# Torque - Minimum tightening torques for normal assembly

## METRIC NON-FLANGED HARDWARE

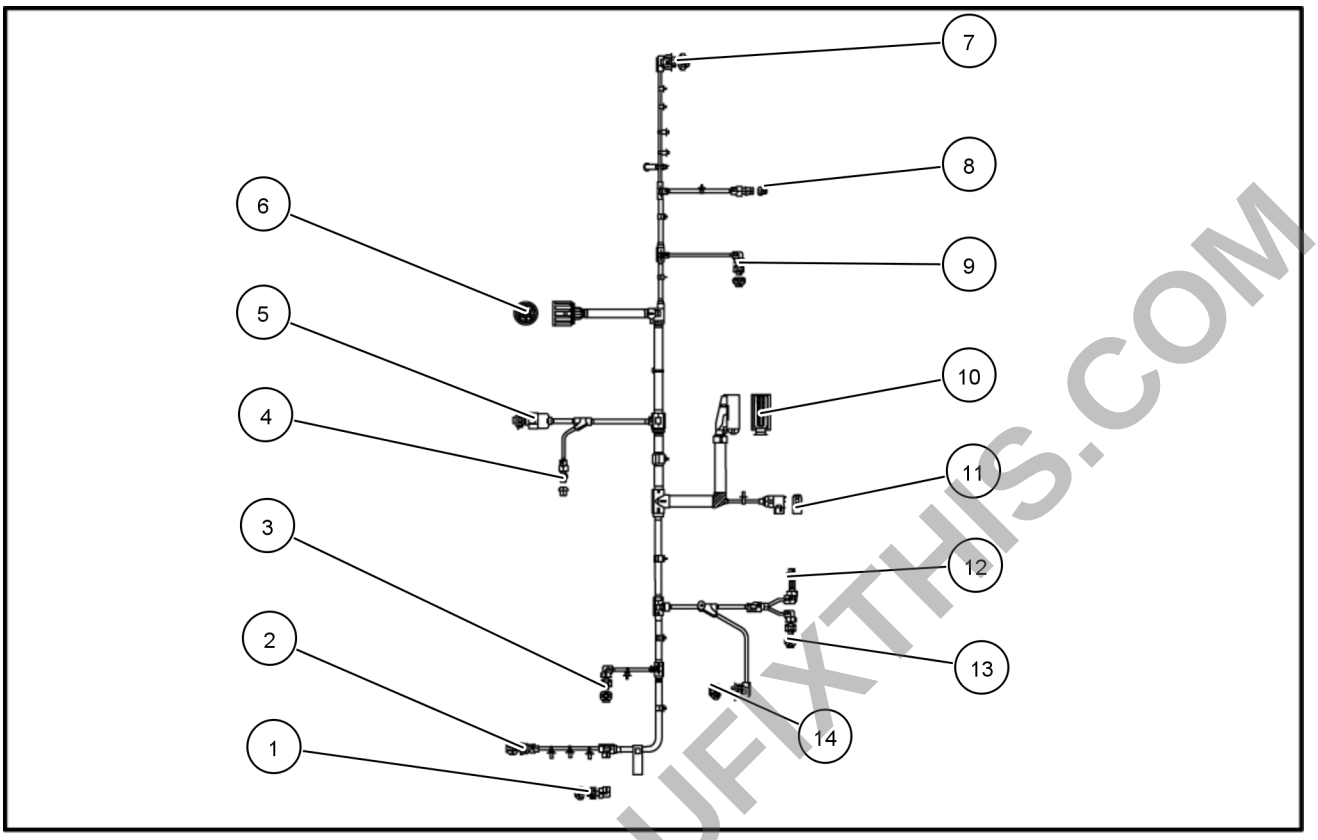
| NOM. SIZE | CLASS 8.8 BOLT and CLASS 8 NUT | | CLASS 10.9 BOLT and CLASS 10 NUT | | LOCKNUT CL.8 W/CL8.8 BOLT | LOCKNUT CL.10 W/CL10.9 BOLT |
|---|---|---|---|---|---|---|
| | UNPLATED | PLATED W/ZnCr | UNPLATED | PLATED W/ZnCr | | |
| M4 | 2.2 N·m (19 lb in) | 2.9 N·m (26 lb in) | 3.2 N·m (28 lb in) | 4.2 N·m (37 lb in) | 2 N·m (18 lb in) | 2.9 N·m (26 lb in) |
| M5 | 4.5 N·m (40 lb in) | 5.9 N·m (52 lb in) | 6.4 N·m (57 lb in) | 8.5 N·m (75 lb in) | 4 N·m (36 lb in) | 5.8 N·m (51 lb in) |
| M6 | 7.5 N·m (66 lb in) | 10 N·m (89 lb in) | 11 N·m (96 lb in) | 15 N·m (128 lb in) | 6.8 N·m (60 lb in) | 10 N·m (89 lb in) |
| M8 | 18 N·m (163 lb in) | 25 N·m (217 lb in) | 26 N·m (234 lb in) | 35 N·m (311 lb in) | 17 N·m (151 lb in) | 24 N·m (212 lb in) |
| M10 | 37 N·m (27 lb ft) | 49 N·m (36 lb ft) | 52 N·m (38 lb ft) | 70 N·m (51 lb ft) | 33 N·m (25 lb ft) | 48 N·m (35 lb ft) |
| M12 | 64 N·m (47 lb ft) | 85 N·m (63 lb ft) | 91 N·m (67 lb ft) | 121 N·m (90 lb ft) | 58 N·m (43 lb ft) | 83 N·m (61 lb ft) |
| M16 | 158 N·m (116 lb ft) | 210 N·m (155 lb ft) | 225 N·m (166 lb ft) | 301 N·m (222 lb ft) | 143 N·m (106 lb ft) | 205 N·m (151 lb ft) |
| M20 | 319 N·m (235 lb ft) | 425 N·m (313 lb ft) | 440 N·m (325 lb ft) | 587 N·m (433 lb ft) | 290 N·m (214 lb ft) | 400 N·m (295 lb ft) |
| M24 | 551 N·m (410 lb ft) | 735 N·m (500 lb ft) | 762 N·m (560 lb ft) | 1016 N·m (750 lb ft) | 501 N·m (370 lb ft) | 693 N·m (510 lb ft) |

