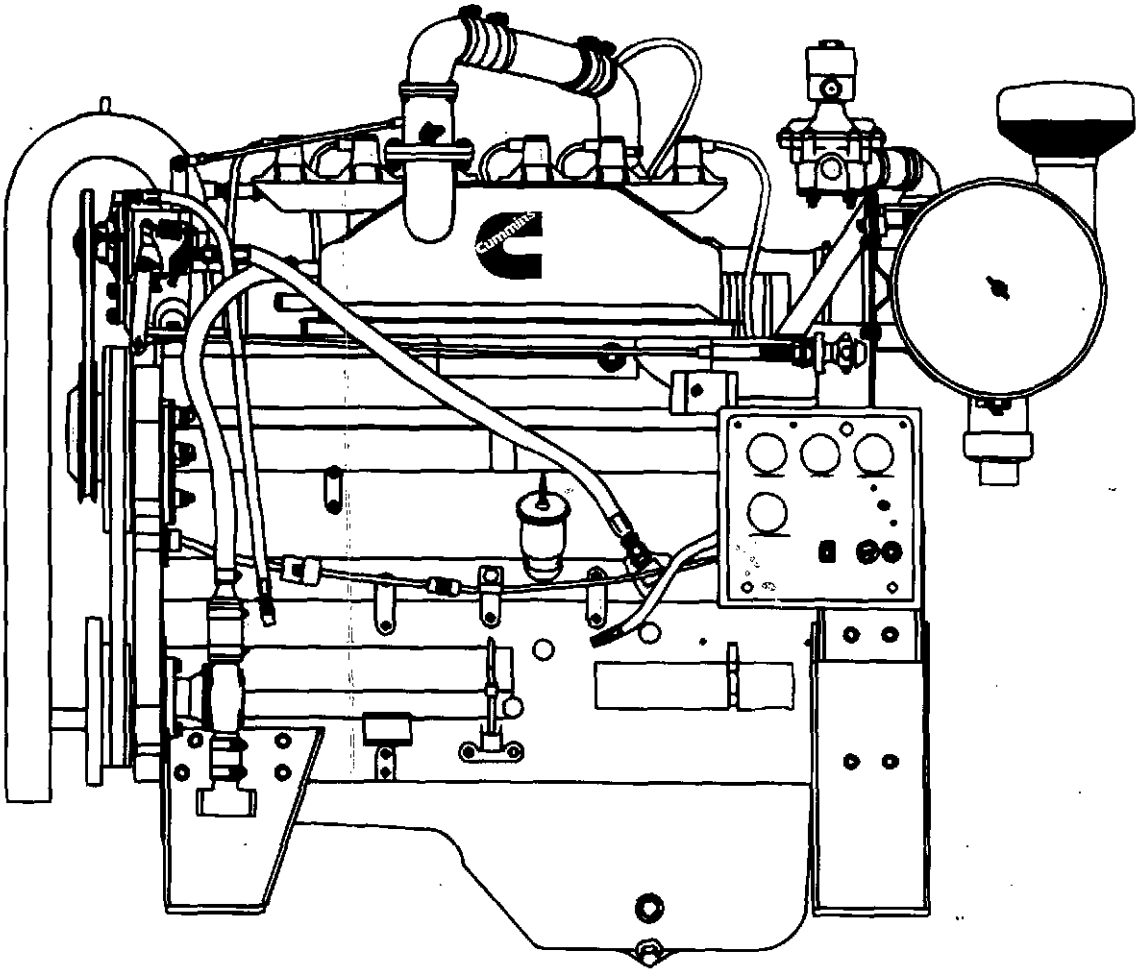
Natural Gas Engines

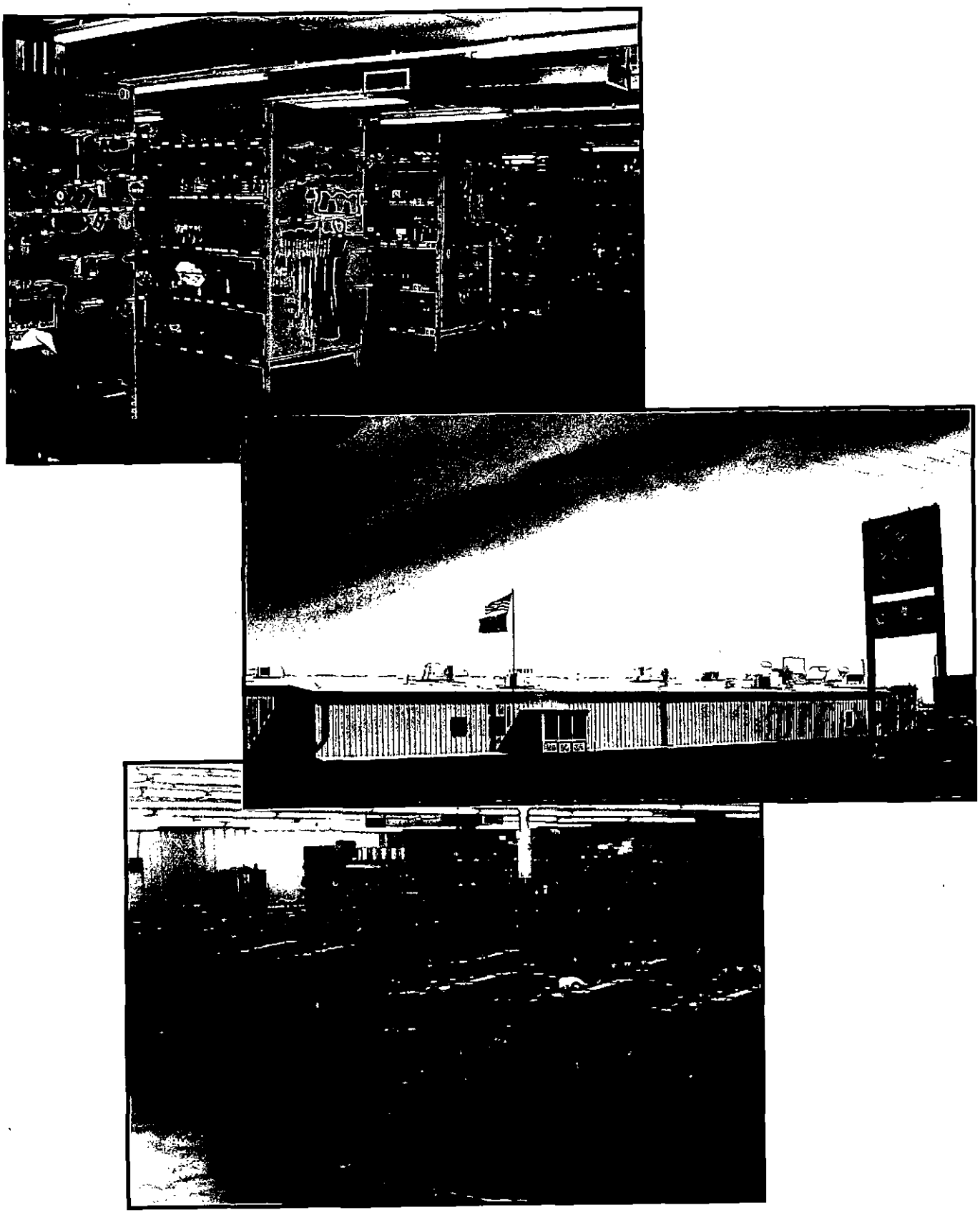


GTA 8.3 OPERATION AND MAINTENANCE MANUAL

Natural Gas Engines

GTA 8.3 OPERATION AND MAINTENANCE MANUAL

Bulletin #OM980201-3, 12/2001



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

Table of Contents

Foreword

This manual is applicable to the GTA8.3 Spark Ignited Engines currently being produced by Cummins Natural Gas Engines, Inc. 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 should be performed by specially trained personnel who are available at all Cummins Distributors and Dealer locations.

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

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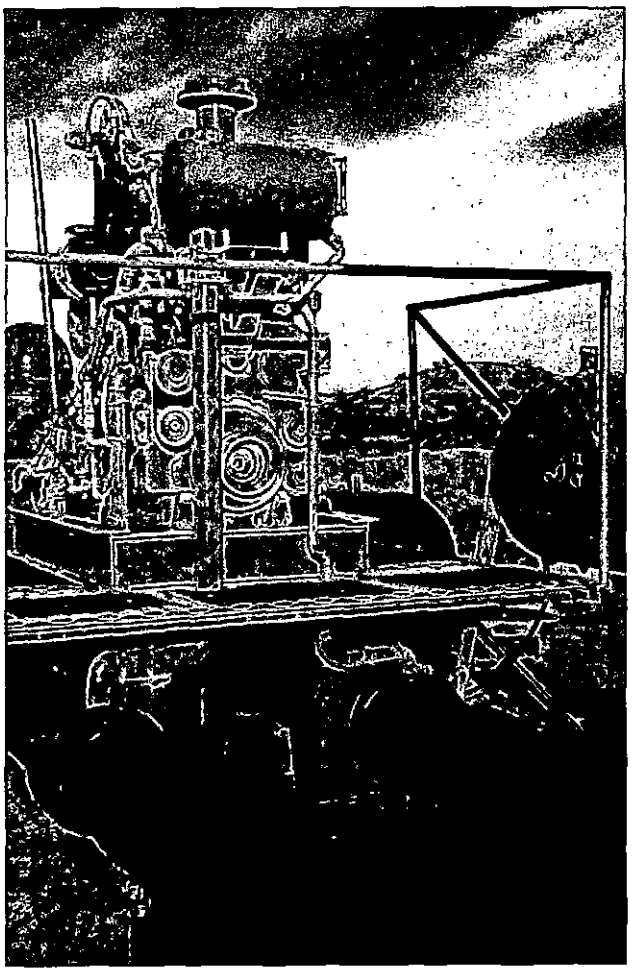
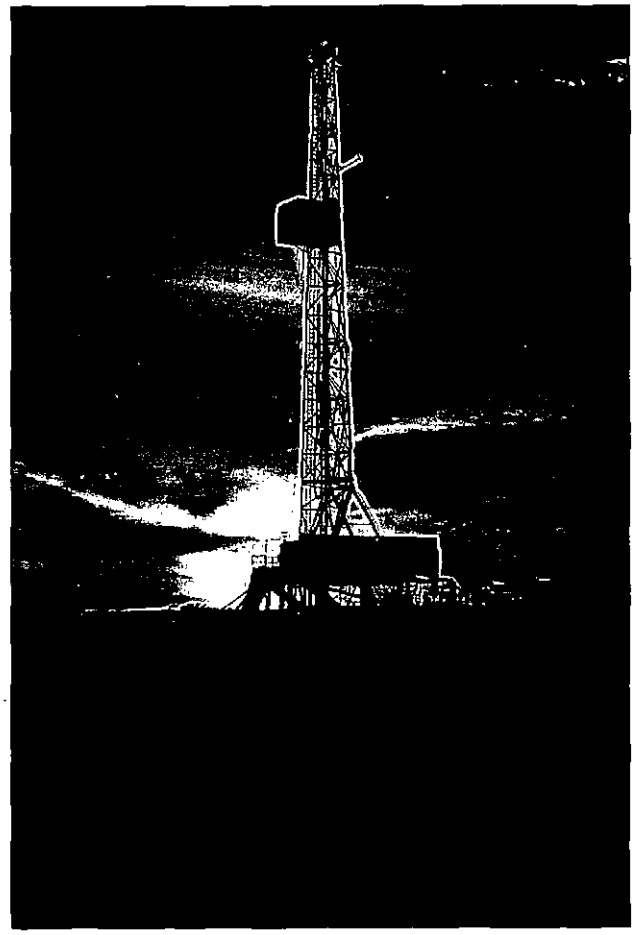




Section 1
Introduction

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 C Automotive Gas 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
CAC	Charge Air Core
° C	Celsius
CCW	Counter Clockwise
C.I.D.	Cubic Inch Displacement
cm	Centimeter
cSt	Centistokes
CW	Clockwise
cu.	Cubic
DBTDC	Degrees Before Top Dead Center
DCA	Diesel Coolant Additive
ECM	Electronic Control Module
ECS	Emission Control Sensor
° F	Fahrenheit
FCU	Fuel Control Valve
FTM	Federal Test Method
ft.	Feet
ft-lb	Foot Pound
FSO	Fuel Shut-Off Valve
"G"	Ground
"G"	Gas-Spark Ignited
Gal	Gallon
"H"	High
Hg	Mercury
HHV	High Heat Value
HP	Horsepower
hr.	Hour
H_2O	Water
ICM	Ignition Control Module
ISCV	Idle Speed Control Valve
in.	Inch
in-lb	Inch Pound
kg	Kilograms
kPa	Kilopascal
"L"	Low
LE	Low Emission
l	Liter
lb.	Pound
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
O2	Oxygen
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
™	Trademark
U.S.	United States
"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 (fluorocarbons) into the atmosphere. Federal law requires capturing 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 pressure regulator and allowing engine to burn off all residual fuel-gas. CNGE recommends that all fuel-gas be shut-off before turning off the ignition switch.*

- *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 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. Overtightening or undertightening 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

ENGINE DATAPLATE

Refer to the enclosed illustration for the dataplate location.

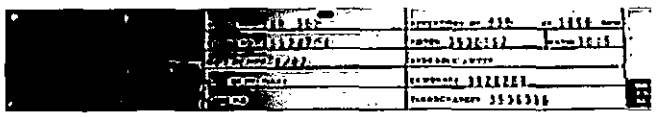


Photo #2-01 - Engine Dataplate

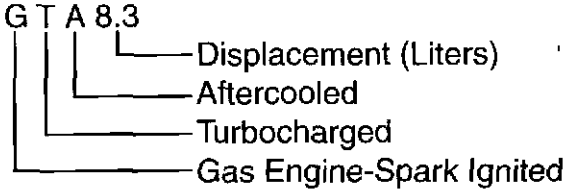
Note: The engine dataplate, must not be changed unless approved by CNGE.

The engine dataplate 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.

How to Identify Your Engine



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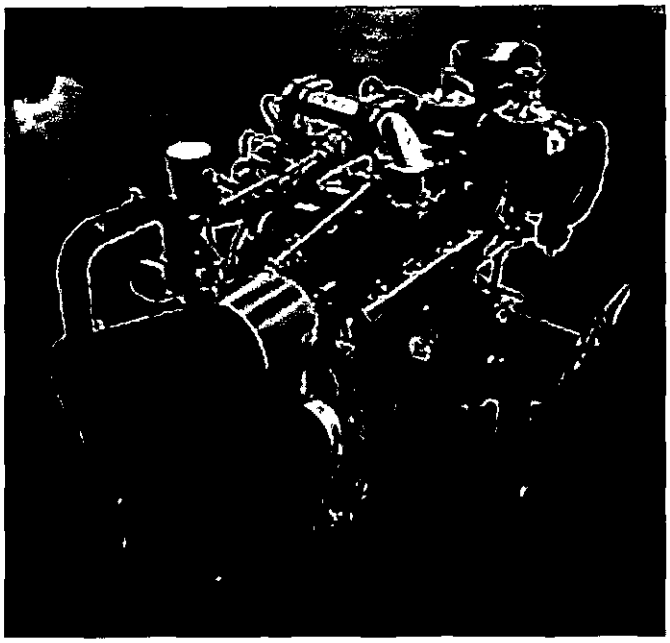


Photo #2-02 - GTA8.3

Turbocharger Data Plate.

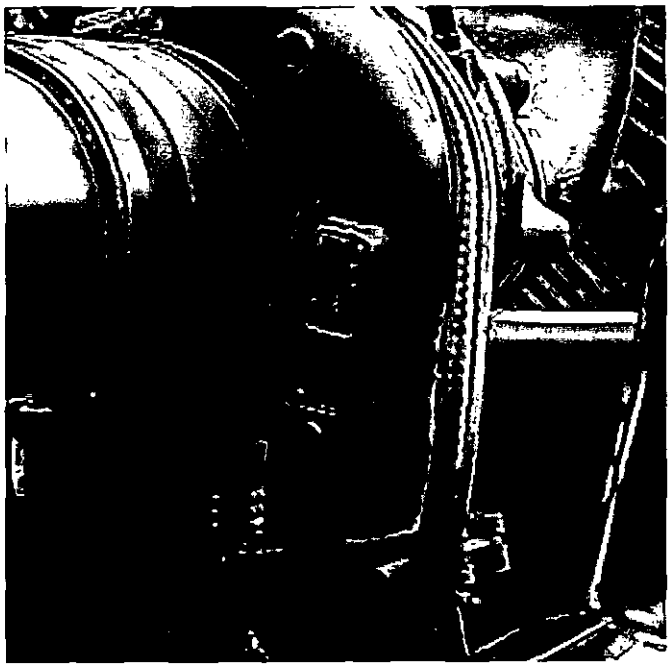


Photo #2-03 - Turbocharger Data Plate

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.*

GTA8.3 - Aftercooler Side

1. Auxiliary Water Pump.
2. Aftercooler.
3. Ignition Module. (behind panel)
4. Ignition Coils.
5. Governor.
6. Throttle Body.
7. Vibration Damper. (not visible)
8. Gas Regulator. (not visible)
9. Fuel Shutoff Valve.
10. Dipstick Location.

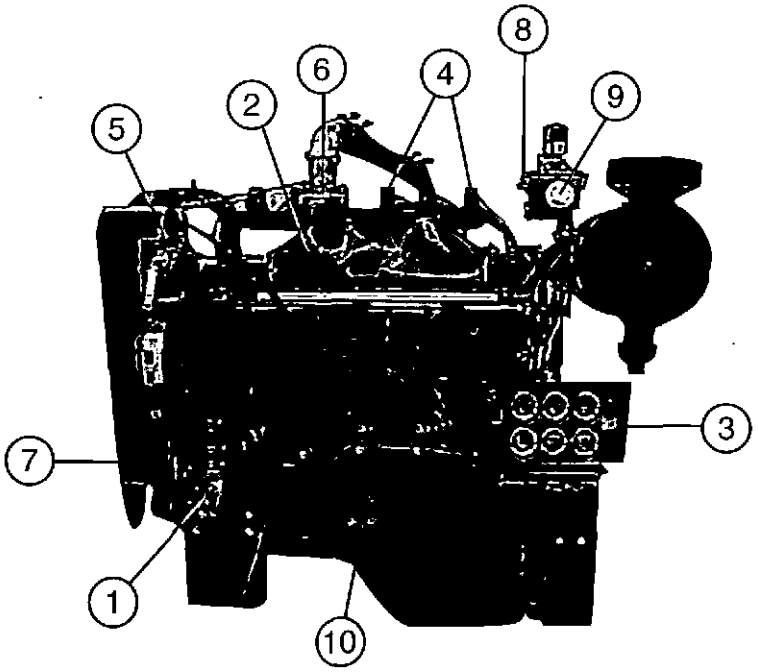


Photo #2-04 - GTA8.3 Aftercooler Side

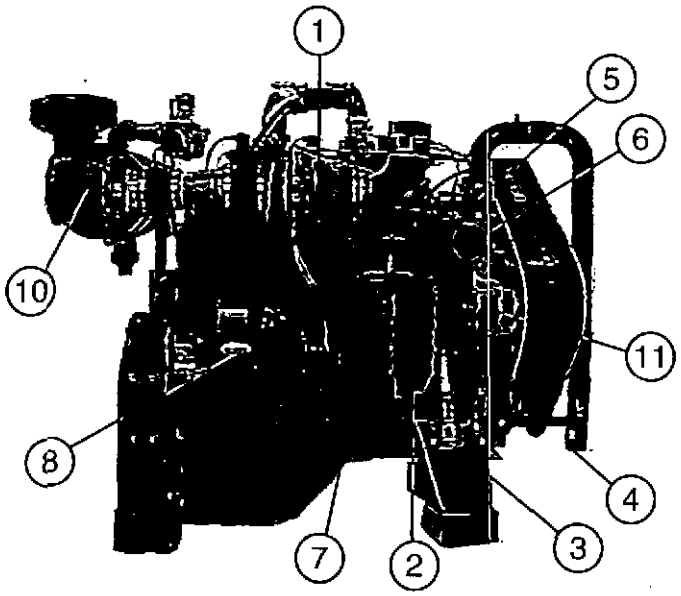


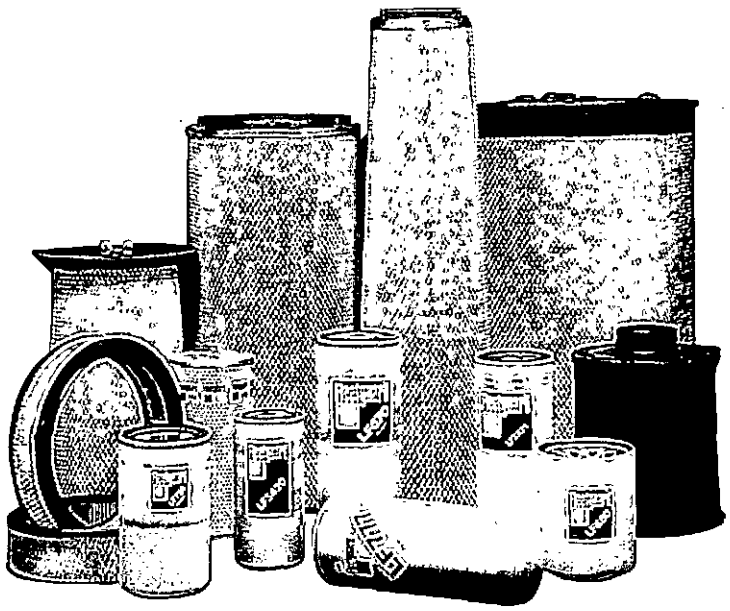
Photo #2-05 - GTA8.3 Exhaust Side

GTA8.3 - Exhaust Side

1. Turbocharger.
2. Oil Cooler.
3. Coolant Inlet.
4. Coolant Outlet.
5. Thermostat Housing.
6. Coolant Filter.
7. Lubricating Oil Full Flow Filter.
8. Starter.
9. Fan Hub. (not visible)
10. Carburetor.
11. Alternator.

Section 3
Operating Principles & Systems Information

Table of Contents



Operating Principles & Systems Information

Operating Principles

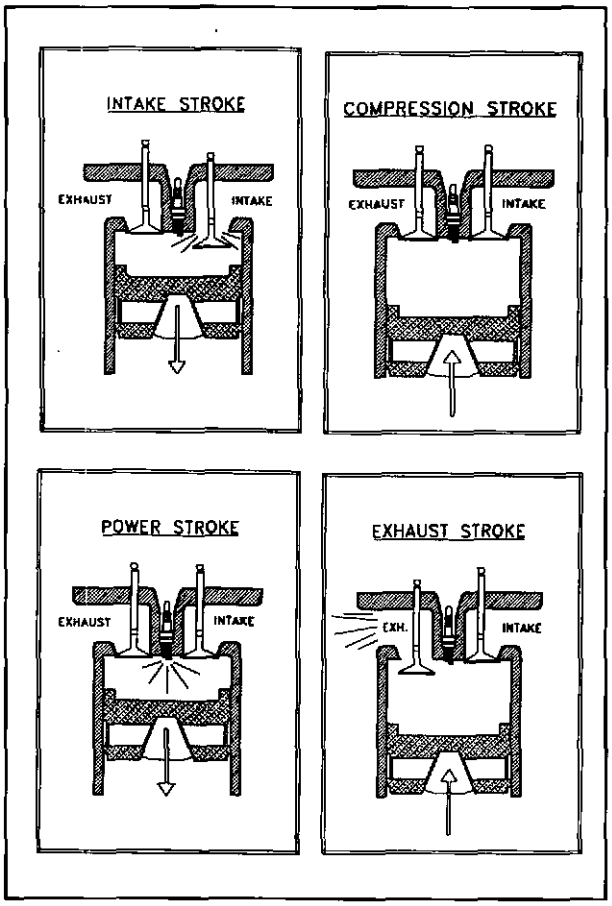
The most satisfactory service can be expected from a Cummins Natural Gas Engine, Inc. (CNGE) spark- ignited engine when the operation procedures are based upon a clear understanding of the engine working principals. Each part of the engine affects the operation of every other working part and of the 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 fuel may be pipeline quality natural gas or a liquid propane gas (HD-5) or in some cases a "field" gas. Power ratings are tabulated in the enclosed bulletin in the front of this manual.

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 contains 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".

The application of CNGE engines on HD-5 liquid propane or propane vapor and non-processed gas requires careful gas analysis of the fuel to decide the proper compression ratio selection. Check with your local CNGE dealer or Cummins distributor for proper compression ratio and power rating for individual applications.

CNGE engines are primarily specified to run off a good pipeline quality of dry processed natural gas. With the correct configuration, CNGE engines can be specified to also run off LPG (HD-5) propane gas. With pre-approval from the CNGE factory these engines can be adjusted to run off digester gas, and field gas.

Engines that are run off **"landfill"** gas require that the gas is run through a scrubber to remove any sulfur compounds and a drier to remove any moisture such as water. In addition, a high ash multi-viscosity oil may be required to combat contaminants that will get into the engine lubricating oil from **"blowby"** gases.

Located between the gas supply line and the engine intake manifold are the following components which make up the fuel system for a naturally aspirated engine.

Low Pressure Natural Gas System

1. Gas Filter.
2. Flexible Pipeline Connection.
3. Manual or Automatic Gas Shut-Off Valve.
4. Engine Mounted Pressure Regulator.
5. Carburetor (Before Turbocharger on TA Engine).
6. Charge Air Core (CAC) on an Air-to-Air TA system.
7. Throttle Body Valve (After Turbocharger and CAC 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 an air-to-air aftercooler with a charge air core (CAC) prior to the throttle body valve. On a water-to-air system the intercooler will be after the throttle butterfly in the intake manifold.

Low Pressure Propane Gas System (Liquid) - Unique Components

1. Engine Mounted Solenoid Shut-Off Valve
2. Liquid Propane Filter.
3. Liquid Propane Converter.
4. Carburetor (Before Turbocharger on TA Engine).
5. Charge Air Core (CAC) on an Air-to-Air TA Engine.
6. Throttle Body Valve (After Turbocharger & CAC on TA Engine).

Low Pressure Propane Gas System (Vapor) - Unique Components

1. Gas Filter.
2. Flexible Connection.
3. Engine Mounted Manual or Automatic Shut-Off valve.
4. Engine Mounted Gas Regulator.
5. Carburetor (Before the Turbocharger on TA Engine).
6. CAC (After the Turbocharger on TA Engine).
7. Throttle Body (After Turbocharger & CAC on TA Engine).

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.

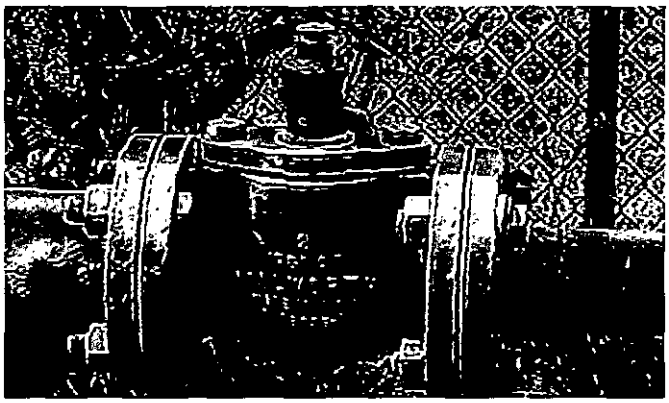


Photo #3-01 - Manual Gas Shut-Off Valve

Line Pressure Regulator

The line gas 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 pressure regulator and the engine mounted regulator. The CNGE engine mounted regulator requires an inlet pressure between 10 to 20 inches of W.C.(water column) pressure at full load operating conditions.

