chamber before entering the cylinder
- A distillate pilot fuel is then injected into the cylinder to initiate combustion of the gas/air mixture.

Key Parameters

- Phosphorus content:
 - Resistance to oxidation and nitration.
 - Government legislation is setting strict limits on NOx and HC emissions from stationary gas engine exhaust
 - Catalyst manufacturers have specified restrictions on Phosphorus to avoid catalyst poisoning and extend catalyst life
- Corrosion inhibitors:
- Especially with landfill gases.
- Landfill gases contain corrosive organic halides

Sulfated Ash Levels

- Is the amount of incombustible material (ash) left when a certain quantity of the oil is burned (ASTM D874)

Sulfated Ash

- Must be in correct concentration
- Too low of ash content can lead to exposing the valves faces to high temperatures and aggressive elements in the fuel
- Too high of an ash content can lead to formation of ash in the combustion chamber, on the piston, causing pre-ignition, spark plug fouling, valve burning

Lubricant Classification



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- Ashless oils are used for two cycle engines
- Low ash lubricants are used in four cycle engines
- Medium and High ash are common with aggressive fuels such as landfill, sour and sewage gases

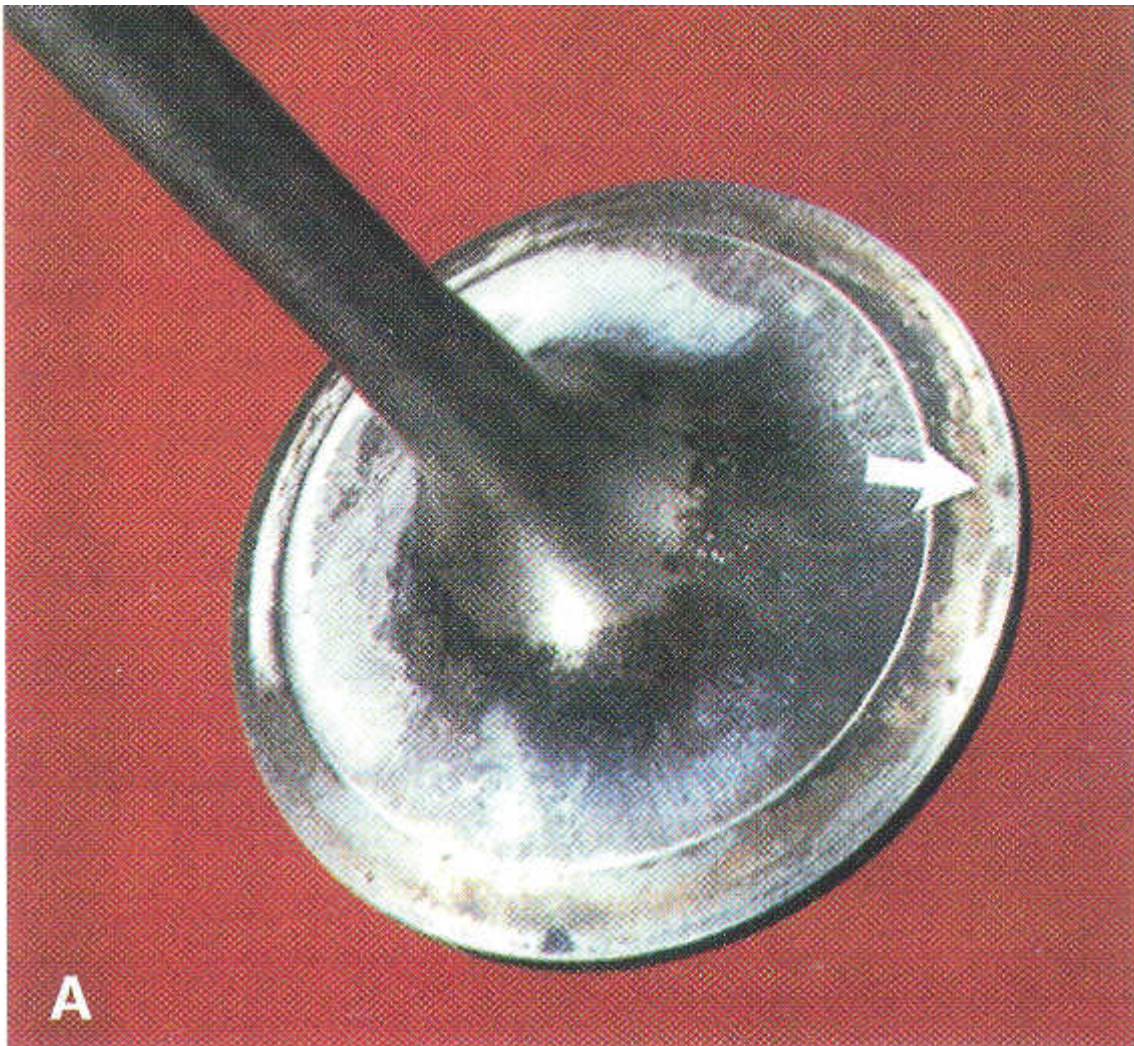
Lubricant Properties

- Classified according to their ash level.
- | <u>Ash Content</u> | <u>Classification</u> |
|--------------------|-----------------------|
| < 0.1 | Ashless |
| 0.4 – 0.6 | Low ash |
| 0.7 – 1.0(0.91) | Medium ash |
| > 1.0 | High ash |
- < 0.1 Ashless
- 0.4 – 0.6 Low ash
- 0.7 – 1.0(0.91) Medium ash
- > 1.0 High ash

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Ash Deposits

- The results of ash deposit build up. Notice beginning of ash build up and valve recession



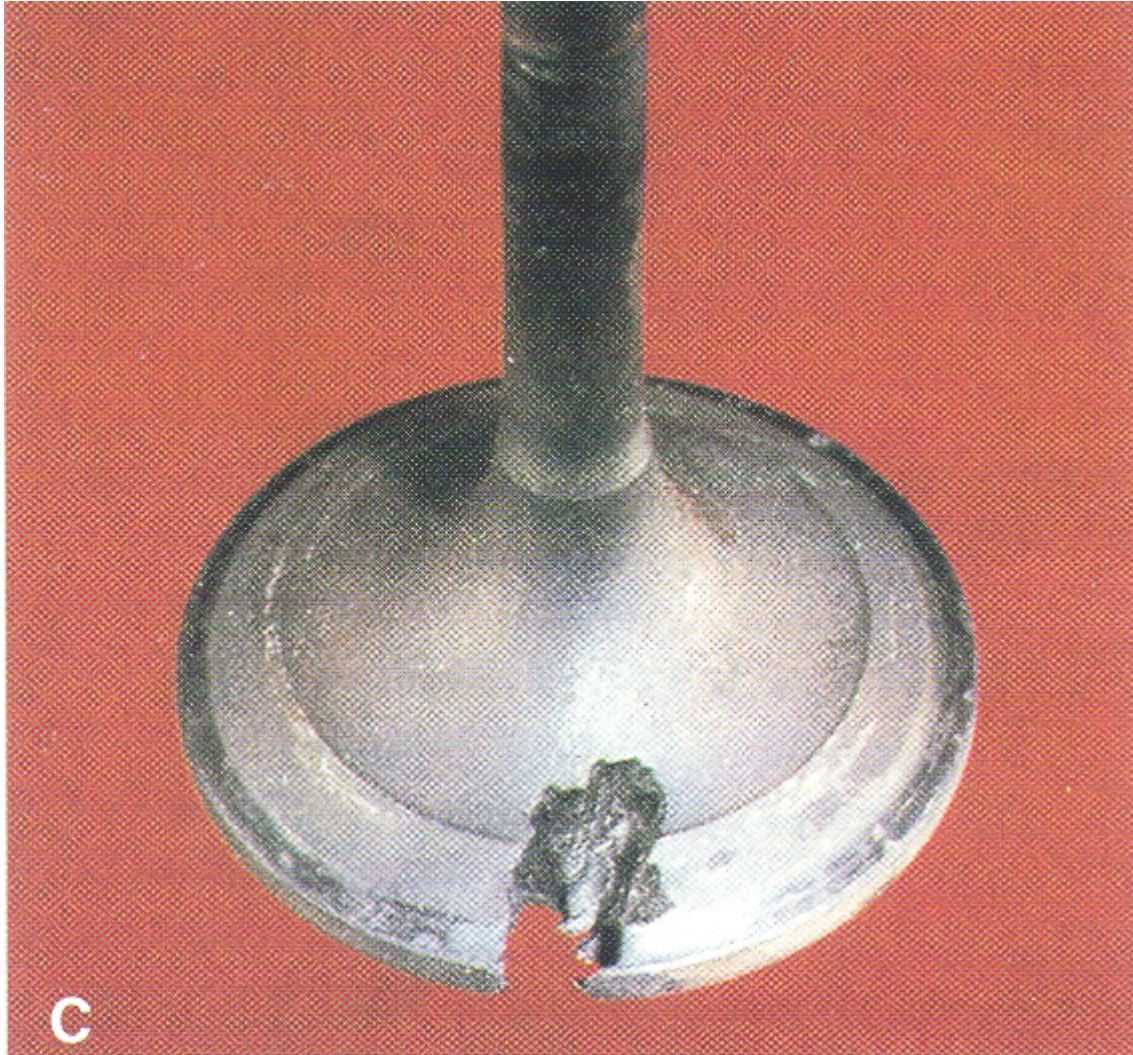
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Ash broken away from valve recession



