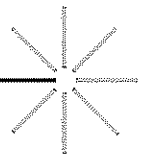
Natural Gas Engines



GTA 38 AND GTA 50
OPERATION AND MAINTENANCE MANUAL

Bulletin #OM990901, 09/99

Cummins Natural Gas Engines, Inc. Assembly Plant
Clovis, New Mexico

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Notes:

Foreword

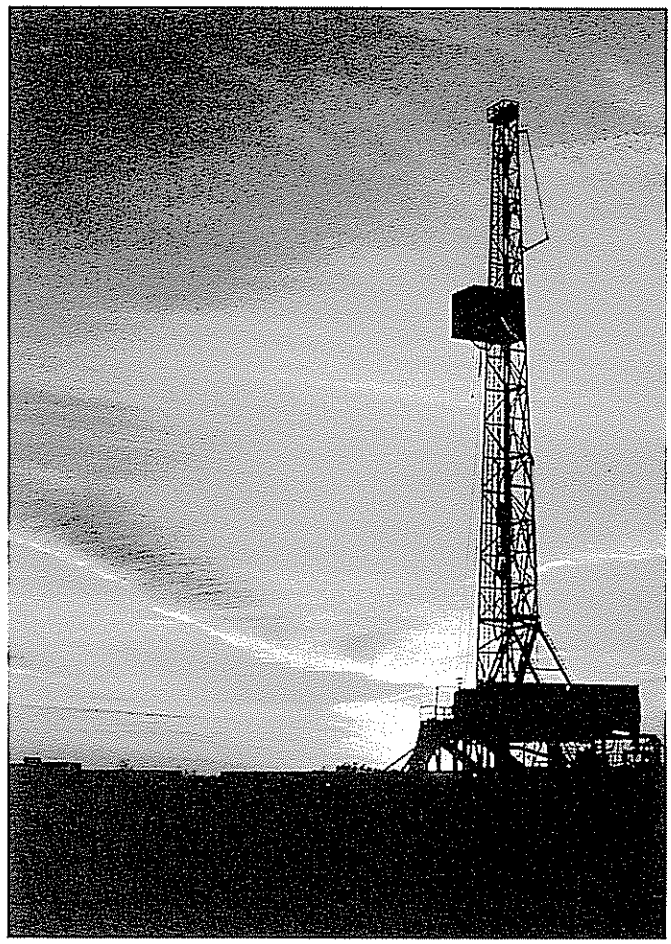
This manual is applicable to the GTA38 and GTA50 Spark Ignited Engines currently being produced by Cummins Natural Gas Engines, Inc. (CNGE). It contains instructions for operators that will enable them to get the best service from their engines. Before operating the engine become familiar with the procedures described.

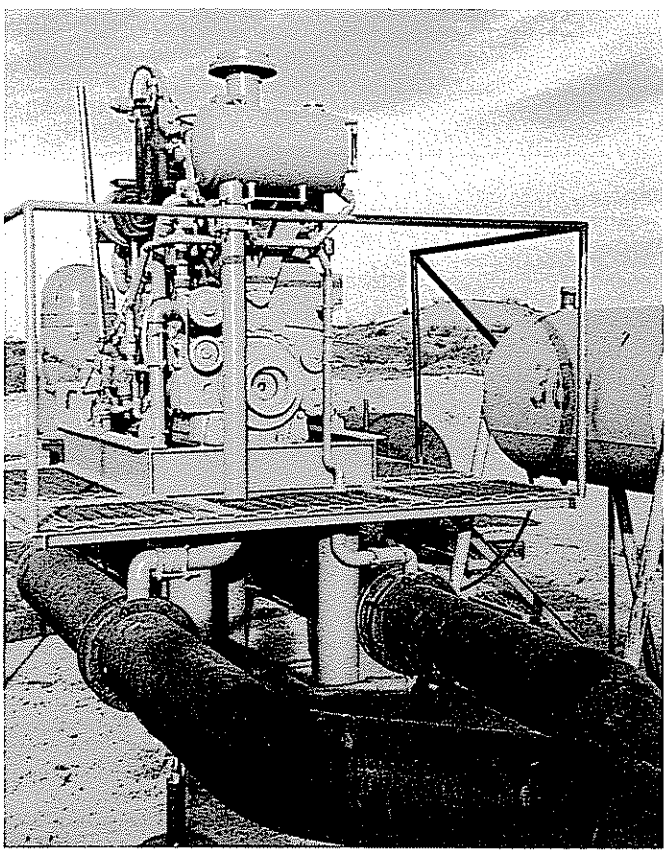
The maintenance section is for the people who are responsible for the upkeep and availability of the engine on the job. The maintenance program is simple, realistic, easy to control and a profitable one to practice.

Repair operations on CNGE engines should be performed by specially trained personnel. Contact your local Cummins Distributor for a list of authorized CNGE repair locations in your area.

The latest technology and the highest quality components were used to produce this engine. When replacement parts are needed, CNGE recommends using only genuine Cummins ReCon exchange parts and CNGE replacement parts. These parts can be purchased from your closest Cummins authorized repair location.

Cummins Natural Gas Engines, Inc.
8713 Airport Freeway, Suite 316
Fort Worth, Texas, U.S.A. 76180





Notes:

Section 1
Introduction

About the Manual

This manual contains information needed to correctly operate and maintain your engine as recommended by Cummins Natural Gas Engines, Inc. Additional service literature, such as the Operation & Maintenance Manual, Shop Manual, Troubleshooting & Repair Manual for the Cummins KTA38 and KTA50 Diesel Engine are available. These books contain information that will be helpful and can be ordered from your local Cummins Distributor.

This manual does not cover equipment maintenance procedures. Consult the equipment manufacturer for specific maintenance recommendations.

Both metric and U.S. customary values are listed in this manual. The metric value is listed first, followed by the U.S. customary in brackets.

Abbreviations Used in this Manual

A	Aftercooled
AFC	Air Fuel Control
API	American Petroleum Institute
ASTM	American Society of Testing and Materials
BHP	Brake Horsepower
BTU	British Thermal Units
° C	Celsius Degrees
CCA	Cold Cranking Amps
CCW	Counter Clockwise
CFM	Cubic Feet Per Minute
C.I.	Cubic Inch
C.I.D.	Cubic Inch Displacement
Cm	Centimeter
cSt	Centistokes
CW	Clockwise
DBTDC	Degrees Before Top Dead Center
DCA	Diesel Coolant Additive
D.C.	Direct Current
ECM	Electronic Control Module
E.C.S.	Emission Control Sensor
E.S.N.	Engine Serial Number
° F	Fahrenheit Degrees
FCV	Fuel Control Valve
FTM	Federal Test Method
ft.	Feet
ft-lb	Foot Pound
FSO	Fuel Shut-Off
"G"	Gas-Spark Ignited Engine
Gal	Gallon
"GR"	Ground
"H"	High
Hg	Mercury
HHV	High Heat Value
HP	Horsepower
hr.	Hour
H_2O	Water
ICM	Ignition Control Module
In.	Inch
in-lb	Inch Pound
kg	Kilograms
km	Kilometers
km/l	Kilometers per Liter
kPa	Kilopascal
"L"	Low
LE	Low Emission
l	Liter
lb.	Pound
lbf	Pound Force
LHV	Lower Heat Value
max.	Maximum
m	Meter
min.	Minimum
mm	Millimeter
Mpa	Megapascal
N	Newton
NA	Naturally Aspirated
NG	Natural Gas
N•m	Newton-meter
NPTF	National Pipe Thread Fine
O2	Oxygen
OD	Outside Diameter
OEM	Original Equipment Manufacturer
ppm	Parts Per Million
psi	Pounds Per Square Inch
PWB	Parts Warranty Bulletin
qt.	Quart
RPM	Revolutions Per Minute
SAE	Society of Automotive Engineers
SI	Spark Ignited
ST	Service Tool
T	Turbocharged
TDC	Top Dead Center
™	Trademark
U.S.	United States
V	Volts
"VS"	Valve Set
WB	Warranty Bulletin
WC	Water Column
WF	Water Filter

Safety Precautions & Warnings

Improper practices or carelessness can cause burns, cuts, mutilation, asphyxiation or other bodily injury or death.

Read and understand all of the safety precautions and warnings before performing any repair. This list contains the general safety precautions that must be followed to provide personal safety. Special safety precautions have been included in the procedures when they apply.

Note: *It is not possible for Cummins Natural Gas Engines, Inc. to anticipate every possible circumstance that can involve a potential hazard.*

- *Make sure that the work area surrounding the product is dry, well lit, ventilated, free of clutter, loose tools, parts, ignition sources and hazardous substances. Be aware of hazardous conditions that can exist.*
- ***Always*** *wear protective glasses and protective shoes when working.*
- *Rotating parts can cause cuts, mutilation or strangulation.*
- *Do* ***not*** *wear loose-fitting or torn clothing. Remove all jewelry when working.*
- *Do* ***not*** *work on anything that is supported ONLY by lifting jacks or a hoist.* ***Always*** *use blocks or proper stands to support the product before performing any service work.*
- *Disconnect the batteries negative (-) and positive (+) cables and discharge any capacitors before beginning any repair work. Disconnect the air starting motor, if equipped, to prevent accidental engine starting. Put a* ***"Do Not Operate"*** *tag in the operator's compartment or on the controls.*
- *Do* ***not*** *connect the ground cable of any welder to the ignition or governor components or leads. Attach the welder ground cables as close as possible to the part being welded.*
- *Do* ***not*** *connect the jumper starting or battery charging cables to any ignition or governor control wiring. This can cause electrical damage to the ignition generator or governor.*
- *The natural gas exhaust system normally operates at a higher temperature than similar diesel exhaust systems. To* ***avoid*** *burns,* ***do not touch*** *exhaust components. Do* ***not*** *route lines or hoses which can deteriorate from heat near the exhaust gas components.*
- *To* ***prevent*** *suffocation and frostbite, wear protective clothing and ONLY disconnect fuel or liquid refrigerant (freon) lines in a well ventilated area. To protect the environment, liquid refrigerant systems* ***must*** *be properly emptied and filled using equipment that prevents the release of refrigerant gas (fluorocarbon) into the atmosphere. Federal law requires capture and recycling refrigerant.*
- *To* ***avoid personal injury****, use a hoist or get assistance when lifting components that weigh 23 kg [50 lb] or more. Make sure hooks are positioned correctly.* ***Always*** *use a spreader bar when necessary. The lifting hooks must not be side-loaded.*
- ***Always*** *shutdown your CNGE Spark-Ignited engine by either using an automatically operated fuel shutdown valve as close to the engine as possible or by shutting off the manual shutoff valve upstream of the gas flow pressure regulator and allowing the engine to burn off all residual fuel-gas. CNGE recommends that all fuel-gas be shut-off before turning off the ignition switch.*
- ***Always*** *close fuel line manual fuel shut-off valve before disassembly of engine or engine components.*
- *Use ONLY the correct crankshaft barring techniques for manually rotating the crankshaft. Do* ***not*** *attempt to rotate the crankshaft by pulling or prying on the fan or vibration damper. This practice can cause serious* ***personal injury****, property damage, or damage to the fan blade(s), causing premature fan failure.*
- *If an engine has been operating, and the coolant is hot, allow the engine to cool before you slowly loosen the filler cap and relieve the pressure from the cooling system.*
- *To* ***avoid*** *burns, be alert for hot component parts just after the engine has been shut off and hot fluids in lines, tubes and compartments.*
- *Relieve all pressure in the air, fuel, oil, and cooling systems before any lines, fittings, or related items are removed or disconnected. Be alert for possible pressure when disconnecting any device from a system that uses pressure. Do* ***not*** *check for pressure leaks with your hand. High pressure oil or water can cause* ***personal injury****.*
- *Corrosion inhibitor contains alkali. Do* ***not*** *get the substance in your eyes. Avoid prolonged or repeated contact with skin. Do* ***not*** *swallow internally. If skin is contacted, immediately wash with soap and water. If the eyes are contacted, immediately flood with large amounts of water for a minimum of fifteen minutes.* ***IMMEDIATELY CALL A PHYSICIAN. KEEP OUT OF REACH OF CHILDREN.***

- ***Always*** *use tools that are in good condition. Make sure you understand how to use them before performing any service work.*

- ***Always*** *use the same fastener part number (or equivalent) when replacing fasteners.* ***Do not*** *use a fastener of lesser quality if replacements are necessary.* ***Always*** *torque fasteners and fuel connections to the required specifications. Over-tightening or under-tightening can allow leakage.*

- ***Never*** *use gasoline or other flammable materials to clean parts.* ***Always*** *use approved cleaning solvent. Naphtha and Methyl Ethyl Ketone (MEK) are flammable materials and must be used with caution.* ***KEEP OUT OF THE REACH OF CHILDREN.***

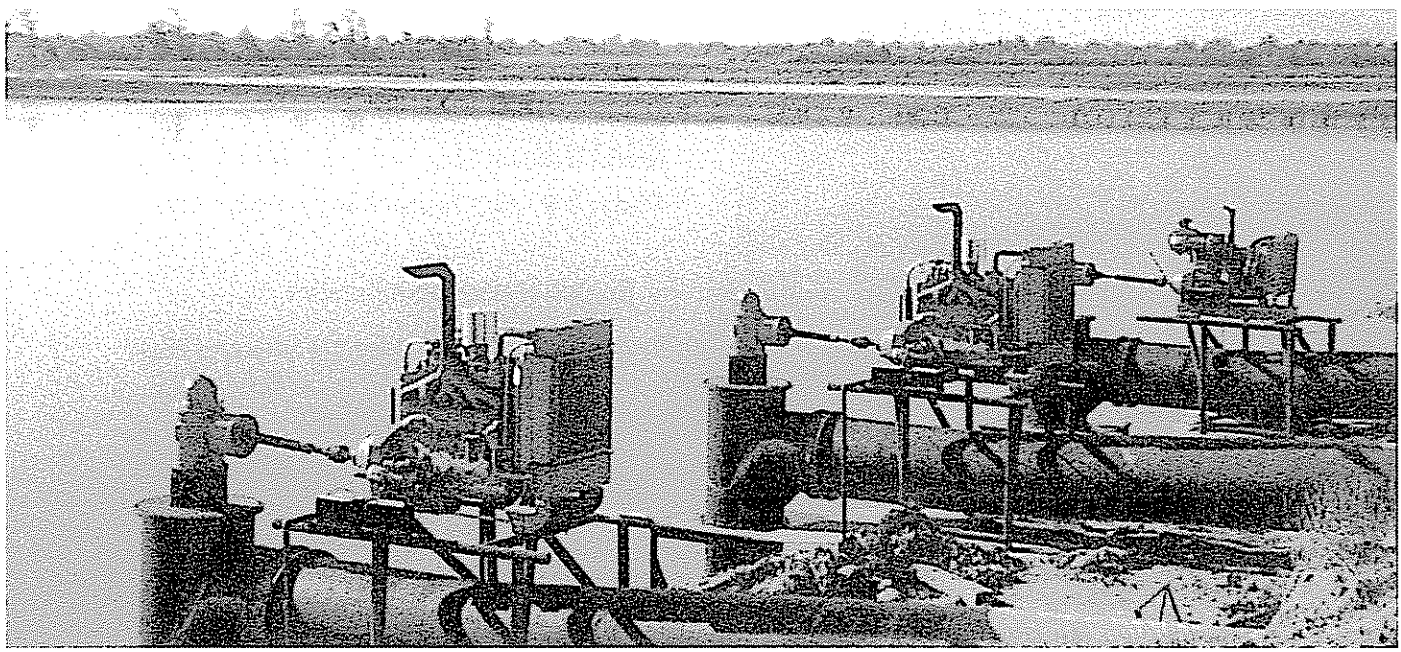
- *Use caution when working around a spark-ignited CNGE engine.* ***Never*** *expose the engine to an open flame or spark.*

- ***Never*** *use alcohol or gasoline based starting aids. Engines in proper tune require no intake spray starting aids. The uncontrolled use of spray starting aids may lead to fire or explosion of the air/fuel mixture in the intake manifold.*

- *Some state and federal agencies in the United States of America have determined that used engine oil can be carcinogenic and can cause reproductive toxicity.* ***Avoid*** *inhalation of vapors, ingestion, and prolonged contact with used engine oil.*

- *The CNGE spark ignited engine ignition system produces high voltage when the engines are operating.* ***Do not touch*** *any ignition wiring or components while the engine is operating unless you use suitably insulated tools. Failure to comply with this* ***warning*** *can cause serious shock.*

Notes:



Section 2
Engine & Component Identification

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Engine & Component Identification

Engine Identification

- **How to Identify Your Engine**

- **ENGINE DATA-PLATE**

Refer to the enclosed illustration for the data-plate location.

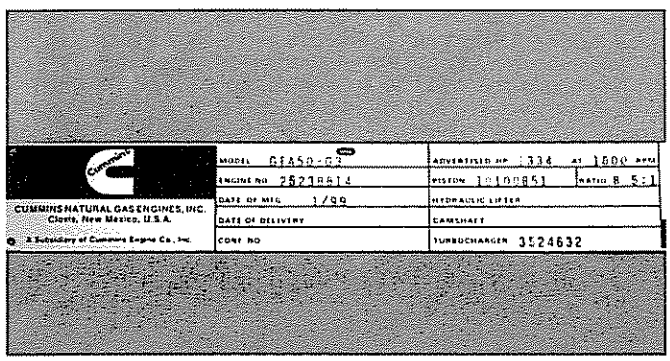


Photo # 2 - 01 - Engine Data-Plate

Note: The engine data-plate, must not be changed unless approved by CNGE.

The engine data-plate shows specific information about your engine, such as;

- Model Type.
- Engine Serial Number.
- Date of Manufacture.
- Date of Delivery.
- Configuration No.
- Advertised HP (Horsepower).
- Rated RPM (Revolutions Per Minute).
- Piston Part Number.
- Compression Ratio.
- Camshaft Part Number.
- Turbocharger Part Number.

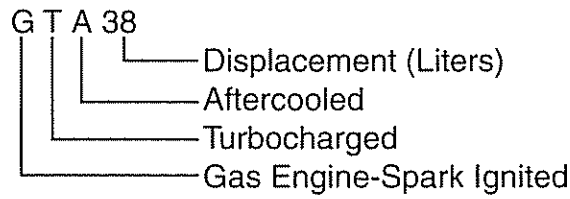
The date of delivery will be used as a starting point to measure warranty for the end user customer.

- **Turbocharger Data-Plate**

Photo # 2 - 02 - Turbocharger Data-Plate

- **Engine Model Identification**

The model name provides the following data:



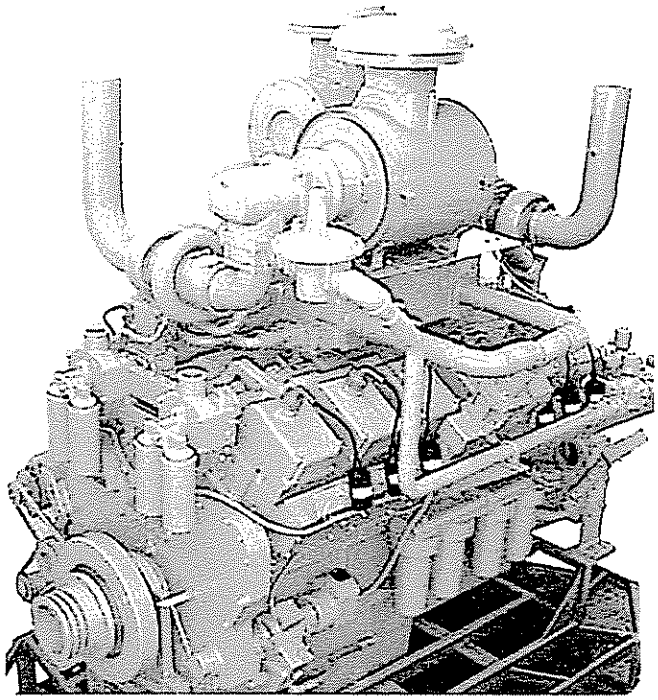


Photo # 2 - 03 - GTA38

External Engine Components

The illustrations that follow show the locations of the major external engine components, filters and other service and maintenance points. Some external components will be at different locations for different engine models.

Note: The illustrations are only a reference to show a typical engine.

Engine Diagram - GTA38

- **Left Bank View**

1. Turbocharger.
2. Support, Thermostat Housing
3. Housing, Thermostat.
4. Cover, Front Gear
5. Housing, Front Gear
6. Filter, Full-Flow Lubricating Oil (4 Shown)
7. Breather, Crankcase
8. Filter Head, Lubricating Oil
9. Housing, Flywheel
10. Cover, Cam Follower
11. Manifold, Intake
12. Bracket, Lifting
13. Manifold, Exhaust
14. Housing, Air Filter
15. IMPCO 600 Carburetor IMPCO 600
16. ASCO Fuel Shut-Off Valve
17. Ignition Generator - ALTRONIC III
18. Wiring Harness
19. Ignition Coils
20. Aftercooler Assembly
21. Governor Actuator

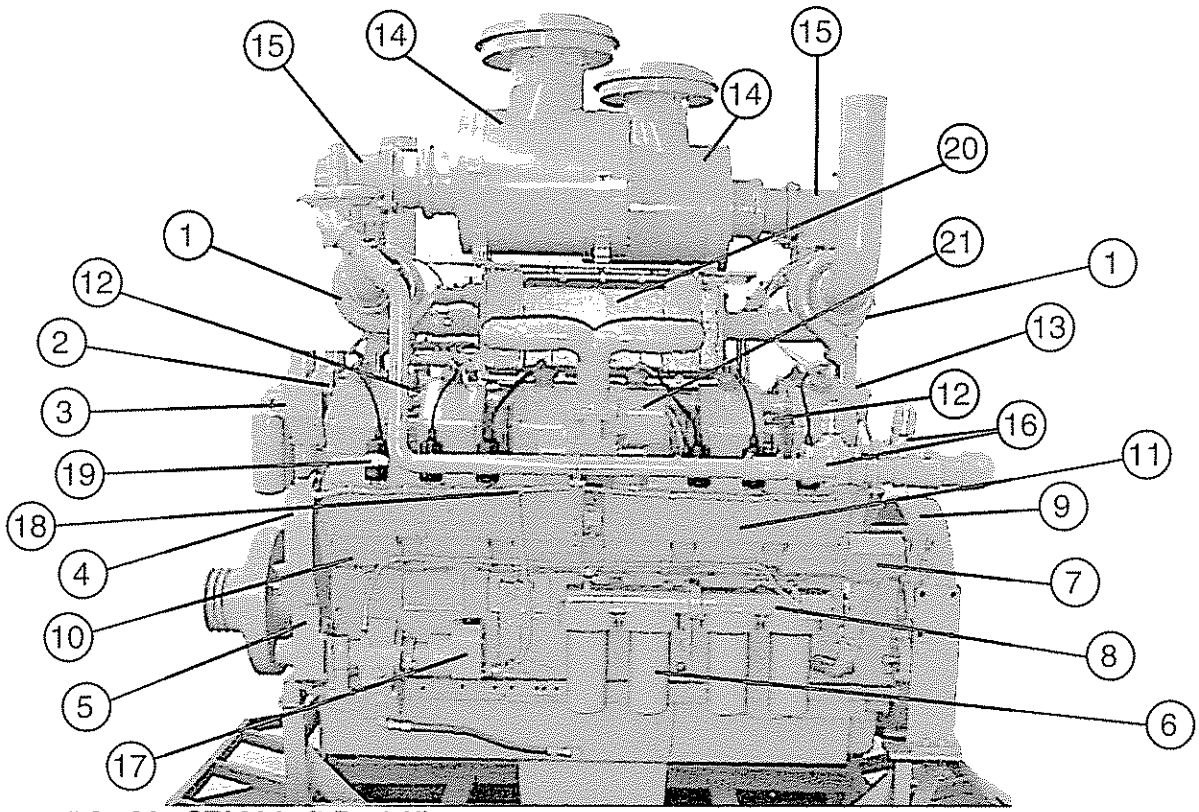


Photo # 2 - 04 - GTA38 Left Bank View

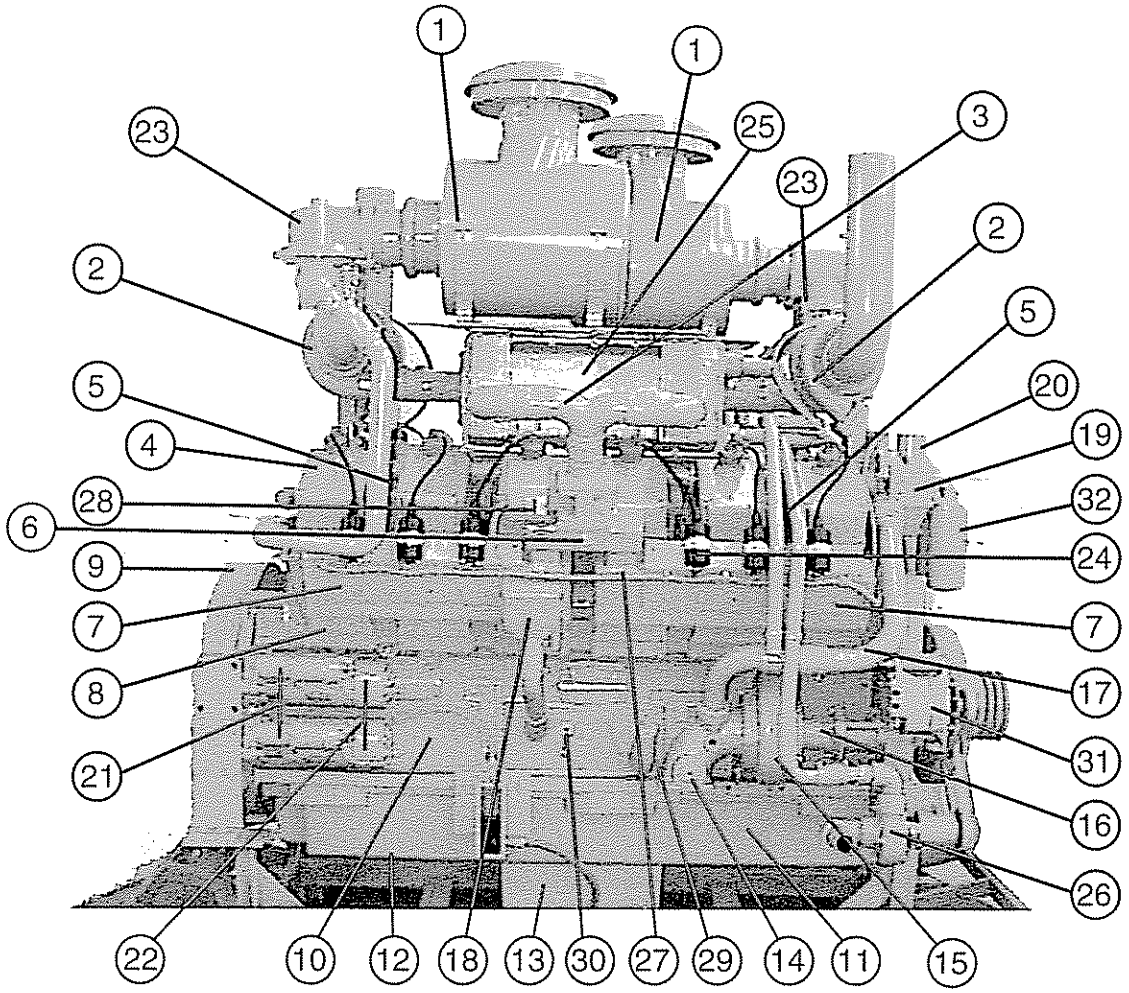


Photo # 2 - 05 - GTA38 Right Bank View

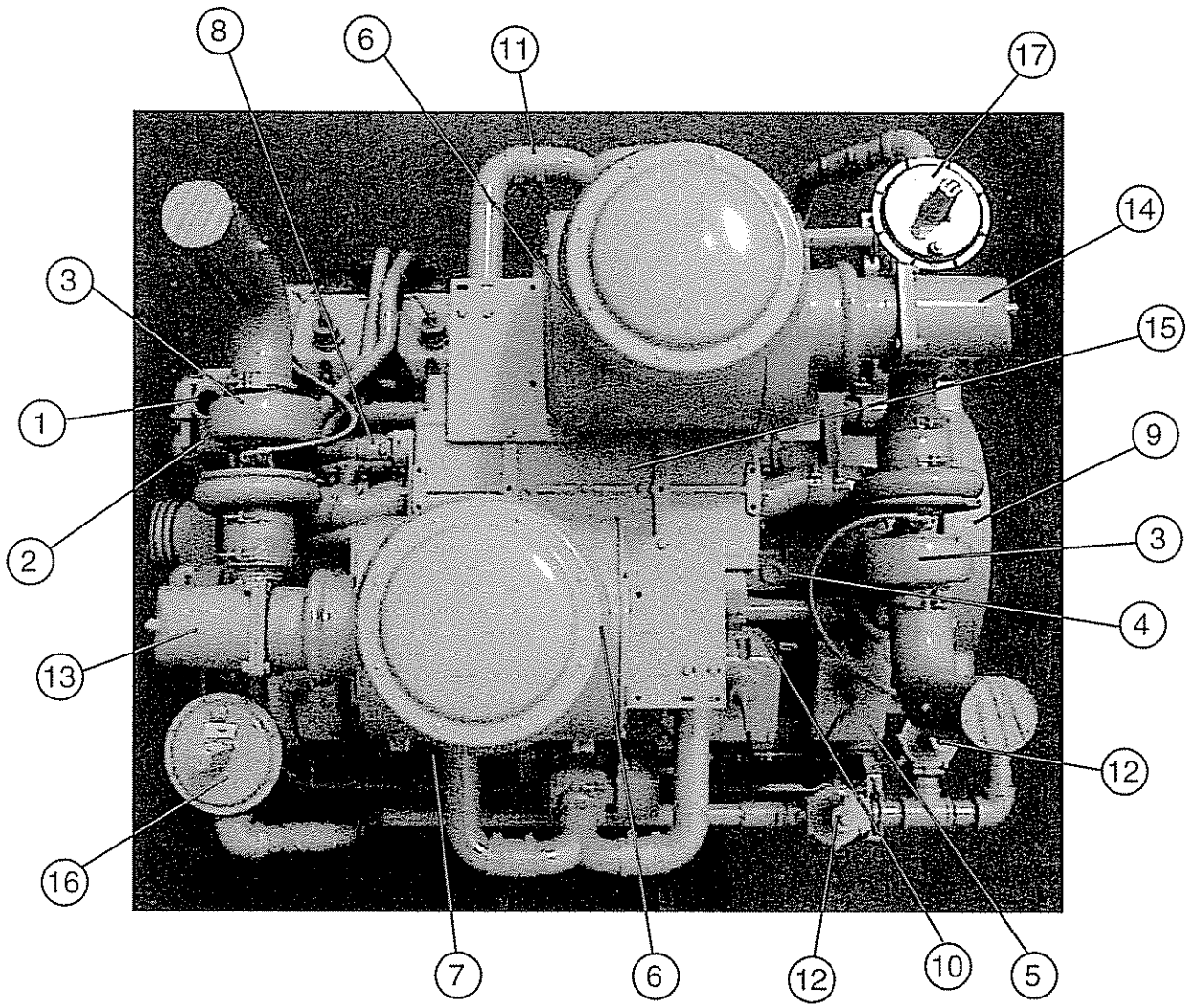
- **Right Bank View**

1. Housing, Air Filter
2. Turbocharger
3. Connection, Air Crossover
4. Cover, Rocker Lever
5. Bracket, Lifting (not seen behind gas and cooling pipes)
6. Connection, Air-Gas Intake
7. Manifold, Intake
8. Cover, Cam Follower
9. Housing, Flywheel
10. Cover, Hand Hole
11. Adapter, Oil Pan
12. Plate, Oil Pan Adapter Cover
13. Pan, Oil
14. Connection, Water Inlet
15. Pump, Water
16. Drive, Water Pump
17. Tube, Water By-pass
18. Breather, Crankcase
19. Housing, Thermostat
20. Connection, Water Outlet
21. Starter (Dual)
22. Starter Solenoid
23. Carburetor - IMPCO 600D
24. Ignition Coils
25. Aftercooler Assembly
26. Aux. Water Pump
27. Wiring Harness
28. Governor Actuator
29. Tube, Oil Fill
30. Gauge, Oil Level (Dipstick)
31. Alternator
32. Water Filter

Photo # 2-06 - Top View

- **Top View**

1. Outlet, Right Bank Water
2. Housing, Right Bank Thermostat
3. Turbocharger
4. Manifold, Left Bank Exhaust
5. Cover, Rocker Lever
6. Housing, Air Filter
7. Manifold, Intake
8. Manifold, Right Bank Exhaust
9. Housing, Flywheel
10. Housing, Rocker Lever
11. Crossover, Air
12. ASCO Shut-Off Valve
13. Carburetor - Left Bank IMPCO 600
14. Carburetor - Right Bank IMPCO 600
15. Aftercooler Assembly
16. RV91 Gas Regulator Left Bank
17. RV91 Gas Regulator Right Bank



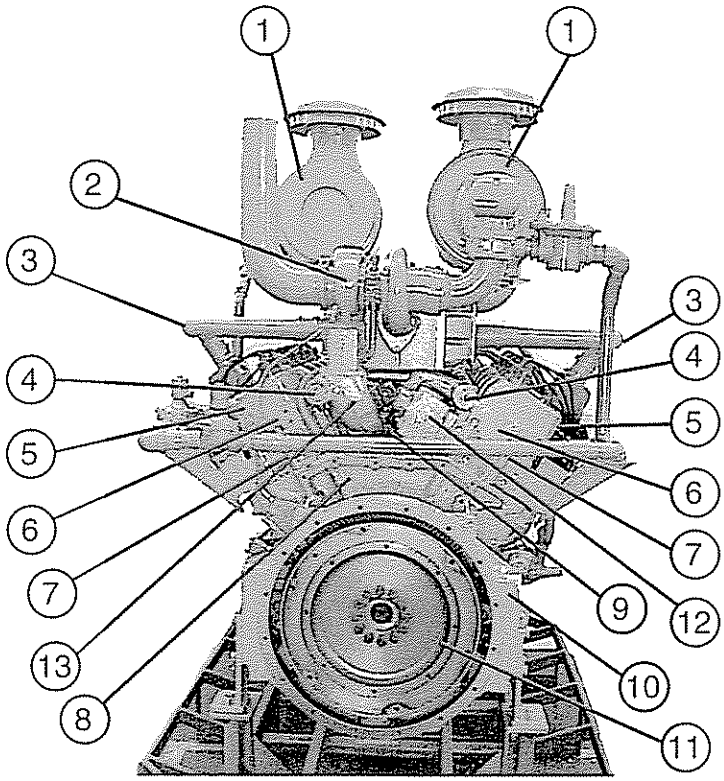


Photo # 2-07 - Rear View

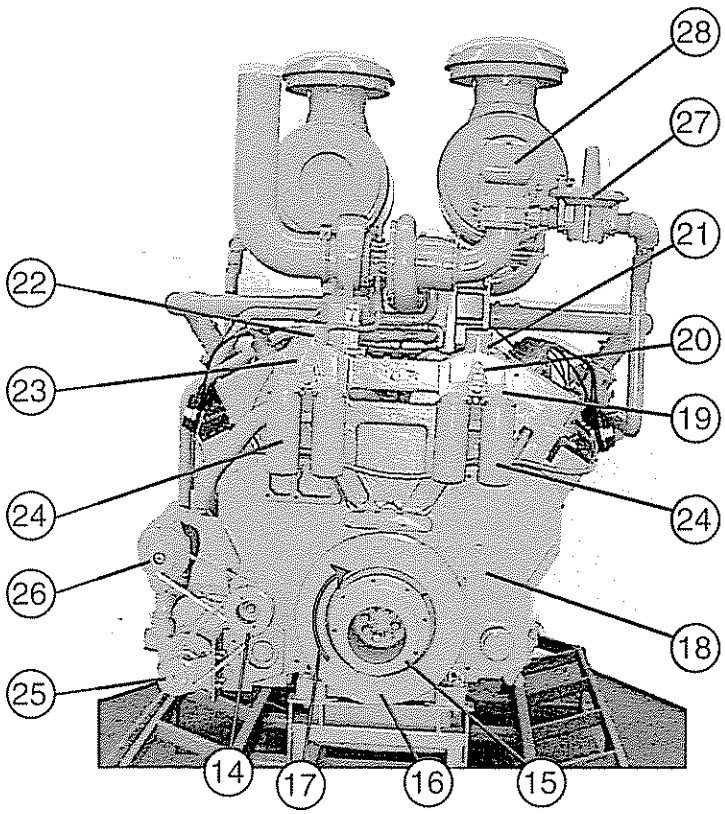


Photo # 2-08 - Front View

- **Rear and Front Views**

1. Housing, Air Filter
2. Turbocharger
3. Crossover, Air
4. Passage, Water Outlet
5. Cover, Rocker Lever
6. Housing, Rocker Lever
7. Head, Cylinder
8. Block, Cylinder
9. Cooler, Oil
10. Housing, Flywheel
11. Flywheel
12. Manifold, Right Bank Exhaust
13. Manifold, Left Bank Exhaust
14. Pulley, Alternator Drive
15. Pulley, Crankshaft
16. Damper, Vibration
17. Direction of Rotation
18. Cover, Front Gear
19. Head, Water Filter
20. Housing, Left bank Thermostat
21. Outlet, Left Bank Water
22. Outlet, Right Bank Water
23. Housing, Right Bank Thermostat
24. Filter, Water (4 Required)
25. Aux. Water Pump Pulley
26. Alternator
27. RV 91 Gas Regulator
28. IMPCO 600 Carburetor

The model name provides the following data:

G T A 50
- 50 — Displacement (Liters)
- A — Aftercooled
- T — Turbocharged
- G — Gas Engine-Spark Ignited

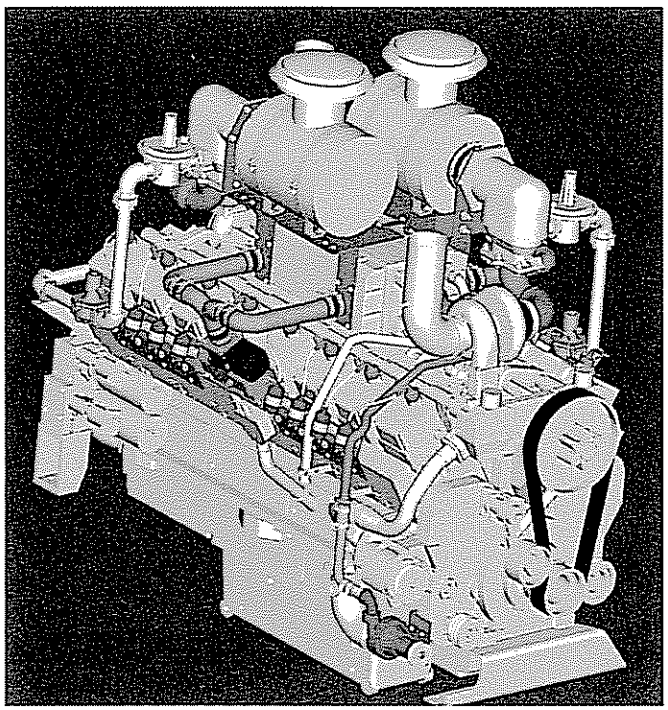


Photo # 2 - 09 - GTA50

Engine Diagram - GTA50

- **Left Bank View**

1. Turbocharger.
2. Support, Thermostat Housing
3. Housing, Thermostat.
4. Cover, Front Gear
5. Housing, Front Gear
6. Filter, Full-Flow Lubricating Oil (4 Shown)
7. Breather, Crankcase
8. Head, Lubricating Oil
9. Housing, Flywheel
10. Cover, Cam Follower
11. Manifold, Intake
12. Bracket, Lifting
13. Manifold, Exhaust
14. Housing, Air Transfer
15. IMPCO 600D Carburetor
16. ASCO Fuel Shut-Off Valve
17. Ignition Generator - ALTRONIC III
18. Wiring Harness
19. Ignition Coils
20. Aftercooler Assembly
21. Governor Actuator
21. Cover, Rocker Level

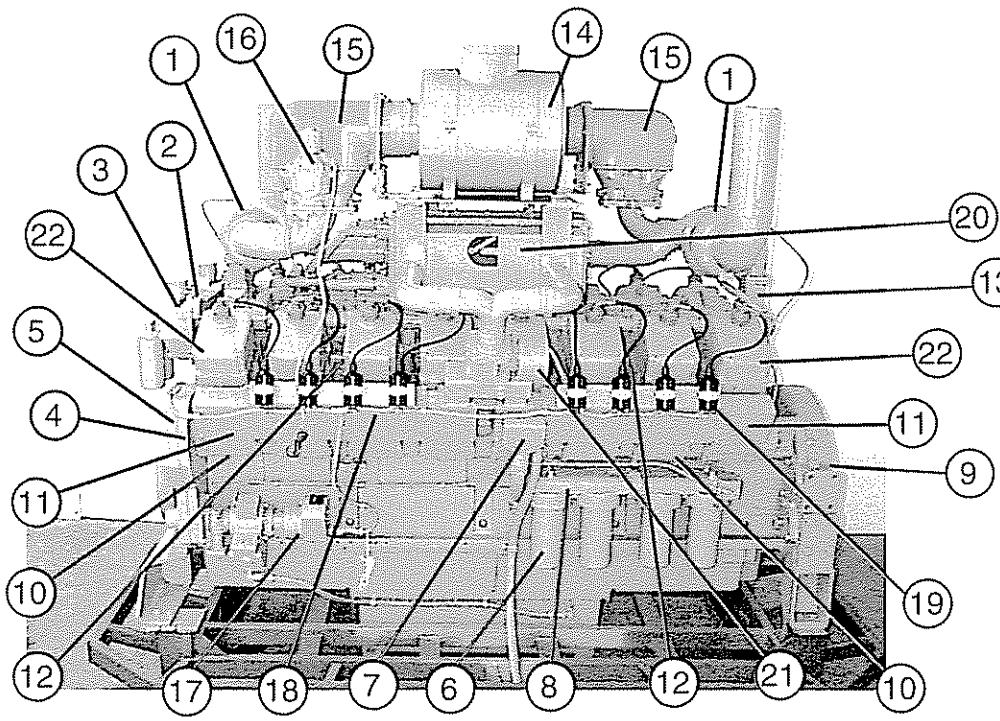


Photo # 2 - 10 - GTA50 Left Bank View

- **Right Bank View**

1. Housing, Air Filter
2. Turbocharger
3. Connection, Air Crossover
4. Cover, Rocker Lever
5. Bracket, Lifting
6. Connection, Air Intake
7. Manifold, Intake
8. Cover, Cam Follower
9. Housing, Flywheel
10. Cover, Hand Hole
11. Adapter, Oil Pan
12. Plate, Oil Pan Adapter Cover
13. Pan, Oil
14. Connection, Water Inlet
15. Pump, Water
16. Drive, Water Pump
17. Tube, Water By-pass
18. Breather, Crankcase
19. Housing, Thermostat
20. Connection, Water Outlet
21. Starter(Dual)
22. Starter Solenoid
23. Carburetor - IMPCO 600D
24. Ignition Coils
25. Aftercooler Assembly
26. Aux. Water Pump
27. Wiring Harness
28. Governor Actuator
29. Date Plate Engine
30. Gauge, Oil Level (Dip Stick)
31. Port Oil Fill
32. Delco Remy Alternator

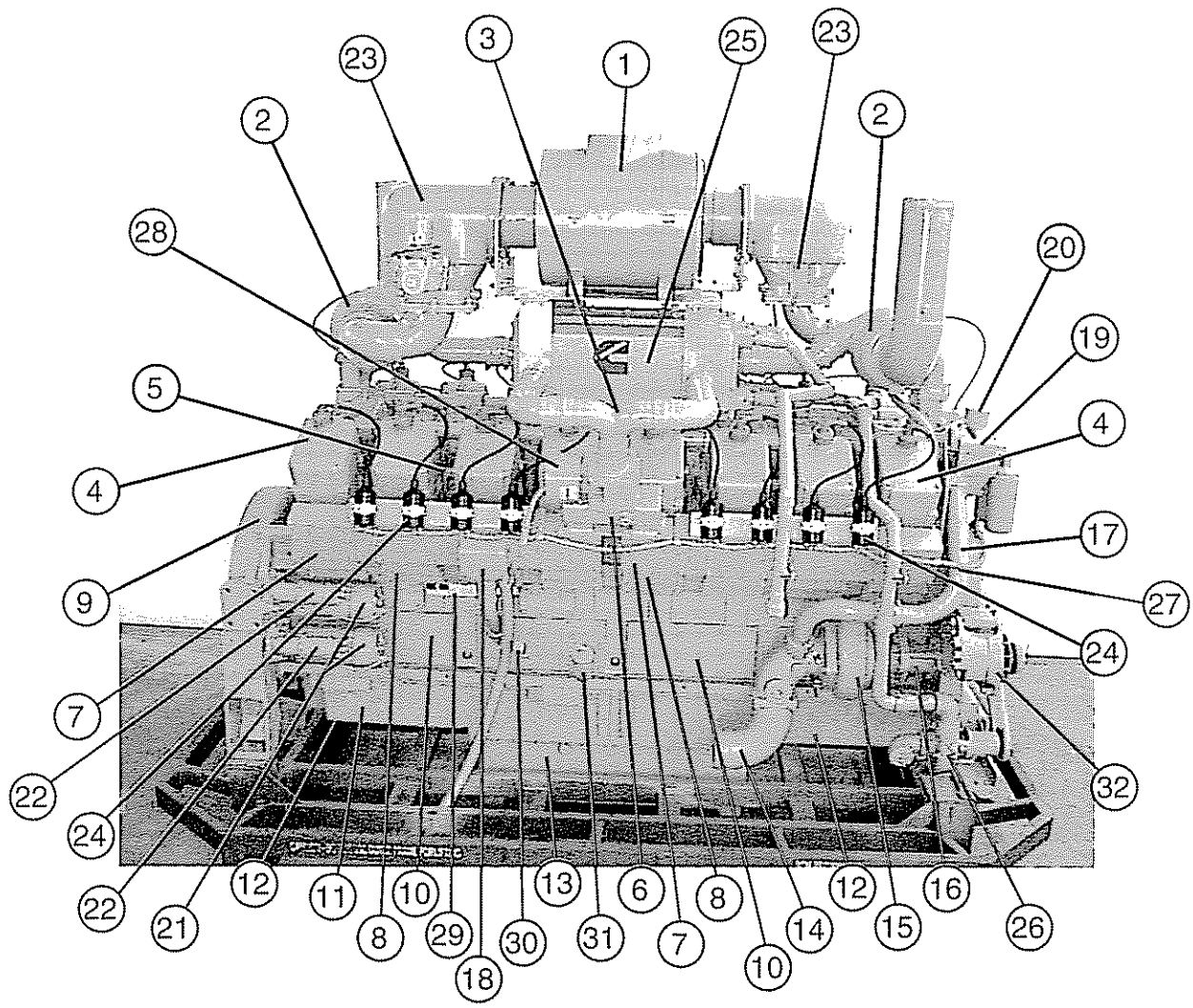


Photo # 2 - 11 - GTA50 Right Bank View

- **Top View**

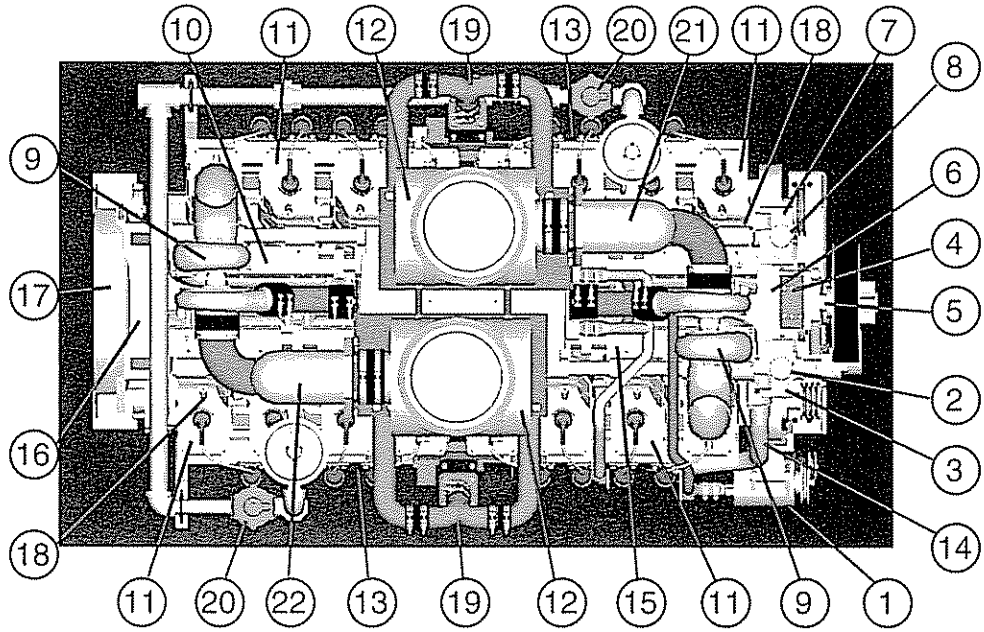


Photo # 2-12 - Top View

- **Top View**

1. Alternator
2. Outlet, Right Bank Water
3. Housing, Right Bank Thermostat
4. Bracket, Fan Hub
5. Shaft Fan Hub
6. Support, Thermostat Housing
7. Housing, Left Bank Thermostat
8. Outlet, Left Bank Water
9. Turbocharger
10. Manifold, Left Bank Exhaust
11. Cover, Rocker Lever
12. Housing, Air Filter
13. Manifold, Intake
14. Tube, Water Transfer
15. Manifold, Right Bank Exhaust
16. Housing, Rear Gear
17. Housing, Flywheel
18. Housing, Rocker Lever
19. Crossover, Air
20. ASCO Shut-Off Valve
21. Carburetor - Left Bank
22. Carburetor - Right Bank
23. Aftercooler Assembly (not shown- under air filter mount bracket)

- **Rear View**

1. Housing, Air Filter
2. Turbocharger
3. Crossover, Air
4. Passage, Water Outlet
5. Cover, Rocker Lever
6. Housing, Rocker Lever (not shown)
7. Head, Cylinder
8. Block, Cylinder
9. Cooler, Oil
10. Housing, Flywheel
11. Flywheel
12. Manifold, Right Bank Exhaust
13. Manifold, Left Bank Exhaust

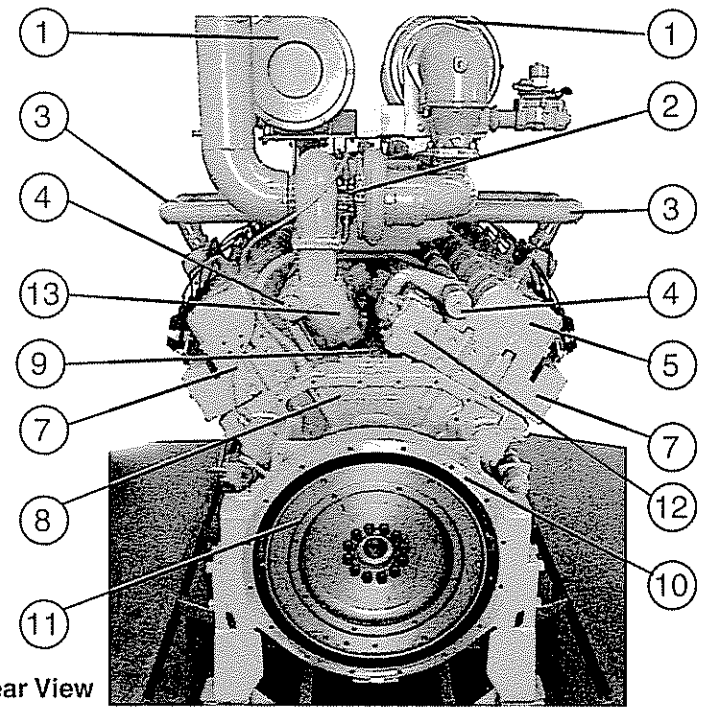


Photo # 2-13 - Rear View

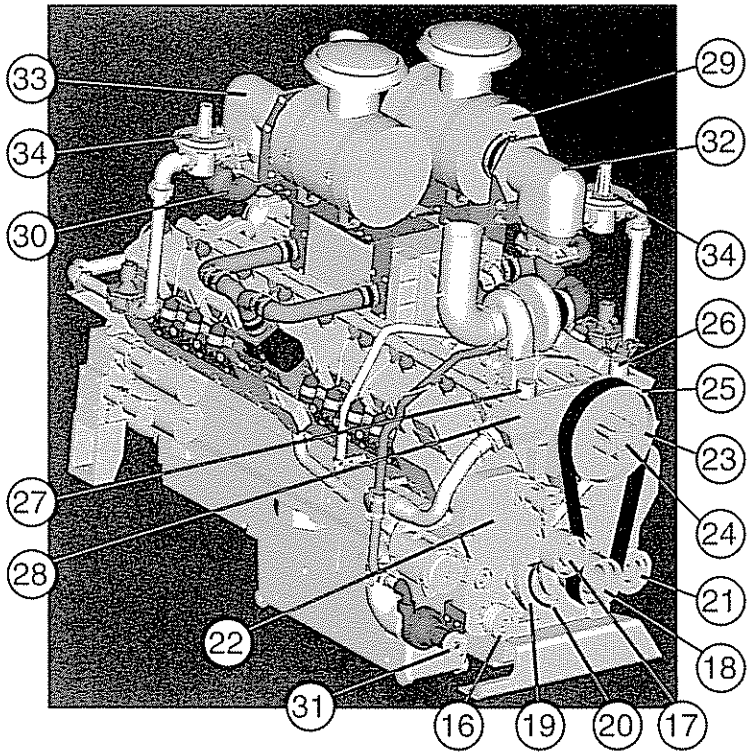


Photo # 2-14 - Front View - A

- **Front View - A**

16. Pulley, Alternator Drive
17. Pulley, Fan Idler
18. Pulley, Crankshaft
19. Damper, Vibration
20. Direction of Rotation
21. Pulley, Accessory Drive
22. Cover, Front Gear
23. Pulley, Fan
24. Hub, Fan
25. Housing, Left bank Thermostat
26. Outlet, Left Bank Water
27. Outlet, Right Bank Water
28. Housing, Right Bank Thermostat
29. Air Cleaner Housing - Front
30. Air Cleaner Housing -Rear
31. Aux. Water Pump Drive Pulley
32. Carburetor -Left bank
33. Carburetor - Right Bank
34. ASCO Shut-Off Valve

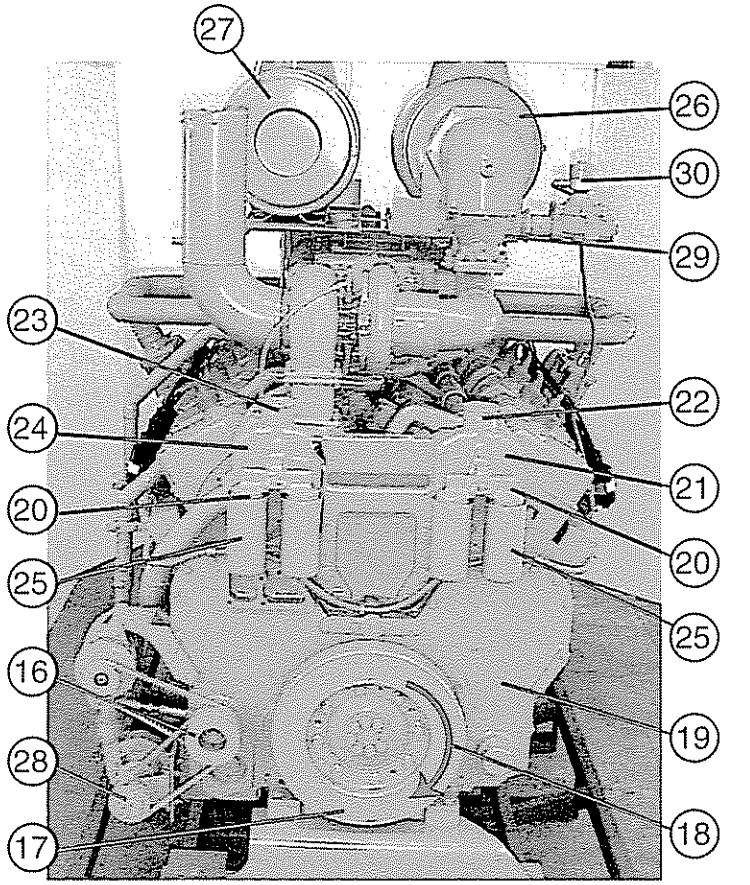


Photo # 2-15 - Front View - B

- **Front View - B**

16. Pulley, Alternator Drive
17. Damper, Vibration
18. Direction of Rotation
19. Cover, Front Gear
20. Head, Water Filter
21. Housing, Left bank Thermostat
22. Outlet, Left Bank Water
23. Outlet, Right Bank Water
24. Housing, Right Bank Thermostat
25. Filter, Water (4 Required)
26. Air Cleaner Housing - Front
27. Air Cleaner Housing -Rear
28. Aux. Water Pump Drive Pulley
29. Carburetor -Left bank
30. ASCO Shut-Off Valve

Notes:

Section 3
Operating Principles & Systems Information

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Operating Principles & Systems Information

Operating Principles

The most satisfactory service can be expected from a Cummins Natural Gas Engine, Inc. (CNGE) spark ignited engine when the operation procedures are based upon a clear understanding of the engine working principals. Each part of the engine affects the operation of every other working part and of the engine as a whole.

