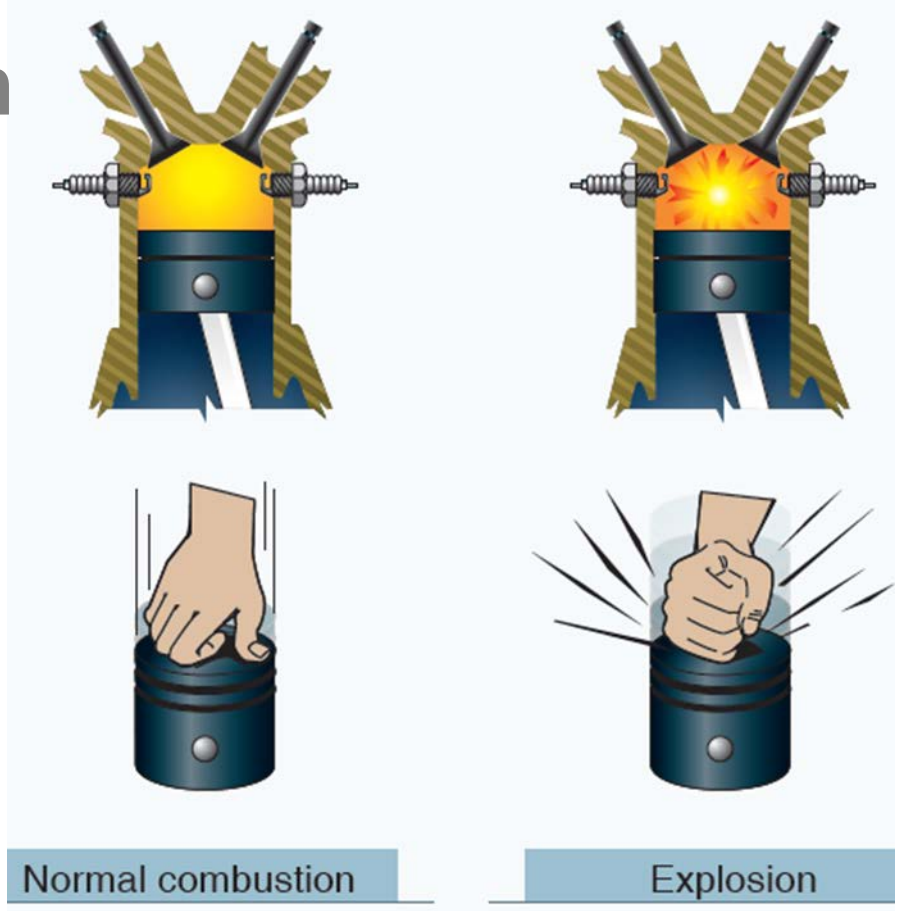
The National FAA Safety Team Presents

Federal Aviation Administration

Pre-ignition/Detonation



Presented to: Aviation Professionals

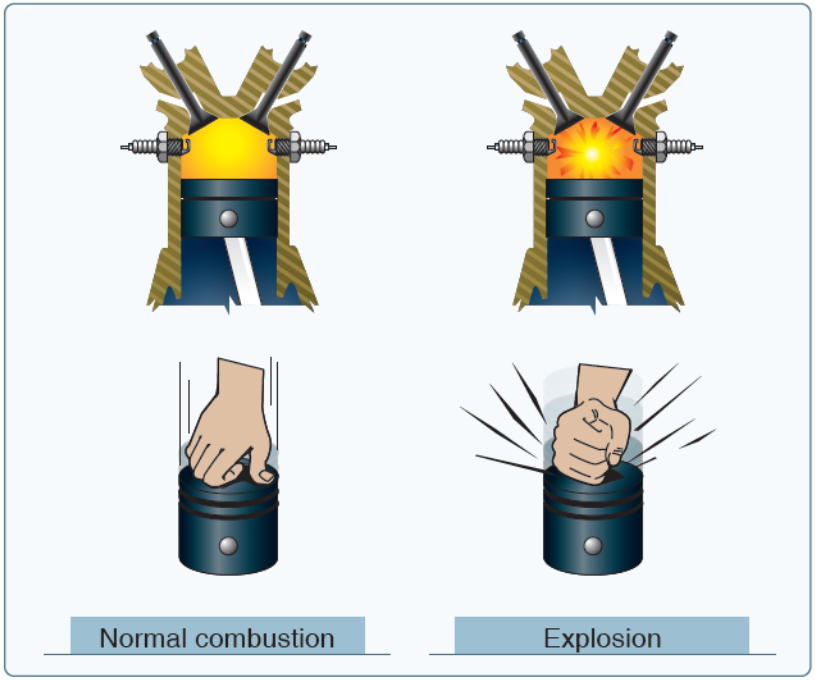
By: Chuck Holsclaw

Date: April 2019

Produced by:
The FAA Safety Team

Welcome

- Exits
- Restrooms
- Emergency Evacuation
- Breaks
- Sponsor Acknowledgment
- Cell Phones to Stun