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Valve Burn



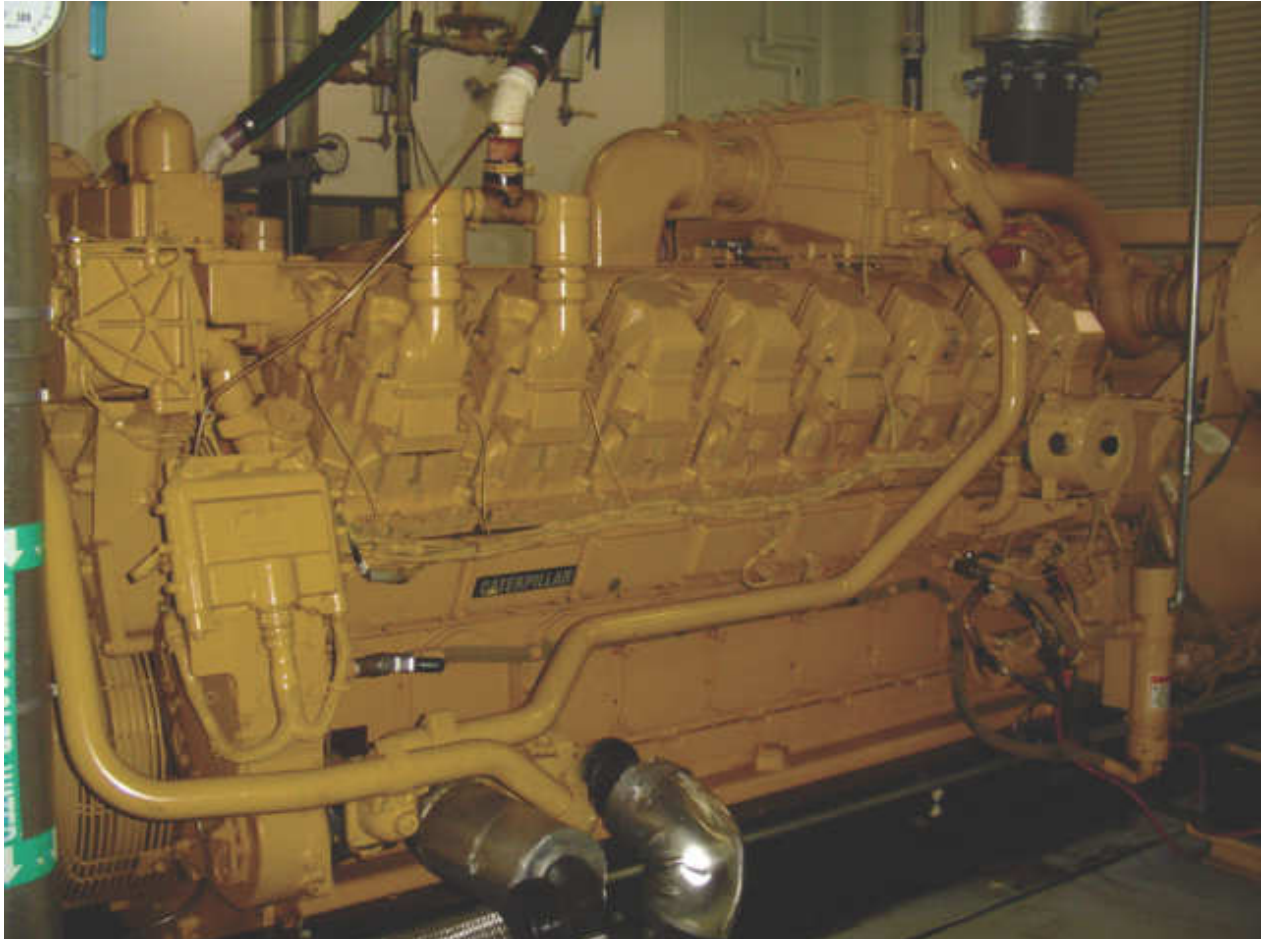
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Valve Burn