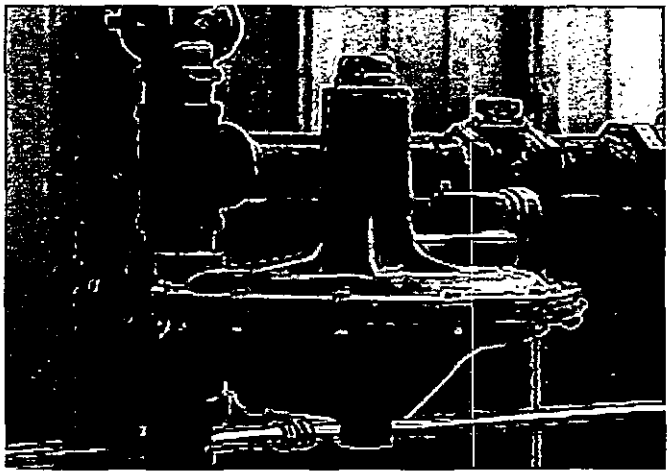


Photo #3-02 - Line Pressure Regulator

Pipeline

The pipeline must be sized so that the required maximum fuel-gas flow is supplied to the engine gas flow regulator. The pipeline system should be capable of producing the required amount of gas flow at a minimum of 10 in of water column pressure at full load operation . Refer to the appropriate engine
datasheet 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 10 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.

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 inlet fuel pressure should be at a maximum of 100 psi to the filter or less. CNGE also recommend that a gas flow shutoff valve (manual or electric) be installed between the line gas flow regulator and the gas filter.

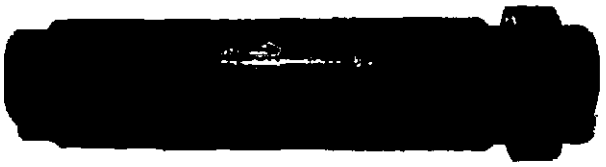


Photo #3- 03 - Gas Filter

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.

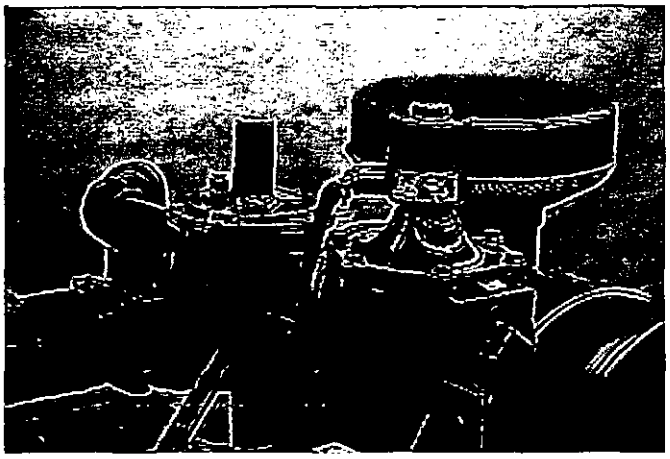


Photo #3-04 - Automatic Gas Shut-Off Valve

Engine Mounted Pressure Regulator

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

Effective 3/01/91, CNGE began installing an engine mounted regulator that requires a minimum gas pressure to the regulator after the filter, shutoff valves, and line pressure drops of 10 in. H_2O. at full load operating conditions. For CNGE engines manufactured before that date, CNGE used various pressure regulators.

Table 3-01 - Gas Pressure Regulators

Engine Model	Regulator	Spring	Max. Gas Flow cu ft./hr.
GTA8.3 -G2	RV61	Silver	1804 @ 1800 RPM

Note: All gas 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).

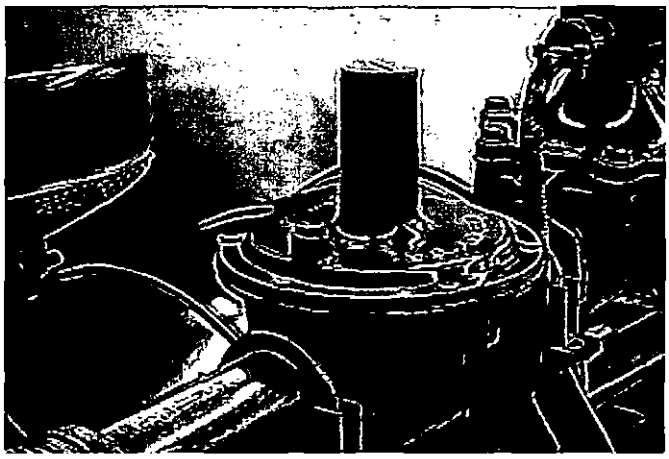


Photo #3-05 - Gas Pressure Regulator - Engine Mounted

Carburetor

The 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.

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 400 VF (vari-fuel) carburetor doesn't provide for a positive seal when the throttle butterfly is at a closed position. Therefore a shut-off valve must be installed. 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 three to six inches of WC (water column) from no load to full load condition when operating with dry processed natural gas fuel.

When operating with a propane (HD5) fuel, the carburetor will be under a negative pressure from -.5 to -8.5 in. of hg. column vacuum.

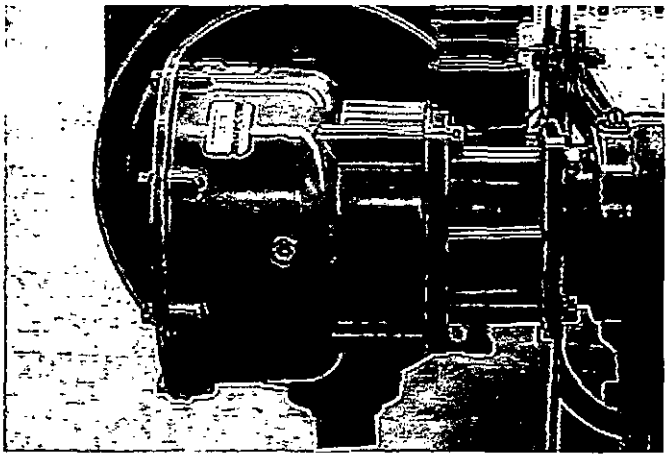


Photo #3-06 - Carburetor

Adjustment of Carburetor Air-Gas Power Valve

Impco Model # 400 VF (Vari-Fuel)

On the model 400 VF, 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.

The adjustment is made with the engine under a full load condition and together with the utilization of an oxygen meter 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.

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

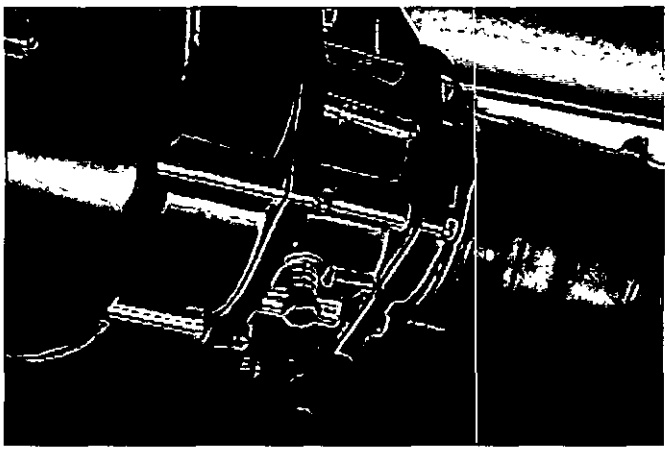


Photo #3 -07 - Power Valve - Impco Model 400 Vari-Fuel

Throttle Body

The last component of the fuel system is the throttle body. This assembly consist of a flat round plate mounted on a shaft inside of a throttle body housing. The shaft is connected to a series of levers and linkages that connect to the engine governing assembly. As the engine load increases or decreases the engine governor can control the position of the butterfly causing a change in the amount of fuel gas that can enter into the intake manifold.

CNGE carburetors will vary between engine models. Refer to Table #3-02 for the appropriate carburetor for your specific engine.

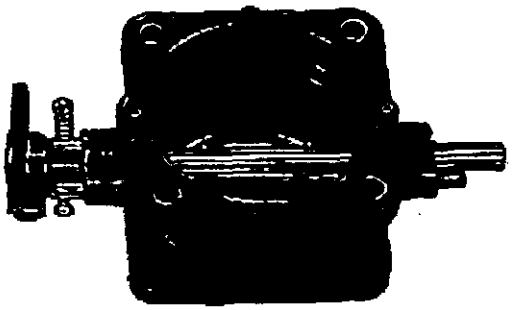


Photo #3-08 - Throttle Butterfly

Table #3-02 - CNGE Carburetors

Engine Model	Carburetors	Bullet Valve P.N.
GTA8.3	400 VF(Vari-Fuel)	V2-78

Low Pressure Propane Gas System Components (Liquid) - Unique to L.P.

Manual Liquid Gas Shut-Off Valve

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.

Engine Mounted Solenoid Valve

The engine mounted solenoid valve is a 2-way , normally closed , internal pilot-operated solenoid valve. The valve is closed when the solenoid is de-energized and open when energized. The solenoid valve is mounted on the engine, before the engine mounted gas pressure regulator.

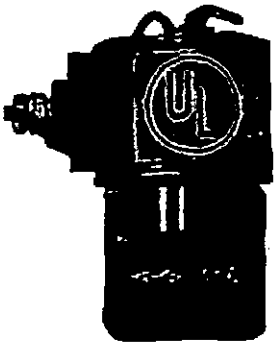


Photo #3-09 - Engine Mounted Solenoid Valve

Liquid Propane Filter

Any CNGE engine that uses HD-5 liquid propane fuel requires a liquid propane filter to be mounted before the liquid propane gas convertor. CNGE recommend s that the filter be checked and replaced on an annual basis.

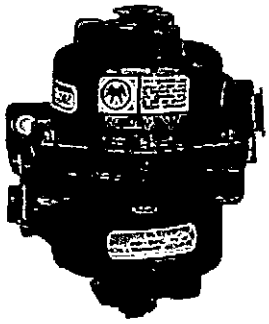


Photo #3-10 - Liquid Propane Filter

Liquid Propane Converter

When CNGE engines are using a liquid propane fuel (HD-5), a "converter" is used
to allow the liquid propane to convert to a vapor at atmospheric conditions.

When propane in a liquid state is released to a low pressure area, the sudden change to a gas causes a refrigeration process. The gas will enter the vaporizer at a -42° C [-44° F]. To compensate the engine jacket coolant is plumbed to the vaporizer to raise the HD-5 gas temperature up to 4° C [40° F].

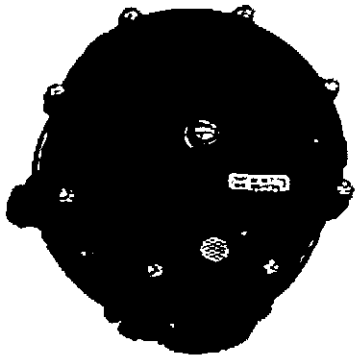


Photo #3-11 - Liquid Propane Converter

Low Pressure Propane Gas System Components [Vapor] - Unique to Propane Vapor

In those cases where propane vapor is available from the propane storage tanks in sufficient quantities that will handle the specific propane engine, a converter will not be necessary.

When using a straight propane vapor from the top of a storage tank, it is important to insure that the vapor does not carry condensate or propane "droplets" of liquid propane. It may be necessary to install a separate heater to increase the temperature of the propane vapor.

Caution: Check with the local authorities for the correct type and correct installation of any propane heater.

Propane will generally cause higher Exhaust Gas Temperatures (EGT) and has a lower critical temperature point, therefore CNGE requires that all CNGE turbocharged engines be applied at a C.R. of 8.5:1 when using propane as a fuel. At times, it may be necessary to reduce engine power due to elevated EGT when using propane as a fuel.

Caution: Propane as a gas is generally heavier than air and will tend to fall rather than rise like methane gas. When using propane as a fuel, one needs to be aware and cautious at all times.

Engine Mounted Gas Regulator

The propane vapor will flow through a pressure regulator, a shutoff valve and then to an engine mounted regulator that has been inverted with the internal spring removed. The engine will then create a vacuum at the carburetor that will pull the propane vapor from the regulator in the desired quantities.

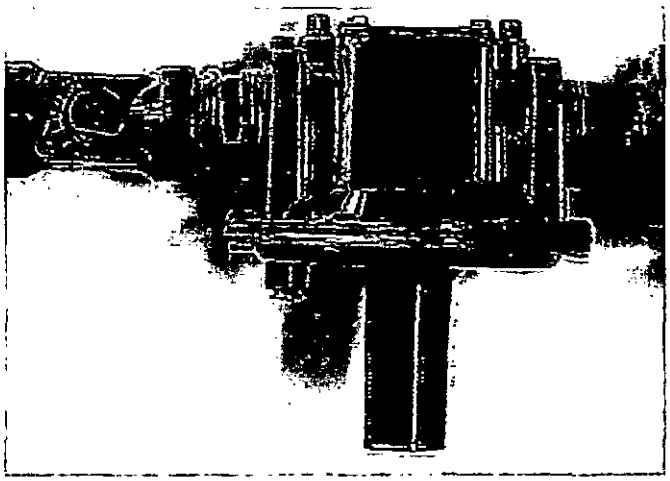


Photo #3-12 - Engine Mounted Gas Regulator - Propane Vapor

The Ignition System

CNGE use ignition systems supplied by Altronic.

Altronic CD1

The Altronic CD1 consist of a capacitor-discharge, electronic microcircuit-based ignition system. The CD1 employs digital circuitry by processing signals from a magnetic pickup . This provides for accurate and consistent timing. CNGE uses the single firing mode. The system is powered by a 12 - 24 VDC and has no mov-

ing parts. The CD1 uses the high-energy, capacitor-discharge (CD) principle which provides maximum engine performance and can extend spark plug life when compared to an inductive system.

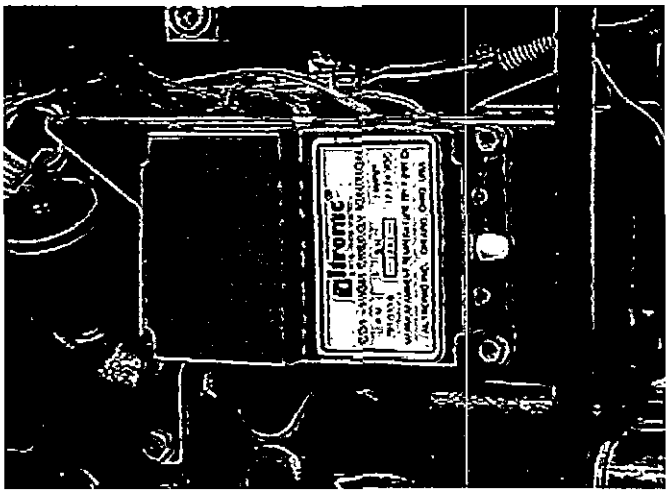


Photo #3- 13 - Altronic CD1

Table #3- 03 - Ignition Systems

Engine Model	Altronic
GTA8.3	CD1

Table #3- 04 - Ignition Timing Values

Engine Model	Degrees (BTDC)	Fuel
GTA8.3	24-26	Natural Gas
GTA8.3	18-20	Propane

The Lubrication System

CNGE engines are pressure lubricated. The pressure is supplied by a gerotor lubricating oil pump.

A pressure regulator is mounted in the lubricating oil cooler. 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.

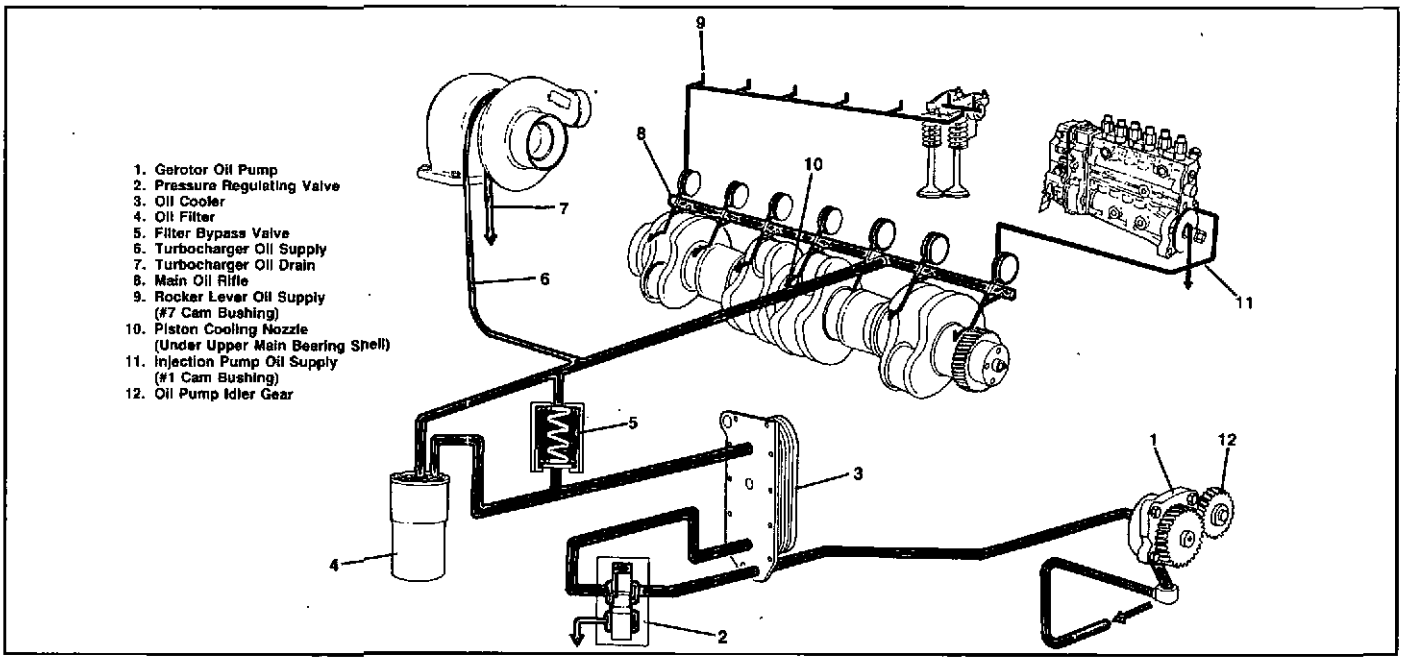
On the GTA8.3 the oil flow is through the oil cooler and on to the oil filter. The GTA8.3 uses an LF3000 full flow/ by-pass combination element.

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 top of the full flow filter directly to the turbocharger.
Some applications will also require a supplemental oil system to increase the oil capacity for extended oil drain periods.

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.

C Series Lubrication System Flow Schematic



Engine Lubricating Oil

The use of a high quality lubricating oils 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 15W-40 heavy duty natural gas engine oil** that meets the **American Petroleum Institute (API)** performance classification **CD .**

A **maximum sulfated ash limit of .5 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.

Caution: The CNGE GTA8.3 engines will also require a **minimum additive package level of Zinc, Phosphorus, and Calcium.**

Phosphorous	**650/850 PPM**
Zinc	**700/900 PPM**
Calcium	**900/1300 PPM**
Total Base Number (TBN)	**4.5**
Total Acid Number (TAN)	**.5/1.5**
Sulfated Ash	**Less than .4/.6%**

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
One Illinois Center
111 East Wacker Drive
Chicago, Ill. U.S.A. 60601
Telephone: (312) 644-6610

The Cooling System

On the GTA8.3 the coolant is circulated by a belt driven centrifugal-type water pump that is mounted directly in the front of the cylinder block. The coolant flows past the oil cooler, past the cylinders, and on to the cylinder head. The coolant flows from the cylinder heads on to the thermostat housing. 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.

Coolant is also supplied to the turbocharger from the thermostat housing during operation.

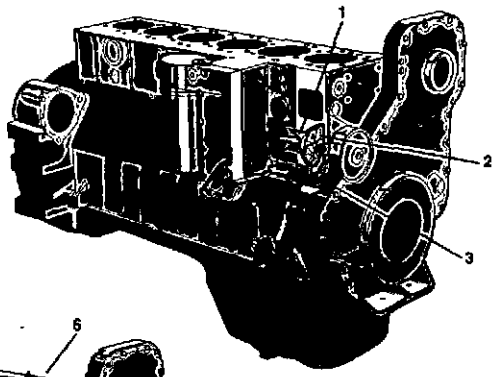
Coolant Recommendations

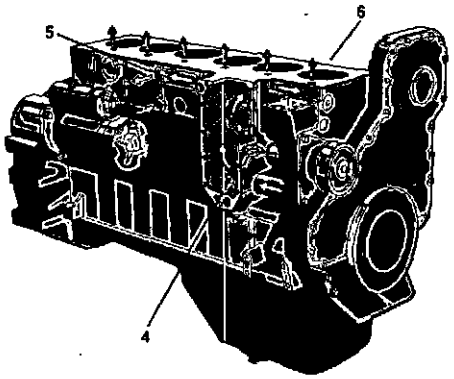
Cummins engines require a balanced coolant mixture of water, antifreeze, and supplement coolant additives. This can be best accomplished by using **Fleetguard's Compleat™.** Compleat™ comes in either a concentrate mixture that is used with a high quality water or in a premix, where no additional water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

C Series Coolant System (1)

Cylinder Block

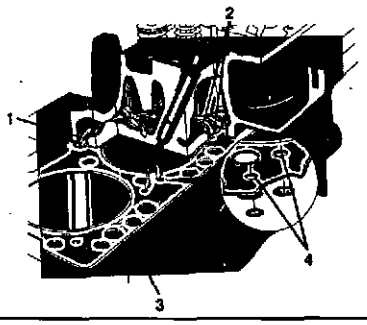
1. Coolant Inlet
2. Pump Impeller
3. Coolant Flow to Cooler
4. Coolant Flow Past Oil Cooler
5. Upper Coolant Manifold
6. Coolant to Cylinder Head





Cylinder Head

1. Coolant Flow from Upper Coolant Manifold
2. Coolant to Liner Cavity
3. Cylinder Head Gasket
4. Coolant Flow Orifice



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-M 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 300 ppm hardness or contain more than 100 ppm 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.

Irrigation Application

The cooling system on irrigation engines consists of a cooling coil in the product water discharge line. This enables the engine to have a cooling system, without the use of a radiator. A deaerating expansion tank is required

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 its separate heat exchanger. A deaerating expansion tank with a separate section for the aftercooler circuit is also required.

Cummins Natural Gas Engines, Inc. recommends that all cooling systems used on CNGE engines be of a design that offers a deaerating feature with properly designed radiator top tanks or through the addition of auxiliary surge tanks.

Both systems should contain fill lines to the suction side of the engine water pump and vent lines from the highest point of the engine cooling system before the thermostat.

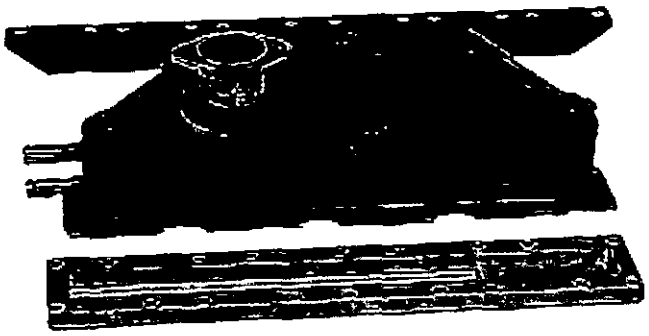


Photo #3-14 - Aftercooler Heat Exchanger - Water -to-Air

Aftercooler Circuit- Air-to-Air

Several models of CNGE engines use an aftercooler section that uses an air-to-air CHARGE AIR CORE (CAC) section of the engine radiator package.

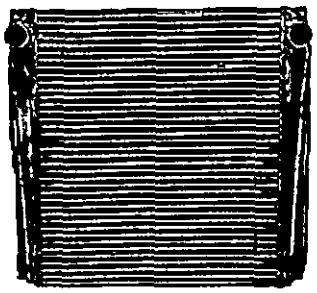


Photo #3-15 - Aftercooler Charge Air Core (CAC) -Air-to-Air

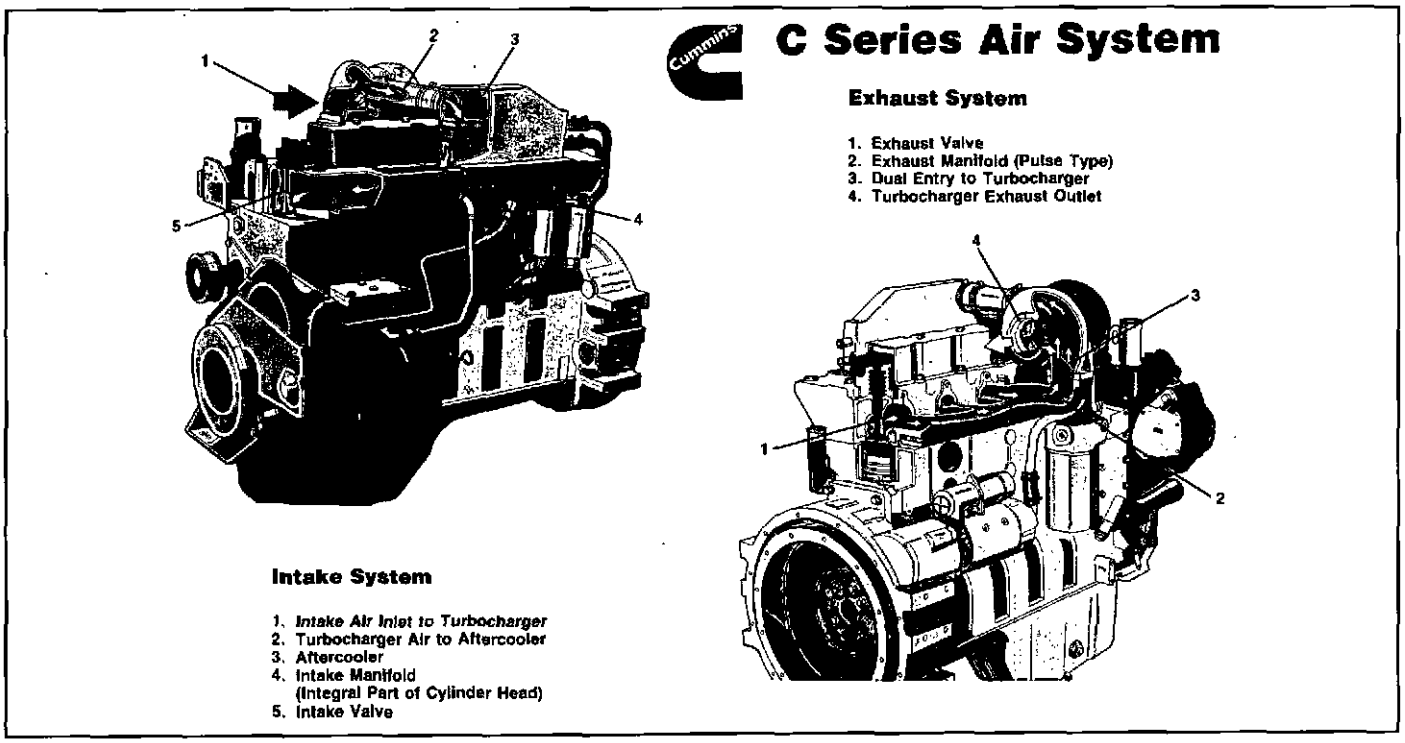
The Air Intake System

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 air flow to the engine for good air-fuel mixture. Refer to your engine datasheet for allowable intake restriction an CFM of air flow.

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

Wastegate Turbocharger

The GTA8.3 turbocharger has a waste gate operation. The wastegate reduces boost pressure when the actuator control rod opens the wastegate valve at a predetermined level. The open wastegate valve allows some exhaust gas to bypass the turbine wheel and exit out the exhaust pipe. When the wastegate valve is closed all of the exhaust air goes out through the turbine wheel and then on to the exhaust pipe.

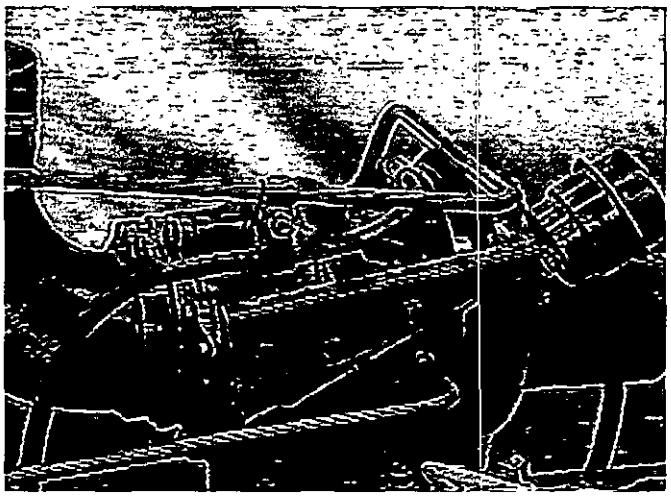


Photo # - 16 - Turbocharger Waste Gate

Catalytic Convertors

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 GTA8.3 engine.

