Service Manual

Generator Set with QSJ5.9G Engine and PowerCommand® 1.1

C45 N6 (Spec A)
C50 N6 (Spec A)
C60 N6 (Spec A)
C70 N6 (Spec A)
C80 N6 (Spec A)
C100 N6 (Spec A)

English
Original Instructions

7-2018

A051X880 (Issue 8)

Table of Contents

1 Important Safety Instructions

1.1 Warning, Caution, and Note Styles Used in This Manual

The following safety styles and symbols found throughout this manual indicate potentially hazardous conditions to the operator, service personnel, or equipment.

⚠ DANGER
Indicates a hazardous situation that, if not avoided, will result in death or serious injury.

⚠ WARNING
Indicates a hazardous situation that, if not avoided, could result in death or serious injury.

⚠ CAUTION
Indicates a hazardous situation that, if not avoided, could result in minor or moderate injury.

NOTICE
Indicates information considered important, but not hazard-related (e.g., messages relating to property damage).

1.2 General Information

This manual should form part of the documentation package supplied by Cummins Inc. with specific generator sets. If this manual has been supplied in isolation, please contact your authorized dealer.

NOTICE
It is in the operator's interest to read and understand all warnings and cautions contained in the documentation relevant to the generator set operation and daily maintenance.

General Safety Precautions

⚠ WARNING
Hot Pressurized Liquid
Contact with hot liquid can cause severe burns.
Do not open the pressure cap while the engine is running. Let the engine cool down before removing the cap. Turn the cap slowly and do not open it fully until the pressure has been relieved.

⚠ WARNING
Moving Parts
Moving parts can cause severe personal injury.
Use extreme caution around moving parts. All guards must be properly fastened to prevent unintended contact.

⚠ WARNING
Toxic Hazard
Used engine oils have been identified by some state and federal agencies to cause cancer or reproductive toxicity.
Do not ingest, breathe the fumes, or contact used oil when checking or changing engine oil. Wear protective gloves and face guard.

⚠ WARNING
Electrical Generating Equipment
Incorrect operation and maintenance can result in severe personal injury or death.
Do not operate equipment when fatigued, or after consuming any alcohol or drug.
Make sure that only suitably trained and experienced service personnel perform electrical and/or mechanical service.

⚠ WARNING
Toxic Gases
Substances in exhaust gases have been identified by some state and federal agencies to cause cancer or reproductive toxicity.
Do not breathe in or come into contact with exhaust gases.

⚠ WARNING
High Noise Level
Generator sets in operation emit noise, which can cause hearing damage.
Wear appropriate ear protection at all times.

⚠ WARNING

Hot Surfaces

Contact with hot surfaces can cause severe burns.

The unit is to be installed so that the risk of hot surface contact by people is minimized. Wear appropriate PPE when working on hot equipment and avoid contact with hot surfaces.

⚠ WARNING

Toxic Hazard

Ethylene glycol, used as an engine coolant, is toxic to humans and animals.

Wear appropriate PPE. Clean up coolant spills and dispose of used coolant in accordance with local environmental regulations.

⚠ WARNING

Combustible Liquid

Ignition of combustible liquids is a fire or explosion hazard which can cause severe burns or death.

Do not store fuel, cleaners, oil, etc., near the generator set. Do not use combustible liquids like ether.

⚠ WARNING

Combustible Gases

Generator sets in operation have combustible gases under pressure, which if ignited can cause eye and ear damage.

Wear appropriate eye and ear protection at all times.

⚠ WARNING

Combustible Gases

Generator sets in operation have combustible gases under pressure, which if ignited can cause severe injury.

Do not operate the generator set with any doors open.

⚠ WARNING

Fire Hazard

Materials drawn into the generator set, as well as accumulated grease and oil, are a fire hazard. Fire can cause severe burns or death.

Keep the generator set and the surrounding area clean and free from obstructions. Make sure the generator set is mounted in a manner to prevent combustible materials from accumulating under the unit.

⚠ WARNING

Automated Machinery

Accidental or remote starting of the generator set can cause severe personal injury or death.

Isolate all auxiliary supplies and use an insulated wrench to disconnect the starting battery cables (negative [–] first).

NOTICE

Keep multi-type ABC fire extinguishers close by. Class A fires involve ordinary combustible materials such as wood and cloth. Class B fires involve combustible and flammable liquid fuels and gaseous fuels. Class C fires involve live electrical equipment. (Refer to NFPA No. 10 in the applicable region.)

NOTICE

Before performing maintenance and service procedures on enclosed generator sets, make sure the service access doors are secured open.

NOTICE

Stepping on the generator set can cause parts to bend or break, leading to electrical shorts, or to fuel leaks, coolant leaks, or exhaust leaks. Do not step on the generator set when entering or leaving the generator set room.

1.3 Generator Set Safety Code

Before operating the generator set, read the manuals and become familiar with them and the equipment. Safe and efficient operation can be achieved only if the equipment is properly operated and maintained. Many accidents are caused by failure to follow fundamental rules and precautions.

⚠ WARNING

Electrical Generating Equipment

Incorrect operation and maintenance can result in severe personal injury or death.

Read and follow all Safety Precautions, Warnings, and Cautions throughout this manual and the documentation supplied with the generator set.

Moving Parts Can Cause Severe Personal Injury or Death

- Keep hands, clothing, and jewelry away from moving parts.
- Before starting work on the generator set, disconnect the battery charger from its AC source, then disconnect the starting batteries using an insulated wrench, negative (**–**) cable first. This will prevent accidental starting.

- Make sure that fasteners on the generator set are secure. Tighten supports and clamps; keep guards in position over fans, drive belts, etc.
- Do not wear loose clothing or jewelry in the vicinity of moving parts or while working on electrical equipment. Loose clothing and jewelry can become caught in moving parts.
- If any adjustments must be made while the unit is running, use extreme caution around hot manifolds, moving parts, etc.

Alternator Operating Areas

⚠ WARNING

Ejected Debris

Debris ejected during catastrophic failure can cause serious injury or death by impact, severing or stabbing.

To prevent injury:

- ***Keep away from the air inlet and air outlet when the alternator is running.***
- ***Do not put operator controls near the air inlet and air outlet.***
- ***Do not cause overheating by running the alternator outside rating plate parameters.***
- ***Do not overload the alternator.***
- ***Do not run an alternator with excessive vibration.***
- ***Do not synchronize parallel alternators outside the specified parameters.***

Always wear suitable PPE when working in the hatched areas shown in the diagram or directly in-line with any air inlet/outlet.

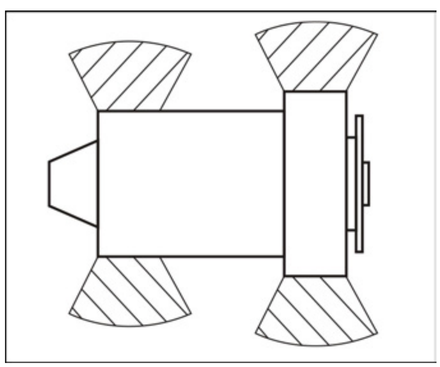

FIGURE 1. HATCHED AREAS

Make sure this consideration is captured in your risk assessment.

1.4 Electrical Shocks and Arc Flashes Can Cause Severe Personal Injury or Death

⚠ WARNING
Electric Shock Hazard
Voltages and currents present an electrical shock hazard that can cause severe burns or death.
Contact with exposed energized circuits with potentials of 50 Volts AC or 75 Volts DC or higher can cause electrical shock and electrical arc flash. Refer to standard NFPA 70E or equivalent safety standards in corresponding regions for details of the dangers involved and for the safety requirements.

Guidelines to follow when working on de-energized electrical systems:

- Use proper PPE. Do not wear Jewellery and make sure that any conductive items are removed from pockets as these items can fall into equipment and the resulting short circuit can cause shock or burning. Refer to standard NFPA 70E for PPE standards.
- De-energize and lockout/tagout electrical systems prior to working on them. Lockout/Tagout is intended to prevent injury due to unexpected start-up of equipment or the release of stored energy. Please refer to the lockout/tagout section for more information.
- De-energize and lockout/tagout all circuits and devices before removing any protective shields or making any measurements on electrical equipment.
- Follow all applicable regional electrical and safety codes.

Guidelines to follow when working on energized electrical systems:

NOTICE
It is the policy of Cummins Inc. to perform all electrical work in a de-energized state. However, employees or suppliers may be permitted to occasionally perform work on energized electrical equipment only when qualified and authorized to do so and when troubleshooting, or if de-energizing the equipment would create a greater risk or make the task impossible and all other alternatives have been exhausted.

NOTICE
Exposed energized electrical work is only allowed as per the relevant procedures and must be undertaken by a Cummins authorized person with any appropriate energized work permit for the work to be performed while using proper PPE, tools and equipment.

In summary:

- Do not tamper with or bypass interlocks unless you are authorized to do so.

- Understand and assess the risks - use proper PPE. Do not wear Jewellery and make sure that any conductive items are removed from pockets as these items can fall into equipment and the resulting short circuit can cause shock or burning. Refer to standard NFPA 70E for PPE standards.
- Make sure that an accompanying person who can undertake a rescue is nearby.

AC Supply and Isolation

NOTICE
Local electrical codes and regulations (for example, *BS EN 12601:2010 Reciprocating internal combustion engine driven generating sets)* may require the installation of a disconnect means for the generator set, either on the generator set or where the generator set conductors enter a facility.

NOTICE
The AC supply must have the correct over current and earth fault protection according to local electrical codes and regulations. This equipment must be earthed (grounded).

It is the sole responsibility of the customer to provide AC power conductors for connection to load devices and the means to isolate the AC input to the terminal box; these must comply with local electrical codes and regulations. Refer to the wiring diagram supplied with the generator set.

The disconnecting device is not provided as part of the generator set, and Cummins accepts no responsibility for providing the means of isolation.

AC Disconnect Sources

⚠ **WARNING**
Hazardous Voltage ***Contact with high voltages can cause severe electrical shock, burns, or death.*** ***The equipment may have more than one source of electrical energy. Disconnecting one source without disconnecting the others presents a shock hazard. Before starting work, disconnect the equipment, and verify that all sources of electrical energy have been removed.***

Medium Voltage Equipment (601 V to 15 kV - U.S. and Canada)

- Medium voltage acts differently than low voltage. Special equipment and training is required to work on or around medium voltage equipment. Operation and maintenance must be done only by persons trained and experienced to work on such devices. Improper use or procedures will result in severe personal injury or death.
- Do not work on energized equipment. Unauthorized personnel must not be permitted near energized equipment. Due to the nature of medium voltage electrical equipment, induced voltage remains even after the equipment is disconnected from the power source. Plan the time for maintenance with authorized personnel so that the equipment can be de-energized and safely grounded.

1.5 Fuel and Fumes Are Flammable

Fire, explosion, and personal injury or death can result from improper practices.

- Do not fill fuel tanks while the engine is running unless the tanks are outside the engine compartment. Fuel contact with hot engine or exhaust is a potential fire hazard.
- Do not permit any flame, cigarette, pilot light, spark, arcing equipment, or other ignition source near the generator set or fuel tank.
- Fuel lines must be adequately secured and free of leaks. Fuel connection at the engine should be made with an approved flexible line. Do not use copper piping on flexible lines as copper will become brittle if continuously vibrated or repeatedly bent.
- Make sure all fuel supplies have a positive shutoff valve.
- Make sure the battery area has been well-ventilated prior to servicing near it. Lead-acid batteries emit a highly explosive hydrogen gas that can be ignited by arcing, sparking, smoking, etc.

Gaseous Fuels

Natural gas is lighter than air, and will tend to gather under covered areas.

Do Not Operate in Flammable and Explosive Environments

Flammable vapor can cause an engine to over speed and become difficult to stop, resulting in possible fire, explosion, severe personal injury, and death. Do not operate a generator set where a flammable vapor environment can be created, unless the generator set is equipped with an automatic safety device to block the air intake and stop the engine. The owners and operators of the generator set are solely responsible for operating the generator set safely. Contact your authorized Cummins distributor for more information.

1.6 Exhaust Gases Are Deadly

- Provide an adequate exhaust system to properly expel discharged gases away from enclosed or sheltered areas, and areas where individuals are likely to congregate. Visually and audibly inspect the exhaust system daily for leaks per the maintenance schedule. Make sure that exhaust manifolds are secured and not warped. Do not use exhaust gases to heat a compartment.
- Make sure the unit is well ventilated.

Exhaust Precautions

⚠ WARNING
Hot Exhaust Gases
Contact with hot exhaust gases can cause severe burns.
Wear personal protective equipment when working on equipment.

⚠ WARNING
Hot Surfaces
Contact with hot surfaces can cause severe burns.
The unit is to be installed so that the risk of hot surface contact by people is minimized. Wear appropriate PPE when working on hot equipment and avoid contact with hot surfaces.

⚠ WARNING
Toxic Gases
Inhalation of exhaust gases can cause asphyxiation and death.
Pipe exhaust gas outside and away from windows, doors, or other inlets to buildings. Do not allow exhaust gas to accumulate in habitable areas.

⚠ WARNING
Fire Hazard
Contaminated insulation is a fire hazard. Fire can cause severe burns or death.
Remove any contaminated insulation and dispose of it in accordance with local regulations.

The exhaust outlet may be sited at the top or bottom of the generator set. Make sure that the exhaust outlet is not obstructed. Personnel using this equipment must be made aware of the exhaust position. Position the exhaust away from flammable materials - in the case of exhaust outlets at the bottom, make sure that vegetation is removed from the vicinity of the exhaust.

The exhaust pipes may have some insulating covers fitted. If these covers become contaminated they must be replaced before the generator set is run.

To minimize the risk of fire, make sure the following steps are observed:

- Make sure that the engine is allowed to cool thoroughly before performing maintenance or operation tasks.
- Clean the exhaust pipe thoroughly.

1.7 The Hazards of Carbon Monoxide

Carbon monoxide (CO) is an odorless, colorless, tasteless and non-irritating gas. You cannot see it or smell it. Red blood cells, however, have a greater affinity for CO than for oxygen. Therefore, exposure even to low levels of CO for a prolonged period can lead to asphyxiation (lack of oxygen) resulting in death. Mild effects of CO poisoning include eye irritation, dizziness, headaches, fatigue and the inability to think clearly. More extreme symptoms include vomiting, seizures and collapse.

Engine-driven generator sets produce harmful levels of carbon monoxide that can injure or kill you.

What Is Carbon Monoxide Poisoning?

Carbon Monoxide (CO) is an odorless, colorless, tasteless and non-irritating gas. You cannot see it or smell it. Red blood cells, however, have a greater affinity for CO than for Oxygen. Therefore, exposure even to low levels of CO for a prolonged period can lead to asphyxiation (lack of Oxygen) resulting in death. Mild effects of CO poisoning include eye irritation, dizziness, headaches, fatigue and the inability to think clearly. More extreme symptoms include vomiting, seizures and collapse.

Special Risks of CO near the Home

⚠ **WARNING**

Toxic Gases

Carbon monoxide (CO) gas can cause nausea, fainting, or death. Residents can be exposed to lethal levels of CO when the generator set is running. Depending on air temperature and wind, CO can accumulate in or near the home.

To protect yourself and others from the dangers of CO poisoning, it is recommended that reliable, approved, and operable CO detector alarms are installed in proper locations in the home as specified by their manufacturer.

Protecting Yourself from CO Poisoning

- Locate the generator set in an area where there are no windows, doors, or other access points into the home.
- Make sure all CO detectors are installed and working properly.
- Pay attention for signs of CO poisoning.
- Check the exhaust system for corrosion, obstruction, and leaks every time you start the generator set and every eight hours when you run it continuously.

1.8 Earth Ground Connection

The neutral of the generator set may be required to be bonded to earth ground at the generator set location, or at a remote location, depending on system design requirements. Consult the engineering drawings for the facility or a qualified electrical design engineer for proper installation.

NOTICE
The end user is responsible to make sure that the ground connection point surface area is clean and free of rust before making a connection.

NOTICE
The end user is responsible for making sure that an earthing arrangement that is compliant with local conditions is established and tested before the equipment is used.

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2 Introduction

2.1 About This Manual

This manual provides troubleshooting and repair information for the generator sets listed on the front cover.

The information contained within the manual is based on information available at the time of going to print. In line with the Cummins Inc. policy of continuous development and improvement, information may change at any time without notice. The users should therefore make sure that before commencing any work, they have the latest information available. The latest version of this manual is available on QuickServe Online (**https://quickserve.cummins.com**).

This manual does not include instructions for servicing printed circuit board assemblies. After determining that a printed circuit board assembly is faulty, replace it. Do not repair it. Attempts to repair a printed circuit board can lead to costly damage to the equipment.

This manual contains basic (generic) wiring diagrams and schematics that are included to help in troubleshooting. The wiring diagrams and schematics that are maintained with the unit should be updated when modifications are made to the unit.

Operating and basic maintenance instructions are in the applicable generator set operator manual. Read and carefully observe all instructions and precautions in this manual.