***NOTE:*** *M4 through M8 hardware torque specifications are shown in pound-inches. M10 through M24 hardware torque specifications are shown in pound-feet.*

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# Wiring harness - Overview




**Main harness**

**(1)** Engine speed sensor (camshaft)
**(2)** Engine speed sensor (flywheel)
**(3)** High-pressure fuel pump
**(4)** Controller area network
**(5)** Connector to frame wiring
**(6)** Wire passage
**(7)** Oil pressure/temperature sensor
**(8)** Oil level sensor
**(9)** Coolant temperature sensor
**(10)** ECU
**(11)** Crankcase pressure sensor
**(12)** Clogged fuel filter sensor
**(13)** Fuel temperature sensor
**(14)** Air pressure/temperature sensor

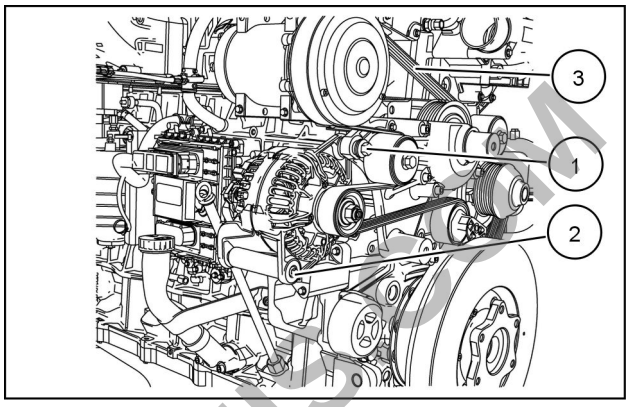
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# Alternator - Remove