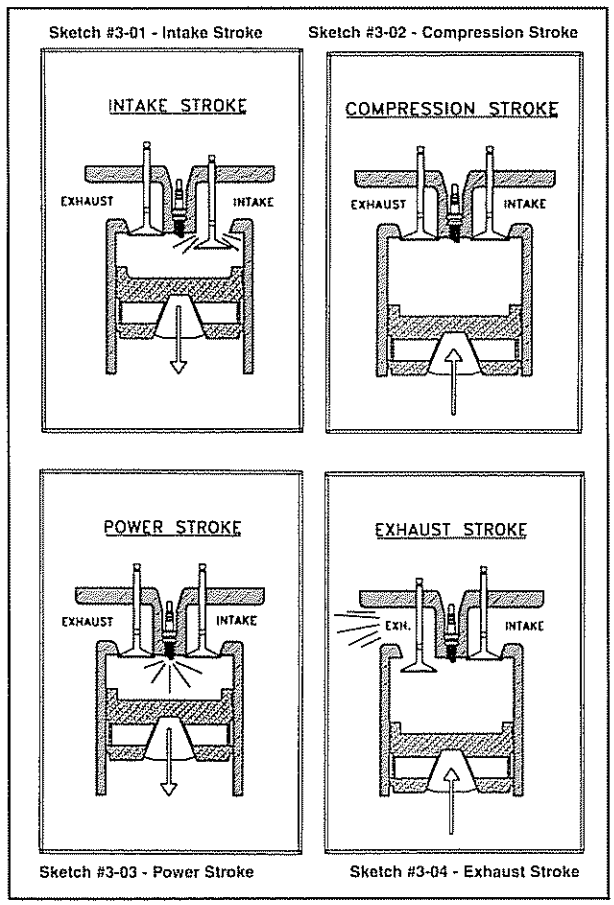
The CNGE Gas Engine

CNGE Gas Engines described in this manual are four-stroke-cycle engines that burn a spark-ignited, controlled mixture of natural gas and air. The recommended fuel gas should be dry pipeline quality natural gas.

Caution: Different fuel gases may require a change in hardware and plumbing of the fuel system to the engine as well as physical changes in hardware on and in the engine. Any fuel-gas other than dry pipeline quality natural gas will require CNGE factory approval.

The CNGE Cycle

It is easier to understand the function of the engine parts if it is known what happens in the combustion chamber during each of the four piston strokes of the cycle. The four strokes and the order in which they occur are Intake Stroke, Compression Stroke, Power Stroke, and Exhaust Stroke.



The CNGE Cycle

Intake Stroke

During the intake stroke, the piston travels downward permitting air and fuel mixture from the carburetor to enter the combustion chamber through the open intake valve(s).

Compression Stroke

The compression stroke starts at the end of the intake stroke. The intake valve(s) close and the piston starts upward on the compression stroke. The exhaust valves remain closed.

By the end of the compression stroke, the air and fuel mixture in the combustion chamber has been forced by the piston to occupy space significantly smaller than the volume occupied at the beginning of the stroke. This change in space is known as the compression ratio.

Power Stroke

Near the end of the compression stroke, the fuel is ignited by the spark plug. During the power stroke with both the intake and exhaust valve(s) closed, the burning fuel causes an increase in pressure above the piston. The increased pressure pushes the piston downward and adds impetus to the crankshaft rotation.

Exhaust Stroke

During the exhaust stroke, the intake valve(s) are closed, the exhaust valve(s) are open and the piston is on its upstroke.

Burned gases are forced out of the combustion chamber through the open exhaust valve port(s) by the upward travel of the piston.

Just slightly before the end of the exhaust stroke and at the very beginning of the intake stroke, the intake valve(s) open and a few degrees later the exhaust valve(s) will close. This is known as valve overlap and is required to remove the last of the remaining exhaust gases during that cycle.

The Fuel-Gas & Carburetion System

Type of Fuel-Gas

Fuel should be clean and must be free of acids, sulfur & halogen compounds, water, pipe scale and other foreign materials which could cause corrosion or abrasion of the cylinder liners, bearings and internal engine parts. Dry processed natural gas usually has the liquids removed and contain primarily methane and a small percent of ethane gases. This type of fuel gas is generally about 905 BTU/cu.ft. L.H.V. (Low Heat Value) and can be used in all CNGE engines that have been structured to run on "Dry Pipeline Natural Gas".

Located between the gas supply line and the engine intake manifold are the following components that make up the fuel system for a turbocharged GTA38 and GTA50 engine.

Low Pressure Natural Gas System

1. Gas Filter.
2. Flexible Pipeline Connection.
3. Manual or Automatic Gas Shut-Off Valve.
4. Off - Engine Mounted Gas Flow Pressure Regulator.
5. Dual Carburetor (Before Turbocharger on TA Engine) (One on each bank).
6. Throttle Butterfly Valve (Woodward Flo-Tech Actuator)(After Turbocharger on TA Engine).

Note: On a turbocharged engine the carburetor power valve and the carburetor air mixer valve are mounted upstream on the low-pressure side of the turbocharger. Downstream of the turbocharger will be a water-to-air aftercooler system located before the Woodward Flo-Tech Actuator. The Woodward Flo-Tech Actuator is mounted to the top of the intake manifold.

Low Pressure Natural Gas Components

Manual Gas Shut-Off Valve

This valve, on a dry pipeline natural gas system, will generally be found upstream of the main line regulator and is normally supplied by the local gas utility.

On propane systems this valve will be found at the propane supply tank and will be on the top of the tank for a propane vapor system and on the bottom of the tank for a propane liquid system.

Caution: Operators should always know the location of the manual gas shut-off valve in cases of an emergency need to shut off the fuel-gas supply.

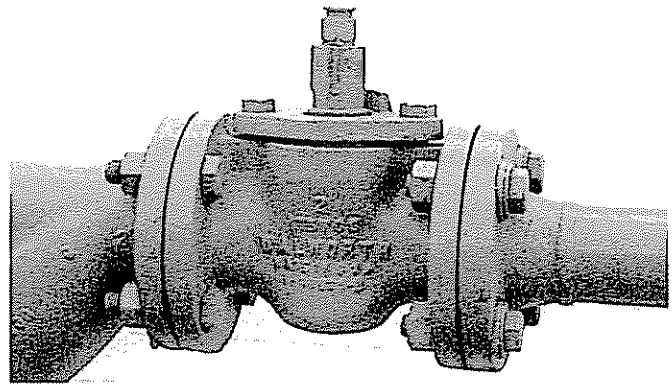


Photo #3-01 - Manual Gas Shut-Off Valve

Main Line Gas Flow Pressure Regulator

The main line gas flow pressure regulator is required to reduce the gas pressure from its line pressure down to a maximum of 125 psi or less. The minimum pressure will depend on the pressure drop between the main line gas flow pressure regulator and the on-engine mounted gas flow pressure regulator required to reduce the gas pressure to the engine carburetor to 4 to 6 inches of water column pressure at maximum load conditions.

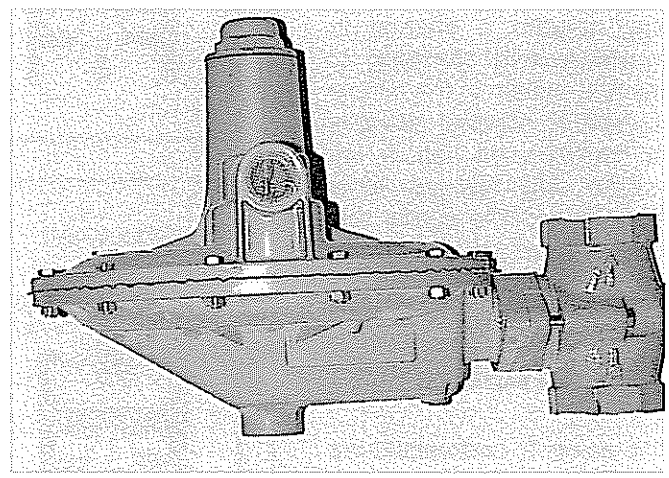


Photo #3-02 - Line Pressure Regulator

Pipeline

The pipeline must be sized so that the required maximum fuel-gas flow is supplied to the on-engine gas flow pressure regulator. The pipeline system should be capable of producing the required amount of gas flow, so that the gas flow pressure from the on-engine gas flow pressure regulator to the engine is at 4 to 6 inches of water column pressure under full load condition. Refer to the appropriate engine data-sheet for the correct minimum pipe size at the engine and the maximum amount of fuel-gas required.

Note: The number of elbows, bends and long pipe runs can introduce sufficient pressure losses to effect the gas flow through the pipeline. For proper sizing contact the local gas utility and advise them on the maximum required gas flow and the minimum required gas pressure to be supplied to the engine.

Gas Filter

The CNGE gas filter is a single pass element made of fiberglass and is capable of filtering down to 5 micron particle size. The filter should be inspected on a regular basis and replaced when necessary. Refer to the appropriate maintenance chart for your respective CNGE engine model. Due to the large amount of gas flow the GTA50 may require two gas filters mounted in parallel.

The filter may plug prematurely if subjected to liquid contaminants in the fuel-gas causing a restriction of gas flow.

Caution: It is important that the filter is installed with the gas flow going from the outside of the element towards the inside of the element.

CNGE recommends that the gas fuel filter be installed before the engine mounted regulator and supported by the incoming fuel line. The filter is rated at a maximum pressure of 100 psi. Operating pressure will depend on the manufacturer & model of the main line gas flow pressure regulator. CNGE also recommend that a gas flow shutoff valve (manual or electric) be installed between the line gas flow regulator and the gas filter.

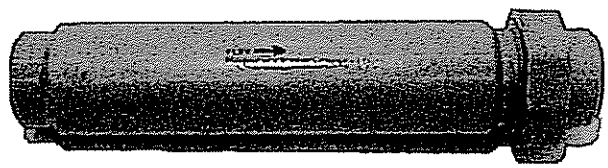


Photo #3- 03 - Gas Filter

Flexible Fuel-Gas Pipeline Connection

The fuel-gas pipeline must be connected to the engine fuel inlet systems by means of a flexible, reinforced and fire resistant hose. The hose should be of the same size I.D. as the pipeline and must meet all local codes.

Manual or Automatic Gas Shut-Off Valve

A gas shut-off valve must be mounted between the line pressure regulator and the gas filter to assure a positive gas shut-off. The valve may be operated manually, electrically, or actuated from the ignition system or from any shutdown safety device such as low oil pressure or low water level, etc.

Caution: When installing the gas shut-off valve it is important to check that the arrow (if equipped) is pointing in the direction of gas flow.

Caution: Do not mount gas shut-off valve between the engine mounted regulator and the carburetor.

Warning: DO NOT OPERATE A GAS ENGINE WITHOUT A GAS SHUT-OFF VALVE.

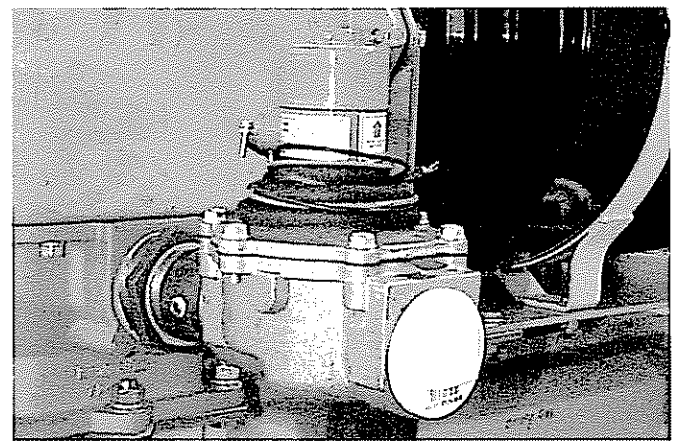


Photo # 3 - 04 - Automatic Gas Shut-Off Valve

Engine Mounted Gas Flow Pressure Regulator

The GTA38 and GTA50 will use two on-engine mounted gas flow pressure regulators, one for each bank.

The on-engine mounted gas flow pressure regulator will reduce the gas pressure at the engine down to a working pressure at the carburetor of from 4 to 6 inches of W.C. (water column). Refer to Table 3-01 Gas Flow Pressure Regulators.

Table 3 - 01 - Gas Flow Pressure Regulators

Engine Model	Regulator	Max. Gas Flow (cu ft./hr.)
GTA38	RV91 (2)	9100 @ 1800 RPM
GTA50	RV91 (2)	11,600 @ 1800 RPM

Note: All gas flow regulators have been sized for a gas flow with a Low Heat Value (LHV) of 905 BTU at 0.6 specific gravity @ 16 °C (60 °F).

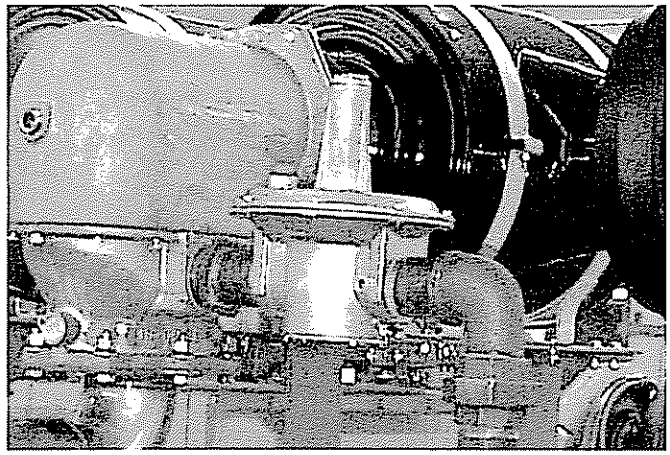


Photo # 3 - 05 - Gas Flow Pressure Regulator

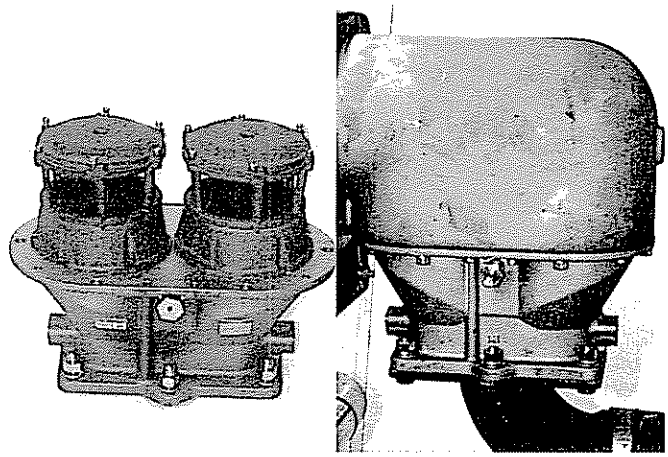


Photo # 3 - 06 - Carburetor - IMPCO Dual 600

Carburetor

Air-gas flow through the carburetor is controlled by an air-gas valve. The air-gas valve meters both air and gas in proper proportions at any throttle setting. It also seals off gas flow when the engine is shut down and provides automatic choke action for starting.

The working parts consist of an Air Measuring Valve (Bullet Valve) mounted on a diaphragm. Mounted within the cup of the Air Measuring valve is the Gas Metering Valve. A metering spring is mounted above the valve assembly. The Dual 600 carburetor doesn't have a closed position and as such requires that the engine have a shut-off valve. The shut-off valve can be either manual or automatic.

As air is drawn through the carburetor into the engine, the metering spring causes a pressure drop below the Air Measuring Valve. The pressure drop is transferred to the top of the diaphragm. The lowered pressure above the diaphragm allows the atmospheric pressure below the diaphragm to raise the assembly a distance that is directly proportional to the volume of air passing through the carburetor, thus making the assembly an Air Measuring Device. The Gas Metering Valve that is connected to the assembly will also rise and will measure the correct amount of gas for any height that the Air Measuring Valve rises.

The carburetor inlet gas pressure should be between 4 to 6 inches of WC (water column) from no load to full load condition when operating with dry processed natural gas fuel.

Adjustment of Carburetor Air-Gas Power Valve

IMPCO Model # Dual 600 Carburetor

On the model Dual 600, the power valve can be identified as a hex-head screw with a spring on the side of the carburetor. The adjustment would be to turn the screw in a clockwise "CW" direction to adjust toward the lean mixture and turn out in a counterclockwise "CCW" to adjust rich.

The adjustment is made with the engine at operating temperature and under a full load condition. An oxygen meter is used to measure the excess oxygen in the exhaust system. The measurement of excess oxygen is taken downstream of the turbocharger exhaust gas outlet or downstream of the exhaust manifold outlet flange on a naturally aspirated engine.

Caution: The GTA50 uses a single IMPCO Dual 600 carburetor on each bank of the engine. CNGE recommend that both carburetors be adjusted at the same time until the desired factory excess oxygen level is obtained. Never adjust more than 1/4 (90 Degrees) of a turn in either direction, "CW" or "CCW",) at a time on each power adjusting screw until the desired excess oxygen level is obtained.

Caution: If the two banks are out of adjustment with respect to each bank, turn both power valves in a "CW" direction until they fully seat and back out two full turns. Start your adjustment process from this point.

For additional information on how to measure the excess oxygen refer to the technical specification section.

Table # 3 - 02 - CNGE Carburetors

Engine Model	Carburetors
GTA38	IMPCO Dual 600
GTA50	IMPCO Dual 600

Refer **Table # 3-02** for the appropriate carburetor for your specific engine.

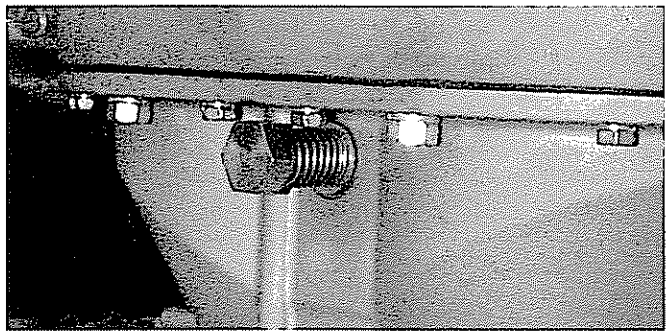


Photo # 3 - 07 - Power Valve - IMPCO Model Dual 600

Governor System

Woodward Flo-Tech Governor Actuator & Speed Control

The last component of the fuel system is the throttle butterfly. The butterfly is part of the Woodward Flo Tech Actuator. The Woodward Flo-Tech Actuator is part of the Governing System of the engine. The Flow-Tec Actuator receives changes in electrical impulses from the Flo-Tech Speed Control allowing the actuator to maintain basic isochronous speed control. The actuator either opens or closes the throttle butterfly valve allowing the engine to more or less air-gas mixture in the intake manifold thus allowing the engine to produce more or less BHP.

Throttle linkage is not required when using the Woodward Flo-Tech Actuator and Flo-Tech Speed Control on the GTA38 & GTA50 engine models.

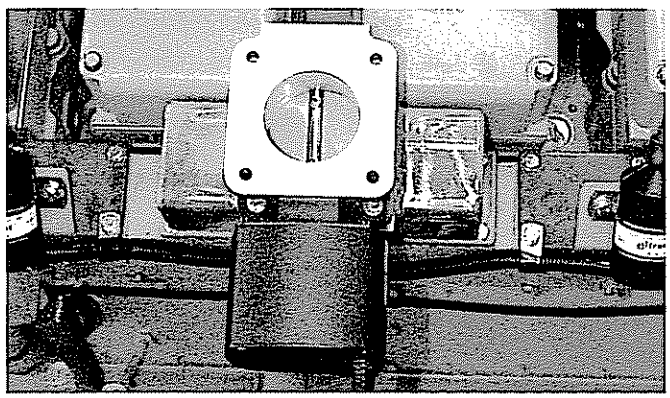


Photo # 3 - 08 - Woodward Flo-Tech Actuator

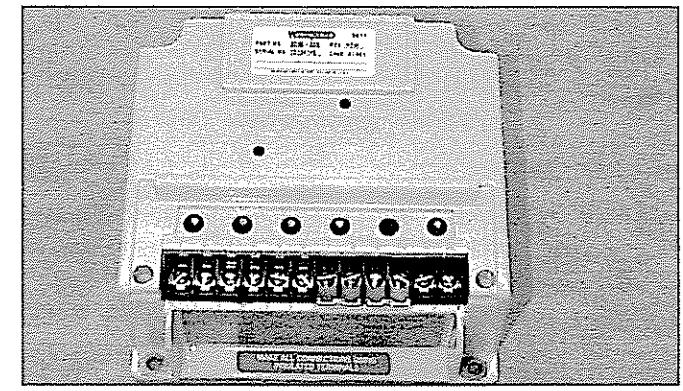


Photo # 3-09 - Woodward Flo-Tech Speed Control

The Ignition System

CNGE use ignition systems supplied by ALTRONIC, Inc.

ALTRONIC III

The ALTRONIC III unit is a self-powered, low tension, capacitor discharge ignition system consisting of an 8 pole permanent magnet alternator, timing & distribution circuits. A wiring harness and one ignition coil per cylinder complete the system.

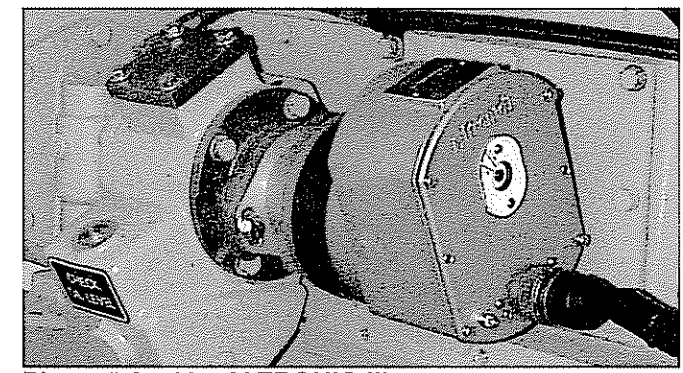


Photo # 3 - 10 - ALTRONIC III

Table # 3 - 03 - Ignition Systems

Engine Model	ALTRONIC
GTA38	III
GTA50	III

Table # 3 - 04 - Ignition Timing Values

Engine Model	Timing DBTDC Natural Gas
GTA38	20-24
GTA50	19-21

The Lubrication System

CNGE engines are pressure lubricated. The pressure is supplied by a positive displacement gear driven oil pump.

A pressure regulator is mounted in the lubricating oil pump. When the regulator is open some of the oil will be by-passed to the oil pan. When the valve is closed all of the oil will be supplied to the oil cooler.

On the GTA38 & GTA50 the oil flow is through the oil cooler and on to the oil filter. The GTA38 uses a bank of four full flow filters. The GTA50 uses a bank of four or five full flow filters.

Note: The GTA38 & GTA50 are not supplied with a by-pass filtration system as standard on the engine for the G-Drive emergency standby market. CNGE recommends that a by-pass lube oil filtration system be installed for long term durability considerations.

The oil then flows to the main oil rifle and throughout the various drillings and passages in the engine.

Oil to the turbocharger is taken off of the camshaft bushing housing directly to the turbocharger.

Some applications may also require a supplemental oil system to increase the oil capacity for extended oil drain periods. Refer to **Table # 3-05** Oil Pan Capacities.

Caution: Extension of oil drain periods should be done by using a good oil analysis program. The addition of more oil will not necessarily allow for oil drain extension.

A by-pass valve is provided in the full flow oil filter as insurance against interruption of oil flow by a dirty or clogged element.

Table # 3-05 - Oil Pan Capacities

Engine Model	Capacity - Gallons(Liters)
GTA38	37 (140)
GTA50	54 (204)

Engine Lubricating Oil

The use of a high quality lubricating oil combined with appropriate oil drain and filter change intervals is a critical factor in maintaining engine performance and durability.

Recommended Oil Specifications

Cummins Natural Gas Engines, Inc. recommends the use of a **high quality SAE 15W40 heavy duty natural gas engine oil** that meets the **American Petroleum Institute (API)** performance classification CD.

A **maximum sulfated ash limit of .85 mass percent** or below is suggested for optimum valve and piston deposit and oil consumption control. A **minimum ash content of .15 mass percent is required for CNGE spark ignited engines.**

Caution: Some catalytic manufacturers require that the sulfated ash content not exceed .5 mass percent. Also certain additives can be harmful to the proper operation of a catalyst. Contact your respective catalytic manufacturer for operation & maintenance requirements as well as ash limit & other restrictions.

Arctic Operation

If an engine is operated in ambient temperatures consistently below -23° C (-10° F) and there are no provisions to keep the engine warm when it is not in operation, use a CE/SF engine oil with adequate low temperature properties such as a synthetic 5W-20 or 5W-30.

The oil supplier must be responsible for meeting the performance specifications required for natural gas engines.

Caution: The use of synthetic base oil does not justify extended oil change intervals. Extended oil change intervals can decrease engine life due to factors such as corrosion, deposits, and wear.

New Engine Break-in Lubricating Oils

Special "break-in" engine lubricating oils are not recommended for new or rebuilt CNGE engines. Use the same type of oil during the "break-in" period that is used in normal operation.

Caution: Operation of CNGE engines with concentrations of Sulfur above 10 PPM will require the use of high **sulfated ash oils**. Higher ash oils can cause short spark plug like, valve or piston damage, deposit buildup on electronic sensors and can lead to excessive oil consumption.

Additional information regarding lubricating oil availability throughout the world is available in the E.M.A. Lubricating Oils Data Book for Heavy Duty Automotive and Industrial Engines. The data book may be ordered from:

Engine Manufacturers Association
401 N. Michigan Avenue, Ste 2400
Chicago, Ill. U.S.A. 60611
Telephone: (312) 644-6610 X3626

The Cooling System

Cummins Natural Gas Engines, Inc. recommends that all cooling systems used on CNGE engines be of a design that offers de-aerating features with properly designed radiator top tanks or through the addition of de-aerating surge tanks when using heat exchanger cooling. This type of system is required for both the engine jacket cooling system and for the water-to-air aftercooler cooling system.

On the GTA38 & GTA50, coolant is circulated by a gear driven centrifugal-type water pump. The water pump is mounted on the right bank side behind the gear cover. Refer to **Photo # 3-11.** The coolant flows past the oil cooler, past the cylinders, and on to the cylinder heads. The coolant flows from the cylinder heads through a water manifold on to the thermostat housing and water-cooled exhaust manifold. At this point the coolant may be re-circulated back to the water pump and on to the radiator or heat exchanger as the thermostat opens.

The engine jacket cooling system should contain fill lines to the suction side of the engine jacket water pump and vent lines from the highest point of the engine jacket cooling system before the thermostat to the highest point on the top of the radiator or surge tank.

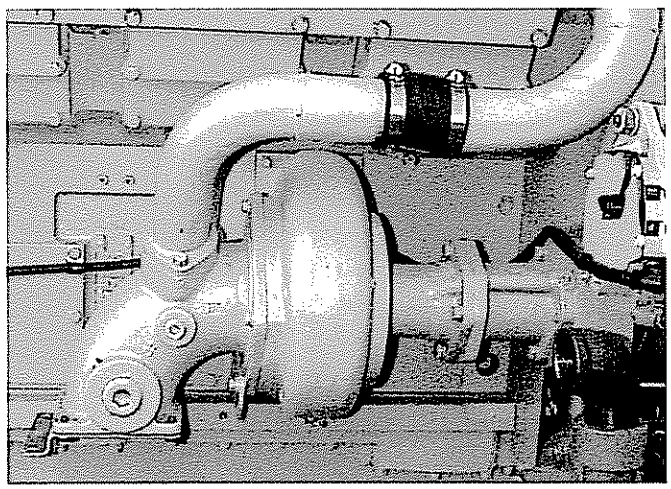


Photo # 3-11 - Engine Water Pump

Coolant Recommendations

Cummins engines require a balanced coolant mixture of water, antifreeze, and supplement coolant additives. This can be best accomplished by using **Fleetguard's Compleat™**. **Compleat™** comes in either a concentrate mixture that is used with a high quality water or in a premix, where no additional water is required. Drain and replace the mixture every two years or 6000 hours, whichever occurs first.

When not using **Fleetguard's Compleat™**, CNGE recommends the following;

1. DCA4™ is recommended for use in all Cummins engines.

2. In climates where the temperature is above -37° C [-34° F], use a coolant mixture that contains 50 percent antifreeze. Antifreeze is essential in any climate. It broadens the operating temperature range by lowering the coolant freeze point and by raising its boiling point.

   Do not use more than 50 percent antifreeze in the mixture unless additional freeze protection is required.

   Caution: Never use more than 68 percent antifreeze under any condition.

3. Use low silicate antifreeze that meets Engineering Standard GM 6038-M or that contains no more than 0.1 percent anhydrous alkali meta-silicate and meets either Engineering Standard GM 1825-or GM 1899-M that are performance specifications.

4. Use soft water in the coolant mixture. Contaminants in the hard water neutralize the corrosion inhibitor components. Water must not exceed 300ppm hardness or contain more than 100ppm of either chloride or sulfate.

5. Maintain supplemental coolant additive levels at 1 unit of DCA4™ per 3.8 liters [1 U.S. Gallon] of coolant by changing the coolant filter at each lubricating oil and filter change interval.

   Cummins recommends the use of DCA4 for the following reasons:

1. Improved compatibility with high-silicate antifreezes to minimize hydro-gel formation if over-concentration occurs.

2. Provides engine protection in the following areas:

   - Solder corrosion/bloom.
   - Oil Fouling.
   - Aluminum cavitation corrosion.
   - Copper corrosion/erosion/stress cracking.
   - Liner cavitation/corrosion.
   - Seal and gasket degradation.

Aftercooler Circuit- Water to Air

Whenever water-cooled aftercoolers are used on turbocharged Cummins Natural Gas Engines, an auxiliary water pump circulates water through the aftercooler and through a separate heat exchanger or radiator core. A deaerating expansion tank with a separate section for the aftercooler circuit is also required for this system.

The aftercooler cooling system should contain a fill line to the suction side of the auxiliary aftercooler water pump and vent lines from the highest point of the aftercooler system to the top of the radiator or surge tank.

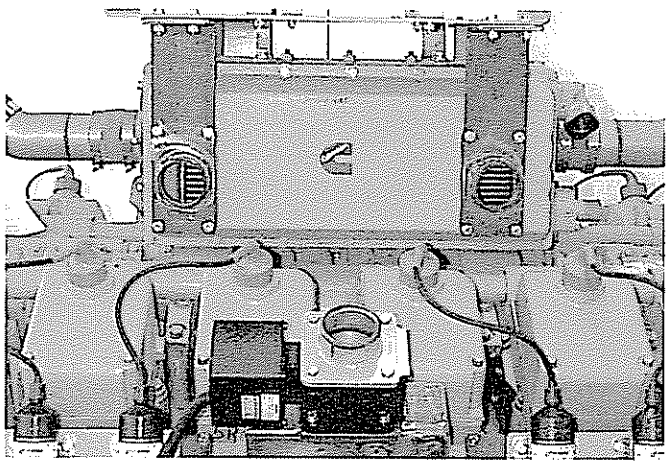


Photo # 3 - 12 - Aftercooler Heat Exchanger - Water - to-Air

The Air Intake System

The required function of the air intake system is to supply clean dry air to the engine without excessive restriction and at a temperature consistent with good engine efficiency.

The total system design should provide minimum intake restrictions to maintain an adequate airflow to the engine for good air-fuel mixture. Refer to your engine datasheet for allowable intake restriction and CFM of airflow.

The air cleaner is generally mounted on the engine and can be either a single stage or a two-stage dry type paper element with a safety element depending on the application.

Air is routed from the air cleaner directly to the carburetor, where it mixes with a metered amount of fuel gas and is dispersed into the intake manifold and on to the cylinders.

On the turbocharged model with a low-pressure system the air will be mixed in the carburetor before the turbocharger.

Caution: Spark-Ignited gas type engines are more critical on the air cleaner restriction than diesel engines. As the air cleaner restriction increases the air-fuel mixture will become rich, increasing the combustion & exhaust gas temperature.

The Exhaust System

The GTA38 & GTA50 turbochargers are top mount with side out exhaust. The right bank turbocharger is mounted at the top-front and the left bank is mounted at the top-rear. The turbocharger outlet stack has been provided with the necessary openings for recording excess oxygen and exhaust gas stack temperature in the exhaust gas stream.

Some locations and applications may require the use of catalytic converters, mufflers, silencers or flame arrestors.

Caution: The additions of exhaust silencers, catalytic converters, long runs of piping, and 90 degree elbows may require that the inside diameter of the exhaust pipe size be increased along with the Turbo Outlet Flange Connection in order to avoid excessive Turbocharger Back-Pressure.

Many locations will, by local code, require the use of a Catalytic Converter to be placed in the exhaust system to help in exhaust emission control. When this occurs, it may be necessary to lower the power requirement on the engine to avoid excessively high exhaust gas temperature.

CNGE engines are factory set with a Stoichiometric Air/Fuel ratio toward the "lean" side of Stoichiometry for the express purpose of providing the lowest possible exhaust gas temperature required for exhaust valve durability.

The use of a Catalytic Converter will generally require that the Air/Fuel ratio be set to the "rich" side of Stoichiometry. When this occurs the exhaust gas temperature will elevate to a higher level that may reduce exhaust valve life.

Caution: Some manufacturers of catalytic converters require that the engine oil have a sulfated ash content of no more than .5% mass of sulfated ash. In addition there may be restrictions placed on the amount of phosphorous and zinc that can be allowed in the additive packages that are used in some natural gas engine oils. Under no circumstances should the levels of zinc and phosphorous fall below the minimum required level for proper operation of the GTA38 & GTA50 engines.

The Electrical System

The electrical system consists of 24 VDC batteries, 24 V electrical starters, 24 V Alternators on some applications and various wiring diagrams such as:

ALTRONIC III and Wiring Harness
Woodward Flo-Tech Actuator & Speed Control System
Starter Wiring Diagram

Refer to Section 6 for wiring diagrams.

Notes:

Section 4
Installation Instructions

Remove all tape and plastic covers from cooling, fuel, lubricating oil, exhaust and air intake connections.

Locate unit on a firm base and secure in desired position with anchor bolts and shock mounts. Check alignment of engine with driven unit, shim as necessary to obtain desired alignment. Allow for sufficient space to provide access to all sides of unit. If radiator cooled be aware of prevailing winds and position unit in the proper direction (blower fan away from prevailing winds & sucker fan facing prevailing winds).

On installations with external coolant lines, such as cooling towers and heat exchangers, install piping with flexible connections to reduce stress on rigid piping due to engine vibration. If using raw water for both engine and aftercooler system from same pipe, always plumb through aftercooler circuit first and engine circuit last if plumbing in series. If plumbing in parallel be sure to install a raw water flow control valve in order to balance the flow between the aftercooler circuit and the engine circuit.

Provide for outside venting of exhaust gas if unit is installed in an enclosed area; also, venting of radiator cooling air must be provided.

Connect your gas supply piping and observe all required local codes. Be sure to install the correct pipe size ID, if possible, consider increasing the size for the last four to six feet of pipe to help in providing sufficient gas when a sudden increase in load is required.

Install a flexible connection between your gas supply line and the engine mounted gas shut-off valve.
Insure that the flexible connection meets all required local codes for gas plumbing.

Caution: Do not use rubber hose for flexible connection.

Inspect unit for damaged or missing parts. Check all bolts and nuts for tightness; replace as necessary.

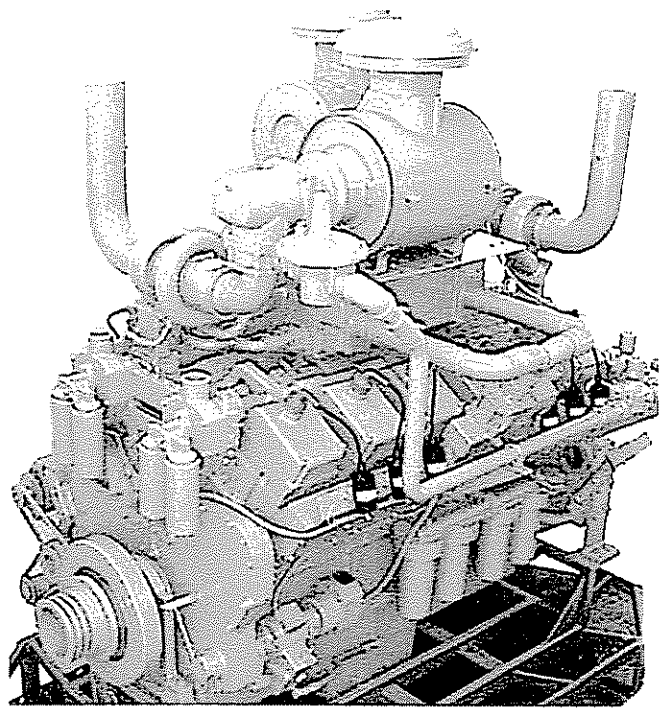
Inspect all wires for cut or frayed insulation; replace all damaged wiring.

Check the throttle control to see if you have free travel, correct as necessary.

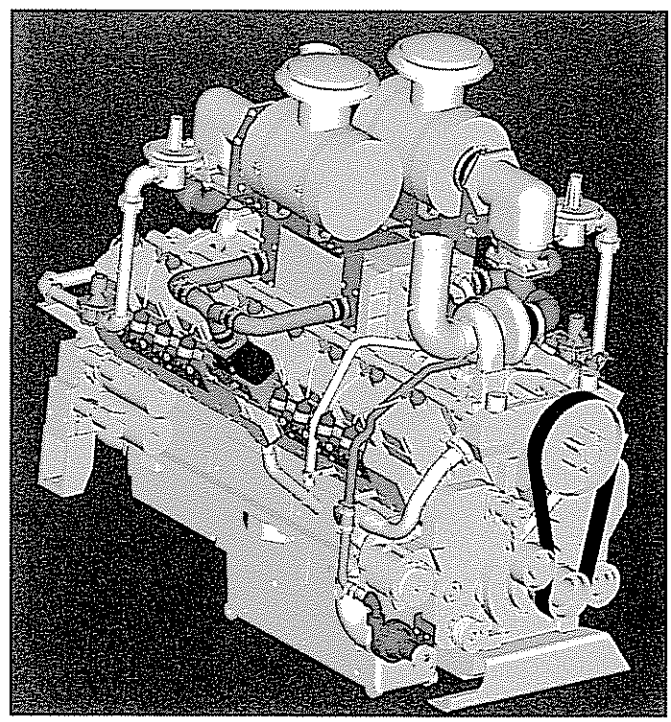
Note: Application Engineering Bulletins, Installation Guidelines are available in the form of Installation Requirements Bulletins (IRB'S) from your local Cummins distributor.

Note: CNGE installation drawings and wiring diagrams are also available from your local Cummins Distributor.

If not sure about your installation, contact the local Cummins distributor and ask for an installation review.



GTA38



GTA50

Section 5
Start-Up & Operating Instructions

Table of Contents Page

Operating Instructions

General - All Applications

Correct care of your engine will result in longer life, better performance, and more economical operation.

Follow the maintenance guidelines referred to in the maintenance section of this manual.

Check the oil pressure indicators, temperature indicators, warning lights, and other gauges daily to make sure that they are operational.

WARNING: Do not operate a natural gas engine in locations where there are or can be combustible vapors in the atmosphere. These vapors can be sucked through the air intake system and cause the air/fuel ratio to become excessively rich, which could elevate combustion & exhaust gas temperature (EGT) and cause engine over-speed situations. CNGE recommends the use of safety shutdown devices such as, but not limited to; over-speed and high EGT safety devices.

Initial Inspection and Start-Up

the responsibility for an initial inspection and proper new engine start-up rests with the end user customer. CNGE recommends that all new CNGE engines have an initial inspection & start-up by either the local Cummins distributor or an authorized CNGE dealer. This presents to the end user of the CNGE engine, the opportunity to insure that the engine is properly adjusted for the on-site conditions. Proper start-ups and adjustments will generally avoid having unnecessary premature failures.

In addition, it offers an opportunity for the end user operator to become familiar with the proper start-up and operation of the equipment. It also allows the end user to establish a source for proper supply of genuine service parts and maintenance supplies.

The Cummins distributor or dealer service representative will generally give the engine and its related systems a visual inspection looking for any items that will need to be adjusted or corrected before starting the unit.

The service technician will check to insure that all fluids such as lubricating oil, engine coolant, aftercooler coolant, etc. are at their proper levels. All belts will be checked for proper adjustment.

The engine will then be instrumented with the necessary gauges to measure some key parameters for future

reference. The technician will start the unit following the instructions covered in this section and will make final adjustments to the engine.

Final adjustments include, but are not limited to:

1. Confirming that the on-site load is within the range of the specific engine.

2. Confirming with the customer that the engine rating is at the proper level for the type of fuel being used and for the specific altitude at the job-site.

3. Measuring & adjusting ignition timing to the specific load, altitude and type of fuel used.

4. Adjusting the air/fuel ratio for the proper gas mixture required for the lowest exhaust gas temperature (EGT) within the proper load & speed range.

5. Confirming that all equipment supplied by CNGE is working and that the following baseline readings will be recorded if the engine is equipped with the required gauges.

- Gas pressure to regulator(s).
- Gas pressure to carburetor(s).
- Ignition timing.
- Oil pressure at idle rpm.
- Oil pressure at rated rpm.
- Oil temperature at rated load and rpm
- Engine coolant cylinder block pressure at load.
- Engine coolant top tank temperature at loaded conditions.
- Intake manifold vacuum/pressure and temperature at idle and at load on both banks.
- Excess Oxygen reading in exhaust gas at rated load and rpm on both banks.
- Exhaust gas temperature at manifold outlet at rated load and rpm on both banks.
- Engine rpm at idle and at load.
- Hour-meter reading.
- Ambient temperature.
- Altitude.

6. If equipped with Safety Shutdowns the service technician will confirm the set points and correct if required and if applicable.

- Water temperature.
- Water pressure.
- Oil pressure.
- Intake manifold vacuum/pressure on both banks.
- Intake manifold temperature on both banks.
- Over-speed device.

Note: All safety shutdowns are set for running at rated speed and load.

7. The Engine data-plate will be stamped with the inspection date.

At the conclusion of the inspection the service technician will supply the customer a copy of the inspection report that will later be filed with CNGE.

All end user customers should give strong consideration to having the local distributor or authorized dealer perform a new engine start-up & inspection. The cost is a minor investment when compared to the major expense from failures that are the result of either no inspection or an improper inspection.

Note: CNGE does not require an initial inspection to start the end user's warranty coverage. For warranty details refer to the warranty certificate.

New Engine Break-in

CNGE engines are run in on engine dynamometers before being shipped from the factory and are ready to be put to work in applications such as emergency standby generator sets.

Caution: All CNGE engines require an on-site adjustment at time of installation and at the initial start-up. Refer to the Start-Up and Inspection.

In other applications, the engine can be put to work after the start-up & inspection, but the operator has an opportunity to establish conditions for optimum service life during the initial 20 hours of operation by:

1. Warm up the engine before placing it under any load.
2. Operate the unit at no more than 75% of its rated load.
3. Do not operate the engine at idle or at full load for more than 5 minutes.
4. Observe lubricating oil pressures and temperatures and engine coolant temperatures. Reduce the engine load if the oil temperature reaches 121(C [250(F] or the engine coolant Temperature reaches 91(C [195(F].
5. Check oil and coolant levels frequently during the break-in period.

Starting Procedure

Priming the Lubricating System

A dipstick oil gauge is located on the side of the engine. The dipstick supplied with the engine has a "H" (high) and "L" (low) level mark to show proper operating oil levels. The dipstick supplied with the engine is not interchangeable with other dipsticks supplied with similar engines for similar oil pans.

Always check the oil level when the engine has been stopped and sufficient time has passed for the oil to drain back to the engine crankcase.

1. Fill crankcase to the "H" (high) mark on the dipstick.

2. Crank the engine for 15 seconds (with the ignition in the "OFF" position) until oil pressure appears on the gauge or the warning light goes out.

   Caution: Do not engage starter motor for more than 30 seconds at a time. Wait for two minutes between each start.

3. Refill crankcase to the "H" (high) mark on the dipstick.

   Caution: After the engine has run for several minutes it will be necessary to add lubricating oil to compensate for the oil that is absorbed by the filter element(s) and oil cooler.

Check Electric Governor

The GTA38 & GTA50 engine models use the Woodward Flo-Tech 75 mm Actuator with the Woodward Speed Control for the Governor System. The Speed Control is wired in series to each Actuator on each of the engine operating banks. Refer to the enclosed wiring diagram at the end of Section 3

Make sure on the initial start-up that all electrical connections have been properly wired, coated with di-electric grease and the engine is properly grounded.

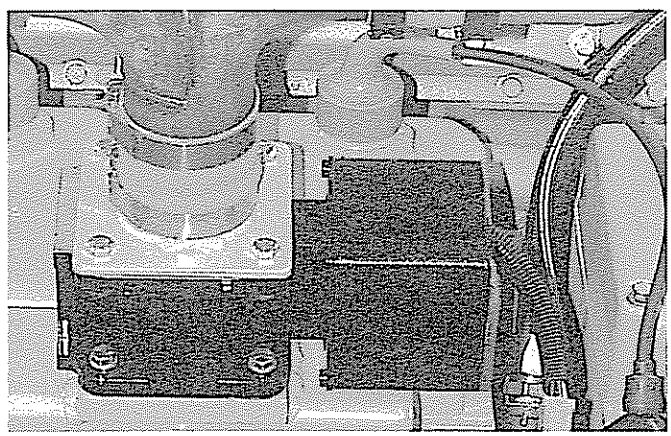


Photo # 5-01 - Woodward Flo-Tec Governor

Check Air Connections

Check the air connections to any air equipment, if used, and to the air cleaners and air crossovers to assure that they are all secure and have no damage.

Photo # 5-02 - Air Connections

Check Engine Coolant Supply

1. Remove the radiator or expansion tank cap and check the engine coolant supply. On systems with a separate reservoir for the aftercooler water circuit check to see that it is properly filled. Add coolant to both the engine and aftercooler systems as needed.

2. Make a visual check for leaks and open the water filter shut-off valves.

   Note: Check with the radiator manufacturer or supplier of the radiator on your package for any required specifications or maintenance requirements.

   Cooling system specifications that are required for any radiator are included in the appropriate engine model data-sheet under the Cooling System heading.

Starting the Engine

Starting requires only that clean air and fuel are supplied to the combustion chamber in proper quantities and are spark-ignited at the correct time.

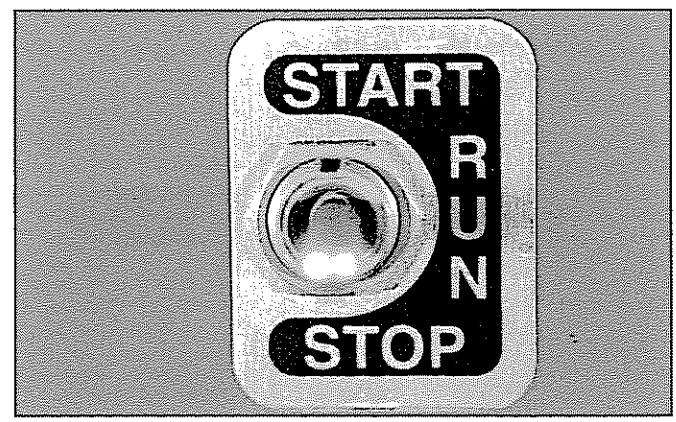


Photo # 5-03 - Start-Stop Button or Switch

Normal Starting Procedure (Above 0° C [32° F])

Warning: Before starting be sure that everyone is clear of the engine and the equipment.

If the engine is equipped with an over-speed stop, push the **"Reset"** button before attempting to start the engine.

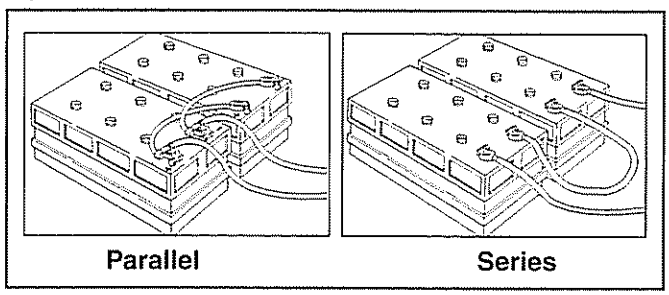
1. Check the lubricating oil and engine coolant levels.
2. Set the throttle for idle speed.
3. Disengage the clutch (if equipped) or open the main circuit breaker on generator set applications.
4. Open the gas supply shut-off valve.
5. If equipped with fuel shut-off valves with a manual reset, return manual reset to open position before cranking engine. The lever will lock in the open position. After the engine starts and oil pressure begins to rise the shut-off valve will return to its normal operating position.
6. Push the **"reset"** button on the instrument panel.
7. Hold in the safety switch override button and push the start button.

   Caution: To prevent electric cranking motor damage, do not crank the engine for more than 30 seconds at a time. If the engine fails to start in the first 30 seconds, wait for two minutes before attempting to crank the engine again.

   Caution: When using jumper cables to start the engine, make sure to connect the cables in Parallel positive (+) to positive (+) and negative (-) to negative (-). When using an external electrical source to start the engine, turn the "disconnect switch" to the "OFF" position. Remove the key before attaching the jumper cables to prevent unintentional starter engagement.

   Note: Engines equipped with air-gas starting motors allow a maximum of 1035 kPa [150 psi] inlet pressure.

Sketch # 5-01 - Battery Connections - Proper Hook - Up for Parallel and Series Connections



   Warning: **Caution should be taken when operating starters on gas because of the danger of fire, explosion or inhalation. Ensure that air/gas starters are exhausted out of buildings & enclosures.**

8. Release the override button when the oil pressure gauge shows an increase in oil pressure. Oil pressure must be indicated within 15 seconds after starting. If oil pressure has not registered within 15 seconds, shut off engine immediately to avoid engine damage. Check engine oil level.
9. Engage the clutch, if equipped, and run the engine at just above idle to allow the engine coolant to warm up. When starting a cold engine, increase the engine speed (RPM) slowly to provide adequate lubrication to the bearings and to allow the oil pressure to stabilize.

   Caution: Do not idle the engine for excessively long periods of time. Long periods of time (more than 10 minutes) can damage an engine.

10. Idle the engine no more than 3 to 5 minutes at 1000 RPM before applying the load or until the engine water temperature reaches 60° C (140° F). If the application permits, run the engine for the next 10 to 15 minutes or until the water temperature reaches 71 to 73.9° C (160 to 165° F) at a reduced load before applying full load.

    Caution: Continuous operation with low coolant temperature below 60° C [140° F] or high coolant temperature above 100° C [212° F] can damage the engine.

Cold-Weather Starting

Note: A jacket water and oil heater is recommended for stand-by emergency generator set applications installed in cold climate locations.

Engine Warm-up

When the engine is started, it takes a while to get the lubricating oil film reestablished between the shafts and the bearings and between the pistons and liners. The most favorable clearances between the moving parts are obtained only after all engine parts reach normal operating temperature.

Avoid seizing pistons and running dry shafts in dry bearings by bringing the engine up to operating speed gradually as it warms up.

On some emergency equipment warm-up may not be necessary due to the equipment being housed inside a heated building. For an engine starting with a parasitic load, such as an emergency stand-by generator set, the coolant temperatures must be at a minimum of 49° C [120° F].

Operate by the Instruments

Instrument Panels

Whatever the application, the operator must use the panel board instruments. The instruments show at all times the engine's operating characteristics.

Tachometer

Governed engine speed is the maximum rated RPM that a properly adjusted governor will allow the engine to turn under a full load. Never over-ride the governor under normal operation or allow the engine to exceed the rated RPM during operation.

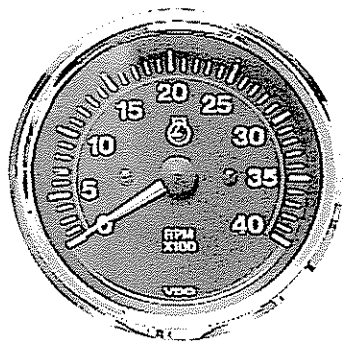


Photo #5-04 - Tachometer

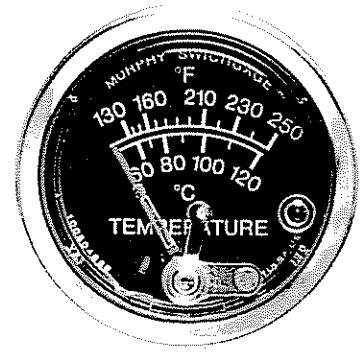
Water Temperature

A water temperature of 71 to 93° C [160 to 200° F] is the best assurance that the working parts of the engine have expanded evenly to the most favorable oil clearances. MAXIMUM engine coolant top tank temperature should not exceed 100° C [212° F].

Keep thermostats in the engine always, summer and winter, and avoid long periods of idling.

Never operate the engine at temperatures below 71° C [160° F]. If necessary in cold weather, use radiator shutters or louvers to assist in preventing overcooling.

Overheating conditions indicate the need for mechanical correction. Excessive temperatures may be due to loose water pump belts, clogged radiator or heat exchanger cooling systems, excessive concentration of antifreeze in the coolant mixture or just insufficient cooling capacity for the operating load and associated ambient conditions. Report all cases of over-heating to the maintenance department for corrections.

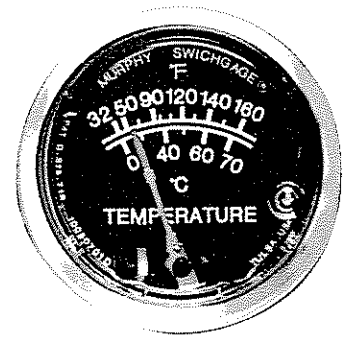


WATER

Photo #5-05 - Water Temperature Gauge - Thermostat Housing Outlet

Aftercooler Coolant Inlet Temperature

On water-to-air systems the aftercooler coolant inlet temperature to the aftercooler coolant pump must be maintained at a maximum of 54° C [130° F.] on systems with 8.5:1 compression ratio (C.R.) pistons. The expected intake manifold air gas temperature would be 140(to 145(F. [60(to 62.8(C].



AFTERCOOLER

Photo # 5-06 - Aftercooler Coolant Temperature Gauge

Oil Temperature

The oil temperature gauge should read between 82° C [180° F] and 107° C [225° F] for best lubrication. Under full load conditions a temperature of 116° C [240° F] for a short period is not to be considered a cause for alarm.

