

LAB - Engine Rebuild

NAMES:

Engine Rebuilding is a required part of Level I Mechanics at GESS. Students may elect to rebuild their own engine at their own cost, or they may rebuild an engine belonging to or provided by the school at no charge.

UNDERSTAND AND ACCEPT THE FOLLOWING RISKS:

YOUR ENGINE:

- Many times it is not cost-effective to rebuild a very worn engine. You must make the call. Proper testing can help you decide before the engine is disassembled.
- Once an engine is taken apart, money must be spent on replacement gaskets and rings (at a minimum) to make it run again.
- There is no warranty whatsoever on engines rebuilt at the school. The school will not be held liable for anything that happens to your engine while at, or after leaving the school.
- It is in your best interest to complete the rebuilding of the engine faithfully and accurately.

SCHOOL ENGINE:

- Each group leaving an engine unassembled at the end of the course will have each student charged \$100 per hour per for me to reassemble the engine.
- Each group intentionally losing parts or intentionally assembling the engine incorrectly will have each student charged \$100 per hour for me to replace parts and/or reassemble the engine.
- This will also include travel time and additional costs for parts lost or destroyed during the student's involvement with the engine.

I would rather not charge you – But I would rather spend time with my family instead of assembling your engine.

READ AND FOLLOW EVERY STEP IN THIS BOOKLET!
IF YOU ARE UNSURE ABOUT ANYTHING – ASK!
I REALLY ENJOY TEACHING YOU ABOUT ENGINES

Your engine is:

(Year)

(Make)

(Model)

(Engine)

LAB - Engine Rebuild

Students: 1. _____
2. _____
3. _____

Date: _____
Block: _____

FOLLOW THE INSTRUCTIONS

NO PARTS FROM THIS ENGINE SHALL BE THROWN OUTWITHOUT THE INSTRUCTOR'S APPROVAL

ENGINE IDENTIFICATION

Record ALL Block Casting Numbers & Identification on your engine:

SPECIFICATIONS

Find the following specifications You might not find ALL, but most are CRITICAL:

Torque Specifications (*units!!!!*)

Intake Manifold bolts: _____
Exhaust Manifold bolts: _____
Flywheel/Flexplate bolts: _____
Cylinder Head bolts: _____
Connecting Rod bolts: _____
Main Bearing Cap bolts: _____
Front Crank Pulley Bolt: _____
Camshaft Sprocket bolt: _____

Valves and Valvetrain

Valve stem diameter: _____
Valve stem-guide clearance: I: _____ E: _____
Valve lash (Rocker clearance) I: _____ E: _____

Pistons and Rings

Piston-to-bore clearance: _____
Piston ring end gap(s): 1st _____ 2nd _____

Crankshaft and Connecting Rods

Main bearing journal diameter: _____
Main bearing clearance: _____
Rod bearing journal diameter: _____
Rod bearing journal clearance: _____

SKETCH a diagram for setting **CAMSHAFT TIMING** (ALIGNMENT) on this engine (you will wish you drew this better later on):

STOP!!

INSTRUCTOR'S INITIALS:

PREPARATION

DO YOU WANT SUCCESS?

DO YOU WANT EASY?

NOTE:

- | | |
|--------------------------------------|---|
| 1. There is a way things come apart | 5. Use the service manual (NOT the owner's manual) |
| 2. There is a way things go together | 6. Everything has a purpose - there ain't nothing "random" in an engine |
| 3. You need to be very organized | 7. "It's just nuts and bolts" |
| 4. Take pictures | |

AVOID THE WRATH OF YOUR INSTRUCTOR

NOTE:

1. NO PARTS from this engine shall be THROWN OUT!
2. NOTHING on this engine shall be DESTROYED!
1. ASK FOR HELP – They pay me to help you (*if you don't ask, they still pay me*)

GET:

1. Containers for parts storage
2. Masking tape and Pen/Felt for labelling
3. Digital Camera for taking pictures of assemblies



You are ready to start

STOP!!

INSTRUCTOR'S INITIALS:

REMOVE THE CYLINDER HEAD

NO PARTS FROM THIS ENGINE SHALL BE THROWN OUT WITHOUT INSTRUCTOR'S APPROVAL

- **FOLLOW** the service manual procedure to remove the cylinder head from the engine.

- **EVERY ENGINE IS DIFFERENT** – I cannot make this lab follow EVERY engine.

- **ASK** if you are unsure.



OHV

Label and remove the pushrods & lifters – they must be kept IN ORDER

NOTE!

Some OHV engines set their **LIFTER PRE-LOAD** by pushrod lengths!

YOU MUST KEEP THE PUSH-RODS IN ORDER AND KNOW EXACTLY WHERE THEY CAME FROM!!

Remove the lifters from the block – otherwise they will fall out onto the floor later.

I'm totally going to make fun of you when I hear your lifters clatter on the floor.

See page 9

- **ALL ENGINES** – You WILL be removing:

- THE VALVE COVERS

- THE INTAKE MANIFOLD

- THE EXHAUST MANIFOLD(S)

- **SOME ENGINES** – You MIGHT be removing:

- THE ALTERNATOR

- THE DISTRIBUTOR

- PUSHRODS

- **OVER HEAD CAM (OHC) ENGINES** – You **MUST** remove:

- **IF BELT:** THE FRONT PULLEY, TIMING BELT COVER, AND TIMING BELT
 - See page 14 if you have to remove a Harmonic Balancer

- **IF CHAIN:** CAMSHAFT SPROCKET

- NOTE any missing or damaged HEAD ALIGNMENT DOWELS/PINS

- LABEL EVERYTHING; THREAD FASTENERS BACK INTO THEIR HOLES

- ***NOW REMOVE THE HEAD BOLTS AND REMOVE THE HEAD(S)***

TAKE PICTURES!

You won't remember how it goes back together months from now!