Mufflers, Silencers, Flame Arrestors

Some locations and applications may require the use of mufflers, silencers or flame arrestors in addition to catalytic convertors.

Caution: The addition of exhaust mufflers, silencers or arrestors, 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. CNGE engines have a maximum acceptable level of back pressure of 2" of hg.

The Electrical System

The electrical system consists of 12-24 VDC batteries, 12-24 V electrical starters, 12-24 V Alternators on some applications and various wiring diagrams such as:

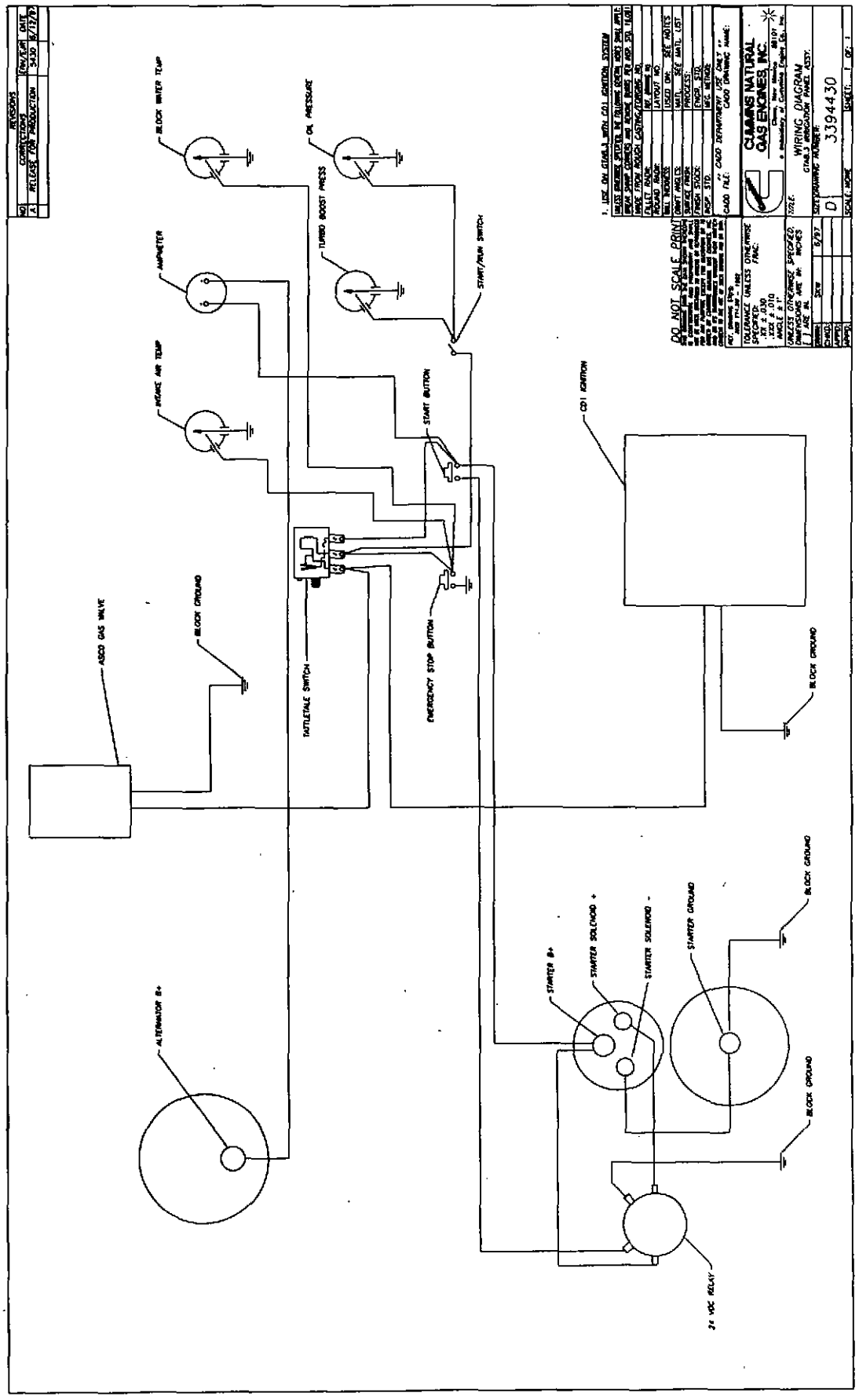
GTA8.3 Irrigation Panel Assy. (5 Gauge Panel)

GTA8.3 Irrigation Panel Assy. (Wiring)

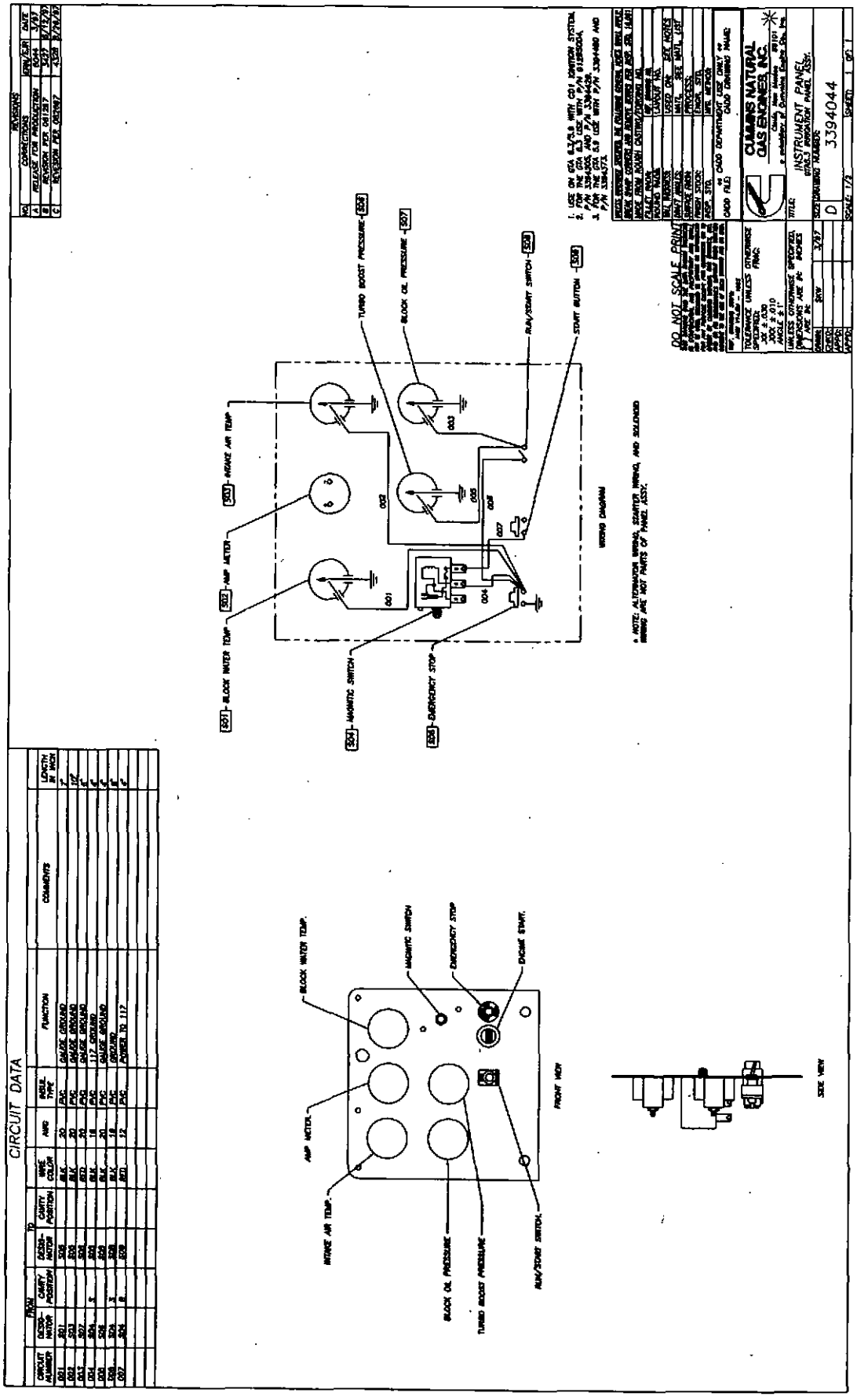
GTA8.3 Wiring Harness

Notes:

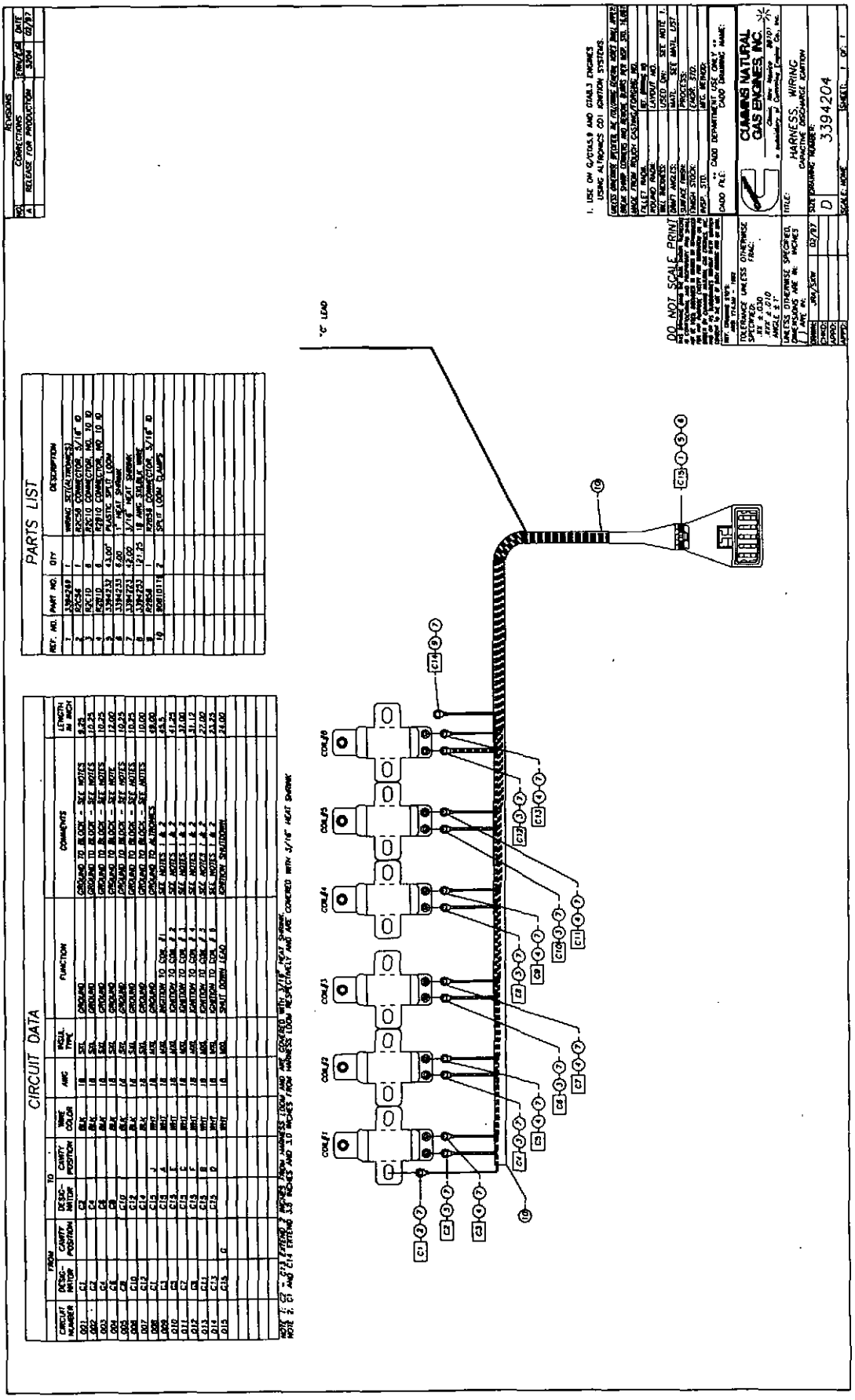
GTA8.3 Irrigation Panel Assy. (5 Gauge Panel)



GTA8.3 Irrigation Panel Assy. (Wiring)



GTA8.3 Wiring Harness



Section 4
Installation Instructions

Remove all tape and plastic covers from fuel, lubricating oil 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.

On installations with external coolant lines, such as cooling towers and heat exchangers, piping should be installed with flexible connections to reduce stress on rigid piping due to engine vibration.

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.

Install a flexible connection between your gas supply line and the engine mounted gas shut-off valve.

Caution: Do not use rubber hose for flexible connection.

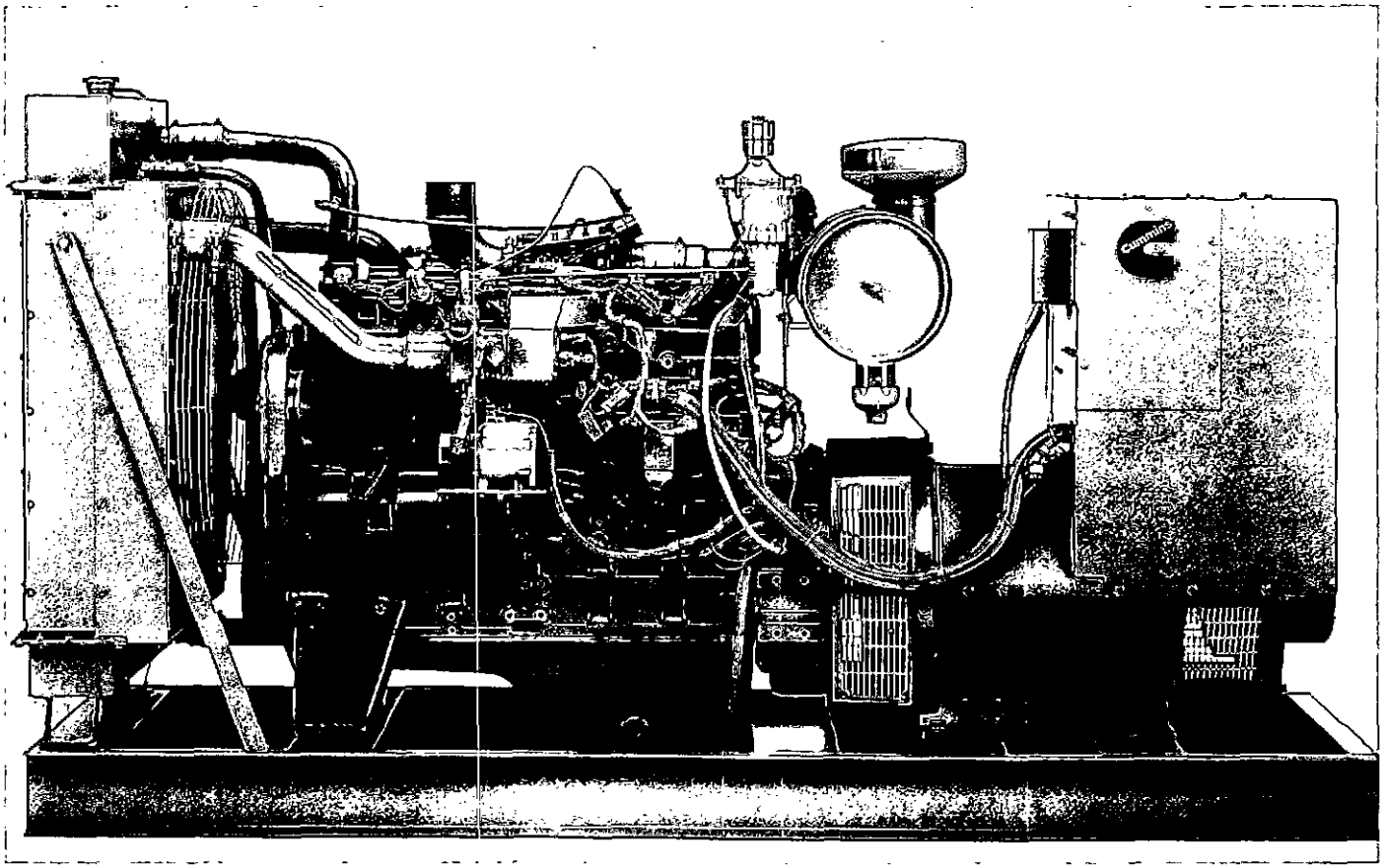
Inspect unit for damaged or missing parts. Check all bolts and nuts for tightness; replace as necessary.

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

Check throttle for free travel; correct as necessary.

Note: Application and 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 available from your local Cummins Distributor.



GTA 8.3-G

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 overspeed situations. CNGE recommend overspeed 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 pre-mature 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.
   - Gas pressure to carburetor.
   - Ignition timing.
   - Oil pressure at idle rpm.
   - Oil pressure at rated rpm.
   - Engine coolant cylinder block pressure at load if equipped with proper gauge.
   - Engine coolant top tank temperature at loaded conditions.
   - Intake manifold vacuum/pressure and temperature at idle and at load.
   - Excess Oxygen reading in exhaust gas at rated load and rpm.
   - Exhaust gas temperature at manifold outlet at rated load and rpm.
   - Engine rpm at idle and at load.
   - Hourmeter reading.
   - Ambient temperature.
   - Altitude.

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

   - Water temperature.
   - Water pressure.
   - Oil pressure.
   - Intake manifold vacuum/pressure.
   - Intake manifold temperature.
   - Overspeed device.

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

At the conclusion of the inspection the service technician will supply to 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: Although all CNGE engines require an adjustment for on-site conditions, the start-up & initial inspection is not used to establish the new engine warranty start date. The new engine warranty start date begins on the date of delivery for the first end user. For warranty details refer to the appropriate 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 Lubrication System

Note: On turbocharged engines, remove the oil inlet line from the turbocharger and pre-lubricate the bearing by adding 50 to 60 cc [2 to 3 oz.] of clean lubricating oil. Reconnect the oil supply line.

A dipstick oil gauge is located on the side of the engine. The dipstick supplied with the engine has a **FULL** and **ADD** mark to show proper operating oil levels. The dipstick supplied with the engine is not inter- changeable

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 **FULL** 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 **FULL** 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 Hydraulic Governor

Many engines used in stationary power applications are equipped with belt driven mechanical governors. The GTA8.3 uses engine oil to lubricate the hydraulic governor.

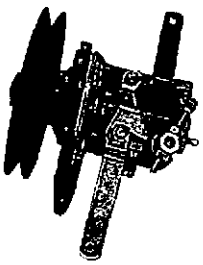


Photo #5-01 - Hydraulic Governor

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.

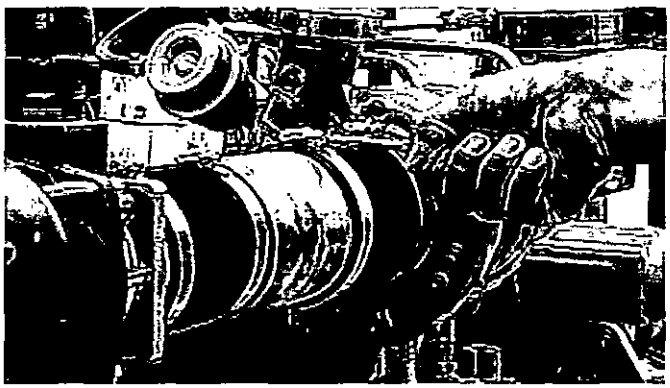


Photo #5-02 - Air Connections

Check Engine Coolant Supply

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

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

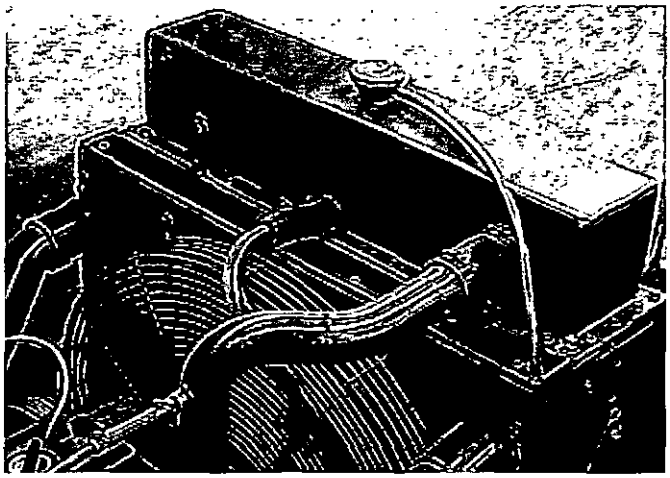


Photo #5-03 - Radiator & Expansion Tank Caps

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.

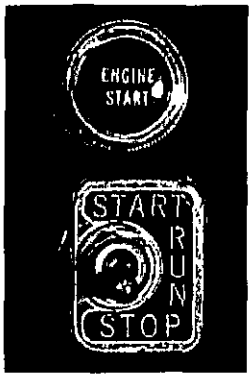


Photo #5-04 - Start-Stop Button or Switch

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

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

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

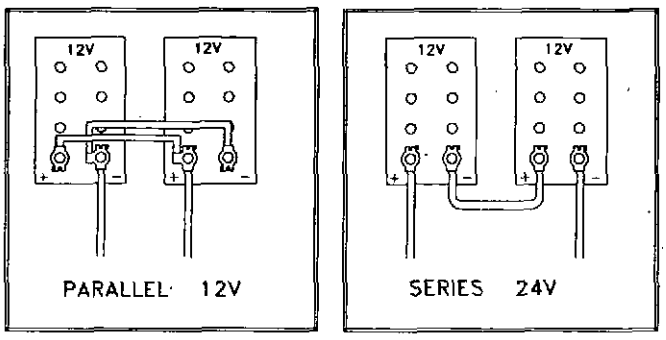
If the engine is equipped with an over-speed stop, push the **"Reset"** button before attempting to start the engine.

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 shutoff 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 the fuel shut-off valve will be held in the run position.
6. Push the **"reset"** button on the instrument panel.
7. Hold in the safety switch override button or turn the timer past 20 seconds 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. A minimum pressure of 863 kPa(125 psi) is required for the air-gas starting motors.



Sketch #4-01 - Battery Connections - Proper Hook -Up

Warning: Caution should be taken when operating starters on gas because of the danger of fire, explosion or inhalation.

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].

Instrument Panels

Operate by the Instruments

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

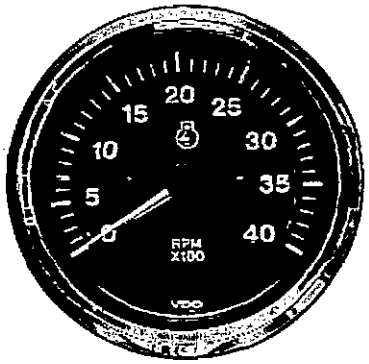


Photo #5-05 - Tachometer

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.

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 to assist in preventing overcooling.

Under stabilized operating temperature and for best results, CNGE recommends an engine jacket water temperature of 88° to 91° C [190° to 195° F.]

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.

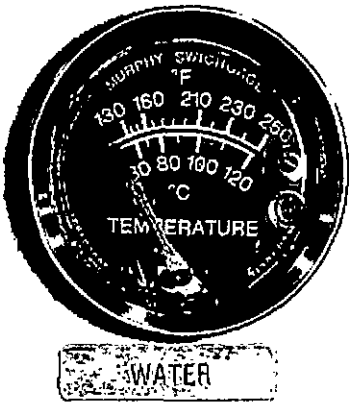


Photo #5-06 - Water Temperature Gauge - Thermostat Housing Outlet

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 32° C [90° F] on systems with a 10.5:1 compression ratio (C.R.) pistons. With a C.R. equal to 8.5:1, the water inlet temperature to the aftercooler coolant pump must be maintained at or below 54° C [130° F] at all times and during all ambient weather conditions.

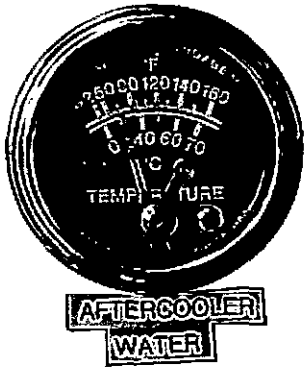


Photo #5-07 - Aftercooler Coolant Temperature Gauge

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 60° 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 & acid formation in the crankcase that will quickly accelerate engine wear.

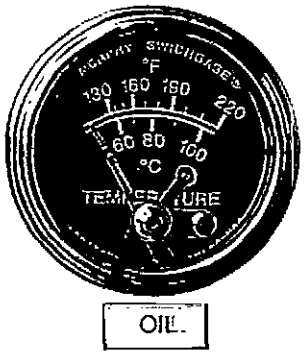


Photo #5-08 - Oil Temperature Gauge

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. Refer to the engine data sheet for specifications.

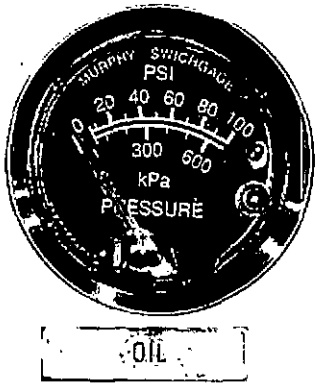


Photo #5-09 - Oil Pressure Gauge

Intake Manifold Air-Gas Temperature

On engines with air-to-air aftercooler systems, the cooling air to the remote Charge Air Core (CAC) must be held to 100° F or lower on engines with a C.R. of 10.5:1 and held to 130° F. or lower on engines with a C.R. of 8.5 :1 in order to keep intake manifold air-gas temperature below the point of detonation.

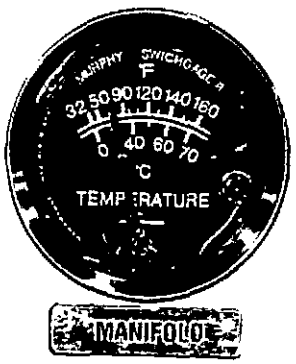


Photo #5-10 - Intake Manifold Air-Gas Temperature Gauge

Intake Manifold Turbocharger Boost Pressure

The engine intake manifold boost pressure needs to be maintained at 18 psi or lower at 1800 RPM and at the full power rating.

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

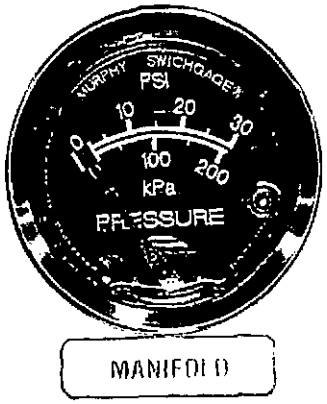


Photo #5-11 - Intake Manifold Boost Pressure Gauge

High Altitude Operation - De-Rating Requirements

Turbocharged Engines

The 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, and at the **CONTINUOUS or PRIME POWER RATING** up to 1524 m [5000 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 100° F and when altitudes are over 3000 ft.

Photo #5-12 - 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 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:

- An increase in oil consumption.
- An 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.

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

1. 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.

2. 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 accessory 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.

3. 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 engines 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 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, low temperature lubricating oils.
3. Protection from low temperature air. The rate of heat dissipation is affected from 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

Page

Engine Specifications

GTA8.3 Specification Sheet

See Enclosure

GTA8.3 Datasheets

See Enclosure

GTA8.3 Performance Curves

See Enclosure

Fuel-Gas 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 and is sometimes called sour gas.

Dry natural gas will contain Methane (CH_4), and Ethane(C_2H_6). In some areas the gas may contain up

to 5 % of Propane and a small amount of Butane. Refer to pages 6-5 through 6-6 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.

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 6-5.

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.

CNGE requires that ALL OTHER GASES have a Gas Analysis made to decide if they are suitable for use in a CNGE engine.

Examples of gases are:

Field Gas or Wellhead 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 that a high ash oil not more than .85% of sulfated ash with a high TBN number that meets a CD API specification is used to help neutralize the acid.

Digester Gas

This gas is a by-product of digester tanks where various material is going through a biodegrading 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 as "sour gas".

