AUTO-1300: AUTOMOTIVE ENGINES

Cuyahoga Community College

Viewing: AUTO-1300 : Automotive Engines

Board of Trustees:
December 2021

Academic Term:
Fall 2022

Subject Code
AUTO - Automotive Technology

Course Number:
1300

Title:
Automotive Engines

Catalog Description:
Operation of internal combustion gasoline engine including engine fundamentals and removal, lubrication and cooling system operation, and cylinder head and engine block diagnosis. Engine disassembly, measurements for correctness, proper assembly techniques, and gasket and sealing information included.

Credit Hour(s):
3

Lecture Hour(s):
1

Lab Hour(s):
6

Other Hour(s):
0

Requisites

Prerequisite and Corequisite
None.

Outcomes

Course Outcome(s):
Diagnose, repair, and maintain the vehicles powertrain components.

Essential Learning Outcome Mapping:
Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

Objective(s):
1. Complete work order to include customer information, vehicle identifying information, customer concern, related service history, cause, and correction.
2. Research vehicle service information including fluid type, internal engine operation, vehicle service history, service precautions, and technical service bulletins.
3. Verify operation of the instrument panel engine warning indicators.
4. Inspect engine assembly for fuel, oil, coolant, and other leaks; determine needed action.
5. Install engine covers using gaskets, seals, and sealers as required.
6. Verify engine mechanical timing.
7. Remove and replace timing belt; verify correct camshaft timing.

8. Perform common fastener and thread repair, to include: remove broken bolt, restore internal and external threads, and repair internal threads with thread insert.
9. Inspect, remove and/or replace engine mounts.
10. Identify service precautions related to service of the internal combustion engine of a hybrid vehicle.

Course Outcome(s):

Diagnose, repair, and maintain the engines Cylinder Head and Valve Train Components

Essential Learning Outcome Mapping:

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

Objective(s):

1. Inspect pushrods, rocker arms, rocker arm pivots and shafts for wear, bending, cracks, looseness, and blocked oil passages (orifices); determine necessary action.
2. Adjust valves (mechanical or hydraulic lifters).
3. Inspect and replace camshaft and drive belt/chain; includes checking drive gear wear and backlash, end play, sprocket and chain wear, overhead cam drive sprocket(s), drive belt(s), belt tension, tensioners, camshaft reluctor ring/tone-wheel, and valve timing components; verify correct camshaft timing.
4. Establish camshaft position sensor indexing
5. Inspect valve springs for squareness and free height comparison; determine necessary action.
6. Replace valve stem seals on an assembled engine; inspect valve spring retainers, locks/keepers, and valve lock/keeper grooves; determine necessary action.
7. Inspect valve guides for wear; check valve stem-to-guide clearance; determine necessary action.
8. Inspect valves and valve seats; determine necessary action.
9. Check valve spring assembled height and valve stem height; determine necessary action.
10. Inspect valve lifters; determine necessary action.
11. Inspect and/or measure camshaft for runout, journal wear and lobe wear.
12. Inspect camshaft bearing surface for wear, damage, out-of-round, and alignment; determine necessary action.
13. Remove cylinder head; inspect gasket condition; install cylinder head and gasket; tighten according to manufacturer's specifications and procedures.
14. Clean and visually inspect a cylinder head for cracks; check gasket surface areas for warpage and surface finish; check passage condition.

Course Outcome(s):

Diagnose, repair, and maintain the Engine Block Assembly

Essential Learning Outcome Mapping:

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

Objective(s):

1. Remove, inspect, and/or replace crankshaft vibration damper (harmonic balancer).
2. Disassemble engine block; clean and prepare components for inspection and reassembly.
3. Inspect engine block for visible cracks, passage condition, core and gallery plug condition, and surface warpage; determine necessary action.
4. Inspect and measure cylinder walls/sleeves for damage, wear, and ridges; determine necessary action.
5. Inspect and measure camshaft bearings for wear, damage, out-of-round, and alignment; determine necessary action.
6. Inspect crankshaft for straightness, journal damage, keyway damage, thrust flange and sealing surface condition, and visual surface cracks; check oil passage condition; measure end play and journal wear; check crankshaft position sensor reluctor ring (where applicable); determine necessary action.
7. Inspect main and connecting rod bearings for damage and wear; determine necessary action.
8. Identify piston and bearing wear patterns that indicate connecting rod alignment and main bearing bore problems; determine necessary action.
9. Inspect and measure piston skirts and ring lands; determine necessary action.
10. Determine piston-to-bore clearance.
11. Inspect, measure, and install piston rings.