You won't know what you SHOULD HAVE taken a picture of until you're putting it back together!

STOP!!

INSTRUCTOR'S INITIALS:

DISASSEMBLE THE CYLINDER HEAD

IF THIS IS
ONE OF THE
SHOP
ENGINES,
JUST DO
ONE(1)
CYLINDER
HEAD.

IF THIS IS
YOUR
ENGINE, DO
BOTH

WEAR EYE
PROTECTION

WEAR EYE
PROTECTION

WEAR EYE
PROTECTION

WEAR EYE
PROTECTION

DO I NEED TO
PUNCH YOU IN
THE FACE?

WEAR EYE
PROTECTION

WEAR EYE
PROTECTION

WEAR EYE
PROTECTION

WEAR EYE
PROTECTION

THE VALVE
SPRING WILL
PUNCH YOU IN
THE FACE!

WEAR EYE
PROTECTION

WEAR EYE
PROTECTION

WEAR EYE
PROTECTION

WEAR EYE
PROTECTION

NO PARTS FROM THIS ENGINE SHALL BE THROWN OUT WITHOUT INSTRUCTOR'S APPROVAL

- **DISASSEMBLE** the cylinder head according to the SERVICE MANUAL

**EVERY ALUMINUM HEAD USES STEEL SHIMS UNDER
THE VALVE SPRINGS DO NOT LOSE THEM!!!**

**ALL VALVES ARE ASSEMBLED WITH RETAINERS
AND KEEPERS - DO NOT LOSE THEM!!!**

READ THE STEPS IN THE MANUAL!

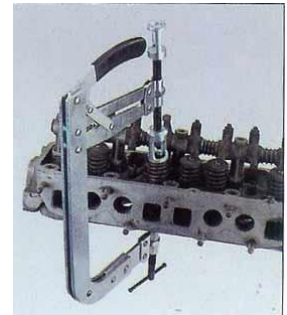
- **KEEP TRACK** of EACH valve, spring, retainer, keeper, rocker arm, push rod, etc. as appropriate
- **HAVE** I yelled at other kids already for not doing this? Convince me right now that you can read!
- **KNOW EXACTLY** where they came from. **KEEP THEM IN ORDER!**
- **WIRE-WHEEL** the carbon off the valves and mark their locations on them with a felt
- **LABEL** each part location – **KNOW** where everything goes!

OHV ENGINES: REMOVE the LIFTERS from the block, label their EXACT location! DO NOT LOSE THEM!

- **CLEAN** the cylinder head(s) and parts in the **SOLVENT TANK**. Clean again with the **Pressure Washer**, then blow dry with compressed air and spray with **WD40 AS SOON AS POSSIBLE!**
- Head must be **WHITE-GLOVE CLEAN**
- **THREAD FASTENERS BACK INTO THEIR HOLES SO THEY ARE NOT LOST**



Mr. Wellwood's Demo



STOP!!

INSTRUCTOR'S INITIALS:

INSPECTING THE CYLINDER HEAD

DESCRIBE the visual condition of ALL the valve stems, valve faces, valve tips, and rocker arms (if equipped). You are looking for any damage or excessive wear on any moving contact surface:

DESCRIBE the visual condition of ALL the valve retainers, valve springs, keepers. You are looking for any damage - these parts don't usually wear:



MrW's
Demo

Pick your WORST looking intake valve, and your WORST looking exhaust valve

Using a MICROMETER, measure and record the smallest diameter of each valve stem (look for the most wear)

Your Intake Valve Stem Smallest Diameter: _____

Your Exhaust Valve Stem Smallest Diameter: _____

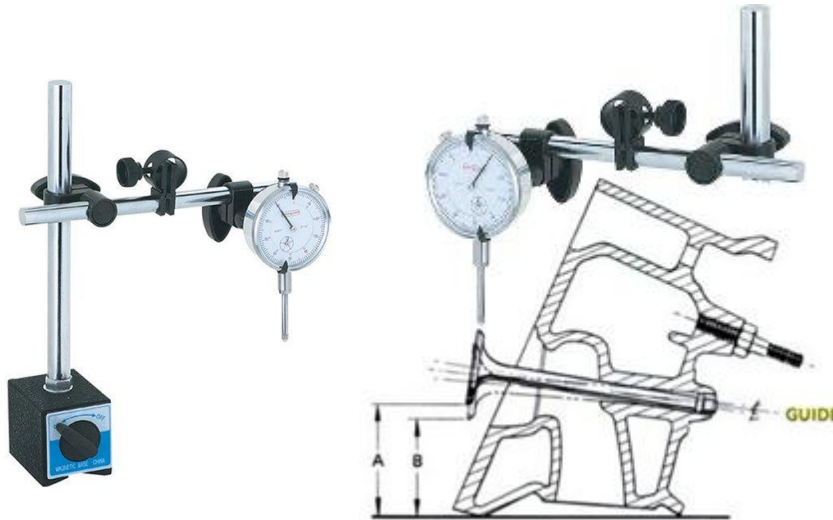


Copy Valve Stem Spec here:



Circle

ATTACH a DIAL INDICATOR with a MAGNETIC BASE to your cylinder head and measure and record the valve guide clearance of these two valves sitting in THIER guides (sticking out only as far as the wear shows on the stem):



Copy Valve Guide Clearance spec here:



Circle

Typical oil clearances in a motor are about the thickness of a human hair – that's not much!!

Your Intake Valve Guide Largest Clearance: _____

Your Exhaust Valve Guide Largest Clearance: _____

STOP!!

INSTRUCTOR'S INITIALS:

INSPECTING THE CYLINDER HEAD

INSPECT AND KEEP IN ORDER:

OHC

"Over Head Cam"

Camshaft is IN the HEAD, not the engine block.