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

Gas Measurement Conversion Factors

Example:

Methane Gas at 60 F

1 MCF = 1000 cubic feet..
1 Decatherm = 1000 cubic feet.
1 Decatherm = 10 Therms.
1 Therm = 100 cubic feet.
1 Therm = 101,200 BTU (HHV)
1 cubic feet = 1012 BTU.(HHV)
100 cubic feet = 101200 BTU.(HHV)
100 cubic feet = 91080 BTU (LHV)

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

Table #6-01- 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	C_3H_6	2335
Propane	C_3H_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	C_5H_{12}	4003
Pentene-1	C_5H_{10}	3829
N-Pentane	C_5H_{12}	4015
Hexane	C_6H_{14}	4756
Heptane	0_7H_{16}	5503
Octane	C_8H_{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	0

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.

The purpose of this bulletin 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

The engine may be operated at the MAXIMUM RATING up to 914m [3000 ft.] altitude and 38° C [100° F] inlet air temperature, and at the CONTINUOUS RATING up to 1542m [5000 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.].

Fuel De-Rating Requirements

Fuel de-rating factors are to be 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 905 BTU per standard cubic feet (LHV) of compressed 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 has 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.

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 H_2S 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.

Notes:

_____

_____

_____

_____

_____

_____

Example Calculation

Specific Conditions:

- Model = GTA8.3
- Altitude = 6000 feet
- RPM = 1800
- Inlet Air Temperature = 107° F
- HP = 200
- C.R. = 10.5:1

A. Altitude De-Rating %

6000 - 5000 = 1000 feet subject to de-rating
1000/1000 X 4% = 4%

B. Inlet Air Temperature

107 - 100 = 7° F subject to de-rating
7/10 X 1% = 0.7%

C. Altitude & Temperature Combined

4% + 0.7% = 4.7%

D. Fuel Analysis

Con.	Inerts (%)	Analy. (%)	Hydrocarbons Max. Corr. (%)	Perm. prior to derate(%)	Excess (%)	Der. Fac. (%)	De-rating (%)
N_2	2.20	—	—	—	—	—	—
CO_2	1.86	—	—	—	—	—	—
CH_4	—	63.42	66.10	100	—	—	—
C_2H_6	—	14.56	15.18	100	—	—	—
C_3H_8	—	9.18	9.57	100	—	—	—
C_4H_{10}	—	1.71	1.78	50	—	—	—
NC_4H_{10}	—	3.61	3.76	15	—	—	—
IC_5H_{12}	—	1.05	1.10	15	—	—	—
NC_5H_{12}	—	1.03	1.07	0	1.07	4.0	4.28
$C7+ H_{16}$	—	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 200HP by 10.04 % or 21 HP to 179HP.

Chart # 1

FUEL DE-RATING FACTORS
MAXIMUM PERMISSIBLE COMBUSTIBLES -%

	Turbocharged	
Compression Ratio	8.5:1	10.5:1
Type of Gas		See #1
Methane (C)	100	100
Ethane (C_2)	100	100
Propane (C_3)	100	2
ISO-Butane (IC_4)	7	.2
Hydrogen (H_2)	7	TR.
Normal Butane (NC_4)	3	.2
ISO-Pentane (IC_5)	3	.2
Normal Pentane (NC_5)	1	.1
(C_6)	1	.1
(C_7)	1	.1

Note #1: No de-rating is allowed. When the maximum permissible percentage of combustibles is exceeded in the fuel then the compression ratio under consideration needs to be lowered to the next available compression ratio.

Chart # 2

FUEL DE-RATING FACTORS
STARTING POINT FOR DE-RATING - %

	Turbocharged	
Compression Ratio	8.5:1	10.5:1
Type of Gas		* see #1
Methane (C)	NA	NA
Ethane (C_2)	NA	NA
Propane (C_3)	NA	*
ISO-Butane (IC_4)	2	*
Hydrogen (H_2)	2	*
Normal Butane (NC_4)	0	*
ISO-Pentane (IC_5)	0	*
Normal Pentane (NC_5)	0	*
(C_6)	0	*
(C_7)	0	*

Note #1: No de-rating is allowed. When the maximum permissible percentage of combustibles is exceeded in the fuel then the compression ratio under consideration needs to be lowered to the next available compression ratio.

Chart # 3

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

	Turbocharged	
Compression Ratio	8.5:1	10.5:1
Type of Gas		
Methane (C)	0	0
Ethane (C_2)	0	0
Propane (C_3)	0	0
ISO-Butane (IC_4)	.5	0
Hydrogen (H_2)	.5	0
Normal Butane (NC_4)	1	0
ISO-Pentane (IC_5)	1	0
Normal Pentane (NC_5)	4	0
(C_6)	4	0
(C_7)	4	0

Timing & Excess Oxygen Specifications

Ignition Timing - Checking/Adjusting

Engine timing is fixed. However it requires adjustment for load, type & quality of the fuel, altitude and the rated speed (RPM) of the engine.

It is therefore important that this adjustment 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 #6-02.

Caution: CNGE sets all engines at Clovis, New Mexico conditions of 4200 feet altitude and to the limits in Table #6-02 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 #6-02 - Initial Engine Timing (@ 4200 ft. Clovis, N.M.)

Engine Model	Timing Range DBTDC	
	Nat. Gas	LPG Gas (HD-5)
GTA8.3	24 - 26	18 - 22

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.

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 # 03.

Table #6-03 - Excess Oxygen - Without Catalytic Convertor

Engine Model	O2 Reading - %		
Application	Stand-By (Maximum)	Prime (Continuous)	Industrial
GTA8.3	4.0 - 4.7	3.8 - 4.5	4.0 - 4.7

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.

Note: When using a catalytic convertor, contact the catalytic manufacturer for the correct air/fuel ratio and the limits of acceptable excess Oxygen in the exhaust gas. If the excess Oxygen limits are required to be below .5 the engine may require a reduction in load to avoid excessive exhaust gas temperature and a change in ignition timing.

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 Manufactures Association - EMA

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

Engine Manufactures Association
One Illinois Center
111 East Wacker Drive
Chicago, IL 60601/USA

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 GTA8.3 the use of a natural gas oil that meets the following specifications.

API	CD Quality
SAE Viscosity	15W40
Sulfated Ash	Less than .4/.6 %
Phosphorous	650/850 PPM
Zinc	700/900 PPM
Calcium	900/1300 PPM
TBN (ASTM D2896)	4.5
TAN(ASTM D664)	.5/1.5

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 .5% is recommended.**

CNGE does not recommend the use of ashless 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 an oil is a measure of its resistance to flow. The Society of Automotive Engineers has classified engine oils in viscosity grades. CNGE recommend 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 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 has 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 #6-04.

Table #6-04 - 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 Method

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 not to exceed the maximum point of 400 operating hours or 6 months.

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 oil change recommended point would be at some hour interval prior to the oil failing to pass the test criteria.

Under no circumstance does CNGE approve of extended oil change intervals that would exceed the maximum point of 400 operating hours without using an acceptable oil analysis program.

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 infra-red 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 #6-05 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.

These analysis are not 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 and forming a lacquer and maroon-colored deposits. In both cases the oil change interval must be lowered. 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.

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.

Table #6-05 - Oil Analysis Test

Property	ASTM Method	CNGE Oil Guideline Limit
Viscosity @ 40° & 100° C	D445	+ or - 1 SAE Grade
Sulfated Ash	D874	.5 % Max.
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.

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 environment 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 is 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# 6-06.

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].

Table #6-06 - Arctic Oil Recommendations

Parameter (Test Method)	Specifications
Performance Quality Level	API classification CC/SC & CC/CD
Viscosity	10,000 mPa*s Max. at -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)	.5% by Weight Maximum Content

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.

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% = -2° 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 recommends that the cooling system be maintained by using Fleetguard's™ DCA4™ Water Filter Element.

Maintain the Fleetguard DCA4™ Water Filter 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 antifreezes also contain anti-leak additives such as inert inorganic fibers, polymers particles or ginger root. These types of antifreezes 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™ recharge element. This element is compatible with plain water or all permanent-type anti-freeze except Methoxy Propanol.

2. At the first oil change period the DCA4™ precharge element should be changed to a DCA4™ service element. *See Table #6-07 for the correct element for your* cooling system.

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, precharge per *coolant specifications*, Table # 07.

4. The service element change point may be extended to the next service interval if the DCA-4L™ 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 (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.

To protect against corrosion, a new coolant charge must be brought up to 0.26 DCA4™ unit per liter [one DCA4™ unit 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 #6-07. 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.

Table #6-07 - DCA4™ Coolant Filter Service Chart

Liters[Gallons] To Be Serviced	SCA Units			DCA4™ Filter(s)		
	250 Hrs	500 hrs	750 Hrs	250 Hrs	500 Hrs	750 Hrs
19 - 38 [6-10]	2	4	6	WF2070	WF2071	WF2072
42 - 57 [11-15]	4	6	10	WF2071	WF2072	WF2074
60 - 76 [16-20]	6	12	18	WF2072	WF2074	WF2076
79 - 114 [21-30]	10	15	20	WF2074	WF2075	WF2076
117 - 189 [31-50]	15	25	35	WF2075	WF2075(2)	WF2076(2)

Note: CNGE recommend that the Fleetguard test kit be used to determine the current concentration of DCA4™ in the cooling system. This test kit can be purchased from any Fleetguard dealer.

Caution: Never over concentrate the cooling system with DCA4™. Damage may occur to water pump seals.

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.

Grease Test Specifications

Test	Test Procedure
High-Temperature Performance	
Dropping point,° F.	ASTM D 2265 350 min.
Bearing life, hours 10,000 rpm	FTM 331 at 300° F 600 min.
Low-Temperature Properties	
Torque, GCM	ASTM D 1478
Start at 0° F	15,000 max.
Run at 0° F	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	10 max.
500 hours	25 max.
Copper Corrosion	***FTM 5309** Pass
Dirt Count, Particles/cc	***FTM 3005**
25 Micron	5,000 max.
75 Micron	1,000 max.
125 Micron	None
Rubber Swell	***FTM 3603** 10 max.

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

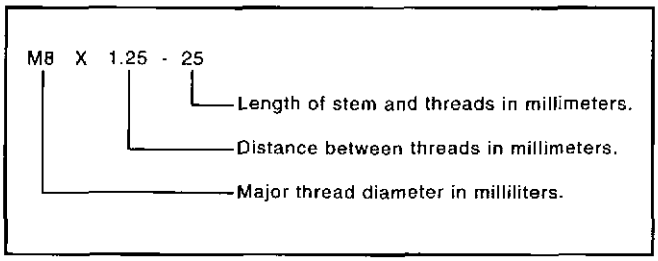
Torque Specifications

The C series engine uses parts that are of metric dimensions.

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

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

Metric Capscrew Nomenclature Capscrew Markings and Torque Values - Metric



Metric capscrews are identified by the grade number stamped on the head of the capscrew or on the surface of metric nuts. The higher the number, the greater the strength of the capscrew.

Commercial Steel Class	8.8	10.9	12.9
Thread Diameter mm	**Torque Nm (ft-lb)**	**Torque Nm(ft-lb)**	**Torque Nm(ft-lb)**
5	6 (5)	8 (6)	8 (6)
6	10 (5)	15 (10)	15 (10)
8	24 (18)	34 (25)	38 (280)
10	43(32)	64 (47)	88 (570)
12	77 (57)	112 (830	137 (101)
14	127 (94)	180 (133)	216 (159)
16	195 (144)	266 (196)	319 (235)

Notes:

1. *Do not use these values when the torque values are* specified in anther section of the manual.

2. These values are based on clean, dry threads. Reduce the value by 10% when a lubricant is used. Reduce the value by 20% if new plated capscrews are used.

When the correct length is not known, apply the following general rule:

Capscrew Length = Thread Engagement + Mounting Flange Width + Washer (Lock and Plain) Width.

The minimum Thread Engagement depends on the type of material that will be receiving the capscrew.
If the material is cast iron or steel, multiply the thread diameter by 1.5. if the material is aluminum, multiply the thread diameter by 2.0.

Additional torque values can be found in Cummins C Series Shop manual, bulletin # 3810275.

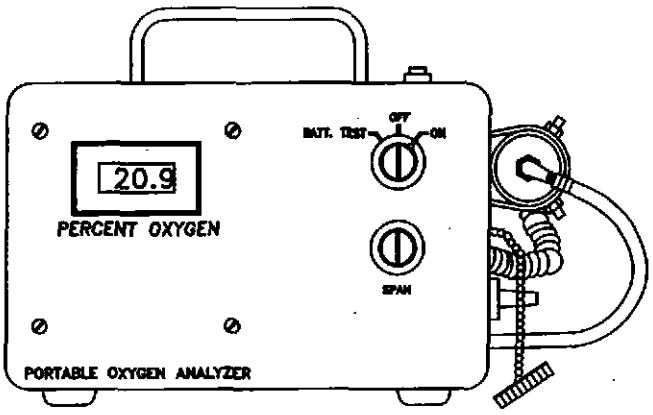
Specialized Service Tools

• Customer Tools

Standard metric tools required to maintain and repair the C series engines are listed at the end of the Operation and Maintenance Section of this manual.

CNGE Special Tools

CNGE offers the following special service tools required for a customer to do basic maintenance and some limited checking of the engine. These tools can be purchased from CNGE through the local Cummins Distributor.



Oxygen Meter Model 320 P/D

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)(Three Required)
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.(TypeE).
91400039	Fitting 1/8 npt Thermocouple (Each). Recommend a minimum of 12.
60210006	*Pliers for Ignition Wire Crimping.*
3395077	Digital Thermometer 450 AET Type E.
3395076	Spark Plug Removal 5/8".
91372624	Spark Plug Gap Tool.
60110001	*Compression Tester.*
60810002	Set of Feeler Gauges.
3375049	Oil Filter Wrench.
3375208	DCA4™ Test Kit.
61210002	*Tachometer Hand Held.*
91400210	Carrying Case Small.
91400909	Carrying Case Large.

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 also to allow one to operate with the lowest possible exhaust gas temperatures.

91372621	*Oxygen Meter - 320 P/D*
91372622	Max 5 Oxygen Analyzer

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 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 O_2 fuel cell holder.

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

   A. Turbocharged engines have a 1/4" npt fitting in the exhaust elbow 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 their is no fitting then the tubing should be inserted into the exhaust stack so it is at the half way point when measuring the distance from the engine to the end of the stack.

   B. Insure that the tubing is coiled several times to cool the exhaust gas sample and 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.

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 O_2 cell. The CO_2 in the exhaust gas will shorten the O_2 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 320 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 O_2 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 ready for continue 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 - Range of Excess Oxygen

   Excess Oxygen reading from 4.0 to 4.7 % for stand-by or maximum power, and 4.0 % to 4.7 % for prime or continuous power.

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 5" to 6" 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 understood to be made with the engine set at its published ignition timing for the appropriate model.

Note: When using a Catalytic Convertor the excess oxygen may need to be readjusted to a level of .5% of O_2 or lower.

Section 7
Maintenance Instructions

Table of Contents

Maintenance Items ---------- Recommended Interval ---------- Engine Family = GTA8.3						
Operating Hours	Daily	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				
Aftercooler Coolant Level	X					
Aftercooler Coolant DCA4 (™)	X					
Thermostat Operation		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		
Propane Liquid Fuel Filter				X		
Propane Converter				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 Externall y	X					
Check Ignition System	X					
Spark Plugs		X				
Shielded Spark Plugs			X			
Ignition Coils			X			
Ignition Generator & Voltage			X			
Wiring Harness & S.P. Wires			X			
Ignition Timing			X			

Maintenance Items ---------- Recommended Interval ---------- Engine Family = GTA8.3						
Operating Hours	Daily	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				Std. Lube Syst.
Change Engine Lube Oil & Filters		X				Hgh Cap. L.Syst.
Leaks & Correct	X					
Check Hydraulic Governor	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 & Capscrews				X		
Engine Cylinder Compression		X				
Water Pump				X		
Auxiliary Water Pump					X	
Turbocharger					X	
Vibration Damper					X	Replace @
						15000 hrs.
Fan Hub					X	
Valve Adjustment		X			X	1st adjustment
						@ 250 hrs.
Crankcase Breather		X				
Cylinder Heads Replacement					As Required	
Floating Plate Tappets						As Required
Visually Inspect Engine	X					
Damage, Leaks, Loose or Frayed						
Belts, Loose Hoses/Clamps	X					
Visually Inspect Radiator Core	X					

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 is 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.

A - Maintenance Check - Daily

- General information.
- Check operator's report or log-sheet.
- Check and bring to proper level:
  - Engine oil.
  - Engine coolant.
  - Aftercooler coolant.
- Check for gas leaks and correct.
- Check governor.
- Visually inspect engine for damage, lube oil and coolant leaks, loose or frayed belts, loose hoses and clamps and correct as required.
- Visually inspect radiator & charge air cores externally for contamination and clean if required.
- Visually inspect cooling fan.

B - Maintenance Check - 250 Hours or 6 Months

- Change/Replace:
  - Lubricating oil & filter change interval.
  - Lubricating oil & filters.
- Check/Inspect Following:
  - Check engine crankcase breather.
  - Engine coolant DCA4™ concentration level. Add make-up DCA4™ if required.
  - Check air intake system for wear points or damage to piping, loose clamps, and leaks.
  - Check air cleaner restriction, element and change if required.
  - Check governor:
    - Linkage
    - Governor adjustments:
    - Idle speed setting.
    - Speed droop.
    - Isochronous control.
- Adjust:
  - Intake & exhaust valves (After first 250 hours all adjustments are at 1500 hour intervals)

C1 - Maintenance Check - 750 Hours or 6 Months

- Check/Clean/Inspect/Replace:
  - Ignition timing, Altronic CD1 only.
  - Engine cylinder compression.
  - Spark plug wires, spark plug wells, spark plug(s), ignition coils.

C2 - Maintenance Check - 1500 Hours or 1 Year

- Adjust:
  - Intake & exhaust valves
- Check/Clean/ Replace:
  - Gas filter.
  - Gas pressure to on engine regulator.
  - Gas pressure to carburetor.
  - Carburetor adjustment for excess oxygen:
  - Adjustment of power valve.
  - Antifreeze concentration.
  - Drive belt tension.

D - Maintenance Check - 6000 Hours or 2 Years

- Inspect/Replace:
  - Spark plug wire - replacement.
- Exchange/Rebuild:
  - Engine water pump.
  - Fan hub (belt driven).
  - Aftercooler water pump.
- Inspect/Exchange:
  - Turbocharger.
  - Vibration damper.
- Check:
  - Cooling system maintenance.
  - Coolant draining.
  - Cooling system flushing.
  - Cooling system filling.

Annual

- Steam clean engine (if possible).
- Check torque on turbocharger mounting nuts.
- Check torque on engine mounting nuts.
- Replace hoses as required.
- Clean cooling system (internally and externally) and change coolant and antifreeze (every two years).
- Inspect cooling fan.
- Thermostats and thermostat seals.

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. Replace the Vibration Damper at 15,000 hours.
4. Follow the manufacturer's recommended maintenance procedures for the starter, alternator, generator, batteries, electrical connections, carburetors, gas regulators, governors, and any other accessory item that may be supplied with your CNGE engine.
5. CNGE recommends that a daily log is maintained showing all maintenance performed.
6. Storage for engines out of service.

Adjustment, Replacement and Repair - Section A

- Adjustment, replacement & repair procedure:
  - Air system repair:
    - Turbocharger - replacement.
  - Cooling system repair:
    - Belt tensioner - replacement.
    - Drive belt - replacement.
    - Fan pulley - replacement.
    - Thermostat - replacement.
    - Water pump - replacement.
    - Aftercooler pump - replacement.
  - Electrical system repair:
    - Alternator - replacement.
    - Starter - replacement.
  - Lubricating system repair:
    - Oil cooler element and gasket - replacement.
    - Oil pressure regulator, valve and spring - replacement.
- Repair tools required.

A - 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.

Check and Bring to Proper Level

- **Engine Oil Level - Checking**

Never operate the engine with the oil level below the **ADD** mark or above the **FULL** 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 **FULL** mark as possible.

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

Low Mark to High Mark Oil Capacity:

15.1 - 18.9 litres [4.0 - 5.0 U.S. Gal.] - 5.0 U.S. Gal.]

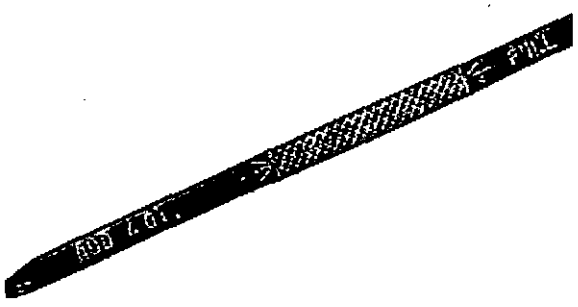


Photo #7-01 - Dipstick - ADD & FULL Marks

Use a 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.

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.

Fill the cooling system with the correct mixture of antifreeze, water and the correct number of DCA4™ units.

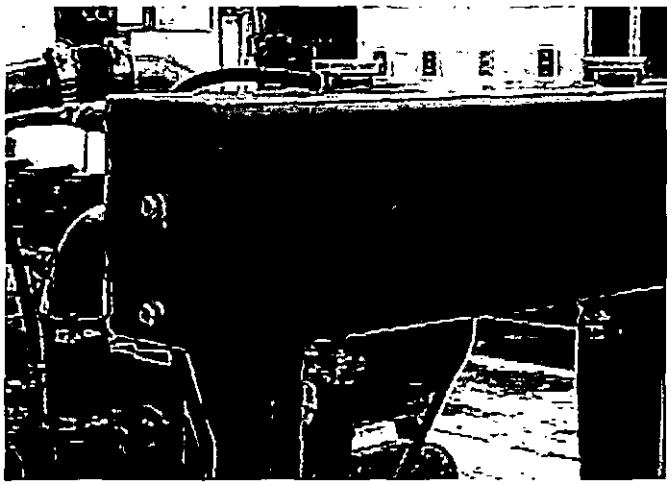


Photo #7-02 - Sight Glass - Engine Jacket Surge Tank & Surge Tank Fill Tube

- **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.

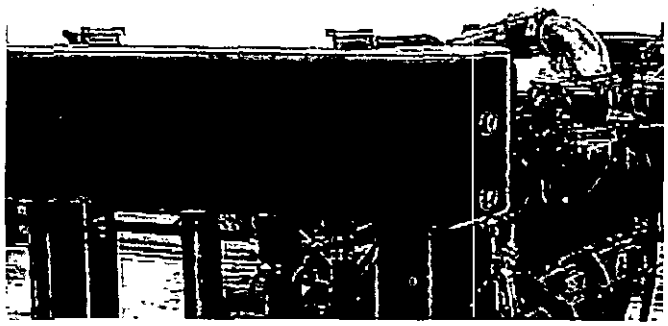


Photo #7-03 - Sight Glass - Aftercooler Surge Tank & Surge Tank Fill Tube

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.
3. On CNGE turbocharged engine models, check the throttle shaft seals for leaks with the engine at rated power.

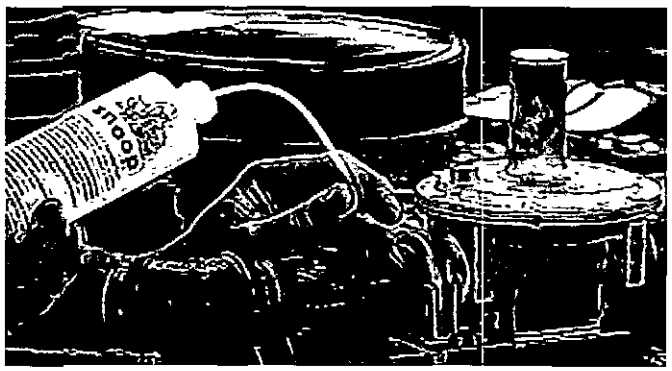


Photo #7-04 - Applying Liquid Soap

Check Governor

Many engines used in stationary power applications use mechanical or electrical governors. For proper maintenance refer to the specific governor manufacturer's recommendations.

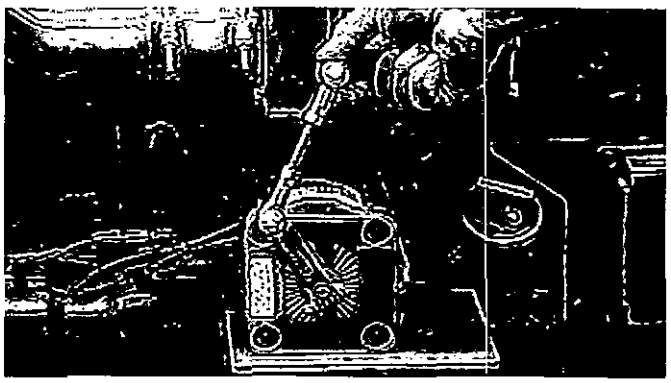


Photo #7-05 - Checking Governor

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.

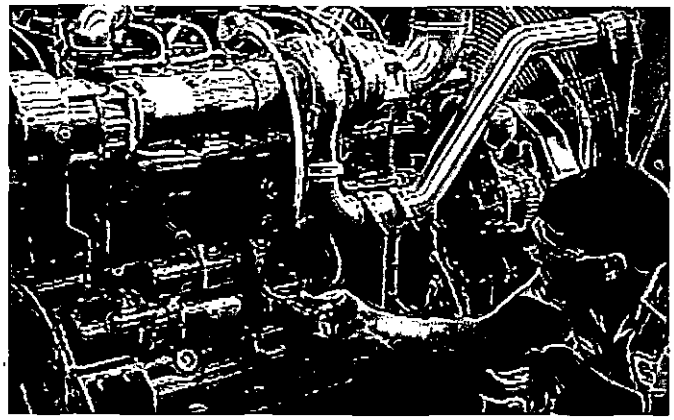


Photo #7-06 - Visual Inspection - Engine

- **Belt - Inspection**

Visually inspect all belts. Check the belt 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.

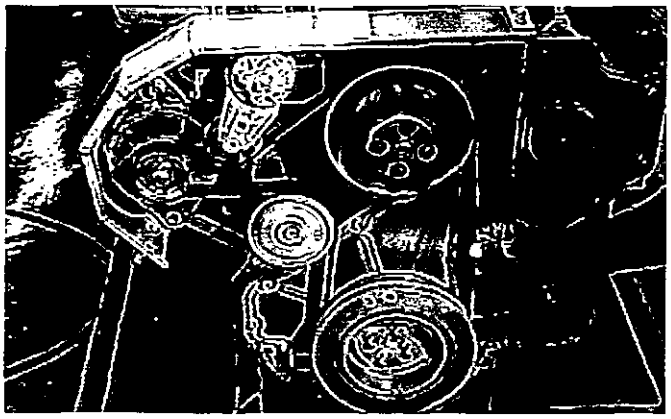


Photo #7-07 - Belt Inspection

Visually Inspect Radiator & Charge Air Core Externally

The radiator or aftercooler core 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 aftercooler core or lodged between the radiator/aftercooler and the cooling fins and tubes. Contamination of the radiator/aftercooler cores will affect the ability of the cooling system to transfer heat and properly cool the engine and intake manifold.

Caution: The aftercooler coolant temperature must be maintained below 32° C [90° F] with a 10.5:1 compression ratio piston.

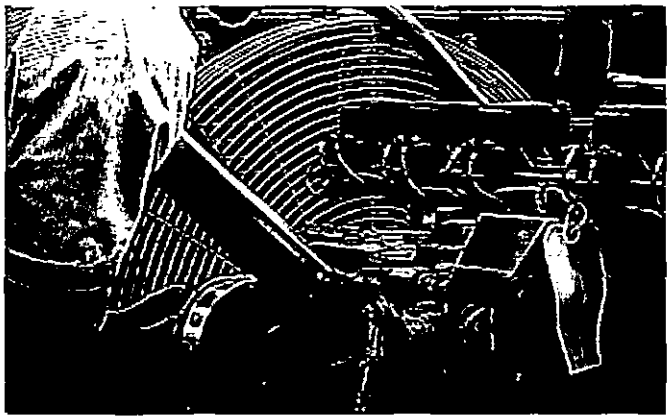


Photo #7-08 - Radiator & CAC(Charge Air Core) External Inspection

Visually Inspect Cooling Fan

Warning: Never use the fan to rotate the crankshaft. The blade(s) can be damaged causing a fan failure which can result in personal injury or property damage. *Use the proper barring tool.*

Check fan for cracks. On metallic fans, check for loose rivets, and bent or loose blades. Make sure it is securely mounted. Tighten the capscrews if loose. Replace damaged fans.