12. Inspect auxiliary shaft(s) (balance, intermediate, idler, counterbalance and/or silencer); inspect shaft(s) and support bearings for damage and wear; determine needed action; reinstall and time.
13. Assemble engine block.

Course Outcome(s):

Diagnose, repair, and maintain the engines Lubrication and Cooling Systems

Essential Learning Outcome Mapping:

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

Objective(s):

1. Perform cooling system pressure and dye tests to identify leaks; check coolant condition and level; inspect and test radiator, pressure cap, coolant recovery tank, heater core and galley plugs; determine necessary action.
2. Identify causes of engine overheating.
3. Inspect, replace, and/or adjust drive belts, tensioners, and pulleys; check pulley and belt alignment.
4. Inspect and/or test coolant; drain and recover coolant; flush and refill cooling system; use proper fluid type per manufacturer specification; bleed air as required.
5. Inspect, remove, and replace water pump.
6. Remove, inspect, and replace thermostat and gasket/seal.
7. Perform oil pressure tests; determine necessary action.
8. Inspect oil pump gears or rotors, housing, pressure relief devices, and pump drive; perform necessary action.
9. Inspect and test fan(s), fan clutch (electrical or mechanical), fan shroud, and air dams; determine needed action.
10. Diagnose the cause of excessive oil consumption, coolant consumption, unusual exhaust color, odor, and sound; determine needed action.

Course Outcome(s):

Demonstrate and utilize common shop and personal safety practices. Safety is a primary and ongoing concern while in the repair environment for automotive engines, including using tools and equipment, working around supplemental restraint (SRS) or high voltage circuits, wearing personal protection equipment, awareness of personal clothing, adornments and body, and knowledge of fire safety and evacuation routes

Essential Learning Outcome Mapping:

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

Objective(s):

1. Identify general shop safety rules and procedures.
2. Utilize safe procedures for handling of tools and equipment.
3. Identify and use proper placement of floor jacks and jack stands.
4. Identify and use proper procedures for safe lift operation.
5. Utilize proper ventilation procedures for working within the lab/shop area.
6. Identify marked safety areas.
7. Identify the location and the types of fire extinguishers and other fire safety equipment; demonstrate knowledge of the procedures for using fire extinguishers and other fire safety equipment.
8. Identify the location and use of eye wash stations.
9. Identify the location of the posted evacuation routes.
10. Comply with the required use of safety glasses, ear protection, gloves, and shoes during lab/shop activities.
11. Identify and wear appropriate clothing for lab/shop activities.
12. Secure hair and jewelry for lab/shop activities.
13. Demonstrate awareness of the safety aspects of supplemental restraint systems (SRS), electronic brake control systems, and hybrid vehicle high voltage circuits.
14. Demonstrate awareness of the safety aspects of high voltage circuits (such as high intensity discharge (HID) lamps, ignition systems, injection systems, etc.).
15. Locate and demonstrate knowledge of material safety data sheets (MSDS).

Course Outcome(s):

Identify and demonstrate proper use of tooling used to repair automotive engines.

Essential Learning Outcome Mapping:

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

Objective(s):

1. Identify tools and their usage in automotive applications.
2. Identify standard and metric designation.
3. Demonstrate safe handling and use of appropriate tools.
4. Demonstrate proper cleaning, storage, and maintenance of tools and equipment.
5. Demonstrate proper use of precision measuring tools (i.e. micrometer, dial-indicator, dial-caliper).

Course Outcome(s):

Analyze customer and vehicle information, along with prior service history to ensure proper work order documentation of concern, cause, and correction.

Essential Learning Outcome Mapping:

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

Objective(s):

1. Identify information needed and the service requested on a repair order.
2. Identify purpose and demonstrate proper use of fender covers, mats.
3. Demonstrate use of the three C's (concern, cause, and correction).
4. Review vehicle service history.
5. Complete work order to include customer information, vehicle identifying information, customer concern, related service history, cause, and correction.

Methods of Evaluation:

1. Participation and discussion
2. Observation
3. Written assignments
4. Exams
5. Quizzes
6. Lab tasks
7. Classroom recitations

Course Content Outline:

TOPICAL OUTLINE

- a. Engine operation
    - i. Compression and combustion
        1. vacuum
        2. the four-stroke cycle
        3. reciprocating engine
- b. Major engine parts
    - i. Cylinder block
        1. crankcase
        2. crankshaft and connecting rod
            a. flywheel
            b. engine rotation
    - ii. Cylinder Head
        1. camshaft
        2. valves
            a. valve arrangement
            b. valve lifters
            c. number of valves
- c. Cylinder arrangement
    - i. Engine balance
    - ii. Firing order

d. Engine displacement and compression ratio
    i. Engine displacement
    ii. Compression ratio
e. Ignition system
    i. Common ignition intervals
    ii. Unusual ignition intervals
    iii. Spark frequency
        1. firing order
            a. in-line engines
            b. v engines
f. Engine-ignition synchronization
    i. Distributor drive
    ii. Crankshaft position
    iii. EI Ignition systems
    iv. Coil on plug systems
    v. Burn time
    vi. Engine speed
g. Initial (base) timing
    i. Timing marks
    ii. Adusting Ignition Timimg
    iii. Verify proper timing
h. Other engine types
    i. Two-stroke engine
    ii. Diesel engine
    iii. Rotary (Wankel) engine
i. Engine torque
j. Engine horsepower
    i. Torque and horsepower relationships
        1. brake horsepower
        2. indicated horsepower and actual horsepower
    ii. Airflow requirements
    iii. Volumetric efficiency
k. Chemistry and combustion
    i. Gasoline and combustion
    ii. Detonation
    iii. Preignition
    iv. Octane rating
l. Engine operation and air pressure
m. Air-fuel ratios
    i. Stoichiometric air-fuel ratio
    ii. Engine air-fuel requirements
    iii. Power versus economy
n. Engine materials
    i. Iron
    ii. Cast iron
    iii. Steel
    iv. Steel alloys
    v. Alloy tool steel
    vi. Aluminum
    vii. Magnesium
    viii. Titanium
    ix. Aluminum-silicon
    x. Plastics
    xi. Ceramics
    xii. Other composites
o. Manufacturing operations
    i. Casting
    ii. Forging

iii. Machining
iv. Stamping

p. Material treatments
i. Heat treating
ii. Hardening
iii. Tempering
iv. Annealing
v. Normalizing
vi. Casehardening
vii. Shot-peening
viii. Plating
ix. Anodizing
x. Surface finishes

q. Machining operations
i. Internal machining
ii. Boring
iii. Honing
iv. Drilling
v. Reaming
vi. Tapping
vii. Broaching
viii. External machining
ix. Milling
x. Grinding
xi. Polishing

r. Cooling system function
i. Air cooled systems
ii. Liquid cooled systems
iii. Achieving proper operating temperature (emissions)
iv. Maintaining temperature

s. The development of engine coolant
i. Etheyne glycol
ii. Propylene glycol
iii. General Motors Dex-cool
iv. Organic Acid Technology (OAT)
v. G05 - Hybrid Organic Acid Technology (HOAT)

t. Cooling system components
i. Water pump
ii. Thermostat
1. Inlet Thermostat designs
2. Outlet Themostat designs
3. OBD II Thermostat Monitor
iii. Radiator
iv. Radiator cap
1. system pressure
2. system vacuum
v. Coolant recovery tank
1. Pressurized Surge Tank
2. Non-Pressurized Recovery Tank
vi. Radiator fan
1. Mechanically driven clutch fans
2. Electronically controlled fans
vii. Radiator hoses and drive belts
viii. Water jackets
ix. Core plugs
x. The heater core

u. Engine temperature effects on mechanical wear and emissions
v. The intake system

i. Airflow
    1. fuel atomization
    2. fuel vaporization
ii. The intake manifold
    1. intake manifold design
    2. unequal distribution and manifold design
    3. manifold and intake charge heat
iii. Basic intake manifold types
    1. single-plane manifolds
    2. dual-plane manifolds
iv. port fuel-injection manifolds
    1. two-piece manifolds
    2. one-piece manifolds
    3. variable induction systems

w. The exhaust systems
    i. Exhaust system arrangement
    ii. Exhaust system components
        1. exhaust manifolds
            a. high-performance exhaust manifolds
            b. exhaust header
        2. pipes
        3. mufflers and resonators
        4. catalytic converters

x. Purposes of motor oil

y. Motor oil composition and additives
    i. Motor oil additives
        1. additive precautions
    ii. Synthetic motor oils

z. Motor oil designations
    i. API service classification
    ii. SAE viscosity grades
    iii. Energy-conserving oils
    iv. Engine oil identification

aa. Engine oiling system and pressure requirements
    i. Oil reservoir
        1. ventilation
        2. PVC system
    ii. Oil pump and pickup
    iii. Pressure relief valve
    iv. Filter
    v. Galleries, lines, and drillways
    vi. Indicators
        1. dipstick
        2. oil level sensor
        3. oil pressure warning lamp
        4. oil pressure gauge
        5. Oil life systems

bb. Engine lubrication effects on mechanical wear

cc. Cylinder block design
    i. Cylinder block size
    ii. Ribs and webs
    iii. The crankcase
    iv. Main bearings
    v. main bearing number
    vi. Cylinders
        1. siamesed cylinder bores
        2. cylinder bore taper
    vii. Cylinder Sleeves