Caution: Any sudden increase in oil temperature that is not caused by an increase in load is a warning of possible mechanical failure and should be investigated at once.

During the warm-up period, apply the load gradually until the oil temperature reaches the 140° C [140° F]. While the oil is cold it does not do a good job of lubricating. Continuous operation or long periods of idle with oil temperatures below 60° C [140° F] may cause water and acid formation in the crankcase that will quickly accelerate engine wear.

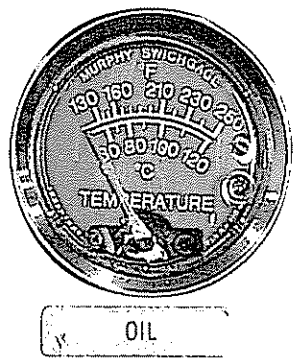


Photo # 5-07 - Oil Temperature Gauge

Oil Pressure

The oil pressure gauge indicates the operating pressure in the lubricating oil system. Any sudden drop in oil pressure shows a mechanical malfunction in the lubricating oil system. The operator should take note of the loss of oil pressure and shut down the engine before major damage occurs.

Photo # 5-08 - Oil Pressure Gauge

Intake Manifold Air-Gas Temperature

The intake manifold air-gas temperature must be held to a temperature well below the point of detonation. For the water-to-air aftercooler system, the cooling air to the remote charge air core (CAC) must be held to 130° F or lower for engines operating with 8.5:1 compression ratio pistons.

Note: There are no 10.0:1 pistons available for this engine.

Note: There is no air-to-air CAC cooling system approved for this engine.

The maximum intake manifold air-gas temperature under full operating load conditions can never be higher than 145° F. for engines operating with 8.5:1 compression ratio pistons.

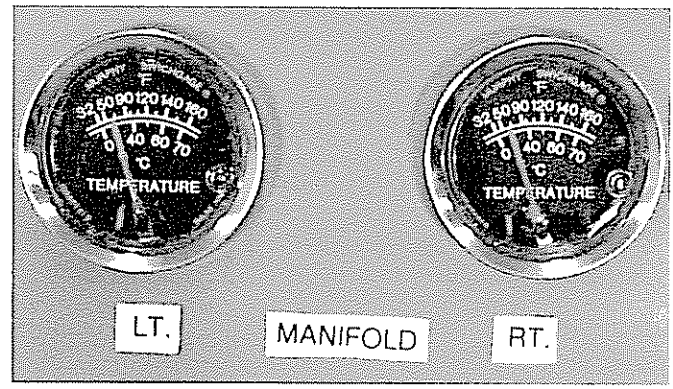


Photo # 5-09 - Intake Manifold Air-Gas Temperature Gauge

Intake Manifold Boost Pressure (Turbocharged Models)

The engine intake manifold boost pressure needs to be maintained at a level below 17 psi.

Caution: As the engine fuel air ratio is leaned the turbo boost pressure will rise.

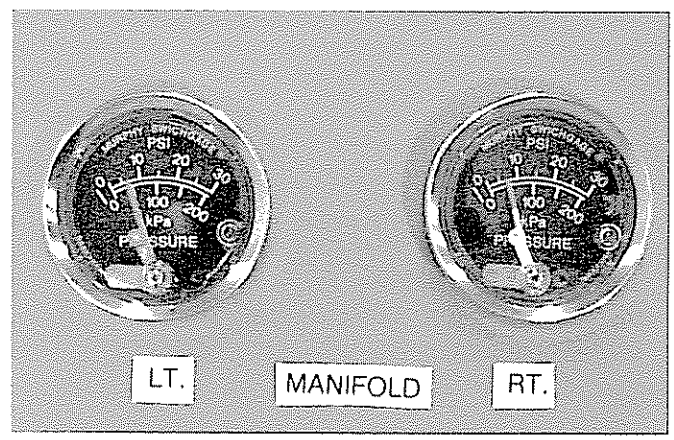


Photo # 5-10 - Intake Manifold Boost Pressure Gauge

High Altitude Operation - De-Rating Requirements

Turbocharged Engines

The G1 & G2 engine models of the GTA50 engine may be operated at the **MAXIMUM or EMERGENCY STAND-BY RATING** up to 914 m [3000 ft] altitude and 38° C [100° F] inlet air temperature. For sustained operation at high load factors at higher altitudes and temperatures, please derate by 4% per 1000 feet and 1% for each 10 degrees F increase.

The G3 rating of the GTA50 engine model may be operated at the **MAXIMUM or EMERGENCY STAND-BY RATING** up to 305m [1000 ft] altitude and 38° C [100° F] inlet air temperature. For sustained operation at high load factors at higher altitudes and temperatures, please derate by 4% per 1000 feet and 1% for each 10 degrees F increase.

Altitude and temperature de-rating factors are to be considered as additive when temperatures exceed 100° F and when altitudes are over 1000 ft. or 3000 ft. depending on the rating. Refer to Section 6 for additional information.

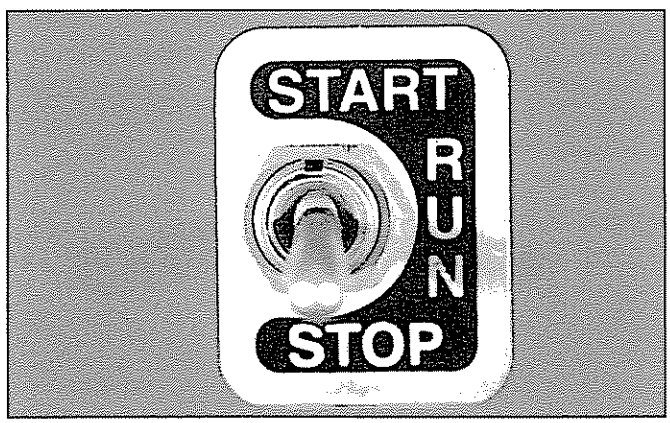


Photo # 5-11 - Start-Stop Switch - "OFF" Position

Engine Shut-Down Procedure

Let the engine idle a few minutes before shutting it down.

Idle the engine 3 to 5 minutes before shutting it down to allow lubricating oil and water to carry heat away from the combustion chamber, bearings, shafts, etc.

Turn off the fuel-gas with either the automatic or manual shut-off valve and allow the engine to come to a complete stop. Next, turn the Ignition Switch To **"OFF"** Position.

The engine can be shut down by turning off the ignition switch on those engines equipped with a gas shut-off valve that is actuated by the ignition system. When the ignition switch is moved to the **"OFF"** position, the ignition system also will close the gas valve shutting off the gas supply to the carburetor.

Caution: Always know the location of the manual fuel shut-off valve in the event of an emergency or while servicing the engine.

Stop the Engine Immediately If Parts Fail.

Practically all failures give some warning to the operator before the parts fail and ruin the engine. Many engines are saved because an alert operator heeds warning signs and immediately shuts down the engine. Some changes to look for are as follows:

- Increase in oil consumption.
- Increase in fuel consumption.
- Unusual engine noise.
- Fuel gas, oil, or coolant leaks.
- Sudden changes in operating temperature or oil pressure.
- Smoke.
- Vibration.
- Engine misfires.
- Loss of power.
- High coolant temperature
- High turbocharger boost pressure

A delay of ten seconds after a bearing failure may result in a ruined crankshaft or allow a block to be destroyed from a broken connecting rod.

Never continue to operate the unit after the engine indicates that something is wrong.

For operations that will not have an operator, the engines should be specified with the appropriate safety shutdown devices to protect the engine from unnecessary progressive damage. Consult your local Cummins Distributor for details.

Cold Weather Protection

For cold weather protection, use a proper antifreeze and soft water mixture. CNGE recommends the use of Fleetguard's **"Compleat"™** or a proper **DCA4™** - Antifreeze & Water package.

If an engine is to be shut down for an extended period during winter operating conditions, it is important to drain the engine cylinder heads, cylinder block, oil cooler, aftercooler cooling system (if used) and other water cooled accessories if used. Open all vent cocks and all petcocks on the top and side of the engine.

Oil coolers may have to be removed to drain the cooler completely. Failure to drain any of these units may lead to serious freeze damage.

Caution: On CNGE Water-to-Air Aftercooler systems the aftercooler must be drained separately from the engine since it is a separate system. The aftercooler system also will need to be properly treated for freeze and corrosion protection.

Immersion-type water and oil heaters are available for engines used in cold-weather operations and to maintain temperatures to permit the engine to operate at full load at start-up.

Engine Operation in Cold Weather

Satisfactory performance of a CNGE engine operating in low ambient temperature conditions requires modification of the engine, surrounding equipment, operating practices and maintenance procedures. The colder the temperatures encountered, the greater the amount of modification required, and yet with the modifications applied, the engine must still be capable of operation in warmer climates without extensive changes. The following information is provided to engine owners, operators, and maintenance personnel on how the modifications can be applied to get satisfactory performance from their natural gas engines.

There are three basic objectives to be accomplished:

1. Reasonable starting characteristics followed by practical and dependable warm-up of the engine and equipment.

2. A unit or installation that is as independent as possible from external influences.

3. Modifications that will maintain satisfactory operating temperatures with a minimum increase in the maintenance of equipment and accessories.

If satisfactory engine temperature is not maintained, higher maintenance costs will result due to increased wear, poor performance and formation of excessive carbon, varnish and other deposits.

Special provisions to overcome low temperatures are definitely necessary. However, a change to warmer climate should normally require only a minimum of revision. Most of the accessories should be designed so that they can be disconnected so there is little effect on the engine when they are not in use.

Two of the most commonly used terms associated with low temperature operation are "Winterizing" and "Arctic" specifications.

Winterizing

Winterizing of the engine or components so starting and operation are possible in the lowest temperature to be encountered requires:

1. Use of correct materials.
2. Proper lubrication and use of low temperature lubricating oils.
3. Protection from low temperature air. The rate of heat dissipation is affected by low temperature air.
4. Heating to be provided to increase the engine cylinder block and component temperature to a minimum of -32° C [-25° F] for starting in lower temperatures.
5. Proper external heating source.
6. Electrical equipment capable of operating in the lowest expected temperature.

Arctic Specifications

Arctic Specifications refer to the design material and specifications of the components necessary for satisfactory engine operation in extreme low temperatures to -54° C [-65° F]. Contact Cummins Natural Gas Engines, Inc. or the equipment manufacturer to obtain the special items required.

Notes:

Section 6
Engine Specifications

Table Of Contents Page

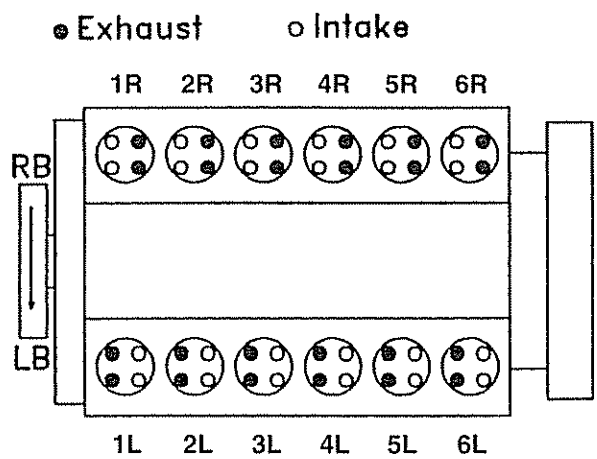
Engine Specifications

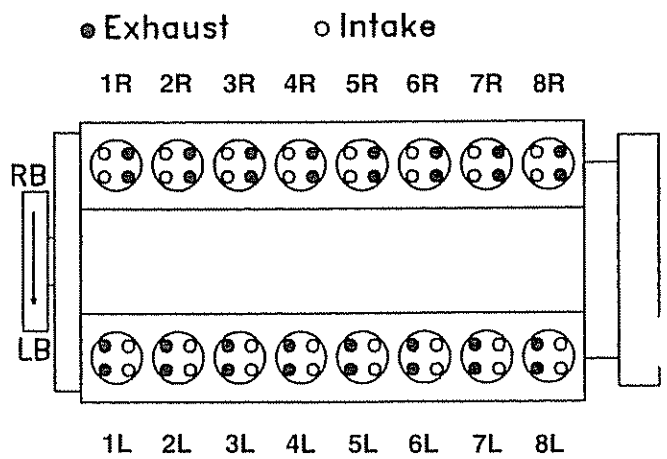
General Information

	GTA38	GTA50
Aspiration:	GTA	GTA
G=Spark Ignited T=One Stage Turbocharging A=Aftercooled		
Market Application:	GS GP - TBD GC - TBD IP - TBD	GS GP - TBD GC - TBD IP - TBD
GS=Stand-by Generator Set GP=Prime Power Generator Set GC=Continuous Duty Generator Set IP=Stationary Industrial Power		
Bore & Stroke:	159 mm x 159 mm	159 mm x 159 mm
Compression Ratio:	8.5:1	8.5:1
Displacement:	37.7 L [2300 cu.in.]	50.3 L [3067 cu.in.]
Firing Order:	1R-6L-5R-2L-3R-4L- 6R-1L-2R-5L-4R-3L	1R-1L-3R-3L-2R-2L-5R-4L- 8R-8L-6R-6L-7R-7L-4R-5L
Maximum Rating:	779 kWm [1045 bhp]	995kWm [1334bhp]
Type:	4 Cycle, 60 Degree Vee, 12 Cylinder	4 Cycle, 60 Degree Vee 16 Cylinder
Weight:	Refer to Datasheet	Refer to Datasheet

Cylinder Number Sequence:
RB=Right Bank of Cylinders
LB=Left bank of Cylinders

Intake and Exhaust Valve Locations:



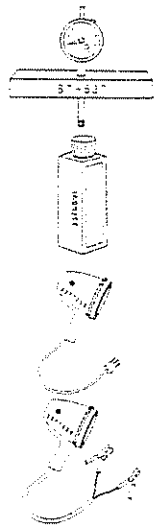


General Information	GTA38	GTA50
Exhaust Back Pressure-Minimum:	50 mm-Hg [2 in.-Hg]	50 mm-Hg [2 in.-Hg]
Exhaust Pipe Size-Minimum:	127 mm [5 in.]	152 mm [6 in.]
Minimum Dirt Holding Capacity:		
Heavy Duty Cleaner	53 grams liters/second [25 grams CFM]	53 grams liters/second [25 grams CFM]
Air Intake Restriction: (Maximum at Rated Speed and Load):		
With Clean Filter Element	380 mm H2O [15 in. H2O]	380 mm H2O [15 in. H2O]
With Dirty Filter Element	635 mm H2O [25 in. H2O]	635 mm H2O [25 in. H2O]
Coolant Capacity (Engine Only): [125 U.S. Quarts]	118 Liters [162 U.S. Quarts]	153 Liters
Standard Thermostat:		
Modulating Range:	82(C-93˚ C [180˚ F-200˚ F]	82˚ C-93˚ C [180˚ F-200˚ F]
Coolant Pressure Cap:	69 kPa [10 psi]	69 kPa [10 psi]
Coolant Temperature Maximum Top Tank:		
Standby Generator	100˚ C [212˚ F]	100˚ C [212˚ F]
Prime Power	93˚ C [200˚ F]	93˚ C [200˚ F]
Oil Pressure, Main Rifle:		
Maximum at Rated RPM:	483 kPa [70 psi]	483 kPa [70 psi]
Minimum at Rated RPM:	345 kPa [50 psi]	345 kPa [50 psi]
Minimum at Idle RPM:	138 kPa [20 psi]	138 kPa [20 psi]
Oil Temperature Maximum:	121˚ C [250˚ F]	121˚ C [250˚ F]
Oil Pan Capacity:	140 liters [37 U.S. Gal]	204 liters[54 U.S. Gal]
Oil Filter Capacity:	2.7 liters [0.70 U.S. Gal] 4 Filters	2.7 liters [0.70 U.S. Gal] 4 or 5 Filters
Low Idle Speed:	725-775 RPM	725-775 RPM
Rated Speed:	1800 RPM 1500 RPM	1800 RPM 1500 RPM

Combustion Air Specifications

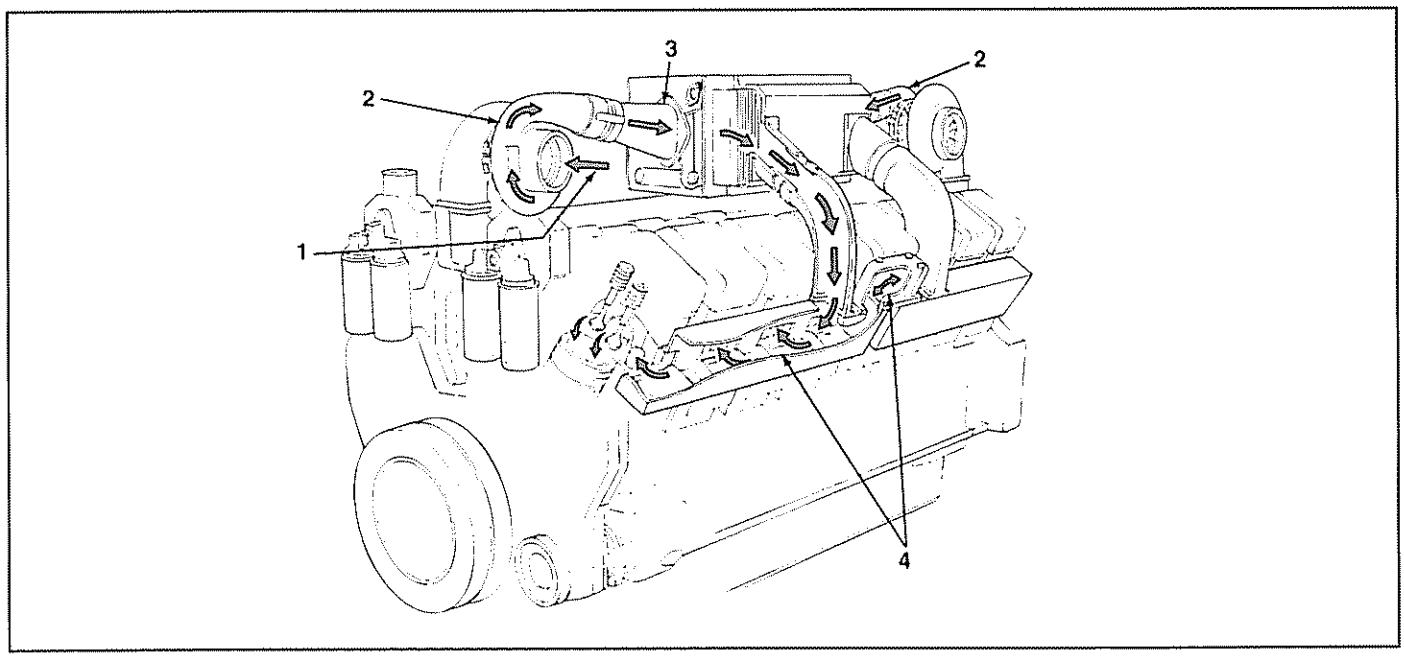
Required Service Tools

The following Special tools are recommended to perform the procedures covered in this section. These tools can be purchased from your local Cummins Authorized Repair Location.

Tool No.	Tool Description	Tool Illustration
ST-537	**Dial Depth Gauge** Measures turbocharger axial motion.	
3376891	**Fluorescent Tracer** Add to the oil. Use with black light to find oil leaks.	
3377253	**Black-light (AC)** Inspect for oil & water leaks	
3377394	**Black-light (DC)** Inspect for oil & water leaks	

Intake System Flow Diagram

Intake System — Center Mount Aftercooler

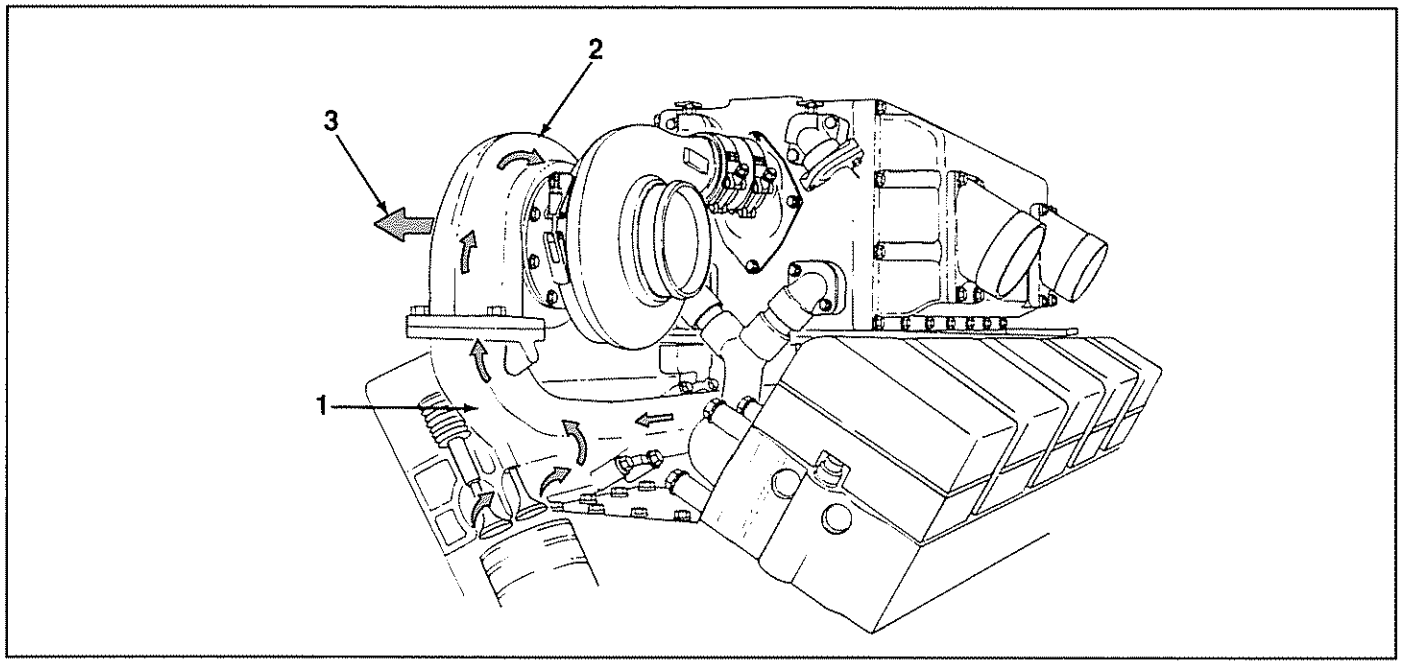


1. IntakeAir/Gas Fuel Mixture to Turbocharger From Carburetor
2. Turbocharger
3. Turbocharger Compressed Air/Gas Fuel Mixture to Aftercooler
4. Cooled Intake Air/Gas Mixture to Throttle Body, Intake Manifold and Cylinder

Exhaust System Flow Diagram

Exhaust System— Center Mount Aftercooler

1. Exhaust Manifold
2. Turbocharger
3. Turbocharger Exhaust Outlet

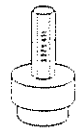


Cooling System Specifications

Required Service Tools

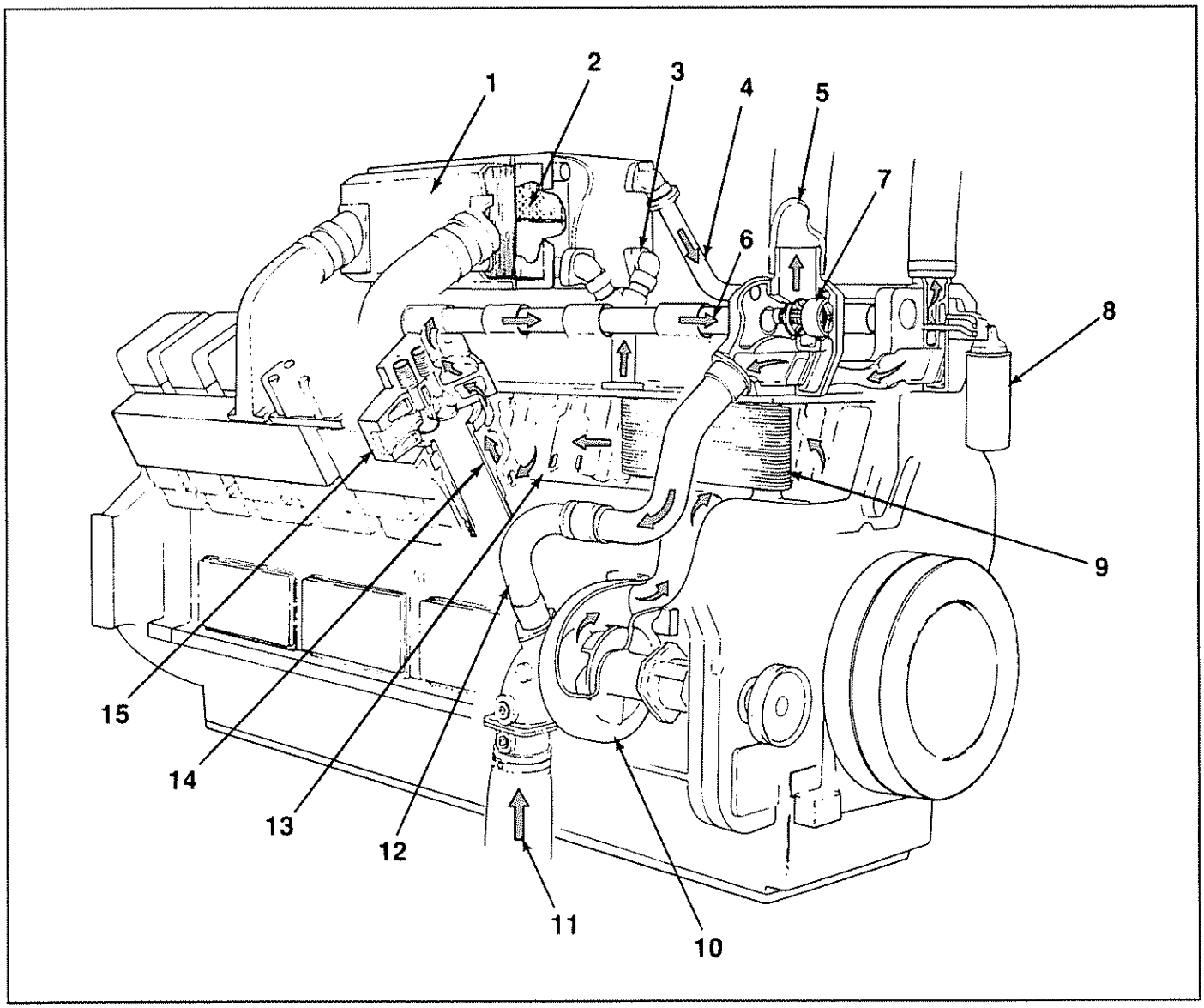
Cooling System

The following Special tools are recommended to perform the procedures covered in this section. These tools can be purchased from your local Cummins Authorized Repair Location.

Tool No.	Tool Description	Tool Illustration
CC-2626	**DCA4™ Coolant Test Kit** Measure chemical concentration in the Coolant to determine if the system is Adequately protected.	
3375411	**Thermostat Seal Mandrel** Install the thermostat seal in the thermostat housing.	
3377462	**Optical Tachometer** Measure the RPM of any rotating part. Can be Used to measure engine RPM. Contains Part No. 3377464 Reflective Tape.	
3377464	**Reflective Tape** Used with Part No. 3377462 Optical Tachometer.	

Cooling System Flow Diagrams

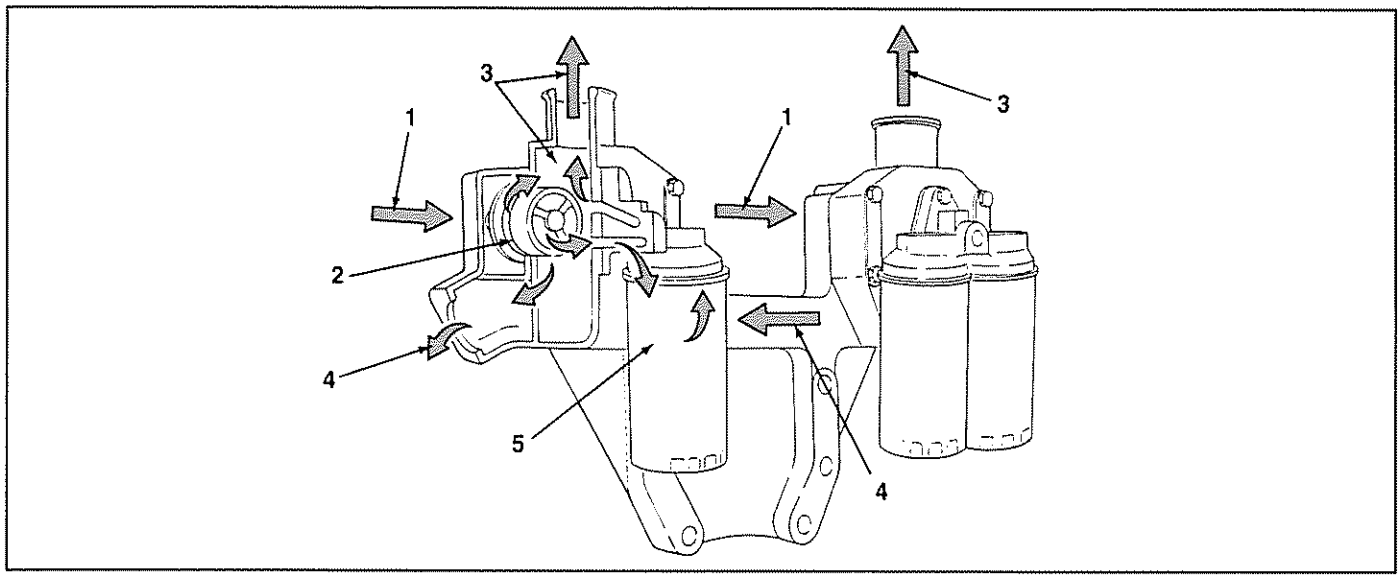
Cooling System— Top Mounted Aftercooler



1. Aftercooler Housing
2. Aftercooler Core
3. Aftercooler Coolant Supply
4. Aftercooler Coolant Return
5. Coolant Return to Radiator / Heat Exchanger
6. Coolant Transfer Tube (Head to Head)
7. Thermostat
8. Coolant Filters
9. Oil Cooler
10. Engine Water pump
11. Coolant Supply from Radiator / Heat Exchanger
12. Bypass Tube
13. Coolant to Block V
14. Cylinder Liner
15. Cylinder Head

Note: CNGE Engines use a separate Aftercooler Cooling System with a separate Auxilliary Water Pump.

Cooling System Flow Diagrams



Cooling System— Thermostat Housing Flow
Non - LTA

1. From Coolant Manifold
2. Thermostat
3. Coolant to Radiator / Heat Exchanger
4. Bypass Coolant
5. Coolant Filter

Notes:

Coolant Specifications

Water should be clean and free of any corrosive chemicals such as chloride, sulfates and acids. It should be kept slightly alkaline with a pH value range of 8.5 to 10.5. Any water that is suitable for drinking can be treated as described in the following paragraphs for use in an engine.

Heavy-duty CNGE engines require a balanced coolant moisture of water and antifreeze. Drain and replace the mixture every 2 years or 6000 hours of operation (whichever occurs first) to eliminate buildup of harmful chemicals.

Antifreeze is essential in any climate. It broadens the operating temperature range by lowering the coolant freezing point and by raising its boiling point. Do not use more than 50 percent antifreeze in the mixture unless additional freeze protection is required. Never use more than 68 percent antifreeze under any condition.

Use soft water in the coolant mixture. Contaminants in hard water neutralize the corrosion inhibitor components. Water **must not** exceed 300 ppm hardness, or contain more than 100 ppm of either chloride or sulfate.

Specifications - Use low-silicate antifreeze, which meets ASTM4985 test (GM6038M spec.) criteria.

Concentration - Antifreeze must be used in any climate for both freeze and boiling point protection.

CNGE recommends a 50 percent concentration level (40 percent to 60 percent range) of ethylene glycol or propylene glycol in most climates. Antifreeze at 68 percent concentration provides the maximum freeze protection and must never be exceeded under any condition. Antifreeze protection decreases above 68 percent.

Ethylene Glycol	Propylene Glycol
40% = -23° C [-10° F]	40% = -21° C [-6° F]
50% = -37° C [-34° F]	50% = -33° C [-27° F]
60% = -54° C [-65° F]	60% = -49° C [-56° F]
68% = -71° C [-90° F]	68% = -63° C [-82° F]

Concentration Testing - Antifreeze concentration must be checked using a refractometer (such as Fleetguard Part No. CC2800). "Floating ball" type density testers or hydrometers are not accurate enough for use with heavy duty spark ignited cooling systems.

CNGE recommend that the cooling system be maintained by using Fleetguard's™ DCA4™ Water Filter Elements.

Maintain the **Fleetguard™ DCA4™** Water Filters on the engine. The filter bypasses a small amount of coolant from the system via a filtering and treating element that must be replaced periodically.

1. In summer or winter select an antifreeze with the proper mixture as described above.

   Note: Some antifreeze contain anti-leak additives such as inert inorganic fibers, polymers particles or ginger root. These types of antifreeze should not be used together with the water filter. The filter element will filter out the additives or become clogged and ineffective.

2. Install or replace the DCA4™ water filter as follows.

New Engines Going into Service Equipped with DCA4™ Water Filters.

1. New engines shipped from CNGE are equipped with water filters containing a DCA4™ Precharge element. This element is compatible with plain water or all permanent-type antifreeze except Methoxy Propanol.

2. At the first oil change period the DCA4™ precharge element should be changed to a DCA4™ service element. See Table # 6-01 & Table # 6-02

3. Replace the DCA4™ service element at each succeeding oil change period.

   a. If make-up coolant must be added between element changes, use coolant from a pretreated supply, such as the Fleetguard "Compleat".

   b. Each time the system is drained, pre-charge per coolant specifications in **Table #6-01 & Table # 6-02.**

4. The service element change point may be extended to the next service interval if the DCA4™ direct chemical additive is added to the cooling system at each oil change period. One bottle of direct additive should be used for every 10 gallons of cooling system capacity.

5. To ensure adequate corrosion protection, have the coolant checked at each third element change or more often.

DCA4™ Unit Maintenance Guide

Use supplemental coolant additives (SCA)(corrosion inhibitors) to protect the engine cooling system from corrosion. Antifreeze alone does not provide enough corrosion protection for a heavy-duty natural gas engine.

Supplemental corrosion protection must be supplied through periodic additions of supplemental coolant additives (SCA)to the coolant.

To protect against corrosion, a new coolant charge must be brought up to 0.40 DCA4™ units per liter [1.5 DCA4™ units per U.S. Gallon] of coolant (initial charge). Maintain the correct DCA4™ concentration by changing the maintenance coolant filter at each oil drain interval.

Each time the coolant is drained and replaced, the coolant must be recharged with supplemental coolant additives. Use the appropriate DCA4™ spin-on filter listed in Table # 6-03. The mixture must be drained and replaced every two years or 6000 hours of operation, whichever first occurs.

When using other supplemental coolant additives, refer to the manufacturer's instructions.

For an 80 gallon system, three (3) gallons of DCA4™ liquid must be added to pre-charge the coolant to the correct SCA concentration level.

U.S. Custom Example:

80 gallons X 1.5 Units/gallon = 120 units

120 units + 20 units/1/2 gallom DCA4™ = 6 half gallon containers of DCA4™ or 3 gallons of DCA4™

Metric Example:

300 liter X 4 units/Liter = 120 units

120 units + 20 units/1.89 Liters DCA4™ = (6) 1.89 Liter Containers of DCA4™

Table # 6-01 - DCA4™ Pre-charge Units of DCA4™ Maintenance Chart

Liters[Gallons] of Coolant to be Serviced	DCA4™ Gallons	DCA4™ Liquid Per Gal.	DCA4™ Units Units
193- 284 [51- 75]	2.25	90	1.2 - 1.8
288- 378 [76-100]	3.00	120	1.2 - 1.6
382- 568 [101-150]	4.50	180	1.2 - 1.8
572- 757 [151-200]	6.00	240	1.2 - 1.6
761- 946 [201-250]	7.50	300	1.2 - 1.5
950-1136 [251-300]	9.00	360	1.2 - 1.4
1139-1325 [301-350]	10.50	420	1.2 - 1.4
1329-1514 [351-400]	12.00	480	1.2 - 1.4

Table # 6-02 - DCA4™ Service Element Change Interval

Hours	DCA4™ Service Filter Units of DCA4™ Req.				Gallons of Coolant	Add DCA4™ Liquid Pints as shown 250 hrs.	500 hrs
					51-75	4	8
625	60	68	100	125	76-100	5	10
500	40	50	80	100	101-150	8	15
375	30	38	60	75	151-200	10	20
250	20	25	40	50	201-250	13	25
					251-300	15	30
	51-75	76-100	101-150	151-200	301-350	18	35
				351-400	20	40	

8 Pints Equals 1 U.S. Gallon

System Size in Gallons

Some units will require liquid in addition to the largest Fleetguard Filters.

Notes: Consult the equipment manufacturer's maintenance information for total cooling system capacity.

After draining and replacing the coolant, always precharge the cooling system to a SCA level of 1.5 units per gallon. This concentration level must never be allowed to go below 1.2 units and must be controlled when level is greater than 3 units. Action needed when level goes below 1.2 is a filter and liquid; above 1.2 to 3.0 filter only; above 3.0, test and add filters when 3.0 and below.

Caution: Under NO circumstances MUST a customer exceed one B Maintenance Check interval before adding chemicals (by filter or liquid) to the coolant. If the recommended service intervals are neglected, there is a high probability that cylinder liner corrosion will occur.

Note: When performing service which requires draining the cooling system, take Special precautions to collect it in a clean container, seal it to prevent contamination, and save for reuse.

Change coolant filters at each oil change to protect the cooling system. The service filters are satisfactory for use with maintenance intervals from 125 to 6,000 hours.

Water Pump & Fan Hub Lubricants

Grease

Caution: Do not mix brands of grease. Damage to the bearings may result. Excessive lubrication is as harmful as inadequate lubrication. After lubricating the fan hub, replace both pipe plugs. Use of fittings will allow the lubricant to be thrown out due to rotating Speed.

CNGE recommends use of grease meeting the specifications of Mil-G-3545, excluding those of sodium or soda thickeners. Contact the lubricant supplier for grease meeting these specifications.

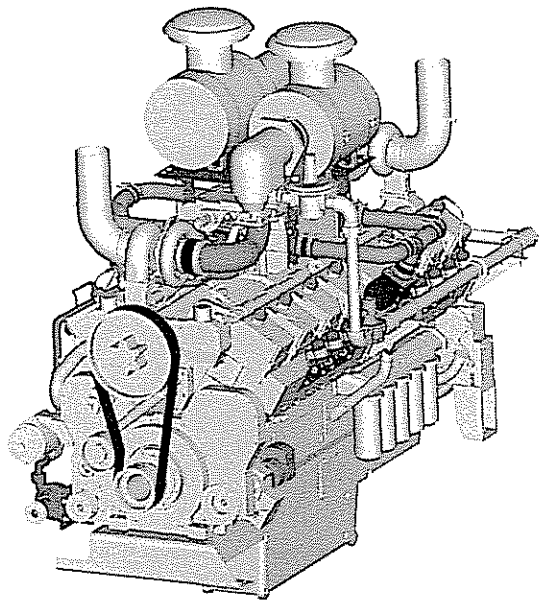


Table # 6-03 - Fleetguard™ DCA4™ Service Filters and Liquid Pre-Charge

Fleetguard Part No.	Cummins Part No.	DCA4™ Units
Spin-On Coolant Filters		
WF-2070	3318157	2
WF-2071	3315116	4
WF-2072	3318201	6
WF-2073	3315115	8
WF-2074	3316053	12
WF-2075	3318318	15
WF-2076	3318319	23
DCA4™ Liquid		
DCA60L (1 pint)	3315459	5
DCA65L (1/2 Gallon)	3305373	20
DCA75L (5 Gallons)	3317428	200
DCA80L(55 Gallons)		2200
DCA4™ Powder		
DCA95	3318320	20

Test	Test Procedure
High-Temperature Performance	
Dropping point, °F.	ASTM D 2265 350 min.
Bearing life, hours at 300° F 10,000 rpm	*FTM 331 600 min.
Low-Temperature Properties	
Torque, GCM Start at 0° F Run at 0° F	ASTM D 1478 15,000 max. 5,000 max.
Rust Protection and Water Resistance	
Rust Test	ASTM D 1743 Pass
Water resistance	% ASTM D 1264 20 max.
Stability	
Oil separation, % 30 hours @ 212° F	*FTM 321 5 max.
Penetration	
Worked 250-300	ASTM D 217
Bomb Test, PSI Drop	**ASTM D 942**
100 hours 500 hours	10 max. 25 max.
Copper Corrosion	***FTM 5309** Pass
Dirt Count, Particles/cc 25 Micron + 75 Micron + 125 Micron +	***FTM 3005** 5,000 max. 1,000 max. None
Rubber Swell 10 max.	***FTM 3603**

* Federal Test Method Standard No. 791a.

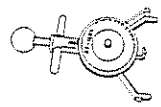
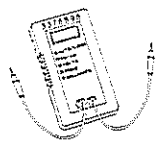
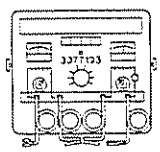
Notes:

Electrical System Specifications

Required Service Tools

Electrical System

The following special tools are recommended to perform the procedures covered in this section. These tools can be purchased from your local Cummins Authorized Repair Location.

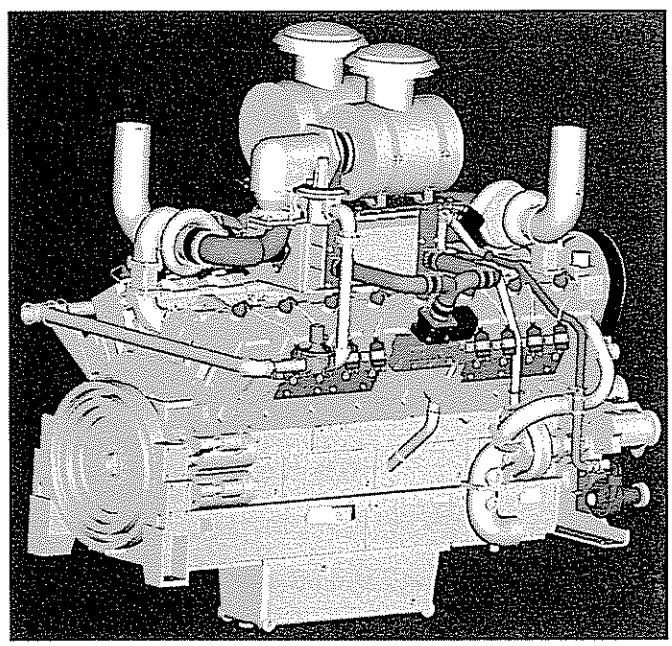
Tool No.	Tool Description	Tool Illustration
N/A	**Battery Charger** Restore the state of electrical charge of a battery.	
N/A	**Battery Hydrometer** Check specific gravity of individual battery cells (for batteries with removable cell caps or covers).	
ST-1293	**Belt Tension Gauge** Measure belt tension of alternator belt .	
3376898	**Digital Multimeter** Measure voltage (volts) and resistance (ohms) in a circuit.	
3377193	**Inductive Charging - Cranking Systems Analyzer** Test generators, alternators, relays, starters, voltage regulators, and batteries. Contains built-in voltmeter and ammeter.	

General System Requirements

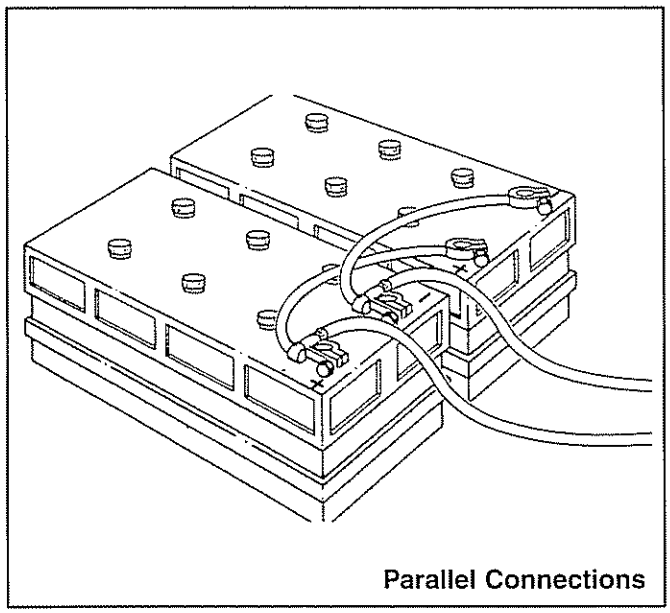
The base heavy-duty electrical system consists of :

- Batteries - (Usually three or four connected in Parallel).
- Starter- GTA38/50 uses 2 starting motors.
- An Alternator
- A magnetic Switch (Automatic Shut Down Valve)
- An ignition switch
- All necessary wiring

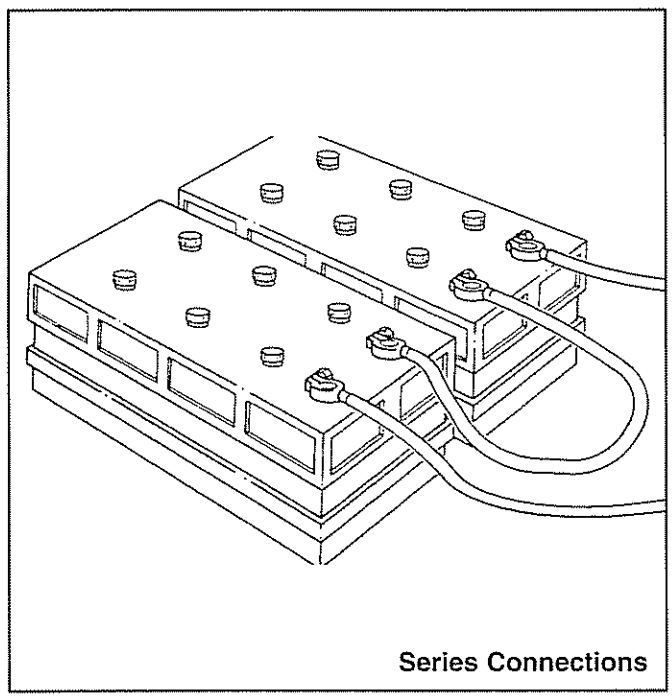
Notes: The electrics in the Ignition sytem (Ignition Generator, Wiring Harness, Ignition Coils) and Governor System or covered in other sections in this manual.



Battery Requirements



Parallel Connections



Series Connections

Table # 6 - Battery Requirements

Battery Size	Ambient Temperature	
	-18° C [0° F]	0° C [32° F]
	Cold Cranking Amperes	Cold Cranking Amperes
24 Volt**	1800	1800

• The number of plates within a battery size determine the reserve capacity. Reserve capacity determines the length of time sustained cranking can occur.

** Per battery (two 12-volt batteries in series)

Maximum allowable resistance of the starting circuit	
24 volt starter - OHMS	0.002

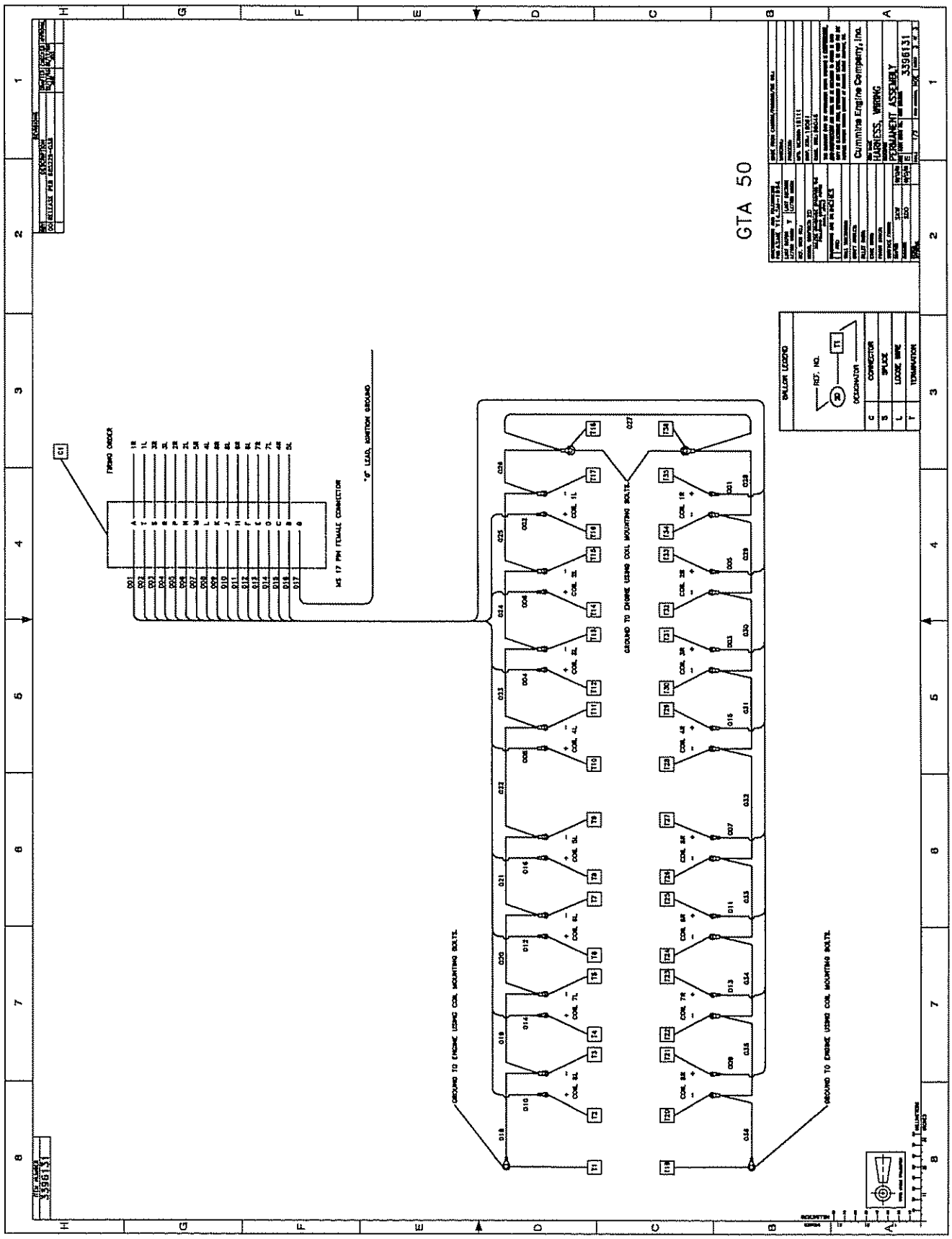
Note: Cold starting aids are required when the ambient temperature is at 4° C [40° F] or lower. Starting aids such as block heaters, lubricating oil pan heaters, etc. are available from your local Cummins distributor.

Wiring Diagrams

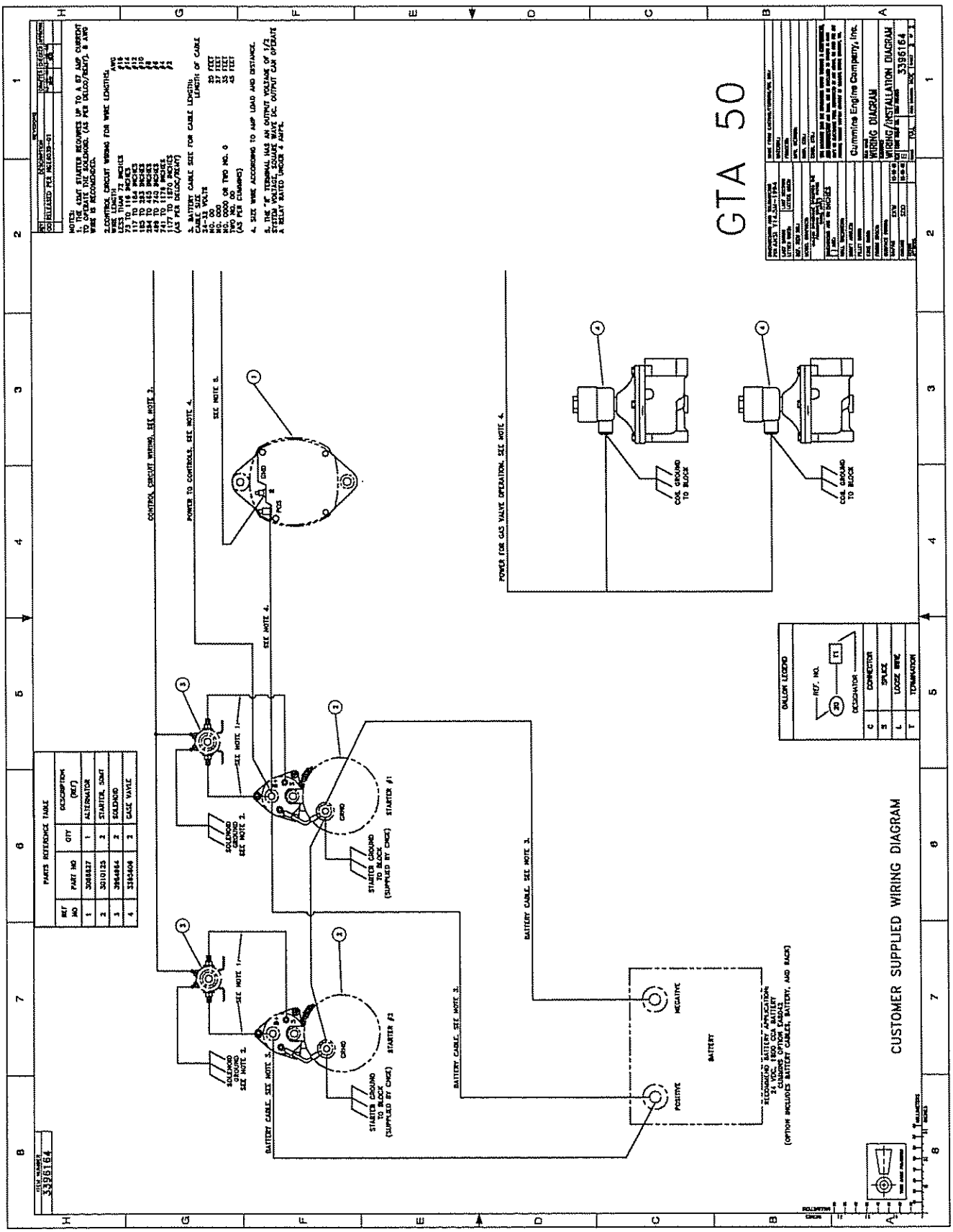
ALTRONIC III and Wiring Harness
Starter Wiring Diagram
Woodward Flo-Tech Actuator & Speed Control System

Notes:

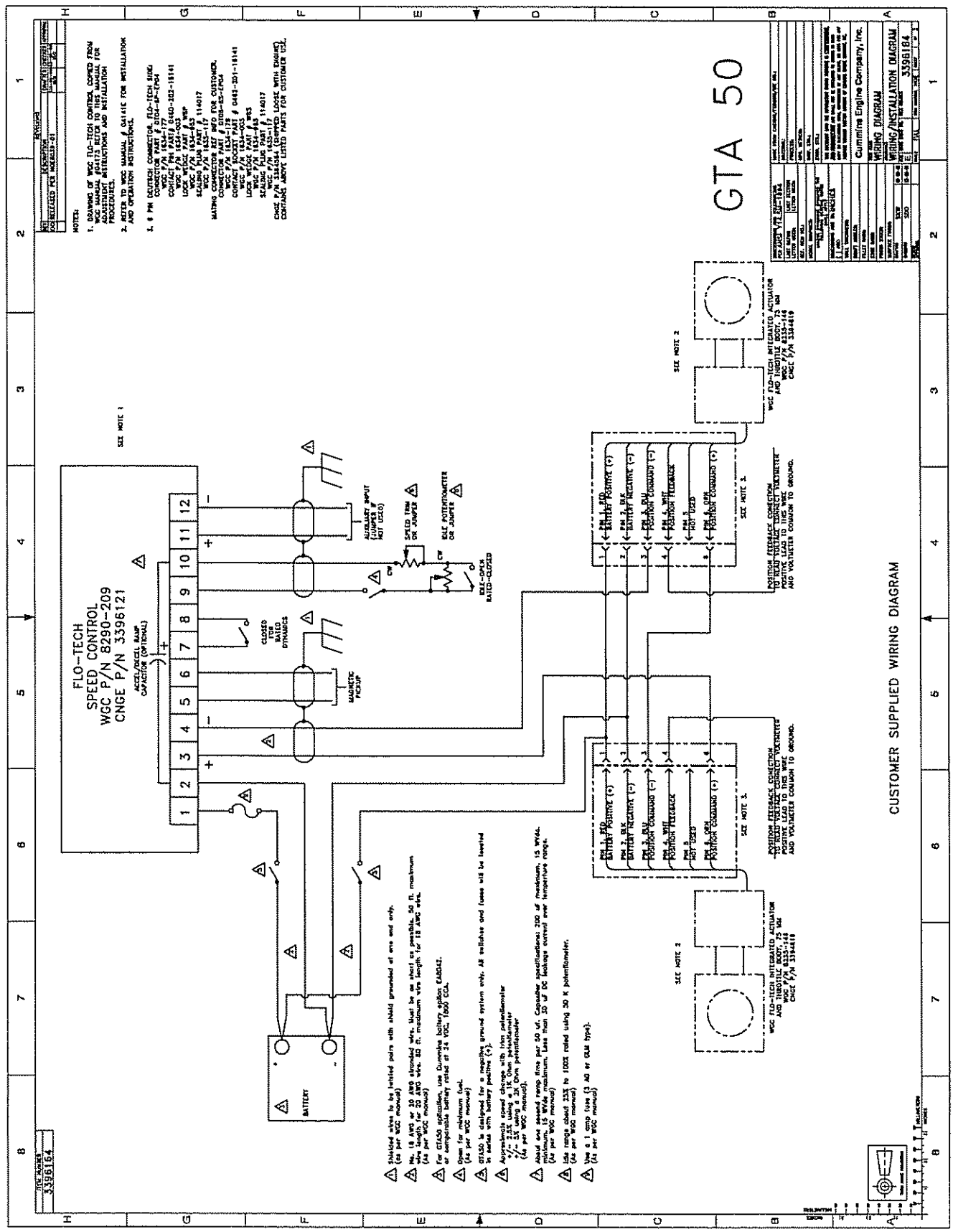
Altronic III - 3396131



Starter Circuit - 3396164



Woodward Flo-Tech - 3396164



Fuel System Specifications

Fuel-Gas

Dry Natural Gas

CNGE recommends the use of a dry processed natural gas, sometimes called "pipeline" natural gas. Commercial gases in this category should have less than 10 PPM of H_2S (Hydrogen Sulfide). Gas with more than 10 PPM of H_2S is considered a high sulfur fuel.

