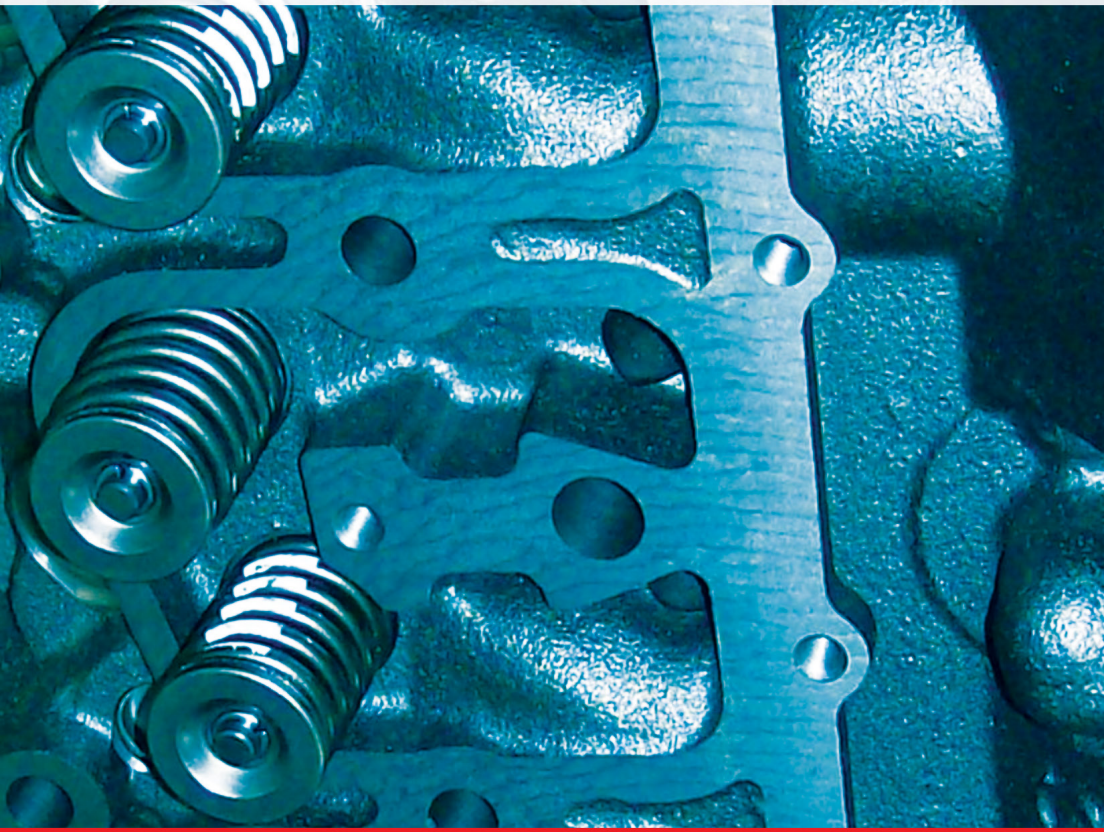
ENGINE
START-UP & BREAK-IN PROCEDURES



ATTENTION

FAILURE TO ADHERE TO THESE PROCEDURES, MAY VOID OR LIMIT YOUR ENGINE'S WARRANTY.

Thank you for choosing us as your engine supplier. We can assure you that every reasonable effort has been made to ensure the engine you are receiving meets the highest standards of quality. Additionally, this publication has been provided to help make the engine installation process as simple and painless as possible.

SUPPLIER RECOMMENDATIONS

We realize that the best warranty is the one you never have to use. As such, we offer this publication to help you avoid many of the common pitfalls and problems you may encounter during the initial conversion, start-up, and break-in procedure. If, at any time, you have any questions or concerns, please do not hesitate to contact your supplier.

REMEMBER, ORIGINAL MANUFACTURER'S SPECIFICATIONS AND RECOMMENDATIONS ALWAYS TAKE PRECEDENCE.