- **OHC ONLY:** Remove & inspect Camshaft, Rocker-Arms/Cam-Followers/Spring-Buckets
 - Lobes should be smooth, sharp edges, consistent shape between lobes.
 - Worn camshafts can be re-ground and installed with new or re-ground cam followers
 - Wear/Damage found:



OHV

"Over Head Valve"

Camshaft is IN the BLOCK, not the cylinder head.

- **OHC ONLY:** Inspect Timing Chain/Belt/Gears/Tensioner
 - Timing chains and belts are usually replaced in a rebuild. Gears usually last forever.
 - Inspect the "looseness" of the chain. Idler and Tensioner pulleys should spin freely
 - Wear/Damage found:



Cylinder Head Demo

- **OHV AND OHC:** Warpage
 - Usually means overheating. Warped heads must be machined flat. ANY warpage is bad.

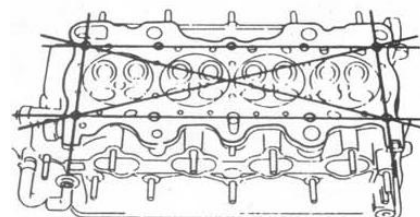
Use a **STRAIGHT EDGE**
and **FEELER GAUGES**

Check:

- Outside edges of the head surface
- Center of head surface
- Diagonally

Largest feeler gauge size: _____

Circle: 😊 ☹️



STOP!!

INSTRUCTOR'S INITIALS:

REASSEMBLY

- Valve seats and faces can be lapped, re-ground, or merely re-assembled depending on what you have found.

What rebuilding does this cylinder head need to have done? **BE DETAILED:**

- MACHINE the cylinder head as needed.
- THOROUGHLY clean the cylinder head, and all its components.
- Cylinder Head must be WHITE GLOVE clean prior to assembly. You do not want crud inside your nice new engine when you're done. CLEAN!!!
- Reassemble the cylinder head according to the service manual.
- Use new valve seals if this is your engine, and then show this sentence to your instructor for a bonus.
- Don't forget any spring shims
- **USE OIL ON EVERY MOVING SURFACE!**
- **NEVER re-assemble anything "dry"**



You want
CLEAN.

You should
be able to
lick the
engine and
taste only
metal, not
oil or
grease

(Oil and
Grease
taste nasty!
Ask me
how I
know)

STOP!!

INSTRUCTOR'S INITIALS:

ENGINE BLOCK

DO NOT TAKE ANYTHING APART YET **DISPLACEMENT**

We taught
you
BEDMAS
for a
reason

And MATH

And you do
know what
 π is, right?

Measure the BORE: _____

Measure the STROKE: _____

Using ($\pi r^2 h n$):

$$\pi \times (\text{BORE} \div 2)^2 \times (\text{STROKE}) \times (\# \text{CYLINDERS})$$

What is the displacement of this engine?

25.4mm per inch
1000cc per liter
16.39 cc per cubic inch



INSPECTION

- **SKETCH** the top of a piston
 - Include any VALVE RELIEFS (these are pie-shaped cut outs in the top of the piston to allow the valves to open further)
 - Include the **NOTCH** (points to the *front* of the engine – Front is where the pulleys are)
- Pistons **MUST** be reassembled a certain way (the pin is not actually centered – it is offset to reduce "*piston slap*" sound)
- Rotate the engine on the stand to remove the oil pan*
- Report ANY missing parts, fasteners, bearings, components you see inside the engine:

Piston Top Sketch

←←←←←← Front of motor

DON'T be
like the kid
who drew
this
correctly,
AND STILL
MANAGED
TO PUT ALL
THEIR
PISTONS IN
BACK-
WARDS!!!

*This is
where I
hear all
your lifters
fall onto
the floor,
and I come
and make
fun of you

See page 4

DO NOT REMOVE –ANY- PISTONS YET

STOP!!

INSTRUCTOR'S INITIALS:

PREPARATION FOR DISASSEMBLY

DO NOT REMOVE ANYTHING YET!

THERE IS A WAY TO NOT DESTROY THIS CRANKSHAFT; 3 THINGS YOU NEED TO KNOW:

1. THE CONNECTING RODS MUST BE NUMBER STAMPED BY CYLINDER ORDER

Connecting Rods and Main Bearings are so precisely machined, if the caps get mixed up or put on backwards, the engine will not even turn!!!!



DO NOT REMOVE ANYTHING YET!

2. THE HARD CONNECTING ROD BOLT THREADS CAN DAMAGE THE SOFT IRON OF THE CRANKSHAFT JOURNAL - RUBBER BOOTS ARE SLIPPED OVER THE THREADS



USE RUBBER BOOTS OVER THE CONNECTING ROD BOLTS TO PROTECT THE CRANK JOURNALS!

DO NOT REMOVE ANYTHING YET!

3. THE CRANKSHAFT NEEDS TO BE ROTATED TO REMOVE PISTONS, THEREFORE, ONLY REMOVE PISTONS ONE AT A TIME

DO NOT REMOVE ANYTHING YET!

NOW RECITE THESE 3 THINGS BACK TO YOUR INSTRUCTOR

Rods & caps MUST be numbered

NOT ALL MAKERS NUMBER THEIR RODS FROM THE FACTORY!!!
(I'm looking at YOU, Chevy...)

Rubber boots on the hardened threads to protect the crankshaft journals

Remove ONE AT A TIME

STOP!!

INSTRUCTOR'S INITIALS:

PLASTIGAUGE®

ONE OF THE SEVEN WONDERS OF THE UNIVERSE

#1 THE ROD BEARING CLEARANCE

We can measure the
CONNECTING ROD Oil
clearance really easily using



Image: www.veritec-competition.com

- Plastigauge® is used to measure the **Connecting Rod** Bearing clearances by being squished inside the bearing clearance. How wide it squishes tells us how tight the clearance is.

- Most crankshaft bearing clearances are around 0.001" to 0.0015"



Plastigage Demo

CHECK
the
QR CODE
for a
DEMO!