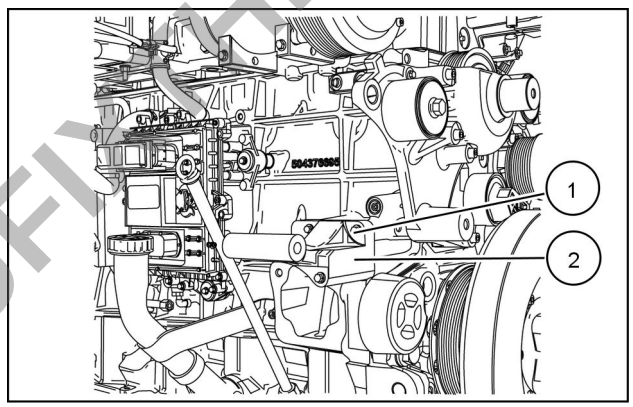
**Prior operation:**
**Fan and drive Belt - Remove (B.50.A)**

1. Remove the belt **(3)**.
2. Disconnect all electrical connections from the back of the alternator.
3. Remove the bolts **(1)** and **(2)** securing the alternator.




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4. Remove bolts **(1)** securing the mounting bracket **(2)** to the engine.




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**Next operation:**
**Alternator - Install (A.30.A)**

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# ENGINE - Troubleshooting

| Problem | Possible Cause | Correction |
|---|---|---|
| **Engine does not develop full power** | Clogged air cleaner | Inspect and replace air cleaner if necessary |
| | Fuel line obstructed | Check for crimped fuel line. Inspect fuel lifter for cleanliness |
| | Low cylinder compression | Check engine compression |
| | Insufficient fuel injection | Repair at authorized shop |
| | Improper valve lash adjustment | Adjust valves to correct tolerances |
| | Burned, worn or sticking valves | Inspect and replace as necessary |
| | Blown head gasket | Replace head gasket |
| | Worn or sticking piston rings | Overhaul as necessary |
| **Low oil pressure** | Engine oil level low | Fill to proper level |
| | Wrong grade of oil | Replace with correct grade oil |
| | Clogged oil pump filter | Change oil and filter |
| | Faulty oil pressure relief valve | Replace relief valve |
| | Worn oil pump drive shaft gears, or broken oil pipe | Inspect oil system and components. Replace defective components |
| | Excessive main or connecting rod bearing clearances | Replace bearings or shaft if necessary |
| **Engine will not stop** | Faulty starter switch | Replace starter switch |
| **Low cylinder compression** | Burned, worn or sticking valves | Replace valves |
| | Bent valve stem | Replace valves |
| | Broken or weak valve spring | Replace valve spring |
| | Blown cylinder head gasket | Replace head gasket |
| | Worn or sticking piston rings | Replace piston rings |
| | Scored piston | Replace piston |
| **Poor engine idling** | Air in injection pump | Purge air from the system |
| **Oil pressure warning light fails to operate** | Bulb burnt out | Replace the bulb |
| | Oil pressure sensor is faulty | Replace oil pressure sensor |
| | Warning light circuit faulty | Replace warning light circuit |
| **Engine knocks** | Diluted or thin oil | Change engine oil and filter. Check for fuel in oil |
| | Insufficient oil supply | Check engine oil level |
| | Low oil pressure | Inspect lube system for restrictions |
| | Worn crankshaft thrust bearing | Replace thrust bearing |
| | Excessive flywheel runout | Replace flywheel |
| | Excessive connecting rod or main bearing clearance | Replace bearings |
| | Seized bearing | Replace bearing and affected component if necessary |
| | Clogged oil passage | Clean out oil passages |
| | Bent or twisted connecting rod | Replace connecting rod |
| | Crankshaft journals out of round | Rework or replace crankshaft |
| | Excessive piston to cylinder bore clearance | Replace piston with correct oversized piston |
| | Excessive piston ring side clearance | Replace piston rings |
| | Broken or damaged ring | Replace piston ring |
| | Excessive piston pin clearance | Replace piston pin or bushing |
| | Seized piston | Replace piston and, if necessary, engine block |
| | Piston pin retainer loose or missing | Replace retainer |
| | Improper valve lash adjustment | Adjust valve lash to specification |
| | Worn valve lifter | Replace valve lifter |
| | Excessive timing gear backlash | Replace all timing gears |
| **Excessive oil consumption** | Engine oil level too high | Remove excess oil |
| | Leakage in cylinder head gasket | Replace head gasket |