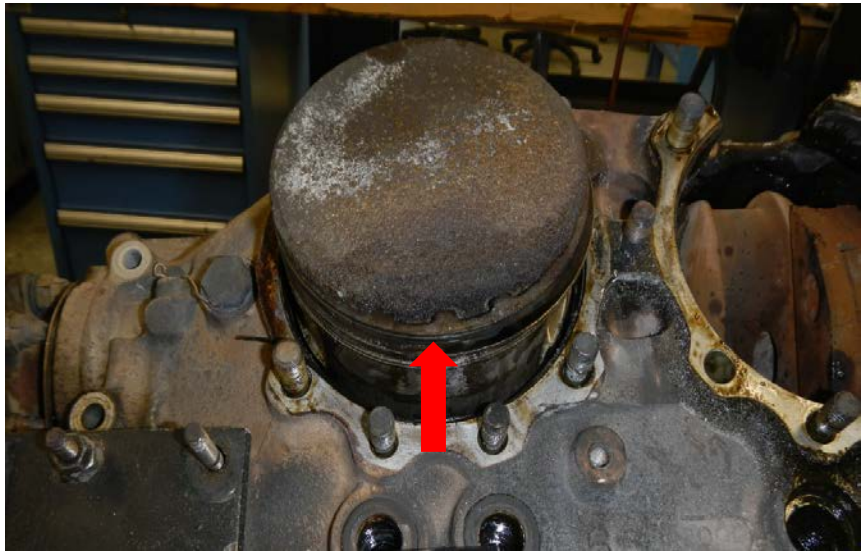


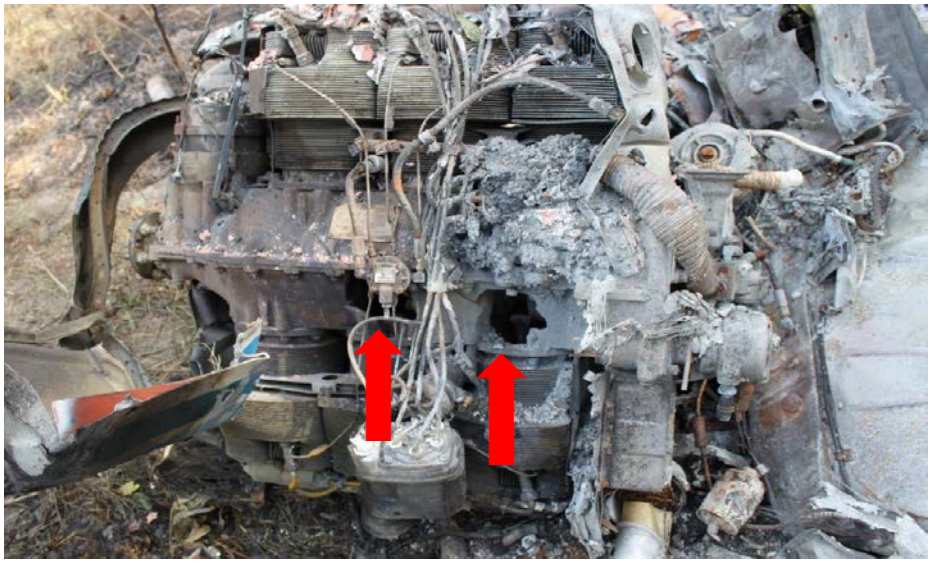
Pre-ignition and Detonation…

…are Deadly

Pre-ignition and Detonation…are Deadly!

This engine is from a Beech S35 Bonanza Fatal accident. The #6 piston was eroded and begun to melt. The rings and piston skirt were compromised by thermal expansion and metal transfer. The red arrow is pointing at the deep pitting and erosion of the piston face. This caused combustion gases to bleed into and over pressurized the crankcase, forcing engine oil out of the breather. Connecting rods then failed in short order because of the lack of lubrication. The rods then smashed holes in the crank case. Causing lost of power and engine failure.





What is Pre-ignition

Preignition

1. Piston moves up, but air-fuel mixture ignites early (before spark plug fires).
2. Excessive pressure and resistance is created.