- REMOVE a Connecting Rod Cap and lay the Plastigauge® on a main bearing journal (recommended: all).
- Install and torque the Rod Cap to spec (DO NOT ROTATE THE CRANKSHAFT)
- Remove the Cap and compare the squish to the stripes on the wrapper - measure the bearing clearance:
- Scratch the Plastigauge® off the bearing and the journal with your thumbnail.

DO NOT rotate the crankshaft or you will smear the Plastigage

Measured Clearance:

Copy Rod Bearing
Clearance spec here:



Excessive rod bearing clearance can cause "knocking" sounds from inside the motor. Also, the oil can escape more easily, resulting in low oil pressure, and flooding the piston rings with extra oil.

STOP!!

INSTRUCTOR'S INITIALS:

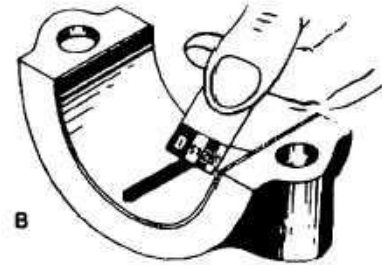
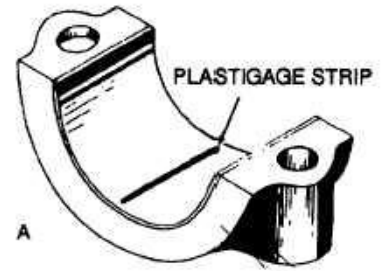
#2 THE MAIN BEARING CLEARANCE

We can measure the MAIN BEARING Oil clearance really easily using Plastigage®



Plastigage Demo

- Plastigage® is used to measure the main bearing clearances by being squished inside the bearing clearance. How wide it squishes tells us how tight the clearance is.



- Most crankshaft bearing clearances are around 0.001 to 0.0015"
- Lay the Plastigage® on a main bearing journal (recommended: all).
- Install and torque the main cap to spec.
- Remove the main cap and compare the squish to the stripes on the wrapper - measure the bearing clearance:

DO NOT rotate the crankshaft or you will smear the Plastigage

Measured Clearance:

Copy Main Bearing spec here:



Circle

- Scratch the Plastigage® off the bearing and the journal with your thumbnail.

Excessive main bearing clearance can cause "rumbling" sounds from inside the motor. Also, the oil can escape more easily, resulting in low oil pressure, and flooding the piston rings with extra oil.

STOP!!

INSTRUCTOR'S INITIALS:

THRUST BEARINGS!

STILL DO NOT REMOVE -ANYTHING- YET!

There are special Thrust Bearings that restrain the crankshaft from moving fore/aft. Where are they in your engine?

Thrust bearings are CRITICAL! DO NOT LOSE THEM!

INSTRUCTOR'S INITIALS:

NOW: REMOVE PISTONS (ONE AT A TIME, USE RUBBER BOOTS, DANG IT!)

DO NOT REMOVE THE CRANKSHAFT YET

DO NOT BEAT, BANG, DAMAGE or RISK DAMAGING ANY PART OF THIS ENGINE – EVERYTHING COMES APART EASILY – JUST ASK FOR HELP

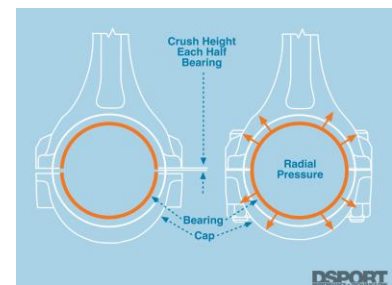
- **LABEL** each piston, bearing, oil pump part, etc. as appropriate.
- Wire-wheel the tops of the pistons (**NOT** the skirts).
- **LABEL** each part location, and ask the guy in charge of this class for a magical extra mark
- **NOW** parts in solvent tank, clean with soap and water, then blow dry with compressed air AS SOON AS POSSIBLE, and coat lightly with oil



THREAD FASTENERS BACK INTO THEIR HOLES SO THEY ARE NOT LOST

Bearings are kept in their location by CRUSH – they are slightly larger than the bearing journal housing, so when they are assembled, they are CRUSHED in tightly.

Bearing shells also have one more special way to locate them in their bores. Have a close look! What is it? How are they aligned with each other?



PAY ATTENTION TO HOW BEARINGS ARE INSTALLED

YOU NEED TO ASSEMBLE THEM PROPERLY!

STOP!!

INSTRUCTOR'S INITIALS:

TIMING CHAINS/SPROCKETS and GEARS

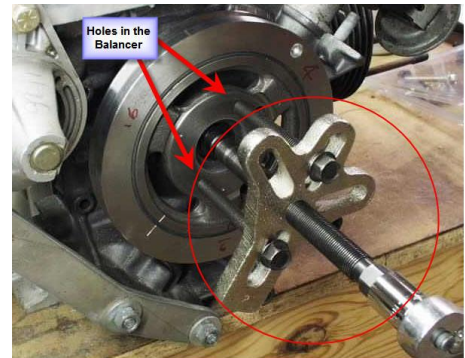
Remove the **front pulleys** (if any). You may have one on a water pump, you will likely have one on the crankshaft.

Harmonic Balancers are an important part for the life of a crankshaft. It absorbs vibrations, preventing the crankshaft from cracking.

It has a heavy cast iron ring that is glued to a rubber band around a cast iron hub. The rubber allows vibrations to be absorbed or "countered" by the heavy outer ring.



You CANNOT use a pulley puller that grabs the outside of the pulley – it will pull the outer ring off, **RUINING** it.



USE A HARMONIC BALANCER REMOVER

DO NOT USE AN IMPACT WITH THIS PULLER!!!!