1. types of sleeves
2. sleeveless cylinders
3. block dimensions
4. crankshaft offset
5. cylinder offset

dd. Cylinder heads
   i. Combustion chamber design
      1. combustion efficiency and breathing ability
         a. squish area
         b. quench area
         c. spark plug placement
         d. surface-to-volume ratio
         e. valve shrouding
         f. valve placement
         g. valve number
         h. auxiliary valves
      2. combustion chamber shape
         a. wedge-shaped combustion chambers
         b. hemispherical combustion chambers
         c. modified-wedge chamber designs
         d. pentroof combustion chambers
         e. fast-burn combustion chambers
         f. stratified charge combustion chambers
   ii. Intake and exhaust ports
      1. port design
      2. port polishing

ee. Valve Design
   i. valve materials
   ii. valve coatings
   iii. valve face angles
   iv. valve cooling

ff. Springs
   i. Valve float
   ii. Spring material
   iii. Spring installations
      1. spring retainers
      2. spring height
   iv. Spring design
      1. dual springs
      2. dampers
      3. variable rate spring
      4. coil bind
   v. Valve rotators

gg. Guides
   i. Insert guides
   ii. Integral guides
   iii. Valve guide clearances

hh. Valve guide seals
   i. O-ring seals
   ii. Umbrella seals
   iii. Positive seals

ii. Valve seats
   i. Integral valve seats
   ii. Induction hardening
   iii. Valve seat inserts
   iv. Valve seal insert material
   v. Valve seat angles

jj. Valve, spring, guide, and seat relationships

kk. Camshafts

i. Camshafts in the cylinder block
ii. Camshafts in the cylinder head

ll. Camshaft drives
i. Chains
ii. Gears
iii. Belts
iv. Tensioners and guides
v. Accessory drives
vi. Cam thrust

mm. Camshaft design
i. Cam lobe construction
ii. Camshaft materials
iii. Cam lobe conditioning
iv. Camshaft lubrication
v. Camshaft scuffing

nn. Valve timing
i. Lift
ii. Duration
iii. Overlap
iv. Lobe separation angle
v. Camshaft installation position
vi. Valve-to-piston interference

oo. Valve lifters and cam followers
i. Valve lifters
ii. Valve clearance
iii. Solid lifters
iv. Hydraulic lifters
1. hydraulic lifter pump-up
2. installing hydraulic lifters
v. Cam and flat tappet wear
vi. Followers

pp. Pushrods
i. Pushrods and valve clearance
ii. Pushrod guide plates
iii. Pushrod lubrication

qq. Rocker arms
i. Shaft-mounted rockers
ii. Stud-mounted rockers
iii. Pedestal-mounted rockers
iv. Rocker arm ratio
v. Rocker arm lubrication
vi. Rocker arm geometry

rr. Crankshafts
i. Main bearing journals
1. thrust surface
2. thrust bearing
ii. Rod bearing journals
iii. Fillets
iv. Crankshaft throws and firing impulses
v. Firing order
vi. Counterweights
vii. Keyways and threads
viii. Lubrication
ix. improved rod journal lubrication
x. Cast crankshafts
xi. Forged crankshafts

ss. Flywheels

i. Dual mass-flywheels
ii. Heavy duty mass flywheel

tt. Flexplates
uu. Vibration dampers
vv. Engine balance
ww. Balancing shafts
i. Crankshaft balance
ii. Custom engine balancing

xx. Pistons
i. Piston crowns
ii. Piston bosses
iii. Ring grooves And lands
iv. Piston skirts
v. Piston materials
1. hypereutectic cast pistons
2. alloy pistons

vi. Piston expansion
1. piston clearance
2. piston noise

vii. Piston pins
1. piston pin attachment
2. full floating piston pins

viii. Piston offset

yy. Piston rings
i. Compression rings
1. compression ring operation
2. compression ring design
a. compression ring width
b. compression ring tension

ii. Oil control rings
1. oil ring design
2. oil consumption

iii. Ring gap
1. ring friction
2. ring leakage

iv. Piston ring materials
1. ring face coatings
2. low tension rings

zz. Connecting rods
i. Connecting rod materials
ii. Powder-forged rods
iii. Cracked connecting rods
iv. The effects of rod length

aaa. Main and connecting rod bearings
i. Plain bearing construction
1. bearing retention
2. oil grooves
3. thrust bearings
4. plain bearing dimensions

