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:	**SCHOOL 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.	• 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.* *NOTE: I will not punish you if you accidentally break something – things happen. I am MOSTLY mean, not ALL mean.*

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

Your engine is:

(Year)	(Make)	(Model)	(Engine)

LAB - Engine Rebuild

Students: 1. _____ Date: _____
2._____ Block:_____
3._____

FOLLOW THE INSTRUCTIONS!!!

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

ENGINE IDENTIFICATION

Record ALL Block Casting Numbers & Identification on your engine (they may not look important, but they tell us what specific engine you have):

SPECIFICATIONS

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

Torque Specifications

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?

Note:

1. There is a way things come apart
2. There is a way things go together
3. You need to be very organized
4. Take pictures

DO YOU WANT EASY?

5. Use the service manual (NOT the owner's manual)
6. Everything has a purpose - there ain't nothing "random" in an engine
7. "It's just nuts and bolts"

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
3. 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

DO:

- Remove intake and exhaust manifolds, LABELLING parts/hoses/wires
- Remove distributer, alternator, water pump, etc. Note their locations.
- Show this sentence to your instructor for bonus (it shows you are actually reading this)
- LABEL each part location for non-obvious parts
- THREAD FASTENERS BACK INTO THEIR HOLES SO THEY ARE NOT LOST

You are ready to start

NOTE!

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

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

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.

- **ALL ENGINES** - You WILL be removing:
    - THE VALVE COVERS
    - THE INTAKE MANIFOLD
    - THE EXHAUST MANIFOLD(s)
    - HEAD BOLTS
- **SOME ENGINES** - You MIGHT be removing:
    - THE ALTERNATOR
    - THE DISTRIBUTOR
    - PUSHRODS

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 back together!

OHV
Label and remove the pushrods & lifters – they must be kept in order

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

- **OVER HEAD CAM (OHC) ENGINES** – You MUST remove:
    - **IF BELT:** THE FRONT PULLEY and TIMING BELT
        - *see Page 14 if you have to remove the Harmonic Balancer*
    - **IF CHAIN:** CAMSHAFT SPROCKET
- NOTE any missing or damaged HEAD ALIGNMENT DOWELS/PINS
- LABEL EVERYTHING; THREAD FASTENERS BACK INTO THEIR HOLES

STOP!! ***INSTRUCTOR'S INITIALS:***

DISASSEMBLE THE CYLINDER HEAD

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

The magic of your motor is the FLOW of the cylinder heads, and the DESIGN of the camshaft

- DISSASSEMBLE the cylinder head according to the SERVICE MANUAL.

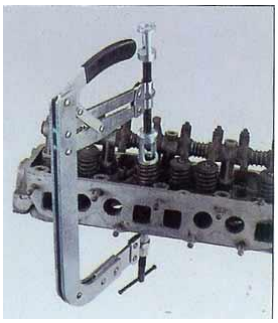
EVERY ALUMINUM HEAD USES <u>STEEL SHIMS</u> UNDER THE VALVE SPRINGS
<u>DO NOT LOSE THEM!!!!</u>

ALL VALVES ARE ASSEMBLED WITH RETAINERS AND KEEPERS
<u>DO NOT LOSE THEM!!!!</u>

Mr.Wellwood's Demo

The VALVE ITSELF is the single biggest LIMIT to FLOW

READ THE STEPS IN THE MANUAL!



- **KEEP TRACK** of **<u>each</u>** valve, spring, retainer, keeper, rocker arm, push rod, etc. as appropriate.
- **<u>KNOW EXACTLY</u>** where they came from. ***Keep them IN ORDER***.
- **WIRE-WHEEL** the carbon off the valves and mark their location on them with a felt.
- **LABEL** each part location - KNOW where everything goes.