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Cat 3516



Engine with 975 hours using 114LF

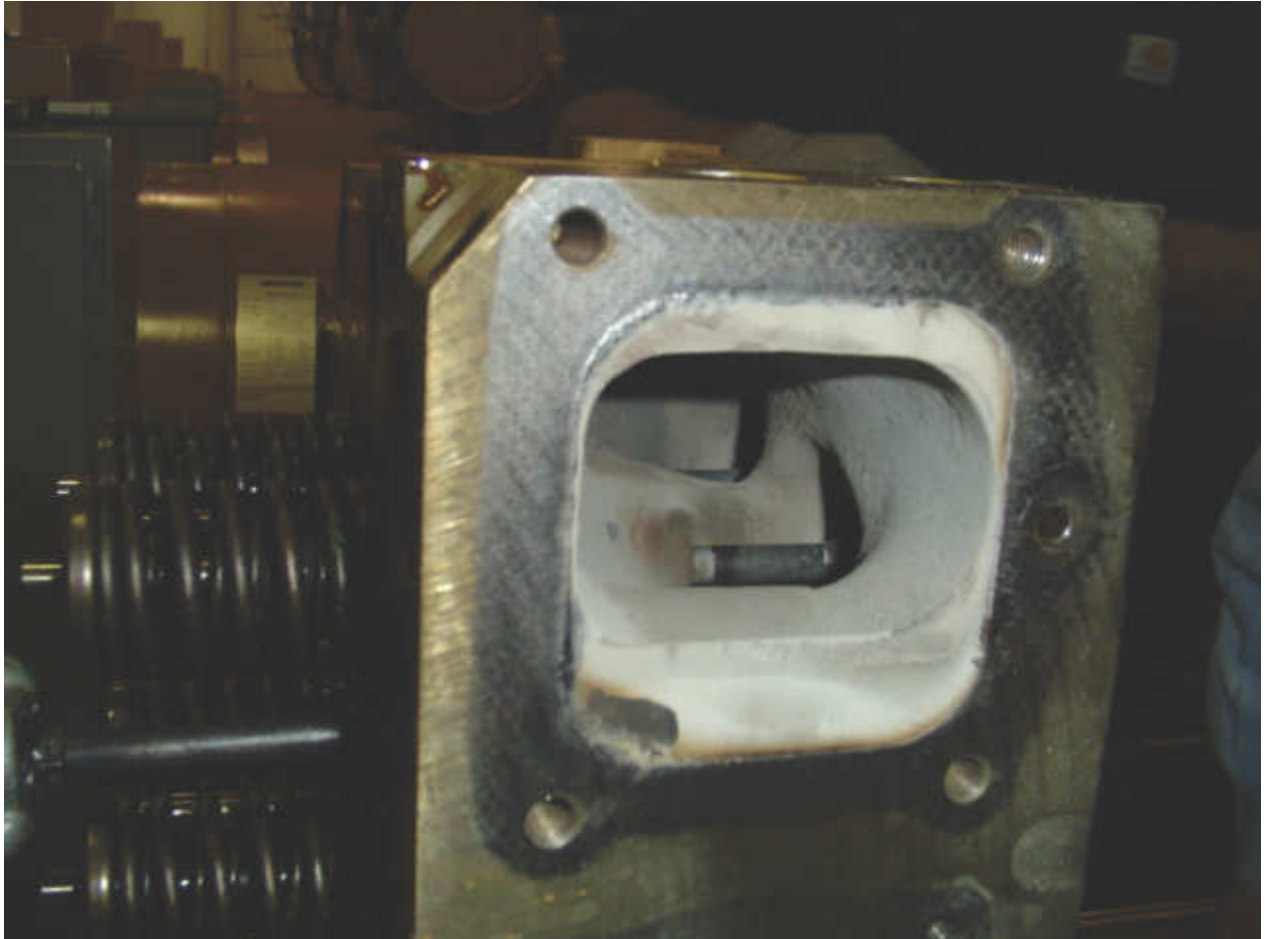
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Top of Head