To help ensure the best possible outcome, we recommend:

- All work be completed by a competent, qualified professional, with an ASE certificate or equivalent, in a licensed facility.
- All belts, hoses, filters, vibration dampers, PCV valves, oil coolers, and fluids be replaced with new OEM or equivalent.
- All specifications detailed in this publication and your original manufacturer's recommendations be stringently adhered to.
- Initial start-up and break-in be performed in a controlled environment, such as a dynamometer testing facility, where factors such as: load, horsepower, oil pressure, RPM, and temperature can be controlled and monitored.
- ALL individuals and facilities involved with the installation, start-up, and break-in of this engine be supplied with this publication along with the original manufacturer's specifications and recommendations.

This information is provided from the best available sources at the time of publication, however, the supplier assumes no responsibility for data accuracy or consequences of its application. Be aware that this publication is NOT a warranty.

The purchaser, and/or their representative, is responsible for ensuring all necessary steps are taken to: receive, inspect, prepare, convert, start-up, and break-in this engine in a manner in keeping with the information provided herein, the original manufacturer's specifications, all warranty requirements, OSHA and AERA recommended safety procedures, and common sense; failure to do so, for any reason, **WILL VOID YOUR WARRANTY**.

The supplier offers no warranty or guarantee of any kind, express or implied, other than that expressly stated in the terms of warranty supplied at the time of purchase. Furthermore, the supplier makes no guarantee, express or implied, of suitability for any particular purpose, application, or use. It is the sole responsibility of the purchaser, and/or their representative, to determine whether or not the engine received is the proper unit for their particular application or purposes.

The following recommended procedures and instructions are a partial list and intended only as a guide. If you are not qualified to undertake this installation, do not attempt it as you may be liable for resulting engine failure and/or voiding of the warranty.

ENGINE CONVERSIONS

BEFORE DOING ANYTHING, ENSURE YOU HAVE RECEIVED THE CORRECT ENGINE. CALL YOUR SUPPLIER WITH ANY QUESTIONS!

SHORT BLOCKS

- Ensure your cylinder head is properly cleaned and remachined by a licensed machine shop or replace with new.
- Ensure your cylinder head has no cracks or defects and the valve heights are properly set.
- Where applicable, ensure your camshaft is thoroughly inspected by a licensed machine shop or replace with new.

LONG, MEDIUM, & SHORT BLOCKS

- Ensure all aspects of your gear train (gear teeth, bushings, etc...) are in good condition.
- Ensure the front plate has correct auxiliary holes and bolt pattern.
- Ensure the injection mounting plate has the correct configuration.
- Do not install injectors/spark plugs until AFTER proper cranking oil pressure is attained.

COMPLETE ENGINES, LONG, MEDIUM, & SHORT BLOCKS

- Ensure all mounting holes match, are available, and/or are workable before converting.
- Ensure proper crankshaft nose and flywheel (when supplied) configuration and bolt patterns.
- Ensure engine has proper clearances with regards to your application's engine compartment.
- All conversion/re-used components must be drained, flushed and installed clean.

EXPANSION PLUG NOTICE

Expansion plugs, when supplied, are done so as a courtesy only and are not covered under warranty. It is the responsibility of the purchaser, and/or their representative, to inspect and use or replace at their discretion.

INITIAL ENGINE PREPARATION

- Inspect engine for any damage that may have been incurred during transit.
- Remove any protective shipping devices, when present.
- Thoroughly inspect, flush (fluid systems only), and clean:
  - Air & Fuel System
  - Cooling System - Including Radiator
  - Peripherals - Air Compressor(s), Turbocharger(s), Blower(s), Etc...
- Replace with new:
  - Harmonic Balancer (Vibration Dampner)
  - Fuel, Lubricants, and Coolants
  - Fuel Filters, Oil Filters, and Air Filters
  - Oil Coolers and PCV Valves
  - Belts, Hoses, & Thermostats
- Install new (even if not previously installed):
  - Quality temperature gauge with "Degree" gradations.
  - Quality oil Pressure gauge with "PSI" gradations.