Dry natural gas will contain Methane (CH4), and Ethane (C2H6). In some areas the gas may contain up to 5 % of Propane and a small amount of Butane. Refer to page 6-21 through 6-22 for the maximum permissible combustibles allowed in a CNGE engine before Fuel Deration of the engine is required.

CNGE published data is based on a dry processed natural gas fuel with 905 BTU per standard cubic foot (33.72 kJ/L) lower heating value (LHV).

CNGE requires that ALL OTHER GASES undergo a Gas Analysis to decide if they are suitable for use in a CNGE engine. Some gases will require a mechanical change to the on engine fuel system and a change of the compression ratio of the pistons.

Caution: At this time the only gas approved for use with the GTA38 & GTA50 Engine models is Dry Processed Natural Gas

Examples of other gases are:

Propane

Propane processed to HD-5 specification standards of 95% propane purity with the remaining 5% not heavier than butane may be used for non-lug applications only. Refer to the correct compression ratio for HD-5 propane. Reference Chart # 1 on Page 6-21.

Caution: Since propane is heavier than air, engine room ventilation becomes a serious consideration. CNGE recommends that the local building codes should be checked when considering propane as a fuel. Many areas prohibit the use of liquid propane within the confines of a building and require that the liquid propane vaporizer be installed outside the engine room.

Note: Some commercially bottled gases called "liquid propane" or "liquid bottled gas" will not meet the HD-5 specification.

Propane gas will require a mechanical change to the on engine fuel system. Propane gas will also require a change in compression ratio to 8.5:1 on turbo-charged engines.

Field Gas

Field gas is generally available at the wellhead in a gas field. Sometimes field gas is called "wellhead" gas. Due to the wide variation in gas fields, this gas will always require an analysis to decide its acceptability for use.

Sour Gas

This is a specific field gas that contains sulfur compounds such as hydrogen sulfide. When water vapor and sulfur oxides are present during combustion, sulfuric acid compounds will form. This condition will shorten the life of all internal components, specifically piston rings, cylinder liners, valve guides and bearings.

Sour gas fuels will generally need to be treated to remove all presence of water vapor. In addition, if the hydrogen sulfide content is above 24 ppm, the sour gas will need to be treated to remove the hydrogen sulfide.

The use of sour gas as a fuel will require high ash oil not more than .85% of sulfated ash with a high TBN number that meets a CD API specification be used to help neutralize the acid.

Digester Gas

This gas is a by-product of digester tanks where various materials are going through a bio-degrading process, such as sewage, animal waste, vegetable waste, etc.

This type of gas will be low in heat value.

Landfill Gas

Landfill operations due to the variety and quantity of organic materials can produce large quantities of methane gas. The gas is generally of a low heat value and requires treatment of the gas. A filter capable of removing 99.5% A.C. fine dust is required in the fuel line to remove the abrasive material associated with landfill operations. In addition, a complete fuel gas analysis will be required to determine the specific treatment required for the gas. As a minimum, the fuel should be treated similarly to "sour gas".

Landfills may come under EPA jurisdiction and may require emission controls.

Note: For the use of all gases other than dry pipeline natural gas, CNGE factory approval is required. Failures of the engine as a result of burning gases other than dry pipeline natural gas may have a negative effect on the engine warranty.

Gas Measurement Conversion Factors

Example:

Methane Gas at 60° F

1MCF	= 1000 Cubic feet.
1 Decatherm	= 1000 feet.
1 Decatherm	= 10 Therms.
1 Therm	= 100 Cubic feet.
1 Therm	= 101,200 BTU (HHV).
1 Cubic feet	= 1,012 BTU (HHV).
100 Cubic feet	= 101,200 BTU (HHV).
100 Cubic feet	= 91,080 BTU (LHV).

Utility companies will talk in terms of Therms of gas at HHV levels. The engines will actually use only the LHV of the gas to produce power. The balance of the energy (10%) is consumed in the removal of water from the combustion cycle (Latent heat of vaporization).

Table # 6-04- Fuel Gas BTU Content

Gas	Chemical Formula	BTU per ft 3 Vapor HHV
Methane	CH_4	1012
Ethene	C_2H_4	1601
Ethane	C_2H_6	1783
Propene	$C3H_6$	2335
Propane	$C3H_8$	2558
ISO-Butane	C_4H_{10}	3354
Butene-1	C_4H_6	3084
ISO-Butene	C_4H_6	3066
N-Butene	C_4H_{10}	3368
ISO-Pentane	$C5H_{12}$	4003
Pentene-1	$C5H_{10}$	3829
N-Pentane	$C5H_{12}$	4015
Hexane	$C6H_{14}$	4756
Heptane	$C7H_{16}$	5503
Octane	$C8H_{18}$	6250
Carbon Monoxide	CO	321
Carbon Dioxide	CO_2	.0
Hydrogen	H	324
Hydrogen Sulfide	H_2S	672
Oxygen	O_2	0
Nitrogen	N_2	0
Air		0
Water	H_2O	

FUEL, ALTITUDE & TEMPERATURE - DE-RATING FACTORS

Cummins Natural Gas Engines, Inc. (CNGE) engines are capable of carrying standard published ratings when operated on clean "dry processed natural gas" fuels and on other combustible fuel mixtures. When low BTU content is determined, there may be a requirement to de-rate the engines.

The purpose of this Section is to define those factors of Altitude, Inlet Air Temperature, Choice of Compression Ratio, and Fuel Content that will affect engine performance as required by CNGE for proper engine application.

When engines must be operated beyond standard rating conditions, consideration must be given to the reduced breathing capacity and resultant power loss caused by lower air density, or to possibilities of engine damage by detonation resulting from the lower octane ratings of the higher hydrocarbon fuels. When either of these conditions occur, de-rating factors must be applied. In addition, there also may be a requirement to change to a lower compression ratio piston.

Caution: Improper fuel and incorrect compression ratio application may lead to burnt or detonation failures of pistons, valves and cylinder heads. Failures of this nature are not considered to be of a warrantable nature.

Altitude De-Rating Requirements

Turbocharged Engines

G1 & G2 ratings

The engine may be operated at the **MAXIMUM RATING [Emergency Stand-by Rating]** up to 914m [3,000 ft.] altitude and 38° C [100° F] inlet air temperature, and at the **CONTINUOUS RATING [Prime Power or Continuous Base Load Rating]** up to 1542m [5,000 ft.] altitude and 38° C [100° F] inlet air temperature. For sustained operation at high load factors at higher altitudes and temperatures please consult the factory.

Altitude and temperature de-rating factors are to be considered as additive when temperatures exceed 38° C [100° F] and when altitudes are over 914m [3000 ft.].

The water-to-air aftercooling system has a maximum limit of 145° F (63° C) maximum intake manifold air-gas temperature with 130° F (54° C) or lower water temperature to the aftercooler.

G3 rating

The engine may be operated at the **MAXIMUM RATING [Emergency Stand-by Rating]** up to 305m [1,000 ft.] altitude and 38° C [100° F] inlet air temperature, and at the **CONTINUOUS RATING [Prime Power or Continuous Base Load Rating]** up to 914m [3,000 ft.] altitude and 38° C [100° F] inlet air temperature. For sustained operation at high load factors at higher altitudes and temperatures please consult the factory.

Altitude and temperature de-rating factors are to be considered as additive when temperatures exceed 38° C [100° F] and when altitudes are over 914m [3000 ft.].

The water-to-air aftercooling system has a maximum limit of 125° F (52° C) maximum intake manifold air-gas temperature with 110° F (43° C) or lower water temperature to the aftercooler for the standby rating only.

The CONTINUOUS RATING [Prime Power or Continuous Base Load Rating] for the water-to-air aftercooling system has a maximum limit of 145° F (63° C) maximum intake manifold air-gas temperature with 130° F (54° C) or lower water temperature to the aftercooler.

Note: The prime power and continuous ratings are not currently released.

Fuel De-Rating Requirements

Fuel de-rating factors are based on percentages of each hydrocarbon constituent, as a portion of the total combustibles in the fuel gas.

Inert gases such as nitrogen (N_2), carbon dioxide (CO_2) or water vapor (H_2O), etc., have no effect on engine performance except where they occur in sufficient percentages to lower the heat content of the fuel below the normal 1000 BTU per standard cubic feet of processed natural gas.

Chart # 1 Maximum Permissible Combustibles

This chart shows in percent (%) the maximum allowable fuel combustibles contents of the various hydrocarbons that can be present in the fuel.

Chart # 2 Starting Point for De-Rating

This chart shows the maximum allowable fuel combustibles in percent (%) that can be present in the fuel, before the beginning of any de-rating of the engine due to that specific fuel combustible.

Chart # 3 De-Rate Percentages

This chart shows the percent of de-rate that is to be applied on a "per percent" of the specific combustible.

Water Vapor Content & Liquid Combustibles

Fuel gas must be as dry as possible. All liquid and droplets in the fuel MUST BE REMOVED from the fuel before the first pressure regulator. Condensation from water vapor in the fuel piping can cause engine damage. Liquid fuel droplets can cause uncontrolled fuel burning, detonation, etc., leading to engine damage.

EXCEPTION - HD-5 PROPANE

Propane processed to HD-5 specification standards of 95% propane purity with the remaining 5% not heavier than butane may be used for non-lug applications only. Refer to the correct compression ratio for HD-5 propane.

Only de-rating due to altitude & inlet air temperature will apply. The fuel de-rating is already built into the CNGE specification for HD-5 propane.

Special Notes:

1. Naturally aspirated low compression ratio pistons should be specified only in cases where the fuel quality is beyond the limits of acceptability for use in engines with higher compression ratio pistons. Operation with lower compression ratio pistons will provide a lower level of maximum power available and less fuel economy and with an increase in exhaust gas temperature.

2. High compression ratio pistons for both naturally aspirated and turbocharged engines are extremely sensitive to fuel anti-knock characteristics, therefore a lower level of the maximum permissible percentages have been placed on the higher hydrocarbon constituents. If the percentage of any single constituent exceeds the maximum permissible figure, then the only alternative is to change to a lower compression ratio piston or a more suitable fuel.

Note: The CNGE GTA38 & GTA50 Engine Models will be released with only the 8.5:1 low compression ratio piston.

3. Liquid water is not allowed to enter the engine intake system. The dew point of fuel gas should be at least 20° F. below the minimum ambient temperature at the application site.

4. Hydrogen sulfides above the level of 10 ppm in the fuel can cause corrosive attack of internal engine components. When hydrogen sulfides are present the need for a high ash natural gas lubricating oil should be considered.

   When the H2S is above 24 PPM the gas is described as a sour gas and a treatment facility will be required to remove the hydrogen sulfides.

5. Chlorinated hydrocarbons (halogenated hydrocarbons) can cause corrosive damage to the engine. Acceptable levels are similar to hydrogen sulfides, i.e., 10 to 24 PPM.

6. Fuel gas should be filtered to a 10-micron level to eliminate dust or foreign particles.

Calculations

1. First compute the amount of de-rating required due to Altitude and Inlet Air Temperature.

2. Recalculate each fuel constituent with percentages for the Inert gases removed considering only 100 percent of the combustibles. This step is required before the de-rating factors can be applied.

3. Compute the amount of de-rating required for each fuel hydrocarbon present.

4. Sum the de-rating percent for each fuel hydrocarbon to obtain the required de-rate due to the fuel constituents.

5. Compare the amount of de-rating due to Altitude & Temperature against the amount of de-rating due to the fuel hydrocarbons and use the HIGHER of the two.

Example Calculation

Market Application

Emergency Standby

Specific Conditions:

Model = GTA50
Altitude = 4000 feet
RPM = 1800
Inlet Air Temperature = 107˚F
HP = 1334
C.R. = 8.5:1

A. Altitude De-Rating %

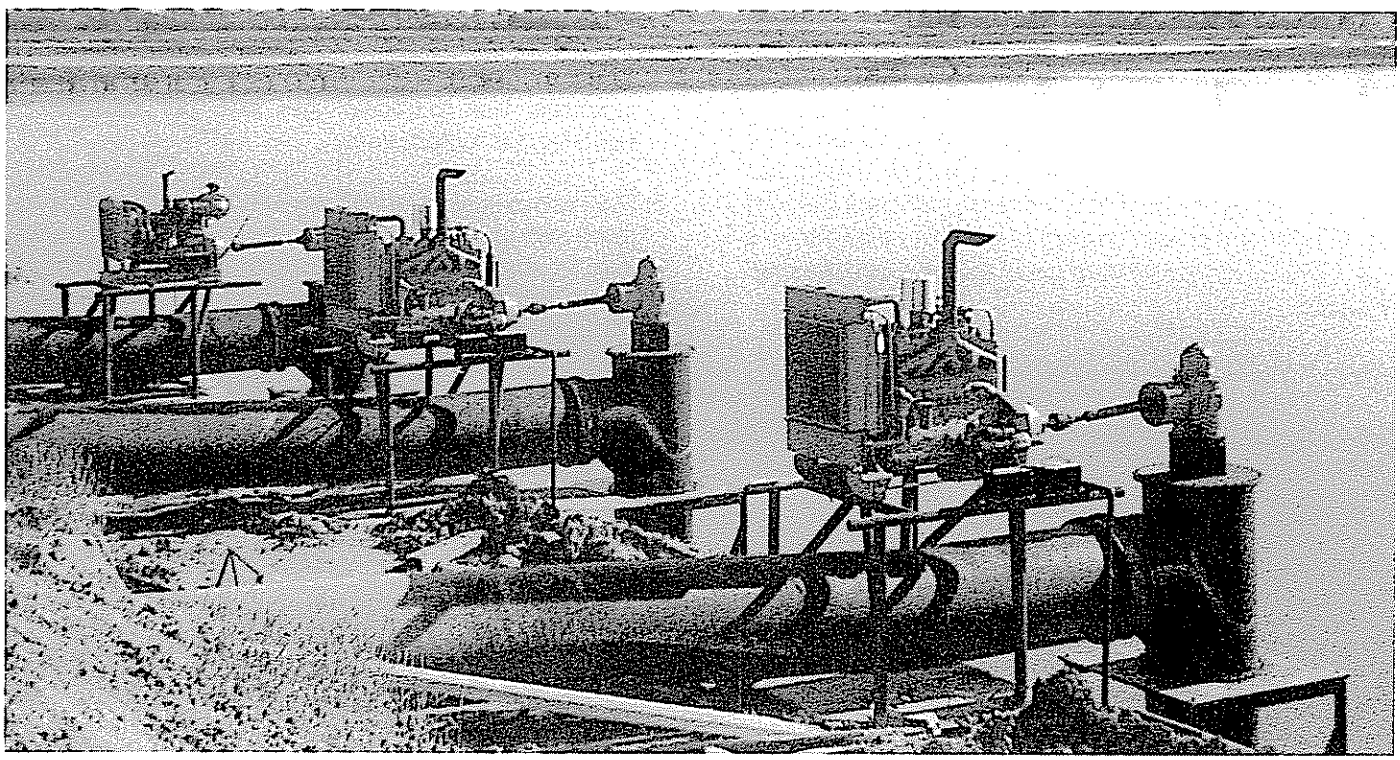
4000 - 3000 = 1000 feet subject to de-rating
4%/1000 x 1000 ft. = 4%

B. Inlet Air Temperature

107 - 100 = 7˚F subject to de-rating
1%/10˚ F x 7˚ F = 0.7%

C. Altitude & Temperature Combined

4% + 0.7% = 4.7%



D. Fuel Analysis

Hydrocarbons Max. Con.	Inerts (%)	Analy. (%)	Corr. (%)	Perm. prior to derate (%)	Excess (%)	Der. Fac. (%)	De-rating (%)
N_2	2.20	—	—	—	—	—	—
CO_2	1.86	—	—	—	—	—	—
$C_1 H_4$	—	63.42	66.10	100	—	—	—
$C_2 H_6$	—	14.56	15.18	100	—	—	—
$C_3 H_8$	—	9.18	9.57	100	—	—	—
$C_4 H_{10}$	—	1.71	1.78	50	—	—	—
$NC_4 H_{10}$	—	3.61	3.76	15	—	—	—
$IC_5 H_{12}$	—	1.05	1.10	15	—	—	—
$NC_5 H_{12}$	1.03	1.07	0	1.07	4.0	4.28	
$C_{7+} H_{16}$	—	1.38	1.44	0	1.44	4.0	5.76
Totals	4.06	95.94	100.00		2.51	10.04	

E. Compare the fuel de-rating of 10.04% against the Altitude & Temperature de-rating of 4.7%. Use the higher of the two.

F. De-rate the engine from 1334HP by 10.04 % or 134 HP to 1200HP.

Chart # 1

FUEL DE-RATING FACTORS

MAXIMUM PERMISSIBLE COMBUSTIBLES - %

	Turbocharged
Compression Ratio	8.5:1
Type of Gas	
Methane (CH_4)	100
Ethane (C_2H_6)	100
Propane (C_3H_8)	10
ISO-Butane (C_4H_{10})	7
Hydrogen (H_2)	7
Normal Butane (C_4H_{10})	3
ISO-Pentane (C_5H_{12})	3
Normal Pentane (C_5H_{12})	1
Hexane (C_6H1_4)	1
Heptane (C_7H_{16})	1

Chart # 2

FUEL DE-RATING FACTORS

STARTING POINT FOR DE-RATING - %

	Turbocharged
Compression Ratio	8.5:1
Type of Gas	
Methane (CH_4)	NA
Ethane (C_2H_6)	NA
Propane (C_3H_8)	5
ISO-Butane (C_4H_{10})	2
Hydrogen (H_2)	2
Normal Butane (C_4H_{10})	0
ISO-Pentane (C_5H_{12})	0
Normal Pentane (C_5H_{12})	0
Hexane (C_6H_{14})	0
Heptane (C_7H_{16})	0

Chart # 3

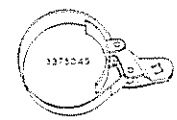
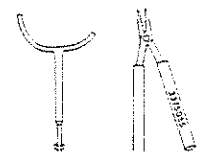
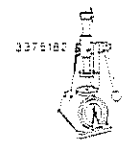
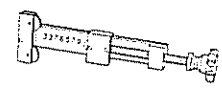
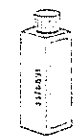
FUEL DE-RATING FACTORS
DE-RATE PERCENTAGE - % per %

	Turbocharged		Turbocharged
Compression Ratio	8.5:1	Compression Ratio	8.5:1
Type of Gas		Type of Gas	
Methane (CH4)	0	Normal Butane (C4H10)	1
Ethane (C2H6)	0	ISO-Pentane (C5H12)	1
Propane (C3H8)	.5	Normal Pentane (C5H12)	4
ISO-Butane (C4H10)	.5	Hexane (C6H14)	4
Hydrogen (H2)	.5	Heptane (C7H16)	4

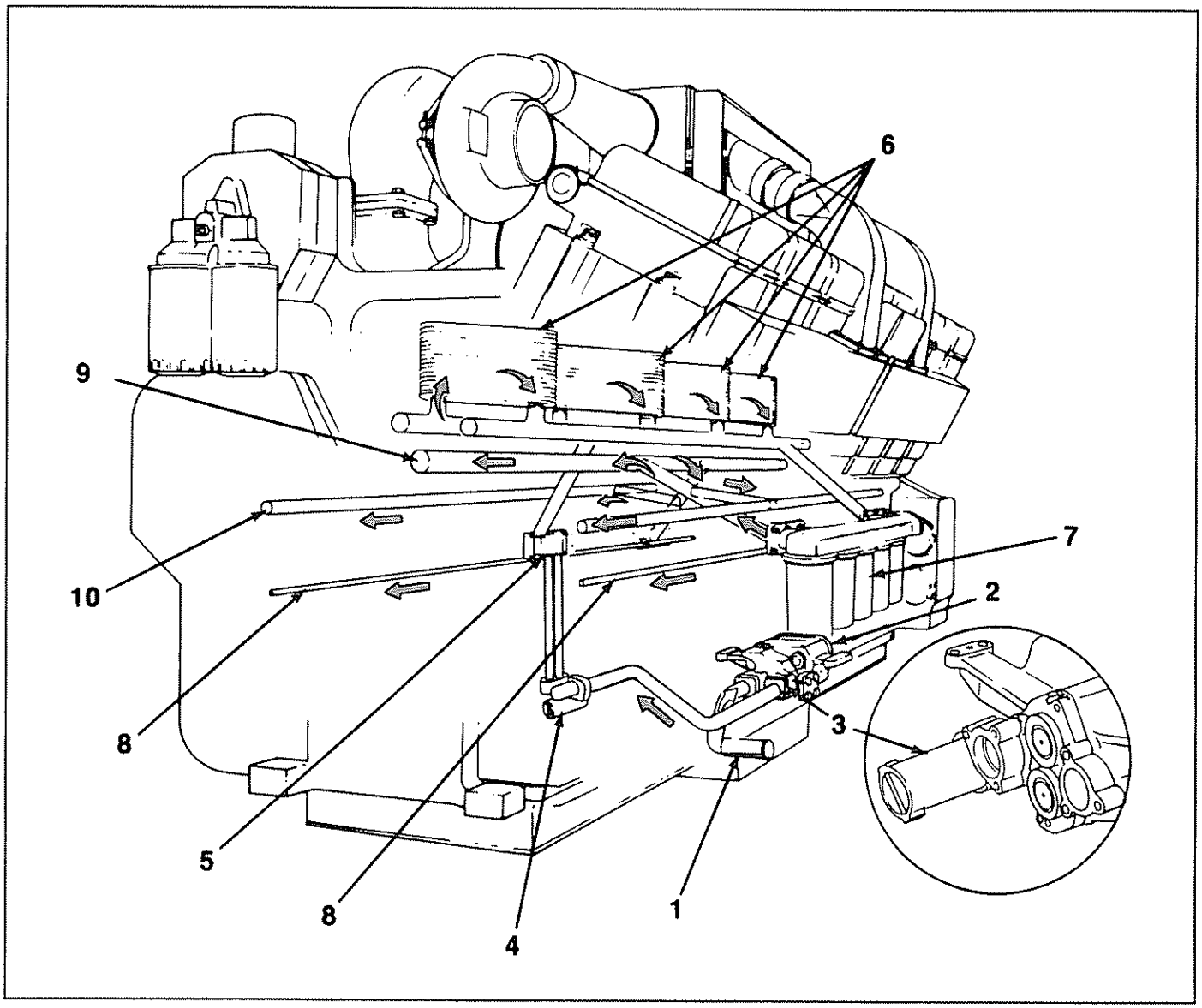
LubricatingSystem Specifications

Required Service Tools
Lubricating Oil System

The following special tools are recommended to perform the procedures covered in this section. These tools can be purchased from your local Cummins Authorized Repair Location.

Tool No.	Tool Description	Tool Illustration
3375049	Oil Filter Wench Remove spin-on oil filter.	
3375055	Pressure Regulator Removal Tool Remove retaining ring from lube oil pump regulator (on engine).	
3375182	Valve Spring Tester Measure spring force at a given spring height.	
3375301 3376579	Tube Cutter Open spin-on full flow filter for inspection.	
3376891	Flourescent Tracer Add to oil. Use with blacklight to find oil leaks.	
3377253	Blacklight (AC) Inspect for oil leak.	
3377394	Blacklight (DC) Inspect for oil leak.	

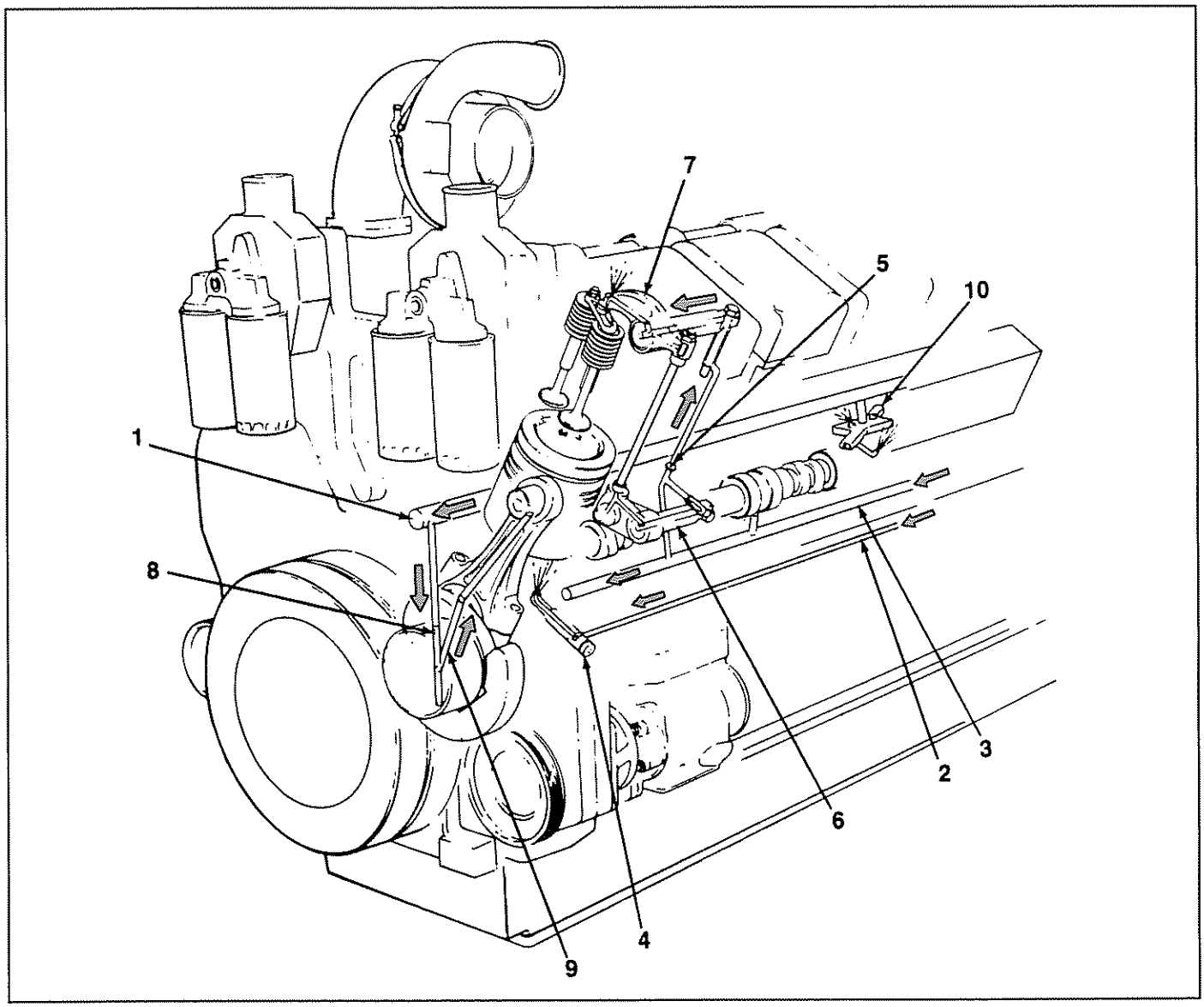
Lubricating Oil Flow Diagrams



Lubricating Oil System

1. Oil Inlet Tube
2. Lubricating Oil Pump
3. High Pressure Relief Valve GTA38
4. High Pressure Relief valve GTA50
5. Jumper Cover
6. Oil Cooler
7. Oil Filter
8. Piston Cooling Rifle (Outboard)
9. Main Oil Rifle
10. Cam Oil Rifle

Lubricating Oil Flow Diagrams



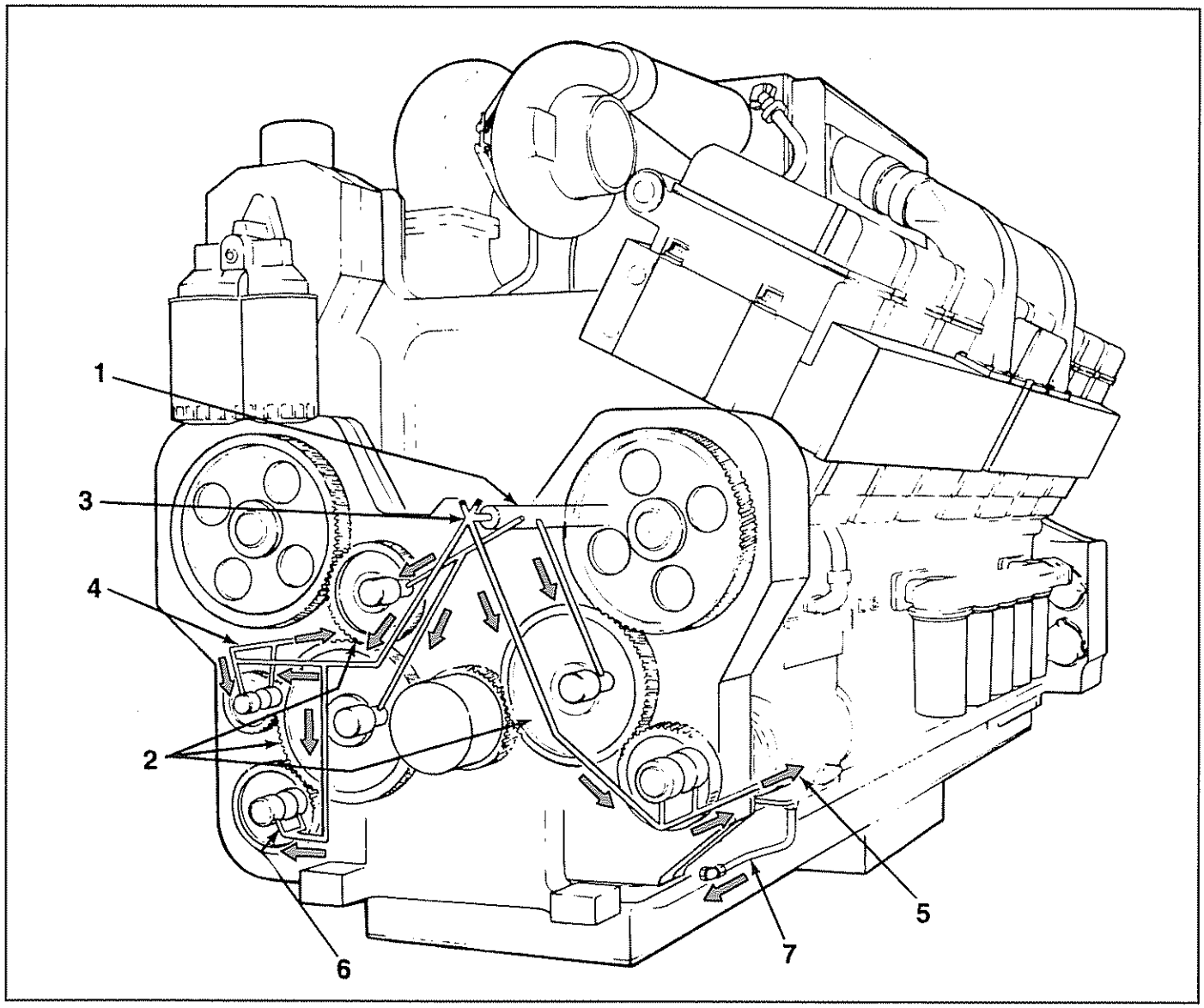
Piston Cooling, Connecting Rod, Overhead

1. Main Oil Rifle
2. Piston Cooling Rifle (Outboard)
3. Cam Oil Rifle
4. Piston Cooling Nozzle (Outboard)
5. Orifice
6. Cam Follower
7. Rocker Lever (Exhaust)
8. Oil Supply to main Bearings
9. Oil Supply to Connecting Rod
10. Piston Cooling Nozzle (Inboard)

Note: Engines with inboard piston cooling nozzles will not possess items 2 and 4.

Older engines with outboard piston cooling nozzles will not possess item 10.

Lubricating Oil Flow Diagrams

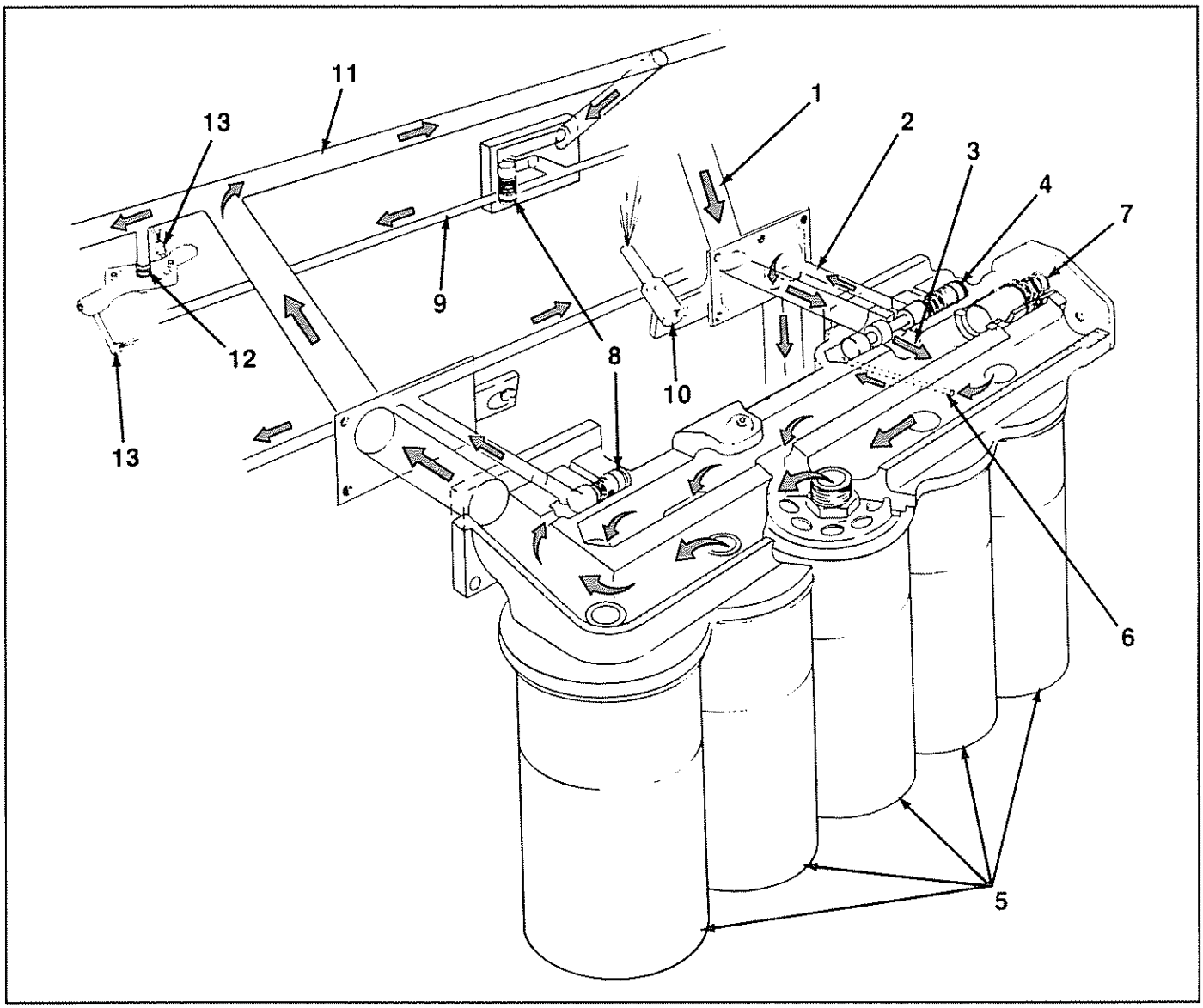


Front Gear Train

1. Main Oil Rifle
2. Idler Gear
3. Oil Flow through Gear Housing into Front Cover
4. Oil to Water Pump
5. Oil to Ignition Drive
6. Oil to Hydraulic Pump Drive
7. Oil Return from Ignition Drive

Note: Oil flow to the idler-gears (2) is through the cylinder block.

Lubricating Oil Flow Diagrams

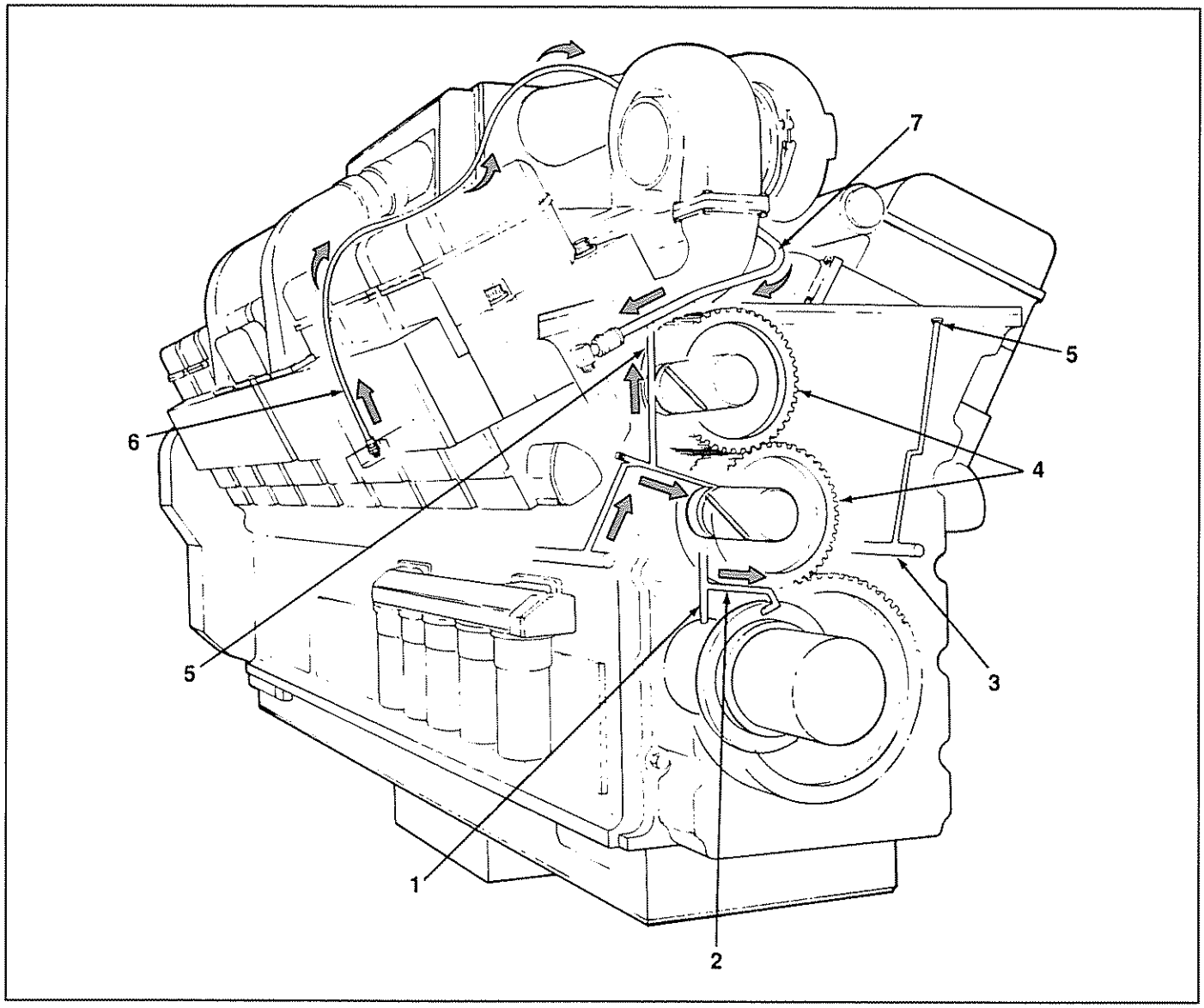


Full Flow Lubricating Oil Filter Head

1. Oil Supply to Filter-head
2. Oil Return to Oil Pan
3. Oil Supply to Oil Filters
4. Oil Pressure Regulator
5. Oil Filter (Some models will have only 4 filters)
6. Control Rifle
7. Filter By-pass Valve
8. Piston Cooling Control Valve (Outboard)
9. Piston Cooling Rifle (Outboard)
10. Piston Cooling Nozzle (Outboard)
11. Main Oil Rifle
12. Piston Cooling Control Valve (Center Mount
13. Piston Cooling Nozzle (Center Mount)

Note: Engines with center mount piston cooling nozzles will not possess Item No's 8, 9 or 10.

Lubricating Oil Flow Diagrams



Rear Gear Train, Turbocharger

1. From Main Oil Rifle
2. Oil Supply to Thrust Bearing
3. Cam Oil Rifle
4. Idler Gear
5. Oil Supply to Upper Output Housing
6. Turbocharger Oil Supply
7. Turbocharger Oil Drain

Note: The Rear Gear Train Option is not available on the CNGE GTA50 Engine Model. The Turbocharger Oil Supply may be taken off of any of the Cam Oil Galley plugs.

Lubricating Oil Specifications

Functions of Lubricating Oil

The lubricating oil used in a CNGE engine must be multi-functional. It must do the primary functions of:

- **Lubrication** by providing a film between the moving parts to reduce wear and friction.
- **Cooling** by serving as a heat transfer media to carry heat away from critical areas.
- **Sealing** by filling in the uneven surfaces in the cylinder wall, valve stems and turbocharger oil seals.
- **Cleaning** by holding contaminants in suspension to prevent a build up of deposits on the engine surfaces.

In addition, it also must provide:

- **Dampening** and cushioning of components that operate under high stress, such as gears and push tubes.
- **Protection** from oxidation and corrosion.
- **Hydraulic Action** for components such as Governors and various hydraulic controls.

Engine lubricating oil must be changed when it can no longer perform its functions within an engine. Oil does not wear out, but it becomes contaminated to the point that it can no longer satisfactorily protect the engine. Contamination of the oil is a normal result of engine operation. During engine operation a variety of contaminants are introduced into the oil. Some of these are:

- Byproducts of Engine Combustion - oxides of nitrogen, carbon, soot, acids from partially burned fuel-gas & lubricating oil.
- Acids, varnish and sludge that are formed because of oxidation of the oil as it breaks down or decomposes.
- Dirt entering the engine through the combustion air, fuel-gas, or while adding or changing lubricating oil.

The oil must have an additive package to combat these contaminates. The package generally consists of:

- **Detergents/Dispersants** that keep insoluble matter in suspension until they are filtered from the oil or are removed with the oil change. This prevents sludge and carbon deposits from forming in the engine.
- **Inhibitors** to maintain the stability of the oil, prevent acids from attacking metal surfaces and prevent rust during the periods the engine is not operating.
- **Other Additives** that enable the oil to lubricate highly loaded areas, prevent scuffing and seizing, control foaming and prevent air retention in the oil.

Oil Performance Classification System

The American Petroleum Institute **(API)**, The American Society for Testing and Materials **(ASTM)** and the Society of Automotive Engineers **(SAE)** have jointly developed and maintained a system for classifying lubricating oil by performance categories. For more information contact the API, ASTM, SAE or EMA.

Engine Manufacturers Association - EMA

The Engine Manufacturers Association (EMA) publishes a book entitled "EMA Lubricating Oils Data Book". Copies may be purchased from:

Engine Manufacturers Association,
401 N. Michigan Avenue, Suite 2400
Chicago, IL 60611

This book lists commercially available oils by oil company and brand name with the API performance categories met by each brand.

Oil Performance Recommendations

CNGE does not recommend the use of any specific brand of engine lubricating oil. CNGE does recommend for the GTA38 & GTA50 Engine Models, the use of natural gas oil that meets the following specifications.

API	CD Quality
SAE Viscosity	15W40
Sulfated Ash	Between .15 and .85%

Note: When operating with a **catalytic converter** the sulfated ash may have to be held to a maximum of .5%. Contact your catalytic converter manufacture for the required limits.

Sulfated Ash Limit

A sulfated ash limit has been placed on lubricating oil for use in CNGE engines. Experience has shown that oils with a high ash content may produce deposits on valves that can progress to guttering and valve burning. A maximum sulfated ash content of .85% is recommended.

CNGE does not recommend the use of ash-less oils for natural gas engines. When the ash content is below .15 mass percent, the ash should represent organo-metallic anti-wear additives, provided such additives do not contain barium or magnesium.

Break-In-Oils

Special "break-in" lubricating oils are not recommended for either new or rebuilt CNGE engines. Use the same lubricating oils used in normal engine operation.

Viscosity Recommendations

The viscosity of oil is a measure of its resistance to flow. The Society of Automotive Engineers has classified engine oils in viscosity grades. CNGE recommends the use of a high quality SAE 15W-40 multi-viscosity heavy-duty natural gas engine oil that meets the API performance classification CD.

Multi-grade oils are generally produced by adding viscosity index improver additives to retard thinning effects that a low viscosity base oil will experience at engine operating temperatures. Multi-grade oils that meet the requirements of the API specifications are recommended for use in CNGE engines.

Cummins have found that the use of multi-grade lubricating oil improves oil consumption control, improved engine cranking in cold conditions while maintaining lubricating at high operating temperatures and may contribute to improved fuel consumption. CNGE does not recommend the use of single grade lubricating oils. In the event that the recommended multi-grade oil is not available, single grade oils may be substituted.

Caution: When the ambient temperature drops below the minimum value for the specific oil being used, drop one viscosity grade. Reference **Table # 6-05**.

Table # 6-05 - Viscosity Grade vs Ambient Temperature

SAE Viscosity Grade	Ambient Temperature
10W-30	-25° C to 35° C [-13° F to 5° F]
15W-40	-10° C & above [14° F & above]
20W-40	0° C & above [32° F & above]

Oil Analysis Procedures

Laboratory Analysis

Laboratory analysis of engine oil can be used to establish oil drain/filter change intervals if a properly designed test and evaluation program is carried out. **New oil must be analyzed before being put into an engine to establish baseline data.** This oil must then be analyzed at 150 hours, 250 hours and then at 50-hour intervals.

Caution: Extended operating hours may lead to a plugged oil filter and the by-passing of unfiltered oil to the engine main oil galley causing damage to rotating parts.

If any of the samples show that the oil has failed to pass any of the ASTM test criteria, then the oil and filters in that engine need to be changed.

The laboratory test should be repeated if either the brand of oil or type of oil is being changed, or if engine operational conditions change.

Following is a listing of the tests that must be performed and the guideline limits that must be followed. These tests were established by the American Society for Testing and Materials, ASTM.

The most CRITICAL TEST for Natural Gas or Propane Engines is the TAN number.

In addition CNGE recommends that the following infrared analysis be used when measuring either Nitration or Oxidation of the Oil.

Nitration. The maximum for nitration should not exceed 25 absorbance units/cm at a wave number of 1630.

Oxidation. The maximum for oxidation should not exceed 25 absorbance units/cm at a wave number of 1710.

Special NOTE: The guideline limits specified in **Table # 6-06** should be used to decide the useful life of the specific oil under test. This group of analyses and the methods recommended are not generally part of the oil analysis offered by most commercial laboratories.

Oil analysis is not a low cost test and can run to a very high level of cost on an individual sample basis.

High Nitration or Oxidation will cause an oil degradation to occur that generally leads to the oil becoming thicker, forming lacquer and maroon-colored deposits. In both cases the oil change interval must be lowered or the volume of oil in the engine must be increased by the addition of by-pass filters. In the case of high nitration, the air-to-fuel ratio may have to be adjusted. Engines that have been optimized for the maximum fuel economy will be running at an air-to-fuel ratio that will tend to produce higher nitrous oxide (NOx).

Adjustments to the air-fuel ratio should be done with caution since changes to reduce NOx may lead to a reduction of power or an increase in Exhaust Gas Temperature affecting service life of the Engine.

Table # 6-06 - Oil Analysis Test

Property	ASTM Method	CNGE Oil Guideline Limit
Viscosity @ 40° & 100° C	D445	+ or - 1 SAE Grade
Sulfated Ash	D874	.85 % Max. .15 % Min.
Insolubles	D893/GCM359	1.0 % Max.
Total Acid Number (TAN)	D664	2.5 Number Increase above new oil.
Total Base Number (TBN)	D 664	2.5 Minimum or 50 % reduction of new oil value or equal to TAN, whichever is reached first.
Water Content	D95	.2 % Max.
Additive Reduction	AES or AAS	25 % Max. of new oil.

Spectrographic (Spectrochemical) Analysis

Spectrographic analysis determines only the wear metals and particulate matter level in lubricating oil. Therefore, Spectrographic analysis alone should not be used to decide the oil change interval.

Change the oil and the filters to remove the contaminants suspended in the oil.

Synthetic Lubricating Oil

Synthetic oils for use in natural gas engines are primarily blended from synthesized hydrocarbons and esters. These base oils, are manufactured by chemically reacting lower molecular weight materials to produce a lubricant that has planned predictable properties.

Synthetic oil was developed for use in extreme environments where the ambient temperature may be as low as -45° C [-50° F] and extremely high engine temperatures at up to 205° C [400° F]. Under these extreme conditions, petroleum base stock lubricants (mineral oil) do not perform satisfactorily.

CNGE recommends synthetic lubricating oil for use in CNGE engines operating in areas where the ambient temperature is consistently lower than -25° C [-13° F]. Synthetic lubricating oils may be used at higher ambient temperatures provided they meet the appropriate API Service categories, viscosity grades and minimum additive package requirements.

CNGE recommends the same oil change interval be followed for synthetic lubricating oil as that for petroleum based lubricating oil.

Arctic Operations

For engine operation in areas where the ambient temperature is consistently below -25° C [-13° F] and where there is no provision to keep the engine warm when it is not operating, the lubricating oil should meet the requirements in the following table.

Table # 6-07 - Arctic Oil Recommendations

Parameter Test Method	Specifications
Performance Quality Level	API classification CC/SC & CC/CD
Viscosity	10,000 mPa's Max. @ -35° C [-31° F] 4.1 mm2/s Min. at 100° C [212° F]
Pour Point (ASTM D-97)	Min. of 5° C [9° F] Below the Lowest Expected Ambient Temperature
Sulfated Ash Content (ASTM D-874)	.85% by Weight Maximum Content .15% by Weight Minimum Content

Oils meeting these requirements usually have synthetic base stocks. SAE 5W viscosity grade synthetic oils may be used provided they meet the minimum viscosity requirement at 100° C [212° F].

Grease

Caution: Do not mix brands of grease. Damage to the bearings may result. Excessive lubrication is as harmful as inadequate lubrication. After lubricating the fan hub, replace both pipe plugs. Use of fittings will allow the lubricant to be thrown out due to rotating speed.

Test	Test Procedure
High-Temperature Performance	
Dropping point,˚F.	ASTM D 2265 350 min.
Bearing life, hours at 300˚ F 10,000 rpm	*FTM 331 600 min.
Low-Temperature Properties	
Torque, GCM Start at 0˚ F Run at 0˚ F	ASTM D 1478 15,000 max. 5,000 max.
Rust Protection and Water Resistance	
Rust Test	ASTM D 1743 Pass
Water resistance	% ASTM D 1264 20 max.
Stability	
Oil separation, % 30 hours @ 212˚ F	*FTM 321 5 max.
Penetration	
Worked	ASTM D 217 250-300
Bomb Test, PSI Drop	ASTM D 942
100 hours 500 hours	10 max. 25 max.
Copper Corrosion	*FTM 5309 Pass
Dirt Count, Particles/cc 25 Micron + 75 Micron + 125 Micron +	*FTM 3005 5,000 max. 1,000 max. None
Rubber Swell	*FTM 3603 10 max.

*** Federal Test Method Standard No. 791a.**

Timing & Excess Oxygen Specifications

Ignition Timing - Checking/Adjusting

Engine timing is not a fixed value but depends upon the load, type & quality of the fuel, altitude and the rated speed (RPM) of the engine as well as local ambient temperatures and barometric pressures.

Therefore, it is important, that the adjustment for excess Oxygen, is made by a qualified CNGE distributor or CNGE authorized dealer service technician at the time of engine inspection and start-up.

Set initial engine timing to the appropriate value listed in **Table # 6-08.**

Caution: CNGE sets all engines at Clovis, New Mexico conditions of 4200 feet altitude and to the limits in **Table # 6-08** for the initial engine timing.

Timing will have to be readjusted due to altitude, temperature, load, type of fuel and the air/fuel excess Oxygen setting.

Table # 6-08 - Initial Engine Timing (@ 4200 ft. Clovis, N.M.)

Model	Timing Range (DBTDC)
	Natural Gas
	8.5:1
GTA38	20-24
GTA50	19-21

Note: The above timing is at CNGE'S plant location in Clovis, New Mexico @ 4200 ft. altitude with fuel-gas at a low heat value (LHV) of 905 BTU. Your engine may have to have the timing either retarded or advanced depending on your operating load, temperatures, LHV of your fuel-gas and for your altitude.

Final timing adjustments are made in connection with the adjustment of the power screw on the carburetor. In addition there is a requirement to hold the excess Oxygen reading in the exhaust gas to a predetermined level. This establishes the Air/Fuel ratio. All of this is done while searching for the lowest possible Exhaust Gas Temperature and lowest intake manifold boost pressure on turbocharged models without sustaining a power or RPM loss.