ii. Bearing clearance
1. undersize bearings
2. oversize bearings

bbb. Camshaft bearings
i. Engines without camshaft bearings
ii. Camshaft bearing replaciment

ccc. Plain bearing operation
i. Fluid friction
ii. Oil clearance
iii. Oil film theory

ddd. Plain bearing materials

i. Qualities
ii. Main and rod bearing materials
1. babbitt bearings
2. multi-layer bearings
3. aluminum alloy bearings

eee. Gaskets
i. Head gaskets
ii. Sandwich gaskets
iii. Multilayer steel gaskets
iv. Intake and exhaust manifold gaskets
v. Toil pan gaskets and valve and cam cover gaskets
vi. Other gaskets

fff. Seals
i. Synthetic rubber seals
1. o-ring seal
2. square-cut seal
3. lip seal
ii. Other types of seals

ggg. Sealants and cements
i. Precautions
ii. Adhesives
iii. Sealants
1. silicone sealants
2. anaerobic sealants
iv. Lubricants
v. Cleaners

hhh. Fasteners
i. Specifications
1. bolt or screw length
2. thread diameter
3. thread pitch
4. thread depth
5. head size and shape
ii. Bolt Torque
1. tightening pattern
2. torquing bolts
a. torque-to-yield-bolts
b. torque angles
iii. Securing fasteners
iv. Thread and bolt sizes
1. american sizes
2. metric sizes

iii. Engine mounts

jjj. Laboratory Topics
i. Personal safety
1. First-aid response
2. Eye protection
3. Work area
ii. Know your shop

kkk. Fire
i. Fire extinguishers
ii. Fire blankets

lll. Solvents and chemicals
i. Carbon monoxide asphyxiation
ii. Chemical exposure

mmm. Vehicle and underhood safety
i. Jump start safety
ii. Battery safety

nnn. Engine repair and rebuilding safety

i. Hand tool safety
ii. Hoists, floor jacks, and jacking
iii. Hydraulic lifts
iv. Engine stand
v. Compressed air and air hose safety

ooo. Power tools and shop equipment
i. Drill motors
ii. Impact wrenches
iii. Air ratchets
iv. Bench grinders
v. Rotary, or die grinders
vi. Compressed air

ppp. Specialized engine tools
i. Head and valve service tools
1. valve spring compressor
2. spring tension tester
3. valve seat grinder
4. valve seat cutter
5. valve grinding machine
6. valve guide renewing
a. valve guide bore gauge
b. knurling
c. guide insert
7. seat insertion tool or machine
8. rocker stud puller
9. hydraulic valve lifter remover
10. head surfacing machines
a. milling machines
b. surface grinders
ii. Block service tools and equipment
1. camshaft bearing removal tool
2. ridge reamer
3. cylinder bore gauge
4. boring machines
5. cylinder hone
6. glaze breaker
7. line boring equipment
8. align honing
9. torque plates for boring and honing
10. block surface mill and grinder
iii. Crankshaft service tools and equipment
1. harmonic balancer puller
2. v-block and dial indicator
3. crankshaft grinder
4. crankshaft balancing machine
5. balancing scale
6. crankshaft polisher
iv. Piston, rod, and ring tools and equipment
1. ring expander
2. piston-pin drift
3. ring-groove cleaner
4. ring end-gap grinder
5. rod honing machine
6. rod aligner
7. rod cap grinder
8. rod heater for pin assembly
9. arbor press

10. hydraulic press
11. ring compressor

qqq. General measurement tools
- i. Straightedges
- ii. Steel rules
- iii. Feeler gauges
  1. blade-type
  2. go-no-go
  3. feeler gauge stock
  4. non-magnetic
  5. round-wire
- iv. Calipers
  1. vernier calipers
  2. dial calipers
- v. Micrometers
  1. using a micrometer
     a. reading a vernier inch micrometer
     b. reading a vernier metric micrometer
  2. digital micrometers
- vi. Dial indicators
  1. dial indicator stands
  2. dial indicator

rrr. Accessories
- i. Telescoping gauges
- ii. Small-hole gauges

sss. Torque measuring tools
- i. Torque beam indicators
- ii. Torque click ratchets
- iii. Torque-to-yield degree wheels

ttt. Manufacturer"s specifications
- i. Identifying the engine
  1. using vehicle identification number (VIN) codes
  2. engine and calibration codes
  3. interpreting casting numbers and casting marks
     a. casting marks
     b. casting numbers
     c. miscellaneous marks and labels
  4. recognizing oversize/undersize codes
- ii. Obtaining specifications
  1. manufacturers" service manuals
  2. manufacturers" service bulletins
  3. aftermarket service manuals
  4. aftermarket component suppliers
  5. Online service information