2.2 Test Equipment

To perform the test procedures in this manual, the following test equipment must be available:

- True RMS meter for accurate measurement of small AC and DC voltages
- Grounding wrist strap to prevent circuit board damage due to electrostatic discharge (ESD)
- Battery hydrometer
- Jumper leads
- Tachometer or frequency meter
- Wheatstone bridge or digital ohmmeter
- Variac
- Load test panel
- Megger or insulation resistance meter
- InPower service tool (PC based generator set service tool)

- Global Control Platform (GCP) Display service tool and harness (models C45 N6, C50 N6, C60 N6)
- 4G Display service tool and harness (models C70 N6, C50 N6, C100 N6)

2.3 Schedule of Abbreviations

This list is not exhaustive. For example, it does not identify units of measure or acronyms that appear only in parameters, event/fault names, or part/accessory names.

Abbr.	Description	Abbr.	Description
AC	Alternating Current	LED	Light-Emitting Diode
AMP	AMP, Inc. (part of Tyco Electronics)	MFM	Multifunction Monitor
ANSI	American National Standards Institute	Mil Std	Military Standard
ASOV	Automatic Shut Off Valve	MPU	Magnetic Pickup
ASTM	American Society for Testing and Materials (ASTM International)	NC	Normally Closed
ATS	Automatic Transfer Switch	NC	Not Connected
AVR	Automatic Voltage Regulator	NFPA	National Fire Protection Agency
AWG	American Wire Gauge	NO	Normally Open
CAN	Controlled Area Network	NWF	Network Failure
CB	Circuit Breaker	OEM	Original Equipment Manufacturer
CE	Conformité Européenne	OOR	Out Of Range
CCA	Cold Cranking Ampere	OORH/ ORH	Out Of Range High
CFM	Cubic Feet per Minute	OORL/ORL	Out Of Range Low
CGT	Cummins Generator Technologies	PB	Push Button
CMM	Cubic Meters per Minute	PCC	PowerCommand® Control
CT	Current Transformer	PGI	Power Generation Interface
DC	Direct Current	PGN	Parameter Group Number

Abbr.	Description	Abbr.	Description
DEF	Diesel Exhaust Fluid	PI	Proportional/Integral
DPF	Diesel Particulate Filter	PID	Proportional/Integral/ Derivative
EBS	Excitation Boost System	PLC	Programmable Logic Controller
ECM	Engine Control Module	PMG	Permanent Magnet Generator
ECS	Engine Control System	PPE	Personal Protective Equipment
EMI	Electromagnetic Interference	PT	Potential Transformer
EN	European Standard	PTC	Power Transfer Control
EPS	Engine Protection System	PWM	Pulse-Width Modulation
E-Stop	Emergency Stop	RFI	Radio Frequency Interference
FAE	Full Authority Electronic	RH	Relative Humidity
FMI	Failure Mode Identifier	RMS	Remote Monitoring System
FSO	Fuel Shutoff	RMS	Root Mean Square
Genset	Generator Set	RTU	Remote Terminal Unit
GCP	Generator Control Panel	SAE	Society of Automotive Engineers
GND	Ground	scfh	Standard Cubic Feet of gas per Hour
HMI	Human-Machine Interface	SCR	Selective Catalytic Reduction
IC	Integrated Circuit	SPN	Suspect Parameter Number
ISO	International Organization for Standardization	SW_B+	Switched B+
LBNG	Lean-Burn Natural Gas	UL	Underwriters Laboratories
LCD	Liquid Crystal Display	UPS	Uninterruptible Power Supply
LCT	Low Coolant Temperature		

2.4 Related Literature

Before any attempt is made to operate the generator set, the operator should take time to read all of the manuals supplied with the generator set, and to familiarize themselves with the warnings and operating procedures.

The literature provided with the generator set is as follows:

- Operator Manual (A051X877)
- Installation Manual (A051X873)

NOTICE
A generator set must be operated and maintained properly if you are to expect safe and reliable operation. The Operator manual includes a maintenance schedule and a troubleshooting guide. **The Health and Safety manual must be read in conjunction with this manual for the safe operation of the generator set:** • **Health and Safety Manual (0908-0110)** • **Warranty Statement (A028U870)** • ***C45 N6, C50 N6 and C60 N6 models only:* Emissions Component Defect Warranty Statement (A028X278)** • ***C70 N6, C80 N6 and C100 N6 models only:* Emissions Component Defect Warranty Statement (A028X279)**

The relevant manuals appropriate to your generator set are also available. The documents below are in English:

- Service Manual (A051X880)
- Parts Manual (A051X891)
- EControls, Inc., Global Control Platform (GCP) Software Service Manual (A035C596)
- EControls, Inc., 4G Software Service Manual (A052G032)
- EControls, Inc., GCP Engine Display Interface Software (EDIS) Training Manual (A035C608)
- EControls, Inc., 4G Software Operator Manual (A052G024)
- Engine Operation & Maintenance Manual for QSJ5.9G (4388606)
- RA Series Transfer Switch Owner Manual (A046S594) - if applicable
- PowerCommand® 1302 Controller Owner's Manual (0900-0661)
- PowerCommand® 2300 Operator Manual (A029M413)
- Service Tool Manual (A043D529)
- Standard Repair Times - HL Family (A053K365)

- T-030: Liquid Cooled Generator Set Application Manual (A040S369) - for application information

2.5 Specifications

UC Winding Resistances

NOTICE

Resistance of windings at 20 °C (68 °F); measured values should be within 10%.

TABLE 1. AVR-CONTROLLED ALTERNATORS RESISTANCE (OHMS)

Name	Main Stator Windings, L-N (leads)				Exciter Stator	Exciter Rotor, L-L	Main Rotor	PMG Stator, L-l
	311 (1 & 2) (5 & 6)	5 (1 & 2)	6 (1 & 2)	17 (1 & 2) (5 & 6)				
UC22C	0.090	0.045	0.030	0.140	21	0.142	0.59	2.6
UC22D	0.065	0.033	0.025	0.100	21	0.142	0.64	2.6
UC22E	0.050	0.028	0.020	0.075	20	0.156	0.69	2.6
UC22F	0.033	0.018	0.012	0.051	20	0.156	0.83	2.6
UC22G	0.028	0.014	0.010	0.043	20	0.156	0.94	2.6
UC27C	0.030	0.016	0.011	0.044	20	0.156	1.12	2.6
UC27D	0.019	0.010	0.007	0.026	20	0.156	1.26	2.6
UC27E	0.016	0.009	0.008	0.0025	20	0.182	1.34	2.6
UC27F	0.012	0.007	0.005	0.019	20	0.182	1.52	2.6
UC27G	0.010	0.006	0.004	0.013	20	0.182	1.69	2.6
UC27H	0.008	0.004	0.004	0.014	20	0.182	1.82	2.6
UCD27J	0.006	N/A	N/A	0.009	20	0.182	2.08	2.6
UCD27K	0.006	N/A	N/A	0.009	20	0.182	2.08	2.6

Model Specifications

NOTICE

Damage caused by failure to follow the manufacturer's recommendation will not be covered by the warranty. Please contact your authorized distributor.

TABLE 2. 5.9L MODEL VARIATIONS

Models	Description
C45 N6, C50 N6, C60 N6, C70 N6, C80 N6, C100 N6	60 Hz, 1800 RPM

TABLE 3. COLD WEATHER SPECIFICATIONS (ALL MODELS)

Temperature	Description	Battery Type	Group
Above 4 °C (40 °F)	Battery charger	Standard	34
-17 to 4 °C (0 to 40 °F)	Battery charger, coolant heater (1000W), CCV heater[1]	Standard	34
Below -17 °C (0 °F)	Battery charger, coolant heater (1500W), oil heater, battery heater, CCV heater[1], cold weather starter[2]	Larger	4D
[1]CCV heaters are provided as part of the cold and extreme cold coolant heater packages. [2]The cold weather starter is provided as part of the extreme cold coolant heater package.			

NOTICE

For NFPA 110 applications, a coolant heater is required. A factory option is available.

TABLE 4. FUEL SPECIFICATIONS 60 HZ, 1800 RPM

Type	Unit	C45 N6	C50 N6	C60 N6	C70 N6	C80 N6	C100 N6
Liquid Propane Full Load	scfh	289.6	321.6	370.2	384.2	420.8	518.7
	BTU/hr	651,600	723,600	832,950	864,450	946,800	1,167,075
Natural Gas Full Load	scfh	711.2	806.3	933.8	988.4	1,083.5	1,317.7
	BTU/hr	721,868	818,395	947,807	1,003,226	1,099,753	1,337,466
Fuel Pressure	6-13 inches of water column (1.5 - 3.2 kPa) under any condition						

TABLE 5. ENGINE SPECIFICATIONS (ALL MODELS)

Type	Specification
Engine	6 cylinder-in-line, single-cam, liquid-cooled, 4-stroke, spark ignited
Bore	102 mm 94.02 in)
Stroke	120 mm (4.72 in)
Displacement	5.88 L (359 in^3)
Compression Ratio (Natural Gas & LPG)	8.5:1
Firing Order	1-5-3-6-2-4
Spark Plug Gap 45, 50, 60 kW)	0.508 mm (0.020 in)
Spark Plug Gap (70, 80, 100 kW)	0.40 mm (016 in)
Spark Plug Torque	38 Nm (28 ft-lb)
Crankshaft Rotation (Viewed from the Front of the Engine)	Clockwise
Engine Weight (Dry, Long Block Only)	413 kg (911 lb)
Valve Clearance (Intake)	0.305 mm (0.012 in)
Valve Clearance (Exhaust)	0.610 mm (0.024 in)
Coolant	• 50/50 coolant solution (50% pure water and 50% anti-freeze) • 16 L (4.23 gal) capacity
Oil Capacity	15 L (4 gal)

Type	Specification
Oil Standards	• Must adhere to Cummins® Engineering Standard (CES) 20085 • Use of improper oils can result in engine damage. Use only the required oils: ◦ 5W-40 (all ambient temperatures) ◦ 15W-40 (***above*** 4 °C [40 °F] ambient temperature) (use of GEO 15W-40 oil in ambient temperatures ***below*** 4 °C (40 °F] could result in engine turbocharger damage) • A sulfated ash limit of 0.6% mass has been placed on all engine lubricating oils recommended for use in Cummins® B, natural gas engines. Higher ash oils can cause valve and/or piston damage, cause spark plug fouling, and lead to excessive oil consumption and degradation of the catalyst.

TABLE 6. LUBRICATING OIL SYSTEM SPECIFICATIONS

Type	Specification
Lubricating Oil Pressure at Idle (Minimum)	104 kPa (15 psi)
Lubricating Oil Pressure at Rated Speed (Minimum)	
Filter Bypass Valve-Opening Pressure	311 kPa (45 psi)
Pressure Regulator Valve-Opening Pressure	449 kPa (65 psi)
Lubricating Oil Capacity (Standard Sump):	
--High	14.2 L (15 qt)
--Low	12.4 L (13 qt)
--Total System	15.1 L (16 qt)

TABLE 7. GENERATOR SET SIZE SPECIFICATIONS

Enclosure Type	Size (L x W x H)
Open/Weather	2489 x 1016 x 1473 mm (98 x 40 x 58 in); does not include exhaust discharge elbow
Sound Level 1	3023 x 1016 x 1473 mm (119 x 40 x 58 in)
Sound Level 2	3454 x 1016 x 1473 mm (136 x 40 x 58 in)

TABLE 8. GENERATOR SET WET WEIGHT (POUNDS) (60 HZ, 1800 RPM)

Configuration	C45 N6	C50 N6	C60 N6	C70 N6	C80 N6	C100 N6
Open	2180	2180	2431	2449	2587	2719
Weather	2359	2359	2610	2628	2766	2898
Sound Level 1	2455	2455	2706	2724	2862	2994
Sound Level 2	2485	2485	2736	2754	2892	3024

NOTICE

Weights are approximate and can be affected by selected options. Refer to outline drawings for specific weight information.

TABLE 9. ALTERNATOR SPECIFICATIONS 60 HZ, 1800 RPM

Type	C45 N6	C50 N6	C60 N6	C70 N6	C80 N6	C100 N6
Generator	Brushless, 4-pole rotating field, single bearing					
Power (kVA) 1 Phase	45	50	60	70	80	100
Power (kVA) 3 Phase	56.3	62.5	75	87.5	100	125
Rated Voltages (V)	120/240, 1 Ph					
	227/480, 3 Ph					
	347/600, 3 Ph					
	120/240, 3 Ph					
	120/208, 3 Ph					
	127/220, 3 Ph					
	F1PO (Reconnectable, Full Single Phase Output)					

NOTICE

Maximum I_2 = 8%. Generator set load unbalance must not exceed 25% between any phases.

TABLE 10. GENERATOR SET DERATING GUIDELINES

<table>
<tr><th rowspan="2">Model</th><th rowspan="2">Phase</th><th colspan="2">Engine Power Available Up To...</th><th colspan="2">Derate At...</th></tr>
<tr><th>Elevation</th><th>Ambient Temperature</th><th>Elevation</th><th>Temperature</th></tr>
<tr><td>C45 N6</td><td>Both</td><td>675 m (2200 ft)</td><td>40 °C (104 °F)</td><td rowspan="9">4%
per 300 m (985 ft)</td><td rowspan="9">2%
per 10 °C (18 °F)</td></tr>
<tr><td>C50 N6</td><td>Both</td><td>150 m (490 ft)</td><td>25 °C (77 °F)</td></tr>
<tr><td>C60 N6</td><td>Both</td><td>1000 m (3280 ft)</td><td rowspan="5">40 °C (104 °F)</td></tr>
<tr><td rowspan="2">C70 N6</td><td>1</td><td>2575 m (8450 ft)</td></tr>
<tr><td>3</td><td>3048 m (10000 ft)</td></tr>
<tr><td rowspan="2">C80 N6</td><td>1</td><td>1825 m (5985 ft)</td></tr>
<tr><td>3</td><td>2500 m (8200 ft)</td></tr>
<tr><td rowspan="2">C100 N6</td><td>1</td><td>700 m (1560 ft)</td><td>25 °C (77 °F)</td></tr>
<tr><td>3</td><td>1000 m (3280 ft)</td><td>40 °C (104 °F)</td></tr>
</table>

TABLE 11. CONTROL SPECIFICATIONS (ALL MODELS)

Control	Purpose
PC 1.1 or PC 2.3	Generator Set
Enovations I28 EPR	Engine (45, 50, 60 kW Generator Sets)
Enovations 4G LDI	Engine (70, 80, 100 kW Generator Sets)

TABLE 12. DC SYSTEM SPECIFICATIONS (ALL MODELS)

Type	Specification
Nominal Battery Voltage	12 VDC
Battery Group	34 standard, 4D high capacity (requires large battery tray)
Battery Type	Maintenance-free
Minimum Cold Crank Amps	850 standard, 1080 high capacity (requires large battery tray)

2.6 After Sales Services

Cummins offers a full range of maintenance and warranty services.

Maintenance

⚠ WARNING
Electrical Generating Equipment
Incorrect operation and maintenance can result in severe personal injury or death.
Make sure that only suitably trained and experienced service personnel perform electrical and/or mechanical service.

For expert generator set service at regular intervals, contact your local distributor. Each local distributor offers a complete maintenance contract package covering all items subject to routine maintenance, including a detailed report on the condition of the generator set. In addition, this can be linked to a 24-hour call-out arrangement, providing year-round assistance if necessary. Specialist engineers are available to maintain optimum performance levels from generator sets. Maintenance tasks should only be undertaken by trained and experienced technicians provided by your authorized distributor.

Warranty

For details of the warranty coverage for your generator set, refer to the *Global Warranty Statement* listed in the Related Literature section.

In the event of a breakdown, prompt assistance can normally be given by factory trained service technicians with facilities to undertake all minor and many major repairs to equipment on site.

Extended warranty coverage is also available.

For further warranty details, contact your authorized service provider.

NOTICE
Damage caused by failure to follow the manufacturer's recommendations will not be covered by the warranty. Please contact your authorized service provider.

Warranty Limitations

For details of the warranty limitations for your generator set, refer to the warranty statement applicable to the generator set.