Carburetor - Excess Oxygen - Adjustment

The air-gas **"power valve"** on the carburetor should be adjusted for the specific engine model's excess oxygen requirement. Refer to Table # 6-09.

Table # 6-09 - Excess Oxygen - Without Catalytic Converter

Engine Model		O2 Reading - % Application		
		Stand-By	Prime	Industrial
GTA38		2.0 - 2.6	2.2 - 3.0	2.2 - 3.0
GTA50	G1	2.7 - 3.3	2.2 - 3.0	2.2 - 3.0
	G2,G3	2.5 - 3.0		

Caution: When making the adjustment, it may be necessary to readjust engine ignition timing.

Caution: CNGE sets all engines at Clovis, New Mexico conditions of 4200 feet altitude.

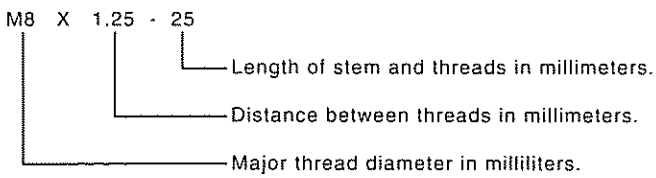
Torque Specifications

The GTA38 and GTA50 Engine Series use parts that are both Metric and U.S. Standard.

Always use caution to be sure that cap-screws from the engine are put back in their proper locations.

When replacing cap-screws, always use a cap-screw of the same measurement and strength as the cap-screw being replaced. Incorrect cap-screws can result in engine damage.

Metric Cap-screw Nomenclature



Additional torque values can be found in Cummins KTA38 & KTA50 Series Shop manual, bulletin # 3810304.

Notes:

Pipe Plug Torque Values

Pipe Plug Torque Values				
Size	Aluminum Housing		Cast Iron Housing	
[Inch]	N•m	[ft-lb]	N•m	[ft-lb]
1/16	5	[45 in-lb]	15	[10]
1/8	15	[10]	20	[15]
1/4	20	[15]	25	[25]
3/8	25	[20]	35	[25]
1/2	35	[25]	55	[40]
3/4	45	[35]	75	[55]
1	60	[45]	95	[70]
1-1/4	75	[55]	115	[85]
1-1/2	85	[65]	135	[100]

Capscrew Markings and Torque Values (10-04)

Caution: When replacing capscrews, always use a capscrew of the same measurement and strength as the capscrew being replaced. Using incorrect capscrews can result in engine damage.

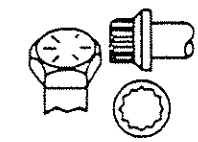
Capscrew Torque

Capscrew Markings and Torque Values - U.S. Customary

SAE Grade Number 5 8

Capscrew Head Markings

These are all SAE Grade 5 (3) line



Capscrew Body Size (Inches) - (Thread)	Capscrew Torque - Grade 5 Capscrew				Capscrew Torque - Grade 8 Capscrew			
	Cast Iron		Aluminum		Cast Iron		Aluminum	
	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb
1/4 - 20	9	7	8	6	15	11	12	9
- 28	12	9	9	7	18	13	14	10
5/16 - 18	20	15	16	12	30	22	24	18
- 24	23	17	19	14	33	24	25	19
3/8 - 16	40	30	25	20	55	40	40	30
- 24	40	30	35	25	60	45	45	35
7/16 - 14	60	45	45	35	90	65	65	50
- 20	65	50	55	40	95	70	75	55
1/2 - 13	95	70	75	55	130	95	100	75
- 20	100	75	80	60	150	110	120	90
9/16 - 12	135	100	110	80	190	140	150	110
- 18	150	110	115	85	210	155	170	125
5/8 - 11	180	135	150	110	255	190	205	150
- 18	210	155	160	120	290	215	230	170
3/4 - 10	325	240	255	190	460	340	365	270
- 16	365	270	285	210	515	380	410	300
7/8 - 9	490	360	380	280	745	550	600	440
- 14	530	390	420	310	825	610	660	490
1 - 8	720	530	570	420	1100	820	890	660
- 14	800	590	650	480	1200	890	960	710

Note: The torque values listed above are established on capscrew threads that have been lubricated with engine oil.

When you have a ft-lb value of less than 10, give consideration to converting the ft-lb value to in-lb value to obtain better torque with an in-lb torque wrench. Example: 6 ft-lb equals 72 in-lb.

Specialized Service Tools

Customer Tools

CNGE offers the following service tools required for a customer to do basic maintenance and some limited checking of the engine.

Tool Part Number	Description
10113858	O_2 Meter Carrying Case
91372621	O_2 Meter
	Does not include copper tubing & Filter media
	Recommend 10 to 15 feet of 3/8 " copper or stainless tubing
	Filter Media Recommend Aquarium Filter Media
91400206	Laser Heat Gun & Carrying Case
91400207	Volt Meter & Hertz Meter
91400208	Timing Light
91400202	Carrying Case Digital Manometer (Each)
91400203	Digital Manometer 0 to 30 psi
91400204	Digital Manometer 0 to 19.99 WC
91400211	Digital Manometer 0 to 199.9 WC
91400205	Hand Held Digital Thermometer with Case
91400037	Thermocouple for Digital Thermometer (Each)
	Recommend a minimum of 6.
91400039	Fitting 1/8 npt Thermocouple (Each)
	Recommend a minimum of 12.
60210006	Pliers for Ignition Wire Crimping
60210007	Spark Plug Removal 13/16 inch
60210008	Spark Plug Adapter Removal 2 & 4 slot
60210018	Spark Plug Adapter Removal - Hex
91372624	Spark Plug Gap Tool
60110001	Compression Tester
60810002	Set of Feeler Gauges
3375049	Oil Filter Wrench
3375208	DCA4™ Test Kit
ST-1274	Belt Tension Gauge
61210002	Tachometer Hand Held
60210002	Seat Sander
91400210	Carrying Case Small
91400909	Carrying Case Large
3395076	5/8 inch Universal Spark Plug Socket

CNGE Specialty Tools

The following tools are recommended for proper optimization of the air/fuel gas ratio and for keeping the engine in a proper balance for emissions and also to allow an engine to operate with the lowest possible exhaust gas temperatures.

91372621	Oxygen Meter

Oxygen Meter Supplemental Instructions

Operating the Teledyne Model 320 P or 320 P/D Oxygen Meter

These suggestions are not intended to replace or to amend the instruction manuals issued with the meters from the manufacturer.

1. Read & follow the manufacturer's manuals, to decide the correct procedure for initial startup of the meters.

2. Test the condition of the batteries before each use. If low (below 500 for the 320P/D or out of test limits for the 320P) then the unit must be recharged before use. It is recommended that the charge should be overnight for 14 hours.

3. Check the condition of the filter material on the back of the unit. Change it if it is wet or dirty.

4. Remove the cell saver cap, check the oxygen calibration with non-tainted or polluted ambient air (20.9%) with the 320P on the high range scale. The 320P/D will auto-range. Adjust with the span dial as necessary. Then install the flow through adapter cap on the O2 fuel cell holder.

5. Connect the temperature reducing tubing to the engine exhaust system.

   A. Turbocharged engines have a 1/4" fitting in the exhaust stack after the turbocharger. Use 10 to 15 feet of 3/8" tubing (Copper or Stainless Steel) and connect to the 1/4" fitting.

      NOTE: If there is no fitting then the tubing should be inserted into the exhaust stack so it is at the-halfway point when measuring the distance from the engine to the end of the stack.

   B. Insure that the tubing is coiled several times or at the minimum has a dip sufficient to act as a water trap.

C. Hook the other end of the tubing to a piece of hose that can be connected to the inlet of the analyzer filter/water trap.

The purpose of this tubing is to lower the exhaust temperature down to a safe range to avoid damage to the meter.

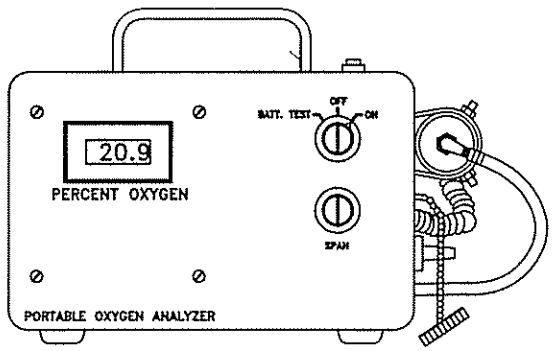


Photo # 6 -01 - Oxygen Meter showing Copper Tubing

6. With the tube attached to the engine exhaust system, depress the pump button on top of the unit to pull in the exhaust sample. Change the range switches as needed on the model 320P. The model 320P/D is automatic.

7. Draw the exhaust sample for no longer than 5 minutes. The temperature of the sample into the unit should be held close to the ambient temperature of the area where the unit is being operated.

8. Remember that the water trap will need to be cleared every 10 minutes. Excess moisture or temperature in the sample will damage the O2 cell. The CO2 in the exhaust gas will shorten the O2 cell life when run through the unit for extended periods.

9. The back-pressure in the exhaust system may be sufficient to allow use of the 320P/D without using the pump. Due to this pressure caution should be taken to assure that the unit is not left hooked up to the exhaust system for more than 5 minutes when not in use or it will shorten the O2 cell life.

10. After each 5 minutes of sampling, purge the unit with clean ambient air until the reading is close to 20.9% Oxygen. Do not recalibrate at this time. The unit is now ready for continued use.
11. When not in use the unit should be turned off and the cell saver cap should be reinstalled. All moisture should be removed from the cooling tube after each operation.

Adjustment of the CNGE Engine

1. Allow a minimum of 30 seconds for the gas sample to reach the meter and be analyzed.

2. Adjust the power valve on the carburetor.

Turbocharged Engines

For excess oxygen limits, refer to **Table 6-09** on page 6-32.

3. After each adjustment of the power valve it will be necessary for a time delay to occur prior to reading the meter. This is required for the gas sample to reach the meter and for gas analysis to occur. This may take from 15 to 45 seconds depending on the length of the gas sample tube.

4. All adjustments should be made at the intermittent rating with the inlet gas pressure to the carburetor set at 3" to 5" of water column. (For propane vapor the carburetor should be measuring a vacuum between 1.5 to 8.5 inches of water (negative pressure)).

5. All adjustments for excess Oxygen are to be made with the engine set at its published ignition timing for the appropriate model.

Conversion Factors

Quanity	U.S. Customary Unit Name	Abbr.	From U.S. Customary To Metric Multiply By Unit Name	Abbr.	From Metric To U.S. Customary Multiply By	
Area	sq. inch	in^2	sq. millimeters	mm^2	645.16	0.001550
Force	pounds force	lbf	Newton	N	4.4482	0.224809
Length	inch	in	millimeters	mm	25.40	0.039370
Pressure	pounds force per sq. in	psi	kilopascal	kPa	6.8948	0.145037
	inches of mercury	in Hg	kilopascal	kPa	3.3769	0.29613
	inches of water	in H_2O	kilopascal	kPa	0.2488	4.019299
	inches of mercury	in Hg	millimeters of mercury	mm Hg	25.40	0.039370
	inches of water	in H_2O	millimeters of water	mm H_2O	25.40	0.039370
Torque	pound force per foot	lb ft	Newton-meter	N•m	1.35582	0.737562
	pound force per inch	lb in	Newton-meter	N•m	0.113	8.850756
Volume:	gallon (U.S.)	gal.	litre	l	3.7853	0.264179
Liquid	gallon (Imp. *)	gal.	Litre	l	4.546	0.219976
Displacement	cubic inch	in^3	litre	l	0.01639	61.02545
Weight	pounds (avoir.)	lb	kilograms	kg	0.4536	2.204623

* British measurement

Decimal and Metric Equivalents

Metric mm	Decimal in.	Fractions	Metric mm	Decimal in.	Fractions
0.39688	0.015625	1/64	13.09687	0.515625	33/64
0.79375	0.03125	1/32	13.49375	0.53125	17/32
1.19062	0.046875	3/64	13.89062	0.546875	35/64
1.58750	0.0625	1/16	14.28750	0.5625	9/16
1.98437	0.078125	5/64	14.68437	0.578125	37/64
2.38125	0.09375	3/32	15.08125	0.59375	19/32
2.77812	0.109375	7/64	15.47812	0.609375	39/64
3.1750	0.125	1/8	15.87500	0.625	5/8
3.57187	0.140625	9/64	16.27187	0.640625	41/64
3.96875	0.15625	5/32	16.66875	0.65625	21/32
4.36562	0.171875	11/64	17.06562	0.671875	43/64
4.76250	0.1875	3/16	17.46250	0.6875	11/16
5.15937	0.203125	13/64	17.85937	0.703125	45/64
5.55625	0.21875	7/32	18.25625	0.71875	23/32
5.95312	0.234375	15/64	18.65312	0.734375	47/64
6.35000	0.250	1/4	19.05000	0.750	3/4
6.74687	0.265625	17/64	19.44687	0.765625	49/64
7.14375	0.28125	9/32	19.84375	0.78125	25/32
7.54062	0.296875	19/64	20.24062	0.796875	51/64
7.93750	0.3125	5/16	20.63750	0.8125	13/16
8.33437	0.328125	21/64	21.03437	0.828125	53/64
8.73125	0.34375	11/32	21.43125	0.84375	27/32
9.12812	0.359375	23/64	21.82812	0.859375	55/64
9.52500	0.375	3/8	22.22500	0.875	7/8
9.92187	0.390625	25/64	22.62187	0.890625	57/64
10.31875	0.40625	13/32	23.01875	0.90625	29/32
10.71562	0.421875	27/64	23.41562	0.921875	59/64
11.11250	0.4375	7/16	23.81250	0.9375	15/16
11.50937	0.453125	29/64	24.20937	0.953125	61/64
11.90625	0.46875	15/32	24.60625	0.96875	31/32
12.30312	0.484375	31/64	25.00312	0.984375	63/64
12.70000	0.500	1/2	25.40000	1.00	1

Engine Testing - Specifications (GTA38 and GTA50 Engine Models)

Governed RPM					
G-Drive	+/- .25 % (9 RPM) of advertised RPM				
Industrial	TBD				
Observed Torque	+/- 5% of Advertised Rating				
Observed Brake Horsepower	+/- 5% of Advertised Rating				
Correction Factor (CF)	TA G1, G2	4% per 1000 ft. above 3000 ft.			
	G3	4% per 1000 ft. above 1000 ft.			
Inlet Air Temperature	TA	100 F Max; Derate 1% per 10° F above 100° F.			
Ignition Timing		1500 RPM		1800 RPM	
		GTA 38	GTA 50	GTA 38	GTA 50
BTDC (NG Fuel)	G1, G2, G3	TBD	TBD	20 - 24	19 - 21
Exhaust O2 %	G1	TBD	TBD	2.0 - 2.6	2.7 - 3.3
	G2, G3	TBD	TBD	2.2 - 3.0	2.5 - 3.0
Gas Pressure to Carburetor	5" WC +/- 1" @ full load				
Gas Pressure to Regulator	10" to 20" H2O at full load operation				
Intake Manifold Temperature	TA	8.5:1 C.R.	135° F - 145° F [57° C - 63°C]		
Intake Manifold Boost Pressure	(Based on Temp, Barometric Pressure and O2)	17 psi max.			
Oil Temperature					
Maximum for Power Check	250° F [120° C]				
Minimum for Power Check	190° F [88° C]				
Operating temperature	225°/230° F [107°/110° C]				
Oil Pressure (15W40 GEO CD Oil at 107 C [225 F]					
Minimum at rated RPM	45 psi				
Maximum at rated RPM	70 psi				
Water Temperature					
Max (top tank)	200° F to 212° F [93° to 100° C]				
Min (water inlet)	160 F [71° C]				
Operating	180 F +/- 5 F [82° +/- 3°C]				
Water Pressure	30 psi - 45 psi				
Exhaust Stack Temperature	1150 F [621° C]				
Turbine Inlet Temperature	1350 F [732° C]				
Blow-by	10 " WC (0.354 oriface - one for each bank)				
Ambient Max. prior to derate	100° F [38° C] at Air Cleaner Inlet				
Aftercooler Water Inlet Temp.	130 F max [54° C]				

Note: The above test specification or for testing a "New" engine or an engine that is being tested for the first time after a major rebuild with new parts.

The blow-by specifications are not intended to be used to determine when an engine rebuild or other repair operation must occur.

Section 7
Maintenance Instructions

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Maintenance Instructions

General

Maintenance is the key to lower operating costs. A CNGE engine requires regularly scheduled maintenance to keep it running efficiently. Good preventive maintenance will help in reducing unnecessary repair costs for repairs that occur because of either poor or no maintenance.

Upon investigation of successful operations where gas engines are used, you will find good, regularly scheduled maintenance programs in effect.

Scheduled Maintenance

Preventive maintenance is the key to long engine life and low operating expense. If the engine is properly maintained, most potential problems can be corrected before causing a major unscheduled breakdown of the engine.

Accessories must be included in a maintenance program. Accessory failures may put an engine out of operation.

Maintenance Schedule

Use the enclosed maintenance schedule as a guide to establish your specific maintenance program.

Engines operating in ambient temperatures consistently below 18° C [0° F] or above 38° C [100° F] should have maintenance performed at shorter intervals than those listed in these schedules. Shorter maintenance intervals are also required if the engine is operated in a dusty environment or if frequent starts & stops are made. Also extended periods of Idle may dictate the need for more frequent maintenance.

Extending the Maintenance Schedule

Extending maintenance intervals should be based on previous operational experience with the engine and through a good oil analysis program. Without these factors, caution should be used in extending maintenance intervals. More details on Oil Analysis are covered under Engine Specifications.

Service Tools or Specialized Mechanics

Some maintenance procedures require special tools and should be performed by qualified personnel. These procedures and tools will be covered in your various engine shop manuals. CNGE uses the Cummins Diesel Shop Manuals where appropriate.

Notes:

Maintenance Items	Recommended Interval						
Engine Family = GTA38 & GTA50							
Operating Hours	Daily	Weekly	250	750	1500	6000	Remarks
Calendar Months			6	6	12	24	
Check Log	X						
Operator's Report	X						
Check Cooling System	X						
Engine Coolant Level	X						
Engine Coolant DCA4™			X				
After-cooler Coolant Level	X						
After-cooler Coolant DCA4™			X				
Thermostat Operation				X		X	
Leaks & Correct	X						
Hose Wear Points	X						
Loose Band Clamps	X						
Flush Cooling System						X	
Change Antifreeze						X	
Check Fuel System	X						
Gas Leaks & Correct	X						
Gas Fuel Filter				X			
Gas Pressure to Regulator					X		
Gas Pressure to Carburetor					X		
Check Exhaust System	X						
Air/Fuel Ratio Adjustment					X		
Excess Oxygen Level in Exhaust				X			
Exh. Mnfd. Outlet Exh. Gas Temp.					X		
Exhaust Gas Back Pressure					X		
Turbocharger Radial/Axial Clearance						X	
Check Air Intake System	X						
Air Cleaner Restriction		X					
Loose Band Clamps	X						
Wear Points	X						
Intake Manifold Boost Pressure				X			
Charge Air Core Externally	X						
Check Ignition System	X						
Spark Plugs & Wires				X		X	
Ignition Coils				X			
Ignition Generator & Voltage					X		
Wiring Harness & S.P. Wires				X			
Ignition Timing			X				

Maintenance Items	Recommended Interval						
Engine Family = GTA38 & GTA50							
Operating Hours	Daily	Weekly	250	750	1500	6000	Remarks
Calendar Months			6	6	12	24	
Check Lubricating System	X						
Engine Lube Oil Level	X						
Change Engine Lube Oil & Filters			X				H.C.Lube System
Leaks & Correct	X						
Leaks & Correct	X						
Check Electric Governor	X						
Wear Points on Linkage		X					
Loose Wiring & Connections			X				
Adjustments					X		
Check Electrical System			X				
Clean Battery Terminals			X				
Loose Wiring & Connections				X			
Solenoid Operation					X		
Starter & Alternator Voltage					X		
Check Engine System	X						
Loose Mounts					X		
Loose Bolts & Cap-screws					X		
Engine Cylinder Compression				X			
Water Pump						X	
Auxiliary Water Pump					X		
Turbocharger						X	
Vibration Damper		X					Replace 15000 hrs.
Fan & Fan Hub	X		X			X	
Valve Adjustment			X		X		1st adj @ 250 hrs.
Cross-head Adjustment			X		X		
Crankcase Breather			X				
Cylinder Heads Replacement							As Required
Cam Followers							As Required
Visually Inspect Engine	X						
Damage, Leaks, Loose or Frayed							
Belts, Loose Hoses/Clamps	X						
Check & Adjust All Belts		X					
Visually Inspect Radiator Core	X						

Section 7A
Daily and Weekly Maintenance Guidelines

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Maintenance Check - Daily

General Information

Preventative maintenance begins with day-to-day awareness of the condition of the engine and its systems. Before starting the engine, check the oil and coolant levels. Look for:

- Leaks.
- Loose or damaged parts, especially in fuel or exhaust systems.
- Worn or damaged belts.
- Any change in engine appearance.
- Odor of fuel-gas.

Check Operator's Report or Log-sheet

The engine must be maintained in top mechanical condition if the operator is to be safe and get optimum satisfaction from its use. The maintenance department needs daily running reports from the operator to make necessary adjustments in the time allotted and to make provisions for more extensive maintenance work as the reports indicate the necessity.

Comparison and intelligent interpretation of the daily report along with a practical follow-up action will eliminate most failures and emergency repairs.

Report to the Maintenance Department

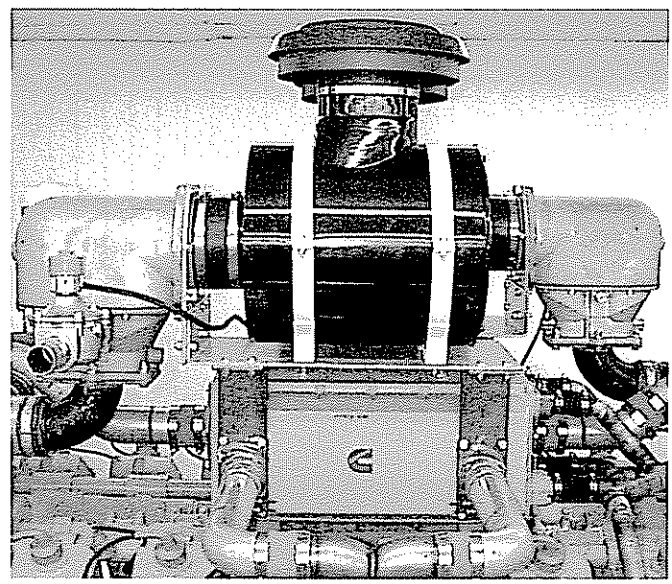
Any of the following conditions:

- Low lubricating oil pressure.
- Low power.
- Power increases or governor surge.
- Abnormal water or oil temperature.
- Unusual engine noise.
- Smoke.
- Excessive use of coolant, fuel or lubricating oil.
- Any fuel, exhaust, coolant, or lubricating oil leaks.
- Fuel-gas odor.
- Erratic or no throttle control or response.

Air Cleaner Pre-Cleaner and Dust Pan - Check/Clean

Under extreme dirty conditions an air pre-cleaner can be used. Clean the pre-cleaner jar and the dry-type air cleaner dust pans daily or more often, as necessary, depending on operating conditions.

Photo # 7A-01 - Air Cleaner



Check and Bring to Proper Level

• Engine Oil Level - Checking

Never operate the engine with the oil level below the "L" (Low) mark or above the "H" (High) mark. Wait at least 5 minutes after shutting off the engine to check the oil level. This allows time for the oil to drain to the oil pan. The oil level should be as close to the "H" mark as possible.

Note: The engine **must** be level when checking the oil level to make sure the measurement is correct.

Low Mark & High Mark Oil Capacity — 174 - 204 Liters [46- - 54 U.S. Gallons]

With a fill to the high mark the oil will just begin to flow from the top pipe plug near the center of the oil pan adapter.

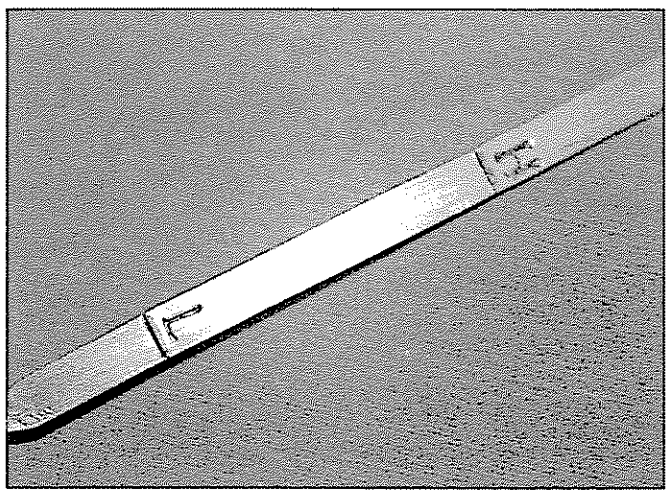


Photo # 7A-02 - Dipstick - "L"(Low) & "H"(High) Marks

Use high quality oil blended for natural gas engines. Refer to the Specifications and Lubricating Oil System Sections for the correct lubricating oil specifications.

• Engine Coolant Level - Checking

Warning: Do not remove the radiator cap from a hot engine. Wait until the temperature is below 50° C [120° F] before removing the pressure cap. Failure to do so can result in personal injury from heated coolant spray or steam. Remove the cap slowly to relieve coolant system pressure.

Note: Never use a sealing additive to stop leaks in the cooling system. This can result in cooling system plugging and inadequate coolant flow causing the engine to overheat.

Caution: Do **not** add cold coolant to a hot engine. Engine castings can be damaged. Allow the engine to cool to below 50° C [120° F] before adding coolant.

The coolant level **must** be checked daily.

Fill the cooling system with coolant to the bottom of the fill neck in the radiator fill or expansion tank. Do not fill the radiator fill tank above the bottom of the fill neck.

Note: Some radiators have two fill necks, both of which must be filled when the cooling system is drained.

CNGE does **not** recommend the use of water and DCA without anti-freeze.

Fill the cooling system with the correct mixture of antifreeze, water, and the correct number of DCA4™ units. Refer to the Specifications Section of this manual for CNGE recommendations.

Caution: Any time a significant amount of coolant is added, the DCA concentration **must** be checked. If the concentration is low, engine damage will result.

• aftercooler Coolant Level - Checking

On turbocharged engines with a water-to-air cooling system a separate cooling system **must** be maintained. Check the coolant level daily. Use the same coolant mixture as in the engine jacket systems. Add coolant as needed.

Check for Gas Leaks and Correct

Check for evidence of gas leakage at the gas pressure regulator and at all pipe connections.

1. Apply liquid soap around the regulator to check for leaking gaskets and ruptured diaphragms.
2. Check for leaks at all line connections by applying liquid soap.

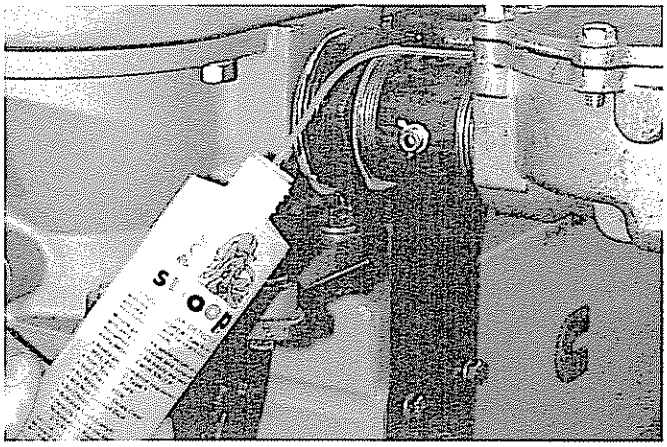


Photo # 7A-03 - Applying Liquid Soap

Check Governor

The GTA38 & GTA50 use a Woodward Flo-Tech Governor Actuator and a Flo-Tech Speed Control. Follow Woodward's recommendation for maintenance operations.

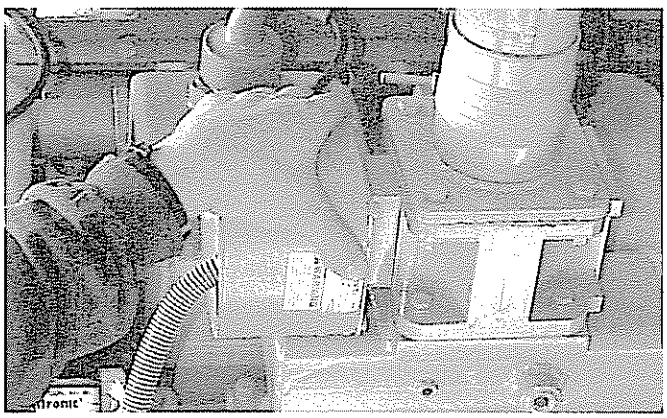


Photo # 7A-04 - Checking Governor

Check Engine Monitoring System (If Equipped)

Check the Engine Monitoring System daily (push button to test) per the manufacturer's recommendations to verify proper operation.

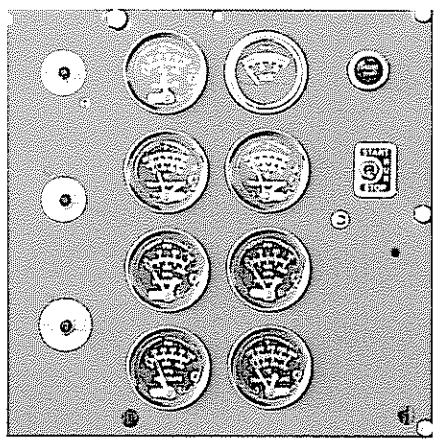


Photo # 7A - 05 - Engine Monitoring Control Panel

Check any Unusual Engine Noise

During the daily maintenance check, listen for any unusual engine noise which can indicate that service is required.

Visually Inspect Engine

- The engine should be inspected daily for engine damage, and for air, oil, fuel gas, and coolant external leakage. Check for loose or frayed belts, loose or damaged hoses, and loose clamps. Take the required corrective action.

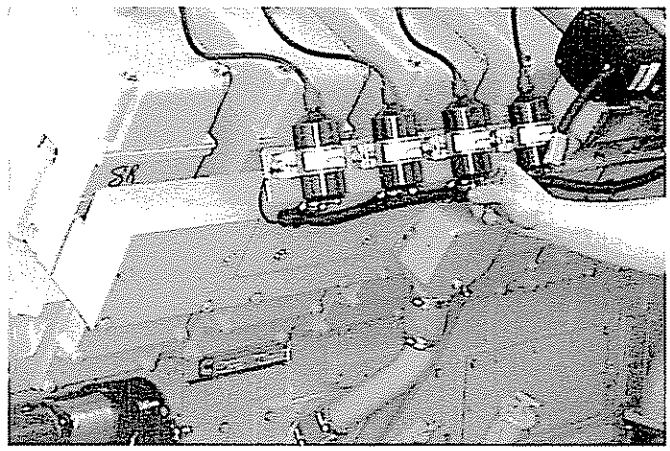


Photo # 7A-06 - Visual Inspection - Engine

- **Belt - Inspection**

Visually inspect all belts. Check the belts for intersecting cracks. Transverse (across the belt width) cracks are acceptable. Longitudinal (direction of belt length) cracks that intersect with transverse cracks are not acceptable. Replace the belts if frayed or if belt material is missing.

Adjust belts that have a glazed or shiny surface, indicating belt slippage. Correctly installed and tensioned belts will show even pulley wear and belt wear patterns.

Belt damage can be caused by:

- Incorrect tension.
- Incorrect size or length.
- Pulley misalignment.
- Incorrect installation.
- Severe operating environment.

All new belts will loosen during use. They must be adjusted to the values listed in the Belt Tension Chart.

Note: A belt is considered used if it has been in operation for 10 minutes or longer.

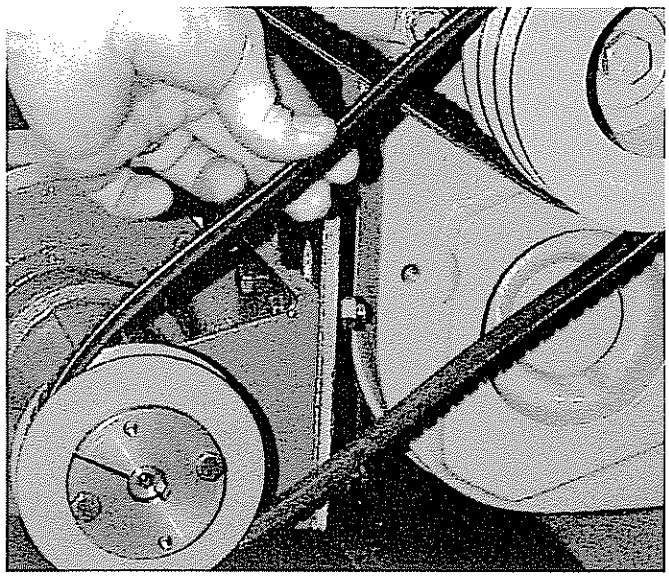


Photo # 7A-07 - Belt Inspection

Visually Inspect Radiator Externally

The radiator must be inspected daily for external damage and contamination. Blow out all insects, dust, dirt and debris such as leaves, bits of paper, rags, etc. that may be on the front of the radiator or lodged between the radiator and the cooling fins and tubes. Contamination of the radiator cores will affect the ability of the cooling system to transfer heat and properly cool the engine and intake manifold.

Maintenance Check - Weekly

General Information

All checks or inspections listed under the daily maintenance interval must also be perormed at this time in addition to those listed under this maintenance interval.

- **Air Cleaner Element - Replacement (Industrial Two Stage Heavy Duty with or without a Safety Element)**

Replace the element if the inlet restriction or vacuum at full power is found to exceed the limits as specified in your applicable engine data-sheet. Changing the elements or breaking the seal on the intake system more than necessary will result in excess dirt in the engine and must be avoided.

Note: CNGE does not recommend cleaning paper type air cleaner elements.

Elements that have been cleaned will clog and air flow to the engine will be restricted.

Caution: Holes, loose end seals, dented sealing surfaces and other forms of damage render the cleaner inoperative and require immediate air cleaner element replacement.

1. Remove the wing nut that secures the air cleaner element cover to the cleaner housing.
2. Remove the cover.
3. Pull the element out of the housing without damaging the element.
4. Remove the gasket or "O"-ring seal from the outlet end of the housing.
5. Inspect the gasket or "O"-ring seal and replace if necessary.
6. Remove the inner safety element and replace if required(Dual Heavy Duty Cleaners with Safety)
7. Replace the element with a new element if required.
8. Assemble the cover to the housing.

Note: If your application has the disposable throw-a-way type of air cleaner, then remove the air cleaner and replace with a new air cleaner as required. Generally this will be the case in the standby generator market unless the Industrial Heavy-duty option is specified at time of purchase.

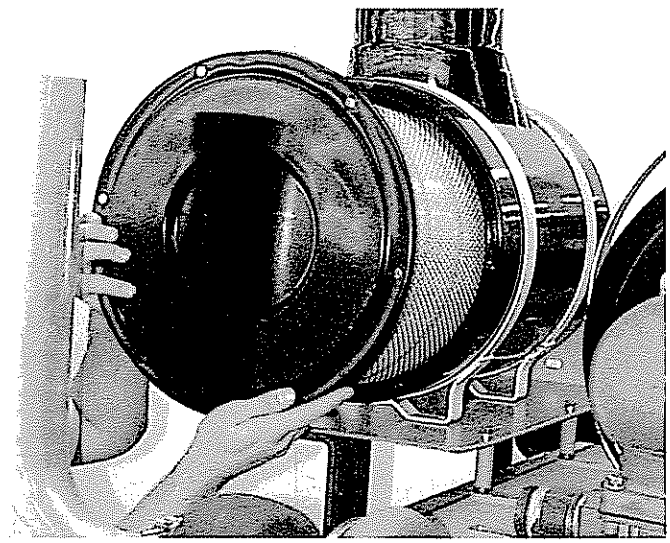


Photo # 7A - 08- Air Cleaner Disassembly

*** Air Intake Hoses, Pipes and Clamps - Checking**

Inspect the intake piping for cracked hoses, loose clamps or punctures which can damage the engine.

Tighten or replace parts as necessary to make sure the air intake system does not leak.

Check for corrosion of the intake system piping under the clamps and hoses. Corrosion can allow corrosive products and dirt to enter the intake system. Disassemble and clean as required.

All hoses on the intake piping must be double clamped or use constant torque type clamps.

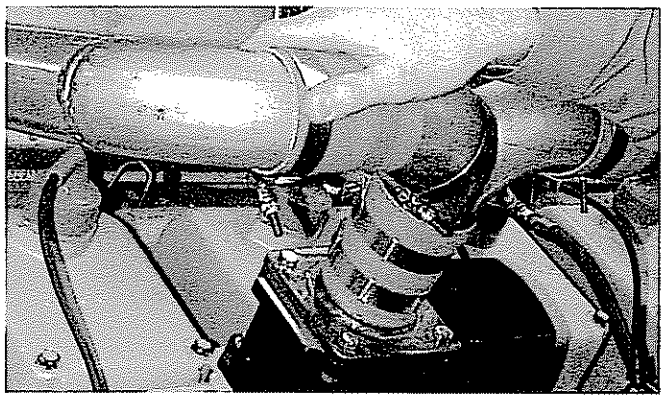


Photo # 7A - 09 - Air Intake Hoses, Pipes and Clamps

- **Inlet Air Restriction Indicators**

- **Mechanical Indicator**

A mechanical restriction indicator is available to indicate excessive air restriction through a dry-type air cleaner. This instrument can be mounted in the air cleaner outlet or in a control panel. The red flag in the window gradually rises as the cartridge loads with dirt. After changing or replacing the air cleaner element, reset the indicator by pushing the reset button.

Restriction or vacuum indicators are to be installed as close to the turbocharger air inlet in order to obtain a true indication of restrictions.

Note: Never remove the felt washer from the indicator. The felt washer absorbs moisture.

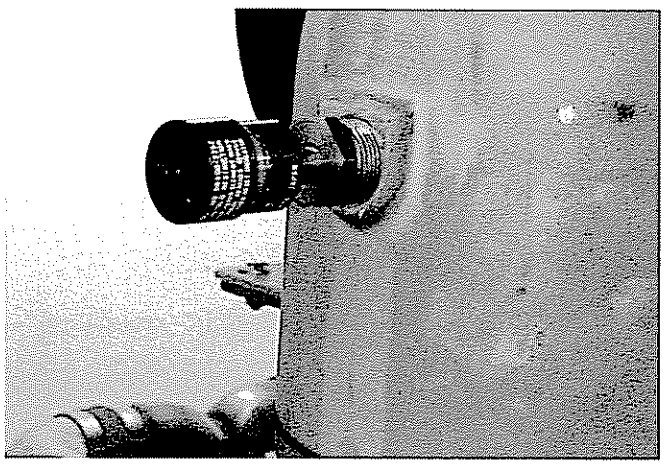


Photo # 7A-10 - Air Restriction Indicator

- **Vacuum Indicators**

Vacuum indicators actuate a warning light on the instrument panel when the air restriction becomes excessive.

Air restriction on turbo-charged engines must not exceed the limits as specified on the specific CNGE engine data-sheet for your engine.

Caution: Natural gas engines are required to have a lower air cleaner restriction because the engines also use a low-pressure carburetor mounted on the air inlet to the turbocharger. The installation of this carburetor also adds to the turbocharger inlet restriction levels.

Air restriction at the turbocharger inlet must not exceed 635 mm [25 inches] of water column under full power conditions.

Notes:

Section 7B
Maintenance Check - 250 Hours or 6 Months

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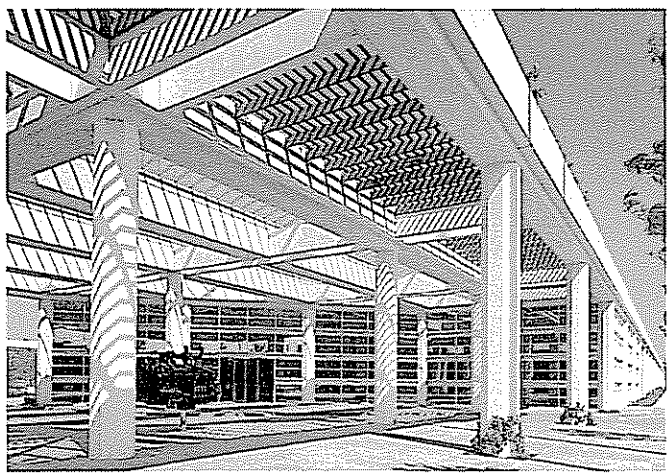

Cummins Corporate Office
Columbus, Indiana

Maintenance Check - 250 Hours or 6 Months

General Information

All checks or inspections listed under the previous maintenance intervals **must** be performed at this time in addition to those listed under the maintenance interval.

Belt Tension - Checking

Use a belt tension gauge to measure the tension of the belt. Refer to **Table 7B-01** for the appropriate tool. An alternate method (deflection method) can be used to check belt tension by applying 110 N (25 lbs.) of force between the pulleys on the v-belts. If the deflection is more than one (1) belt thickness per foot of pulley center distance, the belt **must** be adjusted. Measure the tension in the center span of the pulleys.

The tension of the fan belt on an engine with a fan idler pulley need not be measured. The spring loaded idler used on this design maintains the correct belt tension.

An engine with a two pulley fan drive (one which does **not** have an idler pulley) **must** have the fan belt tension measured.

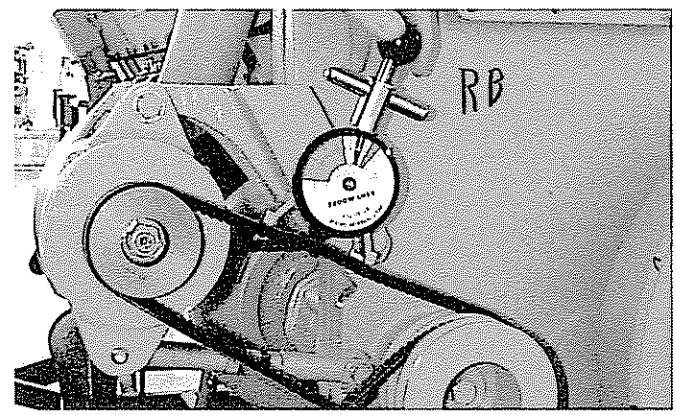

Photo # 7B-01 - Belt Tension Checking

Table # 7B-01 - Belt Tension Tools

Part No.	Description
ST-1138	Use on v-belts (11/16 to 7/8)
ST-1293	Use on v-ribbed belts.
3822524	Use on v-belts (3/8 to 7/8) and v-ribbed belts with 5 ribs or less.
3822525	Use on v-belts larger than 7/8 in. and v-ribbed belts with 6 or more ribs.

Belts - Checking/Adjusting

- **Fan Drive Belt - Automatic Belt Tensioner**

The fan drive belt uses an automatic belt tensioner. No adjustment is required.

- **Two Pulley Fan Drive Belt - Adjustment**

Only one method is acceptable for setting the two pulleys fan drive belt tension. The recommended method is to use a belt tension gauge.

Caution: Incorrect belt tensioning procedures can cause component failure and **personal injury.**

Install the belt tension gauge, Part No. 3823875 or equivalent, on the belt in the middle **between** the two pulleys. Continue tightening the adjusting screw cap-screw to a belt tension of 2668.9 to **2891.3 N [600 to 650 lb-ft].** The belt tension will increase when the cap-screws tighten the fan hub assembly to the fan support. Tighten the cap-screws.

Torque Value: 25 N•m [210 ft-lb]

Remove the tension gauge and position the gauge on the other side of the belt. Verify the belt tension is correct, **2891.3 to 3336.2 N [650 to 750 lbf].** If the belt tension is not correct, loosen the cap-screws and adjust to the correct tension again.

Torque Value: 285 N•m [210 ft-lb]

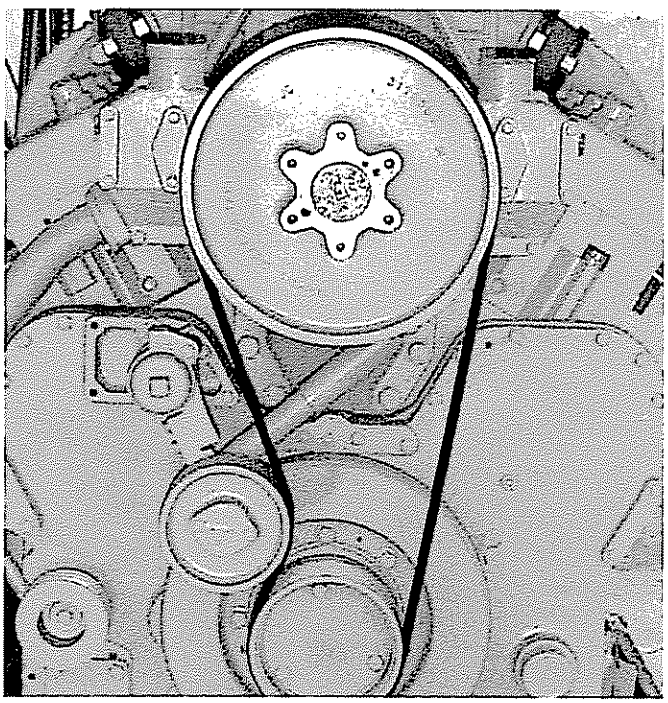

Photo # 7B-02-Fan Drive Belt

- **Aftercooler Auxiliary Water Pump Drive Belt - Adjustment**

Take special care when tightening the belt for the engine mounted aftercooler auxiliary water pump. CNGE believes it is best accomplished by insuring that the deflection measures a minimum of 1 inch with 25 lbs. Of force applied between the pulleys. Over-tightening of this belt may cause aftercooler auxiliary water pump seal and bearing failures

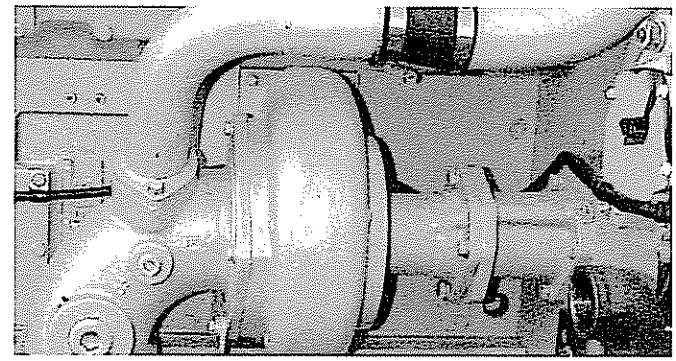

Photo # 7B-03 - Aftercooler Auxiliary Water Pump Drive Belt

- **Alternator Drive Belt - Adjustment**

Note: The lower jam nut has left handed threads.

Loosen the alternator and adjusting link mounting cap-screws. Loosen the jam nuts on the adjusting screw.

Turn the adjusting screw clockwise to tighten the belt tension.

Belt Tension: 356 N [80 lbf]

Burroughs Tension Gauge: (ST-1293)

Note: Over-tensioning of alternator belts can result in premature accessory drive bushing wear and seal leakage.

Tighten the jam nuts on the adjusting screw to **55 N•m[40ft-lb].**

Check the belt tension again to make sure the tension is correct.

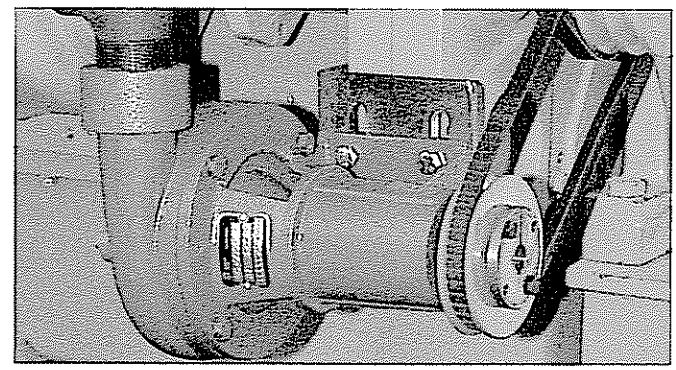

Photo # 7B-04 - Alternator Drive Belt

- **Drive Belts - Replacement**

Note: When a drive uses two or more belts, replace the belts as a complete set.

Loosen the adjusting mechanism and move the pulley centers as close as possible. The belts can then be installed without excessive force.

To prevent damage, do **not** roll a belt over the pulley or pry it on with a tool.

Refer to the **Table # 7B-02 -Belt Tension Chart** to select the correct gauge and tension specifications.

Pulley misalignment **must not** exceed 6 mm for each meter [1/16 in. for each 12 inches] of distance **between** the pulley centers.

Belts **must not** touch the bottom of the pulley grooves nor **must** they protrude over 3 mm [3/32 in.] above the top edge of the groove.

When a drive uses two or more belts, the belt riding depth must not vary over 2 mm [1/16 in.] **between** belts.

Table # 7B-02 - Belt Tension Chart (Pounds)

Belt Width (inches)	New Belt Belt Gauge	* Tension Min. - Max.	Used Belt Tension Min. - Max.
.380	ST-1274	130 - 150	80 - 120
.440		130 - 150	80 - 120
.500		130 - 150	80 - 120
.6875		130 - 150	80 - 120
.750	ST-1138	130 - 150	80 - 120
.875		130 - 150	80 - 120
4 Rib		130 - 140	80 - 120
5 Rib	3822524	190 - 210	90 - 120
6 to 12 Rib	3822525	190 - 210	155 - 165

* Adjust used belts to the values in this column.

Note: Any belt in use with more than 10 minutes is considered **USED**.

Cooling Fan

Warning: Personal injury can result from a fan blade failure. Never pull or pry on the fan. This can damage the fan blade(s) and cause fan failure.

Note: Rotate the crankshaft by using the engine barring gear only.

Check the cooling fan every 250 hours or 6 months. Check for cracks, loose rivets, and bent or loose blades. Check the fan to make sure it is securely mounted. Tighten the cap-screws if necessary. Replace any fan that is damaged.

Change / Replace

- **Lubricating Oil and Filter - Changing**

Caution: Some state and federal agencies in the United States of America have determined that used engine oil can be carcinogenic and can cause reproductive toxicity. **Avoid** inhalation of vapors, ingestion, and prolonged contact with used engine oil.

Protect The Environment: Handling and disposal of used engine oil may be subject to federal, state and local law and regulation. Use authorized waste disposal facilities including civic amenity sites and garages providing authorized facilities for receipt of used oil. If in doubt, contact your state and local environmental authorities or the Environmental Protection Agency for guidance as to proper handling and disposal of used engine oil.

- **General Information**

- **Lubricating Oil and Filter Change Interval**

Engine oil becomes contaminated and essential oil additives are depleted with use. The amount of contamination is related to the total amount of fuel-gas and oil consumed.

There are two methods available to decide the oil drain interval.

1. Fixed number of hours or calendar time, whichever comes first as shown on the maintenance schedule.

   Note: CNGE recommends the fixed oil change method for deciding the oil change period.

2. Utilization of a detailed oil analysis program.

As the engine oil becomes contaminated, essential oil additives are depleted. Lubricating oils protect the engine as long as these additives are functioning properly. Progressive contamination of the oil between oil and filter change intervals is normal. The amount of contamination will vary depending on the type of operation of the engine, the fuel-gas being consumed and the hours of operation.

Caution: Under no circumstances can the oil drain interval extend beyond 500 hours of operation or 6 months, whichever occurs first without the addition of more capacity and filtration.

Extended oil drain intervals can decrease engine life due to factors such as corrosion, deposits and wear.

Refer to the Specifications section for more information on oil analysis.

- **Lubricating Oil and Filter - Changing**

Change the lubricating oil and filter(s) at every oil change.

Note: Oil for natural gas engines does not darken and look as dirty as diesel oil does. Use the recommended maintenance intervals to determine the oil change requirement, not the oil's appearance.

Note: If the engine is in service then the oil change interval of 250 hours or 6 months should be observed.

Change the oil and filters to remove the contaminants suspended in the oil.

Note: Drain the oil only when it is hot and the contaminants are in suspension.

Warning: Avoid direct contact of **hot oil** with your skin. **Hot oil** can cause **personal injury.**

1. Operate the engine until the water temperature reaches 60∫ C [140∫ F]. Shut the engine off. Remove the oil drain plug. Use a 1 1/4 "wrench or socket.

   Note: Use a container that can hold 204 liters [54 U.S. Gallons] of oil.

2. Clean the area around the lubricating oil filter head. Remove the filter using a 118 to 131 mm Filter Wrench. Clean the gasket surface on the filter head.

   Note: The o-ring can stick on the filter head. Make sure it is removed before installing the new filter.

   Cut all the way around the top of a full flow filter using a pipe cutter or hack saw. Inspect the pleated paper element for metal debris. Metal debris in the filter can reveal impending engine failure. If debris is found, find the reason for the debris and make the needed repairs.

3. Make sure that the correct oil filter is installed. The external appearance of the full flow and the by-pass filters is the same. The full flow filter contains 1 1/2 16 inch threads. The by-pass filter contains 1 3/8 16 inch threads.

   Note: The CNGE GTA38 engine uses 4 of the LF-670 full flow filters. The GTA50 engines will use either 4 or 5 of the LF-670 full flow filters depending on build date..

   Note: CNGE Customer Support recommend that when the by-pass filter is in use, that 2 of the LF 777 by-pass filters be used.

4. Fill the oil filter with clean lubricating oil. The lack of lubrication during the delay until the filter is pumped full of oil is harmful to the engine.

5. Apply a light film of lubricating oil to the gasket sealing surface before installing the new filter.

   Caution: Mechanical over- tightening can distort the threads or damage the filter element seal.

6. Install the filter as specified by the filter manufacturer.

7. Check and clean the oil drain plug threads and sealing surface.

8. Install the oil drain plug.

   Torque Value is 100 N•m [75 ft-lb]

   Note: Use high quality oil blended for natural gas engines. Choose the correct oil as outlined in the specifications section and in the Lubricating system section of this manual.

9. Fill the engine to the proper levels. Refer to **Table # 7B-03** - Lube System Capacities.

Table # 7B-03 - Lube System Capacities

	GTA38	GTA50
• Pan Capacity (liters [U.S. Gallons]	140 [37]	204 [54]
• Full-Flow Filters (4) Capacity (liters [U.S. Quarts]	19.7 [5.2]	19.7[5.2]
• Total System capacity liters [U..S. Gallons]	159.7 [38.3]	223.7[55.2}

Note: Capacities assume the standard oil pan. Total system capacity assumes the standard oil pan.

Caution: Either pre-lube the engine or crank the engine with the manual fuel valve in the off position until oil pressure appears on the oil pressure gauge. When pressure appears on the gauge open the manual fuel valve and start the engine.

10. Operate the engine to idle to inspect for leaks at the filters and drain plugs.

    Note: Engine oil pressure **must** be indicated on the gauge within 15 seconds after starting. If oil pressure is **not** registered within 15 seconds after starting, shut off the engine immediately to **avoid** engine damage. Confirm the correct oil level in the oil pan.

11. Stop the engine. Wait for approximately 5 minutes to let the oil drain from the upper parts of the engine. Check the oil level again.