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Exhaust Port form Head



- **Exhaust port on head. Again there is no build up of any carbon.**

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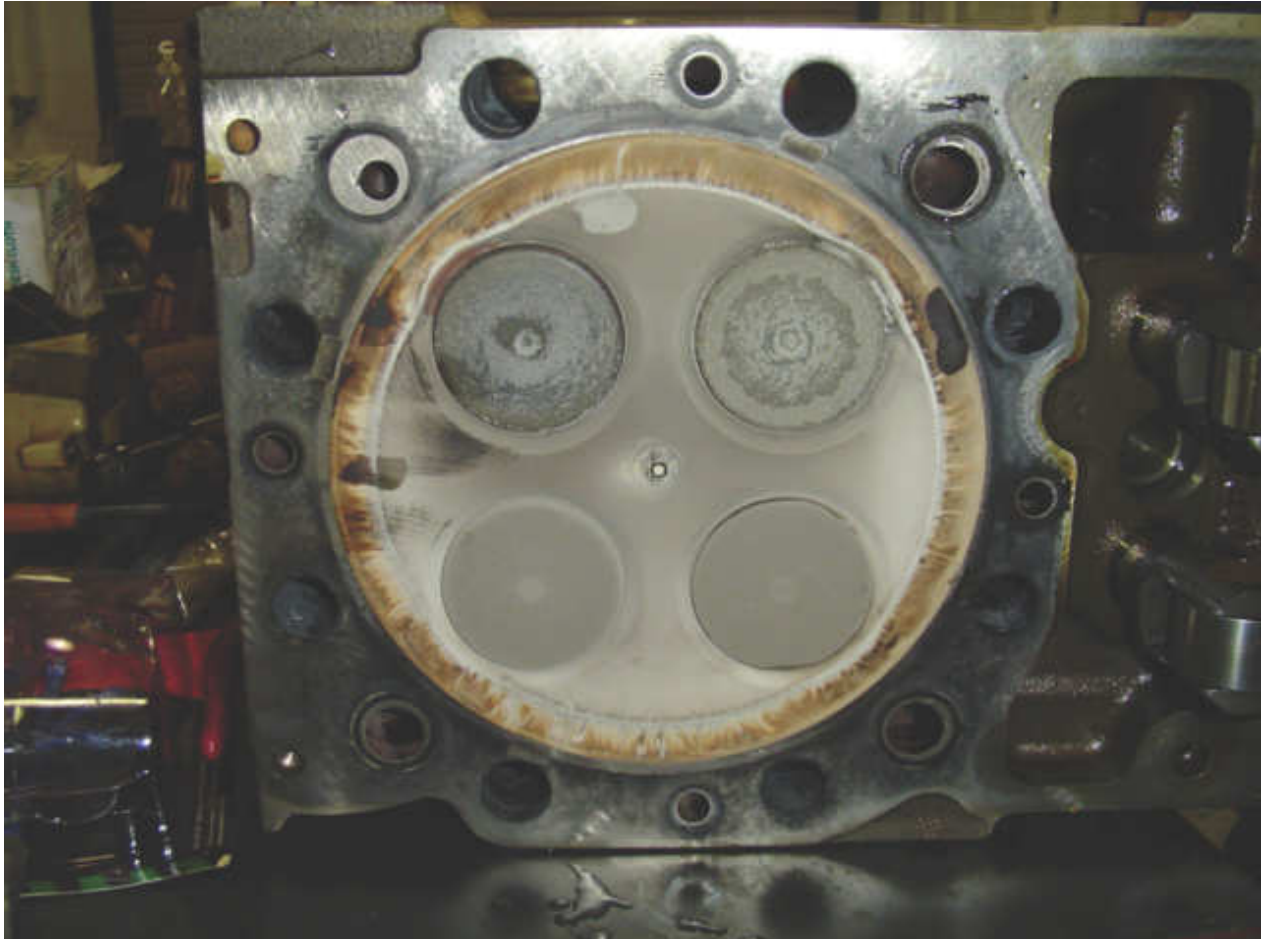
Exhaust Port



- **Exhaust port on engine has no build up of carbon**

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Underside of Head.