2.7 Manufacturing Facilities

Facility	Address	Phone Numbers
U.S. and CANADA	Cummins Inc. 1400 73rd Ave. NE Minneapolis, MN 55432 USA	Toll Free 1-800-CUMMINS™ (1-800-286-6467) Phone +1 763-574-5000 Fax +1 763-574-5298
EMEA, CIS	Cummins Inc. Columbus Avenue Manston Park Manston, Ramsgate Kent CT12 5BF United Kingdom ----------- Cummins Inc. Royal Oak Way South Daventry Northamptonshire NN11 8NU United Kingdom	Phone +44 1843 255000 Fax +44 1843 255902
ASIA PACIFIC	Cummins Inc. 10 Toh Guan Road #07-01 TT International Tradepark Singapore 608838	Phone +65 6417 2388 Fax +65 6417 2399
BRAZIL	Rua Jati, 310, Cumbica Guarulhos, SP 07180-900 Brazil	Phone +55 11 2186 4195 Fax +55 11 2186 4729
CHINA	Cummins Inc. 2 Rongchang East Street, Beijing Economic – Technological Development Area Beijing 100176, P.R. China	Phone 86 10 59023001 Fax +86 10 5902 3199
INDIA	Cummins Inc. Plot No B-2, SEZ Industrial Area, Village-Nandal & Surwadi, Taluka- Phaltan Dist- Satara, Maharashtra 415523 India	Phone +91 021 66305514
LATIN AMERICA	3350 Southwest 148th Ave. Suite 205 Miramar, FL 33027 USA	Phone +1 954 431 551 Fax +1 954 433 5797

Facility	Address	Phone Numbers
MEXICO	Eje 122 No. 200 Zona Industrial San Luis Potosi, S.L.P. 78395 Mexico	Phone +52 444 870 6700 Fax +52 444 824 0082

How to Obtain Service

When a product requires service, contact the nearest authorized Cummins Inc. service provider. To locate the service provider, refer to **www.cummins.com/support** and select Sales & Service Locator. When contacting the service provider, always supply the complete model, specification, and serial number as shown on the nameplate.

Locating a Service Provider

In the U.S. and Canada

Contact us at 1-800-CUMMINS™ (1-800-286-6467) or visit http://www.cummins.com/support to contact the nearest Cummins Inc. service provider in the United States or Canada.

If unable to arrange a service or resolve an issue, contact the Service Manager at the nearest Cummins Inc. service provider for assistance.

When contacting the service provider, always supply the complete Model, Specification, and Serial Number as shown on the product nameplate.

Outside the U.S. and Canada

Refer to **power.cummins.com** and select Sales & Service Locator, or send an email to ask.powergen@cummins.com.

Service Technician Support

For technical support for service technicians, call 1-800-CUMMINS™ (1-800-286-6467) in the U.S. or Canada. Distributors should contact their Cummins Inc. service contact.

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3 Maintenance

3.1 Maintenance Safety

⚠ WARNING
Automated Machinery
Accidental or remote starting of the generator set can cause severe personal injury or death.
Isolate all auxiliary supplies and use an insulated wrench to disconnect the starting battery cables (negative [–] first).

⚠ WARNING
Hydrogen Gas
Arcing can ignite explosive hydrogen gas given off by batteries, causing severe personal injury or death. Arcing can occur when cables are removed or replaced, or when the negative (–) battery cable is connected and a tool used to connect or disconnect the positive (+) battery cable touches the frame or other grounded metal part of the generator set.
Insulated tools must be used when working in the vicinity of the batteries. Always remove the negative (–) cable first and reconnect last.

⚠ WARNING
Explosive Fumes
Arcing can ignite explosive fumes causing severe personal injury or death.
Make sure hydrogen from the battery, engine fuel and other explosive fumes are fully dissipated before working on the generator set.

⚠ WARNING
Working at Heights
Using the incorrect equipment when working at heights can result in severe personal injury or death.
Suitable equipment for performing these tasks must be used in accordance with the local guidelines and legislation. Failure to follow these instructions can result in severe personal injury or death.

⚠ WARNING

Access

Using the generator set or part of as a means of access when attaching lifting shackles, chains, or other lifting aids, may damage the generator set, causing severe personal injury or death.

Do not use the generator set as a means of access. Failure to follow these instructions can result in severe personal injury or death.

⚠ WARNING

Exposed Terminations

Some panel internal components may have live exposed terminations even if the generator set is not running. Voltages are present which can cause electrical shock, resulting in personal injury or damage to equipment.

Isolate all external electrical supplies prior to access of the control panel

NOTICE

Only authorized and qualified maintenance technicians who are familiar with the equipment and its operation should carry out maintenance.

NOTICE

Dependent upon the control system fitted, this unit may operate automatically and could start without warning.

NOTICE

Always disconnect a battery charger from its AC source before disconnecting the battery cables. Failure to do so can result in voltage spikes high enough to damage the DC control circuits of the generator set.

All maintenance tasks must be performed, but be sure to assess them for health and safety risks before starting. For example, perform a task with someone present if doing so will add significantly to the safety of the task.

Read, understand, and comply with all Caution, Warning, and Danger notes in this section, the Important Safety Instructions section, and the documentation supplied with the generator set.

Make sure that adequate lighting is available.

Locking the Generator Set Out of Service

NOTICE
Automated Machinery
Accidental or remote starting of the generator set can cause severe personal injury or death.
Isolate all auxiliary supplies and use an insulated wrench to disconnect the starting battery cables, negative (–) cable first.

Before any work is carried out for maintenance, etc., the generator set must be immobilized. Even if the generator set is put out of service by pressing the Off switch on the Operator Panel (or the STOP button if applicable), the generator set cannot be considered safe to work on until the engine is properly immobilized, as detailed in the following procedure.

NOTICE
Refer also to the engine-specific Operator Manual, if applicable. This manual contains specific equipment instructions that may differ from the standard generator set.

To immobilize the generator set:

1. Press the Off switch from the display and then press the E-Stop button to shut down the engine. This will prevent the starting of the generator set regardless of the Start signal source and will therefore provide an additional safety step for immobilizing the generator set. Alternatively, make sure the generator set is in manual mode (which allows it to be started by manually pushing the buttons).

NOTICE
When the E-Stop button is pressed, the Operator Panel indicates the Shutdown condition by illuminating the red Shutdown status LED and displaying a message on the graphical LCD display.

2. Thoroughly ventilate the generator set before disconnecting any leads.
3. Turn off and disconnect the heater (where fitted) from the AC source before disconnecting the battery cables.
4. Turn off and disconnect the battery charger (where fitted) from the AC source before disconnecting the battery cables.
5. Turn off the fuel supply to the engine.
6. Disconnect the battery. Disconnect the negative (–) cable first, using an insulated wrench.
7. Place warning notices at each of the above locations that state, "Maintenance in Progress – Immobilized for Safe Working."

3.2 Periodic Maintenance

⚠ WARNING

Electrical Generating Equipment

Accidental or remote starting of the generator set can cause severe personal injury or death.

Before working on the generator set, make sure that the generator set is in Off mode, disable the battery charger, and remove the negative (–) battery cable from the battery to prevent starting.

The table(s) that follow show the recommended service intervals for a generator set on standby service. If the generator set will be subjected to extreme operating conditions, the service intervals should be reduced accordingly.

At each scheduled maintenance interval, perform all previous maintenance checks that are due for scheduled maintenance.

Some of the factors that can affect the maintenance schedule are:

- Extremes in ambient temperature
- Exposure to elements
- Exposure to salt water
- Exposure to windblown dust or sand

Consult with your authorized Cummins Inc. service provider if the generator set will be subjected to any extreme operating conditions, and determine if extra protection or a reduction in service intervals is needed. Use the engine hours shown on the system status screen to keep to keep an accurate log of all service performed for warranty support. Perform all service at the time period indicated, or after the number of operating hours indicated, whichever comes first.

Repair or replace worn, damaged, or improperly functioning components identified during periodic maintenance procedures.

Periodic Maintenance Guidelines

Regularly performing the following periodic maintenance tasks greatly reduces the chances of a generator set shutdown:

- Maintain an appropriate oil level.
- Keep battery connections clean and tight.
- Do not overload the generator set.
- Keep the air inlet and outlet openings clear.

Periodic Maintenance Schedule

NOTICE
Perform maintenance tasks as specified using daily or hourly periods, whichever is sooner.

TABLE 13. PERIODIC MAINTENANCE SCHEDULE

Maintenance Items	After Every 24 Hours of Run Time[1]	After Every 50 Hours of Run Time	12 Months or After 250 Hours[2]	2 Years or After 500 Hours[2]
Check air cleaner restriction indicator (where fitted): If the indicator shows red, replace air cleaner element and reset the indicator.	■			
Check air intake system for leaks: Visually inspect for signs of wear or damage. Check audibly when the generator set is running. Replace worn or damaged components.	■			
Check coolant level of radiator: If low, top up to coolant system specifications level, with Cummins recommended coolant mix.	■			
Check cooling fan blades: Visually inspect the blades through the guarding for signs of wear or damage. To replace, contact your authorized distributor.	■			
Checking drive belt condition and tension: Visually check belt for evidence of wear or slippage. To replace, contact your authorized distributor.	■			

Maintenance Items	After Every 24 Hours of Run Time[1]	After Every 50 Hours of Run Time	12 Months or After 250 Hours[2]	2 Years or After 500 Hours[2]
Check radiator airflow: Visually inspect the radiator through the guarding for blockage, debris or signs of wear or damage. To clean or replace, contact your authorized distributor.	■			
Check fuel lines and hoses: Visually check for leaks, worn or damaged hoses. To replace, contact your authorized distributor.	■			
Check engine oil level: If low, top up to engine specifications level with recommended oil.	■			
Check charge alternator: Check visually and audibly when the generator set is running. To replace, contact your authorized distributor.	■			
Check all exhaust components and hardware (fittings, clamps, fasteners, etc.): Visually inspect the exhaust system for signs of wear or damage. Check audibly when the generator set is running.	■			
Check generator set enclosure: Visually check enclosure. Make sure no inlets/outlets are restricted, service access doors are operational. To replace damaged parts, contact your authorized distributor.	■			
Check operation of operator panel: Check display (the system will perform a control panel test on initial activation). Replace component if not functioning properly.	■			

Maintenance Items	After Every 24 Hours of Run Time[1]	After Every 50 Hours of Run Time	12 Months or After 250 Hours[2]	2 Years or After 500 Hours[2]
Check operation of Emergency Stop Button (where fitted): With the generator set running, press the Emergency Stop button. Check all systems before resetting the fault.		■		
Replace air cleaner.			■[3]	
Check coolant lines and radiator hoses for leaks, wear and cracks: Visually check the hoses. Replace worn or damaged components.			■	
Clean radiator core.			■[3]	
Check water pump for leaks. Check weep holes for evidence of leaks. Replace if leaking.			■	
Verify that the coolant heater has power and is running (where fitted). Check for evidence of leaks. Remove any corrosion from fittings.			■	
Check CCV heater (where fitted). Check for evidence of leaks. Remove any corrosion from fittings.			■	
Check alternator heater (where fitted). Check general condition and wiring connections.			■	
Check battery heater (where fitted). Check general condition and wiring connections.			■	
Check engine oil heater. Check general condition and wiring connections.			■	
Check battery: Check connections to verify that they are secure.			■	

Maintenance Items	After Every 24 Hours of Run Time[1]	After Every 50 Hours of Run Time	12 Months or After 250 Hours[2]	2 Years or After 500 Hours[2]
Check battery for general condition. Remove any corrosion on terminals with wire brush.			■	
Check electrical connections (battery, starter motor, alternator connections). Check for tight connections, general condition and remove any corrosion.			■	
Replace engine oil and filters. Refer to the Engine Oil section for the procedure.		■[4]	■[4]	
Check engine ground. Clean as necessary.			■	
Check engine mounts for general condition and for signs of excessive wear.			■	
Check starting motor.			■	
Check turbocharger for signs of leakage. Listen for excessive noise when test running the generator set.			■	
Inspect spark plugs. Replace if showing signs of excessive wear, carbon deposits, oil accumulation or damaged.			■	
Replace spark plugs and spark plug wires.				■
Check charge air cooler for damage and debris.			■	
Check valve lash and adjust if required. See the Valve Clearance Adjustment procedure (service manual only).				■
Check fan drive idler arm and fan belt tensioner for general condition, as well as for excessive play in both.				■

Maintenance Items	After Every 24 Hours of Run Time[1]	After Every 50 Hours of Run Time	12 Months or After 250 Hours[2]	2 Years or After 500 Hours[2]
Replace cooling system coolant. Check coolant sensor for damage and debris.				■

[1] This interval is based on generator run time: daily in an outage or after every 24 hours of run time.
[2] To be performed by a qualified Service Technician.
[3] Cleaning schedule may be reduced depending on operating conditions/environment.
[4] After the initial 50 hour interval and every 250 hours thereafter.

3.3 Engine Oil

Recommended Engine Oil

Check the oil level prior to starting the generator set to verify that the oil level is between the High and Low marks. The generator set is shipped with engine oil.

The use of quality engine oils combined with appropriate oil and filter change intervals are critical factors in maintaining engine performance and durability.

Cummins Inc. recommends the use of a high quality SAE 5W-40 GEO (all ambients) or SAE 15W-40 GEO (above 40 °F [4 °C]) engine oil for natural gas engines. In addition, oil needs to conform with CES 20085. Refer to the Model Specifications section for oil specification details.

NOTICE
Use of improper oils can result in engine damage. Use only the recommended oils.

NOTICE
Use of GEO 15W-40 oil in ambient temperatures below 40 °F (4 °C) could result in engine turbocharger damage.

Checking Engine Oil Level

⚠ WARNING
Automated Machinery ***Accidental or remote starting of the generator set can cause severe personal injury or death.*** ***Isolate all auxiliary supplies and use an insulated wrench to disconnect the starting battery cables, negative (–) cable first.***

⚠ WARNING

Hot Surfaces

Contact with hot surfaces can cause severe burns. Wear appropriate PPE when working on hot equipment and avoid physical contact with hot surfaces.

⚠ WARNING

Toxic Hazard

State and federal agencies have determined that contact with used engine oil can cause cancer or reproductive toxicity.

Avoid skin contact and breathing of vapors. Use rubber gloves and wash exposed skin.

⚠ WARNING

Toxic Hazard

Crankcase pressure can blow out hot oil and cause severe burns.

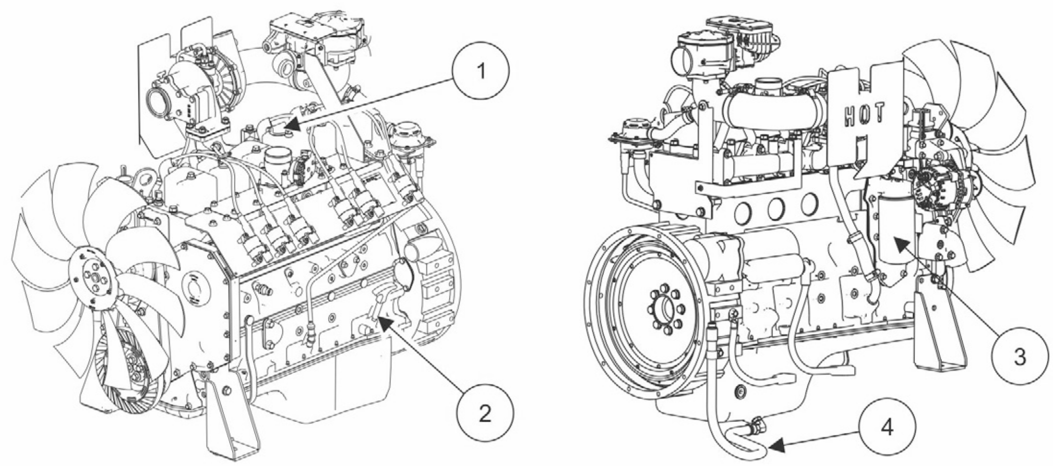
Do NOT check oil while the engine is operating.

NOTICE

Check the engine oil level when the engine is not running and is out of Auto mode.

NOTICE

Overfilling can cause foaming or aeration of the oil, and operation below the low mark may cause loss of oil pressure. Do not operate the engine with the oil level below the low mark or above the high mark.



No.	Description	No.	Description
1	Fill Cap	3	Oil Filter
2	Dipstick	4	Oil Drain Hose

FIGURE 2. ENGINE OIL COMPONENTS

1. Make sure the generator set is shut down and disabled:
   a. Press the Off switch from the display and then press the E-Stop button to stop the generator set. Allow the generator set to thoroughly cool to the touch.
   b. Turn off and disconnect the battery charger from the AC source before disconnecting the battery cables.
   c. Disconnect the negative (–) cable from the battery and secure it from contacting the battery terminals to prevent accidental starting.
2. To check the engine oil level:
   a. Make sure that the engine has not been running for approximately five minutes.
   b. Clean off the area surrounding the dipstick port to prevent entry of debris into the oil pan.
   c. Pull out the dipstick and wipe it clean.
   d. Reinsert and fully seat the dipstick.
   e. Remove the dipstick and check the oil level.

NOTICE
The engine oil level indicated on the dipstick should be between the High (15 qt [14.2L]) and Low (13 qt [12.4L]) marks.

f. Reinsert and fully seat the dipstick.

If the engine oil level check shows excessive or insufficient levels of oil (that is, oil level line above the High mark or below the Low mark), oil must be drained or added. Refer to the following sections for instructions and guidelines for draining and adding oil.

Adding or Draining Oil

⚠ WARNING

Hot Surfaces

Contact with hot surfaces can cause severe burns. Wear appropriate PPE when working on hot equipment and avoid physical contact with hot surfaces.

⚠ WARNING

Hot Engines

Contact with hot engines can cause severe burns. Ensure that the generator set engine has cooled down before adding or draining the oil.

NOTICE

Too much oil can cause high oil consumption. Too little oil can cause severe engine damage. Keep the oil level between the High and Low marks on the dipstick.