The BIGGEST BENEFIT to flow comes from AROUND the valve seats, NOT the ports

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

- **CLEAN** cylinder head(s) and parts in **SOLVENT TANK**, clean with soap and water, 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!**

STOP!! ***INSTRUCTOR'S INITIALS:***

INSPECTING THE CYLINDER HEAD

Visually inspect ALL the valve stems, faces, and tips. You are looking for any damage or excessive wear on any sliding or sealing surface. Describe what you find:

Visually inspect ALL the valve retainers, valve springs, rocker arms (if equipped), keepers. You are looking for any damage - these parts don't usually wear. Describe what you find:

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

MR.W's DEMO

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

Intake Valve Stem Minimum Diameter: _____

Exhaust Valve Stem Minimum 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!!

Intake Guide Clearance: _____

Exhaust Guides Clearance: _____

STOP!! ***INSTRUCTOR'S INITIALS:***

INSPECTING THE CYLINDER HEAD

OHC
"Over Head Cam"

Camshaft is IN the HEAD, not the engine block.

OHV
"Over Head Valve"

Camshaft is IN the BLOCK, not the cylinder head.

When you're buying a vehicle, "new Head-gasket" or "new radiator" usually means "over-heated"

Over-heated engines are usually never the same again

INSPECT AND KEEP IN ORDER:

- **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:

- **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:

Head Warpage Demo

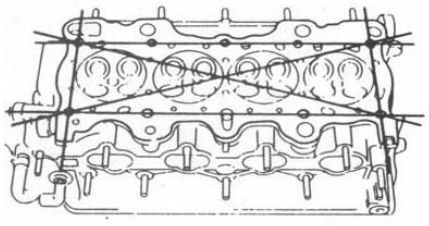
- **OHV AND OHC**: Warpage
  - Usually means overheating. Warped heads must be machined flat. ANY warpage is bad.

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?

- MACHINE the cylinder head as needed.

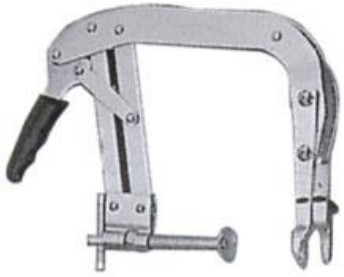
You want CLEAN.

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

(Oil and Grease are nasty. Ask me how I know)

- 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. **WITH OIL!**

- 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"**



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 ($\pi r^2 hn$):

π x (BORE ÷ 2)^2 x (STROKE) x (#CYINDERS)

What is the displacement of this engine?

_____

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

INSPECTION

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

- 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)

Piston Top Sketch

<<<<<<<<<<<< Front of motor

- Pistons MUST be reassembled a certain way (the pin is not actually centered – it is offset to reduce "*piston slap*" sound)

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

- Rotate the engine on the stand to remove the oil pan*
- Report ANY missing parts, fasteners, bearings, components you see inside the engine:

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:

Rods & caps must be numbered

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!

Rubber boots on the hardened threads to protect the crankshaft journals

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!

Remove ONE AT A TIME

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

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 Plastigage®

Image: www.veritec-competition.com

- Plastigage® 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”

CHECK the QR CODE for a DEMO!

Plastigage Demo

- REMOVE a Connecting Rod Cap and lay the Plastigage® 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 Plastigage® off the bearing and the journal with your thumbnail.

Copy Rod Bearing Clearance spec here:

_____

🙂 ☹️

Circle

DO NOT rotate the crankshaft or you will smudge the Plastigage®

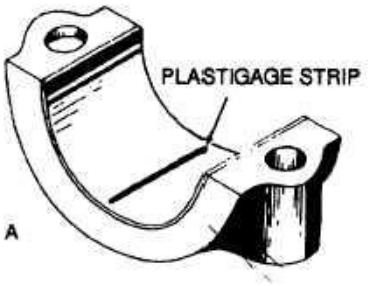
MEASURED:

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

STOP!! ***INSTRUCTOR’S INITIALS:***

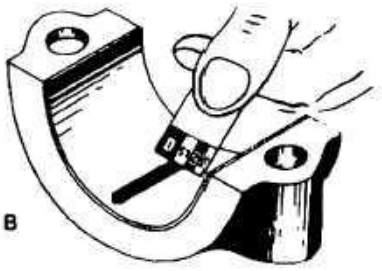
#2 THE MAIN BEARING CLEARANCE

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.