- **No carbon build up on valves**

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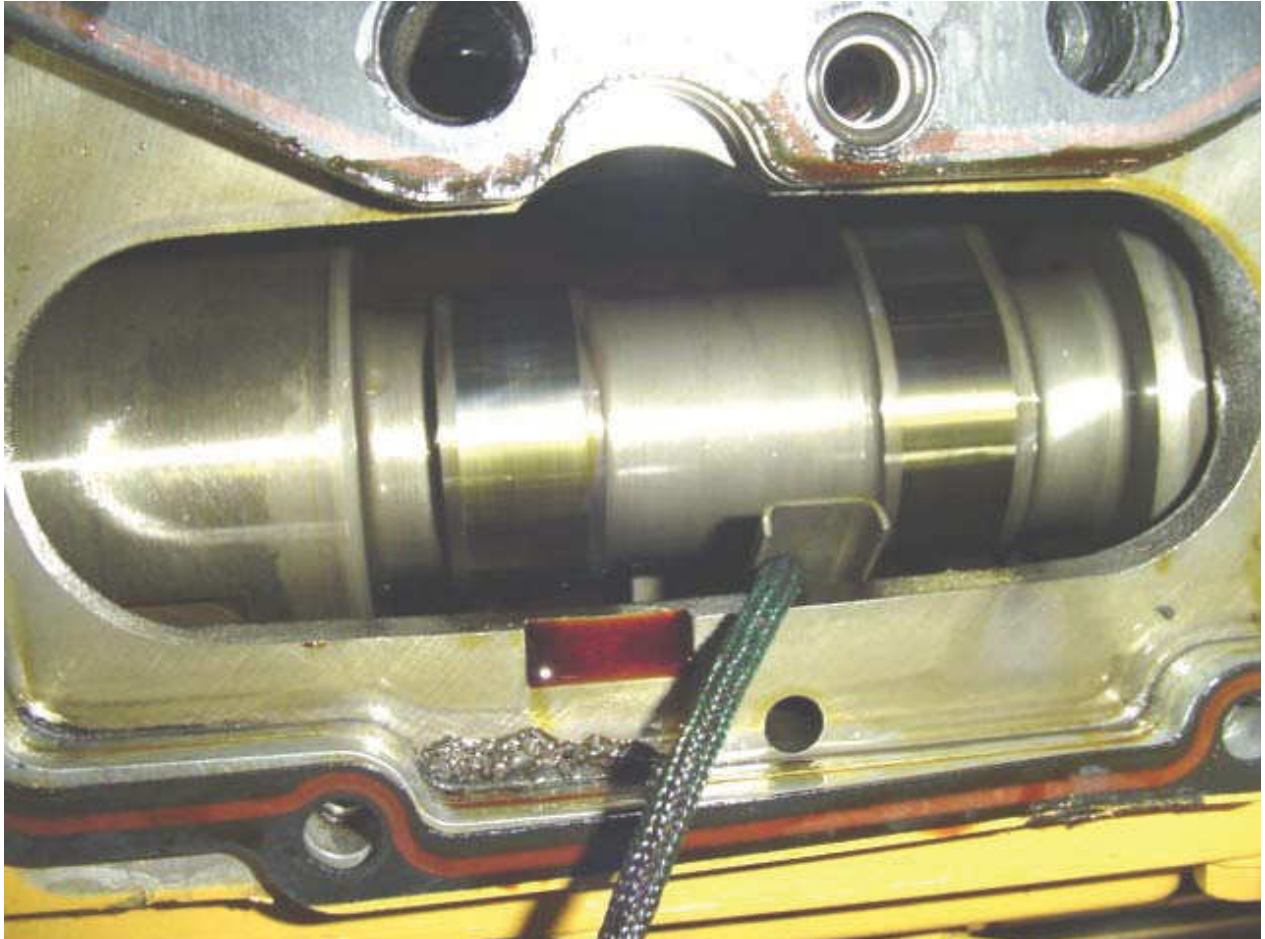
Top of Piston



- **No build up of carbon on top of piston.**

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Cam Shaft



- **Cam is clean with even wear patterns on lobes**

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Rocker Arm Assembly



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Push Rod Ends

Notice offset oil passageways and chamfer