Normal Combustion

1. Piston moves up, compressing fuel.
2. Spark plug fires and ignites compressed fuel.

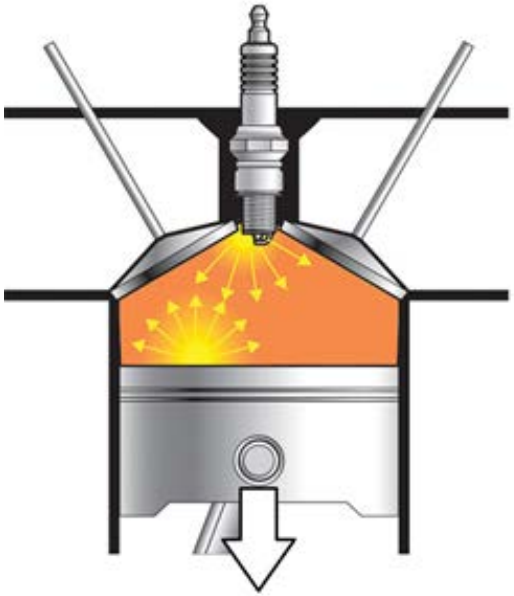
Normal Combustion vs Pre-ignition

Normal combustion – is a progressive burning of the fuel-air mixture within the cylinders. The gasses within the cylinders are ignited from the top. The flame produced as a consequence travels down in an organized way. This combustive force, equally applied to the piston in a stable manner, pushes the piston down. The downward motion of the piston is then mechanically transferred to the propeller. This makes pilots very happy.

"Pre-ignition" is an abnormal combustion event. Pre-ignition is the ignition of the air-fuel charge while the piston is still compressing the charge. The ignition source can be caused by a cracked spark plug tip, carbon or lead deposits in the combustion chamber, or a burned exhaust valve, anything that can act as a glow plug to ignite the charge prematurely. A cross over spark from an ignition system fault can also ignite the fuel air mixture while the piston is still compressing the charge. When this happens the engine works against itself. The piston compresses and at the same time the hot gas expands. This puts tremendous mechanical stress on the engine, and transfers a great deal of heat into the aluminum piston face damaging the piston. Engine failure can happen in minutes.

What is Detonation

Detonation



After TDC

Normal Combustion

Detonation

Detonation - Detonation, as the name suggests, is an explosion of the fuel-air mixture inside the cylinder. It occurs after the compression stroke near or after top dead center. During detonation, the fuel/air charge (or pockets within the charge) explodes rather than burning smoothly. Because of this explosion, the charge exerts a much higher force on the piston and cylinder, leading to increased noise, vibration, and cylinder head temperatures. The violence of detonation also causes a reduction in power. Mild detonation may increase engine wear, though some engines can operate with mild detonation. However, severe detonation can cause engine failure in minutes. Because of the noise that it makes, detonation is called "engine knock" or "pinging" in cars.

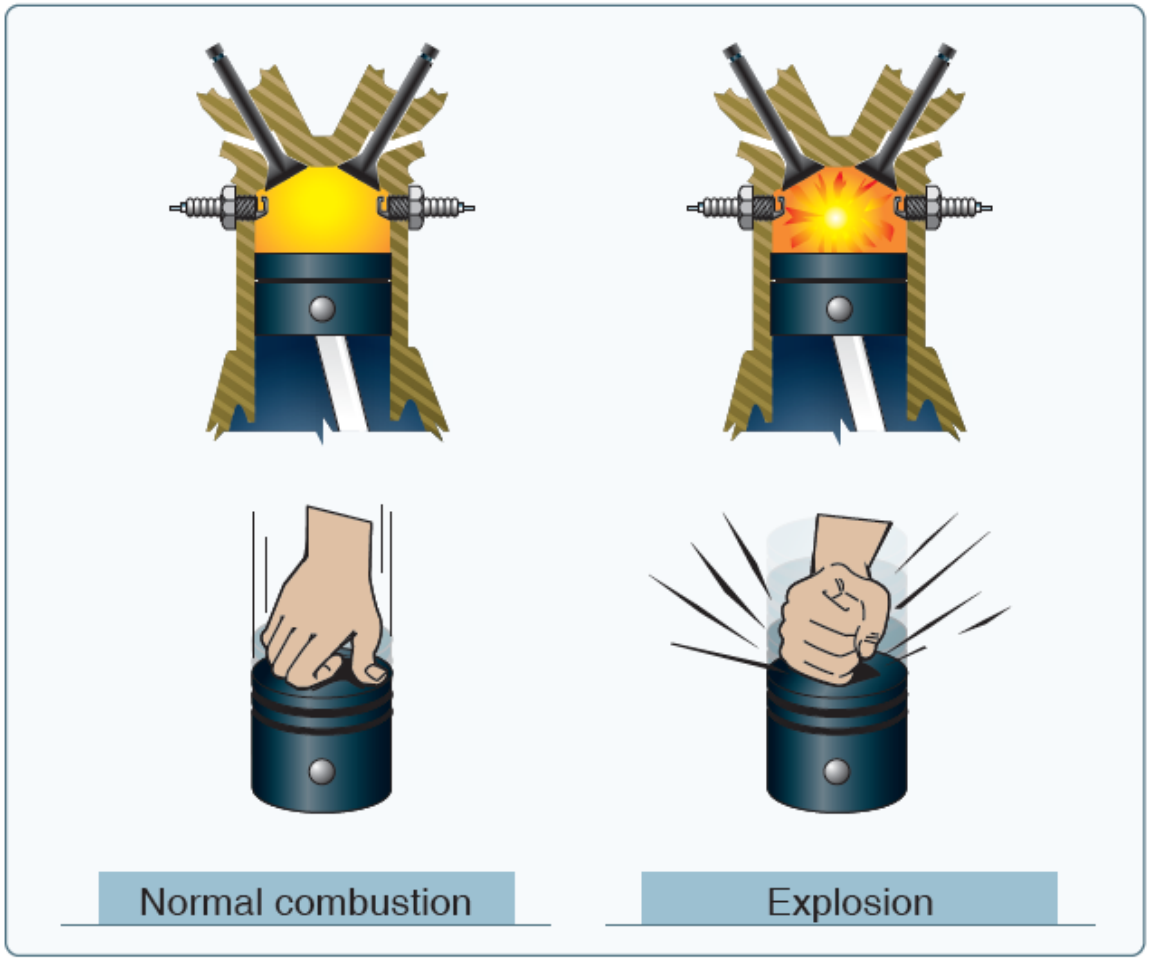
A combination of high manifold pressure and low rpm creates a very high engine load, and can induce damaging detonation. In order to avoid these situations:

- When increasing power, increase the rpm first and then the manifold pressure
- When decreasing power, decrease the manifold pressure first and then decrease the rpm

Other causes of detonation are improper ignition timing, high inlet air temperature, engine overheating, oil in the combustion chamber, or a carbon build up in the combustion chamber.

High heat is detrimental to piston engine operation. Its cumulative effects can lead to piston, ring, and cylinder head failure and place thermal stress on other operating components. Excessive cylinder head temperature can lead to detonation, which in turn can cause catastrophic engine failure. Turbocharged engines are especially heat sensitive.

Why Are These Conditions Important?



Pre-ignition - Detonation

The explosion of pre-ignition and detonation is like hitting the piston with a sledge hammer. The automotive term for the sound it makes is “Ping” (Something pilots cannot hear in aircraft). The ping sound is the entire engine resonating at 6400 hertz. Sounds like a ping, but it is an explosion with enough power to make the engine resound like a gong.

Both pre-ignition and detonation put tremendous mechanical stress on the engine, and transfer a great deal of heat into the piston deck. This can scour the protective layer of insulating air that separates the hot gasses from the aluminum piston surface causing the piston to melt (EGT is 1600 degrees. Aluminum pistons melt at 1200 degrees.) The force of these explosions can knock holes in pistons, bend connecting rods, overcome the lubrication film in the rod bearings, and hammer the babbitt out of rod bearings. Engine failure can happen in minutes.

Why Are These Conditions important?

Pre-ignition and detonation break parts. The bent connecting rod is from an auto engine, but it is just so classic we had to show it to you.

The cylinder two spark plugs are packed with melted piston.

The slide does not do the bearing shells justice, but you may be able to see the surface is rough and an uneven color. The light color at the edges is a babbitt coating. Babbitt is a soft alloy of tin, antimony and lead. These bearing were wiped by the forces of pre-ignition or detonation. This leads to one of the first indications that things are going badly. The extra clearance created by the vacating babbitt allows more oil flow, and lowers the oil pressure.