uuu. Replacement parts, subassemblies, and engines
- i. Overhaul versus rebuild
- ii. Engine families and interchangeability
- iii. Service replacement engine pros And cons
- iv. Engine kits and gasket sets
- v. Used engines

vvv. Oil consumption
- i. Oil passing the piston rings
  1. worn, stuck, or broken rings
  2. incorrectly installed rings
  3. oil viscosity too low
  4. excessive crankcase pressure
  5. excessive oil on cylinder walls
- ii. Oil passing the valve guides

iii. External oil leaks
iv. Internal oil leaks

www. Engine oil pressure
i. Preliminary oil pressure checks
ii. How to use an oil pressure gauge

xxx. Basic diagnostic tests
i. What a vacuum gauge can tell you
ii. how to test the positive crankcase ventilation (PCV) system
1. with a vacuum gauge
2. with a manometer
iii. how to spot vacuum leaks
iv. how to pinpoint problems with the valves
v. how to spot an exhaust restriction
vi. how to check compression with a vacuum gauge
vii. Engine compression testing
1. how to test engine compression
2. compression test results
viii. Cylinder leakage test

yyy. Power balance tests
i. Power balance test equipment
ii. Power balance test precautions
iii. Performing a cylinder power balance test
iv. Interpreting power balance, compression, and leakage test results
v. Good balance, good compression, poor leakage
vi. Poor balance, good compression, good leakage
vii. Poor balance, poor compression, good leakage

zzz. Engine noises
i. Using a stethoscope
ii. Identifying the location of abnormal engine noises
1. valve train noises
a. normal top end sounds
2. abnormal top end sounds
3. bottom end noises
a. crankshaft endplay
b. connecting rod bearings
c. piston slap
d. wrist pin noise
e. main bearings
f. other noises

aaaa. Servicing the camshaft drive
i. Valve interference
ii. Timing chains and gears
1. how to service OHV timing chains and gears
a. removing the OHV timing cover
b. inspecting, removing, and reinstalling the OHV timing gears
c. removing, inspecting, and reinstalling the OHV timing chain
d. reinstalling the OHV timing cover
2. how to service an overhead cam timing chain
a. removing an OHV chain timing cover
b. removing, inspecting, and replacing the timing chain
3. how to install the OHC timing cover
iii. Timing belts
1. how to service an OHC timing belt
a. removing the OHC belt timing cover
b. inspecting the timing belt
c. removing and replacing the timing belt
d. installing the belt

bbbb. Valve train adjustment and repair

i. How to remove and replace the valve cover
ii. Valve clearances
1. adjusting mechanical valve clearances
a. adjusting clearances with the engine running
b. adjusting clearances with the engine off
2. adjusting hydraulic valve clearances
a. adjusting clearances with non-adjustable rocker arms
b. adjusting clearances with adjustable rocker arms
iii. How to replace the valve springs and seals
iv. How to replace a camshaft

cccc. Removing and replacing the cylinder head

dddd. Servicing the bottom end
i. How to remove and replace the oil pan
ii. How to replace the rod bearings
iii. How to replace the crankshaft main bearings
iv. Oil pump

eeee. Preparation
i. Clean the engine first
ii. Plan ahead
iii. Preliminary operations
1. removing wiring and accessories
2. air conditioning systems
3. relieving fuel system pressure

ffff. Removing the engine
i. hoisting the engine from a RWD chassis
ii. hoisting the engine and transaxle from a FWD chassis
iii. hoisting the engine from a FWD chassis
iv. dropping the engine and transaxle from a FWD chassis

gggg. Lifting the engine
i. Hoists
ii. Lifting slings
iii. Pulling the engine
1. removing the engine with the transmission disconnected
2. removing the engine with the transmission attached
3. hoisting the engine

hhhh. Inspect as you go

iiii. Top end disassembly and inspection
i. Remove accessories and manifolds
ii. Remove the cylinder heads
1. OHV rocker arm disassembly
2. cylinder head removal

jjjj. Bottom end disassembly and inspection
i. Remove the harmonic balancer and flywheel
ii. Remove the camshaft and lifters
iii. Remove the oil pan and pump
iv. Remove the crankshaft, rods, and pistons
1. inspecting the rod
2. inspecting the main bearings
v. Remove the gallery plugs, core plugs, and camshaft bearings
1. inspecting the cylinder block
2. inspecting the cylinder head

kkkk. Engine cleaning
i. Cleaning methods
1. steam cleaners
2. parts washers
3. hot tanks
4. spray booths
5. chemical dip tanks
6. bead blasting