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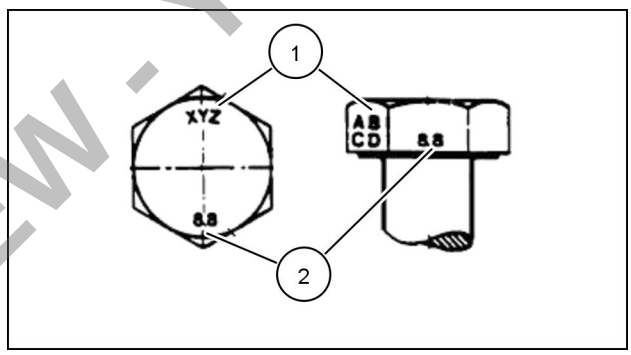

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## METRIC FLANGED HARDWARE

| NOM. SIZE | CLASS 8.8 BOLT and CLASS 8 NUT | | CLASS 10.9 BOLT and CLASS 10 NUT | | LOCKNUT CL.8 W/CL8.8 BOLT | LOCKNUT CL.10 W/CL10.9 BOLT |
|---|---|---|---|---|---|---|
| | UNPLATED | PLATED W/ZnCr | UNPLATED | PLATED W/ZnCr | | |
| M4 | 2.4 N·m (21 lb in) | 3.2 N·m (28 lb in) | 3.5 N·m (31 lb in) | 4.6 N·m (41 lb in) | 2.2 N·m (19 lb in) | 3.1 N·m (27 lb in) |
| M5 | 4.9 N·m (43 lb in) | 6.5 N·m (58 lb in) | 7.0 N·m (62 lb in) | 9.4 N·m (83 lb in) | 4.4 N·m (39 lb in) | 6.4 N·m (57 lb in) |
| M6 | 8.3 N·m (73 lb in) | 11 N·m (96 lb in) | 12 N·m (105 lb in) | 16 N·m (141 lb in) | 7.5 N·m (66 lb in) | 11 N·m (96 lb in) |
| M8 | 20 N·m (179 lb in) | 27 N·m (240 lb in) | 29 N·m (257 lb in) | 39 N·m (343 lb in) | 18 N·m (163 lb in) | 27 N·m (240 lb in) |
| M10 | 40 N·m (30 lb ft) | 54 N·m (40 lb ft) | 57 N·m (42 lb ft) | 77 N·m (56 lb ft) | 37 N·m (27 lb ft) | 53 N·m (39 lb ft) |
| M12 | 70 N·m (52 lb ft) | 93 N·m (69 lb ft) | 100 N·m (74 lb ft) | 134 N·m (98 lb ft) | 63 N·m (47 lb ft) | 91 N·m (67 lb ft) |
| M16 | 174 N·m (128 lb ft) | 231 N·m (171 lb ft) | 248 N·m (183 lb ft) | 331 N·m (244 lb ft) | 158 N·m (116 lb ft) | 226 N·m (167 lb ft) |
| M20 | 350 N·m (259 lb ft) | 467 N·m (345 lb ft) | 484 N·m (357 lb ft) | 645 N·m (476 lb ft) | 318 N·m (235 lb ft) | 440 N·m (325 lb ft) |
| M24 | 607 N·m (447 lb ft) | 809 N·m (597 lb ft) | 838 N·m (618 lb ft) | 1118 N·m (824 lb ft) | 552 N·m (407 lb ft) | |

## IDENTIFICATION

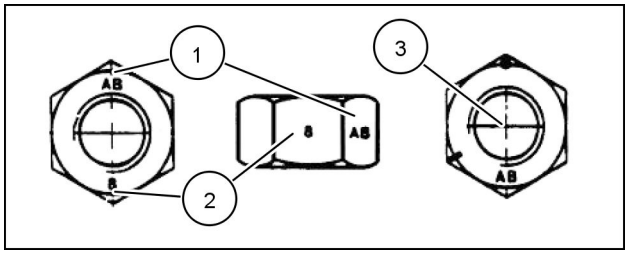
### Metric Hex head and carriage bolts, classes 5.6 and up




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1. Manufacturer's Identification
2. Property Class