FIRST START-UP PROCEDURES

THESE STEPS MUST BE COMPLETED IN THE ORDER DESIGNATED

1. Change over any necessary components from your original engine.
2. Rotate engine 360° by hand as you change over each component to ensure there is no interference.
3. Ensure crankcase and peripherals are filled with the proper type and amount of oil. Use of a quality engine break-in additive is recommended.
4. Fill engine oil filter(s) and oil cooler(s) with oil and install.
5. Ensure there is **NO FUEL** present in the system.
6. Verify proper crankshaft thrust end-play is retained and engine turns over freely by hand; especially after installing into your application.
7. Crank engine for oil pressure **BEFORE** starting.
   - Crank engine, in 20-second intervals, until oil pressure registers.
   - Cranking oil pressure should be a **minimum of 10 PSI** or higher.
   - If proper cranking oil pressure cannot be attained, **STOP** and call your supplier before proceeding.
8. Once cranking oil pressure is attained; check oil level, add if necessary, then fill all associated systems with proper type and amount of fluid.

CRANK FOR OIL PRESSURE BEFORE THE FIRST START-UP!

The following are suggestions only, always reference the original manufacturer's break-in procedures as they pertain to your specific engine and application.

9. Follow all OSHA and AERA recommended safety procedures.
10. Install injectors/spark plugs (if applicable).
11. Check all fluids to ensure proper levels.
12. Have an assistant on-hand and keep all non-essential personnel clear.
13. Have an emergency shutdown procedure in place.
14. Be prepared to continuously watch for leaks throughout start-up & break-in.
15. If installed, ensure attachments are disengaged, clutch has been adjusted to proper free pedal, and proper crankshaft thrust end-play is retained.
16. Start engine. Watch for oil pressure to register (5-10 seconds). If no oil pressure, shutdown immediately and call supplier for technical support.
17. Run engine 1-2 minutes then shutdown and inspect.
18. If all is in order, check all fluids, run engine 2-5 minutes. Check and set idle and run up to 25% throttle then shutdown and inspect.
19. If all is in order, check all fluids, run engine 5-10 minutes. Vary throttle and run up to 50% throttle and 25% load then shutdown and inspect.
20. If all is in order, check all fluids, run engine 15-60 minutes. Vary throttle and run up to 75% throttle and 50% load then shutdown and inspect.
21. Run engine 2 hours, check and set high idle, run under normal load, and proceed with original manufacturer's recommended break-in procedure.

POST BREAK-IN PROCEDURES

This information is to be followed **ONLY** after attaining proper cranking oil pressure and the initial start-up and break-in has been successful. The following steps are recommendations only, always reference your original manufacturer's recommended post break-in procedures as they pertain to your specific engine and application.

1. Be sure all instructions detailed on the previous pages have been adhered to exactly. Pay especially close attention to the recommendations of your original manufacturer as they **ALWAYS** take precedence.
2. Do not put this unit into use without first:
   - Ensuring that proper engine oil pressure, as specified by the original manufacturer, is reached and maintained at all RPM and temperature ranges.
   - Verifying that there are fully functional gauges and warning lights/signals for: Engine Oil Pressure, Engine Temperature, and Engine RPM.
   - Heat cycling the engine and verifying correct thermostat operation.
   - Verifying that the fuel injection pump is operating correctly across the full RPM range, paying especially close attention to high and low RPMs.
   - Checking all belts and hoses. It is recommended all belts and hoses are replaced with new at the time of installation.
   - Checking all air filter seals and attached lines, hoses, and ducting for: splits, scathing, cracks, clogs, and tightness.
3. Monitor engine temperature and oil pressure closely during the first 3-5 hours (non-automotive) or 50-100 miles (automotive). Also, Idle engine for a minimum of 3 minutes when shutting down after heavy operation.
4. Monitor engine oil and coolant levels carefully, especially within the first month of operation.
5. Check **daily**, especially during the first month of operation:
   - Oil is not being thinned down with fuel (injection pump leaks, etc...).
   - Oil and coolant is not mixing in any way.
   - All belts and hoses.
   - For engine leaks. Repair or report any leaks immediately.
6. You **MUST** drain and replace engine oil and filter(s) as follows:
   - After the first: 1-3 hours (non-automotive), 50-100 miles (automotive)
   - After the first 10 hours (non-automotive), 1000 miles (automotive)
   - Always follow your original manufacturer's recommendation.
7. After initial break-in period, follow all normal maintenance procedures as recommended by your original manufacturer.
8. REMEMBER, ORIGINAL MANUFACTURER'S SPECIFICATIONS AND RECOMMENDATIONS **ALWAYS** TAKE PRECEDENCE OVER THIS PUBLICATION.