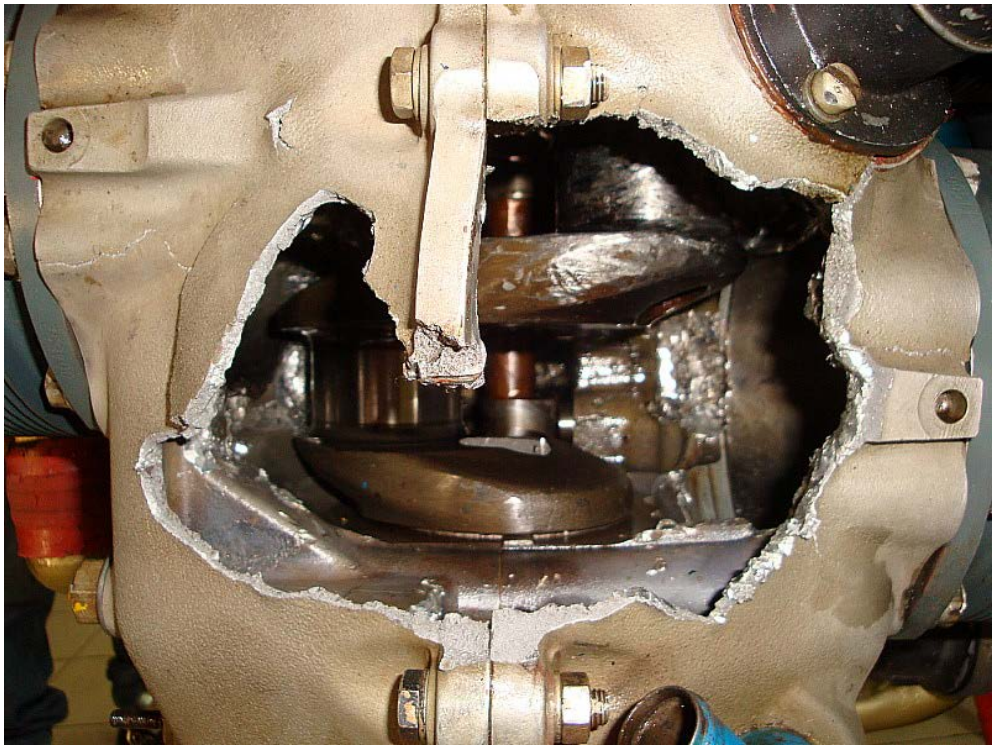
Why Are These Conditions Important?

This is a cylinder head showing signs of pre-ignition or detonation. The carbon coating that normally lines the head dome is knocked off. There is melted piston material in the head and the cylinder sleeve is scored by the overheated piston.

Why Are These Conditions important?

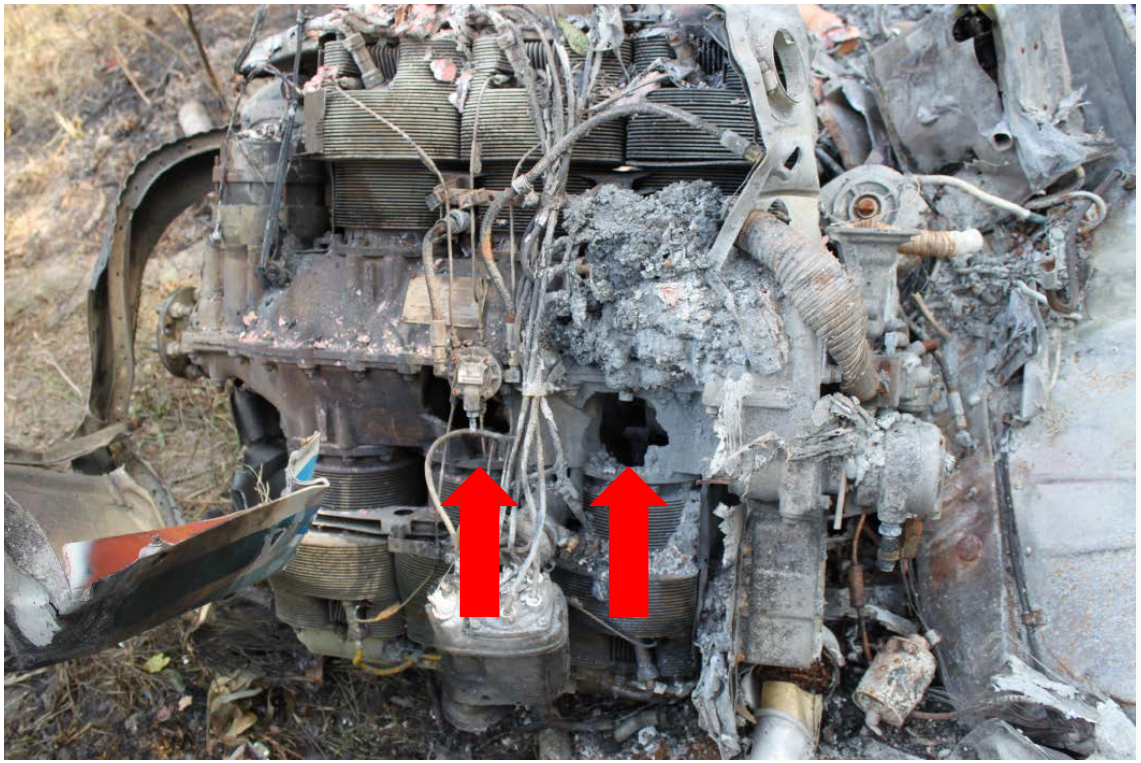
Here is the piston. The piston deck is eroded. The rings are broken. The piston skirt is scuffed from rubbing on the cylinder wall. The reason this is important is that a piston in this condition allows combustion gases into the crank case. This over pressurizes the crankcase and blows engine oil out of the crank case breather…all of the engine oil…in minutes.