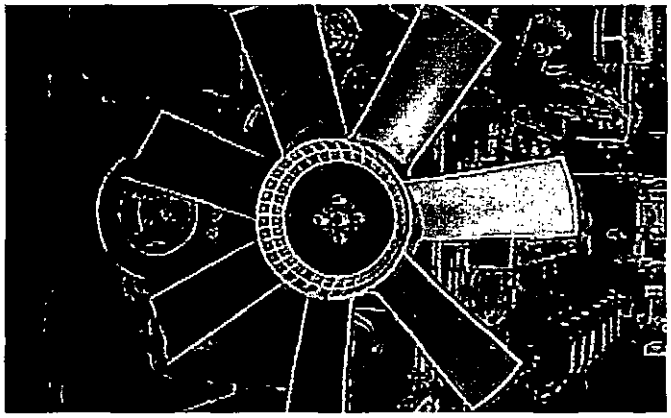


Photo #7-09 - Cooling Fan Inspection

B - Maintenance Check - 250 Hours or 6 Months

Change / Replace

- **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. For the GTA8.3 this is 250 hours or 6 months, whichever occurs first.

   Note: CNGE recommend method # 1 when not using an oil analysis program.

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 400 hours of operation or 6 months, whichever occurs first without the addition of more capacity, filtration and an oil analysis program.

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**

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.

Change the lubricating oil and filter(s) at every oil change, in order to remove contaminants.

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

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

Caution: 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 17 mm wrench or socket.

   Note: Use a container that can hold at least 18.9 liters [20 U.S. qts.] 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.

3. Make sure that the correct oil filter is installed. CNGE GTA8.3 engines use an LF 3000 oil filter.

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 overtightening 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 80 N•m [60 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.

   - **Pan Capacity ----------18.9litres [5 U.S.Gal.].**
   - **Total System Capacity -------34.1litres [9 U.S.Gal.].**

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

   Some GTA8.3 applications use a separate by-pass filter canister in order to increase the capacity for extended drain intervals.

10. Operate the engine at 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 FULL mark on the dipstick.

Photo #7-10 - Lube Oil & Lube Oil Filter Changing

Check Following

- **Check Engine Crankcase Breather.**

Inspect the crankcase breather vent tube & flexible hose for sludge or debris on or in the tube. Inspect the tube more frequently during icy conditions. Check for damage to the tube and see that the tube is clamped at all appropriate locations.

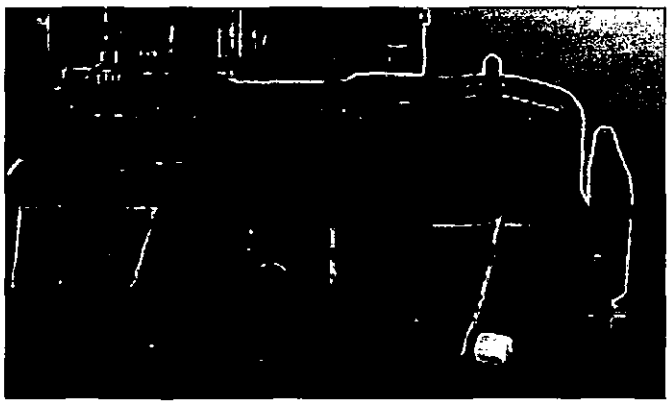


Photo #7-11 - Crankcase Breather

- **Engine Coolant DCA4™ Concentration Level. Add Make-Up DCA4™ if Required.**

- **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.

To protect against corrosion, a new coolant charge must be brought up to 0.26 DCA4™ unit per liter [one DCA4™ unit 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 # -01. 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.

Table #7-01 - DCA4™ Coolant Filter Service Chart

Liters[Gallons] To Be Serviced	SCA Units 250 Hrs	500 Hrs	750 Hrs	DCA4™ Filter(s) 250 Hrs	500 Hrs	750 Hrs.
19 - 38 [6-10]	2	4	6	WF2070	WF2071	WF2072
42 - 57 [11-15]	4	6	10	WF2071	WF2072	WF2074
60 - 76 [16-20]	6	12	18	WF2072	WF2074	WF2076
79 - 114 [21-30]	10	15	20	WF2074	WF2075	WF2076
117 - 189 [31-50]	15	25	35	WF2075	WF2075(2)	WF2076(2)

Note: Use the Fleetguard test kit to determine the correct concentration of DCA4™ in your cooling system.

Caution: Never over concentrate the cooling system with DCA4™. Damage to the water pump seals may occur.

• 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 #7-01 for the correct filter.

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

With the valve in the "on" position, the coolant flows to and from the coolant filter. In the "off" 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.

1. Turn the coolant shutoff valve to the "Off" position.

2. 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.

3. Install the filter as specified by the manufacturer.

   Note: Mechanical overtightening can distort the threads or damage the filter head.

4. Open the shutoff valve and install the coolant system pressure cap.

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

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

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

• 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.

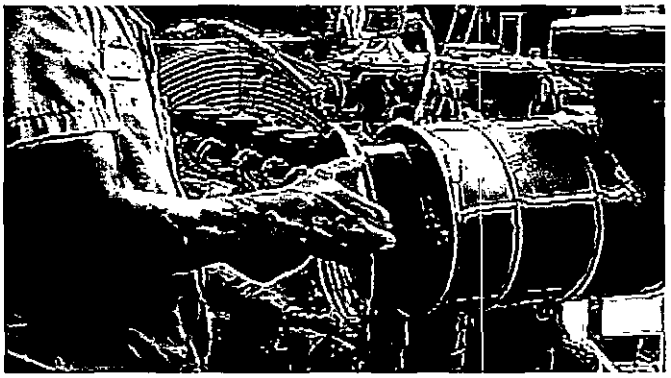


Photo #7-12 - Air Intake System - Inspection

• 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 max. intake air restriction with a dirty element is 635 mm H2O [25 in H2O].

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.

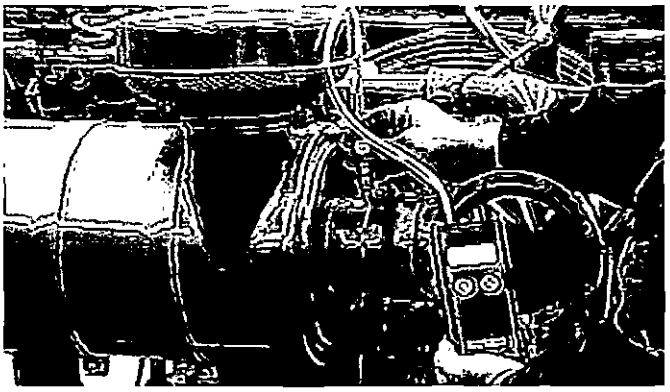


Photo #7-13 - Air Cleaner Restriction - Checking

• Check Governor - Mechanical

Maintain the oil level in the Governor by using a .015 orifice installed in the main oil galley of the engine block, keeping a constant oil flow to the Governor and draining back into the oil pan. Check the oil level regularly.

• Linkage

CNGE gas engines use a butterfly type of throttle valve downstream from the carburetor. The linkage will have to be adjusted to a "Non-Linear" position.

With the linkage in a no-load position the lever attached to the governor and the connecting link must be "in-line" with the governor output shaft and the point of attachment of the connecting link to the butterfly valve. The butterfly lever must be at 90 degrees with the connecting link.

Note: When using the Woodward "Flo-Tech" governor, there will be no linkage adjustment for the throttle body.

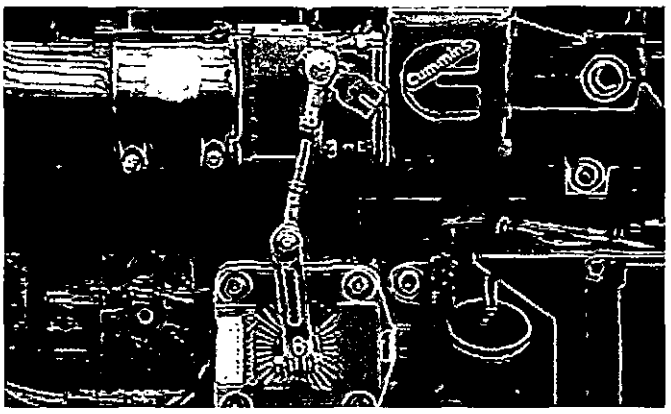


Photo #7-14 - Governor Linkage - Non Linear

• Governor Adjustments - Mechanical

CNGE engines may be equipped with belt driven mechanical governors. For proper operation & maintenance of the mechanical governors please refer to the manufacturer's manuals.

• Idle Speed Adjustment - Electric Governor

After the installation of the governor lever and linkage to the throttle body, check butterfly valve for idle position against the throttle stop pin. If the throttle plate idle adjustment screw does not rest against the stop pin, adjust linkage length until the screw rest against the stop pin.

Manually lift the governor lever through the throttle body travel range and check for linkage bind. If necessary, adjust linkage length and carburetor throttle lever position to eliminate any binding through the throttle travel range. Tighten the linkage and lever assemblies.

Start the engine and adjust the low-speed stop screw on top of the governor head for the desired idling speed, approximately 900 RPM for CNGE engines.

• Speed Droop Adjustments

Since there is no calibration for speed droop, the actual setting requires a trial and error procedure on the engine or adjustment by the use of a dial indicator on the speed droop lever while the governor terminal shaft is being "manually" rotated.

For additional instructions, please refer to the manufacturer's instruction manual.

• Isochronous Control of Electric Governor - Adjustments

Adjustments of these types of governors should be made with a clear understanding of the operation of the electronic governor. CNGE recommends that if your engine is equipped with an electronic governor then you refer to that specific manufacturer's operation & maintenance instructions for proper adjustment.

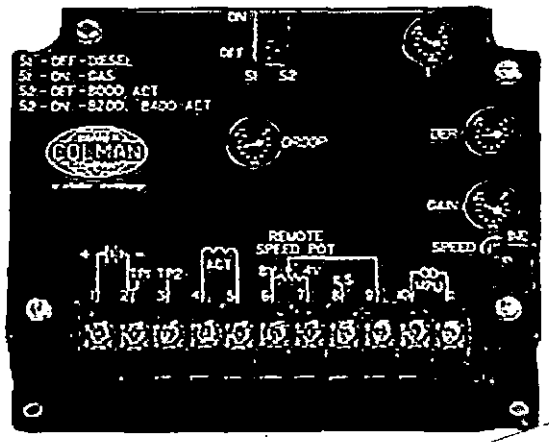


Photo #7-15 - Barber Colman Controller Adjustments

• Woodward Flo-Tech Actuator & Flo-Tech Speed Control

CNGE also use a 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 GTA8.3 engine

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

Photo #7-16 - Woodward Flo-Tech Actuator

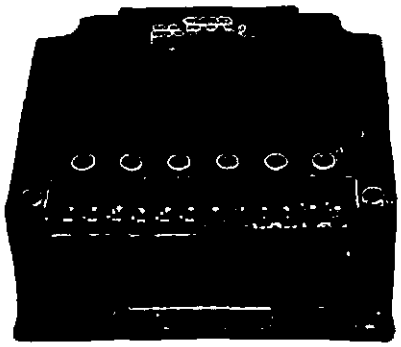


Photo #7-17 - Woodward Flo-Tech Speed Control

Adjust Following

• Intake & Exhaust Valve Procedure

Note: The first intake & exhaust valve adjustment should take place at the 250 hour service interval. After that point check exhaust valves at the C2 check or 1500 hours or 2 years whichever comes first.

1. Remove the air crossover tube (water-to-air system only).

2. Disconnect the support clamps, hose clamps, and remove the vent tube.

3. Remove the valve cover.

4. Locate top dead center (TDC) for cylinder No 1 by observing the marks on the vibration damper.

5. Use a feeler gauge to check or set clearance.

   Intake Clearance; 0.30 mm [0.012 inch].
   Exhaust clearance: 0.61 mm [0.024 inch].

6. Check or set valves with the engine cold (below 60° C [140° F]).

   Note: The clearance is correct when some resistance is "felt" when the feeler gauge is slipped between the valve stem and the rocker lever.

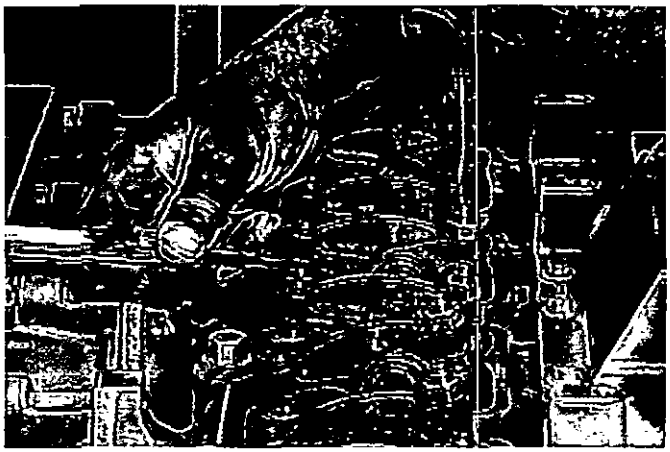


Photo #7-18 - Valve Lash Adjustment

7. After finding TDC for cylinder No. 1 use a flathead screwdriver and set the following valves.

Cylinder No.	Intake Valve	Exhaust Valve
1	Yes	Yes
2	Yes	No
3	No	Yes
4	Yes	No
5	No	Yes
6	No	No

8. Tighten the locknut using a **torque value of 24 N•m [18 ft-lb].** Check the valve lash again.

9. Mark the vibration damper and rotate the engine 360 degrees.

10. Using a flathead screwdriver and set the following valves.

Cylinder No.	Intake Valve	Exhaust Valve
1	No	No
2	No	Yes
3	Yes	No
4	No	Yes
5	Yes	No
6	Yes	Yes

11. Tighten the locknut using a **torque value of 24 N•m [18 ft-lb].** Check the valve lash again.

12. Install the rubber seal into the groove in the valve cover. Start the installation at the overlap area. Do not stretch the rubber seal.

13. Install the valve cover using **a torque value of 24 N•m [18ft.-lb].**

14. Install the crankcase vent tube and secure with the support clamps and hose clamp.

15. Install the air crossover tube (water - to - air only).

C1 - Maintenance Check - 750 Hours or 6 Months

Check/Clean/Replace

• Ignition Timing

Engine timing is a fixed value . However it depends upon the load, type & quality of the fuel, altitude and the rated speed (RPM) of the engine. The Altronic CD1 will need to be adjusted to the specific site conditions.

It is therefore important that this adjustment is made by a qualified CNGE distributor or CNGE authorized dealer service technician at the time of engine installation and start-up.
Set initial engine timing to the appropriate value listed in table # 02- Initial Engine Timing.

Caution: CNGE sets all engines at Clovis, New Mexico conditions of 4200 feet altitude and to the limits in Table # 02 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 # 7-02- Initial Engine Timing (@ 4200 ft. Clovis, N.M.)

Model	Ignition System	Timing Range (DBTDC)
GTA8.3	CD1	24-26

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.

Refer to Carburetor Adjustment in this manual.

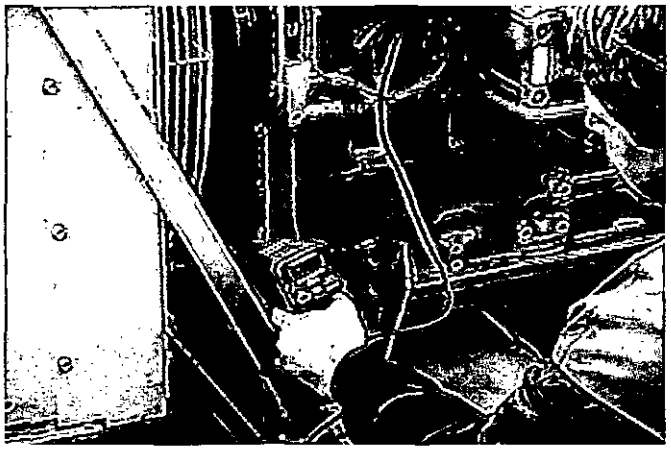


Photo #7-19 - Timing Light

• Engine Cylinder Compression Check

CNGE recommends the following steps when checking cylinder compression.

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

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.

All cylinder pressures should be within a 10 percent variance. Recheck any cylinder that is not within this limit.

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.

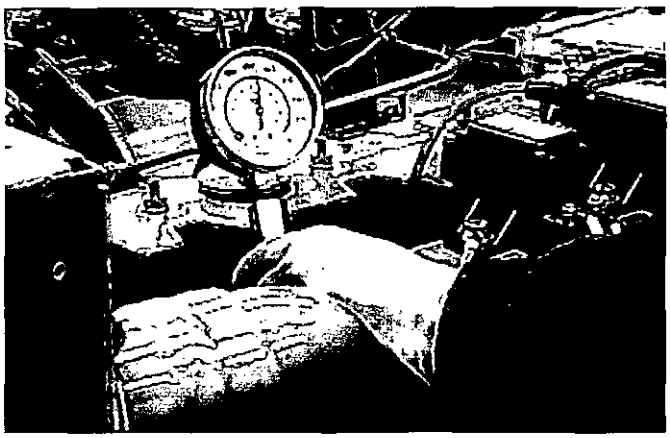


Photo #7-20 - Compression Check Tools

• Spark Plug Wire - Inspection

Inspect the condition of the spark plug wires. Replace any damaged wires.

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

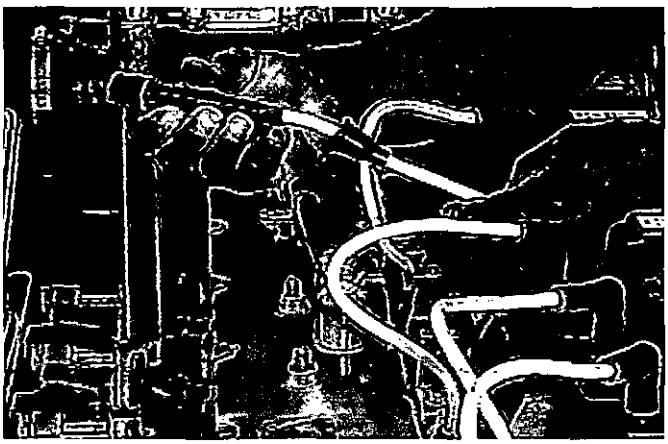


Photo #7-21 - Spark Plug Wire - Inspection

• Spark Plug Removal

1. Disconnect the wires from the ignition coil end first and then from the spark plug end.
2. Remove the rubber insert from the spark plug type sockets to prevent contamination of the spark plugs with dirt or oil.
3. Using an extra long 15.875mm (5/8 in.) deep-well rubber insert spark plug socket, loosen the spark plug with the extension and socket. Turn the plugs counterclockwise to loosen. Do not completely remove the spark plug from the threads.
4. Slip a length of 3/8 inch inside diameter hose over the plug end and continue to turn counterclockwise until the threads are no longer engaged.
5. Lift the spark plug out of the adapter with the hose, being careful not to drop the spark plug. Mark or tag

the spark plugs with the cylinder number from which they are removed.

6. Visually inspect the plug wires, extenders and connections for corrosion, damage or arcing.

Photo #7-22 - Spark Plug Removal

• Checking Spark Plug Well(s).

A visual inspection of the spark plug well for traces of water, & antifreeze should be made.

• Spark Plug(s) - Inspection.

Careful examination of the spark plug(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 pre-ignition 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.

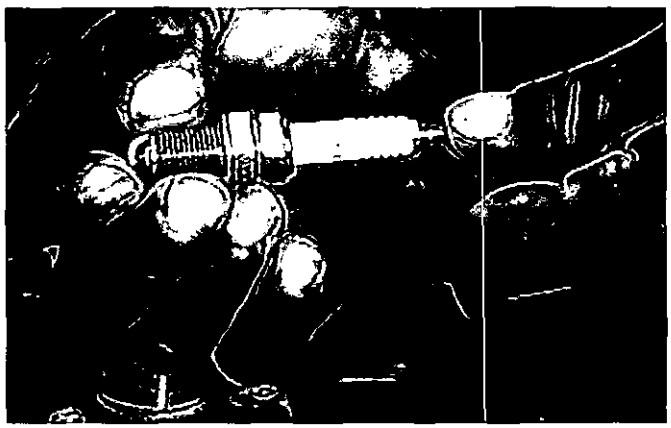


Photo #7-23 - Spark Plug - Inspection

• Spark Plug Gap - Checking

CNGE recommend that the spark plug gap of all CNGE engines should be set at .020 in. The measurement should be made with a spark plug gap wire gauge. CNGE recommend the Snap-On GA461b or equivalent.

Spark Plugs used in CNGE engines should not be re-gapped.

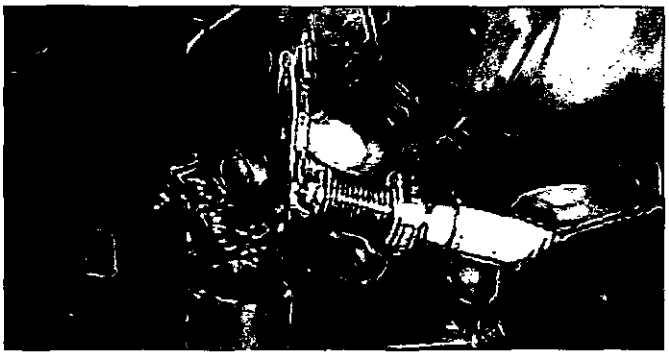


Photo #7-24 - Spark Plug Gap - Checking

• Spark Plug Installation

Caution: Spark plug life is largely dependent on cleanliness of the plug's porcelain. Dirt, oil and finger prints reduce the seal strength between the spark plugboot 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.

Caution: Mechanical overtightening can damage the spark plug and cylinder head. Check plug socket to make sure it is not a source of dirt and oil.

Install a new spark plug in the cylinder head. Make sure that the spark plug insulator porcelain is clean. Use an extension and magnetic spark plug 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.].

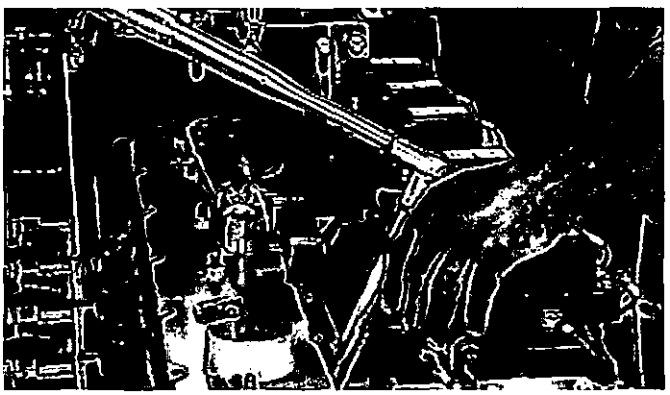


Photo #7-25 - Spark Plug - Installation

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

Carefully place plug boot onto the top of the spark plug 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.*

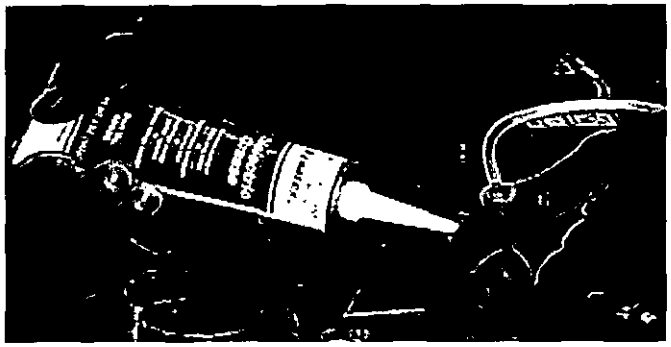


Photo #7-26 - Di-Electric Grease

• Ignition Coil Voltage - Check - Altronic CD1 Ignition System

• Input Voltage.

• Preparatory Steps:

1. *Connect the positive lead of the "Peak Hold" voltmeter* to the positive terminal of the coil.
2. Set the voltmeter to the proper scale.
3. Disconnect and ground the coil high-tension lead wire from the Altronic wiring harness to prevent the engine from starting.
4. Turn the ignition start switch to the start position and begin cranking the engine.
5. Observe the voltage while cranking.
6. The correct voltage should be 160 volts of DC pulsating voltage.
7. *If the voltage is low, check the battery, starter current* draw , ignition switch and ignition unit.

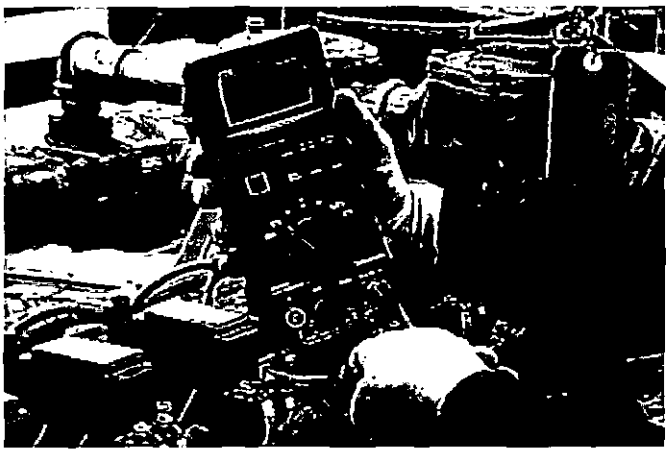


Photo #7-27 - Ignition Coil Voltage - Check

C2 Maintenance Check - 1500 Hours or 1 Year

Adjust Following

• Intake & Exhaust Valve Procedure

1. Remove the air crossover tube (water - to - air only).
2. Disconnect the support clamps, hose clamps, and *remove the vent tube.*
3. Remove the valve cover.
4. Locate top dead center (TDC) for cylinder No 1 by observing the marks on the vibration damper.

Photo #7-28 - Valve Lash Adjustment

5. *Use a feeler gauge to check or set clearance.*

Intake Clearance; 0.30 mm [0.012 inch]
Exhaust clearance: 0.61 mm [0.024 inch]

6. Check or set valves with the engine cold , (below 60 °C [140 °F]).

Note: The clearance is correct when some resistance is "felt" when the feeler gauge is slipped between the valve stem and the rocker lever.

7. After finding TDC for cylinder No. 1 use a flathead *screwdriver and set the following valves.*

Cylinder No	Intake Valve	Exhaust Valve
1	Yes	Yes
2	Yes	No
3	No	Yes
4	Yes	No
5	No	Yes
6	No	No

8. Tighten the locknut using a **torque value of 24 N•m [18 ft-lb].** Check the valve lash again.

9. Mark the vibration damper and rotate the engine 360 degrees.

   Caution: make sure that the timing pin is disengaged. If the engine is started with the pin engaged, the pin will break and can result in engine damage.

10. Using a flathead screwdriver and set the following valves.

Cylinder No.	Intake Valve	Exhaust Valve
1	No	No
2	No	Yes
3	Yes	No
4	No	Yes
5	Yes	No
6	Yes	Yes

11. Tighten the locknut using a **torque value of 24 N•m [18 ft-lb].** Check the valve lash again.

12. Install the rubber seal into the groove in the valve cover. Start the installation at the overlap area. Do not stretch the rubber seal.

13. Install the valve cover using **a torque value of 24 N•m [18ft.-lb].**

14. Install the crankcase vent tube and secure with the support clamps and hose clamp.

15. Install the air crossover tube (water - to - air only).

Check/Clean/Replace

• Gas Fuel Filter

Gas Filter - Replace

CNGE recommends that the gas fuel filter be installed before the engine mounted regulator. The inlet fuel pressure should be at a maximum of 100 psi to the filter.

CNGE supplies a filter as a kit option that is capable of filtering down to 10 micron. This 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.