WARRANTY EXCLUSIONS

The following conditions, regardless of circumstances, will result in your engine's warranty becoming void immediately without recourse:

1. Malfunctions, in any part, caused by any of the following:
    - Storage/transit damage
    - Misuse such as engine or vehicle overload
    - Improper adjustment
    - Modification of the engine
    - Addition or modification of a turbo
    - Alteration
    - Misapplication* - Supplier makes no guarantee of suitability for any particular purpose, application, or use.
    - Tampering such as serial number altered, defaced, or removed
    - Disconnection, Over Rev, or Full Power Stall
    - Improper or inadequate maintenance - Quality of filters, oil, etc...
    - Cavitation erosion due to poor maintenance or poor quality coolants
    - Parts used not previously approved by the engine supplier
    - Oil cooler not replaced at time of engine replacement
    - Failure to thoroughly clean and flush all associated components, especially those that share engine fluid (oil, coolant, etc...) such as air compressors, turbochargers, and the like.

**Misapplication includes, but is not limited to; Installation into a Competition (tractor/truck pulling, racing, etc...), Forestry, Extreme Use, or Military Grade application, or changing horsepower from the original manufacturer's specification without the suppliers endorsement.*

2. Damage resulting from:
    - Abuse
    - Negligence
    - Accident
    - Acts of nature such as: fire, freezing, lightning, earthquake, windstorm, hail, flood, etc...
    - Other acts beyond the control of the supplier
3. Damage due to use of incorrect fuel, lubricants, or coolant for engine type.

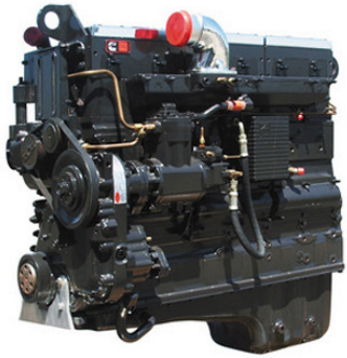
Consumable and maintenance components such as: fuel filters, air filters, water filters, oil filters, coolant, fuel, lubricants, hoses, belts, air cleaner ducting, radiator connections, gaskets & seals, electronic sensors, glow plugs, expansion plugs and frost plug heaters are never covered under warranty.

Additionally, warranty coverage will never exceed the original purchase price of the engine itself. If you have any questions regarding the scope of your engine's warranty, please do not hesitate to contact your supplier .

FOR CUMMINS® B-SERIES AND C-SERIES ENGINES ONLY

Below are tips on changing over the front gear housing on Cummins® B-Series and C-Series engines **ONLY**. These are tips only, the installing mechanic/technician must use their own due diligence when performing this procedure.