CHECK the QR CODE for a DEMO!

- 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 smudge the Plastigage®

Copy ring 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!

Thrust bearings are CRITICAL! DO NOT LOSE THEM!

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

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

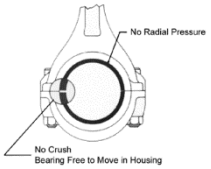
THREAD FASTENERS BACK INTO THEIR HOLES SO THEY ARE NOT LOST

PAY ATTENTION TO HOW BEARINGS ARE INSTALLED

_____

YOU NEED TO ASSEMBLE THEM PROPERLY!

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?

STOP!! ***INSTRUCTOR'S INITIALS:***

TIMING CHAINS/SPROCKETS and GEARS

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

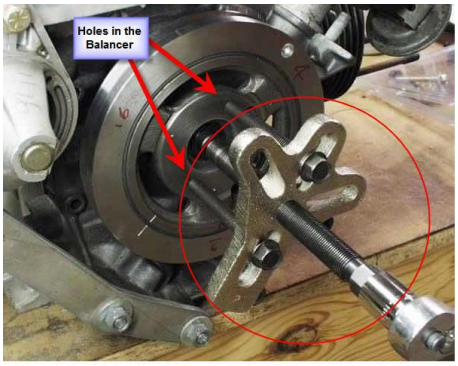
Removal

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 you are doing an Over Head Cam engine, you already did this back in the Cylinder Head section.

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 even **damage!**

GOOD BAD

How is your Timing Chain and Sprockets?

REMOVE the timing chain

STOP!! ***INSTRUCTOR'S INITIALS:***

REMOVING THE CRANKSHAFT

Removal

- 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

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)*

Over Head Cam Engines (OHC) already did this (skip it)

You should have already removed your lifters.

Dig them out now, we need to look at them

CAREFULLY REMOVE THE CAMSHAFT
DO NOT SCRATCH OR GOUGE THE CAM BEARINGS!

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*.

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.

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 helps them rotate the lifters. 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

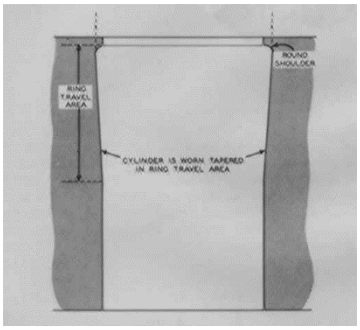
The **BOTTOM** of the cylinder bore is usually the **least worn** due to:

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

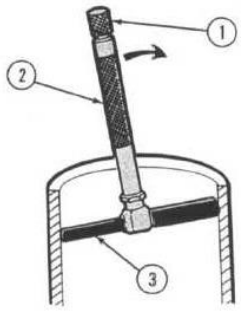
- Rings **seal best** with a perfect cylinder
- Taper within spec can be honed and the old pistons reused with new rings.
- An excessively worn cylinder must be re-bored and over-size pistons fitted.

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:***

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

PISTONS

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?

☺ ☹

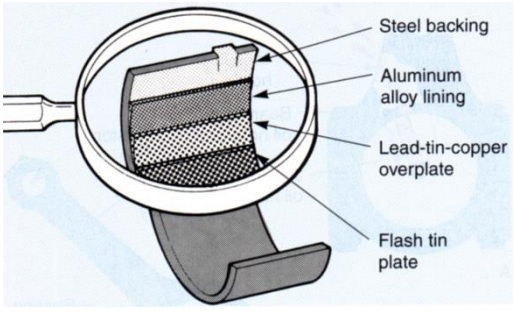
Circle

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

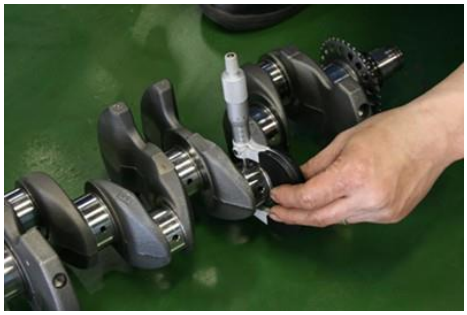
Rod Journals:
Using a micrometer, measure your WORST Rod Bearing Journal Diameter:

_____

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!!!