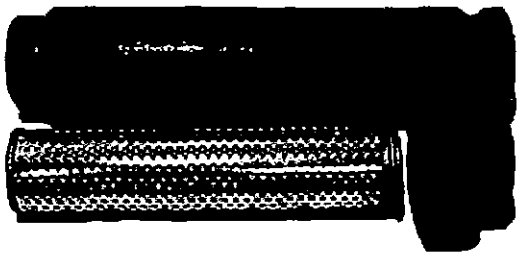


Photo #7-29 - Gas Fuel Filter

• Gas Pressure to On Engine Gas Regulator

Every 1500 hours or 1 year, check the gas pressure to the on engine 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 and should be between 10 and 20 inches of water column pressure under full load conditions.

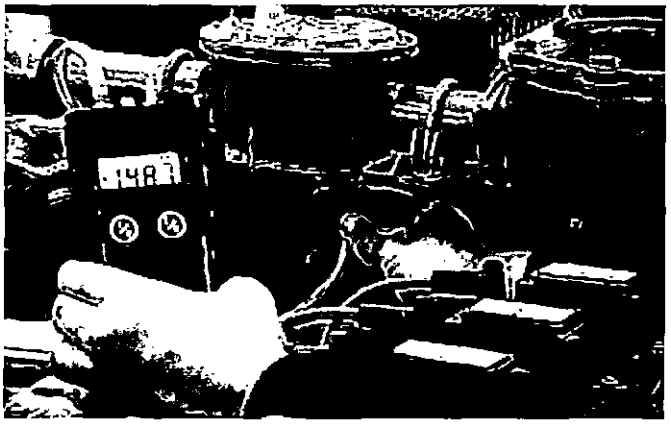


Photo #7-30 - Gas Pressure at Gas Regulator(On Engine) - Checking

• 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 of 5 inches of water column pressure is being supplied.

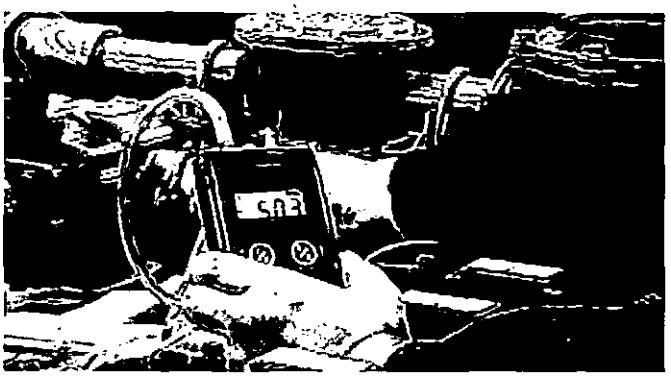


Photo #7-31 - Gas Pressure to Carburetor - Checking

• Carburetor Adjustment for Excess Oxygen

The air-gas **"power valve"** on the carburetor should be adjusted for the specific engine model's excess oxygen requirement. Refer to Table #7-03 - Excess Oxygen.

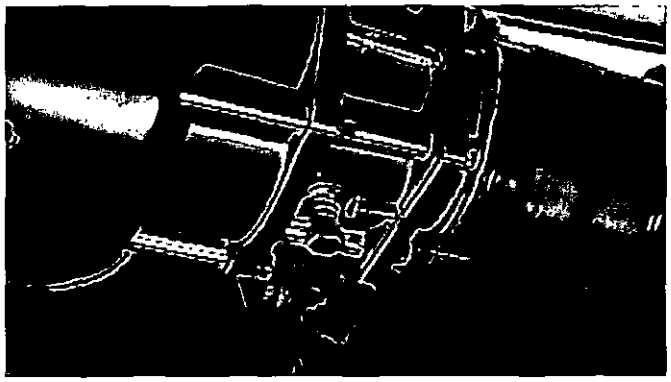


Photo #7-32 - Power Valve - IMPCO 400 VF (Vari - Fuel) Carburetor

Table #7-03 - Excess Oxygen - Without Catalytic Converter

	O_2 Reading - %				
Application	Industrial Continuous			Genset Stand-by	
RPM Model	1500	1800	1500	1800 (G1)	1800(G2)
GTA8.3	4.5	4.0	4.5	4.5	4.0

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 #7-02.

• Adjustment of Air-Gas Power Valve

• Impco Model # 400 VF (Vari-Fuel) Carburetor

On the model 400 VF (Vari-Fuel) 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.

• 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.

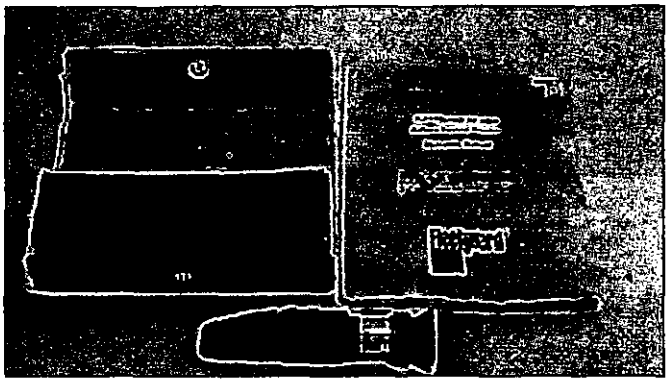


Photo #7-33- Fleetguard Refractometer (P.N. CC-2800)

• Drive Belt Tension - Checking

The GTA8.3 utilizes an automatic drive belt tensioner. It is not necessary to adjust the drive belt tension.

D - Maintenance Check - 6000 Hours or 2 Years

Inspect/Replace

• Spark Plug Wire - Replacement

Caution: To prevent damage to the spark plug wires during removal, do not pull on the wires.

Remove the coil end first, then remove the spark plug end.

Note: Replace the spark plug 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 and spark plug.

Apply a small amount of dielectric grease inside of the spark plug boot and on the outside of the spark plug boot.

Firmly press on the boot until a snap is heard and felt as the boot seats on the spark plug. Install the coil end.

Exchange/Rebuild

• Engine Water Pump - Inspection and Replacement

Every 6000 hours or three years, whichever first occurs, inspect the water pump for drive pulley wobble and water leakage around the water pump shaft. Replace the water pump with a new or rebuilt unit as necessary. Refer to the Cummins Troubleshooting and Repair Manual for removal and replacement instructions.

Preparatory Steps

1. Drain the coolant.
2. Unplug the coolant heater If so equipped.
3. Remove the drive belt.
4. Remove the water pump with a 10 mm wrench.
5. Install a new o-ring into the groove in the water pump.
6. Install the water pump.
   Torque Value: 24 N•m [18 ft-lb].
7. Lift the tensioner arm and pulley to install the drive belt.
8. *Fill the cooling system, check for leaks and install the* pressure cap.

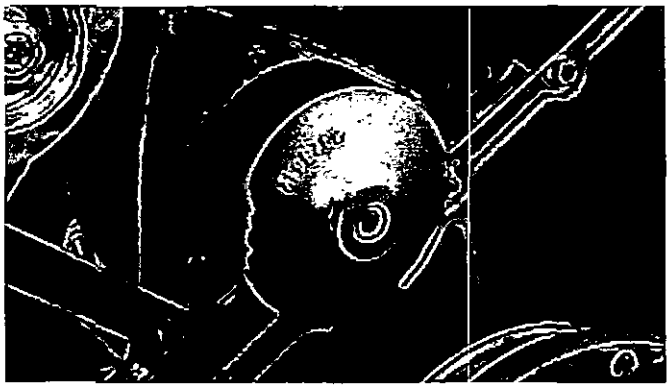


Photo #7-34 - Water Pump

• Fan Hub (Belt Driven) - Inspection

Every 6000 hours or three years, whichever first occurs, inspect the fan hub for wobble and grease leakage. Replace with a new or rebuilt unit as necessary. Refer to the Troubleshooting and repair Manual for removal and replacement instructions.

Preparatory Steps

1. Remove the drive belt.
   Note: Loosen the capscrews before removing the belt and torque the capscrews after the belt is installed.
2. Remove the four 10mm capscrews, fan and spacer. Replace the fan pulley.

   Torque Value: 24 N•m [18 ft-lb].

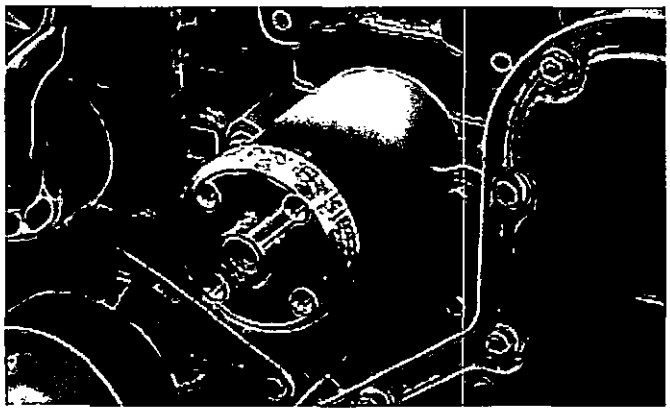


Photo #7-35 - Fan Hub

• Aftercooler 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.

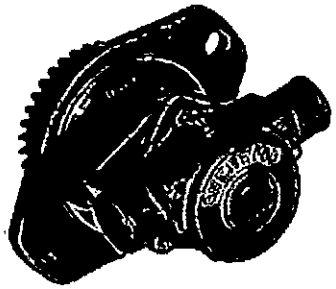


Photo #7-36 - Aftercooler Water Pump

• 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 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 dataplate.

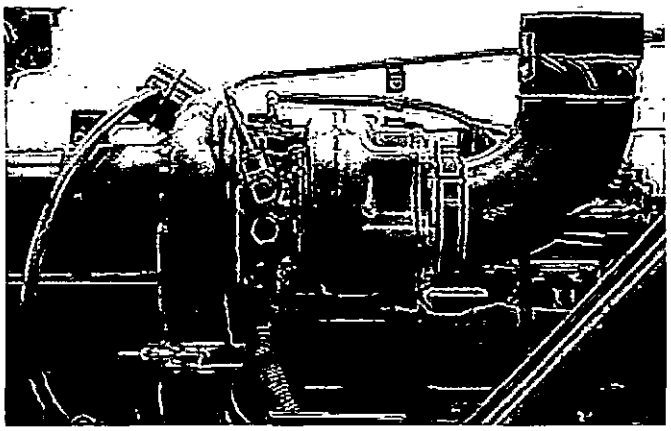


Photo #7-37 - Turbocharger

Table #7-04- Axial Clearance (Measure end to end)

Turbocharger	Dimension	
Model No.	Min.	Max.
HX40W	.03mm[.001in.]	.08mm[.003in.]

Rebuild or replace the turbocharger if axial clearance is greater than specified. Refer to the Cummins Troubleshooting and Repair Manual for removal procedures and to the Cummins Turbocharger Shop Manual, Bulletin # 3810321, for rebuild procedures.

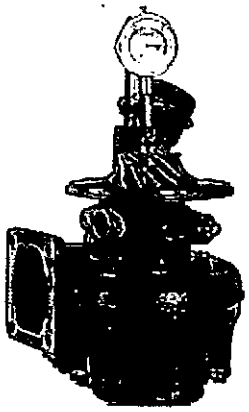


Photo #7-38 - Axial Clearance - Checking

Measure Radial Clearance (Side to Side).

Note: Hold the shaft toward the feeler gauge to check the dimension.

Table #7-05 - Radial Clearance

Turbocharger Model No. HX40W	Dimension Min./Max.(in.) Min.	Max.
Turbine Wheel	.21[0.008]	.46[.018]

Photo #7-39 - Radial Clearance - Checking

• Rubber Damper - Inspection

Every 4500 hours or 2 years inspect the rubber damper.

Check the index lines on the damper hub (inner member) and the inertia member (outer member). If the lines are more than 1.59mm [1/16 in.] out of alignment, replace the damper.

Inspect the rubber member for deterioration. If pieces of rubber are missing or if the elastic member is more than 3.18 mm [1/8 in.] below the metal surface, replace the damper.

Note: Also look for forward movement of the damper ring on the hub. Replace the damper if any movement is detected.

The **VIBRATION DAMPER** should be replaced at 15000 hours of operation if not replaced at earlier inspections.

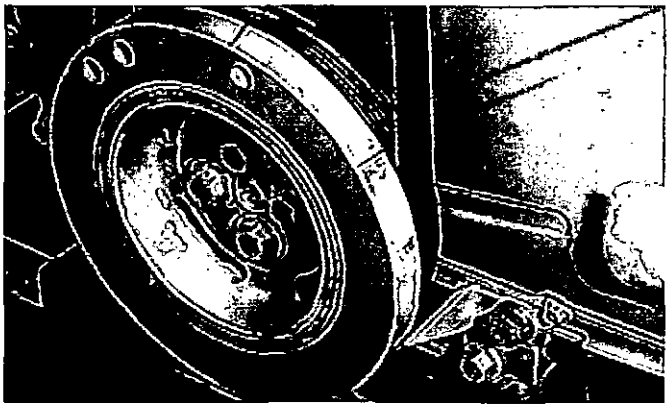


Photo #7-40 - Vibration Damper

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.

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 106 liters [28 U.S. gallons] will be adequate in most applications.

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.

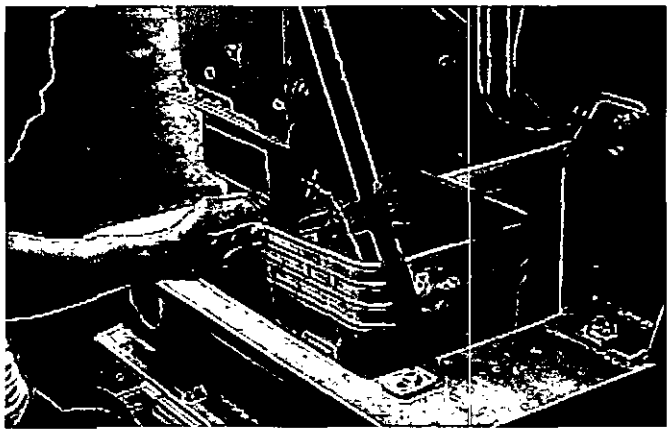


Photo #7-41 - Draining Cooling System

• 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.

Fill the system with a mixture of sodium carbonate and water or a commercially available equivalent.

Note: Use 0.5 kilograms [1.0lb] of sodium carbonate for every 23 liters [6.0 U.S. Gallons] of water.

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 80° C [176° 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 80° C [176° 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 #7-42 - Flushing Cooling System

• Coolant System Filling

The system has a maximum fill rate of 18.9 liters/min. [5 U.S. Gal./min.]. Do not exceed this fill rate.

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 10.9 liter [11.5 U.S. qt.]

Install the pressure cap. Operate the engine until it reaches a temperature of 80° C [176° 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 #7-43 - Filling Cooling System

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.

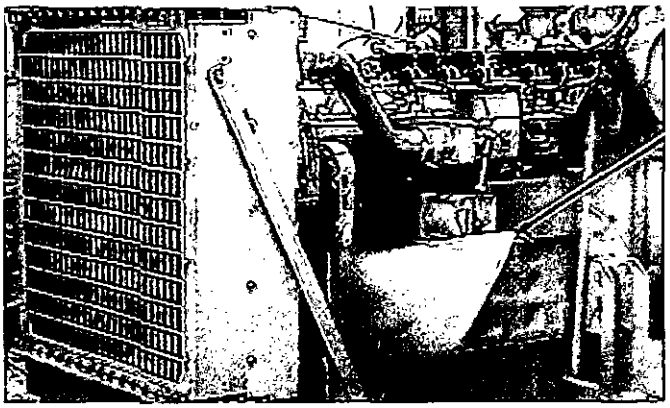


Photo #7-44 - Steam Clean Engine

• 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: 32 N•m [24 ft.-lb.]

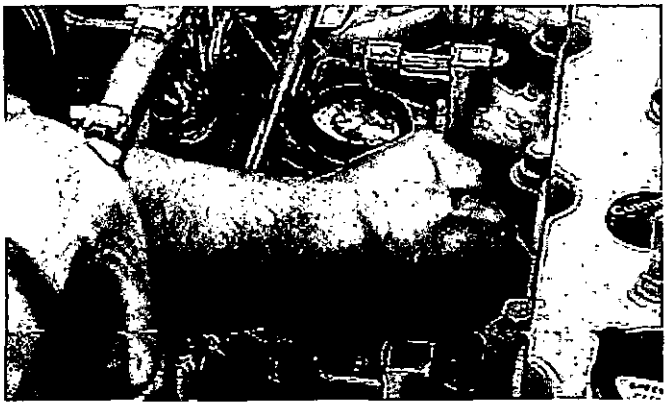


Photo #7-45 - Turbocharging Mounting Nuts - Checking Torque

• 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.

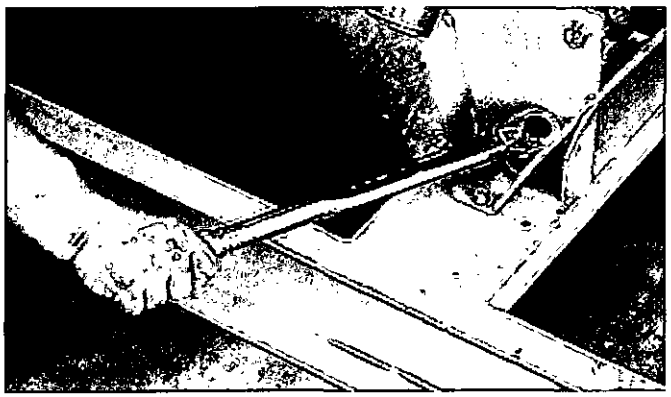


Photo #7-46 - Engine Mounting Bolts - Checking Torque

• 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 #7-47 - Hose Inspection

• Inspect/Replace All Drive Belts

Lift the tensioner arm and pulley to remove and install the drive belt. The belt tensioner winds in the direction that the spring tang is bent over the tensioner body. To loosen the tension on the belt, rotate the tensioner to wind the spring tighter.

Applying excessive force in the opposite direction of wind-up or after the tension has been wound-up to the positive stop can cause the tensioner arm to break.

• 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 section.

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.

• Cooling Fan - Inspection

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 crankshaft barring tools released and recommended by Cummins Engine Co.

A visual inspection of the cooling fan is required daily. Check for cracks, loose rivets, and bent or loose fan blades. Check the fan to make sure it is securely mounted. Tighten the capscrews to the

recommended capscrew torque as listed in the Technical Specifications in this manual. Replace any fan that is damaged.

• Thermostats and Seals - Checking/ Replacing

Remove the thermostats from the thermostat housings and check for proper opening and closing temperature.

All CNGE engines are equipped with a modulating range thermostat. It is considered a good practice to check the thermostat for opening and closing in the fall of each year.

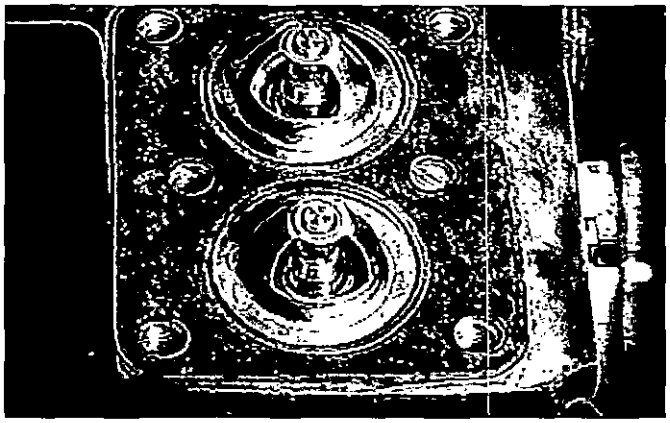


Photo #7-48 Thermostat

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. Replace the Vibration Damper at 15,000 hours.
4. Follow the manufacturer's recommended maintenance procedures for the starter, alternator, generator, batteries, electrical connections, carburetors, gas regulators, governors, and any other accessory item that may be supplied with your CNGE engine.
5. CNGE recommends that a daily log is maintained showing all maintenance performed.
6. 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 Shop Manual for information concerning engine storage procedures

Adjustment, Replacement & Repair Procedure - Section A

• Air System Repair

Turbocharger Replacement

Preparatory Steps

1. Disconnect exhaust and charge air core piping.
2. Drain coolant and disconnect turbocharger coolant lines.
3. Remove the capscrews from the oil drain tube.
4. Remove the oil supply line.
5. Remove the intake manifold pressure supply line from the boost capsule.
6. Remove the turbocharger and gasket.
7. Clean the sealing surface. Inspect the sealing surface and mounting studs for damage.
8. Install a new gasket and apply anti-seize compound to the mounting studs.
   Note: Use only anti-seize compound compatible with oxygen sensors.
9. Install the turbocharger and a new gasket.
   Torque Value: 32 N•m [24 ft-lb].
10. Install the drain tube and gasket on the turbo charger.
    Torque Value: 24 N•m [18 ft-lb].
11. Install the turbocharger coolant lines.
    Note: Keep coolant return line horizontal when tightening.
    Caution: To prevent bearing damage new turbochargers must be prelubricated before start-up. Pour 50 to 60 cc [2 to 3 ounces] of clean engine oil into the supply fitting. Rotate the turbine wheel to allow the oil to enter the bearing housing.

12. Install the oil supply line.
    Torque Value: 15 N•m [11 ft-lb].
13. Install the intake manifold pressure supply line.
14. Install the charge air core and exhaust piping
15. Operate the engine and check for leaks.

• Cooling System Repair

Belt Tensioner - Replacement

1. Remove the drive belt.
2. Remove the belt tensioner from the bracket using a 13 mm wrench.
3. Install the belt tensioner using a **Torque Value of 43 N•m [32 ft-lb].**

Drive Belt - Replacement

1. Lift the tensioner arm and pulley to remove and install the belt.

2. The belt tensioner winds in the direction that the spring tang is bent over the tensioner body. To loosen the tension on the belt, rotate the tensioner to wind the spring tighter.

Note: Applying excessive force in the opposite direction of wind-up or after the tensioner has been wound up to the positive stop can cause the tensioner arm to break.

Fan Pulley - Replacement

Preparatory Steps:

1. Remove the drive belt.

   Note: Loosen the capscrews before removing the belt and torque the capscrews after the belt is installed.

2. Remove the four capscrews, fan and spacer. Replace the fan pulley.

   Torque Value: 8 mm Capscrews - 24 N•m [18 ft-lb].
   10 mm Capscrews 43 N•m [32 ft-lb].

Thermostat Replacement

Preparatory Steps
1. *Disconnect the negative battery cable.*
2. Drain the cooling system to a position lower than the *thermostat housing.*
3. Remove the radiator hose from the outlet connection.
4. *Remove the drive belt.*
5. Loosen the lower alternator link capscrews.
6. *Remove the upper alternator mounting capscrews.*
7. Lower the alternator.
8. *Remove the thermostat housing, lifting bracket, thermostat and thermostat seal.*
9. *Clean the gasket surfaces.*

   Note: Do not let any debris fall into the thermostat cavity when cleaning gasket surfaces.

   Caution: Always use the correct thermostat and never operate the engine without a thermostat. An *incorrect thermostat can cause an engine to overheat* or run too cold. The engine will overheat if operated without a thermostat because the coolant flows back to the inlet of the water pump instead of through the radiator or heat exchanger for cooling.
10. *Package the thermostat, housing and lifting bracket.* Make sure that the gasket is aligned with the capscrew holes. Install the capscrews and use your fingers to tighten. The notched end of the rubber thermostat seal points away from the cylinder head.
11. *Tighten all capscrews.*
    Torque Value: 24 N•m [18 ft-lb].
12. Position the alternator and install the mounting capscrews.
    Torque Value:
    Larger capscrew @ top: 43 N3 N•m [32 ft-lb]
    Smaller capscrew @ bottom: 24 N•m [18 ft-lb]
13. Install the drive belt.
    Note: After the tensioner has been raised to remove/install the belt, check the torque of the tensioner capscrews.
    Torque Value: 43N•m [32 ft-lb]
14. Fill the cooling system. Operate the engine and check for leaks.

Caution: The system must be filled slowly to prevent air locks. During filling, air must be vented from the coolant passages.

The system has a maximum capacity fill rate of 18.9 liters /min.[5 U.S. gal/min.]. Do **not** exceed this fill rate. Wait 2 to 3 minutes to allow air to be vented. Then add coolant to bring the level to the top.

Water Pump - Replacement

Preparatory Steps:

1. Drain the coolant.
2. Remove the drive belt.
3. *Remove the water pump.*
4. Clean the sealing surfaces on the cylinder block.
5. Install a new o-ring into the groove in the water pump.
6. Install the water pump.
   Torque Value: 24N•m [18 ft-lb].
7. Lift the tensioner arm and pulley to install the drive belt.

Caution: The system must be filled slowly to prevent air locks. During filling, air must be vented from the engine coolant passages.
The system has a maximum fill rate of 18.9 liters / min. [5 U.S. Gal./min.]. Do not exceed this fill rate. Wait 2 to 3 minutes to allow the air to be vented. Then add coolant to bring the level to the top.

8. Fill the cooling system with a mixture of 50% water and 50% ethylene-glycol type antifreeze. This will provide freeze protection to - 36 °C [-34 °F].

Coolant capacity (Engine Only) 10.9 liters [11.5 U.S.Qts.]

Aftercooler Pump - Replacement

Preparatory Steps:

1. Drain the coolant.
2. Remove the supply line connection.
3. Remove the discharge line connection.
4. Remove the aftercooler pump.
5. Clean the sealing surfaces on the cylinder block.
6. Install the aftercooler pump along with a new gasket.
   Torque Value: 77 N•m [57 ft-lb].
7. Connect the supply and discharge lines.
   Caution: The system must be filled slowly to prevent air locks. During filling, air must be vented from the engine coolant passages.
8. The system has a maximum fill rate of 18.9 liters / min. [5 U.S. Gal./min.]. Do not exceed this fill rate. Wait 2 to 3 minutes to allow the air to be vented. Then add coolant to bring the level to the top.
9. Fill the cooling system with a mixture of 50% water and 50% ethylene-glycol type antifreeze. This will provide freeze protection to - 36°C [-34°F].

Coolant capacity (Engine Only) 10.9 liters [11.5 U.S.Qts.]

• Electrical System Repair

Alternator - Replacement

Preparatory Steps

1. Disconnect the ground cable from the battery terminal.
2. Identify each electrical wire and tag indicating location.
3. Remove the drive belt.
4. Remove the capscrew from the alternator link.
5. Remove the alternator mounting capscrews.
6. Remove the alternator.
7. Position the alternator on the bracket and secure it with the mounting capscrews.
   Note: Do not tighten at this time.
8. Connect the alternator link to the alternator. Finger tighten.
   Note: Make sure the alternator link is properly positioned for correct belt alignment.
9. Tighten the alternator mounting capscrew.

   Torque Value:
   A = Lower Smaller Capscrew 24 N•m [18 ft-lb].
   B = Higher Larger Capscrew 43 N•m [32 ft-lb].

Starter - Replacement

Preparatory Steps

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.
5. Install the starting motor in the reverse order of removal.

   Torque Value: 77 N•m [57 ft-lb].

• Lubricating System Repair

Oil Cooler Element and Gasket - Replacement

Preparatory Steps.

1. Drain the coolant.
2. Remove the oil filter.
3. Clean all debris from around the cooler.
4. Disconnect the turbocharger oil supply line from the oil filter head.
5. Remove the oil cooler cover, element and gaskets.
6. Clean the sealing surfaces.
7. Pressurize the element to 690 kPa [100 psi] to check it for leaks.
8. Assemble the oil cooler gasket, element, cooler cover gasket and cooler cover to the cylinder block.
   Note: Be sure to remove the shipping plugs from the new cooler element.
   Torque Value: 24 N•m [18 ft-lb].
9. Connect the turbocharger oil supply line.
   Torque Value: 15 N•m [11 ft-lb].
10. Install a new oil filter. Follow the manufacturer's instructions for tightening.
    Caution: The system must be filled slowly to prevent air locks. During filling, air must be vented from the engine coolant passages.
    Note: This system has a maximum fill rate of 18.9 liters/min. [5.0 U.S.Gal./min.]. Do not exceed this fill rate. Wait 2 to 3 minutes to allow air to be vented. Then add coolant to bring the level to the top.
11. Fill the coolant system and operate the engine to check for leaks.
12. Stop the engine and check the coolant and oil level.