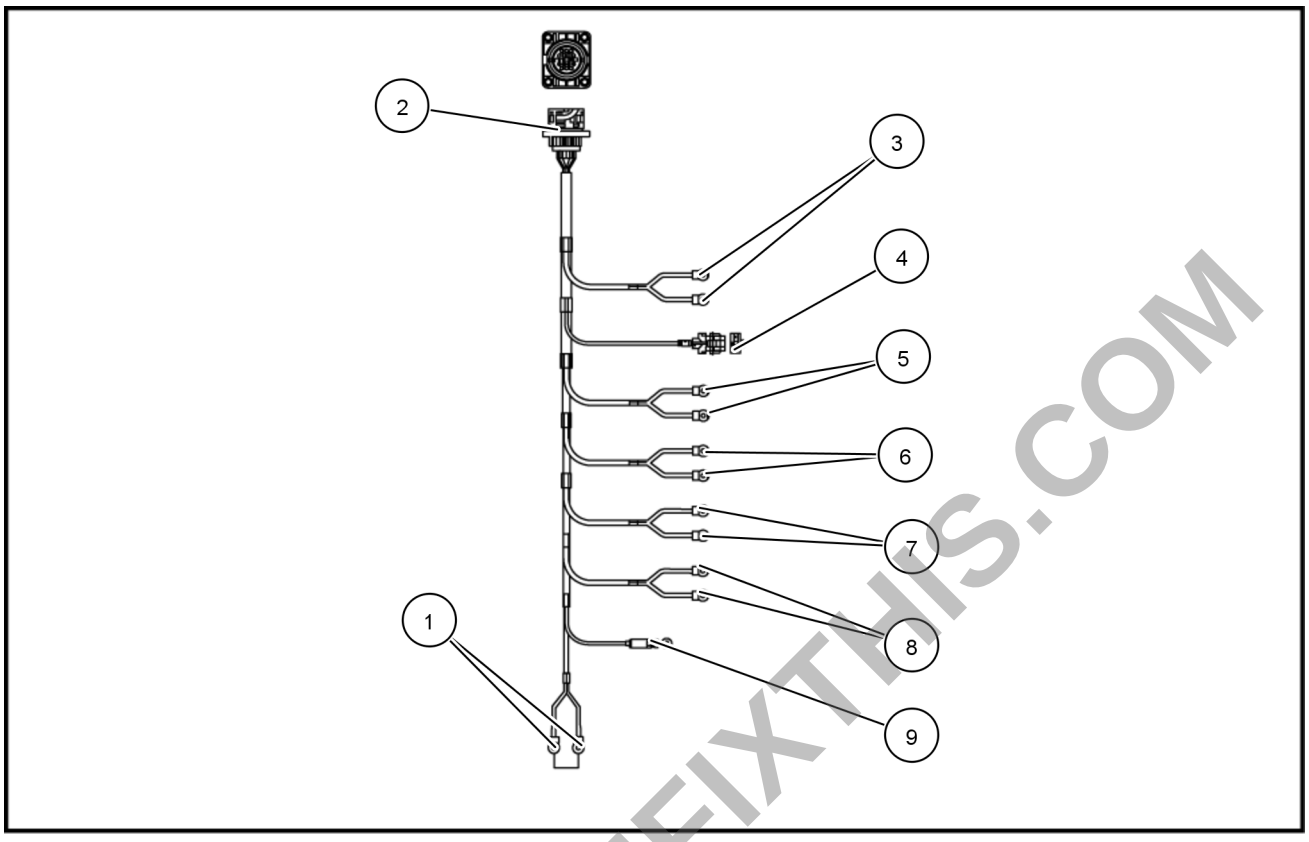
### Metric Hex nuts and locknuts, classes 05 and up




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**Internal harness**

**(1)** Injector 6
**(2)** Wire passage
**(3)** Injector 1
**(4)** Rail pressure sensor
**(5)** Injector 2
**(6)** Injector 3
**(7)** Injector 4
**(8)** Injector 5
**(9)** Electrovalve insert, engine brake

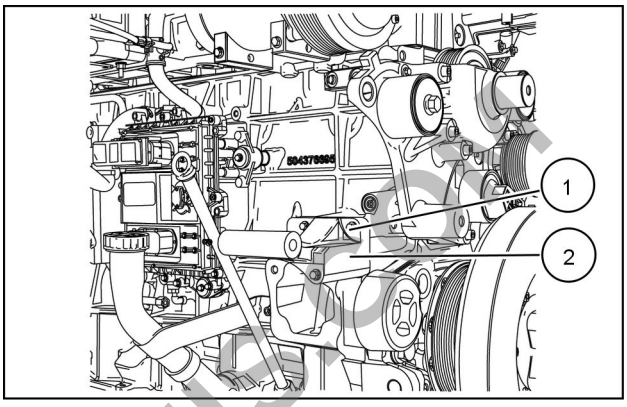
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# Alternator - Install