Why Are These Conditions Important?



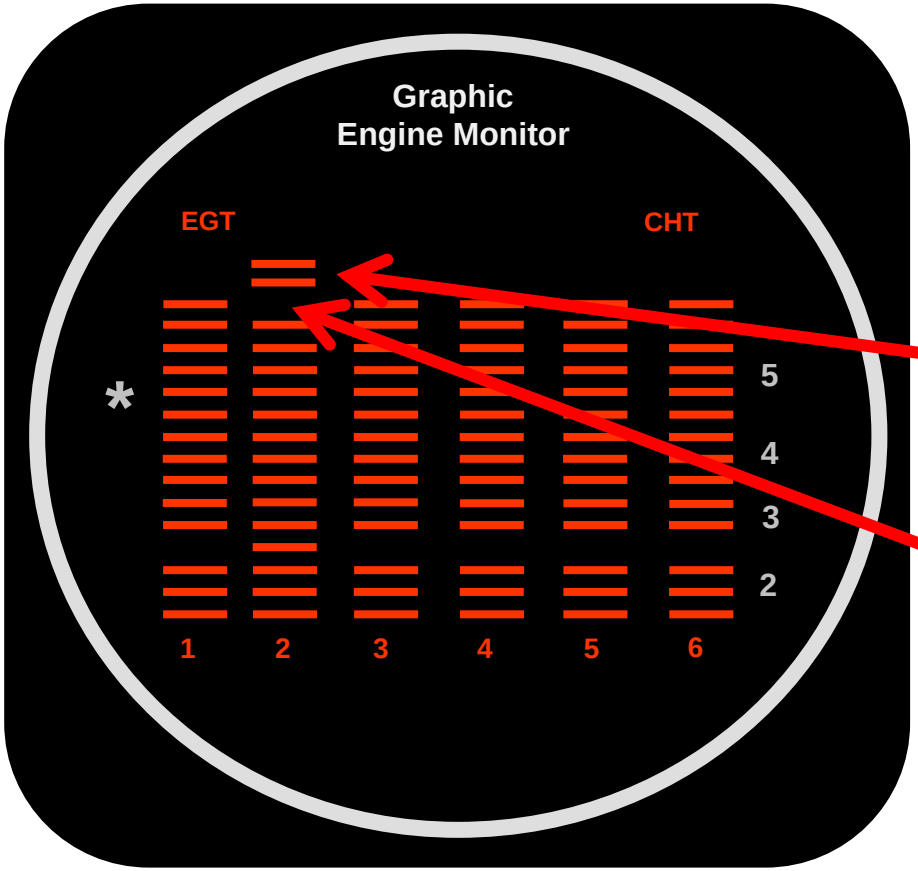
Soon after the engine oil departs the connecting rods try to make a break for it, resulting in giant holes in the crank case.

Why Are These Conditions Important?



This is the engine from the Beech crash. Note the characteristic indication of a pre-ignition event played out to the very end.

How do I detect preignition?