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 LUBRI-CATES LESS, accelerat-ing wear!

NO, SERIOUSLY: <u>YOU NEED TO BE GENTLE HERE!</u>

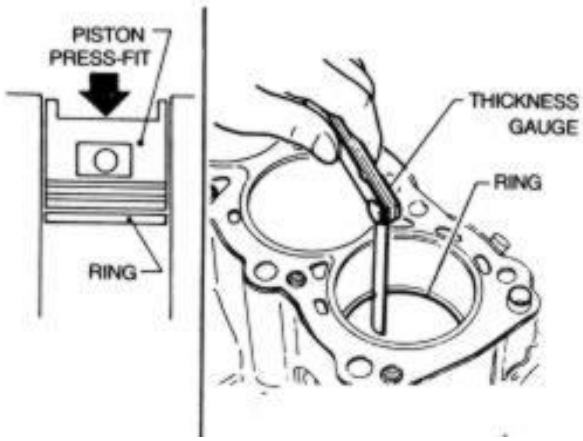
CAREFULLY remove the TOP COMPRESSION RINGS on your WORST cylinder with <u>PISTON RING PLIERS</u> - NOT YOUR FINGERS!!!

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

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 <u>how</u> this engine was running <u>before</u> it died, and <u>what</u> specifically killed it. Be as detailed as possible:

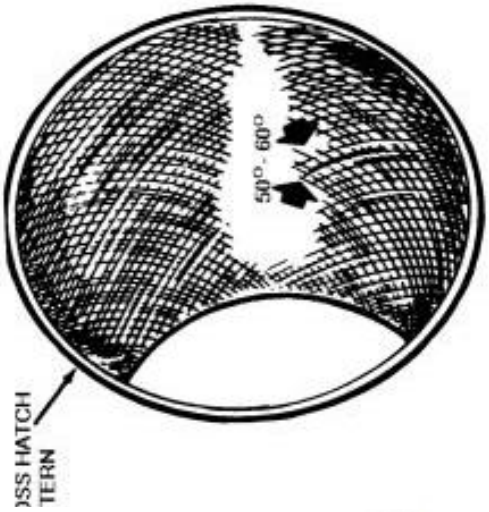
50	Perfectly and thoroughly detailed, no stone unturned, The Force is with you!
40	Very good and reasonable, some contributing causes mentioned
30	Basic description only; root cause identified; I'll probably try leading you to more ideas
20	Marginal evidence of analysis and I'm going to give you a strange 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

CYLINDER HONING

CYLINDER HONING

- Rings and cylinders "wear in" together.
- New rings will not seal against a polished cylinder.
- 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")***
- PROECT 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

How-To

- If this is a cam-in-block V engine, insert the camshaft at this time (it's much harder to do so once the crankshaft is in)
    - **CAM BEARING JOURNALS** are lubed with Motor Oil
    - **CAM LOBES** are lubed with Molybdenum Disulphide grease
    - ***DO NOT SCRATCH OR GOUGE THE CAM BEARINGS!!***
- Insert the main bearing shells **DRY** (no oil)
- **PUT OIL ON THE BEARING SURFACE**, and then gently set the cleaned crankshaft into the block
- 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 crankshaft still turns, then install the next main bearing cap.*
    - ***MAIN BEARING CAPS** have been machined to **ONLY** fit **THAT** engine in **THAT** location, pointing in **THAT** direction, **ONLY**.*

ANYTHING ELSE IS WRONG

(and I don't care how you feel about it; it's WRONG)