7. airless shot blasters
8. tumblers and shaker units
9. cleaning ovens

ii. Toxic waste disposal

llll. Removing broken fasteners

i. How to avoid broken fasteners
1. left-hand threads
2. lubrication
3. proper tools
4. heat

ii. Why did the bolt break?

iii. Removing fasteners with damaged heads

iv. Using screw extractors

v. Broken taps, drill bits, and screw extractors

mmmm. Repairing damaged threads

i. Using taps and dies
1. identifying threads
2. using a tap to cut new threads
3. using a tap to chase old or damaged threads
4. using a threading die to cut new threads
5. using a threading die to chase worn or damaged threads

ii. Thread chasers, restorers, and thread-cutting files

nnnn. Internal thread replacement

i. Drilling oversize

ii. Helical inserts

iii. Threaded inserts
1. self-tapping inserts
2. solid-bushing inserts
3. key-locking inserts
4. reamer-cut spark plug hole inserts

oooo. Crack detection

i. Magnetic particle inspection
1. dry magnetic particle inspection
2. wet magnetic particle inspection

ii. Dye penetrant testing

iii. Pressure test inspection and equipment

pppp. Crack repair

i. Welding cracks

ii. Stop-drilling cracks

iii. Pinning cracks

iv. Sealing cracks with ceramic sealer

v. Epoxies or metallic plastics
1. casting repair with epoxies
2. thread repair with epoxies

qqqq. Tolerances and oil clearances

i. Tolerances

ii. Oil clearances

iii. Calculating oil clearances from specifications
1. housing bore diameter
2. insert thickness
3. bearing inside diameter
   a. maximum bearing inside diameter
   b. minimum bearing inside diameter
4. journal outside diameter
5. calculating oil clearance
   a. maximum oil clearance
   b. minimum oil clearance

iv. Measuring oil clearances

1. housing bore diameter
2. insert thickness
3. bearing inside diameter
4. crankshaft journal outside diameter

rrrr. Block inspection
- i. Inspecting the main bearing bores
  1. main bearing insert wear patterns
  2. straightedge in the housing bores
  3. measure with an inside micrometer or telescoping gauge
  4. measure with a dial bore gauge
     a. adjusting the setting fixture
     b. setting the dial bore gauge
     c. measuring a bearing bore with the dial bore gauge
- ii. Inspecting the deck surface
  1. check for flatness
  2. check for warpage
- iii. Inspect the cylinder bores
  1. check for previous overbore
  2. check for taper and out-of-round

ssss. Main bearing bore reconditioning
- i. Align honing
  1. grinding the main caps
  2. honing the bores
- ii. Line boring

tttt. Deck reconditioning
- i. Surface and alignment considerations
- ii. Surface finishes
- iii. How much should you cut?
  1. amount of cylinder head surfacing
  2. piston clearances
  3. compression ratio
  4. intake manifold to cylinder head alignment
  5. pushrod length
  6. valve timing changes
- iv. Resurfacing the deck surface

uuuu. Cylinder reconditioning
- i. Deglazing cylinders
- ii. Cylinder boring
  1. boring machines
  2. how much should you bore?
  3. boring cylinders to oversize
- iii. Cylinder honing
  1. actual piston size
  2. torque plates
  3. automatic honing
  4. hand honing
- iv. Reconditioning aluminum cylinder bores
  1. machining limitations
  2. refinishing procedures
- v. Cylinder sleeving

vvvv. Crankshaft service
- i. Crankshaft disassembly
- ii. Inspecting main bearings
- iii. Crankshaft inspection
  1. threads, keys, keyways, and pilots bearings
  2. cracks
  3. journal and thrust bearing condition
  4. straightness, snout, and flange runout
- iv. Crankshaft straightening

v. Building up crankshaft journals
vi. Crankshaft grinding
vii. Crankshaft polishing

wwww. Piston and connecting rod service
i. Separating pistons and connecting rods
1. removing free-floating wrist pins
2. removing press-fit wrist pins
ii. Reconditioning pistons
1. removing piston rings
2. cleaning the pistons
3. inspecting and measuring the pistons
iii. Evaluating connecting rod condition
1. inspect rod bearings
a. bent connecting rod
b. improperly assembled offset rods
c. radius ride
2. inspecting rods, caps, bolts
a. pin bore condition and diameter
b. bend and twist
c. big end bore out-of-round
d. cracks, stress risers, and discontinuities
iv. Reconditioning connecting rods
1. correcting rod bend and twist
2. reconditioning the big-end bore
a. grinding the parting faces
b. honing the bearing bore
3. reconditioning the small-end bore
a. pin fitting - full-floating type
v. Piston and connecting rod reassembly
1. final pre-assembly inspection
a. checking bearing clearance
b. checking piston ring end gap
2. installing pistons on rods
a. installing rods with full-floating wrist pins
b. installing rods with press-fit wrist pins
3. piston ring installation
a. checking ring side gap
b. fitting three-piece rings
c. fitting two-piece oil control rings
d. fitting compression rings