1. Setup in a clean, dust-free location.
2. Remove rocker cover bolts, then remove rocker covers.
3. Number (by cylinder) and remove rocker arm assemblies.
4. Number (by cylinder) and remove pushrods.
5. Lay engine on its side.
6. Remove tin front cover.
7. Rotate engine by hand to align timing marks.
8. Remove idler gear.
9. Push all lifters/tappets towards the cylinder head.
10. Make sure camshaft spins freely. Remove camshaft bolts and then remove camshaft.
11. Remove front gear housing, making sure to remove all gasket material from block and housing. Be sure to keep any/all debris out of the engine and off surrounding areas.
12. Install new gasket and front gear housing.
13. Reinstall camshaft and idler gear.
14. Check timing marks. Have a second person verify timing mark alignment.
15. Torque to specs.
16. Set engine upright.
17. Reinstall pushrods (in numbered order). Be sure all pushrods line-up with their lifter sockets properly. Rotate pushrods to ensure proper fit.
18. Reinstall rocker arm assemblies (in numbered order), rotate pushrods to ensure proper fit, and torque to specs.
19. Rotate engine 360°, by hand, to ensure there is no binding or interference.
20. Set valve lash for B-Series intake at: 0.010” COLD and exhaust at: 0.025” COLD. Set valve lash for C-Series intake at: 0.012” COLD and exhaust at: 0.024” COLD.



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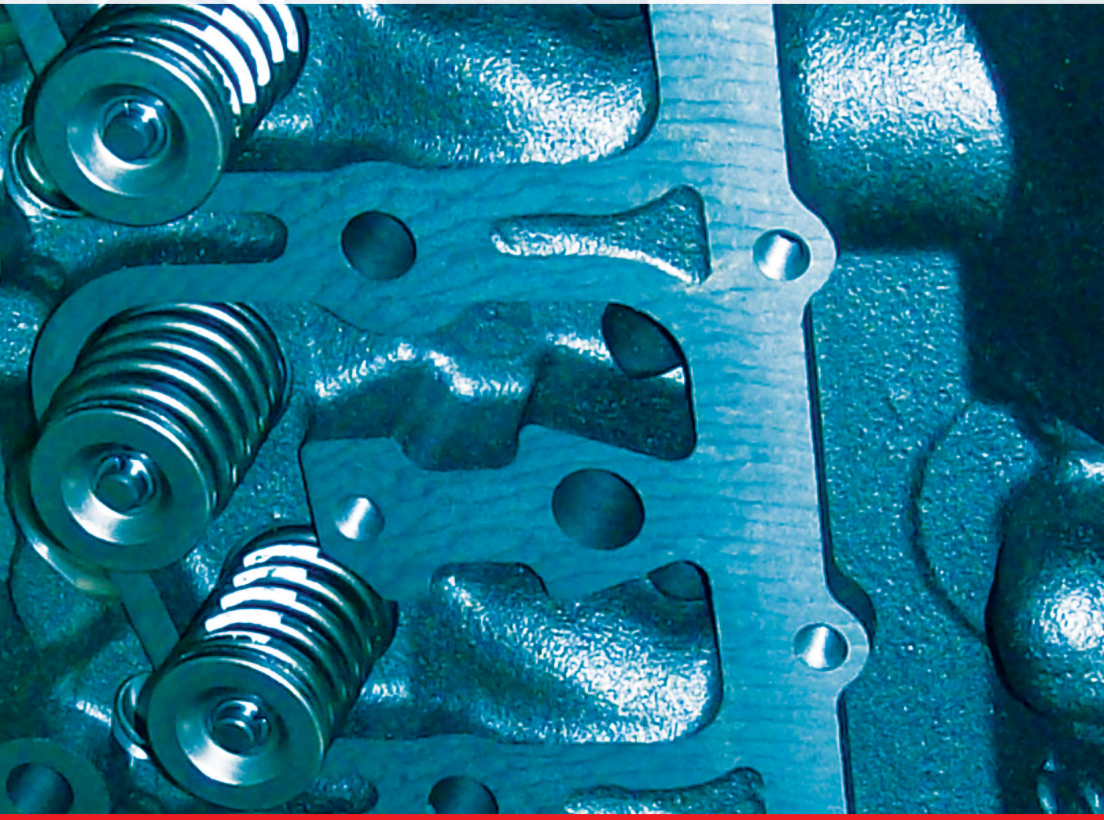

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