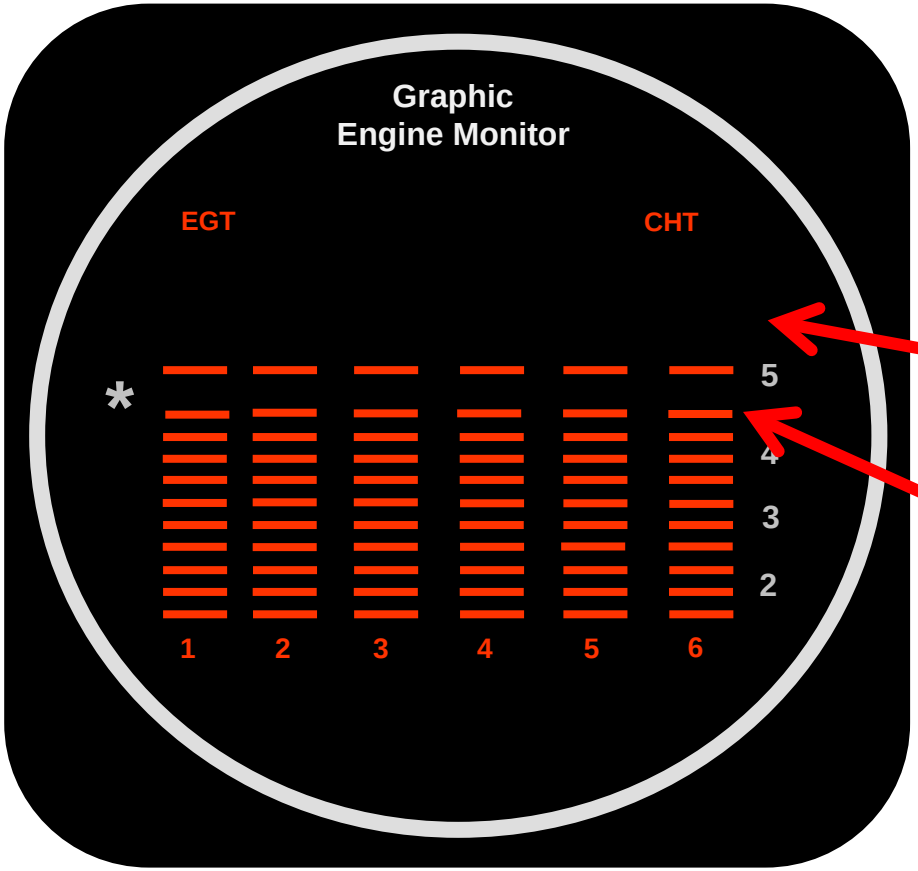


Spiked EGT

Spiked CHT

Rough running Engine should

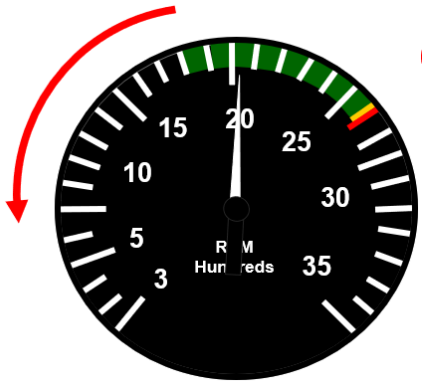
How do I detect detonation?

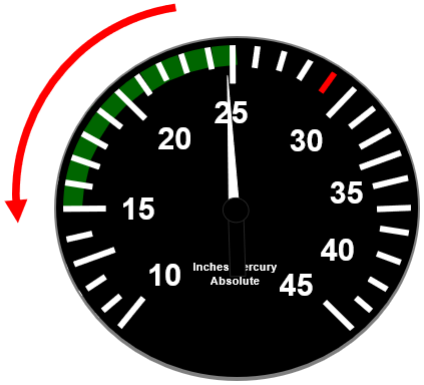


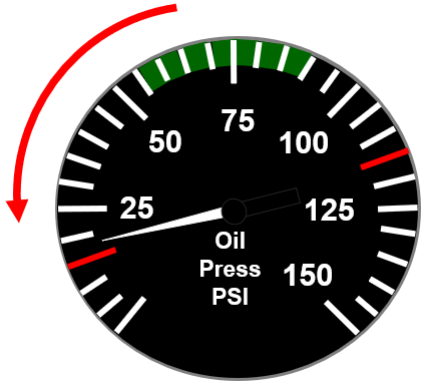
Low EGT

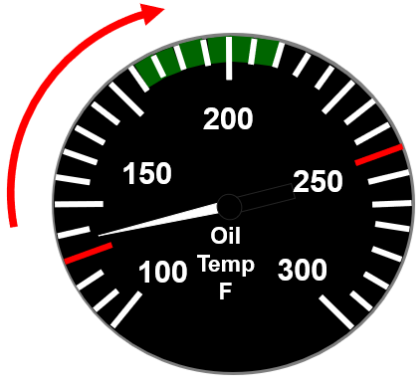
High CHT

Rough running Engine









Classic

- Decreasing RPM
- Decreasing Manifold Pressure
- Decreasing Oil Pressure
- Increasing Oil Pressure
- Engine Runs Rough

How do I react when it happens?

- **Cool the engine**
  - Reduce Power
  - Increase Airspeed
  - Enrich mixture
  - Open the cowl Flaps
- **Land Now!**

How do I prevent preignition?

- **Do Not Take Off Unless the Run Up is Perfect**
- **Maintain The Ignition System**
- **Pay Attention to Cylinder Compression Tests**
- **Use the Proper Heat Range Sparkplugs**
- **Make Sure Cooling Baffles are in Good Repair**

How do I prevent detonation?

- **Lean the Engine Per the Flight Manual**
- **Keep Engine Load to a Minimum**
- **Do not Over Boost**
- **Use Only the Recommended Fuel Grade**

How do I prevent detonation?

- **Make Sure Engine Timing is Properly Set**
- **Make Sure Cooling Baffles are in Good Repair**
- **Be Wary on Hot Dry Days**
- **If in Doubt Run Rich**

How do I prevent preignition?