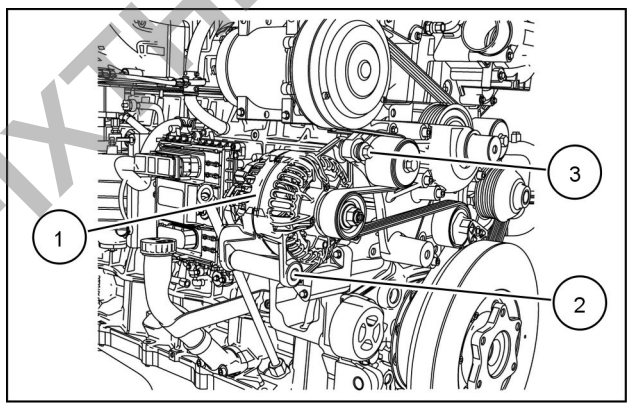
**Prior operation:**
**Alternator - Remove (A.30.A)**

1. Install the alternator support bracket **(2)** .
2. Torque the bolts **(1)** to **22 - 27 N·m** (**16 - 20 lb ft**).




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3. Set the alternator **(1)** on the support and loosely install the bottom through bolt **(2)**.
4. Install the top bolt **(3)** and torque to **22 - 27 N·m** (**16 - 20 lb ft**)
5. Torque the bottom through bolt **(2)** to **40 - 48 N·m** (**30 - 35 lb ft**).




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**Next operation:**
**Fan and drive Belt - Install (B.50.A)**

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| Problem | Possible Cause | Correction |
|---|---|---|
| | Oil loss past the pistons and rings | Replace piston rings |
| | Worn, broken, or sticking piston rings | Replace piston rings |
| | Clogged return hole of oil ring | Unclog return oil hole and replace rings |
| | Worn valves, guides, or seals | Replace valves, guides, or seals |
| | Leakage past oil seals and gaskets | Replace leaking seals and gaskets |
| | External oil leaks from engine | Locate leaks and repair |
| **Engine overheats** | Insufficient amount of coolant in the radiator | Fill coolant to proper level |
| | Hose connection leaking or collapsed hose | Tighten hose connection or replace hose |
| | Radiator leakage | Locate leak and repair or replace radiator |
| | Loose, worn, or broken V-belt | Adjust V-belt tension or replace belt |
| | Radiator fins bent or clogged | Straighten out and clean fins |
| | Radiator cap not sealing | Replace radiator cap |
| | Thermostat operating improperly | Replace thermostat cap |
| | Insufficient amount of oil | Fill to proper level |
| | Water pump operating improperly | Replace water pump |
| | Improper valve clearance | Adjust valve clearance to specification |
| | Restriction in exhaust system | Remove restriction |
| | Improperly installed cylinder head gasket | Replace head gasket |
| | Rust and/or scale clogged water ports | Backflush cooling system |
| | Extended engine idling | Shutdown engine during extended idling periods |
| **Temperature gauge fails to reach normal operating temperature** | Faulty temperature sender | Replace temperature switch |
| | Faulty thermostat | Replace thermostat |
| | Faulty temperature gauge | Replace temperature gauge |
| **Engine does not start** | Faulty starter switch | Replace switch |
| | Insufficient charging or complete discharge of battery | Check battery and charging system |
| | Lack of fuel | Fill fuel tank |
| | Air mixed in fuel system | Inspect fuel system for tightness |
| | Clogged fuel filter | Replace fuel filter |
| | Irregular or faulty fuel supply | Replace fuel supply |
| | Grid heater not heating | Replace grid heater |
| | Improper lubricating oil viscosity | Replace lube oil |
| | Clogged air cleaner | Replace air cleaner |
| | Burned out fuse | Replace fuse |
| **Excessive Exhaust Smoke** | Air cleaner dirty or restricted | Replace air cleaner |
| | Excessive fuel delivery | Replace injection pump, fuel delivery not adjustable |
| **Engine stops while operating** | Lack of fuel in fuel tank | Fill fuel tank |
| | Clogged fuel filter | Replace filter |
| | Air mixed in fuel system | Inspect for air leaks |
| | Burned out fuse | Replace fuse |
| **Undesirable exhaust smoke (white or pale)** | Excess engine oil | Drain oil to proper oil level |
| | Improper lubricating oil viscosity | Replace oil with specified viscosity |
| | Faulty injection pump | Replace injection pump |
| **Undesirable exhaust color (black or light grey)** | Unsuitable fuel | Replace fuel |
| | Excess injection | Replace injection pump |
| | Faulty engine component | Replace as required |
| | Over loading | Decrease load |
| | Clogged air filter | Replace filter |