Oil Pressure Regulator, Valve and Spring - Replacement

Preparatory Steps:

1. Clean debris.
2. Remove the plug and regulator valve.

   Caution: *In order to regulate the oil pressure, the* valve must move freely in the bore.

3. Clean and inspect the bore and regulator valve before assembly.
4. Install the regulator and spring.

   Torque Value: 80 N•m [60 ft-lb].

• Repair Tools Required

Sockets	Wrenches	Other
10 mm	8 mm	Breaker Bar (3/8 in./sq. Drive)
12 mm	10 mm	Flat Screwdriver
13 mm	12 mm	Filter Wrenches (75-80 mm and 90-95 mm)
14 mm	13 mm	Torque Wrench
15 mm	15 mm	3/8 inch Sq. Dr. 20 to 135 N•m [100 ft-lb]
17 mm	16 mm	1/2 inch Sq. Dr. 40 to 338 N•m [250 ft-lb]
18 mm	17 mm	Ratchet (1/2 Square Drive)
19 mm	19 mm	Ratchet (3/8 Square Drive)
22 mm	22 mm	Feeler Gauges
27 mm	24 mm	Engine Barring Tool P.N. 3377371
7/16 inch	27 mm	5/16 Nut Driver
9/16 inch	3/8 inch	Compression Gauge
	7/16 inch	6" Extension (3/8" Drive)

Notes:

Section 8 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:

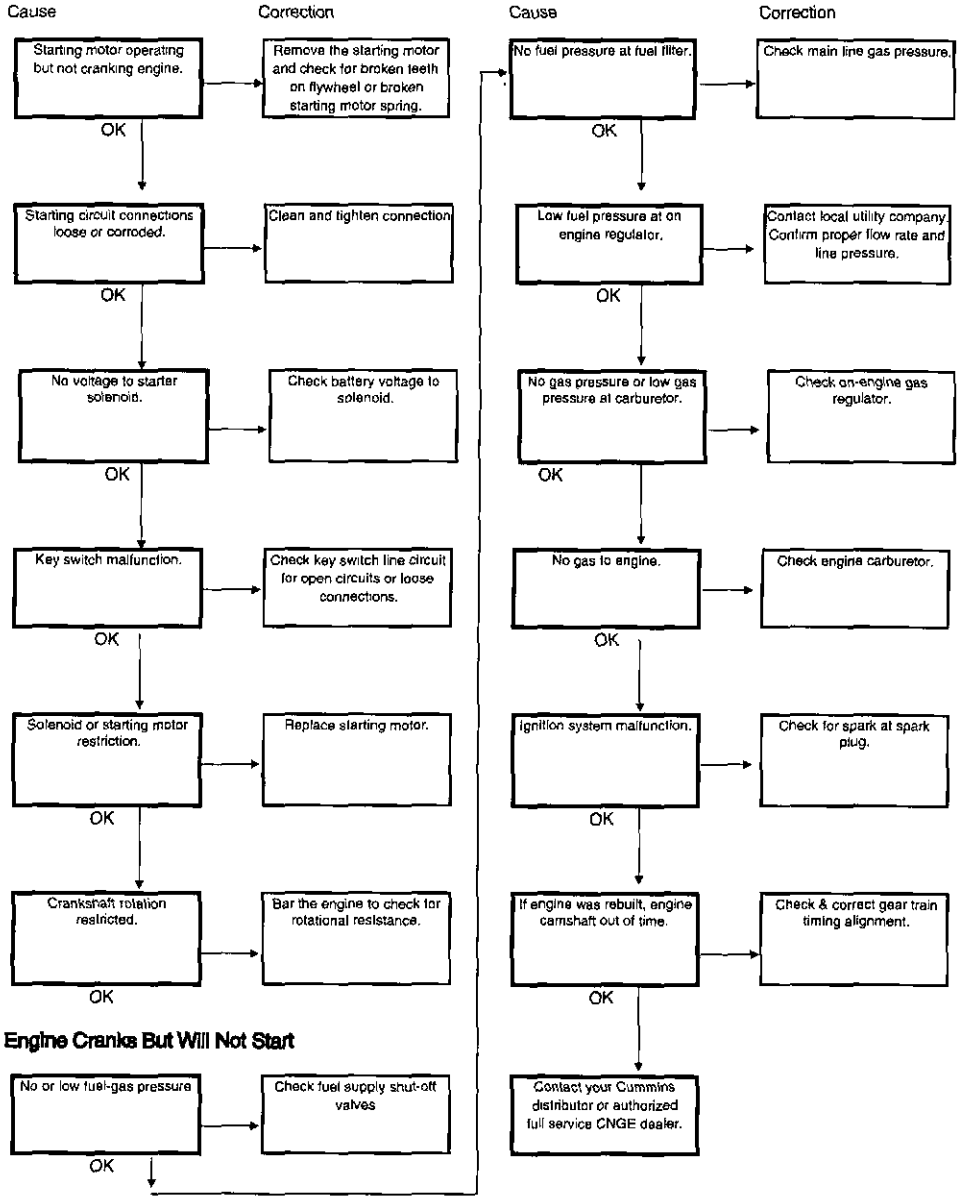
- Study the problem thoroughly before acting.
- Refer to the engine system diagrams.
- Do the easiest and most logical things first.
- Find and correct the cause of the problem.

Instructions

Read each row of blocks from top to bottom. Follow the arrows through the chart to identify corrective action.

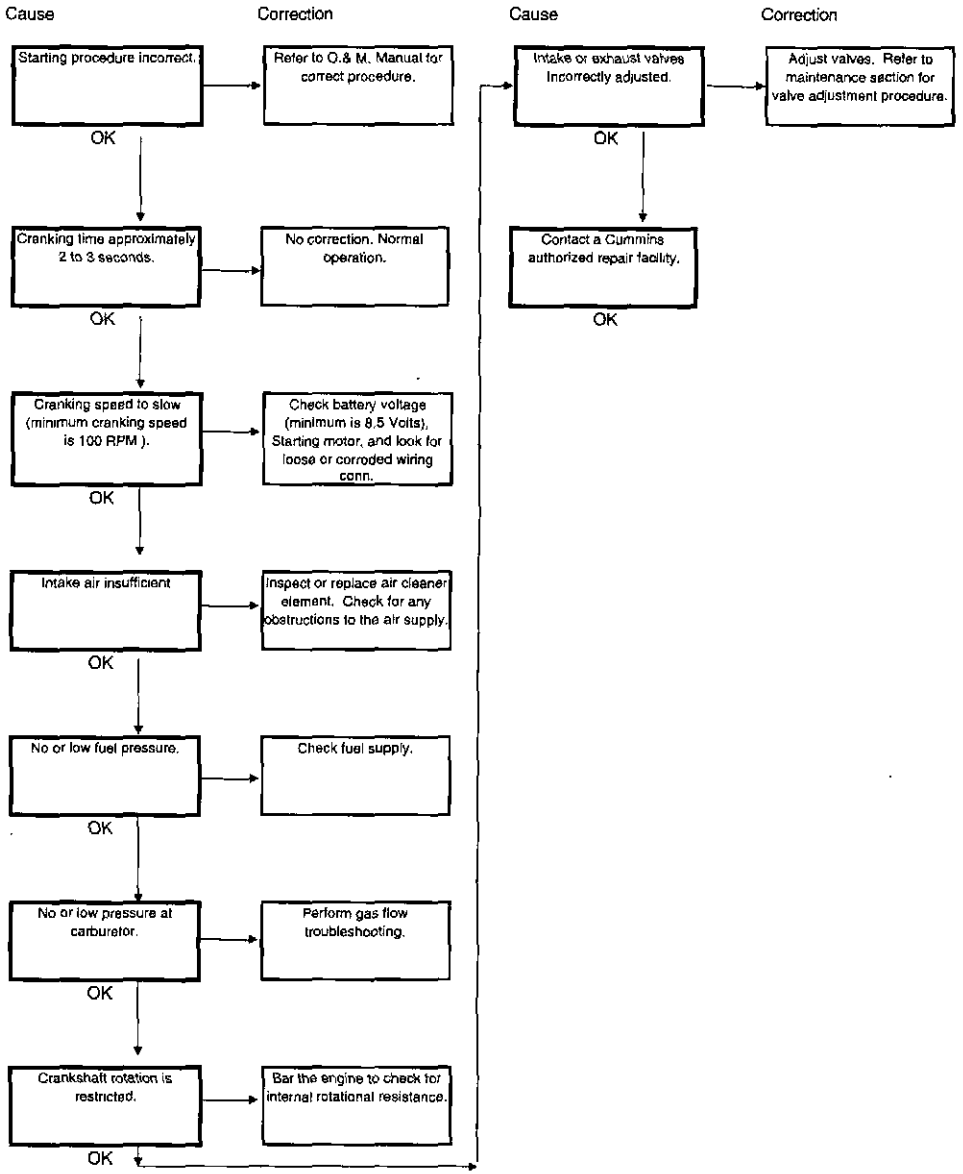
Symptoms Listing

Engine Will Not Crank

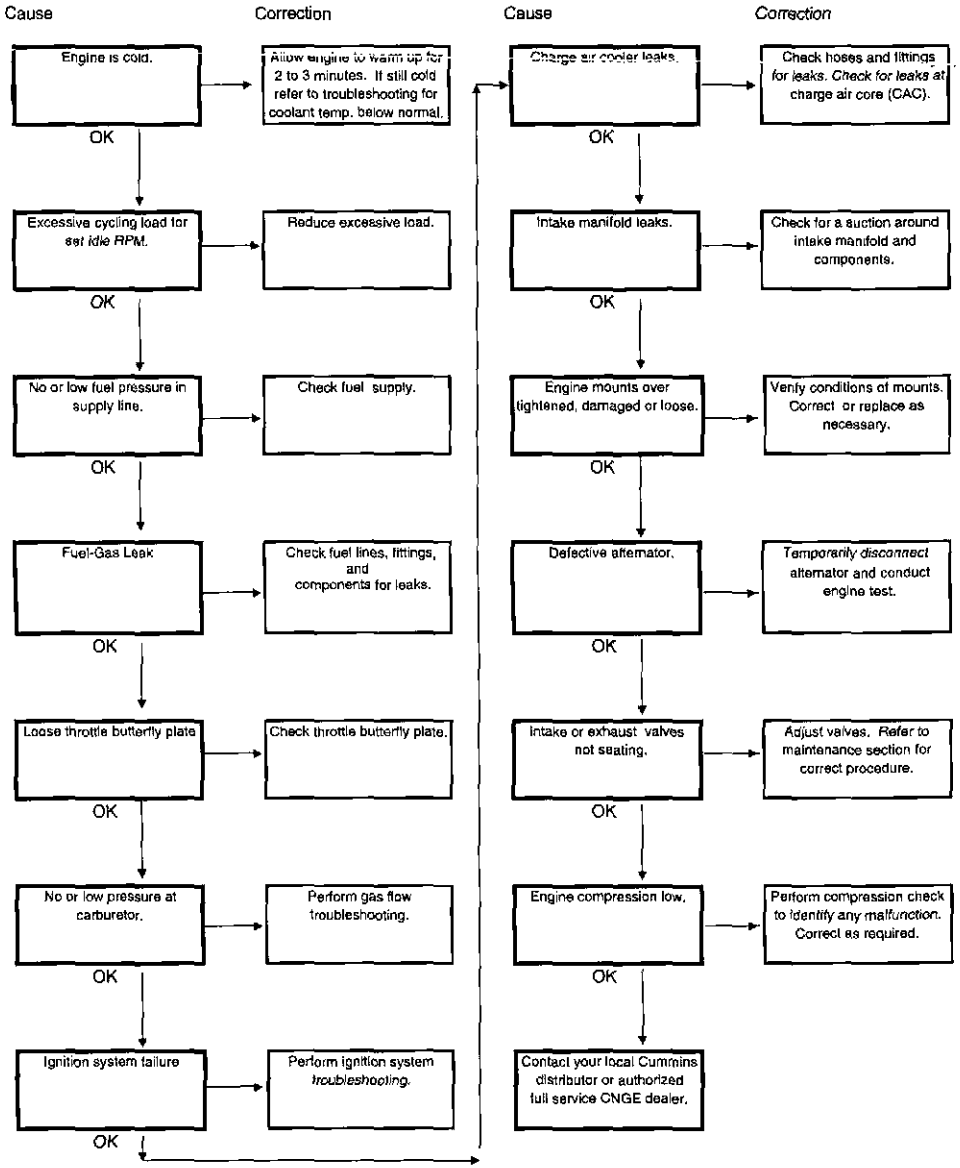


Engine Cranks But Will Not Start

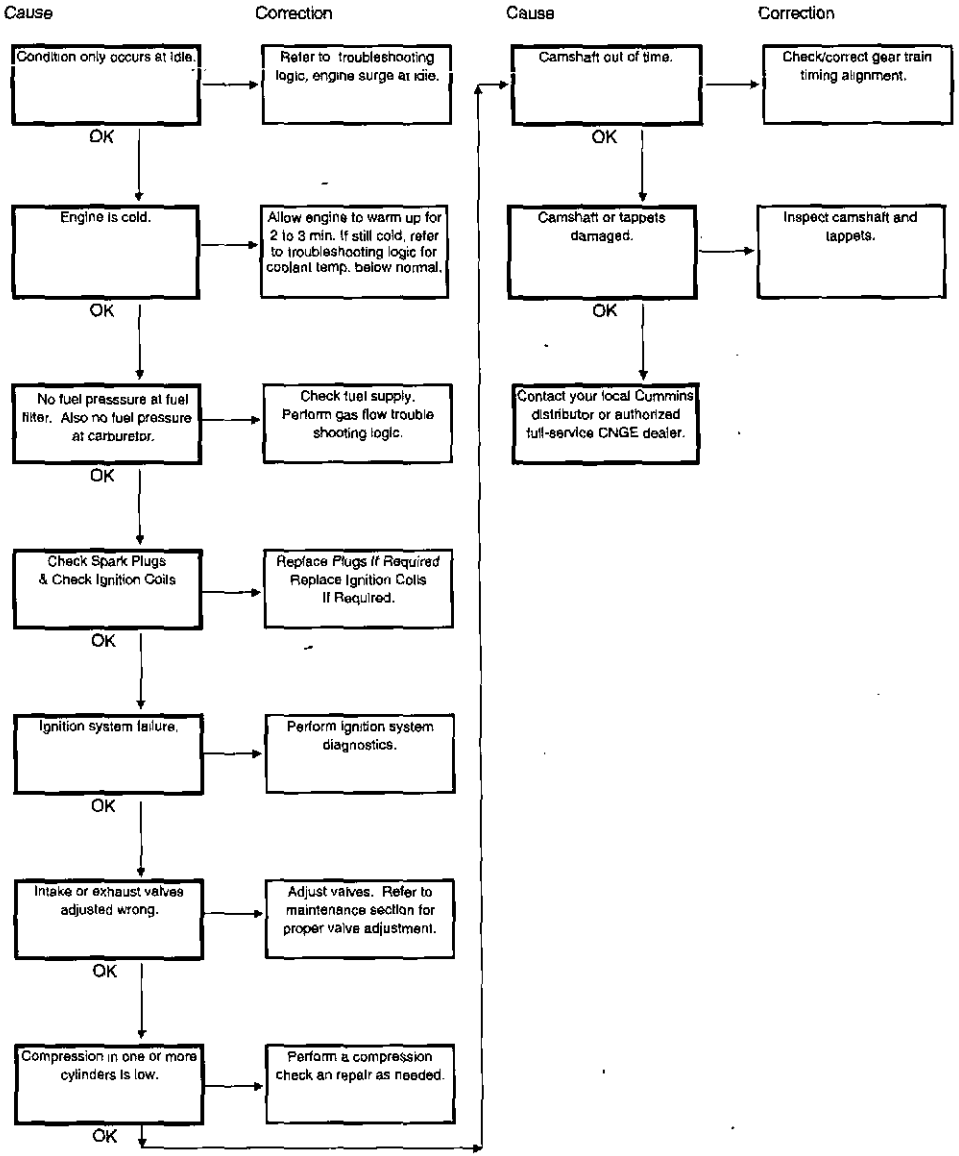
Hard to Start - Long Cranking Time



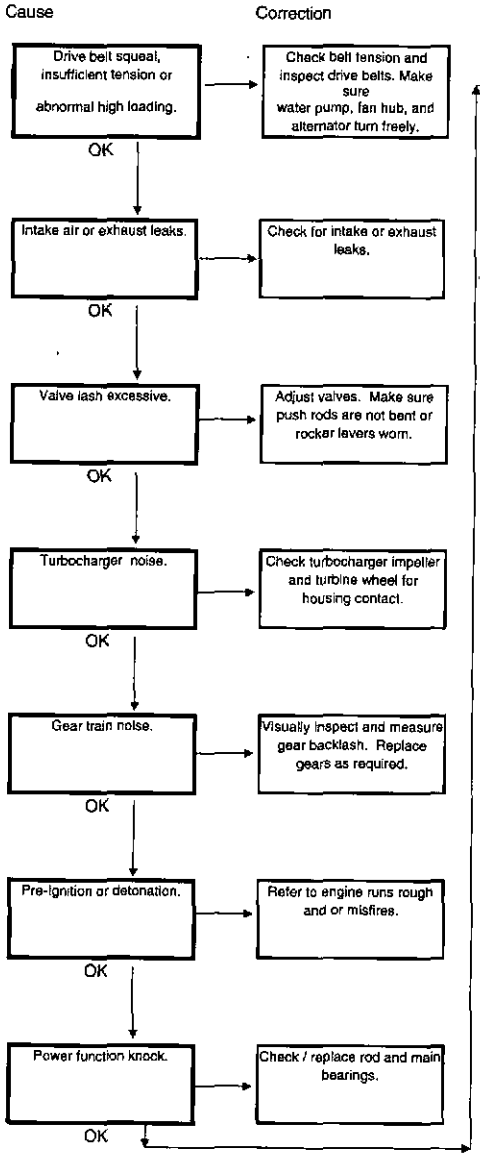
Engine Surge at Low Idle , Engine Shaking or Rough Idle