12. Add oil as necessary to bring the oil level to the **"H" (High)** mark on the dipstick.

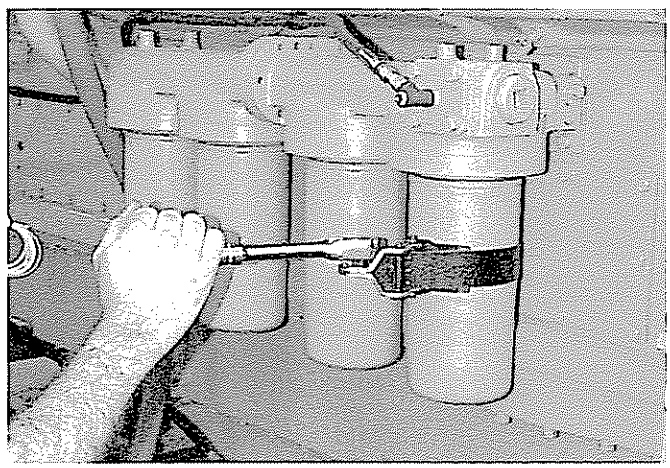

Photo # 7B-06 - Lube Oil & Lube Oil Filter Changing

Check Following

- **Check Engine Crankcase Breather.**

Inspect the crankcase breather tube/hose for sludge or debris on or in the tube. Inspect the tube more frequently during icy conditions. If the tube/hose is blocked, either clean or replace to prevent excess crankcase pressure build-up.

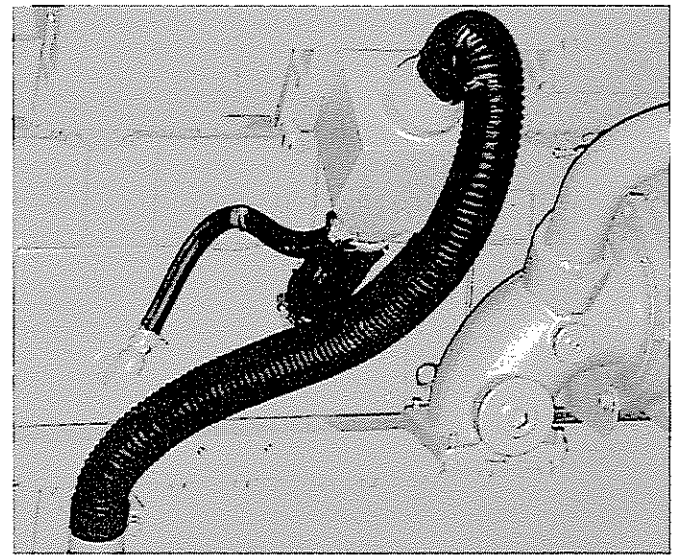

Photo # 7B-07 - Crankcase Breather & Tube

- **Engine Coolant DCA4™ Concentration Level**

Add makeup **DCA4™** if required. Refer to **Table# 6-01** as a reference guide on page 6-9. Use the **Fleetguard® Coolant Test Kit, CC2626**, to check the concentration level. Instructions are included with the test kit.

Caution: Under-concentration of coolant additives can result in liner pitting and system corrosion. Over-concentration can result in water pump seal leakage.

The recommended concentration level of supplemental coolant additives is 1.5 per U.S. gallon of coolant. The additive level **must never** drop below 1.2 units or exceed 3 units per gallon of coolant.

Note: DCA4™ is compatible with all permanent-type antifreeze except Methoxy Propanol antifreeze. If Methoxy Propanol antifreeze is used, reduce the amount of **DCA4™** by one third. This will prevent inhibitor loss due to precipitation, caused by chemical incompatibility.

- **DCA4™ Unit Maintenance Guide**

Use supplemental coolant additives (corrosion inhibitors) to protect the engine cooling system from corrosion. Antifreeze alone does not provide enough corrosion protection for a heavy-duty natural gas engine.

Supplemental corrosion protection must be supplied through periodic additions of supplemental coolant additives to the coolant. Maintain the correct **DCA4™** concentration by changing the maintenance coolant filter at each oil drain interval.

Each time the coolant is drained and replaced, the coolant must be recharged with supplemental coolant additives. Use the appropriate **DCA4™** spin-on filter. The mixture must be drained and replaced every two years or 6000 hours of operation, whichever first occurs. Refer to Section 6 of this manual for the correct service element and proper **DCA4™** concentration levels.

When using other supplemental coolant additives, refer to the manufacturer's instructions.

- **Coolant Filter Replacement**

General Information

Change the coolant filter at every oil change and filter change interval.

The correct coolant filter to be used is determined by the total cooling system capacity and the oil drain interval. Extended drain intervals may require a modification to the engine for dual coolant filters or a reduced change interval for the cooling system. Refer to Table # 7B-03 for the correct filter.

A manual shutoff valve is provided to prevent coolant leakage while changing the coolant filter.

With the valve in a vertical position, the coolant flows to and from the coolant filter. In the horizontal position, the coolant flow is cut off to and from the coolant filter.

Warning: **Do not remove the radiator cap from a hot engine. Hot steam will cause serious personal injury. Remove the coolant system pressure cap and close the coolant filter head shutoff valve before removing the coolant filter. Failure to do so can cause personal injury from heated coolant spray.**

Turn the coolant shutoff valve to the "Off" position

Remove and discard the coolant filter. Clean the gasket surface on the filter head. Apply a light film of **Lubriplate® 105** or its equivalent to the coolant filter gasket sealing surface before installing the coolant filter.

Install the filter as specified by the manufacturer.

Note: Mechanical over-tightening can distort the threads or damage the filter head.

Open the shut-off valve and install the coolant system pressure cap.

Caution: Severe engine damage will result if the valve is left in the closed position.

Operate the engine until the coolant temperature is above 82° C [180° F] and check for leaks.

After the air has been purged from the system, check the coolant level.

Photo # 7B-08 - Coolant Filter - Replacement

- **Air Intake System - Inspection**

Every 250 hours or six months, whichever occurs first, inspect the intake piping for cracked hoses, loose clamps, or punctures that can allow dirt and debris to enter the engine.

Tighten or replace parts as necessary to make sure the air intake system does not leak.

Check for corrosion of the intake system piping under the clamps and hoses. Corrosion can allow corrosive products and dirt to enter the intake system. Disassemble and clean as required.

Photo # 7B-09 - Air Intake System - Inspection

- **Air Cleaner Restriction - Checking**

Every 250 hours or six months, which ever occur first, check the air cleaner restriction.

Turbocharged engines need to be operating at rated RPM and full load to check the air cleaner element when the restriction reaches the maximum allowable limit.

Note: Follow the manufacturer's instructions when cleaning or replacing the air cleaner element.

Check the air cleaner service indicator, or gauge, if equipped.

Change the filter element when the red indicator flag is at the raised position in the window.

After the air cleaner has been serviced, reset the button in the end of the service indicator.

Caution: The settings used on air cleaner indicators for diesel engines will be too high for spark ignited engines. Check with your supplier to insure that you have an indicator that has been set for CNGE engine settings. The maximum intake air restriction with a dirty element is 635 mm H_2O [25 in H_2O].

Caution: Never operate the engine without an air cleaner. Intake air must be filtered to prevent dirt and debris from entering the engine and causing premature wear

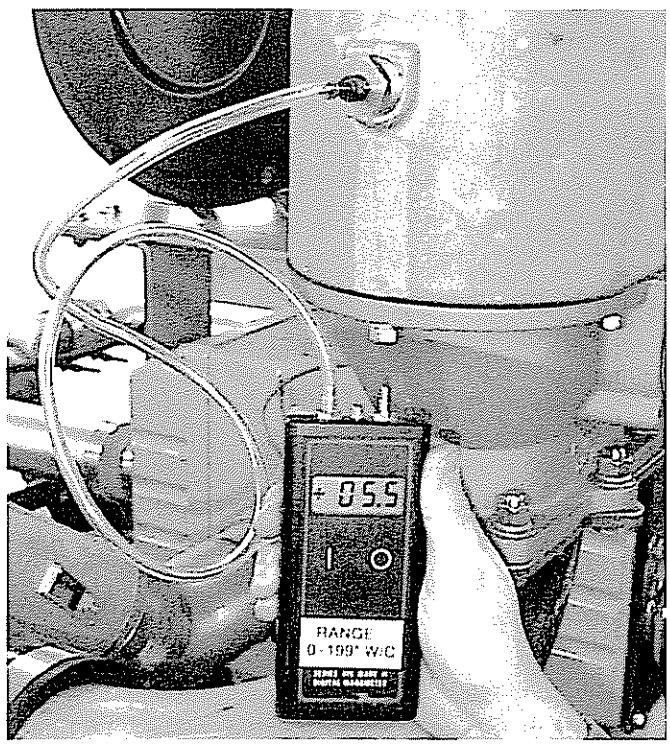

Photo # 7B-10 - Air Cleaner Restriction - Checking

- **Check Governor**

Woodward Flo-Tech Actuator & Flo-Tech Speed Control

The GTA38 & GTA50 use the Flo-Tech Actuator & Flo-Tech Speed Control governing system. The Flo-Tech Actuator is an electrically operated throttle valve. This valve operates as an air/gas control valve for gas engines. The Flo-Tech Actuator receives changes in electrical impulses from the Flo-Tech Speed Control allowing the actuator to maintain basic isochronous speed control.

Throttle linkage is **not** required when using the Woodward Flo-Tech Actuator and Flo-Tech Speed Control on the GTA38 & GTA50 engines.

Refer to the manufacturer's literature for correct installation, operation, calibration, and troubleshooting procedures.

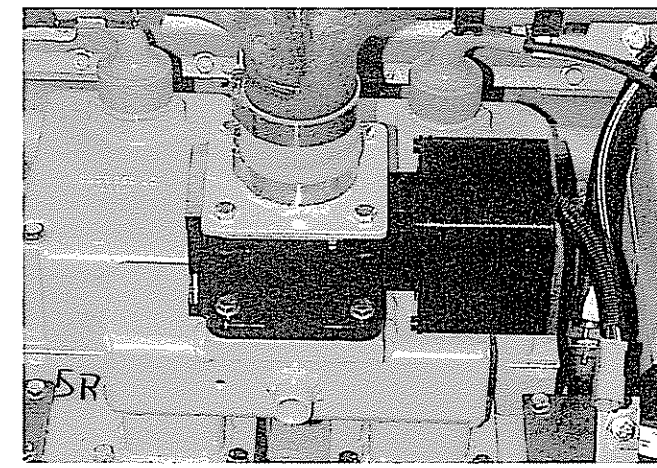

Photo # 7B-11 - Woodward Flo-Tech Actuator

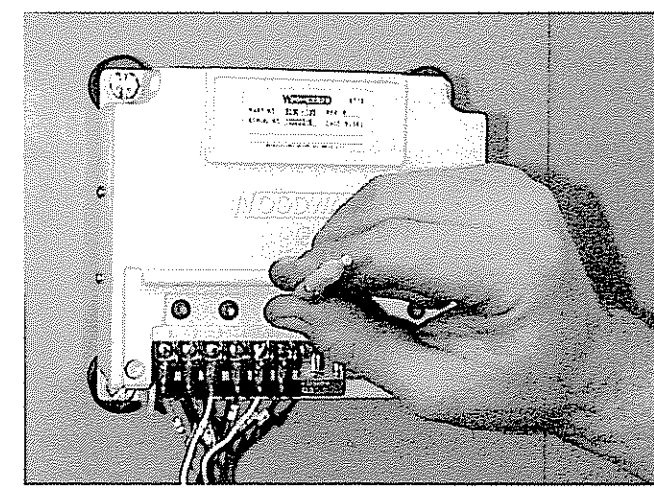

Photo # 7B-12 - Woodward Flo-Tech Speed Control

Adjust Following

- **Intake & Exhaust Valve Procedure**

General Information

Note: The first intake & exhaust valve adjustment should take place at the 250 hour "B" service interval. After that point check exhaust valves at the C2 check or 1500 hours or 2 years whichever comes first. After the C2 adjustment, the process can be increased to the 6000 hour or 2 years, whichever comes first. Check the adjustment after every major repair.

Note: Read the entire procedure for the overhead adjustment before attempting to perform this operation.

Valves **must** be correctly adjusted for the engine to operate efficiently. Valves **must** be adjusted using the values listed in this section.

If the valves are checked during troubleshooting or before scheduled maintenance interval, adjustment is **not** required if measurements are within the recheck limits.

1. The firing order is as follows:

   GTA38 1R-6L-5R-2L-3R-4L-6R-1L-2R-5L-4R-3L
   GTA50 1R-1L-3R-3L-2R-2L-5R-4L-8R-8L-6R-6L-7R-7L-4R-5L

2. The cylinders are numbered from the front gear cover end of the engine. To determine the right and left bank of the engine stand at the flywheel end of the engine and face forward. The ignition generator will be on the left bank.

3. Two crankshaft revolutions are required to adjust all of the valves.

4. Each cylinder has two rocker levers. On the left bank of the engine, the lever nearest to the rear of the engine is the intake lever. On the right bank the lever nearest to the rear of the engine is the exhaust lever.

5. One pair of valves are adjusted at each pulley index mark before rotating the engine to the next index mark.

6. Disconnect the battery.

7. Remove the valve covers. The valve cover gaskets can be used again if they are **not** damaged.

   Note: Do **not** use solvent to clean the valve cover gasket. Solvent will damage the material and cause it to swell.

8. Tighten the rocker lever shaft cap-screws.

   Torque Value: 156 N•m [115 ft.-lb.].

9. The GTA38 and GTA50 engine have valve set marks in three locations.

   For valve adjustment marks on the flywheel with the engine barring device located on the right bank:

   The starter bore cover **must** be removed to see the marks.

   Caution: When using this index mark, the marks on the flywheel that begin with an **"A" must** be used or the valves will not be adjusted correctly causing damage to the push rods.

   For valve adjustment marks on the flywheel with the engine barring device on the left bank:

   The starter bore cover **must** be removed to see the marks.

   Caution: When using this index mark, the marks on the flywheel that begin with a **"C" must** be used or the valves will not be adjusted correctly, causing damage to the push rods.

   Valve adjustment marks are also on the vibration damper. These marks must be aligned with the pointer.

10. The barring device can be used to rotate the engine. To use this device, remove the clip and push the device shaft towards the flywheel. The barring device **must** be rotated **counterclockwise** to turn the flywheel and crankshaft in the direction of rotation.

    The direction of normal rotation is clockwise when viewing the front of the engine.

11. The **VS** represents the valve set mark.

12. Determine the cylinder in position for valve adjustment. The cross-heads and valves are ready to be adjusted on the cylinder that has all valves closed.

13. Check the two cylinders that are shown on the **VS** marking. Start with the cylinder that has all four valves closed.

Cross-head - Adjustment

Note: Cross-head adjustment must always be made before attempting to adjust the valves.

1. Adjust the cross-heads on the cylinder that has both valves closed.
2. Loosen the cross-head adjusting screw lock-nuts on the intake and exhaust valve cross-heads.
3. Use the following procedure to adjust both the intake and exhaust cross-heads.
4. Turn the adjusting screw out one turn.
5. Hold the cross-head down against the guide.
6. Turn the adjusting screw in until it touches the top of the valve stem but does not raise the cross-head.
7. Hold the adjusting screw in this position. The adjusting screw must not turn when the lock nut is tightened to its torque value. Tighten the lock nut. The following torque values are given with and without Part No. ST-669 Torque Wrench Adapter:

With Adapter	**35 N•m [25 ft-lb]**
Less Adapter	**40 N•m [30 ft-lb]**

Valve Adjustment

Valve Adjustment Initial Set

Exhaust Valve	.89 mm [0.035 in.]
Intake Valve	.36 mm [0.014 in.]

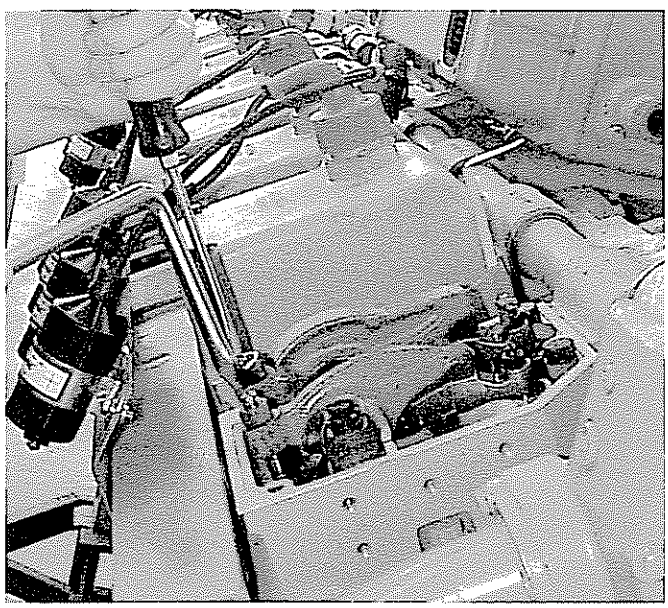

Photo # 7B-13 - Valve Lash Adjustment

1. Select a feeler gauge for the correct valve lash specification. Insert the gauge between the rocker lever and the cross-head.

   Two different methods for establishing valve lash clearance are described below. Either method can be used; however, the torque wrench method has proven to be the most consistent.

   Torque Wrench Method: Use the inch pound torque wrench, **Part No. 3376592**, and tighten the adjusting screw.

   Torque Value: 0.68 N•m [6 in-lb]

   Feel Method: Tighten the adjusting screw until a slight drag is felt on the feeler gauge.

2. Hold the adjusting screw in this position. The adjusting screw must not turn when the lock nut is tightened.

   Torque Value: With torque wrench adapter,
   Part No. ST-669 - 45 N•m [35 ft-lb]
   Without adapter - **60 N•m [45 ft-lb]**

3. After tightening the lock nut to the correct torque value, check to make sure the feeler gauge will slide backward and forward between the cross-head and the rocker lever with only a slight drag.

4. If using the feel method, attempt to insert a feeler gauge that is **0.03 mm [0.001 inch]** thicker between the cross-head and the rocker lever pad. The valve lash is not correct when a thicker feeler gauge will fit.

5. After adjusting the valves on Cylinder No. 1RB, rotate the accessory drive; and align the next valve set mark with the pointer. Repeat the process to adjust all valves in the following sequence. Set valves in order of the firing order.

6. Before installing valve covers, recheck all lock-nuts for tightness. Install the Valve Covers.

Section 7C1
Maintenance Check - 750 Hours or 6 Months

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Maintenance Check - 750 Hours or 6 Months

Check/Clean/Inspect/Replace

- **Ignition Timing**

All Turbo-charged Natural Gas Engines are presently intended for heavy-duty application and, as such, will normally operate over their RPM range of 1200 - 1800 RPM. Engine timing **must** be adjusted to maximize engine efficiency to the particular load and speed required at the job site.

Engine timing is **not** a fixed value but depends upon the load, type & quality of the fuel, altitude, temperature, rated speed (RPM) of the engine and the air fuel ratio. The air/fuel ratio is measured by the amount of excess Oxygen in the exhaust gas. The most critical of these would be the fuel and the change in altitude.

It is therefore important that the adjustment, is made by a CNGE distributor or CNGE authorized dealer service technician at the time of engine installation and initial start-up.

Gas & Ignition Timing Adjustment Procedure

1. **Gas Adjustment** - Install your water manometers on the on-engine gas flow regulator and at the carburetor to ensure that the gas pressures are correct. The gas pressure to the on-engine gas flow regulator should be **between** 10 and 20 inches of water column pressure at full load operating conditions with a gas pressure at the Carburetor of between 4 to 6 inches of water column pressure.

2. **Engine Timing** - Since engine timing is **not** a fixed value, it is the single most important adjustment made on each engine installation. Set the initial engine timing to the appropriate value listed in **Table # 7C1-01** for your specific compression ratio and fuel-gas as a starting point and follow the adjustment procedures.

   Caution: CNGE sets timing on all engines at Clovis, New Mexico conditions of 4200 feet altitude and to the limits in **Table # 7C1-01** for the initial engine timing. Your timing may need to be adjusted to a different setting due to a different altitude, operating load and temperature conditions.

   Generally the timing is retarded or advanced by 4 degree for every 5000 feet of altitude change for natural gas. The change may be less when using propane gas.

Table # 7C1-01 - Initial Engine Timing (@ 4200 ft. Clovis, N.M.)

Model	C.R.	Timing Range (DBTDC) Nat. Gas
GTA38	8.5:1	20-24
GTA50	8.5:1	19-21

3. Proceed to fine-tune the engine as follows:

   A. Install a pyrometer in the 1/4" pipe tapped hole below the turbocharger mounting flange.

   B. Install a 0-30 psi gauge on the intake manifold.

C. Install an Oxygen meter exhaust gas pickup connection in the 1/4" pipe tapped hole in the turbocharger outlet pipe

D. Connect a low and high-tension timing light to the # 1 cylinder. (Follow the procedures for **Connecting the Timing Light and Adjusting Timing).**

E. With the engine running under full load conditions, adjust the power valve on both carburetors to obtain the lowest possible exhaust temperature while observing the excess Oxygen reading. This can best be obtained by turning the power valve closed or clockwise ("CW") for a lean mixture until the engine starts loosing RPM, then turn the power valve open or counterclockwise ("CCW") for a rich mixture until the exhaust temperature reaches the lowest reading.

Caution: Never adjust the power valve adjusting screw more than 1/4 of a turn (90 degrees) in either direction. Always adjust the power valve adjusting screw on both carburetors the same distance. If the carburetors are not in balance, shut down the engine and close the power valve adjusting screw by turning it clockwise ,"CW", until it is fully seated, then open a full two turns. Start the adjustment procedure from this position.

If the power valve is opened beyond the ultimate point, the mixture will become too rich and the exhaust temperature will start to increase. It may be necessary to perform this adjustment two or three times to obtain the proper point of air/fuel ratio which will result in the coolest possible exhaust temperatures.

F. Retard and advance the timing by two degree increments and repeat Step E. to determine if the lowest possible exhaust temperature and lowest boost pressure has been obtained without loosing engine RPM. Repeat and confirm your readings several times.

Note: On ALTRONIC III, the adjustment is made by loosing the two mounting cap-screws in the ignition drive mounting slots and rotating the ignition generator in either a clockwise (advancing) or counterclockwise (retarding) direction. If the slots do **not** allow enough movement for adjusting the timing to the required level, contact your local CNGE distributor. The back cover plate will need to be removed and an internal adjustment will be required on the drive to driven gear. **This adjustment needs to be made by a qualified ignition specialist.**

Note. Lower BTU fuels may require higher main line pressure to obtain proper pressure to the carburetor mixer valve. Do not exceed 20 inches of water to the on-engine gas flow regulator or hard starting could result.

4. **Power Valve** - On turbocharged engines, the power valve should be turned in until the engine begins to lose power, then moved counterclockwise one turn. A more desirable method of adjustment is with the exhaust temperature pyrometer. Adjust the carburetor until the coolest exhaust temperature is reached.

Connecting the Timing Light and Adjusting the Timing

1. Connect the timing light induction pick-up clamp around the spark plug secondary wire for # 1RB cylinder.

2. Connect the red power lead to the positive post (+) of the battery and the black wire to the negative post (-) of the battery.

Caution: Make sure that the voltage of the timing light has the same voltage requirement as the battery power source or you will damage the timing light.

3. Point the timing light toward the timing tape on the engine vibration damper. The timing mark will light up showing the amount of degrees before top dead center (DBTDC) that the engine firing is taking place.

4. If the engine timing needs to be adjusted, loosen the two mounting cap-screws on the ignition generator. To advance the timing, rotate the ignition generator clock wise. To retard the timing, rotate the ignition generator counter-clockwise.

5. Tighten the two mounting cap-screws.

Note: The wires for the ignition generator to the ignition coils are called primary wires. The wires from the ignition coils to the spark plugs are called secondary wires.

Alternative Method for Timing the Engine

As an alternative method, one can follow the following procedure:

1. Adjust the Power Valve as described in the previous procedure searching for lowest EGT

2. **Advance** the timing 2 degrees at a time until the engine begins to **detonate**. Record the timing and **retard** timing until **out of detonation**.

3. Now **retard** the timing 2 degrees at a time until the engine begins to **detonate**. Record the timing and **advance** timing until **out of detonation**.

4. This should establish a timing window of opportunity.

5. Now adjust the timing within this window while observing the exhaust gas temperature (EGT) and the intake manifold air-gas temperature. Try and locate the lowest EGT within this timing window. This is where your engine needs to be timed.

6. Fine tune the adjustment of the Power Valve.

Caution: The engine may need to be re-timed if there is a sudden change to the ambient conditions, such as a change from the hot summer months to the extreme cold months..

Final timing adjustments are made in connection with the adjustment of the power screw on the carburetor. In addition, there is a requirement to hold the excess Oxygen reading in the exhaust gas to a predetermined level. This establishes the Air/Fuel ratio. All of this is done while searching for the lowest possible Exhaust Gas Temperature and lowest intake manifold vacuum on naturally aspirated models or lowest manifold boost pressure on turbocharged models without sustaining a power or RPM loss.

Refer to Carburetor Adjustment in this manual .

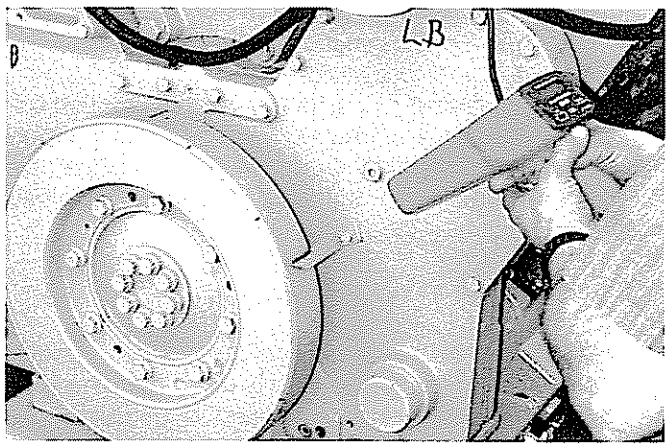

Photo # 7C1-01 - Timing Light

- **Engine Cylinder Compression Check**

Caution: Before starting this check it is important to verify that your batteries have a full charge.

CNGE recommends the following steps when checking cylinder compression.

1. Locate and shut off the gas fuel valve and tag the valve with a DO NOT OPEN tag.
2. Ground the ignition "G" lead to prevent any ignition spark.
3. Remove spark plug probes from the spark plug wells. Check for oil or water contamination and clean before continuing.
4. Remove the spark plugs from ALL cylinders using a proper spark plug removal tool.
5. Block the engine throttle wide open.
6. Install a compression gauge in # 1 cylinder.
7. Crank the engine with the starter until the engine has rotated 6 to 8 revolutions. The compression gauge should be at a stable reading and not moving.
8. Record the reading in pounds per square inch.
9. Release the gauge pressure and remove the gauge.
10. Repeat steps 6 through 9 for each cylinder.

Add all cylinder pressures and divide by the number of cylinders to establish the average cylinder pressure. All cylinders should be between a + or - 5 % of the average cylinder pressure for all cylinders. Recheck any cylinder that is **not** within this limit.

Caution: Cylinder pressure between engines may vary by as much as 40 psi. It is not uncommon to find engines as low as 160 psi and as high as 200 psi. The major concern is the variance between cylinders on the same engine.

The engine **must** be turning over at the same speed for each individual cylinder during testing.

If outside this limit, contact your local Cummins distributor or authorized CNGE dealer for further assistance.

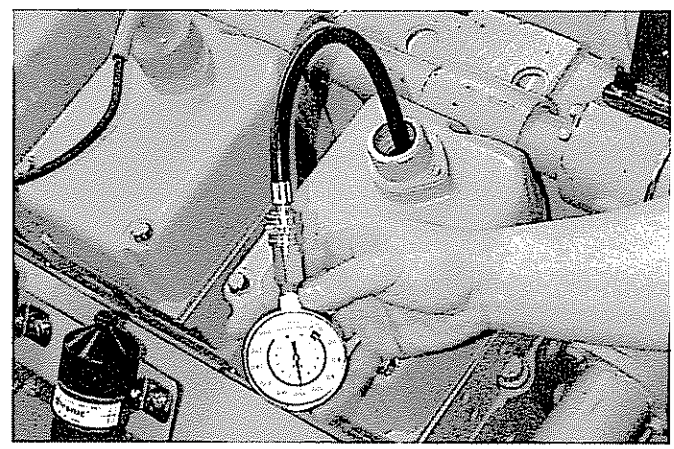

Photo # 7C1-02 - Compression Check Tools

- **Sparkplug Wire(s) - Inspection**

Inspect the condition of the sparkplug wires. Replace any damaged wires.

Visually inspect the sparkplug wires for corrosion, evidence of cracking, worn spots caused by rubbing, or arcing evidenced by burnt spots. Replace as necessary.

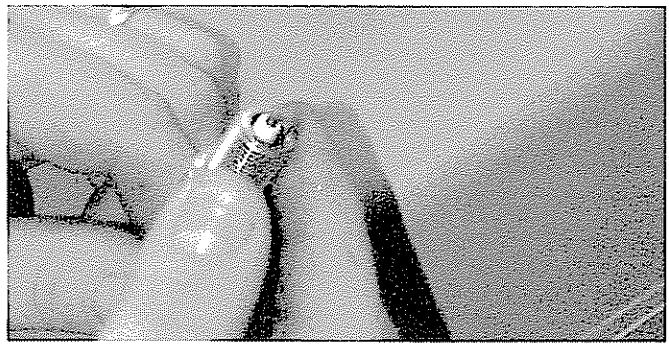

Photo # 7C1-03 - Sparkplug Wire - Inspection

- **Sparkplug Removal**

1. Disconnect the wire assembly from the ignition coil end first and then from the sparkplug end.
2. Remove the rubber insert from the sparkplug type sockets to prevent contamination of the sparkplugs with dirt or oil.
3. Using a 15.875 mm (5/8 in.) deep-well rubber insert sparkplug socket, loosen the sparkplug with the extension and socket. Turn the plugs counterclockwise to loosen.
4. Continue to turn counterclockwise until the threads are **no** longer engaged.
5. Lift the sparkplug out of the adapter, being careful **not** to drop the sparkplug. Mark or tag the sparkplugs with the cylinder number from which they are removed.
6. Visually inspect the plug wires, extenders and connections for corrosion, damage or arcing.

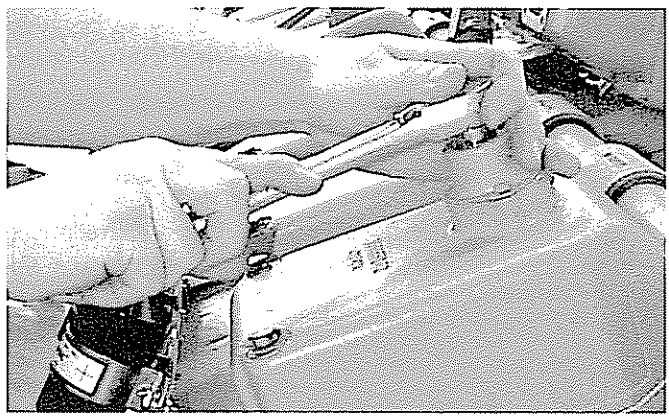

Photo # 7C1-04 - Sparkplug Removal

- **Sparkplug Well(s) - Checking**

A visual inspection of the sparkplug well for traces of water, oil & antifreeze should be made.
If water or antifreeze is present inside the well and cylinder, then the sparkplug adapter "O" rings and the adapter gasket must be replaced. Removal of the sparkplug adapter requires the use of a special tool. Contact your local Cummins Distributor or Authorized CNGE Dealer for assistance.

If oil is present in the sparkplug adapter well, then replace the "O" rings on the sparkplug adapter tube extension.

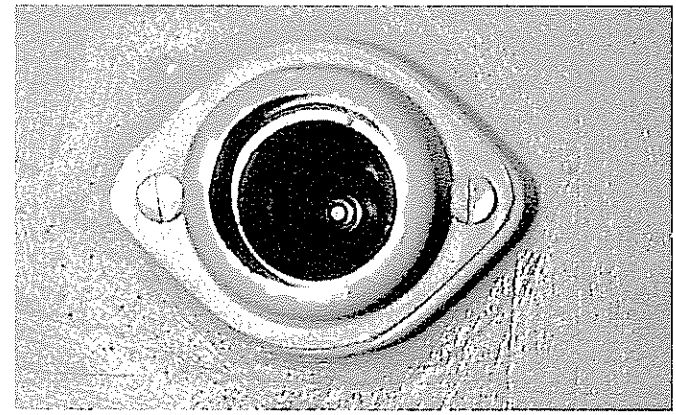

Photo # 7C1-05 - Sparkplug Well - Checking

- **Sparkplug(s) - Inspection**

Careful examination of the sparkplug(s) can be very helpful in preventing future damage to your engine.

Examples:
1. Orange colored residue may indicate a cooling system additive in the combustion chamber and serious cooling system problems.
2. A molten center electrode is an indication of temperatures more than 2800° F and could be signs of preignition or detonation.
3. Crusty white ash deposits may indicate excessive barium or calcium in the oil and usually occur due to a "high-ash" oil.
4. Black carbon deposits may suggest a rich air/fuel ratio.

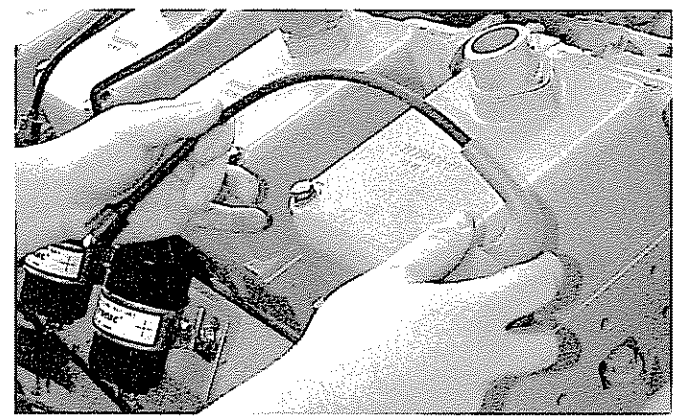

Photo # 7C1-06 - Sparkplug Inspection

- **Sparkplug Gap. - Checking**

CNGE recommends that the sparkplug gap for all new sparkplugs installed in the GTA38 & GTA50 engine models should be set at .020 in. The measurement should be made with a sparkplug gap wire gauge. CNGE recommends the Snap-On GA461b or equivalent.

Sparkplugs that have been used in CNGE engines should **not** be re-gapped.

Photo # 7C1-07 - Sparkplug Gap

- **Sparkplug Installation**

Caution: Sparkplug life is largely dependent on cleanliness of the plug's porcelain. Dirt, oil and finger prints reduce the seal strength between the spark plug boot and the porcelain. Do not touch the porcelain area on the spark plug. If cleaning on porcelain is required, use rubbing alcohol and a lint free cloth. Never lubricate the threads of the sparkplug.

Caution: Mechanical over-tightening can damage the sparkplug and cylinder head.

Check plug socket to make sure it is not a source of dirt and oil.

Install a new sparkplug in the cylinder head. Make sure that the sparkplug insulator porcelain is clean. Use an extension and magnetic sparkplug socket (Snap-On P.N. S971KA) and thread in by hand to make sure that the threads are smooth and the plug is not cross threaded. Turn the plug clockwise to tighten.

Use a torque wrench to complete the installation.

Torque Value: 35 to 41 N•m [26 to 30 ft-lb.]

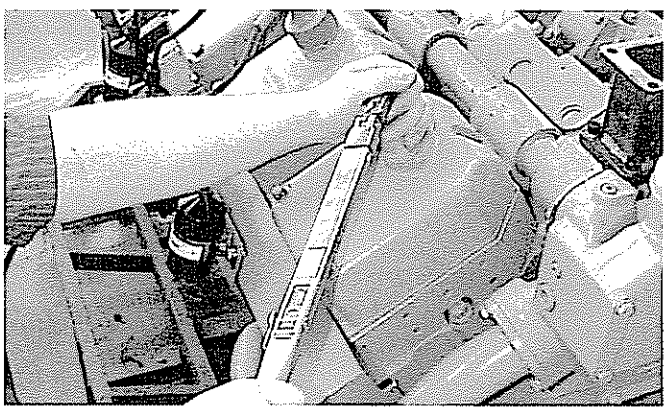

Photo # 7C1-08 - Sparkplug Installation

Apply a small amount of dielectric grease inside the sparkplug boot and outside of the sparkplug boot.

Carefully place plug boot onto the top of the sparkplug terminal. Firmly press each plug boot down until a snap is felt. This snap is the terminal clip being completely pushed over the plug terminal.

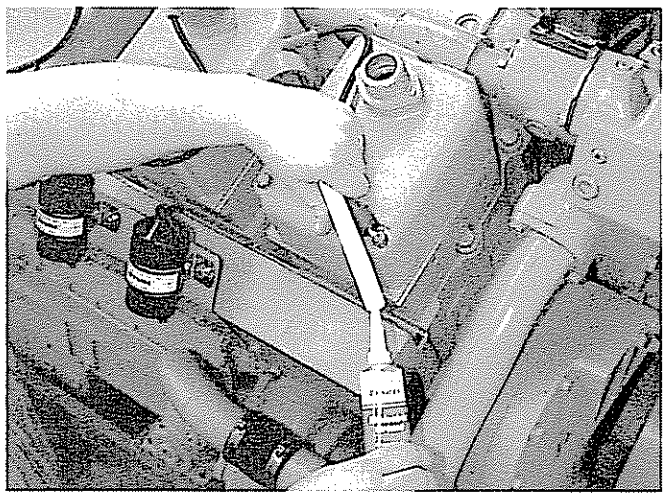

Photo # 7C1-09 - Dielectric Grease

- **Ignition Coil Check**

Blue Epoxy Coil - 501061 (CNGE P/N 3396123)

The following are some simple tests that can be conducted in the field to assist in determining the condition of CD (Capacitor Discharge) ignition coils. It should be noted that they are not all-encompassing and may not provide conclusive results. The only conclusive means for testing coils is on a proper bench test setup using a coil driver and oscilloscope in combination with a high-voltage secondary probe. More complete testing can be done at most authorized Altronic Distributor facilities.

Visual Checks

- Check for cracks or breaks in the epoxy body of the coil.
- Check for proper secure mounting of the coil to the engine.
- Check condition of primary terminals. If bent, broken or loosened in any way, the coil should be replaced.
- Inspect the secondary (high voltage) tower. Foreign materials or products of corrosion should be cleaned and removed.
- Check for an other signs of physical damage or deterioration.

Grounding Checks

- Check for low resistance continuity between the negative primary terminal of each coil and the engine block. A more complete check (one that includes a check of the primary harness) can be conducted by removing the primary harness from the ignition module and checking for continuity from each output lead in the harness to the engine block.

Primary Checks

- With the primary leads removed from the coil, check for continuity between the positive and negative primary terminals. The primary is made up of a relatively low number of turns of wire and therefore the resistance should be very low. Special meters are required to obtain accurate readings of such low resistance. The actual primary resistance should be in the range of 0.1 to 0.2 ohms. However, for field test purposes, the resistance should be a fraction of an ohm, and coils on the engine should display approximately the same resistance. Typical failure of a primary is an open circuit rather than high resistance.

Secondary Checks

- The secondary is composed of a high number of turns of very fine wire. Check the resistance of the secondary between the positive primary terminal and high voltage tower. The resistance should be in the range of 4,000 to 6,900Ω. If outside this range, the coil should be replaced.

  Notes: Secondary failures can occur when a carbon track develops between windings at elevated voltage, thereby reducing the effective number of turns of the secondary, resulting in reduced voltage output of the coil. However, it is common that arcing along the carbon path does not occur at low voltages. As a result, the resistance check described above may not reveal the failure. Typically, an operator may notice reduced spark plug life on the cylinder with the bad coil. Replacing the spark plug solves the problem in the short term, but when the secondary demand once again reaches the reduced output limit of the damaged coil, misfire will occur on that cylinder at an earlier point than on the remainder of the cylinders. If this pattern is noted, the coil should be changed.

  Coils should never be mounted in a "tip to tail" fashion (one coil's secondary in close proximity to another coil's secondary) as this can result in improper operation (coil crosstalk).

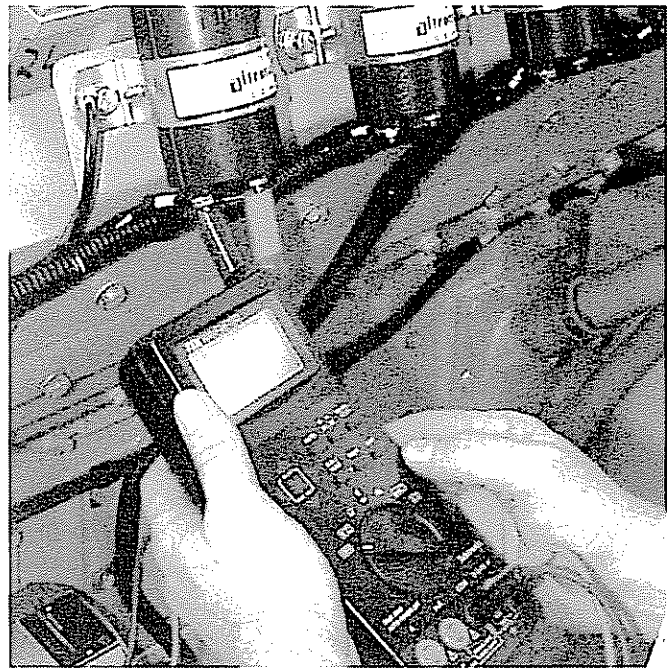

Photo # 7C1-10 - Ignition Coil Voltage Check

Clean Battery Terminals

Visually inspect the battery terminals for loose, broken or corroded connections. Repair or replace broken cables or terminals.

If the connections are corroded, remove the cables and use a battery brush to clean the cable and battery terminal.

Note: A teaspoon of Bicarbonate of soda (Baking Powder) mixed with a pint of water will make a cleaning agent that will remove the corrosion from the battery cables and the battery terminal posts.

Use grease to coat the battery terminals to prevent corrosion.

Check Loose Wiring & Connections

Visually inspect all wiring for loose connections. Special attention should be given to ground wires and to all safety devices to ensure that all devices are functional and that all wiring circuits will allow the engine to start and to shut down as well as allow all safety devices to operate completely.

Section 7C2 Maintenance Check - 1500 Hours or 1 Year

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C2 - Maintenance Check - 1500 Hours or 1 Year

Adjust Following

- **Intake & Exhaust Valve Procedure**

General Information

Note: The first intake & exhaust valve adjustment should take place at the 250 hour service interval. Refer to Section # 7B - Maintenance Check - 250 Hours or 6 Months. After that point check exhaust valves at the C2 check or 1500 hours or 2 years whichever comes first. After the C2 adjustment, the process can be increased to 6000 hour or 2 years, whichever comes first. Check the adjustment after every major repair.

Note: Read the entire procedure for the overhead adjustment before attempting to perform this operation.

Valves must be correctly adjusted for the engine to operate efficiently. Valves must be adjusted using the values listed in this section.

If the valves are checked during troubleshooting or before scheduled maintenance interval, adjustment is not required if measurements are within the recheck limits.

1. The firing order is as follows:
   GTA38 1R-6L-5R-2L-3R-4L-6R-1L-2R-5L-4R-3L
   GTA50 1R-1L-3R-3L-2R-2L-5R-4L-8R-8L-6R-6L-7R-7L-4R-5L

2. The cylinders are numbered from the front gear cover end of the engine. To determine the right and left bank of the engine stand at the flywheel end of the engine and face forward. The ignition generator will be on the left bank.

3. Two crankshaft revolutions are required to adjust all of the valves.

4. Each cylinder has two rocker levers. On the left bank of the engine, the lever nearest to the rear of the engine is the intake lever. On the right bank the lever nearest to the rear of the engine is the exhaust lever.

5. One pair of valves are adjusted at each Vibration Damper or Flywheel index mark before rotating engine crankshaft to the next index mark.

6. Disconnect the battery.

7. Remove the valve covers. The valve cover gaskets can be used again if they are **not** damaged.

   Note: Do **not** use solvent to clean the valve cover gasket. Solvent will damage the material and cause it to swell.

8. Tighten the rocker lever shaft cap-screws.

   Torque Value: 156 N•m [115 ft.-lb.].

9. The GTA38 and GTA50 engine have valve set marks in two locations.

   For valve adjustment marks on the flywheel with the engine barring device located on the right bank:

   The starter bore cover **must** be removed to see the marks.

   Caution: When using this index mark, the marks on the flywheel that begin with an "A" must be used or the valves will not be adjusted correctly causing damage to the push rods.

   For valve adjustment marks on the flywheel with the engine barring device on the left bank:

The starter bore cover **must** be removed to see the marks.

Caution: When using this index mark, the marks on the flywheel that begin with a **"C" must** be used or the valves will **not** be adjusted correctly, causing damage to the push rods.

Valve adjustment marks are also on the vibration damper. These marks **must** be aligned with the pointer.

10. The barring device can be used to rotate the engine. To use this device, remove the clip and push the device shaft towards the flywheel. The barring device **must** be rotated **counterclockwise** to turn the flywheel and crankshaft in the direction of rotation.

    The direction of normal rotation is **clockwise** when viewing the front of the engine.

11. The **VS** represents the valve set mark.

12. Determine the cylinder in position for valve adjustment. The cross-heads and valves are ready to be adjusted on the cylinder that has all valves closed.

13. Check the two cylinders that are shown on the **VS** marking.

Cross-head - Adjustment

Note: Cross-head adjustment **must** always be made before attempting to adjust the valves.

1. Adjust the cross-heads on the cylinder that has both valves closed.
2. Loosen the cross-head adjusting screw lock-nuts on the intake and exhaust valve cross-heads.
3. Use the following procedure to adjust both the intake and exhaust cross-heads.
4. Turn the adjusting screw out one turn.
5. Hold the cross-head down against the guide.
6. Turn the adjusting screw in until it touches the top of the valve stem but does **not** raise the cross-head.
7. Hold the adjusting screw in this position. The adjusting screw **must not** turn when the lock nut is tightened to its torque value. Tighten the lock nut. The following torque values are given with and without Part No. ST-669 Torque Wrench Adapter:

   With Adapter **35 N•m [25 ft-lb]**
   Less Adapter **40 N•m [30 ft-lb]**

Valve Adjustment

Valve Adjustment Initial Set

Exhaust Valve	.89 mm [0.035 in.]
Intake Valve	.36 mm [0.014 in.]

Photo # 7C2-01 - Valve Lash Adjustment

1. Select a feeler gauge for the correct valve lash specification. Insert the gauge between the rocker lever and the cross-head.

   Two different methods for establishing valve lash clearance are described below. Either method can be used; however, the torque wrench method has proven to be the most consistent.

   Torque Wrench Method: Use the inch pound torque wrench, Part No. 3376592, and tighten the adjusting screw.

   Torque Value: 0.68 N•m [6 in-lb]

   Feel Method: Tighten the adjusting screw until a slight drag is felt on the feeler gauge.

   2.Hold the adjusting screw in this position. The adjusting screw must not turn when the lock-nut is tightened.

   Torque Value:With torque wrench adapter,
   Part No. ST-669 —— 45 N•m [35 ft-lb]
   Without adapter —— **60 N•m [45 ft-lb]**

3. After tightening the lock nut to the correct torque value, check to make sure the feeler gauge will slide backward and forward between the crosshead and the rocker lever with only a slight drag.

4. If using the feel method, attempt to insert a feeler gauge that is **0.03 mm [0.001 inch]** thicker between the cross-head and the rocker lever pad. The valve lash is not correct when a thicker feeler gauge will fit.

5. After adjusting the valves on Right Bank Cylinder No. 1, rotate the barring device at flywheel and align the next valve set mark with the pointer. Repeat the process to adjust all valves in the following sequence. Set valves in order of the firing order.

6. Before installing the valve covers, re-check all locknuts for tightness.

7. Install the Valve Covers.

Check/Clean/Replace

- **Gas Fuel Filter**

Gas Filter - Replace

CNGE recommends that the gas fuel filter be installed before the off-engine mounted gas flow regulator. An inlet pressure of 100 psi is the maximum allowable pressure for this filter. However, the off-engine gas flow regulator may be significantly lower in pressure since it must supply the required amount of fuel-gas under maximum load conditions at levels from 3 to 6 inches of water column pressure to the carburetor.

CNGE supplies a filter as a kit option that is capable of filtering down to 10 microns.

CNGE recommends that the gas fuel filter should be checked every 1500 hours or 1 year, whichever occurs first.

Caution: When replacing the element, specific attention needs to be placed on the gas flow to insure that the filter is reassembled with the filter installed in the proper direction.

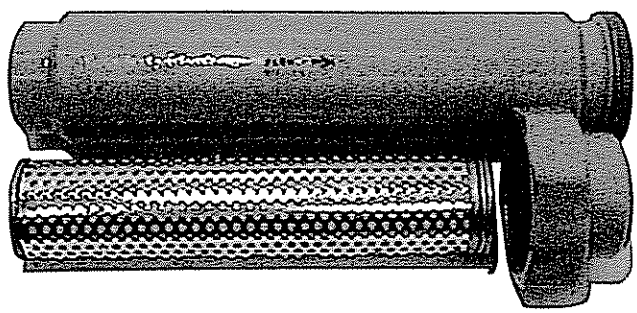

Photo # 7C2-02 - Gas Fuel Filter

- **Gas Pressure to On - Engine Gas Flow Regulator**

Every 1500 hours or 1 year, check the gas pressure to the on-engine gas flow regulator. Use a water manometer or gauge that measures in inches of water column. This reading is taken on the upstream side at the on engine gas regulator. The reading should be 10-20 inches of H_2O column at full operating speed and load.

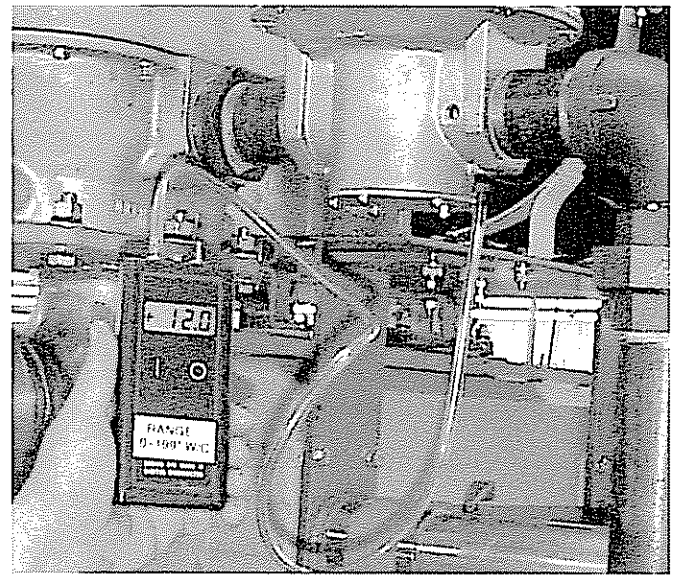

Photo # 7C2-03 - Gas Pressure at Gas Regulator (On Engine) - Checking

- **Gas Pressure to Carburetor**

Every 1500 hours or 1 year, whichever occurs first, the gas pressure to the carburetor should be checked and if required the gas regulator adjusted to insure that the required minimum pressure is being supplied.

Refer to Fuel specifications for fuel pressure requirements. Natural gas will require 4 to 6 in. of H20 column pressure at the carburetor at full load and full speed conditions.

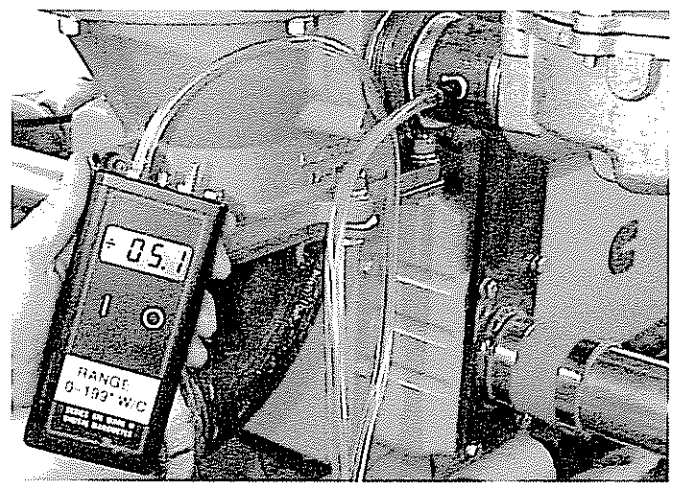

Photo # 7C2-04 - Gas Pressure to Carburetor - Checking

- **Carburetor Adjustment for Excess Oxygen**

The air-gas **"power valve"** on the carburetor should be adjusted at full load condition. Use a good quality Oxygen meter and measure the engine's excess Oxygen content in terms of percent in the exhaust stack downstream of the Turbocharger for each bank. To obtain the specific engine model's excess oxygen requirement, refer to **Table # 7C2-01**.

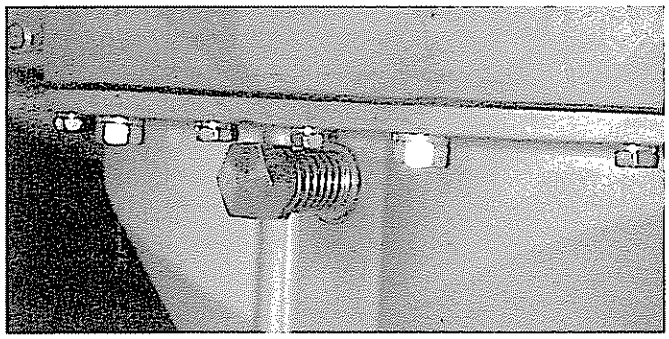

Photo # 7C2-05 - Power Valve - IMPCO 600 D

Table # 7C2-01- Excess Oxygen - Without Catalytic Converter

Engine Model	O2 Reading - % Application	
	Stand-By (Maximum)	Prime (Continuous)
GTA38	2.0 - 2.6	2.2 - 3.0
GTA50 - G1	2.7 - 3.3	2.2 - 3.0
G2/G3	2.5 - 3.0	2.2 - 3.0

Caution: When making the adjustment, it may be necessary to readjust engine ignition timing.

Caution: CNGE sets all engines at Clovis, New Mexico conditions of 4200 feet altitude and to the specifications listed in **Table # 7C2-01**. Your adjustments may be slightly different due to altitude and operating load conditions.

- **Adjustment of Air-Gas Power Valve**

The power valve location will vary depending on the carburetor model.

- **IMPCO Model # 600 and # 600D**

On the IMPCO model 600 D, the power valve can be identified as a hex-head screw with a spring on the side of the carburetor. The adjustment would be to turn the screw in a clockwise **"CW"** direction to adjust toward the lean mixture and counterclockwise **"CCW"** to adjust rich. There are two carburetors used on the GTA38 & GTA50 models, one on each bank. The GTA38 will use the IMPCO Model # 600 and the GTA50 will use the # 600 D. Since these two engine models use a plenum chamber with an aftercooler in the center of the vee to cool the air-gas mixture prior to the Woodward Flo-Tec Actuator throttle bodies, the adjustment of the two carburetors must be done with caution.

It is important to keep the power valve on each carburetor in the same relative position with respect to the number of turns that have been made on the valve and the position of the valve with respect to the carburetor housing.

CNGE recommend that after the carburetor has been adjusted that the power valve and housing be marked by scribing an alignment mark on the housing and the power valve.

- **Antifreeze Concentration - Checking**

Use the Fleetguard® refractometer, Part No. CC-2800, to check the antifreeze concentration.

Check the antifreeze concentration. Use a mixture of 50 percent water and 50 percent ethylene-Glycol base antifreeze to protect the engine to - 37° C [-34° F] year around.

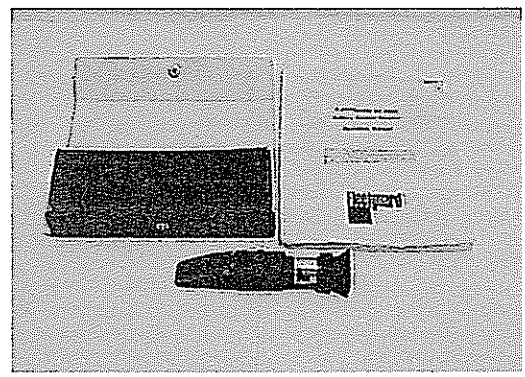

Photo # 7C2-06 - Fleetguard(tm) Refractometer (P.N. CC-2800)

- **Engine Protection System**

General Information

If an Engine Protection System is present, it must be checked every 1500 hours or yearly. Follow the manufacturer's recommended maintenance procedures.