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1. Manufacturer's Identification
2. Property Class
3. Clock Marking of Property Class and Manufacturer's Identification (Optional), i.e. marks **60 °** apart indicate Class 10 properties, and marks **120 °** apart indicate Class 8.

## INCH NON-FLANGED HARDWARE

| NOMINAL SIZE | SAE GRADE 5 BOLT and NUT | | SAE GRADE 8 BOLT and NUT | | LOCKNUT GrB W/ Gr5 BOLT | LOCKNUT GrC W/ Gr8 BOLT |
|---|---|---|---|---|---|---|
| | UN-PLATED or PLATED SILVER | PLATED W/ZnCr GOLD | UN-PLATED or PLATED SILVER | PLATED W/ZnCr GOLD | | |
| 1/4 | **8 N·m (71 lb in)** | **11 N·m (97 lb in)** | **12 N·m (106 lb in)** | **16 N·m (142 lb in)** | **8.5 N·m (75 lb in)** | **12.2 N·m (109 lb in)** |
| 5/16 | **17 N·m (150 lb in)** | **23 N·m (204 lb in)** | **24 N·m (212 lb in)** | **32 N·m (283 lb in)** | **17.5 N·m (155 lb in)** | **25 N·m (220 lb in)** |
| 3/8 | **30 N·m (22 lb ft)** | **40 N·m (30 lb ft)** | **43 N·m (31 lb ft)** | **57 N·m (42 lb ft)** | **31 N·m (23 lb ft)** | **44 N·m (33 lb ft)** |
| 7/16 | **48 N·m (36 lb ft)** | **65 N·m (48 lb ft)** | **68 N·m (50 lb ft)** | **91 N·m (67 lb ft)** | **50 N·m (37 lb ft)** | **71 N·m (53 lb ft)** |
| 1/2 | **74 N·m (54 lb ft)** | **98 N·m (73 lb ft)** | **104 N·m (77 lb ft)** | **139 N·m (103 lb ft)** | **76 N·m (56 lb ft)** | **108 N·m (80 lb ft)** |
| 9/16 | **107 N·m (79 lb ft)** | **142 N·m (105 lb ft)** | **150 N·m (111 lb ft)** | **201 N·m (148 lb ft)** | **111 N·m (82 lb ft)** | **156 N·m (115 lb ft)** |
| 5/8 | **147 N·m (108 lb ft)** | **196 N·m (145 lb ft)** | **208 N·m (153 lb ft)** | **277 N·m (204 lb ft)** | **153 N·m (113 lb ft)** | **215 N·m (159 lb ft)** |
| 3/4 | **261 N·m (193 lb ft)** | **348 N·m (257 lb ft)** | **369 N·m (272 lb ft)** | **491 N·m (362 lb ft)** | **271 N·m (200 lb ft)** | **383 N·m (282 lb ft)** |
| 7/8 | **420 N·m (310 lb ft)** | **561 N·m (413 lb ft)** | **594 N·m (438 lb ft)** | **791 N·m (584 lb ft)** | **437 N·m (323 lb ft)** | **617 N·m (455 lb ft)** |
| 1 | **630 N·m (465 lb ft)** | **841 N·m (620 lb ft)** | **890 N·m (656 lb ft)** | **1187 N·m (875 lb ft)** | **654 N·m (483 lb ft)** | **924 N·m (681 lb ft)** |