If your engine is OHC, you may have already done this



MrW's
PULLER
DEMO

Remove the Timing Cover

INSPECT the Timing Chain/Gear/Sprockets: Should not be excessively loose or sloppy. Teeth should look solid and complete. As the teeth and chain wears, the chain may "jump" and change the cam timing - resulting in a loss of power or damage

How is your Timing Chain and Sprockets?

REMOVE the timing chain



STOP!!

INSTRUCTOR'S INITIALS:

REMOVING THE CRANKSHAFT

- You may now CAREFULLY remove the crankshaft, and disassemble the rest of the engine block (*It's HEAVY*)
- ***INSPECT EACH JOURNAL AND FIND OUT HOW YOU DAMAGED THE SURFACES WITH THE ROD BOLT THREADS, YOU MONSTER!***
- Wrap all the crankshaft journals with masking tape to protect them from any accidental damage



Removal

PROPER STORAGE OF YOUR CRANKSHAFT:

- Crankshafts should be stored standing on end, or suspended by their crank bolt or flywheel flange. They can warp just by gravity if they are laying on their side.



Continue...

OHV: THE CAMSHAFT (*OHC CAN SKIP THIS*)

You should have already removed your lifters.

Dig them out now, we need to look at them

NOTE:
When I rebuild these motors, I have a WEE TINY hone to clean up the lifter bores and make it EASIER to rotate as the cam tries to lift it.

If you have an Over Head Cam Engine (OHC), you already did this (skip it)

NOTICE: Old school OHV engines have **FLAT TAPPET** cams. Modern engines use a **ROLLER LIFTER** to reduce friction. We're going to look at the Flat Tappet design for now:

FLAT TAPPET LIFTER BORES are NOT actually centered over their cam lobe. If you look closely, you will notice that they are slightly offset! This helps make the lifter **WANT** to rotate as the cam tries to lift it – *rotating friction is always better than sliding friction*.

FLAT TAPPET LIFTERS are also slightly **CONVEX** on the bottom (crowned, they have a slight curve). This also makes them **WANT** to rotate as the cam tries to lift it – *rotating friction is always better than sliding friction*.



CHANGE YOUR OIL!

IF YOU DO NOT CHANGE YOUR OIL ON A REGULAR BASIS, THE LIFTERS (among other things) GET GUMMED UP, AND DO NOT WANT TO ROTATE, BECOMING A SLIDING FRICTION!

THIS EATS THE CAM AND EATS THE LIFTERS!

and then... where did all that metal go??

INSPECT YOUR LIFTERS:

Are your lifter bottoms **CROWNED** (junk), **FLAT** (junk), or **CONVEX** (good)?

Camshaft: Should have smooth lobes and bearing surfaces. Flat-Tappet cam lobes are angled slightly. This also makes them **WANT** to rotate as the cam tries to lift it – *rotating friction is always better than sliding friction*. You should see evidence of contact along one side of the lobe. As the lobes and the lifters wear out, that contact will get wider and wider and then start eating the lobe (Image below: see how the wear over the nose is getting significantly wide and covers a lot of the ramp?)

INSPECT YOUR CAM LOBES:

Do the lobes have **EDGE Wear**, or is it getting **WIDE**? Is there a lobe (or more) where the wear is *significant*?



STOP!!

INSTRUCTOR'S INITIALS:

ENGINE BLOCK INSPECTION, MEASUREMENT and DIAGNOSIS

The TOP of the cylinder bore is usually the most worn, due to

1. High heat
2. Limited oil
3. The thrust of the piston.

1. USE a TELESCOPING GAUGE and a MICROMETER, measure and record the TOP of the MOST worn cylinder just below the RIDGE

The BOTTOM of the cylinder bore is usually the least worn due to:

1. Lots of oil
2. Very little heat
3. Very little thrust of the piston.

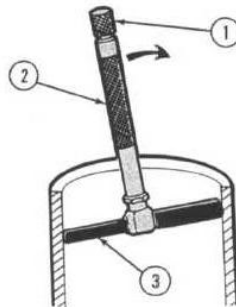
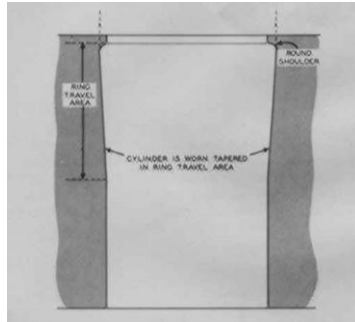
2. USE a TELESCOPING GAUGE and a MICROMETER, measure and record the BOTTOM of the cylinder

- Rings seal best with a perfect cylinder
- Taper within spec can be honed and the old pistons reused with new rings.
- An excessively worn cylinder must be re-bored and over-size pistons fitted.

3. SUBTRACT the BOTTOM of the cylinder from the TOP of the cylinder is to find the TAPER/out-of-round.

My last engine had 0.007" taper

I had it bored 0.020" over and oversize pistons fitted.



Measuring with a telescoping gauge is pretty tricky. Ask for a free demo from your instructor!

1. _____
(TOP)

—

2. _____
(BOTTOM)

=

3. _____
(Total Taper)

STOP!!

INSTRUCTOR'S INITIALS:

PISTONS

EXCESSIVE
Piston-to-
Cylinder
Wall
clearance
results in
"Piston
Slap" which
sounds a
bit like a
the clatter
of a Diesel

Using a MICROMETER, measure the diameter of the piston from your WORST cylinder.

Measure at pin height, 90° to the piston pin:

Piston Clearance is usually about 0.0015" PER INCH OF BORE

DO MATH

How is it?



Circle



MATH MOMENT: Piston Clearance is usually about 0.0015" PER INCH OF BORE

Inspect the piston for physical damage: detonation damage, scoring, scratches, cracks, missing parts, carbon buildup, holes, overbore markings, etc. Describe what you found:

STOP!!