xxxx. Flywheel and flexplate service
i. Flexplate inspection
ii. Flywheel inspection and repair
1. ring gear replacement
2. flywheel machining

yyyy. Head reconditioning
i. Head disassembly
1. disassembling overhead valve cylinder heads
2. disassembling overhead camshaft cylinder heads
ii. Cleaning
iii. Inspection
1. head gasket surface
2. valve Inspection
a. visual inspection
b. measuring valves
3. valve spring inspection
4. valve guide inspection
5. valve seat inspection
6. camshaft bore and saddle inspection
iv. Valve repair

1. oversize valve stems
2. valve facing
3. grinding the valve stem

v. Valve guide repair
1. knurling
2. replacing valve guide inserts
3. installing thin-wall valve guide liners
4. bronze coil inserts
5. general valve guide service tips

vi. Valve seat reconditioning
1. replacing valve seats
2. valve seat grinding
   a. checking valve seat concentricity and configuration
   b. correcting valve seat position and width
3. valve seat cutting

zzzz. Head resurfacing
i. Straightening warped aluminum heads
1. preparing the cylinder head
2. heating and cooling the cylinder head

ii. Head resurfacing
iii. Overhead camshaft bore alignment
iv. Matching manifold angles

aaaaa. Valve testing and assembly
i. Checking valve seat sealing
ii. Installed height
iii. Cylinder head assembly
1. Installing the valves
2. Installing overhead camshafts

bbbbb. Camshaft service
i. Inspecting and measuring the camshaft
1. surface finish and condition
2. wear patterns
3. camshaft straightness
4. measuring journal diameter
5. calculating oil clearance
6. lobe configuration
   a. calculating valve lift
   b. base circle runout

ii. Camshaft Straightening

ccccc. Valve lifter and cam follower service
i. Solid lifters
ii. Hydraulic lifters
iii. Roller lifters
iv. Over head cam lifters
1. bucket-type lifters
   a. mechanical bucket lifters
   b. hydraulic bucket lifters
2. finger-type cam followers
   a. remote-pivot hydraulic adjusters
   b. rocker arm mounted hydraulic adjusters

ddddd. Pushrod service
i. Inspecting the pushrods
ii. Cleaning the pushrods

eeeee. Rocker arm and shaft service
i. Stud-mounted rocker arms
1. disassembling and inspecting
2. assembling and adjusting

ii. Shaft-mounted rocker arms

1. disassembling and inspecting the rocker shaft
    a. inspecting the rocker shaft
    b. rocker arm inspection
    c. spring and spacer inspection
2. rocker shaft assembly

fffff. General assembly practices

ggggg. Oil pump service
- i. Camshaft driven pumps
- ii. Crankshaft driven pumps
- iii. Gear-type pumps

hhhhh. Assembly preparation
- i. Cleaning engine components
- ii. Lubricating engine components

iiiii. Assembling the block and bottom end
- i. Installing core and oil gallery plugs
    1. installing oil galley plugs
        a. threaded plugs
        b. disc-type plugs
    2. installing core plugs
- ii. Installing the camshaft bearings and camshaft
    1. installing the camshaft bearings
    2. installing the camshaft
    3. installing the cam core plug
- iii. Installing the crankshaft
    1. installing a split-type rear main seal
    2. installing the main bearings
    3. installing the crankshaft
        a. installing the main bearing caps
        b. measuring oil clearance with Plastigage(r)
    4. checking crankshaft end play
    5. installing a one-piece main seal
- iv. Installing pistons, rings, and rods
    1. installing piston assemblies
    2. measuring deck clearance
- v. Installing valve timing components

jjjjj. Final bottom end assembly
- i. Installing the oil pump
    1. installing the pickup screen
    2. checking screen to pan clearance
- ii. Installing the oil pan and timing cover
    1. timing covers
    2. oil pans

kkkkk. Assembling the top end
- i. Installing the cylinder heads
- ii. Installing the valve train
- iii. Installing valve timing components

lllll. Final assembly procedures
- i. Installing manifolds
    1. intake manifold installation
    2. exhaust manifold installation
- ii. Installing flywheels and flexplates
    1. checkin

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