Adding Oil

If the oil level is found to be insufficient, oil must be added.

1. Ensure that the oil fill cap area is clean, and prevent debris from entering the engine.
2. Add the appropriate amount of oil, based on the engine oil level check. Refer to the Checking Engine Oil Level section and the Model Specifications section.
3. Recheck the engine oil level. Based on the results, add or drain oil.
4. Clean up and dispose of any oil in accordance with local/state regulations.

Draining Oil

If the oil level is found to be excessive, oil must be drained from the engine.

1. Detach the oil drain hose from the side of the engine.
2. Place the end of the drain hose into an appropriate container.

Refer to local regulations to determine the appropriate container for used oil.

- Open the oil drain valve to release oil from the engine into the appropriate container.

- Recheck the engine oil level. Based on the results, add or drain oil.
- When a sufficient amount of oil has been drained from the system:
  1. Close the oil drain valve.
  2. Wipe the oil drain valve clean.
  3. Re-attach the drain hose to the side of the engine.
  4. Dispose of the used oil in accordance with local/state regulations.

Changing Engine Oil and Oil Filter

⚠ WARNING
Automated Machinery   ***Accidental or remote starting of the generator set can cause severe personal injury or death.***   ***Isolate all auxiliary supplies and use an insulated wrench to disconnect the starting battery cables, negative (–) cable first.***

⚠ WARNING
Toxic Hazard   ***State and federal agencies have determined that contact with used engine oil can cause cancer or reproductive toxicity.***   ***Avoid skin contact and breathing of vapors. Use rubber gloves and wash exposed skin.***

NOTICE
If the oil and/or oil filter are not reused, dispose of them in accordance with local environmental regulations.

NOTICE
Change the engine oil and filter when the engine is not running and is out of Auto mode.

NOTICE
Change the oil more often in hot and dusty environments.

NOTICE
Cummins highly recommends that any service or maintenance work be performed by qualified technicians.

1. Before changing the oil, the generator set should be operated until the water temperature is approximately 60 °C (140 °F).

2. Make sure the generator set is shut down and disabled:
   a. Press the generator set's "O" (Off) button to stop the generator set. Allow the generator set to thoroughly cool to the touch.
   b. If applicable, turn off and disconnect the battery charger from the AC source before disconnecting the battery cables.
   c. Disconnect the negative (–) cable from the battery and secure it from contacting the battery terminals to prevent accidental starting.
3. Drain the oil. Place the end of the drain hose into an appropriate container.

NOTICE
Refer to local regulations to determine the appropriate container for used oil.

4. Remove the oil filter, and clean the filter mounting surface on the engine block. Remove the old gasket if it remains.
5. Make sure the gasket is in place on the new filter and apply a thin film of clean oil to the gasket.
6. Install the new filter until the gasket just touches the block. Turn it an additional 1/2 to 3/4 turn. Do not over-tighten.
7. Remove the container used to collect oil when removing the oil filter.
8. Close the oil drain valve.
9. Add the appropriate amount of oil.

NOTICE
Too much oil can cause high oil consumption. Too little oil can cause severe engine damage. Keep the oil level between the High and Low marks.

10. Operate the engine at idle to inspect for leaks at the lubricating oil filter and the drain plug.
11. Confirm that the correct oil level is in the pan:
    a. Shut the generator set off and wait 5 minutes.
    b. Check the engine oil level.
12. Check and repair any leaks identified.
13. Dispose of the used oil and oil filter according to local environmental regulations.

3.4 Air Intake System

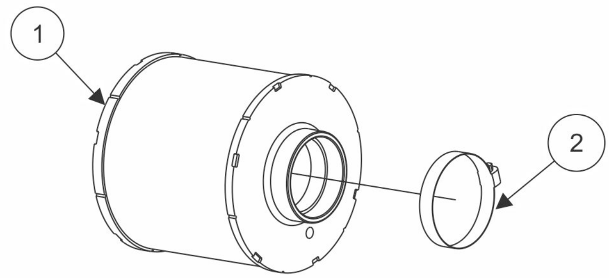
The direct flow air cleaner consists of a primary filter and a secondary filter within the air cleaner housing. The air cleaner has been designed for a maximum restriction, at which point the filter elements should be changed. Refer to the Model Specifications section.

Normal Duty Air Cleaner Element Replacement

NOTICE
Holes, loose-end seals, dented sealing surfaces, corrosion of pipes, and other forms of damage render the air cleaner inoperative and require immediate element replacement or engine damage can occur.

NOTICE
Cummins Inc. does not recommend cleaning paper-type air cleaner elements.

1. Remove the existing air cleaner:
   a. Loosen the strap clamp (2).
   b. Wipe away any debris accumulated around the air cleaner connection to the engine. Ensure that no debris is allowed to enter the body of the air cleaner or the connection on the engine.
   c. Remove the dirty air cleaner (1).
   d. Dispose of the dirty element in accordance with local environmental agency requirements.
2. Install the replacement air cleaner (1) as follows:
   a. Install the air cleaner (1).
   b. Tighten strap clamp (2). Torque to 2.5 - 3.3 ft-lb (4.3 - 4.65 Nm).



No.	Description	No.	Description
1	Air Cleaner	2	Strap Clamp

FIGURE 3. EXAMPLE OF NORMAL DUTY AIR CLEANER

Heavy Duty Air Cleaner Element Replacement

⚠ CAUTION

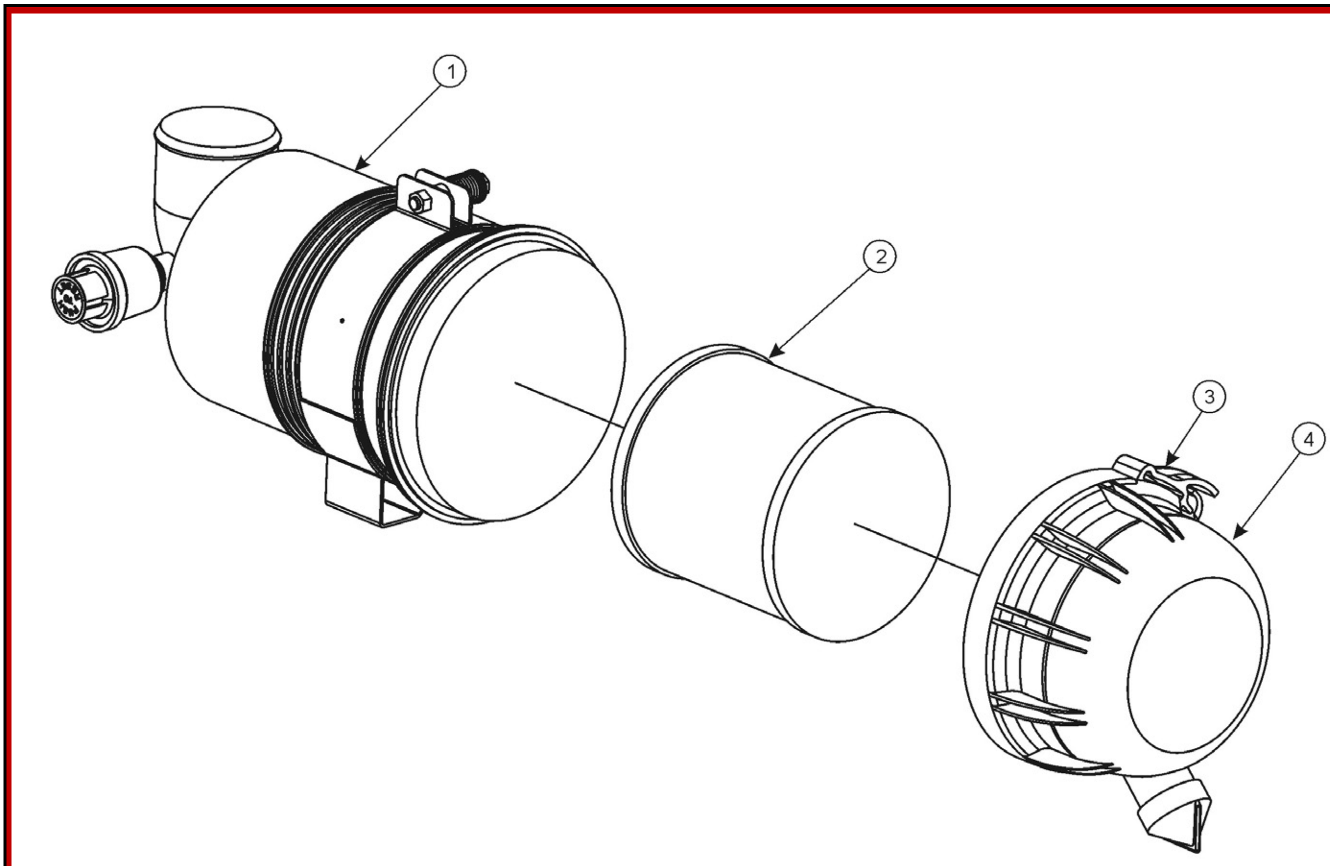
Holes, loose-end seals, dented sealing surfaces, corrosion of pipes, and other forms of damage render the air cleaner inoperative and require immediate element replacement or engine damage can occur.

NOTICE

Cummins Inc. does not recommend cleaning paper-type air cleaner elements.

1. To remove the existing air cleaner element:
   a. Before disassembly, wipe dirt from the cover and the upper portion of the air cleaner.
   b. Lift the latch (3) and turn the end cover (4) counterclockwise.
   c. Pull the end cover (4) away from the housing (1).
   d. Remove the air filter element (2) from the housing (1).
   e. Dispose of the dirty element in accordance with local environmental agency requirements.
2. To install the replacement air cleaner element:
   a. Ensure that no debris enters the filter element or connection point on the air cleaner housing.
   b. Insert the air filter element (2) into the housing (1).
   c. Install the end cover (4) onto the housing (1).

d. Turn the end cover (4) clockwise until the latch (3) snaps into place.



No.	Description	No.	Description
1	Housing	3	Latch
2	Air Filter Element	4	End Cover

FIGURE 4. EXAMPLE OF HEAVY DUTY AIR CLEANER

3.5 Battery Maintenance

⚠ WARNING

Automated Machinery

Accidental or remote starting of the generator set can cause severe personal injury or death. Arcing at battery terminals or in light switches or other equipment, and flames or sparks can ignite battery gas causing severe personal injury.

Always follow these procedures to avoid injury and/or damage:

- ***Ventilate the battery area before working on or near the battery.***
- ***Wear safety glasses.***
- ***Do not smoke.***
- ***Switch a work light on or off away from the battery.***

Make sure the generator set is shut down and disabled:

1. ***Press the generator set's red STOP button on the local display to stop the generator set. Allow the generator set to thoroughly cool to the touch.***
2. ***Turn off and disconnect the battery charger from the AC source before disconnecting the battery cables.***
3. ***Disconnect the negative (–) cable from the battery and secure it from contacting the battery terminals to prevent accidental starting.***
4. ***Once work is complete, reconnect the negative (-) battery cable last.***

See *Battery Charger Maintenance* for troubleshooting the charger.

Always:

- Keep the battery case and terminals clean and dry and the terminals tight.
- Remove battery cables with an insulated wrench or battery terminal puller.
- Make sure which terminal is positive (+) and which is negative (-) before making battery connections, always removing the negative (-) cable first and reconnecting it last to reduce arcing.

NOTICE

If the battery needs to be replaced, make sure that the replacement battery specifications match those found in the Model Specifications in this manual.

3.6 Spark Plugs

NOTICE

Make sure service personnel are qualified to perform electrical and mechanical service.

The generator set has six spark plugs, all accessible from the top of the engine. The spark plugs must be in good condition for proper engine starting and performance. A spark plug that fouls frequently or has heavy soot deposits indicates the need for engine service.

1. Set the generator set control to the Off position before checking the spark plugs.
2. To prevent cross-threading a spark plug, always thread it in by hand until it seats. Torque the spark plug to 38 Nm (28 lb-ft).
3. Return the generator set control to the desired setting when finished performing maintenance.

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4 Troubleshooting

4.1 Avoiding Generator Set Shutdowns

By regularly performing the following periodic maintenance and guidelines, you will greatly reduce the chances of a generator set shutdown:

- Maintain an appropriate oil level.
- Keep battery connections clean and tight.
- Do not overload the generator set.
- Keep the air inlet and outlet openings clear.

Refer to the Maintenance section for more information.

4.2 Fault Code Introduction

Fault code information, together with warning and shutdown information, is provided in this section to assist in locating and identifying the possible causes of faults in the generator set system.

Refer also to the engine-specific operator manual, if it exists. The engine operator manual contains additional information regarding the running and care of the generator set as well as specific equipment instructions that may differ from the standard generator set.

For any fault codes that occur but are not listed, contact your Cummins service representative.

4.3 GATRR Troubleshooting Approach

Cummins Inc. recommends Service Training based on the GATRR (Gather, Analyze, Test, Repair, Retest) troubleshooting approach.

TABLE 14. GATRR TROUBLESHOOTING APPROACH

Icon	Description
	**G - Gather**: Gather customer information, review service history, complete visual inspection, and perform system operation check. Attempt to safely recreate the issue.
	**A - Analyze**: Narrow down the possibilities by system and identify likely problem components.
	**T - Test**: Perform tests in order of likelihood based on troubleshooting tees and symptoms present.
	**R - Repair**: If necessary, perform repair per manufacturing guidelines and document all of the steps taken.
	**R - Re-test**: Re-test the component, verify that the unit operates properly, and ensure that the documentation is complete.

4.4 Service Repair Levels

The following table lists the differences in Repair Level (dealers) versus Full Service Level (distributors).

TABLE 15. SERVICE BILL OF MATERIAL GUIDE

Service Type	Description
Repair Level (Dealer)	• Maintenance items • Water pumps • Exhaust manifold • Starter • Alternator and bracket • Fan hub • Belt tensioner • Valve cover and gasket • Vibration damper • Front cover and front cover gasket • Thermostat • Oil fill cap • Dipstick and dipstick holder • Filters and filter heads • Belts • Spark plugs and wire • Gaskets associated with major components on this list (e.g. water pump gaskets, exhaust manifold gaskets, etc.) • Everything external on a long block (includes electronics and fuel systems)
Full Service (Distributor)	• Maintenance items • Repair items plus internal engine components (internal wear/failure items plus head gaskets, rod/main bearings, rings, and lube pumps) • Component rebuild parts, such as fuel system sub components, turbocharger sub components, and air compressor sub components

4.5 Control System

The generator set control system continuously monitors engine sensors for abnormal conditions, such as low oil pressure and high coolant temperature. If any of these conditions occur, the control will light a yellow Warning lamp or a red Shutdown lamp and will display a message on the graphical display panel. In the event of an engine shutdown fault (red Shutdown LED), the control will stop the engine immediately.

Display Setup and Software Information

NOTICE
Menus are available only on the Local display.

The Display Setup Menu is used to modify the display and user preferences.

- *Access Code:* A display can be set up to require or not require an access code when entering the mode (Auto, Manual Run, or Off).
- *Symbols:* A display can be set up to display international symbols on the Operator Menus (default = Yes).

To access the Display Setup Menu:

1. From any Information Menu, hold down the up and down arrows simultaneously for two seconds. The Service Menu appears.
2. Select **Setup Menus**.
3. Enter the password **574** on the Password screen. The Setup Menu appears.
4. Select **Genset Setup**.
5. Advance through the screens until the Display Setup Menu appears.

To update the Connection, Access Code, or Symbols on the Display Setup Menu:

1. Access the Display Setup Menu.
2. Select **Adjust**.
3. Adjust settings, and press **Save** to save any changes.

When updating these settings, the functions of the keys are as follows:

- The horizontal right arrow key is used to select successive blocks for editing settings on the screen.
- Adjust values by using the + or - keys on the Adjust Menu of the Display Setup Menu.
- Press **Save** to save any changes. After saving, the **Save** button changes to the **Adjust** button.

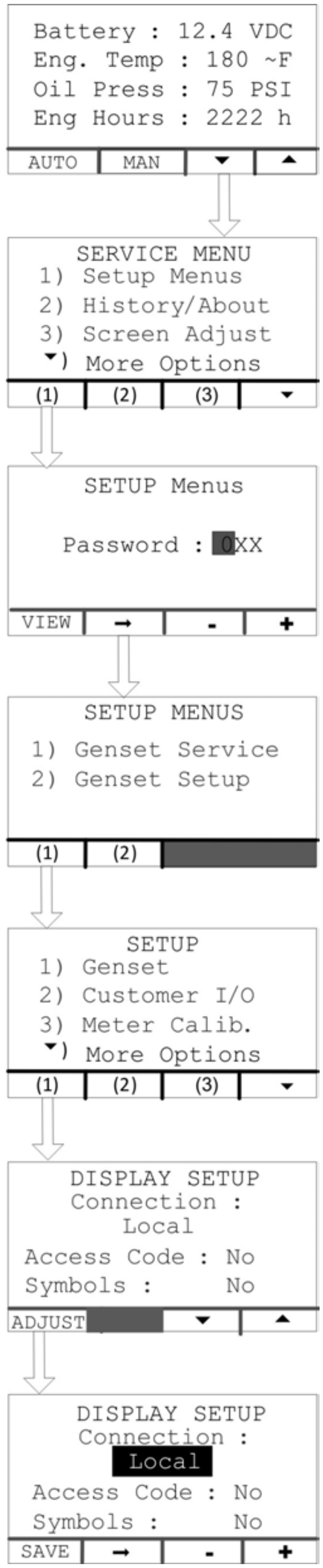


FIGURE 5. DISPLAY SETUP MENU NAVIGATION

4.6 Safety Considerations

⚠ WARNING

Hazardous Voltage

Contact with high voltages can cause severe electrical shock, burns, or death.