INSTRUCTOR'S INITIALS:

BEARING SHELLS:

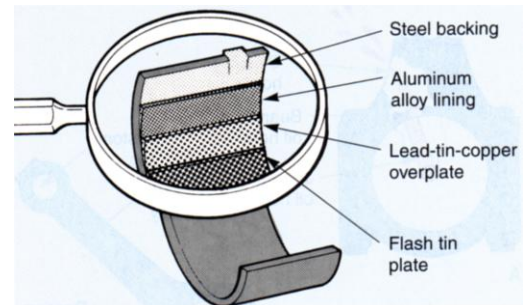
New bearings are a light silver/gray colour. They use a notched steel backing with a notch to keep it in the right place.

Worn bearings will start showing the layers underneath.

Worn bearings allow oil to leak out (engine loses oil pressure), the leaky oil over-splashes the cylinders (increases oil consumption), and increases noise (large clearance with less oil to absorb shock). Explain how worn bearings affect an engine to your long-suffering instructor for a bonus.

Bearings are made slightly larger in diameter than their housing so they are a press-fit (even the rod bearings – the cap “press-fits” them together. A loose fit in the rod will cause the bearing to “spin” – ruining the bearing, the rod, and the crankshaft.

Describe how all the bearings (including the thrust bearings) look:



CRANKSHAFT JOURNALS:

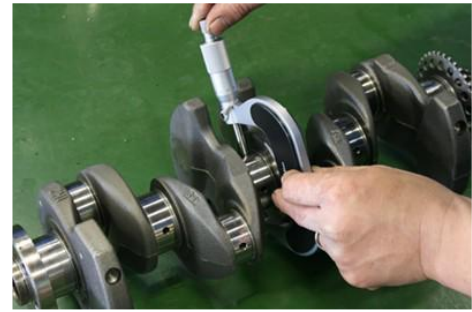
Main Journals:

Using a micrometer, measure your
WORST Main Bearing Journal Diameter:

Copy Main Journal
spec here:



Circle



Rod Journals:

Using a micrometer, measure your
WORST Rod Bearing Journal Diameter:

Copy Rod Journal
spec here:



Circle



This sentence to your instructor for a bonus you will show.

OIL PUMP:

Oil pumps can be found inside the crankcase, outside the engine block, inside the timing cover or wherever the manufacturer saw fit.

Where is your oil pump located?

How is your oil pump driven (what makes the guts rotate so it will pump?)?

Disassemble the oil pump (use an Impact Driver and a Hammer if the fasteners do not come undone easily - DO NOT STRIP THE FASTENERS).

Inspect and Describe the wear and/or damage inside the oil pump (look at every moving surface for scratches, gouges or other damage – anything not perfectly smooth and shiny):

STOP!!

INSTRUCTOR'S INITIALS:

PISTON RINGS – YOU NEED TO BE GENTLE!!!

NO, SERIOUSLY: YOU NEED TO BE GENTLE HERE!

CAREFULLY remove the **TOP COMPRESSION RINGS** on your **WORST** cylinder with PISTON RING PLIERS - NOT YOUR FINGERS!!!

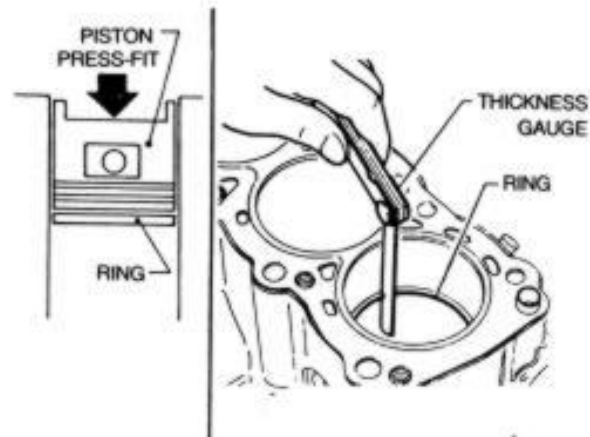
Piston Rings are **VERY** fragile – spread them **ONLY** enough or they **WILL** break – and you *cannot* buy "just one."



NOTE which ring came from which groove, and which way was UP. This is very important for the engine to seal.

YOU MAY REMOVE THE TWO OIL SCRAPER RINGS AND THEIR SEPARATOR WITH YOUR FINGERS

Place a **COMPRSSION RING** in a cylinder, and push it to the bottom of the cylinder using the head of the empty piston (you are pushing the piston back into the cylinder upside down)



Use feeler gauges to measure the piston ring gaps (you might have to stack some and add them:

Top: _____

Second: _____

Excessive ring gap will allow compression pressure to escape into the crankcase (called "blow by"), and draw oil into the cylinder on intake (oil sucked in during intake will burn blue in the exhaust)

Copy ring gap spec here:

TOP: _____

SECOND: _____



Circle

***RING GAP RULE-OF-THUMB: 0.004" per INCH of Cylinder Bore
for naturally aspirated engines***

LOTS of COLD-STARTS and SHORT TRIPS are where an engine burns EXTRA FUEL

EXTRA FUEL washes the oil off the cylinder, making the rings and cylinders WEAR OUT FAST!

EXTRA FUEL getting into the oil, THINS the oil, which LUBRICATES LESS, accelerating wear!

STOP!!

INSTRUCTOR'S INITIALS:

AUTOPSY – CSI AUTOMOTIVE

TELL ME ABOUT:

POWER

NOISES

FUEL
CONSUMPTION

OIL
CONSUMPTION

OVERHEATING

HOW WAS IT
RUNNING
BEFORE IT DIED

WHAT KILLED
IT?