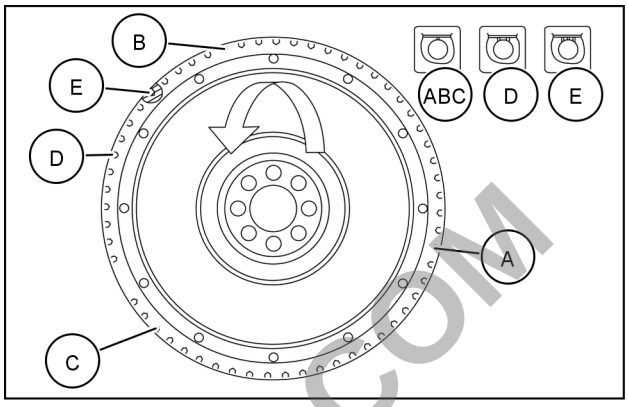
***NOTE:*** *For Imperial Units,* ***1/4 in*** *and* ***5/16 in*** *hardware torque specifications are shown in pound-inches.* ***3/8 in*** *through* ***1 in*** *hardware torque specifications are shown in pound-feet.*

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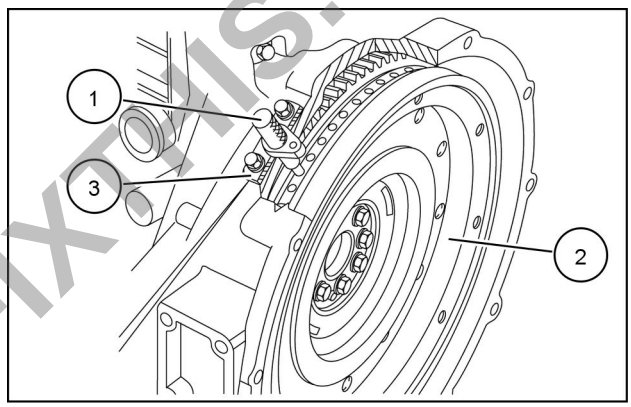
# ENGINE - Service instruction - Finding Top Dead Center (TDC)

1. Using the tool **380000137**, turn the engine flywheel in the direction of normal rotation until you see the hole with two reference marks **(D)**.
2. Continue to turn the flywheel until the hole with one reference mark **(B)** can be seen. This marks TDC of the number one cylinder.




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3. The exact position of piston number one at TDC is obtained when the tool **380000150 (1)** fits into a hole in the flywheel **(2)** through the mounting surface of the engine speed sensor **(3)**.
4. Remove the tool **380000150 (1)**.




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FUEL AND INJECTION SYSTEM ..... B.20.A

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EXHAUST SYSTEM ..... B.40.A

EXHAUST SYSTEM Emissions control ..... B.40.B

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LUBRICATION SYSTEM ..... B.60.A

STARTING SYSTEM ..... B.80.A

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# Safety rules

## Personal safety



This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible death or injury.

Throughout this manual and on machine decals, you will find the signal words DANGER, WARNING, and CAUTION followed by special instructions. These precautions are intended for the personal safety of you and those working with you.

Read and understand all the safety messages in this manual before you operate or service the machine.

⚠ DANGER indicates a hazardous situation which, if not avoided, will result in death or serious injury. The color associated with DANGER is RED.

⚠ WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury. The color associated with WARNING is ORANGE.

⚠ CAUTION, used with the safety alert symbol, indicates a hazardous situation which, if not avoided, could result in minor or moderate injury. The color associated with CAUTION is YELLOW.

**FAILURE TO FOLLOW DANGER, WARNING, AND CAUTION MESSAGES COULD RESULT IN DEATH OR SERIOUS INJURY.**

## Machine safety

***NOTICE:*** *Notice indicates a situation which, if not avoided, could result in machine or property damage. The color associated with Notice is BLUE.*

Throughout this manual you will find the signal word Notice followed by special instructions to prevent machine or property damage. The word Notice is used to address practices not related to personal safety.

## Information

***NOTE:*** *Note indicates additional information which clarifies steps, procedures, or other information in this manual.*

Throughout this manual you will find the word Note followed by additional information about a step, procedure, or other information in the manual. The word Note is not intended to address personal safety or property damage.

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