Make sure that only personnel who are trained and qualified to work on this equipment are allowed to operate the generator set and perform maintenance on it.

⚠ WARNING

Combustible Gases

Ignition of battery gases is a fire and explosion hazard which can cause severe personal injury or death.

Do not smoke, or switch the trouble light ON or OFF near a battery. Touch a grounded metal surface first before touching batteries to discharge static electricity. Stop the generator set and disconnect the battery charger before disconnecting battery cables. Using an insulated wrench, disconnect the negative (–) cable first and reconnect it last.

⚠ WARNING

Automated Machinery

Accidental or remote starting of the generator set can cause severe personal injury or death.

Isolate all auxiliary supplies and use an insulated wrench to disconnect the starting battery cables (negative [–] first).

Only trained and experienced service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review the safety precautions in the Important Safety Instructions section.

High voltages are present when the generator set is running. Do not open the generator set output box while the generator set is running.

NOTICE

Disconnect the battery charger from the AC source before disconnecting the battery cables. Otherwise, disconnecting cables can result in voltage spikes damaging to DC control circuits of the generator set.

When troubleshooting a generator set that is shut down, make certain the generator set cannot be accidentally restarted as follows:

1. Make sure the generator set is in the Off mode.
2. Turn off or remove AC power from the battery charger.

3. Using an insulated wrench, remove the negative (−) battery cable from the generator set starting battery.

4.7 InPower Service Tool

The InPower™ service tool can be used in troubleshooting to perform tests, verify control inputs and outputs, and test protective functions. Refer to the InPower User's Guide, provided with the InPower software for test procedures.

Disabling the AMF Feature

NOTICE
This procedure must be performed by a qualified technician.

On single-phase units, the control is shipped with the Automatic Mains Failure (AMF) feature enabled. This feature has logic to control the RA Automatic Transfer Switch (ATS), including a 5-minute retransfer to utility delay. If you are not using an RA ATS, you can eliminate the 5-minute retransfer to utility delay by disabling the AMF feature using the instructions below.

NOTICE
This procedure is optional. If you do not disable the AMF feature, the generator set will just run for an additional 5 minutes after the utility has been restored.

NOTICE
These steps cannot be performed with the HMI211; they can only be performed with the InPower service tool.

1. Connect to the PCC 1.1 or PCC 2.3 via InPower.
2. Navigate to the Adjustments->Features->Automatic Transfer Switch folder.
3. Select the Auto Mains Failure Enable parameter.
4. Double-click on Enabled in the Value field.
5. A pop-up will appear with available choices. Select Disabled.
6. Select Device->Save Adjustments from the top menu bar.
7. A pop-up will appear asking if the change is to be saved. Click the Save button.
8. After a pop-up appears confirming that the change has been saved, disconnect InPower from the PCC1302.

4.8 Mechanical Service Tools List

Most of the maintenance operations described in this manual can be performed with common hand tools (metric and S.A.E. wrenches, sockets, and screwdrivers). A list of special service tools required is available in QSOL.

4.9 Engine Control Module (ECM) Software

EControls ECM display software (either GCP Display or 4G Display) is required to service all of the models this manual covers, as shown below:

Display Software	Version	Models	Service Password
GCP	255a or newer	C45 N6	DD3F-OSHY-VJLV-IPGC
		C50 N6	
		C60 N6	
4G	284 or newer	C70 N6	GLTX-0BIS-534R-SVUX
		C80 N6	
		C100 N6	
		C125 N6	
		C150 N6	

The software enables the user to view ECM faults, reprogram ECM software, and view gauges.

4.10 Network Applications and Customer Inputs

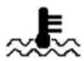
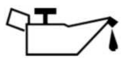
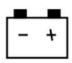
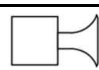
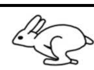
In applications with networks and remote customer inputs, the generator set may start unexpectedly or fail to crank as a result of these inputs. These symptoms may appear to be caused by the base board. Verify that the remote input is not causing the symptom or isolate the control from these inputs before troubleshooting the control.

4.11 Display Text or Symbolic Version

The operator panel graphical display can be set to show text (English only) or symbols for fault messages, operator menus, and the Mode Change Menu. Descriptions of commonly used symbols are included in the following table. Combinations of symbols are used to display some fault conditions.

When shipped from the factory, the display is set to display symbols. Qualified service personnel are required to change the default setting.

TABLE 16. SYMBOLS

Symbol	Text
	Generator Warning Fault
	Generator Shutdown Fault
	Coolant Temperature
	Oil Pressure
	Voltage Alternating Current (VAC)
	Voltage Direct Current (VDC)
	AC Current
Hz	Frequency
	Battery
	Out of Range
	High or Pre-High
	Low or Pre-Low
	Annunciator
	Over Speed
	Crank Fail
	Emergency Stop

4.12 Coolant Thermostat Troubleshooting

⚠ WARNING

Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

⚠ WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 120 °F (50 °C) before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

⚠ WARNING

Batteries can emit explosive gases. To avoid personal injury, always ventilate the compartment before servicing the batteries. To avoid arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

NOTICE

Always use the correct thermostat, and never operate the engine without a thermostat installed. The engine can overheat if operated without a thermostat because the path of least resistance for the coolant is through the bypass to the pump inlet. An incorrect thermostat can cause the engine to overheat or run too cold.

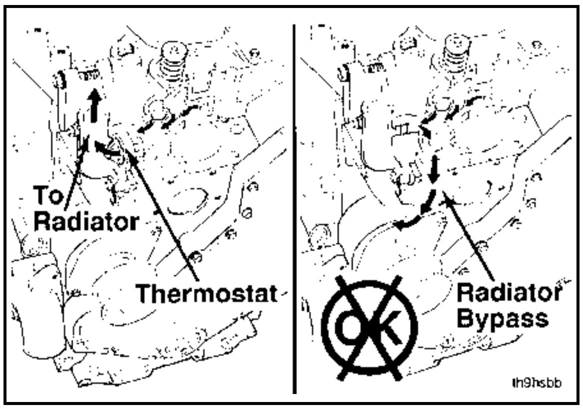


FIGURE 6. ALWAYS USE THE CORRECT THERMOSTAT

NOTICE

Always vent the engine during filling to remove air from the coolant system, or overheating will result.

1. Make sure the generator set is disabled.
    a. Press the STOP button on the operator panel to make sure the control is in the Off mode.
    b. If equipped, activate the E-stop button.
    c. If equipped, disconnect the battery charger. Remove any other electrical supply sources.
    d. Disconnect the negative (-) cable from the battery and secure it from contacting the battery terminals to prevent accidental starting.
2. Drain the coolant.
3. Remove the drive belt.
4. Disconnect the upper radiator hose.

5. Remove the alternator mounting capscrew, loosen the alternator link capscrew, and lower the alternator.
6. Remove three capscrews, the thermostat housing, lifting bracket, thermostat, and thermostat seal.

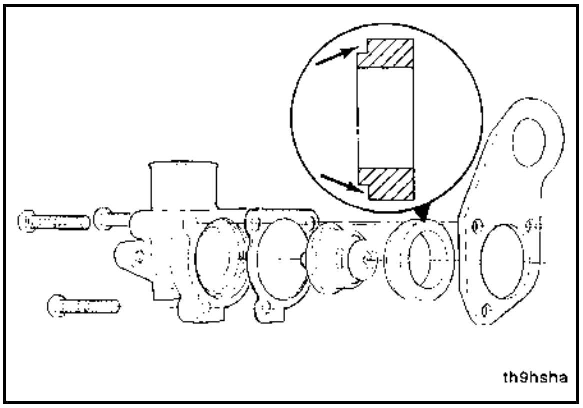


FIGURE 7. REMOVE THREE CAPSCREWS, THE THERMOSTAT HOUSING, LIFTING BRACKET, THERMOSTAT, AND THERMOSTAT SEAL

7. Clean the mating surfaces.

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

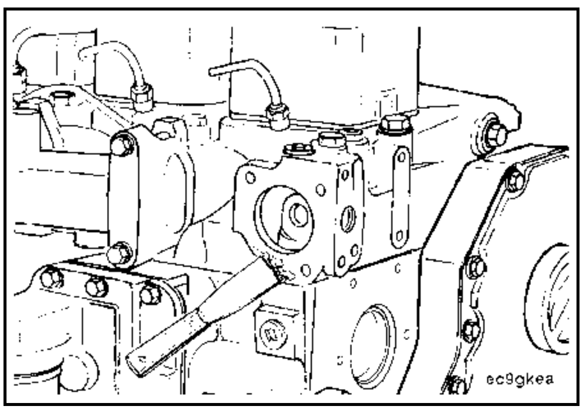


FIGURE 8. CLEAN THE MATING SURFACES

8. Inspect the thermostat for obvious damage, such as obstructions caused by debris, broken springs, or stuck or missing vent pins.
9. Make sure the thermostat is clean and free from corrosion.
10. Suspend the thermostat and a 212 °F (100 °C) thermometer in a container of well-mixed water.

NOTICE
Do not allow the thermostat or thermometer to touch the side of the container.

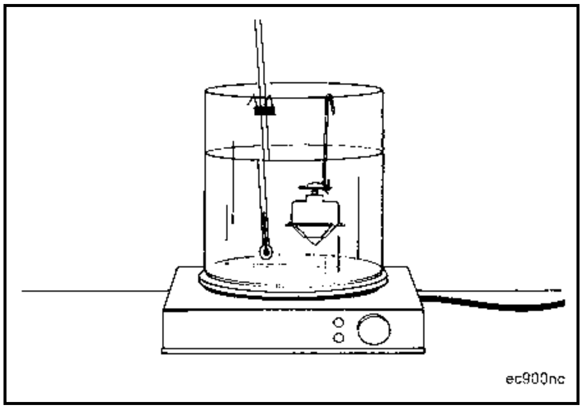


FIGURE 9. SUSPEND THE THERMOSTAT AND THERMOMETER IN WATER

11. Heat the water slowly so the wax element in the thermostat has sufficient time to react to the rising water temperature.
12. Check the thermostat to make sure it meets the following specifications:
    - Starts to open within 2 °F (1 °C) of 180 °F (82 °C)
    - Fully open within 2 °F (1 °C) of 203 °F (95 °C)
    - There is a full-open clearance between the thermostat flow valve and flange.
    - Flow valve and flange clearance (minimum): 0.26 in (6.6 mm)
13. Position the rubber seal as shown for reassembly.

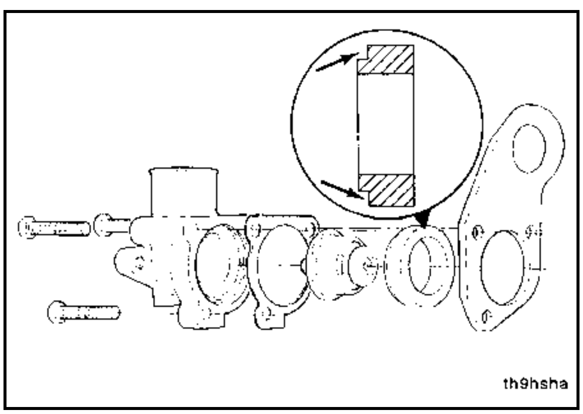


FIGURE 10. POSITION THE RUBBER SEAL

14. Install the thermostat, thermostat seal, thermostat housing, gasket, lifting bracket, and three capscrews. Torque value: 17.8 ft-lb (24 Nm).

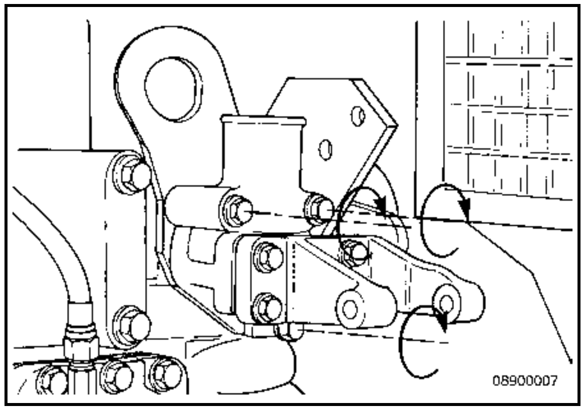


FIGURE 11. INSTALL THE THERMOSTAT, THERMOSTAT SEAL, THERMOSTAT HOUSING, GASKET, LIFTING BRACKET, AND THREE CAPSCREWS

15. Install the alternator. Torque values for A and B in the image below:
    - A: 17.8 ft-lb (24 Nm)
    - B: 32 ft-lb (43 Nm)

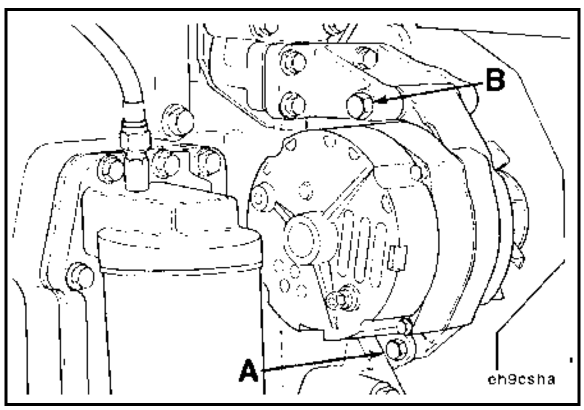


FIGURE 12. INSTALL THE ALTERNATOR

16. Install the drive belt. Refer to the Cooling Fan Drive Belt Maintenance section.

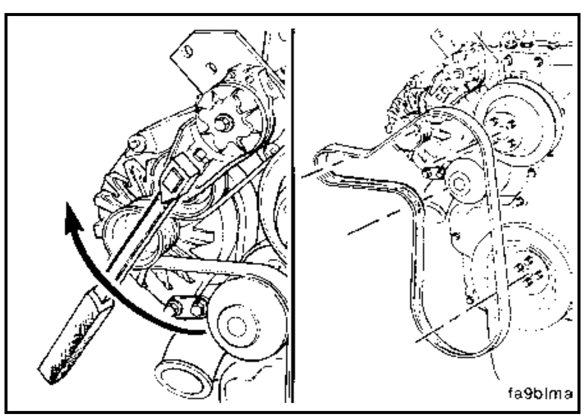


FIGURE 13. INSTALL THE DRIVE BELT

17. After the belt tensioner has been raised to remove/install the belt, check the torque of the tensioner capscrew. Torque value: 32 ft-lb (43 Nm).
18. Fill the cooling system.

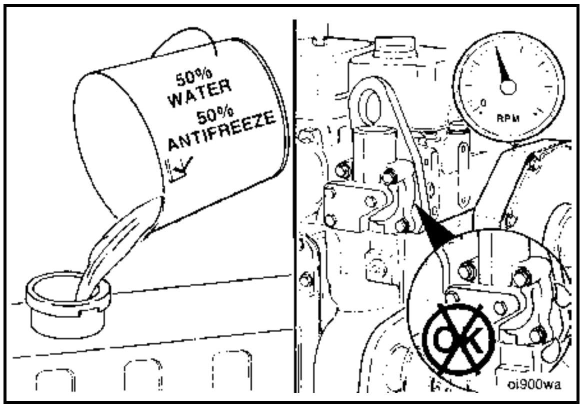


FIGURE 14. FILL THE COOLING SYSTEM

19. Connect the negative (–) cable to the battery.
20. Operate the engine, and check for leaks.

4.13 Alternator Performance Troubleshooting

Low AC Voltage at Startup

Possible Causes:

1. Loss of residual magnetism in the exciter stator lamination

Diagnosis and Repair:

1. Loss of residual magnetism in the exciter stator lamination

   This can be caused by:

   - Extended storage
   - Reversed magnetic field by flashing with wrong battery polarity
   - Exciter stator rewind
   - Mechanical shock (replacement)

   a. Restore magnetism.

      i. Attach leads to a 12VDC battery with a diode in one lead.

NOTICE
The control board will be destroyed if connected with the wrong polarity and no diode.

ii. Run the generator at rated speed, no load.

iii. Briefly (maximum one second) connect positive lead to control board terminal F1: P17-1 and negative lead to control board terminal F2: P17-2.