Based on all the information you've gathered, describe SPECIFICALLY how this engine was running before it died, and what specifically killed it. Be as detailed yet as POINT FORM as possible. Give me *EVIDENCE*:

- 50 Perfectly and thoroughly detailed, no stone unturned, The Force is with you!
- 40 Very good and reasonable, some contributing causes mentioned
- 30 Basic description only; root cause identified; I'll probably try leading you to more ideas
- 20 Marginal evidence of analysis and I'm going to give you a strange look
- 10 You're giving me lame reasons, and I'm merely going to shrug and walk away from you
- 0 Are you actually enrolled in this course?

STOP!!

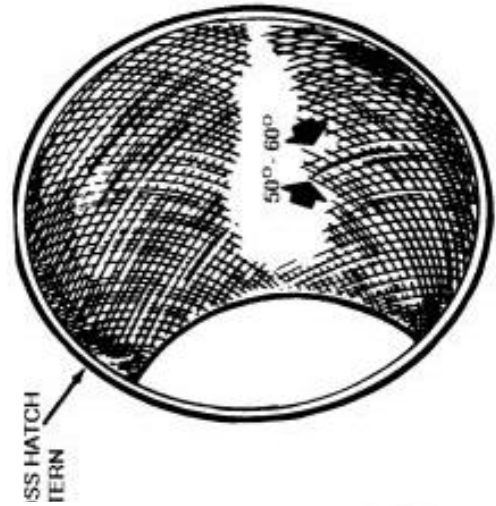
INSTRUCTOR'S MARK:

/50

ASSEMBLY

CYLINDER HONING

1. Rings and cylinders "wear in" together.
2. New rings will not seal against a polished cylinder.
3. Honing the cylinder produces a cylinder wall finish that lets new rings "wear in" properly.



How-To

If merely doing a re-ring, or assembling a "dead" engine, hone the cylinders as shown by your instructor. You must have a 60° crosshatch pattern.

DO NOT HIT THE
CRANK WEBBING
WITH THE
HONING TOOL

USE LIGHT OIL
FOR HONING



- A proper honing pattern is a result of how fast you **SPIN** the hone and how fast you **STROKE** the hone. Somewhere in there is balance. Try it!
- **CHASE** all threaded holes in the block and head(s) with the appropriate tap.



CLEAN threads = ACCURATE torque readings when assembling (CRITICAL!)

STOP!!

INSTRUCTOR'S INITIALS:

CLEAN THE ENGINE

YOU SHOULD BE ABLE TO EAT OFF OF IT

- Scrape off ALL the oil and grease using scrapers, flat screwdrivers, and wire brushes
- Use brand-name Oven Cleaner to soak and remove heavy carbon deposits
- Use degreasers (like solvent, Simple Green, or others) to clean right down to bare steel.
- Rinse thoroughly and blow dry with compressed air. The engine must be WHITE-GLOVE clean.
- You think it's clean? Think again. Get your instructor to check all the nooks and crannies in the engine block. You'd be surprised.



PROTECT THE ENGINE

THIS STEP IS CRITICAL: BARE METAL RUSTS QUICKLY!!!

- SPRAY **WD40** ON THE CYLINDER WALLS AND ALL MACHINED SURFACES ("**WD**" means "**WATER DISPLACEMENT**")
- PROTECT THE CLEAN ENGINE BLOCK AND HEADS IN CLEAN PLASTIC GARBAGE BAGS TO KEEP DUST AND GARBAGE OUT OF THE ENGINE



STOP!!

INSTRUCTOR'S INITIALS:

ENGINE ASSEMBLY

Everything assembled is OILED

Cam lobes like a Molybdenum Disulphide grease to survive break-in

- If this is a cam-in-block V engine, oil and insert the camshaft at this time (it's much harder to do so once the crankshaft is in). New "Flat-Tappet" cams need a "Break-In" lube or it will be wiped flat in the first 20 minutes.
- Insert the main bearing shells **DRY** (no oil)
- **PUT OIL ON THE BEARING SURFACE** and **GREASE ON THE SEAL SURFACE** and then gently set the cleaned crankshaft into the block

PAY ATTENTION HERE



How-To

- **MAIN BEARING CAPS** have been machined to **ONLY** fit **THAT** engine in **THAT** location, pointing in **THAT** direction, **ONLY**.
--- ANYTHING ELSE IS WRONG ---
- Install all the main bearing caps **WITH OIL** (in the right place and pointing the right direction).
 - *It's good practice to tighten down the main bearings **ONE AT A TIME**, and check to see if the engine still turns, then move to the next one.*
- Torque the mains in a spiral pattern **starting** from the **CENTER ONES** and circling outwards
- *If this is **YOUR OWN** engine, consider checking things with Plastigage.*
- **Does the crankshaft STILL ROTATE?**
 - **No? You SCREWED UP. FIX IT!**

STOP!!

INSTRUCTOR'S INITIALS:

Everything assembled is OILED!



Install

DO NOT
BREAK
RINGS

DO NOT
BREAK
PISTONS

DO NOT
BREAK
PISTON
RING
LANDS

DO NOT
DAMAGE
THE CRANK

DEMOS
ARE FREE,
AND I'M
HAPPY TO
DO THEM

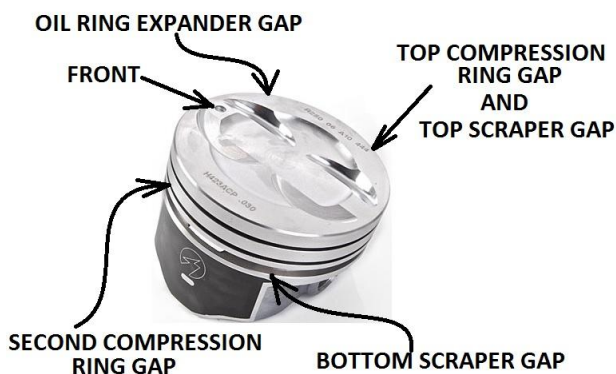
!