- 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?*

STOP!! ***INSTRUCTOR'S INITIALS:***

EVERY moving part is OILED

When I rebuild an engine, I dunk the completed piston and rings in a coffee can of motor oil before installing them

Install

DO NOT BREAK RINGS

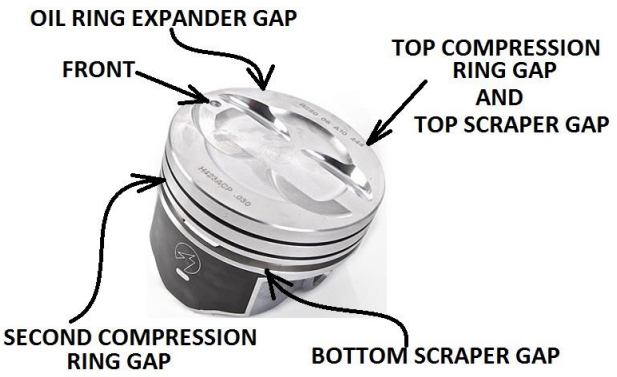
DO NOT BREAK PISTONS

DO NOT BREAK PISTON RING LANDS

DO NOT DAMAGE THE CRANK

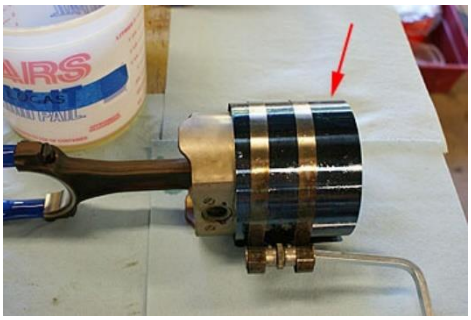
DEMOS ARE FREE, AND I'M HAPPY TO DO THEM

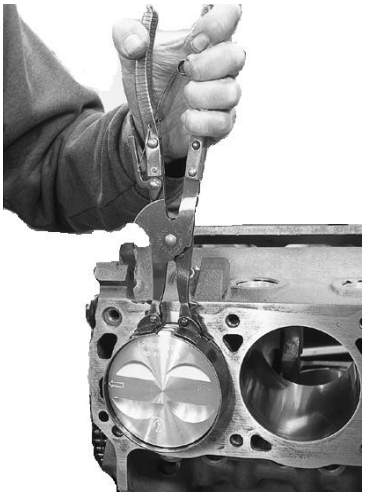
INSTALL THE PISTONS ONE AT A TIME – USE RUBBER BOOTS!!!



- **<u>ALIGN THE PISTON RING END GAPS</u>** around the piston as shown (typical)
  - *Your engine service manual may suggest something different - follow your manual*
- Oil the piston and rings: **<u>IF IT MOVES – IT IS OILED – NEVER ASSEMBLE DRY</u>**
- Use a **<u>PISTON RING COMPRESSOR</u>** to compress the rings onto the piston

Square Key faces UP

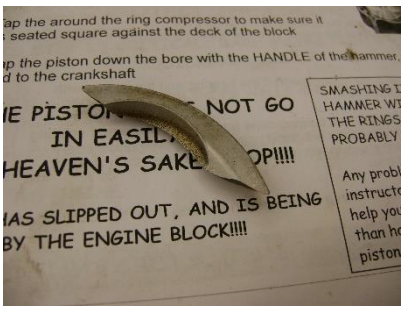




- **<u>RUBBER BOOTS</u>** on the rod bolts to protect the crank!
- Use a hammer to **TAP** around the outside of the **<u>RING COMPRESSOR</u>** to make sure it sits **FLAT** against the **DECK** of the block
- Use the hammer handle to **TAP** the head of the piston into the cylinder, **GUIDING** the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

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

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!!!!



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
- INSTALL the valve train and cam drive
    - **SET THE CAM TIMING** - see the picture you wish you drew better on p.2

You CANNOT just stab the cam in and throw the chain on
THERE IS A WAY IT MUST BE ASSEMBLED

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-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:***

Install

Install the timing cover.

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

You must be able to 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):