- **Front Engine Support**

Use water pump type of grease, **Chevron SRI** grease or its equivalent, to lubricate the front engine support. Lubricate the support until the grease appears at the outside of the support.

Section 7D
Maintenance Check - 6000 Hours or 2 Years

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D - Maintenance Check - 6000 Hours or 2 Years

General Information

All checks or inspections listed under the previous maintenance intervals must also be performed at this time in addition to those listed under this maintenance interval.

Inspect/Replace

- **Sparkplug Wire - Replacement**

Caution: To prevent damage to the sparkplug wires during removal, do not pull on the wires.

Remove the coil end first, then remove the sparkplug end.

Note: Replace the sparkplug wires one cylinder at a time to prevent crossing the wires across cylinders. Move back and forth while pulling upward to remove the wire from the coil or distributor cap and sparkplug.

Apply a small amount of dielectric grease inside of the sparkplug boot and on the outside of the sparkplug boot.

Firmly press on the boot until a snap is heard and felt as the boot seats on the sparkplug. Install the coil or distributor cap end.

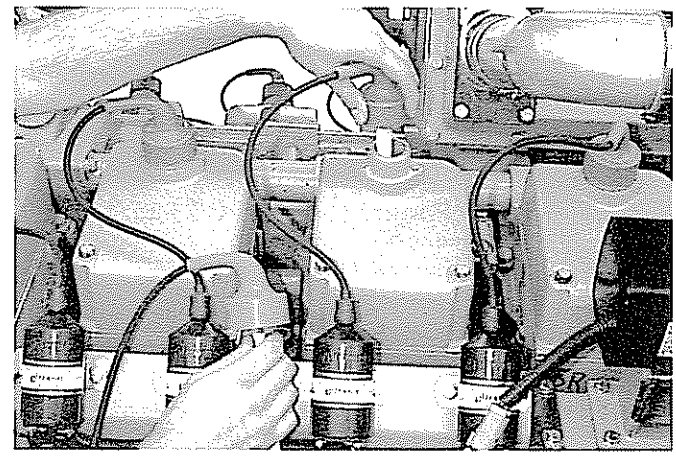

Photo # 7D-01 - Sparkplug Wire Replacement

- **Fan Hub - Inspection**

Every 6,000 hours or 2 years inspect the fan hub for proper end clearance and grease leakage.

Remove the fan belt. **Refer to Section A** for this procedure.

Rotate the fan hub pulley to check for rough or damaged bearings. Inspect the pulley grooves for excessive wear. Check for grease leakage. Use a dial indicator to check the bearing end clearance.

Table # 7D-01 - Bearing End Clearance

Bearing End Clearance		
mm		**in**
0.03	MIN	0.001
0.15	MAX	0.006

Replace a fan hub with a new or rebuilt unit as necessary. **Refer to the Troubleshooting and Repair Manual, K38 and K50 Series Engines, Bulletin No. 3810432**, for removal and replacement instructions.

Install the fan belt. **Refer to Section A** for the installation procedures.

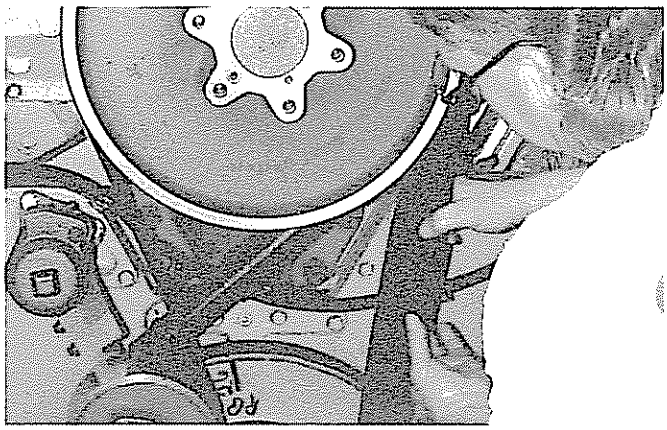

Photo # 7D-02 - Fan Hub - Inspection

Exchange/Rebuild

- **Fan Hub Idler Pulley Assembly**

Every 6000 hours or 2 years inspect the idler pulley assembly. Rebuild or replace the idler pulley as necessary. **Refer to the Troubleshooting and Repair Manual, K38 and K50 Series Engines, Bulletin No. 3810432**, for rebuild and replacement procedures.

Rebuild

Remove the fan belt. **Refer to Section A** for the removal procedure.

Remove the three cap-screws. Remove the idler assembly.

Note: Engines with a 457 mm [18 in] fan center have an adapter plate between the idler and the front gear cover.

Remove the adapter plate.

Refer to the Shop manual, K38 and K50 Engine Series, Bulletin No. 3810304 for rebuild procedures for the fan idler pulley and pivot arm.

Installation

Note: If the engine has two vibration dampers, a longer arm is required.

If the engine has a fan hub with 457 mm [18 in] center (low mount fan), an adapter plate is required between the idler arm and the front gear cover.

Check to make sure the spring on the idler arm is **not** under tension. This will aid the future installation of the fan hub.

Install the fan belt idler assembly, the three lock washers and cap-screws.

Torque Value: 60 N•m [45 ft-lb].

Install the fan belt. **Refer to Section A.**

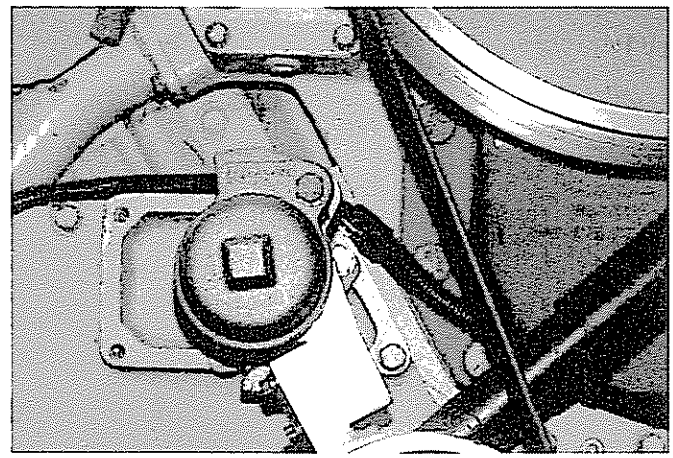

Photo # 7D-03 - Fan Hub Idler Pulley Assembly

- **Engine Water Pump - Inspection and Replacement**

Every 6000 hours or two years, whichever first occurs, rebuild or replace the engine water pump.

Inspect the water pump for seal leakage or for freedom of movement. A minor chemical build-up or streaking at the water pump weep hole is normal. Do not replace the water pump unless an actual leak is confirmed. If the water pump needs to be replaced **refer to the Troubleshooting and Repair Manual, K38 and K50 Engine Series, Bulletin No. 3810432** for removal and replacement instructions.

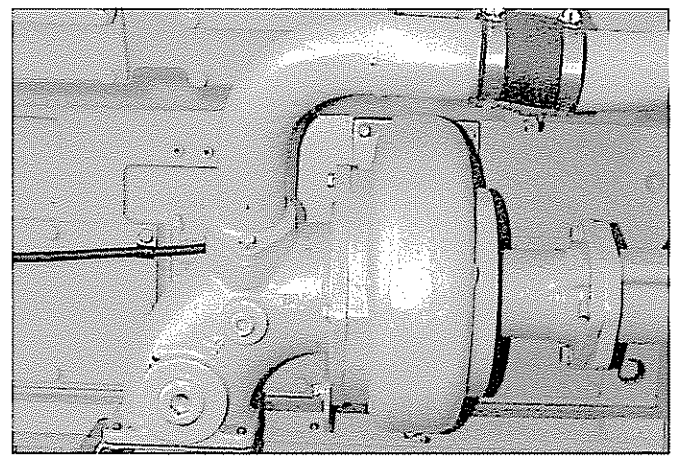

Photo # 7D-04 - Water Pump

- **Aftercooler Auxiliary Water Pump - Inspection**

Follow the manufacturer's recommendations for proper maintenance of the auxiliary water pump used on the aftercooled engines with the water-to-air aftercooling cooling systems.

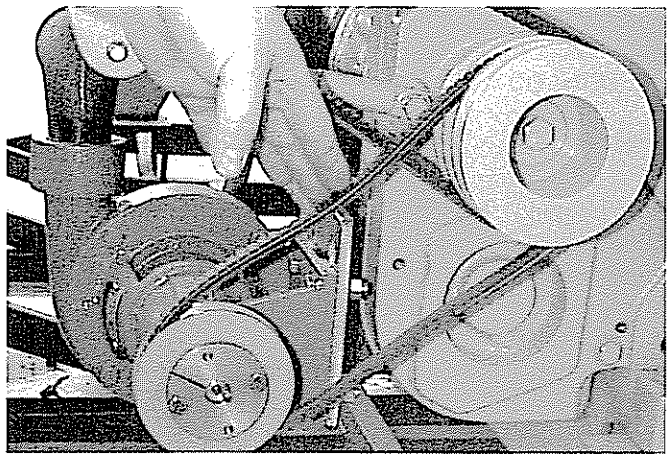

Photo # 7D-05 - aftercooler Water Pump

- **Thermostats and Seals - Replacement**

Remove the:

1. Cap-screws and lock washer (two each).
2. Plate, cover (or water filter head).
3. Seals, o-ring (two each).
4. Cap-screws and lock washers (four each).
5. Shield, heat (right bank only).
6. Cap-screws and lock washers (two each).
7. Housing, thermostat.
8. Gasket.

Check the support. For further information, refer to Procedure No. 08-15, Thermostat Support - Clean and Check for Reuse, in the K38 and K50 Shop Manual, Bulletin No. 3810304.

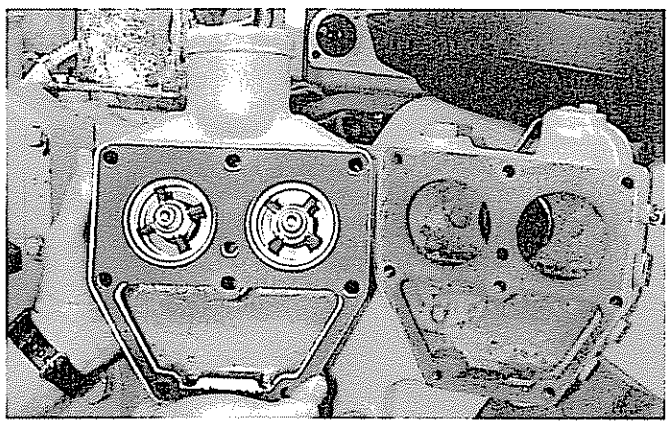

Photo # 7D-06 - Thermostats and Seals

- **Turbocharger - Inspection**

If the engine is equipped with a turbocharger(s), inspect the turbocharger(s) every 6000 hours or two years, whichever occurs first. Remove the air intake and the exhaust piping. Check the turbocharger as follows:

Look for damaged or cracked compressor or turbine blades.

Check for oil leaks on exhaust side of turbine seal.

Check for turbine wheel wear or rubbing of impeller blades.

Check to see that the turbocharger shaft spins freely.

Note: If visual inspections or dimensional checks indicate a problem, contact a Cummins Authorized Repair Location for assistance. Refer to the model number on the turbocharger data-plate.

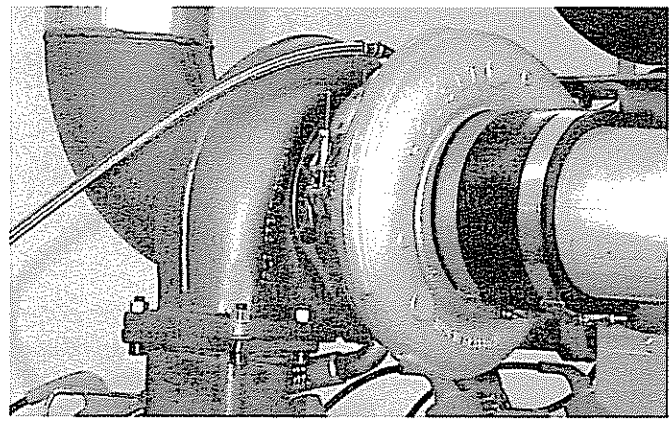

Photo # 7D-07 - Turbocharger

Axial Clearance

Measure the axial clearance (end to end). Rebuild or replace the turbocharger if axial motion (end play) is greater than specified in the following table. **Refer to the Troubleshooting and Repair Manual, K38 AND K50 Engine Series, Bulletin No. 3810432**, for removal procedures and to the **Turbocharger Shop Manual, Bulletin # 3810243 (HC5)**, for rebuild procedures.

Table # 7D-02 - Axial Clearance (Measure end to end)

End Play Dimensions		
Turbocharger Model No.	**Dimension Min.**	**Max.**
HZ	.03m [.001 in.]	.10mm[.004 in.]

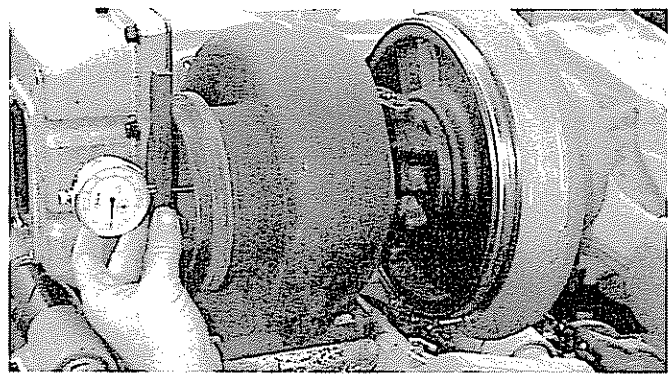

Photo # 7D-08 - Axial Clearance - Checking

Measure Radial Clearance (Side to Side).

Note: Hold the shaft toward the feeler gauge to check the dimension.

Table # 7D-03 - Radial Clearance

Turbocharger Model No.	Dimension Min.	Max.
HZ		
Compressor Wheel	.18 mm [.007 in.]	.46 mm [.018 in.]
Turbine Wheel	.25 mm [.010 in.]	.53 mm [.021 in.]

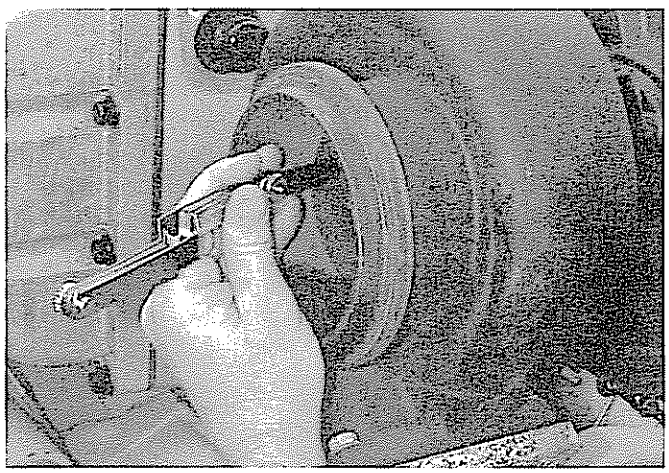

Photo # 7D-09 - Radial Clearance Checking

- **Vibration Damper - Inspection**

Vibration dampers have a limited service life. The damper **must** be inspected every 6000 hours or 2 years of service and **must** be replaced at 24,000 hours of service.

Note: Do not repair or balance a viscous damper in the field.

- Use solvent. Clean the exterior of the damper.
- Inspect the mounting flange for cracks.
- Inspect the housing for dents, bulges, or leaks.
- Replace the damper if damaged.

Thickness Movement

Use a paint solvent and a very fine emery cloth. Remove paint from the front and back of the housing as shown in the photograph. The four areas **must** be at equal spacing.

Measure the thickness at each of the four locations around the damper 90 degrees apart. The readings **must not** vary more than 0.25 mm [0.010 inch]. Refer to the Maximum Vibration Damper Thickness Table for thickness. If the thickness exceeds these specifications, the damper **must** be replaced.

Table # 7D-04 - Maximum Vibration Damper Thickness

Maximum Vibration Damper thickness		
Vendor	**mm**	**In**
Houdaille	65.38	2.574
Made in England F-82 and After	65.66	2.585
Made in England Before F-82	65.91	2.595

Note: If the damper has been in service for 24,000 hours or more, It must be replaced, regardless of the thickness measurement.

Damper Leakage Detection

If visual inspection found signs of leaks, thorough leakage detection is required.

Use crack detection developer, Part No. 3375434 or equivalent. Spray the rolled lip of the damper.

Note: The crack detection kit, Part No. 3375432, contains the necessary cleaner, the penetrate and the developer to check for cracks using the dye penetrate method.

Warning: Wear protective clothing to prevent **personal injury** from burns.

Place the damper in an oven with the rolled lip toward the bottom.

Adjust the temperature of the oven to 93 C [200 F and allow the damper to remain in the oven for 2 hours.

Remove the damper and look for fluid leakage around the rolled lip. The damper must be replaced if there is any fluid leakage.

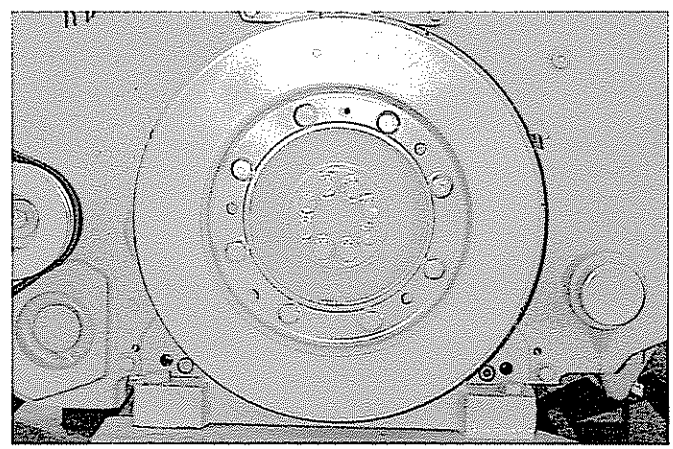

Photo # 7D-10 - Vibration Damper

Engine Protection System

Calibration

The engine protection system **must** be calibrated every 6000 hours or 2 years. Follow the manufacturer's recommended maintenance procedures.

Check

- **Cooling System Maintenance**
- **Coolant Draining**

Caution: Avoid prolonged and repeated skin contact with used antifreeze. Such prolonged and repeated contact can cause skin disorders or bodily injury.

- **Avoid excessive contact - wash thoroughly after contact.**
- **Keep out of reach of children.**

Protect the Environment: Handling and disposal of used antifreeze can be subject to federal, state, and local law regulation. Use authorized waste disposal facilities, including civic amenity sites and garages providing authorized facilities for the receipt of used antifreeze. If in doubt, contact your local authorities or the EPA for guidance as to proper handling of used antifreeze.

Caution: Check the coolant level only when the engine is stopped. Wait until the coolant temperature is below 50° C [120° F] before removing the pressure cap. Failure to do so can cause **personal injury** from heated coolant spray.

Note: The performance of **Fleetguard's® RESTORE** is dependent on time, temperature, and concentration levels. An extremely scaled or flow restricted system, for example, may require higher concentrations of cleaners, higher temperatures, or longer cleaning times or the use of **Fleetguard's® RESTORE PLUS**. RESTORE can be safely use up to twice the recommended concentration levels. **RESTORE PLUS** must be used only at it's recommended concentration level. Extremely scaled or fouled systems may require more than one cleaning.

Name	Part Number	Capacity
RESTORE	CC2610	(1 gallon)
RESTORE	CC2611	(5 gallons)
RESTORE	CC2612	(55 gallons)
RESTORE PLUS	CC2638	(1 gallon)

Drain the cooling system by opening the radiator cap on the radiator and removing the plug in the bottom of the water inlet or in the bottom of the radiator. A drain pan with a capacity of 121 liters [32 U.S. gallons] will be adequate in most applications.

Do **not** allow the cooling system to dry out. **RESTORE** will **not** be as effective if the cooling system is allowed to dry.

Do **not** remove the coolant filter.

Caution: Fleetguard's® RESTORE contains no antifreeze. Do not allow the cooling system to freeze during the cleaning operation.

Check for damaged hoses and loose or damaged hose clamps. Replace as required. Check the radiator for leaks, damage and build up of dirt. Clean and repair as required.

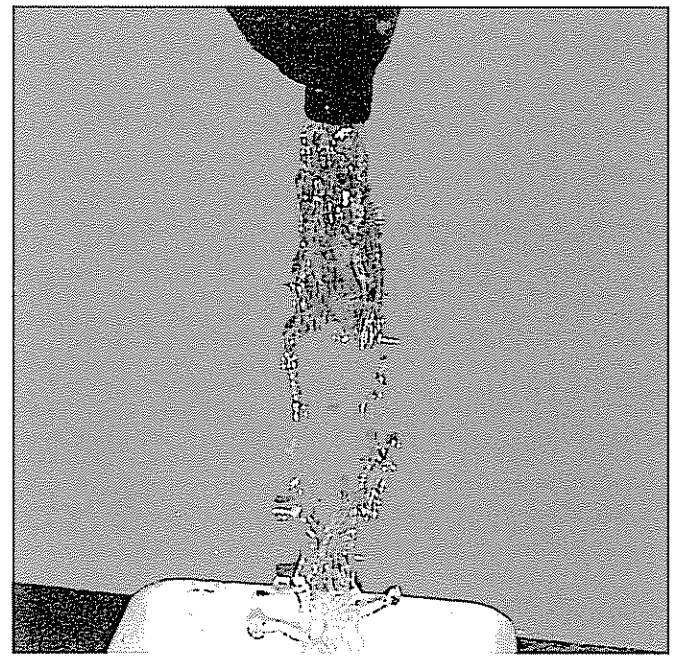

Photo # 7D-11 - Draining Cooling System

- **Cooling System Flushing**

Caution: During filling, air must be vented from the engine coolant passages. The system **must** be filled slowly to prevent air locks. Wait 2 to 3 minutes to allow air to be vented, then add mixture to bring the level to the top.

Immediately add 3.8 liters [1 gallon] of **Fleetguard's® RESTORE, RESTORE PLUS,** (or equivalent) for each 38 to 57 liters [10 to 15 gallons] of cooling system capacity, and fill the system with plain water.

Turn the heater temperature switch to high to allow maximum coolant flow through the heater core. The blower does **not** have to be on.

Caution: Do **not** install the radiator cap. The engine is to be operated without the cap for this process.

Caution: Do **not** use caustic cleaners in the cooling system. Aluminum components will be damaged.

Operate the engine for 5 minutes with the coolant temperature above 85° C [185° F].

Shut the engine off and drain the cooling system.

Fill the cooling system with clean water.

Note: Be sure to allow the engine to vent for complete filling. Do **not** install the radiator cap or a new filter if equipped.

Operate the engine for 5 minutes with the coolant temperature above 85° C [185° F].

Shut the engine off and drain the cooling system.

Note: If the water being drained is still dirty, the system must be flushed again until the water is clean.

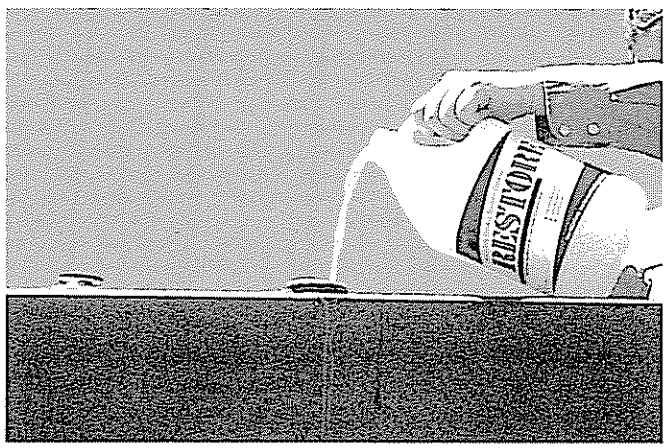

Photo # 7D-12 - Flushing Cooling System

- **Coolant System Filling**

Refer to the engine data-sheet for the cooling system minimum fill rate and the capacity of the engine cooling system.

The engine data-sheet will not contain the cooling system addition needed for either the radiator or remote mounted heat exchanger cooling system. Contact the supplier or manufacturer of the radiator or remote mounted heat exchanger for that information.

Caution: The system **must** be filled slowly to prevent air locks. During filing, air must be vented from the engine coolant passages. Wait 2 to 3 minutes to allow air to be vented, then add mixture to bring the level to the top.

Caution: Never use water alone for coolant. Damage from corrosion can be the result of using water alone for coolant.

Use a mixture of 50 percent water and 50 percent ethylene Glycol antifreeze to fill the cooling system.

The system capacity for the engine is 153 Liter [40.5 U.S. Gal.]

Install the pressure cap. Operate the engine until it reaches a temperature of 85° C [185° F].

Check the coolant level again to make sure the system is full of coolant, or that the coolant level has risen to the hot level in the recovery bottle on the system, if so equipped.

Warning: Before removing the pressure cap, wait until the coolant temperature is below 50° C [120° F]. Failure to do so can cause **personal injury** from heated coolant spray.

Photo # 7D-13 - Filling Cooling System

Notes:

Section 7E
Maintenance Check - Annual & Special Notes

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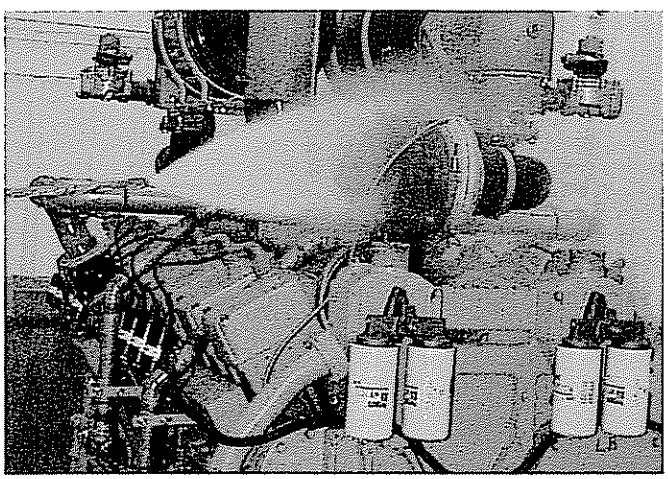
Annual

- **Steam Clean Engine**

Steam clean the engine annually. Steam is the best method of cleaning a dirty engine or piece of equipment. If steam is **not** available, use a cleaning solvent to wash the engine.

Protect all electrical components, openings, and wiring from the full force of the cleaner spray nozzle.

Photo # 7E-01 - Steam Clean Engine



- **Turbocharger Mounting Nuts - Check Torque**

If the engine is equipped with a turbocharger(s), check the turbocharger mounting nuts annually.

Tighten the mounting nuts. **Torque Value: 68 N•m [50 ft.-lb.]**

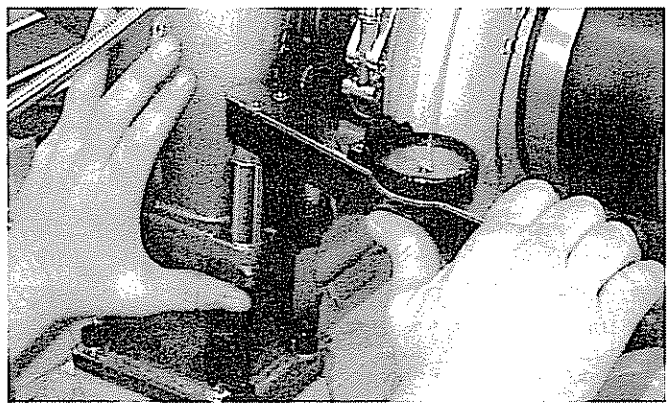


Photo # 7E-02 - Turbocharger Mounting Nuts - Checking Torque

- **Engine Mounting Bolts - Check Torque**

Check the torque on the nuts and bolts annually. Tighten any that are loose. Inspect the rubber for deterioration and age hardening. Replace any broken or lost bolts, capscrews, or damaged rubber.

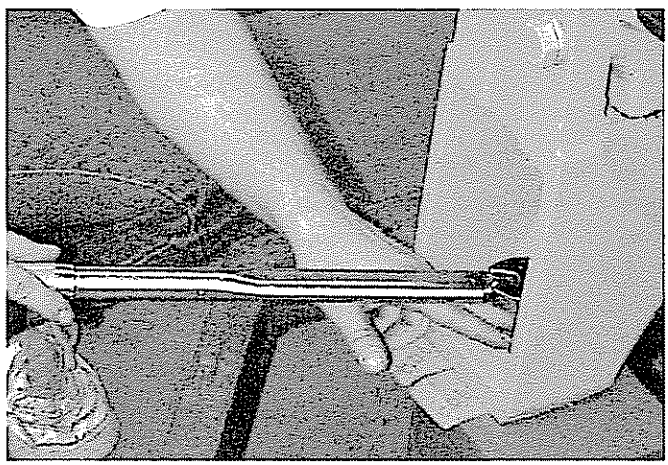


Photo # 7E-03 - Engine Mounting Bolts - Checking Torque

- **Hoses - Checking and Replacement**

Hoses & hose connections should be checked daily for leaks. Annually inspect the cooling system hoses and hose connections for leaks and deterioration. Particles of deteriorated hose can be carried through the cooling system and slow or partially stop circulation.

Photo # 7E-04 - Hose Inspection

- **Clean Cooling System (Internally and Externally)**

Caution: Do **not** use caustic cleaners in the cooling system. Aluminum components will be damaged.

Every 2 years or 6000 hours change the coolant or antifreeze.

The cooling system **must** be cleaned to work correctly. Drain the system and flush with clean water. If the system shows mineral build-up, scale, rust, or oil, clean with a heavy duty engine coolant cleaner and follow the manufacturer's directions.

- **Change Coolant and Antifreeze (Every 2 Years)**

Fill the cooling system with the correct mixture of antifreeze, water, and the **DCA4™** units as outlined earlier in this manual.

Warning: Check the coolant level only when the engine is stopped. Wait until the coolant temperature is below 50° C [120° F] before removing the pressure cap. Failure to do so can cause **personal injury** from heated coolant spray.

Operate the engine and check for coolant leaks.

After the air has been purged from the system, check the coolant level again.

Special Notes

1. The maintenance interval may be adjusted based on a good oil analysis program.
2. At each scheduled maintenance interval, perform all checks in addition to the ones specified.
3. Follow the manufacturer's recommended maintenance procedures for the starter, alternator, generator, batteries, electrical connections, magnetos or Ignition generators, carburetors, gas regulators, governors, and any other accessory item that may be supplied with your CNGE engine.
4. CNGE recommends that a daily log is maintained showing all maintenance performed.

Storage for Engines Out of Service

If the engine will be out of service longer than 6 months, take special precautions to prevent rust. Contact the nearest Cummins or CNGE authorized Repair Location, or consult the Cummins Engine Operation and Maintenance Manual K38 and K50 Engine Series, Bulletin No. 3810497 for information concerning engine storage procedures.

Notes:

Section A
Adjustment, Replacement & Repair Procedures

Table of Contents Page

Adjustment, Replacement and Repair

- **Air System Repair**

Turbocharger Remove and Install

Remove Turbocharger:

Preparatory Steps

1. Disconnect the oil drain hose from the cylinder block. Discard the o-ring seal or gasket.
2. Disconnect the oil drain hose from the turbocharger. Discard the gasket.
3. Check the condition of the hose. Discard the hose if it is cracked, frayed or will not bend without cracking.
4. Disconnect the oil inlet hose. Removal of the fitting and the o-ring seal is not required.
5. Remove any support clamps from the hose. Remove the hose.
6. Newer engines will contain a hose and clamp between the turbochargers and the plumbing from the Carburetor.

   Note. The clamps are special, heavy strength parts.
7. Loosen the clamps.
8. Remove the four cap-screws and nuts.

   Caution: The component weighs 23 kg [50 lb] or more. To avoid **personal injury**, use a hoist or get assistance to lift the component.
9. Remove the turbocharger and gasket.
10. Discard the gasket.
11. On newer engines, remove the hose and clamps. Discard the hose. Check the condition of the clamps. Discard the clamps if they are cracked or have damaged threads.

Install Turbocharger:

Caution: Check to be sure the correct turbocharger assembly number can be found on the data tag that is mounted on the turbocharger. Many turbochargers appear the same physically but contain different internal parts. If the wrong turbocharger assembly is used, engine performance will be less than specification or the engine will be damaged due to excessive cylinder pressure and temperature.

Note: The turbochargers, mounting hardware and connections are **not** the same for all models of K38 or K50 engines. CNGE use turbochargers specifically matched for the spark-ignited engines. CNGE also only use one configuration for the GTA38 and GTA50 engine series.

GTA38 and GTA50 with Center Mount Aftercooler.

Note: Newer engines will use a hose and clamp to connect the turbocharger to the aftercooler connection. The clamps are special to allow a higher torque. Standard t-bolt clamps will become loose and allow an air-gas leak.

1. Install the hose and clamps on the aftercooler connection. Do **not** tighten the clamps.
2. Install the gasket on the exhaust manifold. The raised bead **must** be toward the turbocharger.
3. Install the turbocharger. Push the compressor housing into the hose.

   Note: The cap-screws and the nuts are made from heat resistant material. If the heat resistant material is **not** used, the parts will fail causing an exhaust leak.

4. Use an anti-seize compound to coat the threads of the cap-screws.
5. Install the four cap-screws and the nuts.

   Torque Value: 40 N•m [30 ft-lb].

   Note: Check the angle of the oil drain and the alignment of the compressor housing to the aftercooler connection. If incorrect, make necessary adjustments. Refer to the K38 and K50 Troubleshooting and Repair Manual, Bulletin # 3810432.

6. Tighten the clamps.

   Torque Value: 9 N•m [80 in-lb].

   Note: HOLSET turbochargers use a fitting on the oil inlet that has straight threads and requires an o-ring seal.

7. Install the o-ring seal on the oil inlet fitting. Install the fitting.

   Torque Value: 35 N•m [25 ft-lb].

8. Connect the turbocharger oil inlet hose to the fitting. Install the clamps for the oil inlet hose.

   Note: The other end of the oil inlet hose must be connected to a fitting in the cylinder block.

9. Install the gasket, the hoses, the lock washer and the cap-screws for the turbocharger oil drain.

   Torque Value: 40 N•m [30 ft-lb].

   Note: Newer engines will use the flange and o-ring seal type oil drain hose assembly. The newer hose connects to the cylinder block with a cap-screw.

10. Install the o-ring seal on the hose flange. Use engine oil. Lubricate the seal. Install the flange, the lockwasher, and the cap-screw.

    Torque Value: 40 N•m [30 ft-lb].

11. Repeat this process to connect the other turbocharger and to connect the other hoses.

Caution: When installing new or replacement turbochargers, it may be necessary to pre-lube the turbochargers prior to starting the engine.

- **Cooling System Repair**

Fan Remove and Install

1. Disconnect the batteries to prevent accidental starting of the engine.

   Warning: Do **not** rotate the engine by pulling or prying on the fan. Do **not** straighten a bent fan blade or continue to use a damaged fan. A bent or damaged fan blade can fail during operation and cause serious **personal injury** or property damage.

2. Remove the fan.
3. Install the fan.

Caution: Replace the original equipment fan with a fan of the identical part number. CNGE **must** approve any other fan changes. Using a fan with a different part number can result in failure, causing damage or **personal injury**.

Note: Replacing a fan with a different part number fan can also lead to under-cooling and over heating of the engine.

4. Tighten the mounting cap-screws to 135 N•m [100 ft-lb] torque.
5. Connect the batteries.
6. Check for proper protrusion of the fan blade into the fan shroud.

Note: If using a box shroud and a blower fan the fan blade must protrude into the shroud by 1/3 of the fan blade width. And have 2/3's of the fan blade width out of the shroud for proper fan installation.

Fan Belt - Remove and Install

1. Remove the fan idler shock absorber.

   Warning: The fan belt idler is under tension. Do not allow your hands to get between the idler and the belt, or the fan hub. **Personal injury** can result.

2. Use an 8 point socket and breaker bar or large wrench. Hold the idler in position against the spring tension and remove the cap-screw.
3. Slowly turn the wrench until the spring tension is relieved.

   Spring Tension: 35 N•m [45 ft-lb].

4. Remove the fan belt.
5. Check for reuse. Visually inspect the belt for cracks, glazing, tears or cuts.
6. Install the belt.

7. Rotate the idler against the spring tension until the cap-screw holes are aligned.
8. Install the cap-screws. Tighten the cap-screws to 45 N•m [35 ft-lb].
9. Slowly turn the wrench until the idler is against the belt.
10. Install the shock absorber.

Fan Hub - Remove and Install

Preparatory Steps:

1. Remove the fan.
2. Remove the fan belt.

Caution: This assembly weighs 23 kg [50lb.] or more. To avoid **personal injury**, use a hoist or get assistance to lift this component.

3. Remove the four SAE Grade 8 cap-screws.

Note: Observe which of the holes in the bracket are used. Different holes are used for different fan centers.

4. Clean and check the fan hub for reuse. Rotate the pulley to check for rough or damaged bearings.

5. Check bearing end clearance.

Table # A-01 - Fan Hub Bearing End Clearance

Bearing End Clearance		
Mm		**in**
0.003	MIN	0.001
0.15	MAX	0.006

6. Install the fan hub, the four cap-screws and lock washers. Tighten the cap-screws to:
35 N•m [25 ft-lb]
7. Install the fan belt.
8. Install the fan.

Fan Hub Idler and Shock Absorber - Remove and Install

1. Remove the two cap-screws, the two lock-washers, the three spacers and the shock Absorber.
2. Remove the fan belt.
3. Check the belt for damage. Discard the part if it is damaged.

Caution: The component weighs **23 kg [50 lb.]** or more. To avoid **personal injury**, use a hoist or get assistance to lift the component.

4. Remove the three cap-screws. Remove the idler assembly.
5. Remove the adapter plate.
6. Install the fan belt idler assembly, the three lock washers and cap-screws.

Torque Value: 60 N•m [45 ft-lb].

7. Install the fan belt.
8. Install the shock absorber in the fan support.

Note: The shock absorber **must** be installed with the larger outer tube of the absorber attached to the fan hub support. If the absorber is installed wrong, dirt can enter the tube and cause the part to fail.

9. Install the flat washer, lock washer, and cap-screw in the lower end of the shock absorber.
10. Install the shock absorber on the fan idler arm.
11. Tighten the two cap-screws

Torque Value: 60 N•m [45 ft-lb].

Thermostat Remove and Install

Preparatory Steps

1. Disconnect the negative battery cable.
2. Drain the cooling system to a level just below the thermostat housing.
3. Remove both upper radiator hoses from the thermostat housing.
4. Remove the twelve cap-screws.
5. Remove the thermostat housing and gasket.
6. Remove the thermostats and seals.
7. Clean and inspect the thermostat housing for cracks, pitting or other damage.
8. Check the thermostat for wear or damage, Check for proper operation.
9. The seal must be installed with the part number up.
10. Use a mallet and seal driver Part No. 3375411. Install the seal.

Note: Install the seal no more than 0.51 mm [0.020 in.] below the top of the cast edge.

11. Install the thermostat by pushing on the outer rim.

Note: If the engine being service d is a GTA50, be sure that the correct thermostat is installed.

The K50 thermostats contain a nitrile rubber seat vulcanized to the brass collar at the barrel seat. This seat prevents coolant leakage and wear. The thermostat with the rubber seat must be on GTA50 engines. The thermostat with the rubber seat is not required for the GTA38 engine, but can be installed.

12. Install a new gasket. Install the thermostat housing and cap-screws.
13. Tighten the cap-screws to **45 N•m [35 ft-lb]**.
14. Install the two upper radiator hoses.
15. Tighten the hose clamps to **6 N•m [50 in-lb]**.

Water Pump - Remove and Install

Preparatory Steps

1. Drain the cooling system.

Remove the Coolant By-pass Tube.

2. Loosen the hose clamp. Remove the two cap-screws, the lower tube and the gasket.
3. Disconnect the lower radiator or heat exchanger hose from the water pump inlet.

Remove the Water Pump Inlet Housing.

4. Remove the two cap-screws and heavy washers that hold the support bracket to the cylinder block.
5. Remove the four cap-screws that hold the housing to the water pump. Note that the two washers are heavy washers.
6. Remove the support brackets. Pull the housing from the pump.
7. Remove and discard the o-ring seal.

Remove the Water Pump.

8. Remove the four cap-screws that hold the adapter plate to the cylinder block.

   Caution: This component weighs 23 kg [50lb.] or more. To **avoid personal injury**, use a hoist or get assistance to lift this component.

9. Remove the four cap-screws that hold the pump to the water pump drive.
10. Remove the pump and the coupling.
11. Remove the plate from the pump.
12. Remove and discard the o-ring and gasket.
13. Check the water pump for reuse.

Install the Water Pump.

14. Install the o-ring seal in the groove in the water pump adapter plate. Use vegetable oil to lubricate the o-ring.

    Note: The adapter plate must be installed so that th groove in the plate is toward the pump.

15. Install the adapter plate on the water pump.
16. Install the spline coupling on the water pump shaft
17. Install the gasket on the pilot on the water pump.
18. Align the holes.
19. Position the pump on the water pump drive. Rotate the pump to align the spline coupling with the splines on the water pump drive shaft.
20. Install the four lock washers and cap-screws that hold the drive to the pump.
21. Tighten the cap-screws **only** enough to hold the parts together.
22. Install the gasket between the adapter plate and the cylinder block.
23. Install but do **not** tighten the four lock washers and cap-screws that hold the plate to the cylinder block.
24. Rotate the pump housing so that the pump outlet and the adapter plate are as close to the cylinder block as possible.
25. Tighten the four pump to pump drive cap-screws.

    Torque Value: 60 N•m [45 ft-lb]

26. Tighten the four adapter plate cap-screws that hold the plate to the cylinder block.

    Torque Value: 40 N•m [30 ft-lb]

Install the Water Pump Inlet Housing

27. Install the o-ring seal in the groove on the inlet housing. Us vegetable oil to lubricate the seal.
28. Install the housing in the bore in the water pump.
29. Align the holes. Install the two lock-washers and cap-screws in the top and outside cap- screw holes.
30. Tighten the cap-screws only enough to hold the parts together.
31. Install the bracket to the pump using two large flat washers, lock washers and cap-screws.
32. Tighten the cap-screws only enough to hold the bracket to the housing.
33. Install the two large flat washers, lock washers and cap-screws that hold the bracket to the hand hole cover.
34. Tighten the cap-screws only enough to hold the bracket to the hand hole cover.

    Note: Make sure the bracket remains flat against both the housing and the hand hole cover while tightening the cap-screws. If the bracket does not remain flat, it will be in stress and fail causing the pump or pump drive to also fail.

35. Tighten the four cap-screws that hold the bracket to the inlet housing, and the inlet housing to the pump.

    Torque Value: 40 N•m [30 ft-lb]

36. Tighten the cap-screws that hold the bracket to the hand hole cover.

    Torque Value: 60 N•m [45 ft-lb]

37. Install the bypass connection gaskets. Tighten the cap-screws to 40 **N•m [30 ft-lb].**

38. Tighten the cap-screw to 45 N•m [35 ft-lb]
39. Tighten the hose clamps to 5.6 N•m [50 in-lb]
40. Close the drain-cock on the water pump and cylinder block. There are two drain-cocks on each side of the engine.
41. Replace the coolant filters.
42. Connect the lower radiator or heat exchanger hose to the water pump inlet.
43. Connect the water filter lines.
44. Fill the cooling system.
45. Operate the engine to 70(C [160(F] coolant temperature and check for leaks.

Aftercooler Pump - Remove and Install

Preparatory Steps

1. Disconnect battery ground cable from engine to prevent starting of the engine.
2. Drain all coolant from the aftercooler cooling system.
3. Disconnect both the pressure line and the suction line from the auxiliary aftercooler water pump.
4. Remove both inlet and outlet fittings.
5. Loosen and remove the 4 mounting bolts and nuts.
6. Remove the drive belt.
7. Remove the auxiliary aftercooler drive pulley from the pump.
8. Install a new pump.
9. Install the 4 mounting bolts and nuts and do not tighten at this time.
10. Install the inlet and out let fittings. Use a thread sealant on the pipe threads.
11. Install drive pulley and belt.
12. Align the drive pulley and belt to the engine front crankshaft pulley. And tighten the mounting bolts. **Torque Value = 44 N•m (32 ft-lb).**

    Note: The aftercooler drive belt must have a minimum of 1 inch belt deflection at the mid-point between the two pulleys to insure that the aux. aftercooler water pump does not exceed the side load pressure limitations.

13. Install both the pressure and suction lines to the pump connections.
14. Re-Service the system with treated coolant and vent the system.
15. Reconnect the battery ground cable.
16. Start the engine and vent the system of any entrapped air.

•Electrical System Repair

Alternator - Remove and Install

Preparatory Steps

1. Disconnect the ground cable from the battery terminal.
2. Disconnect the wiring from the alternator. Tag all wires
3. Loosen the adjusting link and the alternator mounting cap-screws.

   Note: One of the jam nuts has left-handed threads.

4. Loosen both of the jam nuts. Turn the adjusting screw to relieve the belt tension.
5. Remove the alternator belt.

   Note: The three cap-screws are **SAE Grade 8** and the three spacers are hardened. Keep the parts together to aid in the assembly procedures.

6. Remove the three cap-screws, spacers, washers and nuts from the alternator mounting.
7. Remove the nut and pulley from the alternator.
8. Clean and check the pulley for reuse.
9. Lubricate the shaft with engine oil. Install the pulley and nut on the alternator shaft. Tighten the nut to **100 N•m [75 ft-lb]**.

Engines with the **older** style alternator adjusting link require that the end with the longest machined area at the cap-screw hole **must** be nearest to the alternator.

Note: The three cap-screws are SAE Grade 8. The heavy flat washers are hardened. The washers have a notch for identification. These parts are installed because they **must** be loosened and tightened more than normal to adjust the alternator belt.

Use your hand to tighten the cap-screws.

1. Install the top cap-screw first. Install the heavy flat washer on the cap-screw. Install the cap-screw and alternator on the bracket. Install the next heavy flat washer and the flange nut.
2. Install the heavy flat washer, the cap-screw, and one end of the adjusting link on the alternator.
3. Install the heavy flat washer, the cap-screw and the other end of the adjusting link to the front gear cover.

   Note: Do not attempt to pry on the pulley. The pulley or belt will be damaged.

4. Install the belt. Turn the adjusting screw counterclockwise to shorten the link if necessary.
5. Turn the adjusting link to tighten the belt to the correct tension.

Table # A-02 - Alternator Belt Tension

Alternator Belt Tension	
Gauge Part No.	**Tension**
ST-1293 (Burroughs)	165 lb.
ST-1274 (Kriket)	88 lb.

Note: One of the jam nuts has left-hand threads.

6. Tighten the jam nuts on the adjusting screw to **55 N•m [40 ft-lb]**
7. Tighten the adjusting link and alternator mounting cap-screws.

Torque Value: 1) 95 N•m [70 ft-lb] (Top Cap-screw)
2) 70 N•m [55 ft-lb] (Bottom Cap-screw at Adjusting Link)
3) 95 N•m [70 ft-lb] (Bottom Cap-screw at gear Cover)

8. Connect the wiring to the alternator.
9. Connect the batteries and remove the tags.

Starter Motor - Remove and Install

Preparatory Steps

Remove

1. Disconnect the ground cable from the battery.
2. Identify the electrical wire with a tag indicating location.
3. Remove the battery cable from the solenoid.
4. Remove the starting motor cap-screws, the starter, spacers and the gaskets. Discard the gaskets.

Install

Note: Installation of the top electric starting motor first will simplify the installation of both starting motors.

5. Install any gaskets.
6. Install the starting motor with three lock washers and capscrews.

Torque Value: 215 N m [160 ft-lb]

7. Install the electrical connections to the starter motor.
8. Connect the batteries.

Starter Motor - Check for Reuse

Caution: Wear protective clothing to prevent **personal injury** from burns caused by steam.

1. Clean the exterior of the motor with steam.
2. Check the gear, shaft, and the bushing for wear and damage.
3. Lubricate the bushing with engine oil.

Note: A pipe plug **must** be removed to lubricate the bushing on some starting motors.

- **Fuel System Repair**

Gas Flow Shut-Off Valve - Remove and Install ASCO Shut-Off Valve

Remove

1. Disconnect battery power from the engine.
2. Shut off manual gas shut-off valve.
3. Remove flexible hose from the shut-off valve and the gas flow regulator.

Caution: The flexible hose may still have gas pressure.

4. Disconnect the two electrical wires.
5. Remove the shut-off valve from the 2 inch pipe.

Install

1. Apply a coat of pipe thread sealant to the 2 inch pipe.

Note: Sealant should be type that is recommended for natural gas use only.

2. Install the shut-off valve onto the pipe and tighten 3 full turns past handtight.
3. Reconnect the two electrical wires.
4. Reinstall the flexible hose from shut-off valve to gas flow regulator.
5. Open manual gas shut-off valve.
6. Apply liquid soap to all connections and check for leaks.
7. Reconnect battery power.

- **Carburetor - Remove and Install**

Remove

1. Disconnect battery power from the engine starter and turn off the manual gas shut-off valve that supplies gas to the engine. This valve is located in the gas line upstream of the engine prior to the ASCO shut-off valves. Apply a "Do Not Open" red tag to the manual shut-off valve as a precautionary move.
2. Disconnect lower piping and ASCO shut-off valve from carburetor and the RV91 gas flow regulator by loosening the 2" pipe coupling right below the RV91 gas flow regulator.
3. Remove the band clamp from the turbocharger inlet and the carburetor air/fuel outlet pipe.
4. Remove the carburetor air/fuel outlet pipe by removing six 1/2" bolts, washers and nuts with two 3/4" wrenches. Do not reuse the gasket.
5. Remove the RV91 gas flow regulator from the carburetor with a 15" pipe wrench by unscrewing the 2" pipe from the RV91 gas flow regulator to the carburetor.
6. Remove the 600D carburetor from the carburetor air inlet by removing the four 1/4" bolts using a 7/16" wrench and remove six 3/8" bolts using a 9/16" wrench.

Installing

Note: Cap-screws threaded into aluminum may require reductions in torque of 30% or more of grade 5 cap-screw torque.

1. Install the 600D carburetor on to the air inlet and install six 3/8" bolts and **Torque to 24 N•m (18 ft-lb)**. Install the four 1/4" bolts and **Torque to 7 N•m (5 ft-lb)**.
2. Install the 2" inlet pipe into the carburetor (apply a thin coat of pipe sealant to the pipe threads of the 2" pipe before installation) and turn by hand in a clockwise direction until tight using a 15" pipe wrench. Tighten 1 full turn until RV91 gas flow regulator is level.
3. Install the carburetor air/gas outlet pipe and gasket (apply a thin coat of silicone sealant to both sides of the gasket to help seal the air/gas mixture) and install the six 1/2" bolts, washers and nuts. **Torque to 53 N•m (39 ft-lbs)**.
4. Install the band clamp on the turbocharger inlet hose and the carburetor air/gas pipe.
5. Reconnect the 2" pipe coupling re-joining the lower gas line and the ASCO shut-off valve with the RV91 gas flow regulator and carburetor.
6. Reconnect the battery to the engine and turn the manual gas shut-off valve back on.
7. Re-Check all fittings for tightness and Check for any gas leaks.

- **Governor System Repair**

Governor Actuator - Remove and Repair

Remove

1. Remove battery power from the engine.
2. Disconnect the electrical plug at Actuator.
3. Remove all hose clamps from the intake air pipe at the aftercooler and at the actuator and remove the air pipe.
4. Remove the four 3/8 " mounting bolts.

Install

Note: All gaskets must have a thin coat of high temperature silicone applied to both sides of the gasket surface.

1. Clean both the actuator mounting gasket surface and the upper air adapter gasket surface.
2. Install lower gasket, Flo-Tech Actuator, upper gasket and upper air adapter with four 3/8" bolts and washers.

Torque Value: 42 N•m [31 ft.-lb.]

3. Install intake air pipe from the air adapter to the Aftercooler asembly and install all hose clamps.
4. Reconnect electrical pulg to actuator.
5. Reconnect battery power to engine.

Governor Controller - Remove and Replace

1. Refer to the **Woodward Flo-Tech Speed Control Manual 04173A**. This manual was included with your literature pack for this engine.

Governor Adjustment

Adjustment Procedure

1. Refer to the **Woodward Flo-Tech Speed Control Manual 04173A**. This manual was included with your literature pack for this engine.

- **Ignition System Repair**

ALTRONIC III - Ignition Generator- Remove and Install

Remove

1. Remove battery from the engine.
2. Disconnect electrical wiring harness plug from ALTRONIC III.
3. Turn Engine over until timing mark is on 20 degrees BTDC and the red pointer in the window on the back cover is on the CW mark.
4. Remove the two mounting 3/8" bolts and nuts holding the ALTRONIC III to the engine accessory drive.

Caution: The ALTRONIC III weight is in the range of 15 lbs.

Install

1. Make sure that the engine is on the 20 degree BTDC at # 1 cylinder.
2. Install gasket and fiber coupling to the ALTRONIC III drive end.
3. Install ALTRONIC III to the engine accessory drive and install 3/8" bolts, washer and the 3/8" self locking nuts and tighten (do not torque at this time).
4. With the engine set at the 20 degree mark remove the four 1/4" bolts that are holding the back cover in place.
5. Slightly tilt the back cover and rotate the big white gear the red pointer in the window points to the CW mark. Close up the back cover and reinstall the four 1/4" bolts until tight.

Note: Only pull the back cover far enough to turn the gear without unplugging the wires from the ignition generator to the generator coils.

6. The engine should now be timed at 20 degrees + or - a degree (19-21).
7. Reinstall the primary wiring harness plug to the ALTRONIC III.
8. Start the engine and with a timing light connect to # 1 cylinder on the Right bank (RB). Time the engine to 20 degrees BDTC by rotating the ALTRONIC III clockwise (CW) to advance the timing and counterclockwise (CCW) to retard the timing.
9. Shut the engine down.
10. Torque the two ALTRONIC III mounting bolts and lock nuts to 42 N•m [31 ft-lbs].

- **Lubricating System Repair**

Refer to the K38 and K50 Troubleshooting and Repair Manual, Bulletin No. 3810432, for the proper procedure.

Section 8
Compressed Air/Gas System

Compressed Air System

Air Starting

Air starting is available as an engine option for most CNGE engine models and is acceptable for use on all Cummins engines. It provides a generally higher cranking speed than electric starting motors and the compressed air source suffers less energy loss at low ambient temperatures than electric storage batteries.

Air-Gas Starters

The air-gas starter system (tanks, line sizes, and valves) is designed and installed by the original equipment manufacturers and the starter suppliers. Refer any questions about air starting systems to the manufacturer.

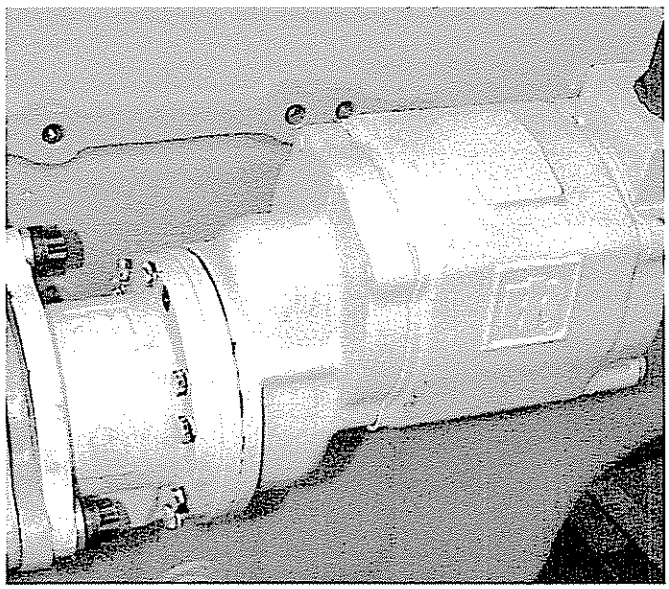


Photo # 8-01 - Air-Gas Starter

Air Starters - Maintenance

Do not operate air starting motors with air pressure lower than 480 kPa (70 psi).