Unstable Voltage (No Load)

Possible Causes:

1. Engine governing unstable
2. Loose or corroded connections
3. Intermittent ground on machine

Diagnosis and Repair:

1. Engine governing unstable
    - Check for engine governor hunting with a frequency meter or tachometer, or cyclic irregularities in the engine with InPower.
    - If any engine DTC fault codes are present, troubleshoot them using the E-Controls manual.
    - Check fuel supply pressure to ensure that it is consistent.
    - Ensure that the throttle assembly moves freely. Clean it if necessary.
    - Check the spark plugs for buildup; ensure that a spark is present at each cylinder. Repair or replace them if necessary.
    - Check for any exhaust restriction. Clean or replace components as necessary.
    - Check for an intake leak. Repair or replace components as necessary.
    - Check for proper function of the crankshaft and camshaft position sensors, and the wiring to the ECM from the sensors. Repair or replace components as necessary.
    - Check the fuel mix control valve for proper operation, such that it can move freely and easily. Clean or replace the valve if necessary.
2. Loose or corroded connections
    - Check electrical connectors on terminals on the control board. Check auxiliary terminals for loose connections. Repair or replace as necessary.
3. Intermittent earth on machine

NOTICE
Voltage induced during megger test may damage the PCC. Disconnect the PCC before megger test.

- Megger test all the windings, including the exciter stator. Low insulation resistance can affect the PCC.

Unbalanced Voltage (With Load)

NOTICE

Maximum I_2 = 8%. Generator set load unbalance must not exceed 25% between any phases.

Possible Causes:

1. Alternator loads unbalanced
2. Engine governing unstable

Diagnosis and Repair:

1. Alternator loads unbalanced
    a. Check that loads are balanced on each leg of alternator output (L1, L2, L3).
2. Engine governing unstable
    - Check for engine governor hunting with a frequency meter or tachometer, or cyclic irregularities in the engine with InPower.
    - If any engine DTC fault codes are present, troubleshoot them using the E-Controls manual.
    - Check fuel supply pressure to ensure that it is consistent.
    - Ensure that the throttle assembly moves freely. Clean it if necessary.
    - Check the spark plugs for buildup; ensure that a spark is present at each cylinder. Repair or replace components as necessary.
    - Check for any exhaust restriction. Clean or replace components as necessary.
    - Check for an intake leak. Repair or replace components as necessary.
    - Check for proper function of the crankshaft and camshaft position sensors, and the wiring to the ECM from the sensors. Repair or replace components as necessary.
    - Check the fuel mix control valve for proper operation, such that it can move freely and easily. Clean or replace the valve if necessary.

Unstable Voltage (With Load)

Possible Causes:

1. Engine governing unstable
2. Leading power factor load created by power factor correction capacitors
3. Fluctuations in load current (motor starting or reciprocating loads)
4. Automatic voltage regulator parameters configured incorrectly

Diagnosis and Repair:

1. Engine governing unstable
   - Refer to the engine service manual (if applicable) or E-Controls service manual.
2. Leading power factor load created by power factor correction capacitors
   - Isolate the power factor correction capacitors until sufficient motor load has been applied to counteract the leading power factor. Adjust as required if corrects the issue.
3. Fluctuations in load current (motor starting or reciprocating loads)
   - Check the load current on a stable supply (i.e., mains), or separately excite the machine. A variable DC supply is required for on load separate excitation tests.
4. Automatic voltage regulator parameters configured incorrectly
   - Contact your local Cummins distributor.

Poor Voltage Regulation (With Load)

Possible Causes:

1. Unbalanced load
2. Voltage drop between alternator and load, caused by losses in supply cable (power losses)
3. Fault on main rectifier or excitation winding
4. Under frequency roll-off protection activated

Diagnosis and Repair:

1. Unbalanced load.
   - Check voltage and load current on all phases. If unbalanced, redistribute the load more evenly across the phases.
2. Voltage drop between alternator and load, caused by losses in supply cable (power losses).
   - Check the voltage at both ends of the cable run at full load.
     - Large differences in voltages indicate a large volts drop along the cable.
     - A larger diameter cable is required in severe cases.
3. Fault on main rectifier or excitation winding.
   - Check the no load excitation voltage across automatic voltage regulator X+ (F1) and XX- (F2). Voltage should be no higher than 12 VDC.
4. Under frequency roll-off protection activated.
   - Under frequency roll-off protection is activated, indicating excessive load. Check that under frequency roll-off set point and slope are correct.

- Load on generator is in excess of rated. Ensure that the load on the generator set does not exceed the generator kW rating. Revisit the generator set sizing process to ensure that the generator set is correctly sized for the application, especially if new loads have been introduced into the system.

Poor Response to Load Surges or Motor Starting (With Load)

Possible Causes:

1. Engine performance
2. Load current surges
3. Active under-frequency roll-off protection on automatic voltage regulator
4. Voltage drop between alternator and load
5. Fault on windings or rotating rectifier
6. Fault in automatic voltage regulator

Diagnosis and Repair:

1. Engine performance
    - Check performance of the engine during the application of load.
2. Load current surges
    - When surges significantly exceed the full load of the generator, check surges with a clip-on ammeter.
        - Check with factory for advice on voltage dips for motor starting.
3. Active under-frequency roll-off protection on automatic voltage regulator
    - Low engine speed will activate under frequency roll-off protection circuit. Check the engine speed dip on load application.
4. Voltage drop between alternator and load
    - The drop is caused by power losses in the supply cable, which will be worse during current surges (motor starting, etc.). Check the voltage at both ends of the cable run at full load.
        - Differences in voltages indicate a volts drop along the cable.
        - A larger diameter cable may be required in severe cases.
        - This will be worse during current surges (motor starting, etc.).
5. Fault on windings or rotating rectifier
    - Check the no load excitation voltage across automatic voltage regulator X+ (F1) and XX- (F2). Voltage should be no higher than 12 VDC.
6. Fault in automatic voltage regulator
    - Replace the automatic voltage regulator and re-test when loaded.

High Voltage (With Load)

Possible Causes:

1. Unbalanced load
2. Leading power factor

Diagnosis and Repair:

1. Unbalanced load.
    - Check voltage on all three phases. If unbalanced, re-distribute loading over the three phases.
2. Leading power factor.
    - Check for capacitive (leading) PF load (i.e. kVA correction fluorescent lights).
        - Apply motor (lagging) PF load, or switch off capacitors.
        - A leading power factor load will give abnormally low DC excitation volts across X+ (F1) and XX-(F2).

Low Voltage (With Load)

Possible Causes:

1. Under frequency roll-off protection activated
2. Faulty permanent magnet generator (PMG) (if used)
3. Fault on winding or rotating diodes
4. Voltage drop between alternator and load, due to power losses in the cable

Diagnosis and Repair:

1. Under frequency roll-off protection activated
    - Under frequency roll-off protection is activated, indicating excessive load. Check that under frequency roll-off set point and slope are correct.
    - Load on generator is in excess of rated. Ensure that the load on the generator set does not exceed the generator kW rating. Revisit the generator set sizing process to ensure that the generator set is correctly sized for the application, especially if new loads have been introduced into the system.
2. Faulty permanent magnet generator (PMG) (if used)
    - Start the generator set and run at rated speed. Measure the voltages at the terminals P2 (J18-1) and P3 (J18-2). These should be balanced and within the range of 60 Hz generators 190 to 220 V.
3. Fault on winding or rotating diodes
    - Any fault in this area will appear as high excitation voltage across X+ (F1) and XX- (F2).
        a. Remove external leads from the alternator.

b. Use appropriate metering equipment (Wheatstone bridge or Kelvin bridge). Measure the winding resistance of the main rotor and stator.

c. Check diodes.

d. Test diodes on the main rotating rectifier assembly with a multimeter.

4. Voltage drop between alternator and load, due to power losses in the cable
   - Check the voltage at both ends of the cable run at full load.
     - Differences in voltage levels indicate a voltage drop along the cable.
     - In severe cases, a larger diameter cable is required.
     - This will be worse during current surges (motor starting, etc.).

Fault Finding

Before starting any fault finding procedure, examine all wiring for broken or loose connections. If in doubt, refer to the wiring diagram supplied with the alternator. Compare measurements with the test report supplied with the alternator.

The following list is to aid in troubleshooting and is not exhaustive. If in doubt, consult Cummins service department.

NOTICE
Perform the tests in order, unless stated otherwise. Perform the method steps in order. Achieve a result before doing the next step.

1. Disconnect the exciter stator leads X+ (F1) and XX- (F2) from the PCC 1302 control board, then do the tests in the table below.

TABLE 17. FAULTFINDING

Test		Result	Action
1	Disconnect the sensing leads from the control (6, 7, and 8), the ground cable, and customer connection from the terminal block. Use a MΩ meter to measure resistance from the leads to ground.	Resistance is less than 1 MΩ.	Clean the main stator, allow it to dry, and repeat the test. If the same result is achieved, replace the alternator/main stator.
		Resistance is greater than 1 MΩ.	Proceed to test 2.
2	Use a multimeter to measure the exciter stator resistance across the leads X+ (F1) and XX- (F2).	Resistance is not with 10% of the relevant value in Section 2.5 on page 17.	Stator windings damaged; replace exciter stator.
		Resistance is within 10% of the relevant value in Section 2.5 on page 17.	Proceed to test 3.

Test		Result	Action
3	Use an insulation tester to megger from the XX- (F2) to ground.	Resistance value is less than 1 MΩ.	Clean the exciter stator, allow it to dry, and repeat the test. If the same result is achieved, replace the exciter stator.
		Resistance value is greater than 1 MΩ.	Exciter stator is good. Proceed to test 4.
4	Connect a 12V battery to the exciter stator windings, positive terminal to X+ (F1), negative terminal to XX- (F2). Disconnect all loads. Run the generator at nominal speed. Measure AC output voltage.	Voltage is balanced between phases within 1%, and within 10% of nominal.	Main stator, main rotor, exciter stator, exciter rotor, and rectifier are functioning properly. Proceed to test 10.
		Voltage is balanced between phases within 1%, but greater than 10% below nominal.	Main stator is functioning properly. Proceed to test 6. If tests 6 and 7 already completed, proceed to test 8.
		Voltage is unbalanced by greater than 1%.	Main stator windings are faulty. Proceed to test 5.
5	At the terminal block, disconnect all leads. Use a μΩ meter/kelvin bridge to measure each winding resistance.	Resistances are not within 10% of the relevant value from **Section 2.5 on page 17**, or are not balanced within 1%.	Replace the alternator.
		Resistances are within 10% of the relevant value from **Section 2.5 on page 17**, and are balanced within 1%.	Reconnect all leads, and return to test 2.
6	Disconnect the flexible lead ends of each diode on the rotating rectifier. Use a multimeter to test each diode.	One or more diodes do not function properly.	Replace all diodes, as well as the varistor. Return to test 4.
		All diodes function properly.	Proceed to test 7.
7	Inspect the varistor for signs of damage or overheating. Disconnect the positive output lead from the rotating rectifier. Measure resistance across the varistor.	The varistor shows signs of a thermal event or measures no resistance in one or both directions.	Replace all diodes and the varistor. Return to test 4.
		The varistor shows no signs of a thermal event and has near infinite resistance in both directions.	Proceed to test 8.

Test		Result	Action
8	Disconnect the 6 exciter rotor leads from the rotating rectifier. Use a μΩ meter to measure the resistance across all of the leads connected to the same polarity diodes.	Resistance is within 10% of the relevant value in **Section 2.5 on page 17**.	Replace the exciter rotor/alternator assembly.
		Resistance is not within 10% of the relevant value in **Section 2.5 on page 17**.	Proceed to test 9.
9	Disconnect one of the main rotor leads from the rotating rectifier. Use a multimeter to measure the resistance of the main rotor.	Resistance value is more than 10% different than the relevant value from **Section 2.5 on page 17**.	Replace the main rotor/alternator assembly.
		Resistance value is less than 10% different than the relevant value from **Section 2.5 on page 17**.	Proceed to test 10.
10	Use a multimeter to check the continuity of the sense leads.	One or more sense leads measure "open".	Replace the sensing leads.
		All sense leads measure continuous.	Proceed to test 11.
11	Use a multimeter to measure the voltage across the leads of the PMG.	All voltages are 170-220V phase to phase and are balanced within 1%.	Replace the control board.
		Voltages are not 170-220V phase to phase and/or not balanced within 1%.	Proceed to test 12.
12	Use a multimeter to measure the resistance of the PMG stator.	Resistance is not within 10% of the relevant value in **Section 2.5 on page 17**.	Replace the PMG stator.
		Resistance is within 10% of the relevant value in **Section 2.5 on page 17**.	Replace the PMG rotor.

4.14 Engine Performance Troubleshooting

Engine Is Difficult to Start or Does Not Start

Possible Causes:

1. Battery voltage is low, interrupted, or open
2. Fuel system issues.
3. Air intake or exhaust issues
4. Sensor issues

5. Base engine problem

Diagnosis and Repair:

1. Battery voltage is low, interrupted, or open
    a. Check the battery connections, unswitched battery supply circuit, and fuses.
    b. Correct or replace if necessary.
2. Fuel system issues
    a. Verify fuel pressure at the generator set.
    b. Inspect fuel lines and connections for leaks. Spray soapy water along the lines and at connection. Bubbling indicates a likely leak location.
        i. Repair the leaks. Refer to the Fuel System section.
    c. The manual fuel shutoff (FSO) valve is closed.
        i. Open the valve.
    d. FSO valve solenoids or circuit are malfunctioning.
        i. Check the FSO valve solenoids and circuit for proper operation. Check for continuity, and proper operation.
        ii. Correct or replace if necessary. Refer to the Fuel System section.
    e. The wiring to the throttle body has failed (shorted or open).
        i. Examine the wiring for damage.
        ii. Check for DTC fault codes. If any are present, troubleshoot as specified in the E-Controls manual.
        iii. Repair if necessary
    f. The throttle plate and shaft are binding.
        i. Check for fault codes using the E-Controls tool. Troubleshoot those as specified in the E-Controls manual.
        ii. Inspect the bore of the throttle body.
        iii. Clean if necessary, or replace if worn.
    g. Inspect the pressure regulator and EPR assembly for damage.
        i. The valve located inside the assembly should move freely.
        ii. Clean or replace if necessary.
3. Air intake or exhaust issues
    a. The air intake system restriction is above specification.
        i. Check the air intake system restriction.
        ii. Clean or replace the air filter and inlet piping if necessary. Refer to the Air Intake section.

b. The exhaust system restriction is above specification.
   i. Check the exhaust system restrictions.
   ii. Correct or replace if necessary. Refer to the Exhaust section.

4. Sensor issues
   a. The intake manifold pressure sensor is malfunctioning.
      i. Check the intake manifold pressure sensor.
      ii. Correct or replace if necessary.
   b. The temperature manifold absolute pressure (TMAP) sensor is malfunctioning.
      i. Refer to the Sensors section.
   c. The crankshaft and/or camshaft speed/position sensors are reading incorrectly.
      i. Refer to the Control System section and/or the Sensors section.
5. Base engine problem
   a. Check the engine for high crankcase pressure and low compression, as well as damaged pistons, camshaft, and other parts.
   b. Correct or replace if necessary.

Engine Experiences Low Power, Poor Acceleration, or Poor Response

Possible Cause:

1. Excessive load
2. Fuel system issues
3. Air intake or exhaust issues
4. Engine speed governor issue
5. Other issues

Diagnosis and Repair:

1. Excessive loads
   - Ensure that the load on the generator set does not exceed the generator set kW rating.
     - Revisit the generator set sizing process to ensure that the generator set is correctly sized for the application, especially if new loads have been introduced into the system.
2. Fuel system issues
   - Inspect fuel lines, fuel connections, and fuel filters for leaks.
     - Repair if leaks are found.

- Fuel shutoff valve solenoid or circuit is malfunctioning.
  - Check the fuel shutoff valve solenoid and circuit.

3. Air intake or exhaust issues
   - Air intake system restriction is above specification.
     - Check the air intake system for restriction.
     - Clean or replace the air filter and inlet piping as necessary.
   - Air intake or exhaust leaks.
     - Inspect the air intake and exhaust systems for air leaks.
   - Exhaust system restriction is above specification.
     - Check the exhaust system for restrictions.
4. Engine speed governor issue
   - Refer to the engine service manual.
5. Other issues
   - The generator set is operating above recommended altitude.
     - Generator set power decreases above recommended altitude.
       - Refer to the Generator Set Data Sheet for the specific generator set for specifications.
   - Base engine problem
     - Check the engine for high crankcase pressure and low compression, as well as damaged pistons, camshaft, and other parts.
       - Refer to the engine service manual.
   - Engine calibration values set in control are not correct.
     - Verify governor settings in control. If needed, contact your service support representative.

Engine Runs Rough or Misfires

Possible Cause:

1. Ignition system issues
2. Engine air intake system or engine exhaust system issues
3. Fuel system issues
4. Other issues

Diagnosis and Repair:

1. Ignition system issues
   a. Inspect the spark plugs.
      i. Clean or replace the spark plugs if necessary.
   b. Test the ignition coils.