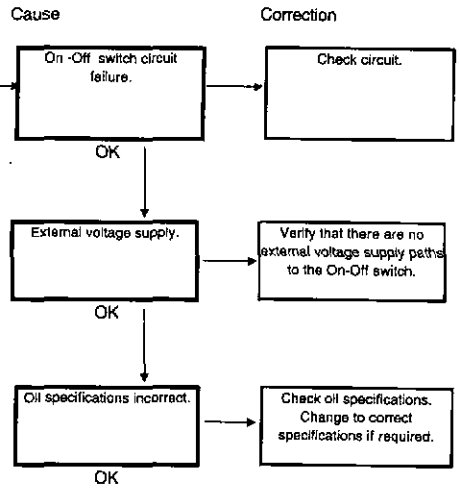
Engine Runs Rough or Misfires



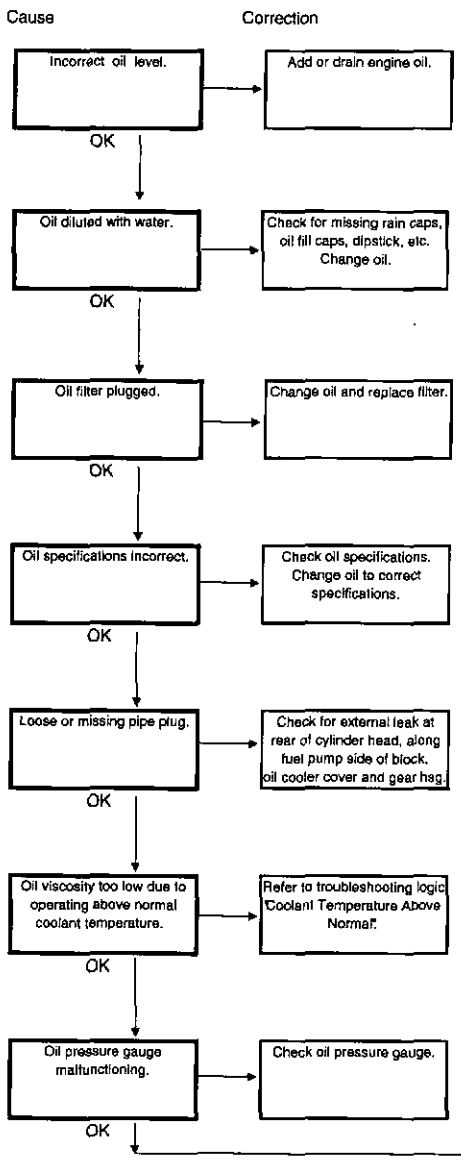
Engine Noise Excessive

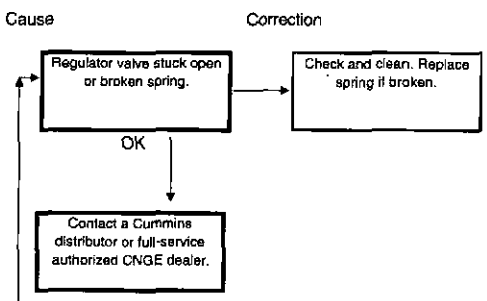


Engine Will Not Shut Off

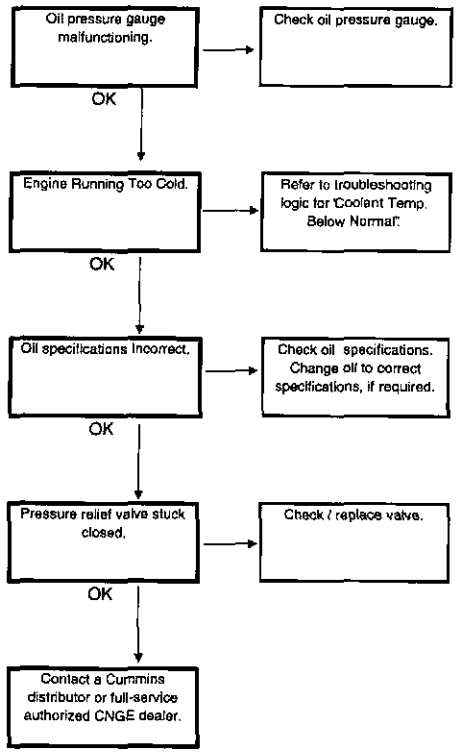


Lubricating Oil Pressure Low

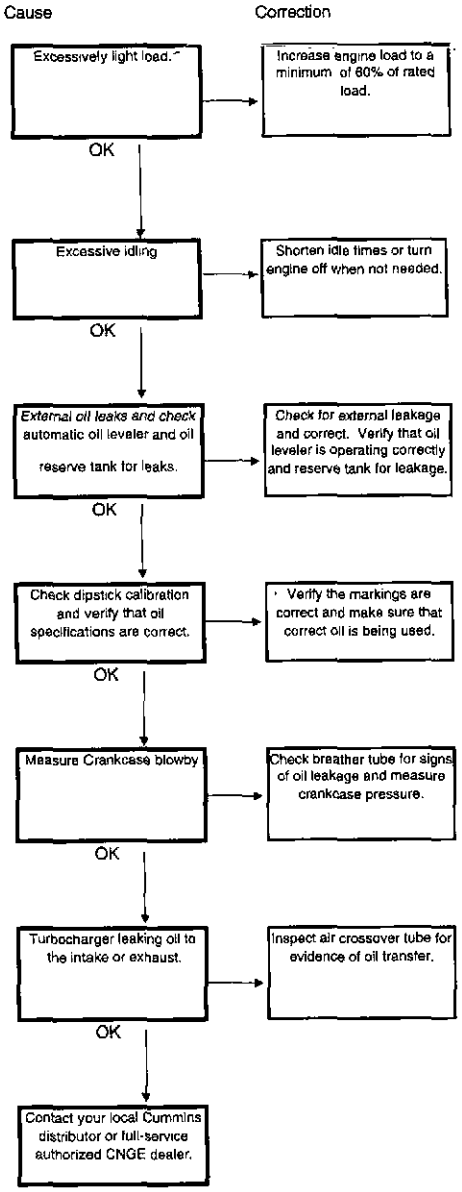




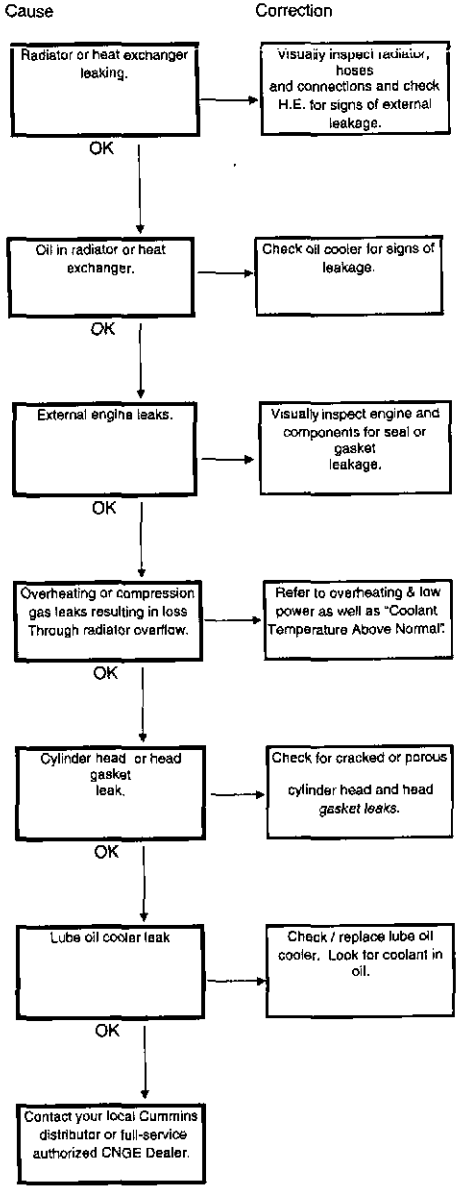
Lubricating Oil Pressure Too High



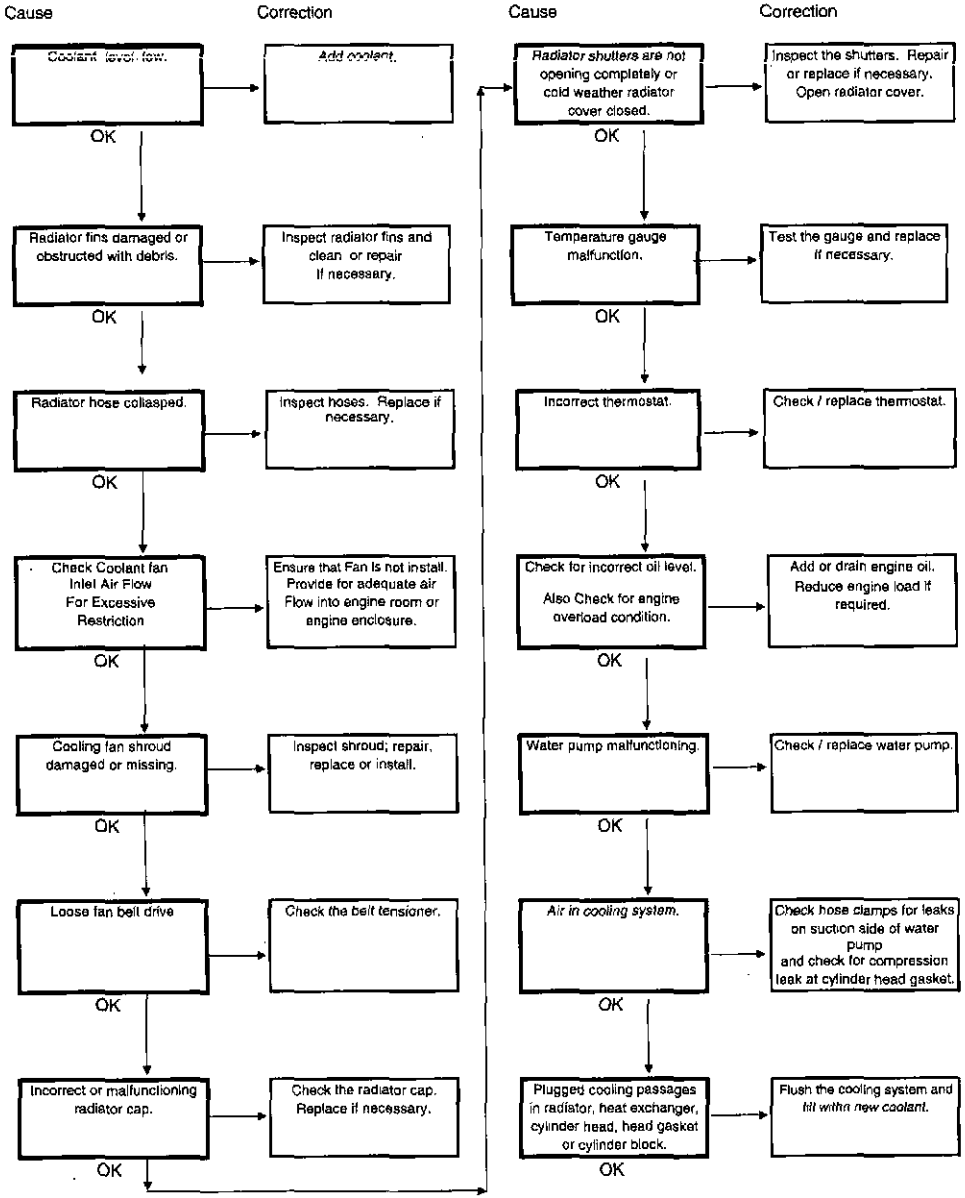
Lubricating Oil Consumption Excessive



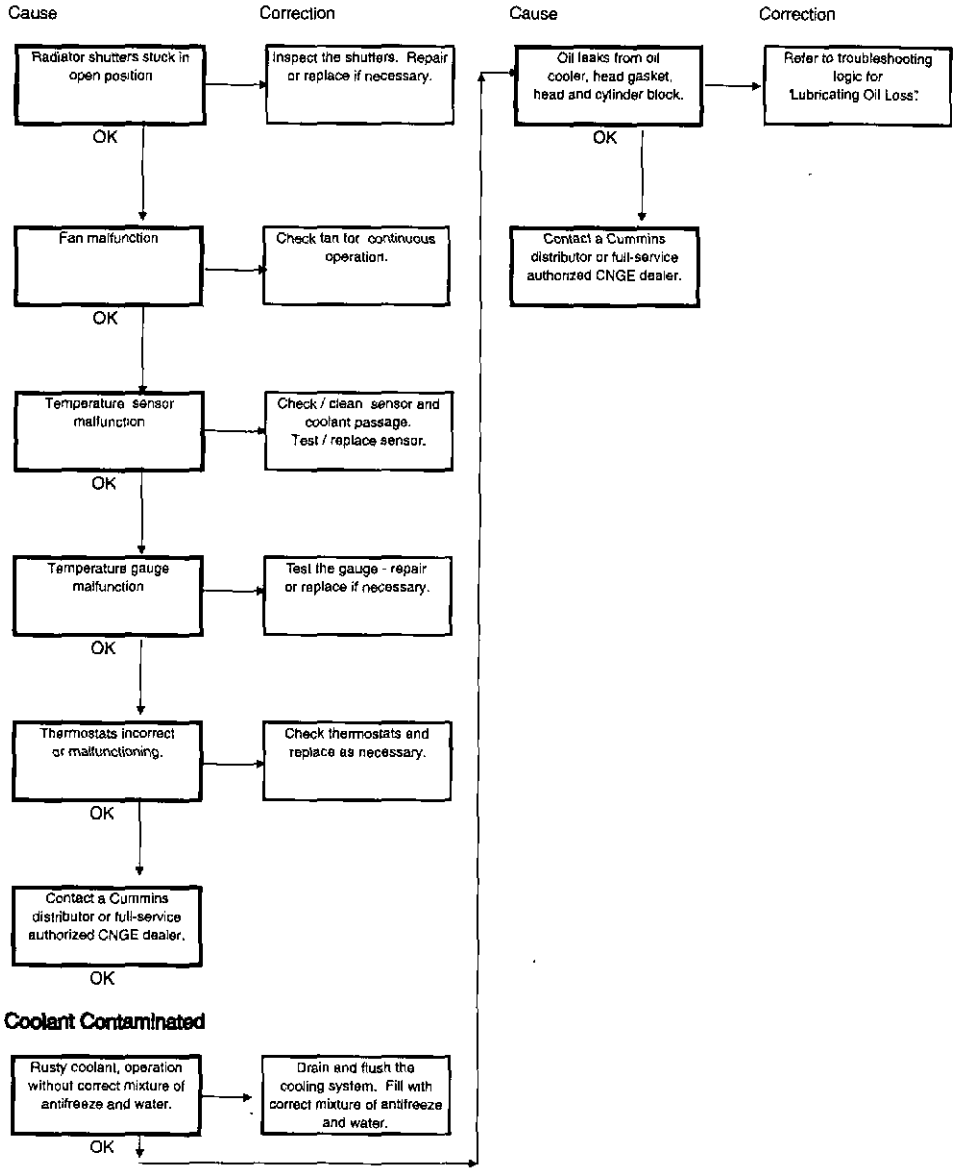
Coolant Loss



Coolant Temperature Above Normal

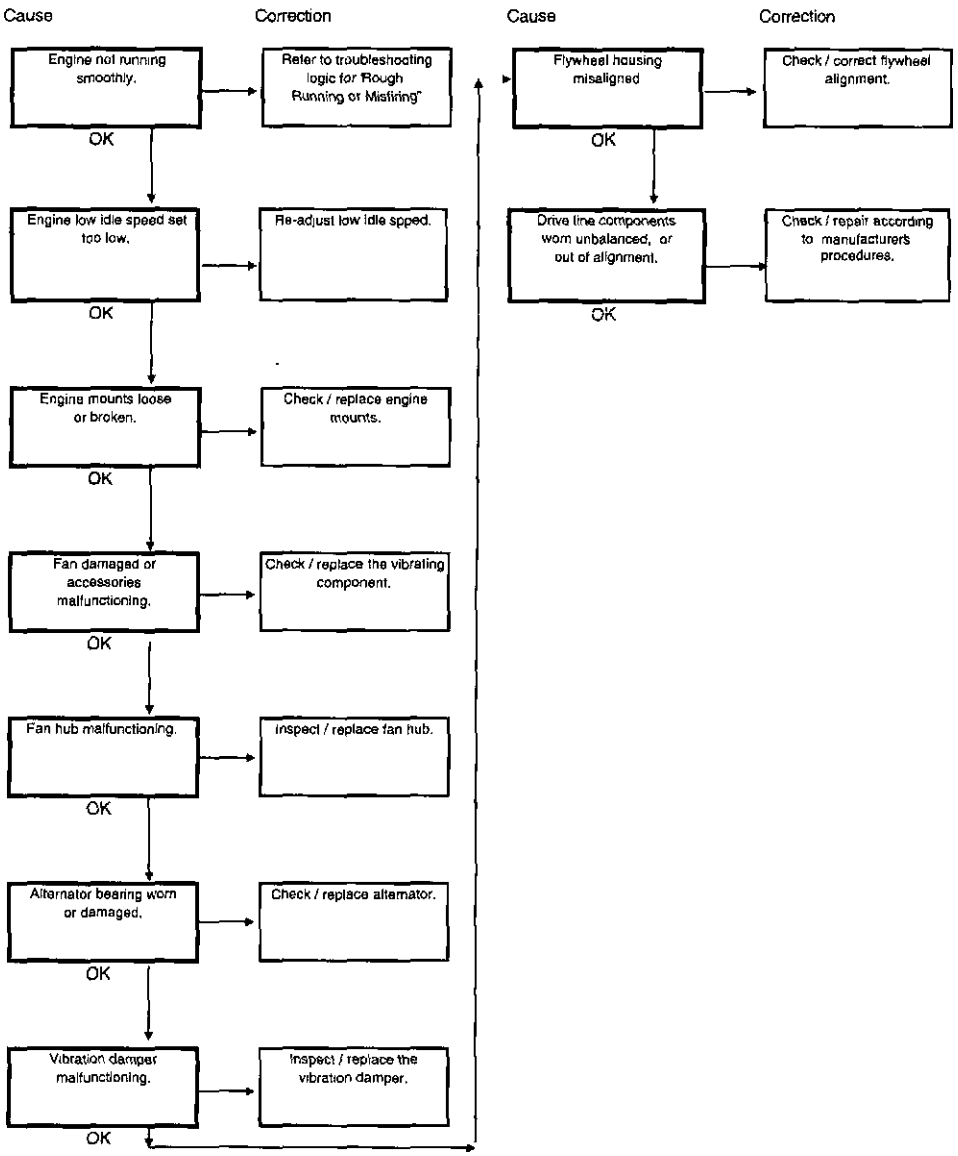


Coolant Temperature Below Normal

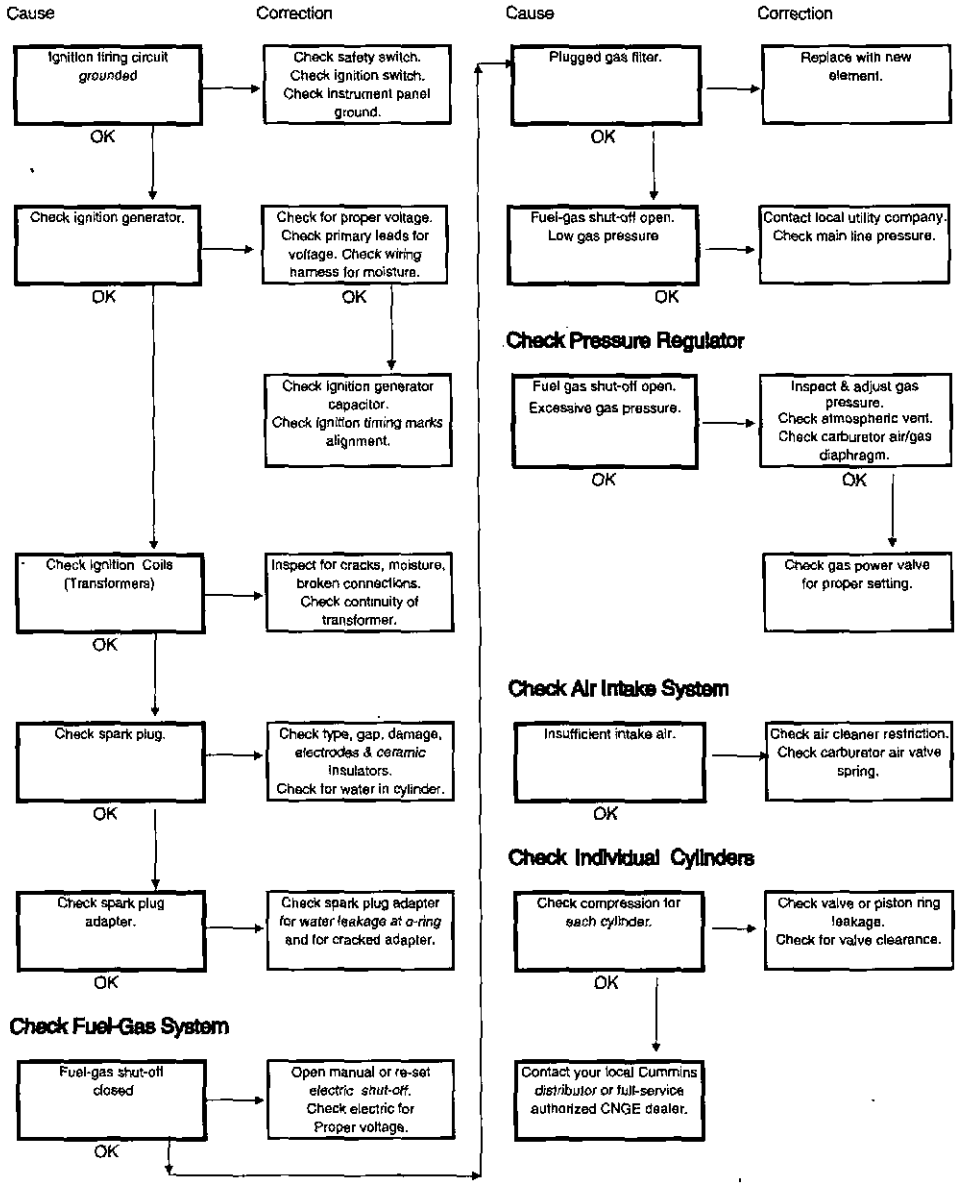


Coolant Contaminated

Engine Vibration Excessive



Check Ignition System



Check Fuel-Gas System

Check Pressure Regulator

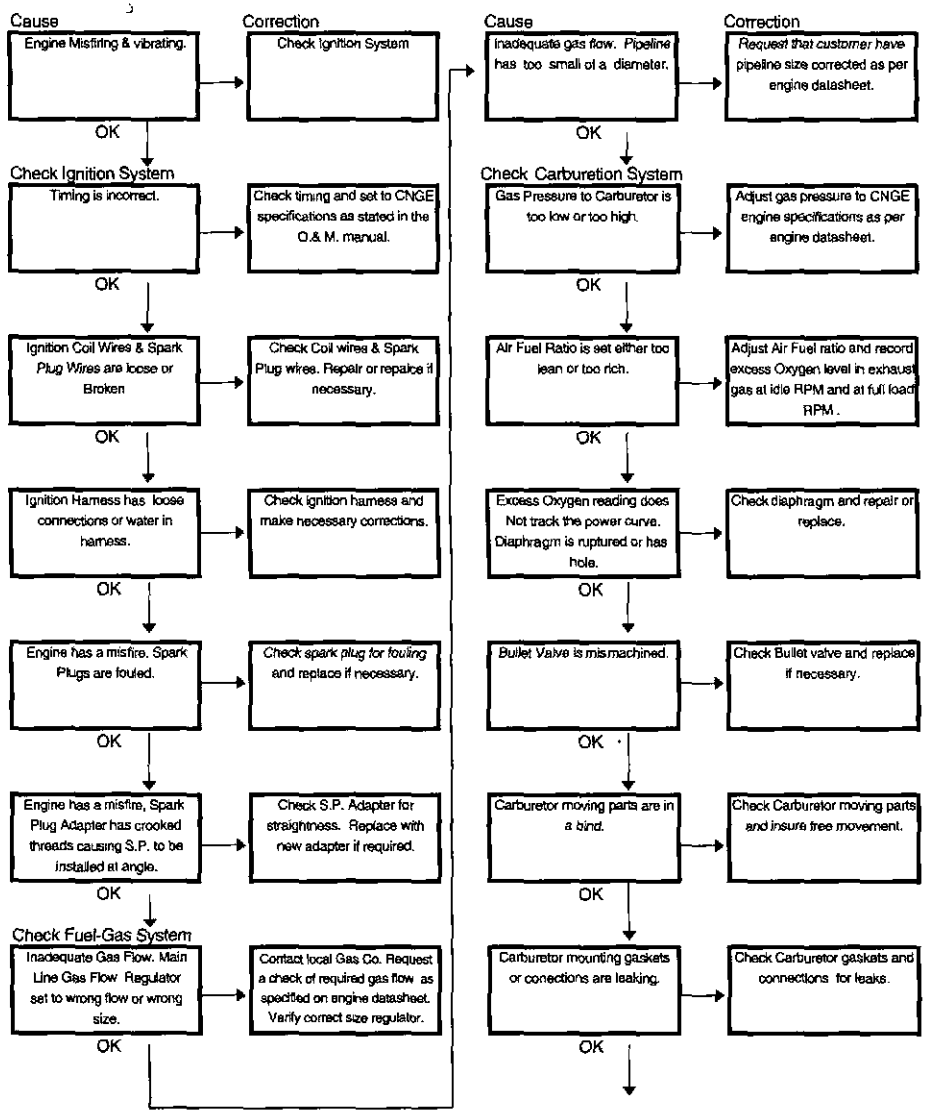
Check Air Intake System

Check Individual Cylinders

Governor Instability

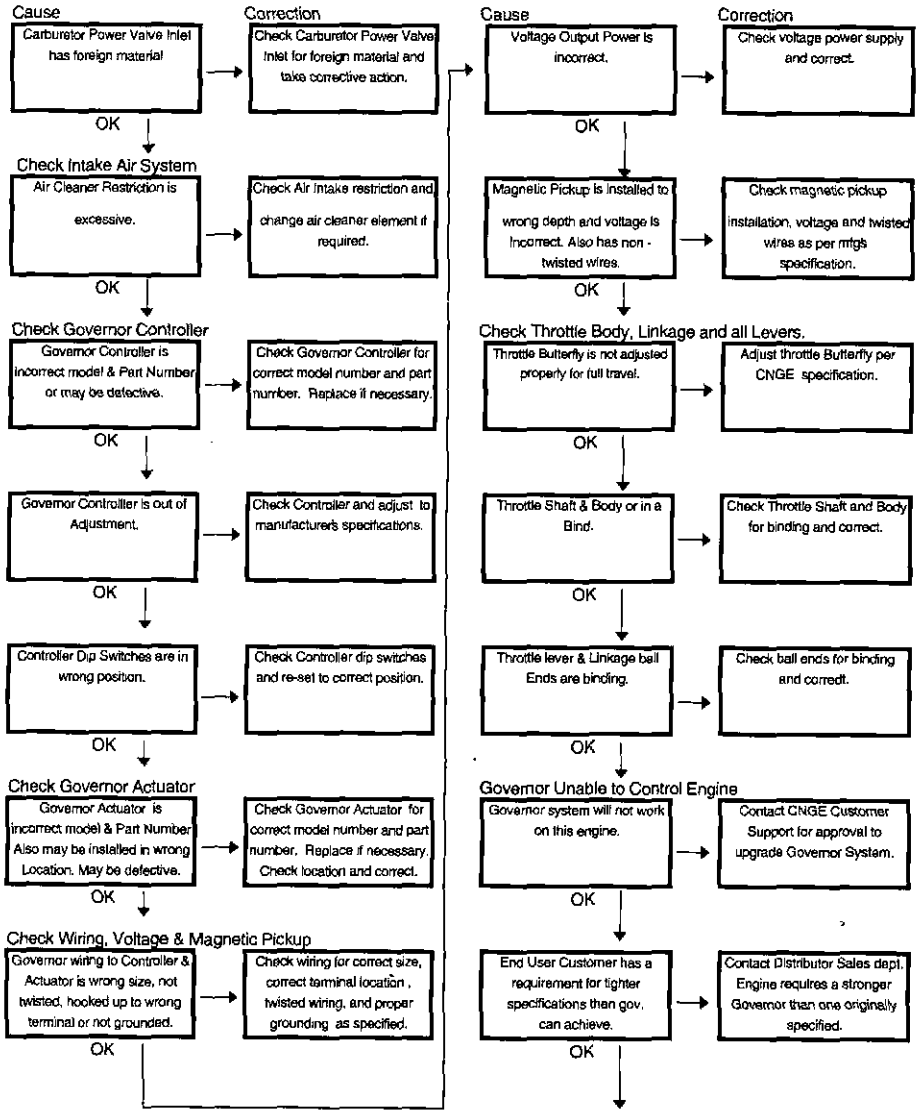
Governor - Unstable - Engine Surges

Fuel System - Dry Processed Natural Gas



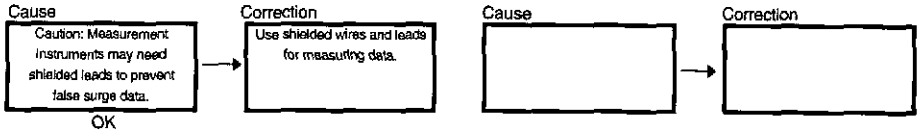
Governor Instability

Fuel System - Dry Processed Natural Gas



Governor Instability

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 interfer with Governor operation.

Section 9
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 Cylinders

Honeywell, Inc.
6 Center Point Dr.
LaPalma, California
90623
(800) 367-4757

Air Heaters

Fleetguard, Inc.
1200 Fleetguard Road
Cookeville, TN 38502
(615)526-9551

Air Starting Motors

Ingersoll-Rand Engine
Starting Systems
888 Industrial Drive
Elmhurst, Il 60126
(312)530-3800

Air-Gas Starting Motors

Ingersoll-Rand Engine
Starting Systems
888 Industrial Drive
Elmhurst, Il 60126
(708)530-3875

Alternators

Delco-Remy
P.O. Box 2439
Anderson, IN 46018
(317)646-3528

Robert Bosch Ltd.
P.O.Box 96
Broadway Park
North Orbital Road
Denham
Uxbridge
Middlesex
UD9 5H6
England
(01895)833633

Belts

Dayco Mfg.
Belt Tech. Center
1955 Enterprise
Rochester Hills, MI 48309
(810) 853-8300

Carburetors

Impco Technologies Inc.
16804 Gridley Place
Cerritos, California 90701
(213) 860-6666

Coolant Heaters

Fleetguard, Inc.
1200 Fleetguard Road
Cookeville, TN 38502
(615) 526-9551

Kim Hotstart, Inc.
E. 5724 Broadway
Spokane, Washington 99212
(509) 534-6171

Electric Starting Motors

Delco-Remy
P.O.BOX 2439
Anderson, IN 46018
(317)646-3528

Fans

Hayes-Albion
1999 Wildwood Avenue
Jackson, MI 49202
(517)782-9421

Brookside
P.O. Box 30
McCordsville, IN 46055
(317)335-2014

Filters

Fleetguard, Inc.
1200 Fleetguard Road
Cookeville, TN 38502
(615)526-9551

Gas Regulators

Fisher Mfg.
Vinson Supply
P.O.Box 94895
Tulsa, Oklahoma 74194
(806) 383-2276

Gas Regulators (cont.)

Maxitrol Co.
P.O.Box 2230
Southfield, Mich. 48037
(313) 356-1400

Gauges

Frank W. Murphy Mfg.
P.O.Box 470248
Tulsa, Oklahoma 74147
(918) 627-3550

The Nasson Co.
P.O.Box 505
West Union, South Carolina 29696
(803) 638-9521

Governors

Woodward Governor Co.
1000 E. Drake Road
P.O.Box 1519
Fort Collins, CO 80522
Telephone:(303)482-5811

Barber Colman Co.
1354 Clifford Ave.
Rochford, IL 61132
(815)537-3000

Heat Exchangers

Modine Mfg. Co.
1500 DeKoven Ave.
Racine, Wisconsin 53401
(414) 636-1200

Young Radiator Co.
2825 4 Mile Road
Racine, Wisconsin 53404
(414) 639-1011

Ignition Systems

Altronic, Inc.
1200 Stambaugh Bldg
Youngston, Ohio 44501
(216) 545-9768

Fairbanks Morse
Engine and Accessory Operations
6402 Rockton Road
Bosco, Illinois 61073
(815) 389-4927

Oil & Coolant Heaters

Fleetguard, Inc.
1200 Fleetguard Road
Cookeville, TN 38502
(615)526-9551

Kim Hotstart Co.
West 917 Broadway
Spokane, WA 99210
Telephone:(509)534-6171

Radiators

Radiator Specialties
P.O.Box 28698
Sacramento, California 95828
(916) 381-4790

G. & O.
160 Gando Drive
New Haven, Connecticut 06513
(203) 562-5121

Spark Plugs

Champion Spark Plug Co.
910 Upton Ave.
Toledo, Okio 43607
(419) 535-2458

Stitt Spark Plug Co.
P.O.Box 327
Conroe, Texas 77305
(409) 756-7796

Shut -Off Valves

Automatic Switch Co.
P.O.Box 13681
Newark, New Jersey 07188
(602) 483-2980

L.P.Gas & Equipment Co.
3216 S. Nordic Road
Arlington Heights, Illinois 60005
(708) 437-2345

Tachometers

Altronic, Inc.
1200 Stambaugh Bldg.
Youngston, Ohio 44501
(216) 545-9768

Section 10
Service Assistance

Table of Contents Page

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-hour, toll-free number for service assistance. In 48 states, you can call Cummins Customer Relations toll free by dialing 1-800-343-7357. In Alaska, Hawaii, and Canada, call collect 1-812-379-6115.

Cummins Owner Assistance

Cummins Natural Gas Engines backs its engines with expert service and complete parts and support through the Cummins Distributor Network on a worldwide basis. Cummins people are trained to provide the CNGE owner with sound advise, expert service, and professional treatment at all 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 that 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 dealer.

   B. Type and make of equipment.

   C. CNGE engine model and serial number.

   D. Total hours of operation.

   E. Nature of the problem.

   F. Summary of the current problem, arranged in 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
Box Number 3005
Columbus, Indiana 47202-3005

We do request that the above steps be followed in order. Most of the actual work done on an engine can be performed at the original location, so please give them a chance to satisfy you first.

CNGE Regional Offices—CNGE Representatives for the following regions are located at the CNGE Headquarters Office in Fort Worth, Texas, 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, Texas 76180
Telephone: (817) 581-7575
Fax: (817) 581-4548
Telex: U.S.A.: 62129850
International: 469579

Cummins Natural Gas Engines, Inc.
Parts Distribution Center
409 South Norris Street
Clovis, New Mexico 88101
Telephone: (505) 769-2173
Fax: (505) 762-4203

Cummins Distributor Service Assistance

Cummins Distributors in Canada, Puerto Rico, and 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:

Index

Contents Page

Contents Page

Contents Page

Contents Page

Contents Page

G

H

I

Contents Page

J

K

L

M

Contents Page

N

O

Contents Page

P

Q

R

S

Contents Page

Contents Page

T

U

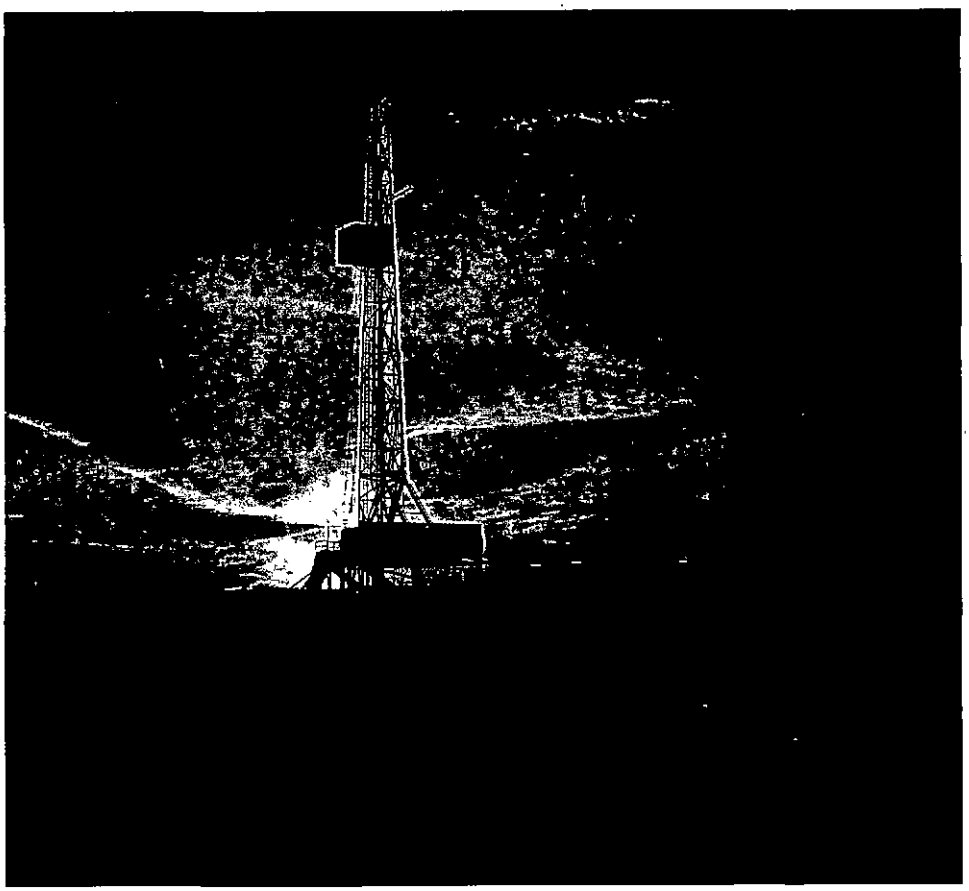
V

W

X

Y

Z



Natural Gas Engines

CUMMINS NATURAL GAS ENGINES, INC.
8713 Airport Freeway, Suite 316
Fort Worth, Texas 76180
(817)581-7575
Fax (817)581-4548

Bulletin #OM980201-3, 12/2001