Air-Gas Starters - Maintenance

Do not operate air-gas starting motors with air-gas pressure lower than 490 kPa (70 psi).

Special Note:

Refer to the original equipment manufacturers and starting motor manufacturer manuals for specific information regarding the starting motors, valves, and systems.

Lubricator - Air-Gas Starter

CNGE pre-lubes the lubricator and then ships the unit in a dry state. It is therefore necessary to add a clean non-detergent lubricant, preferable an SAE 10 (90SSU), or lighter. The rate of oil delivery is adjusted by turning the adjusting screw either clockwise for less oil or counter-clockwise for more oil delivery.

CNGE recommends that you follow the manufacturer's instructions for proper operation and maintenance of the "Economist" lubricator.

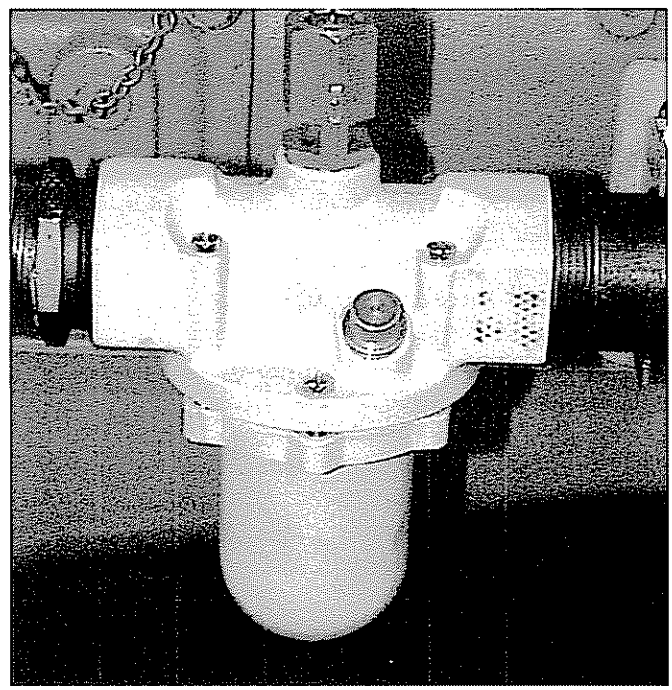


Photo # 8-02 - Economist Lubricator

Section 9
Troubleshooting

Procedures and Techniques

This guide describes some typical engine operating problems, their causes and some acceptable corrections to those problems. Unless noted, the problems listed are those that an operator can diagnose and repair. See a CNGE authorized repair location for diagnosis and repair of problems not listed. Follow the suggestions below for troubleshooting:

- Study the problem thoroughly before acting.
- Refer to the engine system diagrams.
- Do the easiest and most logical things first.
- Find and correct the cause of the problem.

Instructions

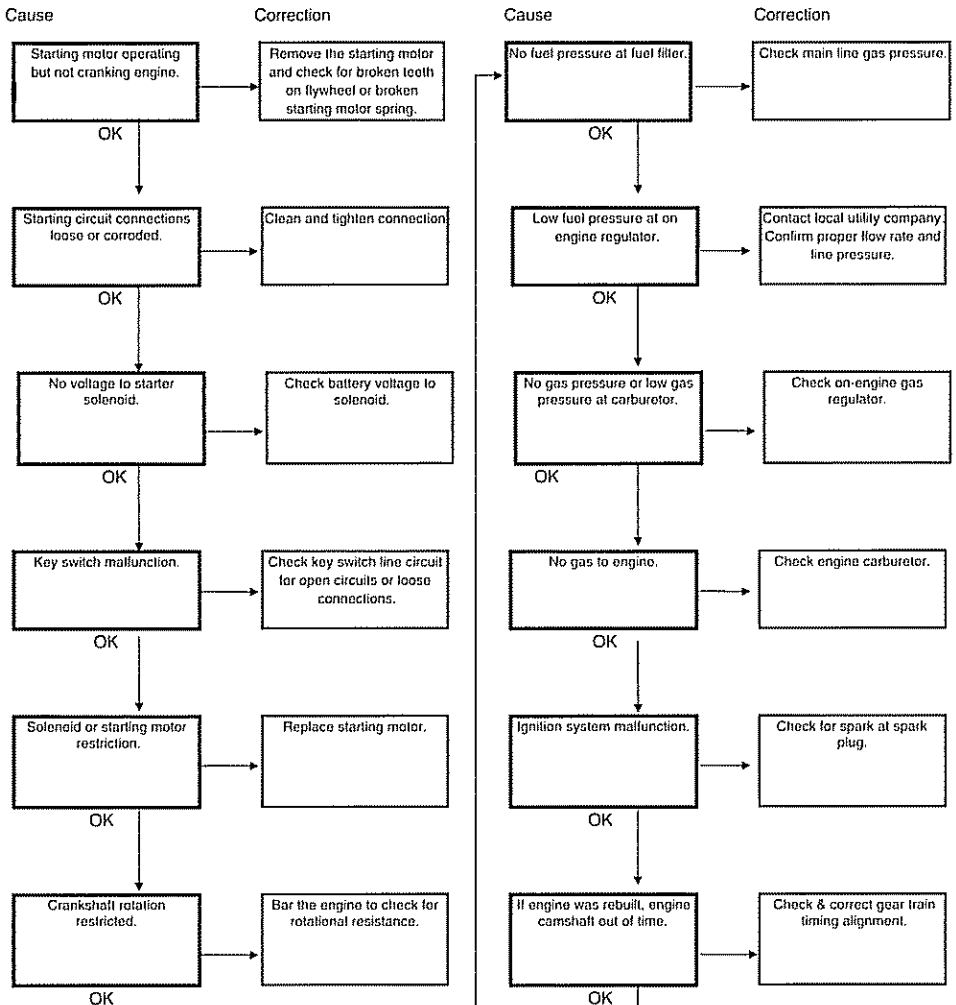
Read each row of blocks from top to bottom. Follow the arrows through the chart to identify corrective action.

Symptoms Listing

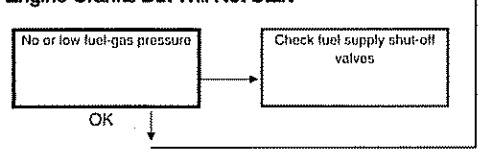
For additional troubleshooting information refer to the Troubleshooting and Repair Manual, K38 and K50 Engine Series, Bulletin No.3810432. This manual can be purchased from your local Cummins Distributor.

Notes:

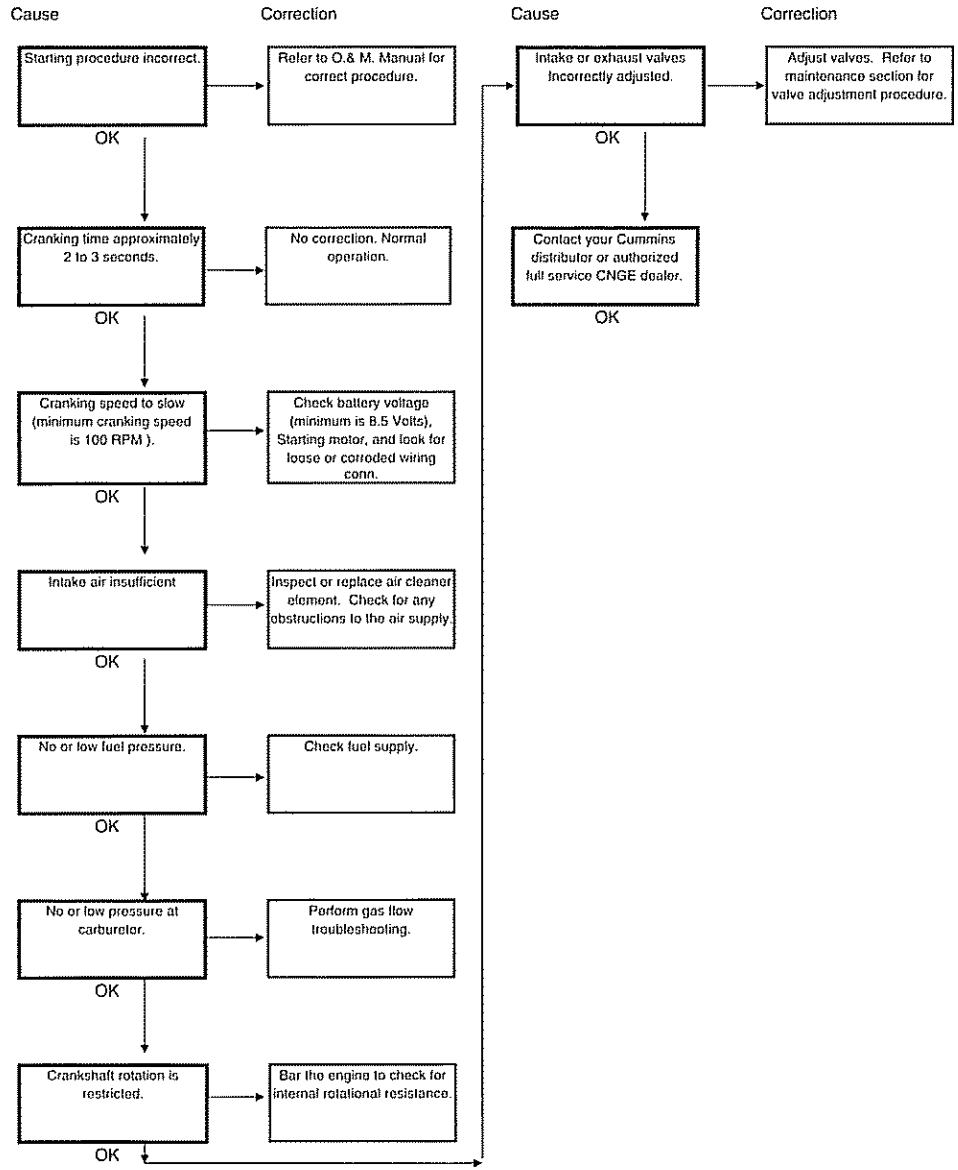
Engine Will Not Crank



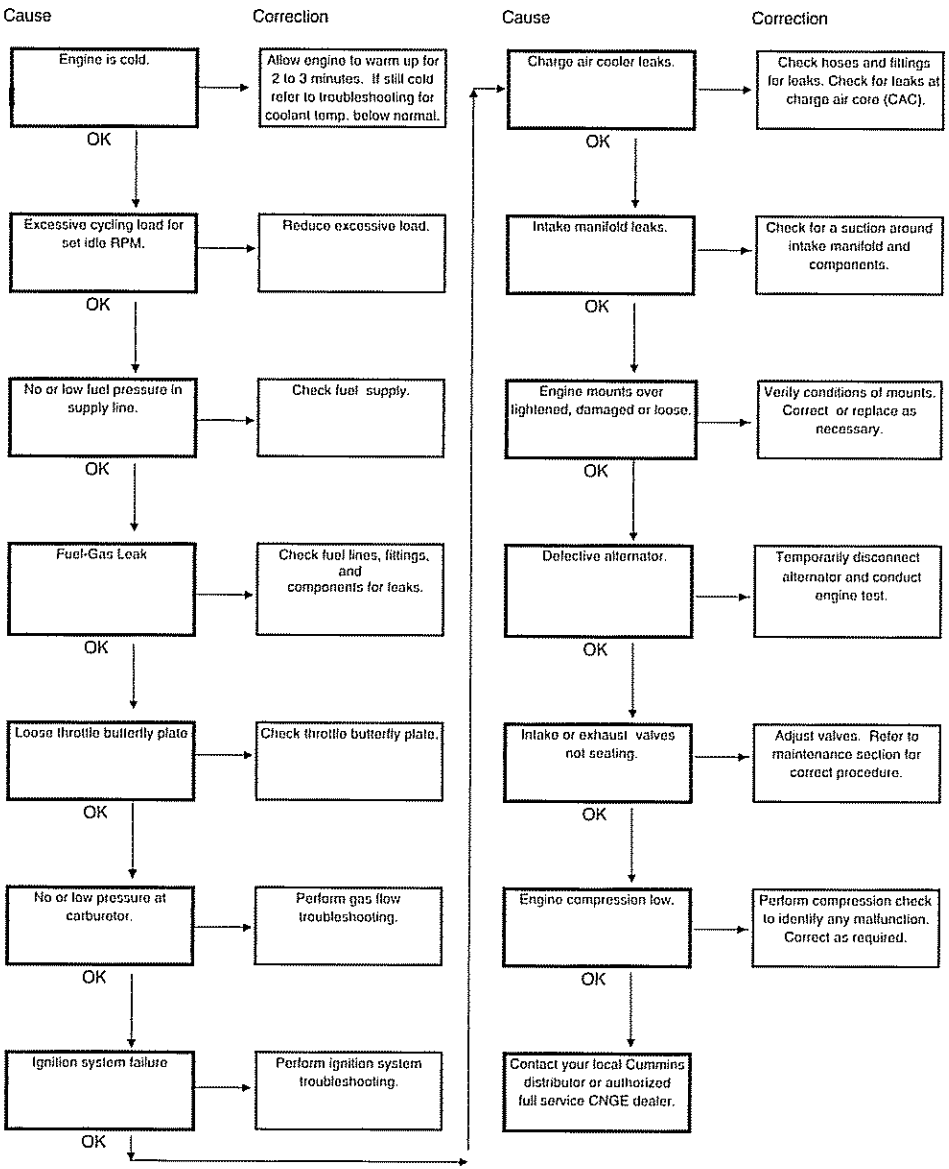
Engine Cranks But Will Not Start



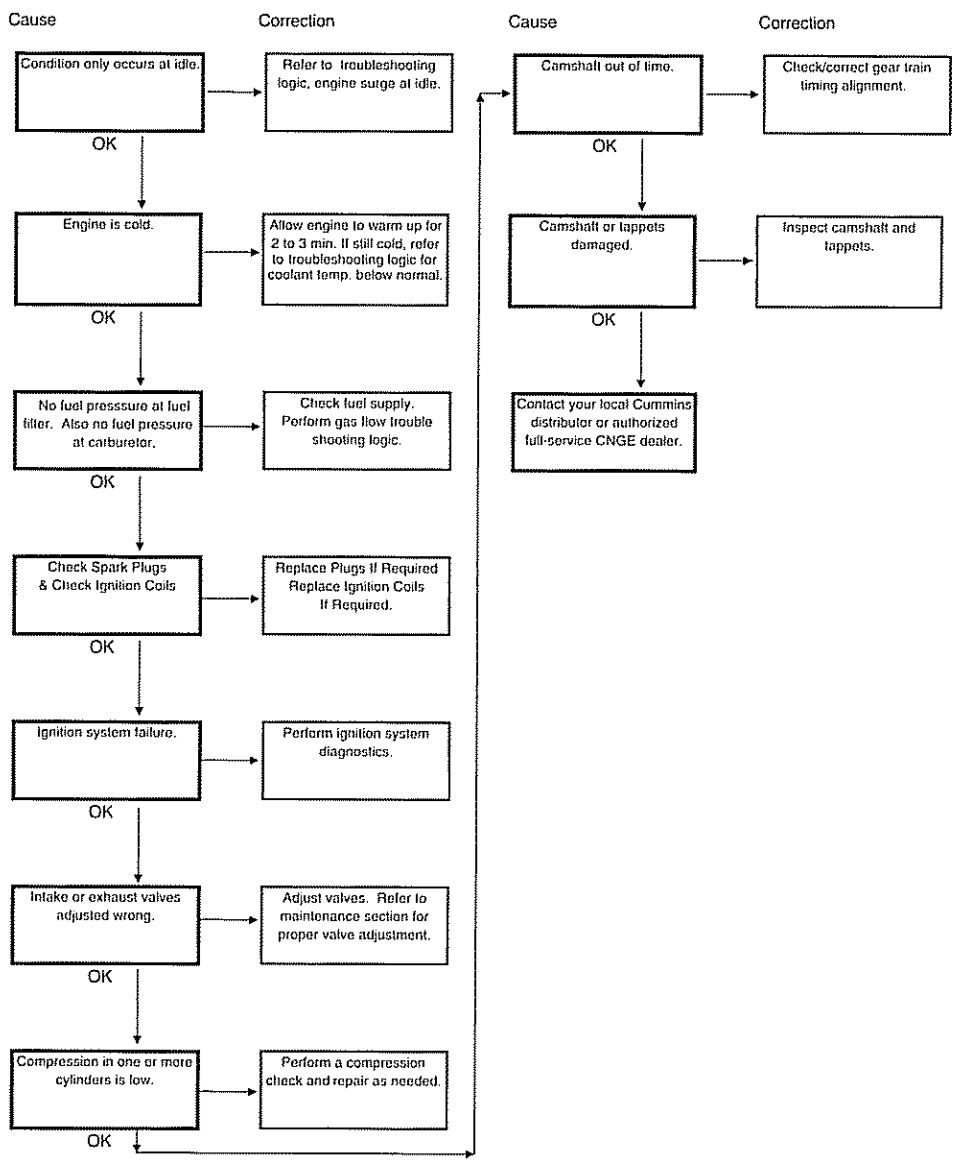
Hard to Start - Long Cranking Time



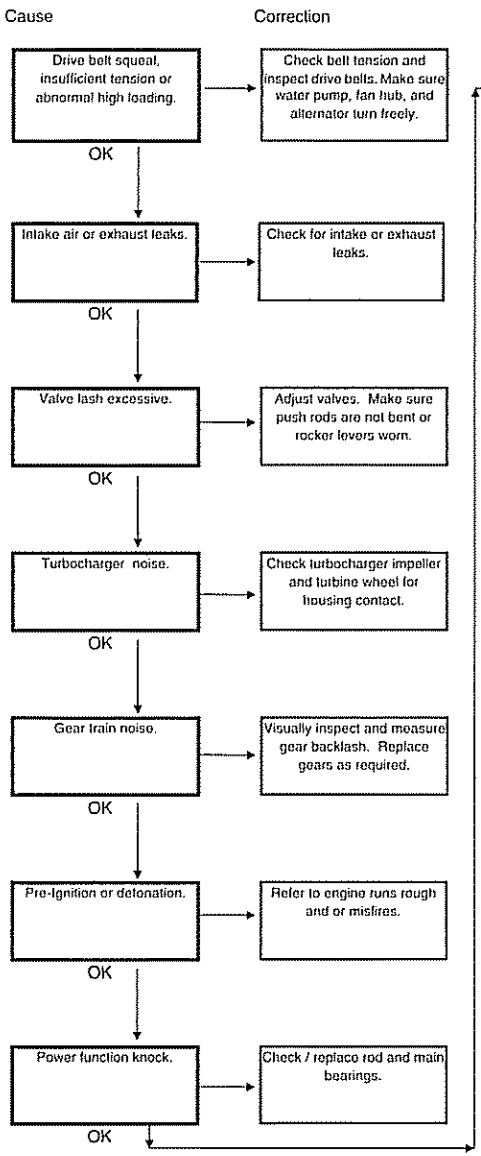
Engine Surge at Low Idle , Engine Shaking or Rough Idle



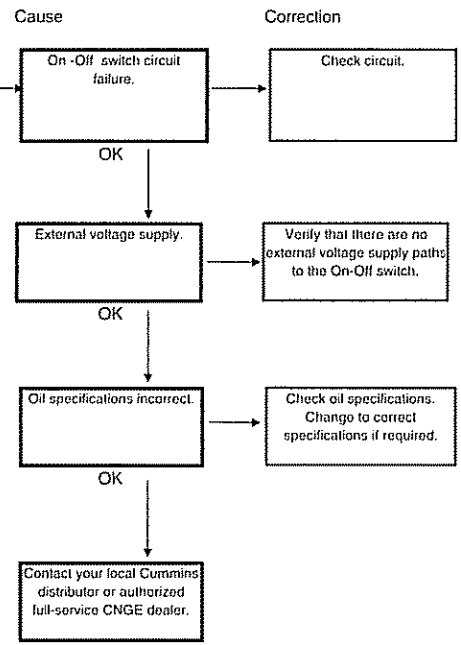
Engine Runs Rough or Misfires



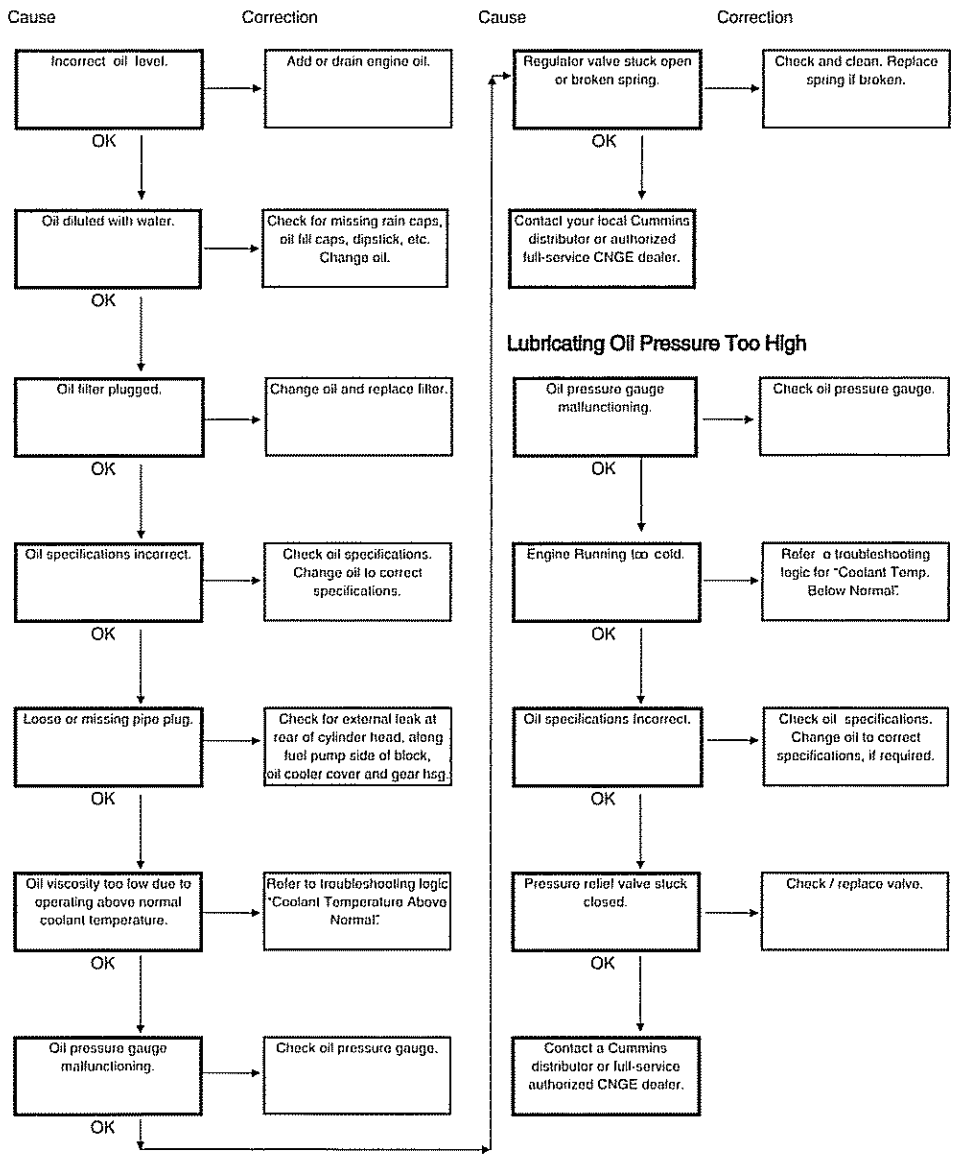
Engine Noise Excessive



Engine Will Not Shut Off

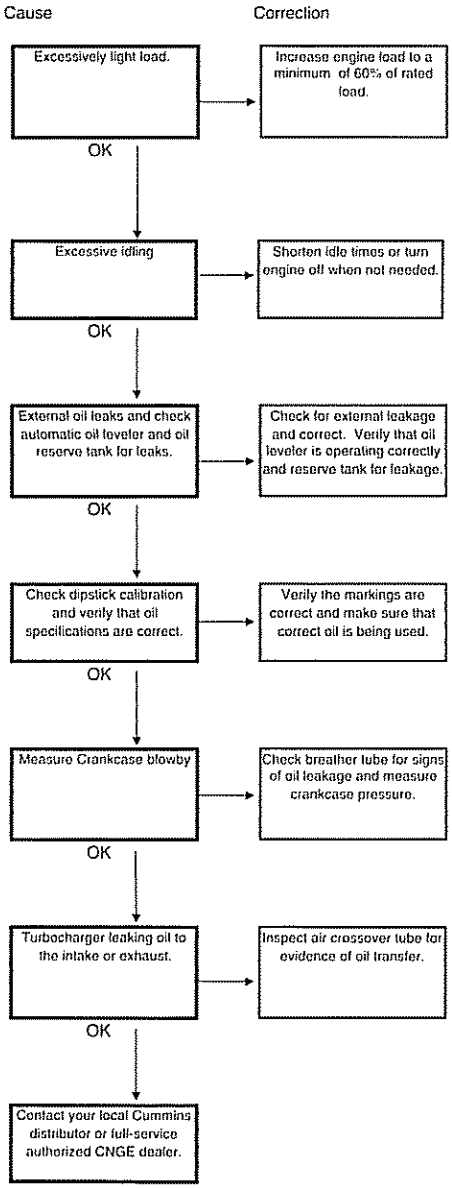


Lubricating Oil Pressure Low

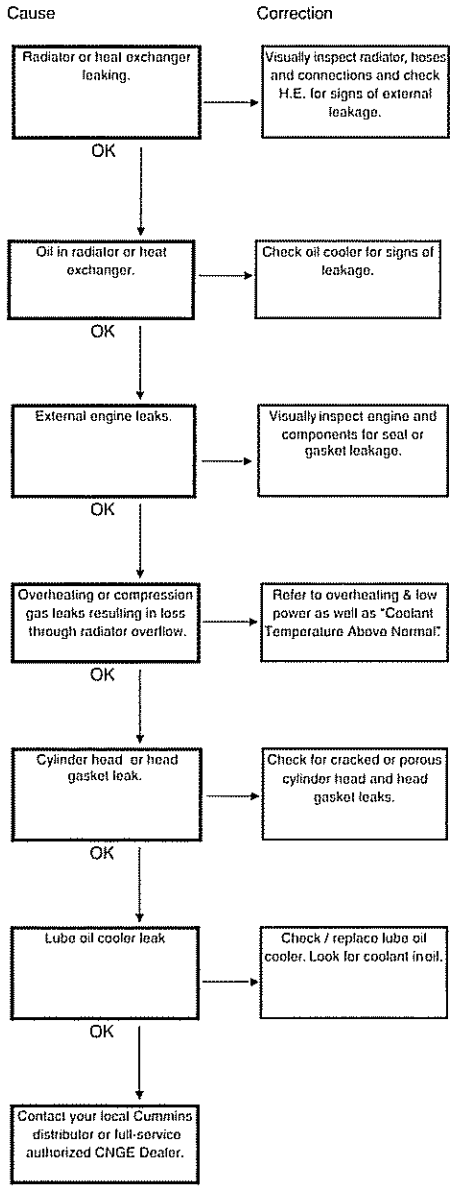


Lubricating Oil Pressure Too High

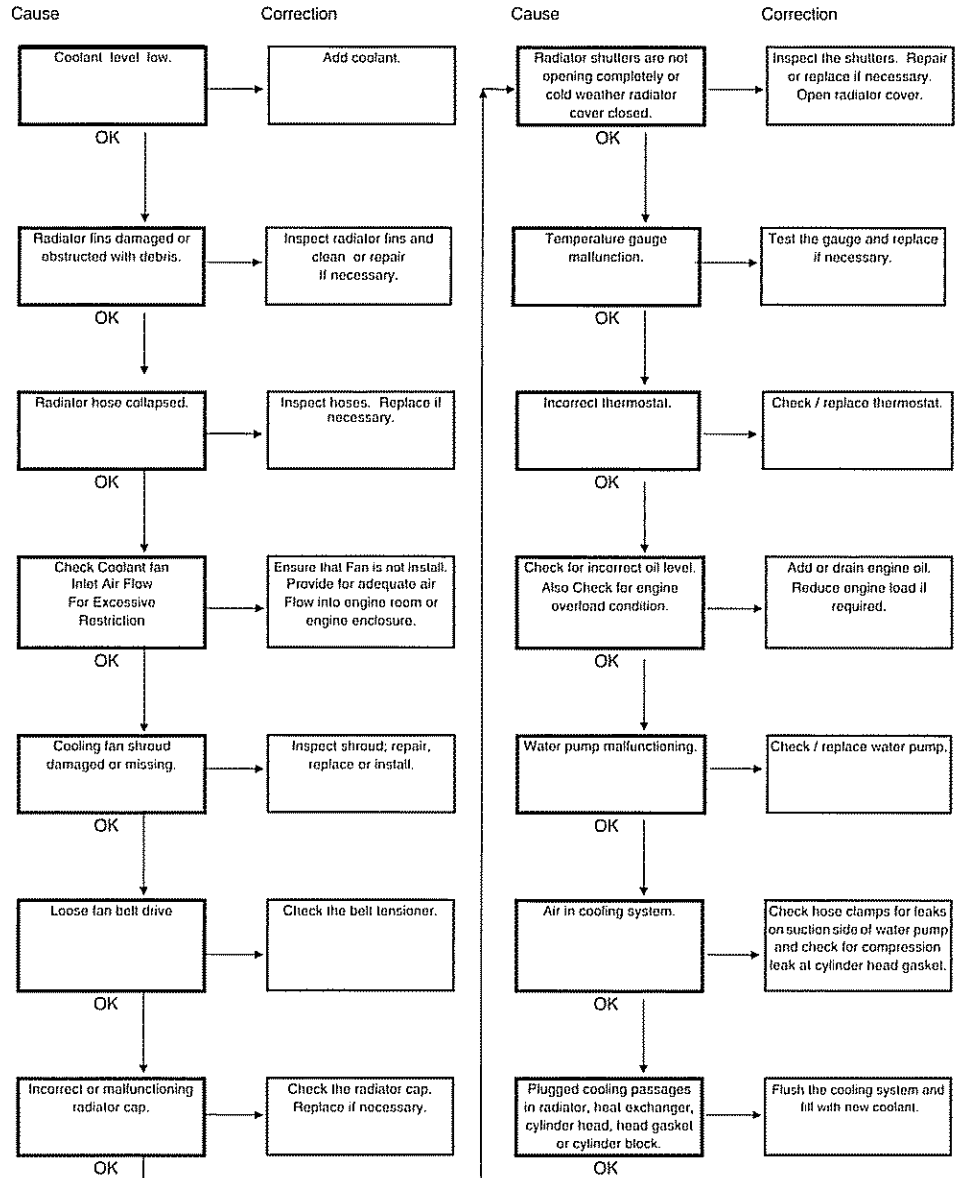
Lubricating Oil Consumption Excessive



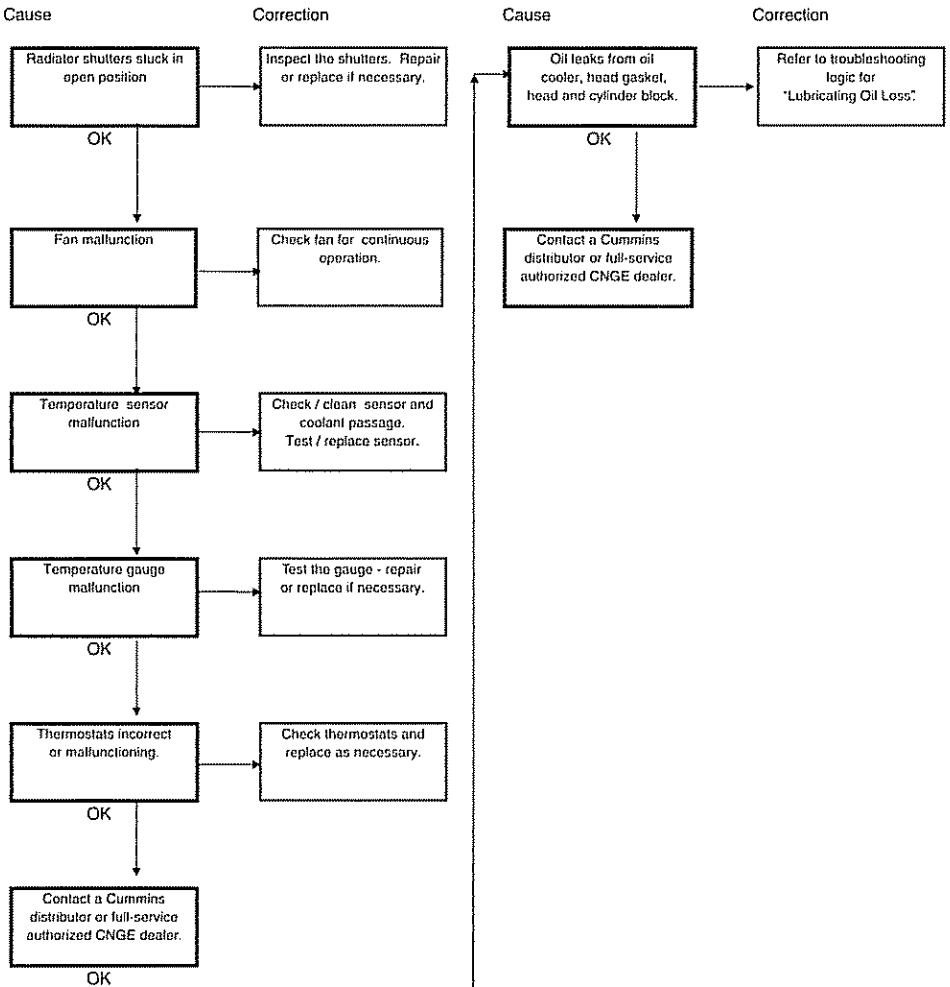
Coolant Loss



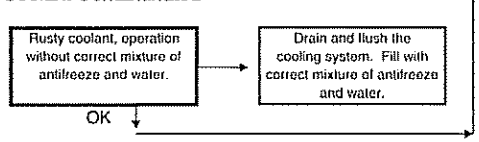
Coolant Temperature Above Normal



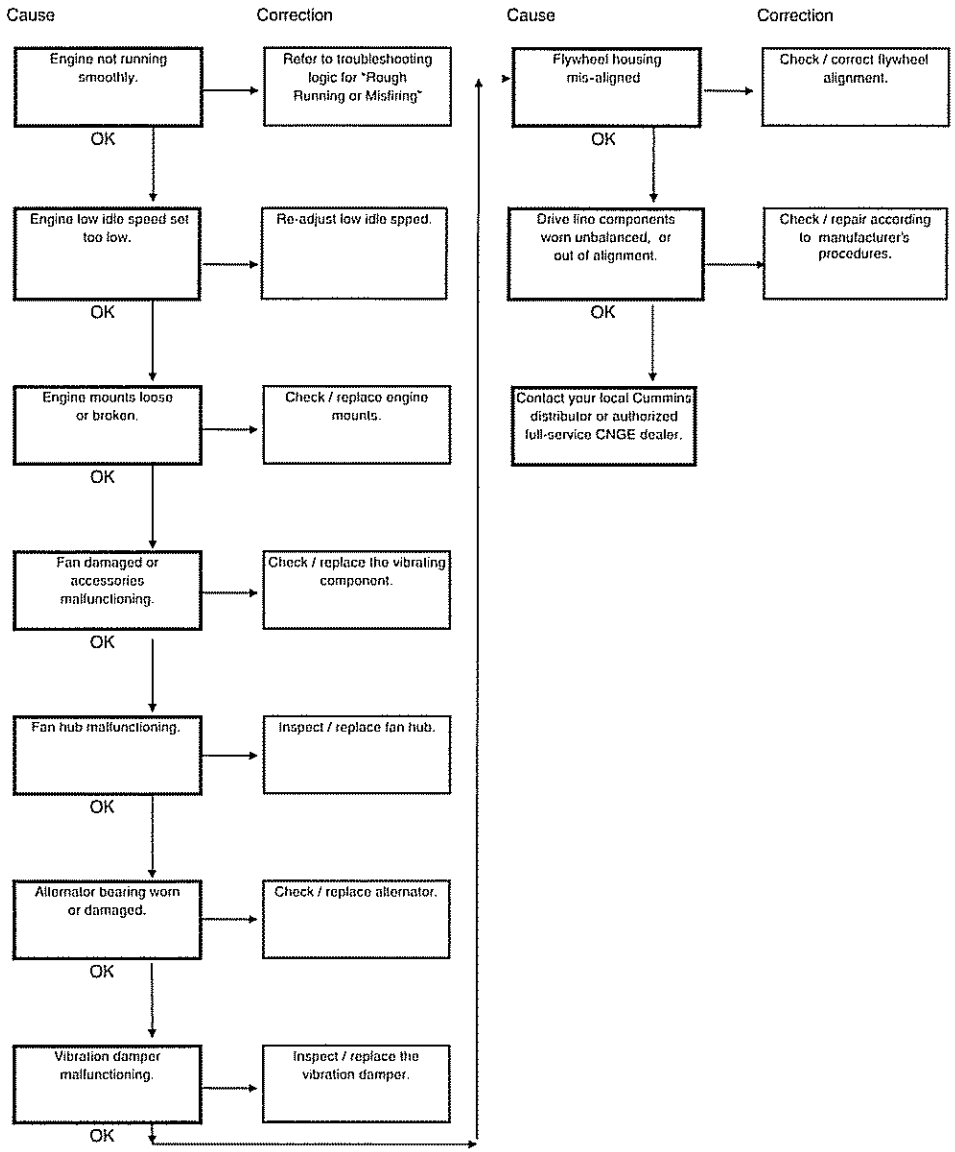
Coolant Temperature Below Normal



Coolant Contaminated



Engine Vibration Excessive



Check Ignition System

Cause	Correction
Ignition firing circuit grounded	Check safety switch. Check ignition switch. Check instrument panel ground.
OK	
Check ignition generator.	Check for proper voltage. Check primary leads for voltage. Check wiring harness for moisture.
OK	OK
	Check ignition generator capacitor. Check ignition timing marks alignment.
Check Ignition Coils (Transformers)	Inspect for cracks, moisture, broken connections. Check continuity of transformer.
OK	
Check spark plug.	Check type, gap, damage, electrodes & ceramic insulators. Check for water in cylinder.
OK	
Check spark plug adapter.	Check spark plug adapter for water leakage at o-ring and for cracked adapter.
OK	

Check Fuel-Gas System

Cause	Correction
Fuel-gas shut-off closed	Open manual or re-set electric shut-off. Check electric for Proper voltage.
OK	

Cause	Correction
Plugged gas filter.	Replace with new element.
OK	
Fuel-gas shut-off open. Low gas pressure	Contact local utility company. Check main line pressure.
OK	

Check Pressure Regulator

Fuel gas shut-off open. Excessive gas pressure.	Inspect & adjust gas pressure. Check atmospheric vent. Check carburetor air/gas diaphragm.
OK	OK
	Check gas power valve for proper setting.

Check Air Intake System

Insufficient intake air.	Check air cleaner restriction. Check carburetor air valve spring.
OK	

Check Individual Cylinders

Check compression for each cylinder.	Check valve or piston ring leakage. Check for valve clearance.
OK	
Contact your local Cummins distributor or full-service authorized CNGE dealer.	

Governor Surge - Troubleshooting Flow Chart

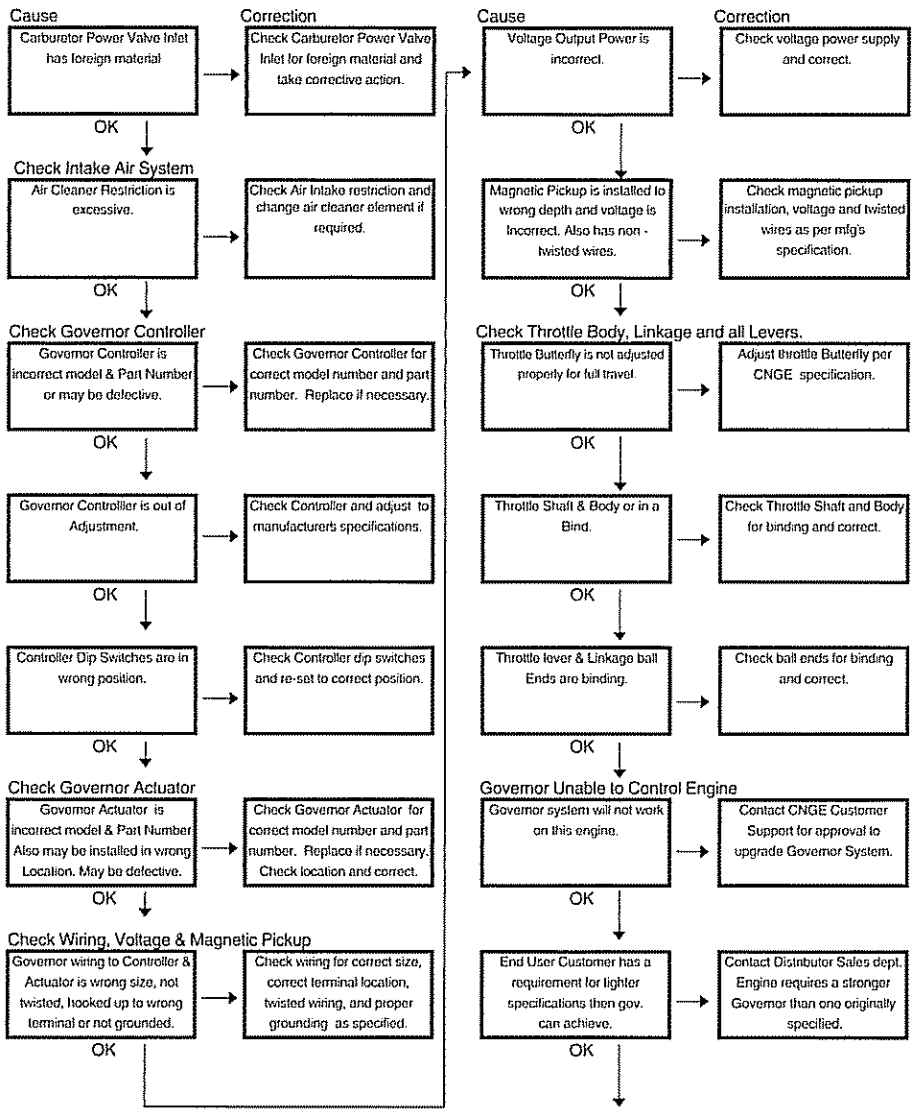
Governor - Unstable - Engine Surges
Fuel System - Dry Processed Natural Gas

Cause	Correction
Engine Misfiring & vibrating.	Check Ignition System
OK	
Check Ignition System	
Timing is incorrect.	Check timing and set to CNGE specifications as stated in the O.& M. manual.
OK	
Ignition Coil Wires & Spark Plug Wires are loose or Broken	Check Coil wires & Spark Plug wires. Repair or repalce if necessary.
OK	
Ignition Harness has loose connections or water in harness.	Check ignition harness and make necessary corrections.
OK	
Engine has a misfire. Spark Plugs are fouled.	Check spark plug for fouling and replace if necessary.
OK	
Engine has a misfire. Spark Plug Adapter has crooked threads causing S.P. to be installed at angle.	Check S.P. Adapter for straightness. Replace with new adapter if required.
OK	
Check Fuel-Gas System	
Inadequate Gas Flow. Main Line Gas Flow Regulator set to wrong flow or wrong size.	Contact local Gas Co. Request a check of required gas flow as specified on engine datasheet. Vanfy correct size regulator.
OK	

Cause	Correction
Inadequate gas flow. Pipeline has too small of a diameter.	Request that customer have pipeline size corrected as per engine datasheet.
OK	
Check Carburetion System	
Gas Pressure to Carburetor is too low or too high.	Adjust gas pressure to CNGE engine specifications as per engine datasheet.
OK	
Air Fuel Ratio is set either too lean or too rich.	Adjust Air Fuel ratio and record excess Oxygen level in exhaust gas at idle RPM and at full load RPM .
OK	
Excess Oxygen reading does Not track the power curve. Diaphragm is ruptured or has hole.	Check diaphragm and repair or replace.
OK	
Bullet Valve is mismachined. Carburetor has incorrect spring.	Check Bullet valve and replace if necessary.
OK	
Carburetor moving parts are in a bind.	Check Carburetor moving parts and ensure free movement.
OK	
Carburetor mounting gaskets or conections are leaking.	Check Carburetor gaskets and connections for leaks.
OK	

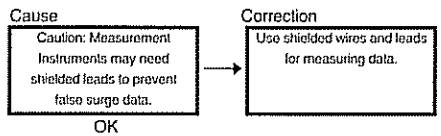
Governor - Unstable - Engine Surges

Fuel System - Dry Processed Natural Gas



Governor - Unstable - Engine Surges

Fuel System - Dry Processed Natural Gas



If you are unable to resolve this problem, then contact the Customer Support department for Technical Assistance.

Note: On older engines the Turbo boost Limiter may need to be moved out of the governor range so that it does not interfere with Governor operation.

Caution: In some cases the generator voltage regulator may have to be adjusted first before the engine governor can be adjusted. Refer to the generator voltage regulator manufacturer's literature for proper adjustment procedures.

Section 10
Component Manufacturers

Note: The following list contains addresses and telephone numbers of suppliers of accessories used on Cummins Natural Gas Engines, Inc. engines. Suppliers may be contacted directly for any specifications not covered in this manual.

Air Heaters

Fleetguard, Inc.
1200 Fleetguard Road
Cookeville, TN 38502
Telephone - (931) 526-9551
Telephone - (800) 223-4583
FAX - (800) 999-8664

Air Starting Motors

Ingersoll-Rand Engine
Starting Systems
888 Industrial Drive
Elmhurst, IL 60126
Telephone - (615) 672-7664
FAX - (615) 672-0805

Air-Gas Starting Motors

Ingersoll-Rand Engine
Starting Systems
888 Industrial Drive
Elmhurst, IL 60126
Telephone - (615) 672-7664
FAX - (615) 672-0805

Alternators

Delco-Remy
P.O. Box 2439
Anderson, IN 46018
Telephone - (765) 778-6588
FAX - (765) 778-6566

Robert Bosch Ltd.
P.O.Box 96
Broadway Park
North Orbital Road
Denham
Uxbridge
Middlesex
UD9 5H6
England
Telephone - (01895) 833633

Auxiliary Water Pumps

Crane Deming
TP Pump
Telephone - (505) 247-4036
Fax - (505) 243-0308

Belts

Dayco Mfg.
Belt Tech. Center
1955 Enterprise
Rochester Hills, MI 48309
Telephone - (800) 848-7902
FAX - (704) 452-9777

Carburetors

IMPCO Technologies Inc.
16804 Gridley Place
Cerritos, CA 90701
Telephone - (562) 860-6666
FAX - (562) 860-3088

Coolant Heaters

Fleetguard, Inc.
1200 Fleetguard Road
Cookeville, TN 38502
Telephone - (800) 223-4583
FAX - (800) 999-8664

Kim Hotstart, Inc.
E. 5724 Broadway
Spokane, WA 99212
Telephone - (509) 534-6171
FAX - (800) 224-5550

Electric Starting Motors

Delco-Remy
P.O.BOX 2439
Anderson, IN 46018
Telephone - (765)778-6588
FAX - (765) 778-6566

Fans

Hayes-Albion
1999 Wildwood Avenue
Jackson, MI 49202
Telephone - (517) 782-9421

Brookside
P.O. Box 30
McCordsville, IN 46055
Telephone - (317) 335-2014

Filters

Fleetguard, Inc.
1200 Fleetguard Road
Cookeville, TN 38502
Telephone - (800)223-4583
FAX - (800) 999-8664

Gas Regulators

Fisher Mfg.
Silver Star Supply
14004 Canyon Dr.
Amarillo, TX 79110
Telephone - (806) 622-2166
FAX - (806) 622-2057

Maxitrol Co.
P.O.Box 2230
Southfield, MI 48037
Telephone - (248) 356-1400
FAX - (248) 356-0829

Gauges

Frank W. Murphy Mfg.
P.O.Box 470248
Tulsa, OK 74147
Telephone - (918) 627-3550
FAX - (918)\664-6146

The Nasson Co.
P.O.Box 505
West Union, SC 29696
Telephone - (864) 638-9521
FAX - (864) 838-7903

Governors

Woodward Governor Co.
1000 E. Drake Road
P.O.Box 1519
Fort Collins, CO 80522
Telephone - (970) 498-3539
FAX - (970) 498-3086

Barber Colman Co.
1354 Clifford Ave.
Rochford, IL 61132
Telephone - (815) 877-0241
FAX - (815) 877-0150

Heat Exchangers

Modine Mfg. Co.
1500 DeKoven Ave.
Racine, WI 53401
Telephone - (414) 636-1200
FAX - (414) 636-1424

Young Radiator Co.
2825 4 Mile Road
Racine, WI 53404
Telephone - (414) 639-1011
FAX - (414) 639-1013

Ignition Systems

Altronic, Inc.
1200 Stambaugh Bldg
Youngston, OH 44501
Telephone - (330) 545-9768
FAX - (330) 545-4446

Oil & Coolant Heaters

Fleetguard, Inc.
1200 Fleetguard Road
Cookeville, TN 38502
Telephone - (800)223-4583
FAX - (800) 999-8664

Kim Hotstart Co.
West 917 Broadway
Spokane, WA 99210
Telephone - (509) 534-6171
FAX - (800) 224-5550

Spark Plugs

Champion Spark Plug Co.
910 Upton Ave.
Toledo, OH 43607
Telephone - (419) 535-2458

Shut -Off Valves

Automatic Switch Co.
P.O.Box 13681
Newark, NJ 07188
Telephone - (714) 937-0811
FAX - (714) 937-1390

L.P. Gas & Equipment Co.
3216 S. Nordic Road
Arlington Heights, IL 60005
Telephone - (708) 437-2345

Tachometers

Altronic, Inc.
1200 Stambaugh Bldg.
Youngston, Ohio 44501
Telephone - (330) 545-9768
FAX - (330) 545-4446

Notes:

Section 11
Service Assistance

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Service Assistance

Emergency Service Assistance

If you should require emergency service assistance, check the yellow pages for the nearest Cummins distributor.

Should you be unable to reach the local distributor in the above manner, Cummins Engine Company has established a 24 hours a day, toll free number for service assistance. **In 48 states, you can call Cummins Customer Relations toll free by dialing 800-343-7357. In Alaska, Hawaii, and Canada, call collect 812-379-6115.**

Cummins Owner Assistance

Cummins Natural Gas Engines backs its engines with expert service and complete parts support through the Cummins Distributor Network on a worldwide basis. Cummins people are trained to provide the CNGE owner with sound advice, expert service and professional treatment at all Cummins locations.

Any problem that you may have in connection with the sale, operation or service of your CNGE engine can be handled at the nearest Cummins location. Occasionally, you may feel a problem has not been handled to your satisfaction. At those times, we urge you to pursue the problem until you are satisfied.

Many problems result from a breakdown in communications and can often be solved by bringing in a third party as a mediator. Bring your problem to the next higher authority to discuss.

CNGE recommends:

1. If a problem originates with a salesperson or service technician, talk to the sales or service manager.

2. If a problem originates with a sales or service manager, talk to the owner of the service location.

3. If a problem originates with a CNGE authorized dealer, talk to the Cummins distributor with whom the dealer has a service agreement.

4. If a problem originates with a distributor, please call the nearest CNGE Regional or Divisional office. The majority of problems can be solved below the divisional office level. However, before you call, write down the following information and have it ready:

   A. Name and location of the Cummins distributor or dealer.
   B. Type and make of equipment.
   C. CNGE engine model and serial number.
   D. Total number of hours of operation.
   E. Nature of problem.
   F. Summary of the current problem arranged in the order of occurrence.

If you still have problems please write:

Customer Relations
Cummins Natural Gas Engines, Inc
8713 Airport Freeway, Suite 316
Fort Worth, Texas 76180
or
Customer Relations
Cummins Engine Company, Inc.
Box Number 3005
Columbus, Indiana 47202-3005

We do request that the above steps be followed in order. Most of the actual work on an engine can be performed at the original location, so please give them a chance to satisfy you first.

CNGE Regional Offices

Representatives for the following regions are located at CNGE Headquarter Office in Fort Worth, TX, U.S.A.

Canadian Region
Central Region
Eastern Region
Western Region
International Region

Cummins Natural Gas Engines, Inc
8713 Airport Freeway, Suite 316
Fort Worth, TX 76180
Telephone (817) 581-7575
Fax: (817) 581-4548

Cummins Natural Gas Engines, Inc
Parts Distribution Center
409 South Norris Street
Clovis, NM 88109
Telephone: (505) 769-2173
Fax: (505) 762-4203

Cummins Distributor Service Assistance

Cummins Distributors in Canada, Puerto Rico and in the United States are listed in the U.S. and Canadian Sales and Service Directory. For Directory Assistance, call 1-800-DIESELS.

International Distributor locations are contained in an International Sales and Service Directory Bulletin #3382133.

Notes:

Notes:

Notes:

Section 12
Service Literature

The following publications can be ordered from your local Cummins Distributor.

Title of Publication — Bulletin No.

Cummins Natural Gas Engines, Inc. publications for the GTA38 & GTA50 engine models.

Operation and Maintenance Manual
GTA38/GTA50 .....OM990901

Parts Catalogs

GTA38 Parts Catalog .....TBD

GTA50 Parts Catalog .....TBD

Cummins Engine Company, Inc. publications for the basic K engine family.

KT/KTA/KTA50 Shop Manual.....3810304

K38/K50 Troubleshooting and Repair 3810432

K19/K38/K50 Alternate Repair Manual 3379035

K38 and K50 Engine Series O. & M. Manual ..3810497

K38 Standard Repair Times 3810334

K50 Standard Repair Times 3810335

Turbochargers Rebuild Manual 3379091

HC-5A Turbocharger Shop Manual 3810243

Installation Recommendations Bulletin .....TBD

Title of Publication — Bulletin No.

Construction, Mining, Logging and Agriculture

Air Intake System 3382108

Cold Weather Operation 3382118

Compressed Air System 3382643

Cooling System 3382171

Engine Mounting 3382362

Engine Performance 3382138

Exhaust System.....3382109

Lubrication System 3382113

Noise Control.....3382110

Power Trains 3382014

Service Accessibility 3382150

Starting & Electrical System 3382452

Torsional Vibration 3382135

The above Installation Recommendations Bulletins are written around the basic diesel engine. Some of the information in these bulletins will be different for the spark ignited engine. If you are not sure contact the local Cummins Distributor for assistance.

Engine Data-Sheets, Performance Curves, Specification Sheets

Engine Model	RPM	C.R.	Marketing Model	BHP Without Fan/With Fan	Datasheet	Perf. Curve	Specification Sheets
GTA38	1800	8.5:1	Gen (G3)	1045/950	DS2041A	PC2041A	ES2041A
		8.5:1	Gen (G2)	956/869	DS2041A	PC2041A	ES2041A
		8.5:1	Gen (G1)	901/819	DS2041A	PC2041A	ES2041A
GTA38	1500	8.5:1	Gen	870/790	DS2043A	PC2043A	ES2043A
GTA50	1800	8.5:1	Gen (G3)	1334/1212	DS2037B	PC2037B	ES2037A
		8.5:1	Gen (G2)	1220/1109	DS2037B	PC2037B	ES2051A
		8.5:1	Gen (G1)	1150/1045	DS2037B	PC2037B	ES2052A
GTA50	1500	8.5:1	Gen	1145/1040	DS2039A	PC2039A	ES2039A

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