- **Beech S35, N334DF, 1 Fatal**
  - Detonation or Pre-Ignition for unknown reason
- **Cessna R172K, N758FQ, 1 Minor injury**
  - Broken spark plug insulator
- **Cessna 210N, N210KW, 4 Fatal**
  - Left Magneto timed to 30 BTC should be 22 BTC
- **Cessna A188B, N4842R, No injuries**
  - Faulty Magnetos

How do I Prevent Preignition?

- **VANS RV4, N7765X, 1 Minor injury**
  - Aftermarket ECU Provided too Lean Mixture
- **MOONEY M20E, N9224M, 2 Fatal**
  - Turbo Over Boost
- **MOONEY M20K, N1168Z, No injuries**
  - Spark Plug Failure
- **EROS 1600, N508AH, 1 Fatal**
  - Improper Fuel Oil Mix, Cracked Carb Adapter

How do I prevent preignition?

- **Beech A36, N920GL, No Injuries**
  - Unapproved Turbocharger Installation/Over Boost
- **Cessna 175A, N6846E, No Injuries**
  - Ignition System Failure, Magneto Drop Over Limit
- **CESSNA 172, N758CQ, No injuries**
  - Left Magneto Bearing Race Loose
- **Beech M35, N9886R, 2 Minor Injuries**
  - Ingestion of an Air Intake Bypass Door

How do I prevent preignition?

- **CESSNA 421C, N741CA, 2 Fatal**
  - 50% Jet Fuel
- **CESSNA 411, N7321U, 1 Fatal 3 Serious**
  - Fuel System Obstructed by Crud after Storage
- **CESSNA 172F, N7939U, 1 Fatal**
  - Auto/Avgas mix, Spark Plug Maintenance
- **PIPER PA-28R-201T, N3035M, No Injuries**
  - Fuel System Misadjusted to Run Lean

Pre-ignition and Detonation are Deadly!

Questions?

Are you Aware of these ?

- **www.FAASafety.gov**
- **WINGS Program**
- **AMT Awards Program**
- **General Aviation Awards Program**

Thank you for attending

- **You are vital members of our GA safety community**

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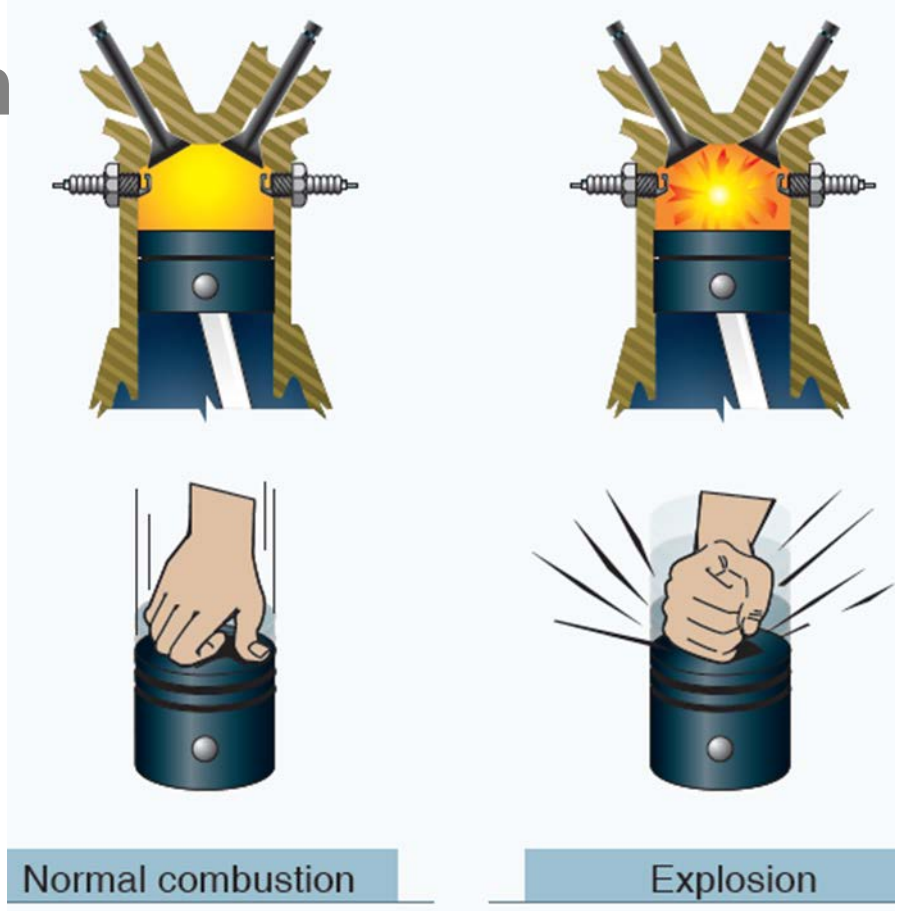

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By: <Presenter>

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