NOTICE
This type of ignition coil cannot be tested using resistance checks.

   i. Use a coil on a plug tester (or in-line spark tester) to isolate the faulty coil.
   ii. Replace the faulty coil if necessary.
   c. Check the coil wiring.
      i. Inspect connectors and wires for breaks, and test continuity.
2. Engine air intake system or engine exhaust system issues
   a. Engine air intake system restriction is above specification.
      i. Check the air intake system for restriction.
      ii. Clean or replace the air filter and inlet piping as necessary.
   b. There are air intake system or exhaust system leaks.
      i. Repair if necessary.
   c. Exhaust system back pressure is above specification.
      i. Check the exhaust system back pressure.
      ii. Replace the exhaust system if necessary.
3. Fuel system issues
   a. Inspect fuel lines and fuel connections for leaks.
      i. Repair if leaks are found.
4. Other issues
   - Verify that the proper fuel type is selected.
   - There is a base engine problem.
      a. Check the engine for high crankcase pressure and low compression, as well as damaged pistons, camshaft, and other parts.
      b. Correct or replace if necessary.

Engine Shuts Off Unexpectedly or Dies during Deceleration

Possible Causes:

1. Emergency Stop (if used)
2. Fuel system issues
3. Wiring to the throttle body has failed (shorted or open)
4. Engine Control Module (ECM) related issues
5. Base engine problem

Diagnosis and Repair:

1. Emergency Stop (if used)
    a. The Emergency Stop circuit is energized.
        i. Make sure that the Emergency Stop circuit is not energized.
2. Fuel system issues
    a. Check the fuel supply for appropriate pressure and flow.
    b. The manual fuel shutoff (FSO) valve is closed.
        i. Open the valves.
    c. The FSO valve solenoids or circuit are malfunctioning.
        i. Check the FSO valve solenoids and circuit.
        ii. Repair if necessary.
3. Wiring to the throttle body has failed (shorted or open)
    a. Verify that the wiring is intact.
    b. Repair if necessary.
4. Engine Control Module (ECM) related issues
    a. The battery voltage supply to the ECM has been lost.
        i. Check the battery connections.
        ii. Check all components in the un-switched battery supply circuit to the ECM.
    b. The ECM is not grounded correctly.
        i. Check the grounding and verify the correct placement of the star washer on the engine block ground cable.
    c. There is a problem between the ECM and the PCC.
        i. Check connections, wiring and components (i.e., relays).
    d. The ECM is malfunctioning.
        i. Correct or replace if necessary.
5. Base engine problem
    a. Check the engine for high crankcase pressure and low compression, as well as damaged pistons, camshaft, and other parts.
    b. Correct or replace if necessary.

Engine Speed Surges Under Load or in Operating Range

Possible Causes:

1. Fuel system issues
2. Sensor issues
3. Other issues

Diagnosis and Repair:

1. Fuel system issues
    a. Inspect fuel lines and connections for leaks. Spray soapy water along the lines and at connection. Bubbling indicates a likely leak location.
        i. Repair if leaks are found.
    b. The throttle plate and shaft are binding.
        i. Check for fault codes using the E-Controls tool. Troubleshoot those as specified in the E-Controls manual.
        ii. Inspect the bore of the throttle body.
        iii. Clean if necessary, or replace if worn.
    c. Inspect the pressure regulator and EPR assembly for damage.
        i. The valve located inside the assembly should move freely.
        ii. Clean or replace if necessary.
2. Sensor issues
    a. Crankshaft and/or camshaft speed/position sensors reading incorrectly.
        i. Check for fault codes at the PCC.
        ii. Check for fault codes at the Engine Control Module (ECM).
        iii. Correct or replace if necessary.
3. Other issues
    a. There is moisture in the wiring harness connectors.
        i. Dry the connectors with Cummins electronic cleaner, Part Number 3824510.
    b. There is a base engine problem.
        i. Check the engine for high crankcase pressure and low compression, as well as damaged pistons, camshaft, and other parts.
        ii. Correct or replace if necessary.
    c. The alternator is malfunctioning.
        i. Temporarily disconnect the alternator and test-run the engine.
        ii. Replace the alternator if necessary.

Poor Engine Transient Response

Possible Cause:

1. Excessive loads
2. Fuel system leaks
3. Air intake or exhaust issues
4. Other issues

Diagnosis and Repair:

1. Excessive loads
   a. Make sure that the load on the generator set does not exceed the generator set kW rating.
      i. Re-visit the generator set sizing process to make sure that the generator set is correctly sized for the application, especially if new loads have been introduced into the system.
2. Fuel system leaks
   a. Inspect fuel lines, fuel connections, and fuel filters for leaks.
      i. Repair if leaks found.
      ii. Refer to the procedures in the troubleshooting and repair manual for the specific engine.
3. Air intake or exhaust issues
   a. There are air intake or exhaust leaks.
      i. Inspect the air intake and exhaust systems for air leaks.
   b. The air intake system restriction is above specification.
      i. Check the air intake system for restriction.
      ii. Clean or replace the air filter and inlet piping as necessary.
   c. The exhaust system restriction is above specification.
      i. Check the exhaust system for restrictions.
4. Other issues
   a. The generator set is operating above the recommended altitude.
      i. Generator set power decreases above the recommended altitude.
         A. Refer to the Generator Set Data Sheet for the specific generator set for specifications.
   b. Base engine problem
      i. Check the engine for high crankcase pressure, low compression, damaged pistons, damaged camshaft, and other damaged parts.
         A. Refer to the engine service manual.
   c. The engine calibration values set in the control are not correct.
      - Verify the governor settings in the control. If needed, contact your service support representative.

Engine Will Not Reach Rated Speed (RPM)

Possible Causes:

1. Excessive loads
2. Air intake or exhaust issues

3. Other issues

Diagnosis and Repair:

1. Excessive loads
   a. Make sure that the load on the generator set does not exceed the generator set KW rating.
      i. Re-visit the generator set sizing process to ensure that the generator set is correctly sized for the application, especially if new loads have been introduced into the system. Refer to the T-030 manual for proper generator set sizing and application.
2. Air intake or exhaust issues
   a. The air intake system restriction is above specification.
      i. Check the air intake system restriction.
      ii. Clean or replace the air filter and inlet piping if necessary.
   b. The exhaust system back pressure is above specification.
      i. Check the exhaust system back pressure.
      ii. Clean or replace if necessary.
3. Other issues
   a. The engine is operating above the recommended altitude.
      i. Verify the product capability at altitude against the installed load.
      ii. Refer to altitude and temperature derates to calculate expected power.
   b. There is a base engine problem.
      i. Check the engine for high crankcase pressure and low compression, as well as damaged pistons, camshaft, and other parts.
      ii. Correct or replace if necessary.

Engine Does Not Crank in Manual Mode (No Fault Message)

Logic: The PCC has not received or recognized a manual start signal.

Possible Causes:

1. No power supplied to the control (green "Heartbeat" LED on the baseboard not flashing)
2. Baseboard not properly calibrated or corrupt calibration (green "Heartbeat" LED on baseboard flashes every 0.5 seconds)
3. Active Emergency Stop switch or defective wiring
4. Defective Manual Run/Stop button, harness, or baseboard
5. Bad starter relay, wiring issue, bad starter or key switch relay

Diagnosis and Repair:

1. No power supplied to the control (green "Heartbeat" LED on the baseboard not flashing)
   a. There are poor battery cable connections.
      i. Clean the battery cable terminals and tighten all connections.
   b. There is a continuity problem.
      i. Remove Fuse F3 and check continuity. If open, replace the fuse with one of the same type and amp rating (20 Amps).
      ii. If Fuse F3 is OK, remove connector PCC-P20 and check for B+ at pins 9, 10, 20, and 21; and ground at pins 2, 4, 7, and 12.
      iii. If B+ and ground are OK, the baseboard may be defective. Cycle power to the baseboard by reconnecting PCC-P20.
      iv. Replace the baseboard if necessary.
2. Baseboard not properly calibrated or corrupt calibration (green "Heartbeat" LED on baseboard flashes every 0.5 seconds)
   a. Confirm that the installed calibration part number matches the serial plate information.
   b. Re-enter a calibration file if necessary.

NOTICE
When properly installed, the green "Heartbeat" LED flashes once every second.

3. Active Emergency Stop switch or defective wiring
   a. With the Emergency Stop push button not activated, remove connectors JE and PE.
   b. Bypass the Emergency Stop switch by connecting the JE and PE connectors.
   c. Attempt to start the generator set in manual mode. If it starts, the Emergency Stop Switch is faulty.
   d. Correct or replace if necessary.
4. Defective Manual Run/Stop button, harness, or baseboard
   a. Remove connector PCC-P25 from the baseboard and check for continuity from pin PCC-P25-10 to Display P1-6.
   b. If there is no continuity when pressing the Manual Run/Stop button, replace the front membrane panel.
5. Bad starter relay, wiring issue, bad starter or key switch relay
   a. Inspect and test these components.
   b. Correct and replace components if necessary.

Engine Does Not Crank in Remote Mode (No Fault Message)

Logic:

The PCC has not received or recognized a remote start signal.

Possible Causes:

1. Faulty remote start customer wiring
2. Bad starter relay, wiring issue, bad starter, or key switch relay

Diagnosis and Repair:

1. Faulty remote start customer wiring
    a. Reset the control. Attempt to start and check for wiring connections.
    b. If ground is not present, isolate to the remote switch or customer wiring. Repair if necessary.
2. Bad starter relay, wiring issue, bad starter, or key switch relay
    a. Inspect and test these components.
    b. Correct and replace components if necessary.

Engine Starts but Will Not Keep Running

Possible Causes:

1. Battery voltage is low, interrupted, or open
2. Run/Stop circuit issues
3. Fuel system issues
4. Base engine problem

Diagnosis and Repair:

1. Battery voltage is low, interrupted, or open.
    a. Check the battery connections, unswitched battery supply circuit, and fuses.
    b. Correct or replace if necessary.
2. Run/Stop circuit issues
    a. The alternator Run/Stop circuit is malfunctioning.
        i. Check the alternator Run/Stop circuit.
        ii. Correct or replace if necessary.
3. Fuel system issues
    a. Verify fuel pressure at the generator set.
    b. Inspect fuel lines and connections for leaks. Spray soapy water along the lines and at connection. Bubbling indicates a likely leak location.
        i. Repair leaks, if found

c. The fuel shutoff (FSO) valve is closed.
    i. Open the valve.
d. FSO valve solenoid or circuit are malfunctioning.
    i. Check the FSO valve solenoids and circuit for proper operation. Check for continuity, and proper operation.
    ii. Correct or replace if necessary.
e. The wiring to the throttle body has failed (shorted, or open).
    i. Examine the wiring for damage.
    ii. Check for DTC fault codes. If any are present, troubleshoot as specified in the E-Controls manual.
    iii. Repair if necessary
f. The throttle plate and shaft are binding.
    i. Check for fault codes using the E-Controls tool. Troubleshoot those as specified in the E-Controls manual.
    ii. Inspect the bore of the throttle body.
    iii. Clean if necessary. Replace if worn.
g. Inspect the pressure regulator and EPR assembly for damage.
    i. The valve located inside the assembly should move freely.
    ii. Clean or replace if necessary.

4. Base engine problem
    a. Check the engine for high crankcase pressure and low compression, as well as damaged pistons, camshaft, and other parts.
    b. Correct or replace if necessary.

Engine Will Not Shut Off

Possible Cause:

1. Run/Stop circuit issue

Diagnosis and Repair:

1. Run/Stop circuit issue
    a. Run/stop circuit is malfunctioning.
        i. Check the alternator Run/Stop circuit.
        ii. Correct or replace if necessary.

Fuel Consumption Is Excessive

Possible Causes:

1. Excessive loads
2. Maintenance, repair or environmental effects

3. Air intake or exhaust issues
4. Fuel system issues
5. Crankshaft and/or camshaft speed/position sensors are reading incorrectly
6. Other issues

Diagnosis and Repair:

1. Excessive loads
    a. Make sure that the load on the generator set does not exceed the generator set kW rating.
        i. Re-visit the generator set sizing process to make sure that the generator set is correctly sized for the application, especially if new loads have been introduced into the system. Refer to the T-030 manual for proper generator set sizing and application.
2. Maintenance, repair or environmental effects
    a. Fuel consumption has increased after an engine repair.
        i. Evaluate the engine repair to determine its effect on fuel consumption.
            A. Correct if necessary.
        ii. Check part numbers to make sure the correct parts were used.
            A. Replace incorrect parts.
    b. Lubricating oil level is above specification.
        i. Check the oil level.
        ii. Verify the dipstick calibration and oil pan capacity.
        iii. Fill the system to the specified level.
    c. Environmental factors are affecting fuel consumption.
        i. Consider altitude and ambient air temperature when evaluating fuel consumption. Refer to the specific Engine Data Sheets for altitude derate information.
3. Air intake or exhaust issues
    a. There are air intake or exhaust leaks.
        i. Inspect the air intake and exhaust systems for air leaks. Refer to the Air Intake System section.
    b. The air intake system restriction is above specification.
        i. Check the air intake system for a restriction.
        ii. Clean or replace the air filter and inlet piping if necessary. Refer to the Air Intake System section.
4. Fuel system issues
    a. There are leaks in fuel lines and/or fuel connections.
        i. Repair the leaks. Refer to the Fuel System section.

b. The fuel system pressure sensors (fueling/timing) are malfunctioning.

i. Check the fuel system pressure sensors (fueling/timing), including: the camshaft sensor, fuel pressure sensors, throttle positions sensors, crankshaft sensor, O2 sensor, and TMAP sensors for proper operation. Refer to the E-Controls manual for test methods for each device.

5. Crankshaft and/or camshaft speed/position sensors are reading incorrectly

a. Check the sensors.

b. Check for ECM fault codes related to these sensors. Refer to the Engine Control Module (ECM) section.

c. Correct or replace if necessary.

6. Other issues

a. Engine parasitics are excessive.

i. Check engine-driven units for correct operation. Refer to the operator manual.

ii. Check the cooling fan for correct operation. With fan belt removed, the fan should spin freely by hand in both directions.

A. Correct or replace if necessary.

b. There is a base engine problem.

i. Check the engine for high crankcase pressure, low compression, damaged pistons, camshaft, and other parts. Listen for unusual noises, and inspect possible causes. Analyze the oil and inspect the filters to locate an area of probable damage.

ii. Correct or replace if necessary.

Engine Noise Is Excessive

Possible Cause:

1. Air intake or exhaust leaks
2. Turbocharger noise
3. Mechanical or internal component wear or damage

Diagnosis and Repair:

1. Air intake or exhaust leaks

a. There are air intake or exhaust leaks.

i. Inspect the air intake and exhaust systems for air leaks. Refer to the Air Intake System section and/or Exhaust System section.

b. There is a faulty muffler.

i. Replace the muffler if necessary. Refer to the Exhaust System section.

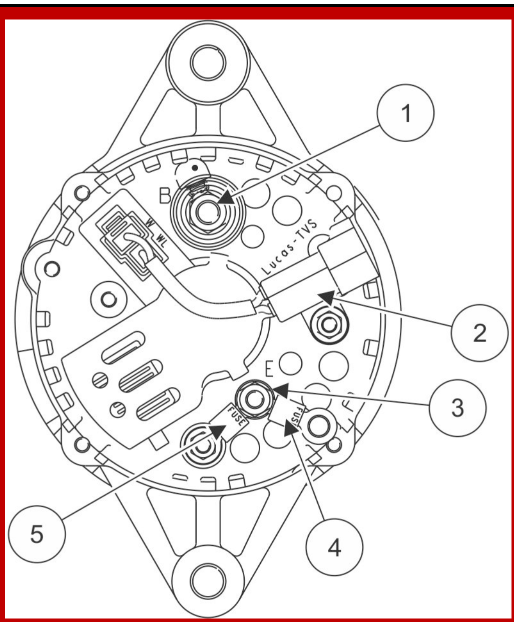
2. Turbocharger noise
    a. Inspect the turbochargers for excessive mechanical noise.
        i. Replace them if necessary.
3. Mechanical or internal component wear or damage
    a. There is internal engine damage.
        i. Analyze the oil and inspect the filters to locate an area of probable damage.
        ii. Inspect and further investigate area of probable damage.
    b. Valvetrain components are damaged.
        i. Replace damaged components.
    c. The vibration damper is damaged.
        i. Replace the vibration damper.
    d. There is main bearing or connecting rod bearing noise.
        i. The engine is damaged, and needs repair or replacement.
    e. Flywheel or flexplate cap screws are loose or broken.
        i. Check the flywheel or flexplate and the mounting cap screws.
        ii. Tighten any loose screws; replace any broken screws.
    f. Piston, piston rings, or cylinder liner is/are worn or damaged.
        i. Replace worn or damaged components.

DC (Battery-Charging) Alternator Troubleshooting

⚠ WARNING
Acid is extremely dangerous and can damage the machinery and can also cause serious burns. Always provide a tank of strong soda water as a neutralizing agent when servicing the batteries. Wear goggles and protective clothing to reduce the possibility of serious personal injury.