DO YOU
HAVE
"FRAC-
TURED"
ROD CAPS?
CLAMP
THEM
TOGETHER
BACK-
WARDS
ONCE AND
THEY ARE
JUNK

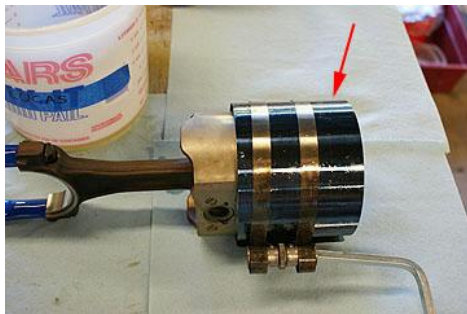
!

INSTALL THE PISTONS ONE AT A TIME – USE RUBBER BOOTS!!!

- **ALIGN THE PISTON RING END GAPS** around the piston as shown (typical)
 - *Your engine service manual may suggest something different - follow your manual*



- Oil the piston and rings: **IF IT MOVES – IT IS OILED – NEVER ASSEMBLE DRY**
- Use a **PISTON RING COMPRESSOR** to compress the rings onto the piston
Square Key faces UP



- **RUBBER BOOTS** on the rod bolts to protect the crank!
- Use a hammer to **TAP** around the outside of the **RING COMPRESSOR** to make sure it sits **FLAT** against the **DECK** of the block
- Use the hammer handle to **TAP** the head of the piston into the cylinder, **GUIDING** the rod to the crankshaft

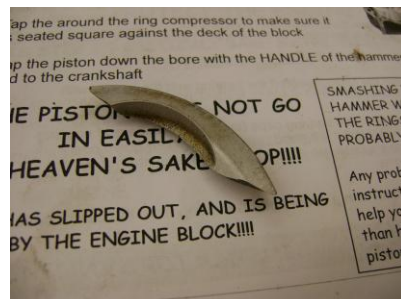
**IF THE PISTON DOES NOT GO IN
EASILY,**

FOR HEAVEN'S SAKE STOP!!!!

Likely....

**A RING HAS SLIPPED OUT, AND IS BEING
HELD UP BY THE ENGINE BLOCK!!!!**

**SMASHING IT WITH A
HAMMER WILL DESTROY
THE RINGS, AND
PROBABLY THE PISTON!!!!**



I would rather help you with each piston, than have you destroy even one ring.
Rings cannot be purchased individually – only as a COMPLETE SET \$\$\$

TORQUING

- If this is YOUR OWN ENGINE (not mine), consider using Plastigage® to confirm the rod and main bearing clearances
- Connecting rod bolt torque is CRITICAL
 - Too loose and the nut could come undone, fall off, and grenade the engine
 - Too tight and the bolt could break, losing the cap and grenade the engine.
- Install the oil pump, pickup and shaft (as equipped)



STOP!!

INSTRUCTOR'S INITIALS:

ASSEMBLY

- Do one last check to make the engine block is complete
- Install the head gasket and cylinder head onto the block **NOTE ANY ALIGNMENT DOWELS!**
- Torque to specs in a **spiral sequence** and in **stages** - NOTE: head bolts that thread into the water jacket require a special sealant on the head bolt threads
- Show this sentence to your instructor for a bonus
- Finish installing the valve train and cam drive
- **SET THE CAM TIMING** exactly as described in the manual (refer to the picture you wish you drew better on p.2)

STOP!!

INSTRUCTOR'S INITIALS:

Some engines REQUIRE valve lash (clearance) at the rocker arm

Some engines adjust clearance HYDRAULICALLY

Some engines have ADJUSTMENT

Some engines have NONE

Some engines go wee-wee-wee all the way home

How do you adjust the valve clearances (Valve Lash) on this engine? (see manual):

- Adjust the valves and **DEMONSTRATE YOUR MAD TYTE VALVE ADJUSTING SKILLZ** to your instructor

Valve lash is often set larger on exhaust than intake – WHY?

SHOW your instructor that the following components are installed correctly:

- | | |
|-------|-------------------------------|
| _____ | Oil pump pickup |
| _____ | Oil pump & drive |
| _____ | Main bearing caps |
| _____ | Connecting rods and caps |
| _____ | Timing chain and timing marks |
| _____ | Valvetrain |
| _____ | Fuel pump cam (if equipped) |

STOP!!

INSTRUCTOR'S INITIALS:



MrW's
DEMO
AT INSTALL

Install the timing cover. Rubber seals should be greased so they don't get cut.

Smear a bit of grease on the sealing surface of the Harmonic Balancer so as not to CUT the seal on install.

Install the **HARMONIC BALANCER**:

The **Harmonic Balancer** and/or crankshaft can be damaged by improper installation (NO HAMMERS!)

Use the Harmonic balancer Installer to install.

- Place harmonic balancer on end of crankshaft
- Center bolt of installer is threaded BY HAND into the crankshaft
- Bearing and Nut are tightened with a wrench to push into place



FINAL ASSEMBLY

- Install the Oil Pan (straighten any dents)
- Install the manifolds and valve cover(s) and any other accessories removed for disassembly. Paint as required.
- Reinstall any other components removed
- No bolts left behind

SHOW your instructor that the following components are installed **CORRECTLY**:

_____	Oil pan
_____	Timing cover
_____	Timing mark tab
_____	Harmonic balancer
_____	Pulleys
_____	Accessories
_____	Water pump
_____	Intake manifold
_____	Exhaust manifold
_____	Fuel pump (if equipped)
_____	Distributor
_____	Valve cover
_____	Dip stick
_____	Oil filter

YOU MADE
IT!

How do you
feel?



Circle

This lab is not complete until you finish the last page

STOP!!

INSTRUCTOR'S FINAL INSPECTION:

Return the engine to its storage place.

Describe FOUR ways you improved in your mechanical ability through this lab:

1.

2.

3.

4.

Describe any areas of this lab that were unclear to you (this helps me refine the lab for next year):