⚠ WARNING
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

ALTERNATOR WIRING SYSTEMS



Key	Terminal	Connected To
1	BAT	Battery
2	I	Flash signal
3	GRD	Ground
4	Spare Fuse	--
5	Fuse	--

FIGURE 15. ALTERNATOR (LUCAS)

TEST

1. Check for open circuits.

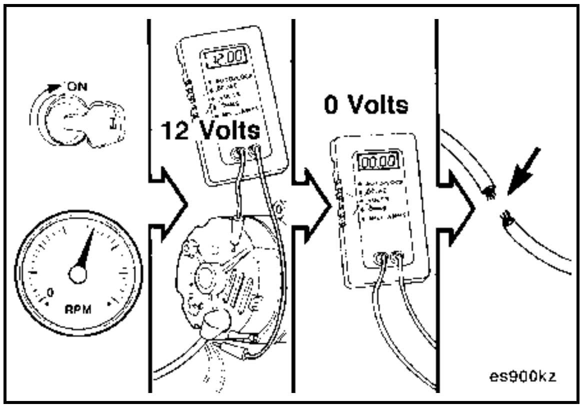


FIGURE 16. CHECK FOR OPEN CIRCUITS

2. Connect a multimeter to alternator “BAT” terminal to ground.
3. Run the generator and check for battery voltage on the meter.

4. Stop the generator set.
5. Connect a carbon-pile load (battery/alternator tester) across the batteries in one of the battery boxes.

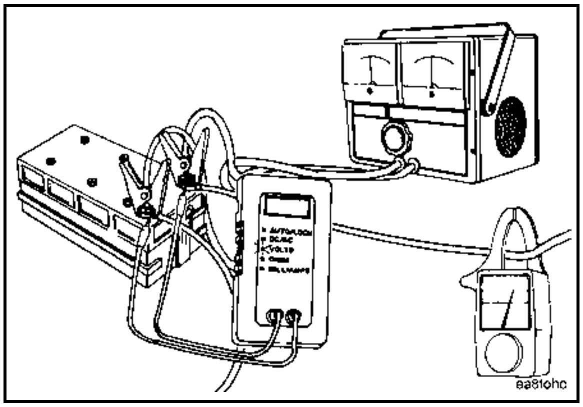


FIGURE 17. CONNECT A CARBON PILE LOAD

6. Clamp an induction pickup-type ampere-hour meter around the battery cable.
7. Disconnect the 120V battery charger (if present).

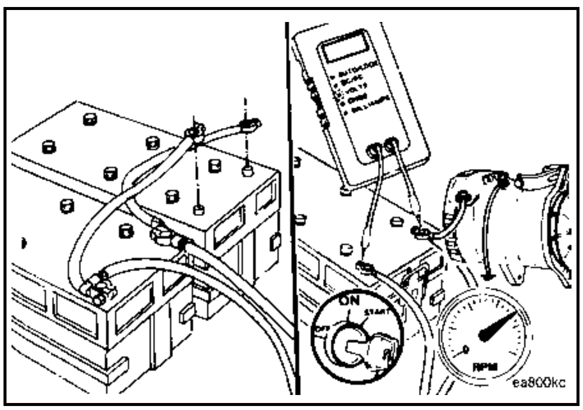


FIGURE 18. DISCONNECT BATTERY CABLES; MEASURE THE ALTERNATOR VOLTAGE OUTPUT

8. Operate the engine.
9. Measure the alternator voltage output to the batteries with a digital multimeter as shown in the image above. Refer to the alternator manufacturer's specifications.

NOTICE
Any multimeter reading of zero voltage indicates an open circuit.

10. Operate the engine.

11. Adjust the carbon-pile load-testing equipment to apply the maximum rated amperage load to the alternator. Refer to the alternator manufacturer's specifications.

NOTICE
The alternator maximum rated amperage output is normally stamped or labeled on the alternator.

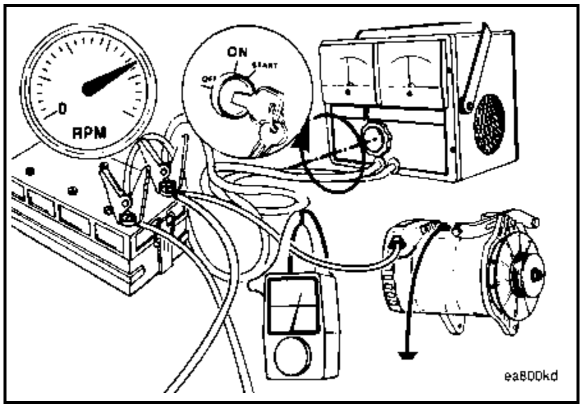


FIGURE 19. APPLY THE MAXIMUM RATED AMPERAGE LOAD

12. Measure the alternator amperage output. Refer to the alternator manufacturer's specifications.
13. If the alternator output (amps) is not within 10% of rated output, repair or replace the alternator. Refer to the alternator manufacturer's instructions for repair procedures.
14. Shut off the engine, and remove the test equipment.

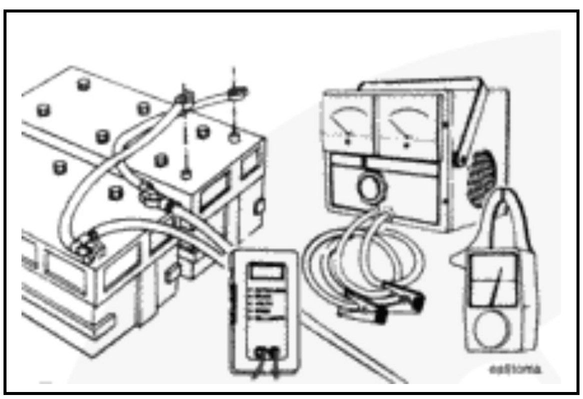


FIGURE 20. REMOVE TEST EQUIPMENT

15. Connect all battery cables, negative (-) cables last.

Cylinder Head Gasket Troubleshooting

Low compression on a single cylinder can be caused by an external leak or a leak to a coolant passage.

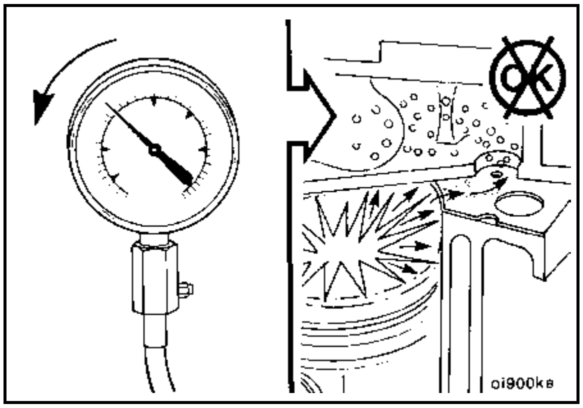


FIGURE 21. LOW COMPRESSION

1. Perform the following tests:
   a. Perform a dry compression test.
      - If low compression is indicated in any cylinder(s), perform a wet compression test.

   b. Perform a wet compression test with liquid soap to determine if there is an external cylinder head gasket leak.
      - If so, replace the gasket with a new one. Refer to the Cylinder Head Maintenance section.

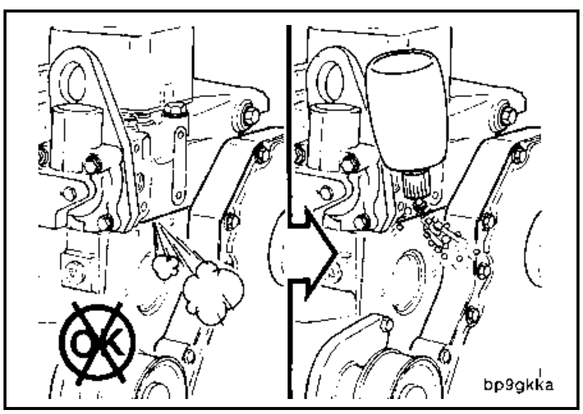


FIGURE 22. USE LIQUID SOAP TO DETERMINE IF THERE IS A LEAK

   c. If there is no external cylinder head gasket leak, but compression was found to be low on adjacent cylinders:
      i. Oil the rings to increase the pressure.
      ii. Re-check the pressure.

iii. If the pressure has still not increased, the head gasket is probably leaking between the cylinders. Replace the gasket with a new one. Refer to the Cylinder Head Maintenance section.

NOTICE
Never reuse the old head gasket. Always use a new head gasket to prevent leakage.

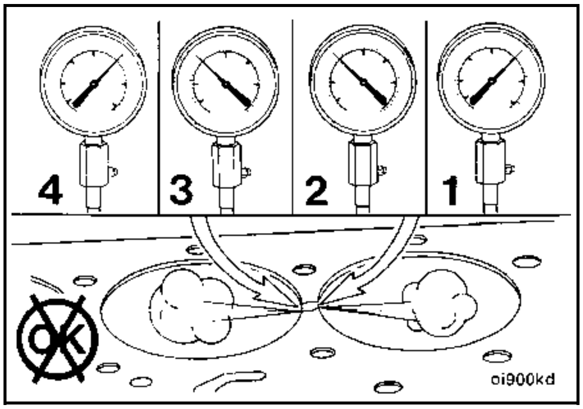


FIGURE 23. LEAKS BETWEEN THE CYLINDERS

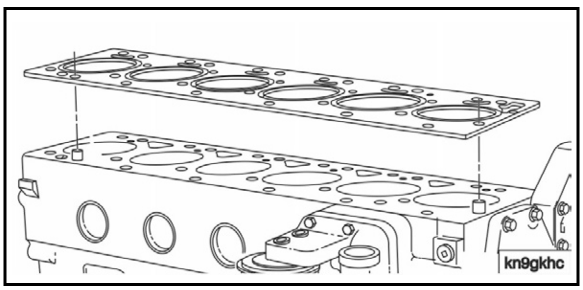


FIGURE 24. REPLACE THE HEAD GASKET

4.15 Code 135 - Oil Pressure Sensor OOR - High

Logic:

Engine oil pressure sensor signal is out of range – shorted high.

Possible Causes:

1. Faulty oil pressure sensor and/or circuit
2. Faulty ECM
3. Faulty ECM connection or harness

Diagnosis and Repair:

1. Faulty oil pressure sensor and/or circuit
   a. Connect the GCP service tool.
   b. Start the generator set.
   c. Check the oil pressure voltage. If the value is *greater than* that the limit defined in calibration, stop the engine and disconnect the oil pressure sensor from the wire harness.
   d. Re-check the oil pressure voltage. If the value *is greater than or equal to* 4.9 VDC, jumper the oil pressure sensor circuit to 5V Analog Return.
   e. Re-check the oil pressure voltage.
      i. If the value is *less than* 0.1 VDC, then at least one of the following conditions apply:
         - There is a faulty connection to the sensor. Inspect the oil pressure sensor and harness connectors and pins. Repair as needed.
         - The oil pressure sensor is faulty. Repair or replace it.
      ii. If the value displayed is *greater than* 0.1 VDC, jumper the oil pressure sensor circuit to ground.
      iii. Re-check the oil pressure voltage. If the service tool displays a value that is *less than* 0.1 VDC, then at least one of the following conditions apply:
         - There is a faulty connection to the sensor. Inspect the oil pressure sensor and harness connectors and pins. Repair as needed.
         - The oil pressure sensor is faulty. Repair or replace it.
         - There is an open oil pressure ground (5Vrtn1) circuit. Repair it.
2. Faulty ECM connection or harness
   a. Connect the GCP service tool.
   b. Start the generator set.
   c. Check the oil pressure voltage. If the value is greater than the limit defined in calibration, stop the engine, disconnect the oil pressure sensor from the wire harness.
   d. Re-check the oil pressure voltage. If the value displayed is *less than* 4.9 VDC, the ECM is faulty. Repair or replace as necessary.
3. Faulty ECM
   a. Check the ECM, and wiring harness for bent, broken, or missing pins. Repair as necessary.
   b. If none of the previous steps fix the problem, replace the ECM.

4.16 Code 141 - Oil Pressure Sensor OOR Low

Logic:

Engine oil pressure sensor signal is out of range – shorted low.

Possible Causes:

1. Faulty oil pressure sensor
2. External wiring problem
3. Faulty ECM

Diagnosis and Repair:

1. Faulty oil pressure sensor
    a. Connect the GCP service tool.
    b. Start the generator set.
    c. Check the oil pressure voltage. If the value displayed is *less than* the limit defined in calibration, stop the engine and disconnect the oil pressure sensor from the wire harness.
    d. Re-check the oil pressure voltage. If the value displayed is *greater than or equal to* 4.9 VDC, the oil pressure sensor is faulty. Repair or replace it.
2. External wiring problem
    a. Connect the GCP service tool.
    b. Start the generator set.
    c. Check the oil pressure voltage. If the value displayed is *less than* the limit defined in calibration, stop the engine and disconnect the oil pressure sensor from the wire harness.
    d. Re-check the oil pressure voltage. If the value displayed is *not greater than* 4.9 VDC, the oil pressure sensor signal circuit oil is faulty. Check the wire harness for a short to ground. Repair or replace the harness.
3. Faulty ECM
    a. If none of the previous steps fixes the problem, refer to the Engine Control Module (ECM) section. If the ECM is faulty, replace it.

4.17 Code 143 - Engine Oil Pressure Low (Warning)

Logic:

Engine oil pressure is below the low oil pressure warning threshold.

NOTICE
Although this is an ECM-driven fault, it does not have a corresponding DTC in the E-Controls Manual.

Possible Causes:

1. Low lubricating oil level
2. External leak
3. Lubricating oil does not meet specifications
4. Lubricating oil contaminated with coolant or fuel
5. Engine angularity during operation exceeds specification
6. Coolant temperature above specification
7. Faulty main oil pressure regulator
8. Loose or broken lubricating oil suction or transfer tube
9. Faulty lubricating oil pump
10. Incorrect lubricating oil cooler installed
11. Plugged lubricating oil cooler
12. Lubricating oil temperature above specification
13. Damaged or incorrectly installed piston cooling nozzles
14. Inaccurate or blocked oil pressure sensor
15. Fault simulation enabled or the threshold set too high

Diagnosis and Repair:

1. Low lubricating oil level
   a. Check the oil level. Add or drain oil, if necessary. Refer to the Periodic Maintenance section.
2. External leak
   a. Inspect the engine and surrounding area for external oil leaks.
   b. Tighten the capscrews, pipe plugs, and fittings.
   c. Replace gaskets, if necessary.
3. Lubricating oil does not meet specifications
   a. Verify lubricating oil meets the specifications. Refer to the Periodic Maintenance section.
   b. Verify alternative oil and additives were not added during the oil life.
   c. Verify the age of the lubricating oil.
   d. If necessary, take an oil sample. Refer to oil analysis technique bulletins for instructions on how to take an oil sample.
4. Lubricating oil contaminated with coolant or fuel
   a. Refer to the Engine Oil section.
5. Engine angularity during operation exceeds specification
   a. Verify container is level or near level. Refer to the engine specification to determine suitable amount of angularity.

6. Coolant temperature above specification
    a. On the display or using the InPower service tool, read the engine coolant temperature.
    b. Compare the coolant temperature against the expected coolant temperature for that engine model.
    c. If the coolant temperature is outside of the expected range, refer to FC 145 to troubleshoot an above-normal coolant temperature.
7. Faulty main oil pressure regulator
    a. Inspect the plunger and plunger bore for nicks or scratches.
    b. Verify the plunger moves freely in the bore.
    c. If the regulator meets the above specifications, the regulator is not faulty.
8. Loose or broken lubricating oil suction or transfer tube
    a. Inspect lubricating oil suction tube or transfer tube for leaks. Visually inspect for cracks, kinks, or tears.
    b. Inspect the capscrews for signs of leaks.
    c. Inspect the gaskets and o-rings for signs of damage, excessive wear or pinching.
9. Faulty lubricating oil pump
    a. Check the amount of oil added versus the mileage to verify the correct oil consumption rate.
    b. Verify the correct lubricating oil drain interval. Refer to the oil recommendations in the Model Specifications section.
    c. Low oil and coolant temperatures can be caused by long idle time (greater than 10 minutes). Shut off the engine rather than idle for long periods. If idle time is necessary, raise the idle speed. Refer to the oil recommendations in the Model Specifications section.
    d. Inspect the engine for external oil leaks. Tighten the capscrews, pipe plugs, and fittings. Replace gaskets, if necessary. Refer to the Torque Specifications section.
    e. Verify that the lubricating oil meets the specifications for operating conditions. If not, change the oil and filters. Refer to the oil recommendations in the Model Specifications section.
    f. If none of the previous steps fixes the problem, contact a Cummins Authorized Repair Facility.
10. Incorrect lubricating oil cooler installed
    a. Check if the correct lubricating oil cooler part number is installed. Verify against the appropriate parts manual.
11. Plugged lubricating oil cooler
    a. Visually inspect the oil cooler for cleanliness.
    b. Clean the oil cooler housing.

12. Lubricating oil temperature above specification
    a. On the display or using the InPower service tool, read the engine oil temperature.
    b. Compare the oil temperature against the expected oil temperature. Refer to the coolant or block heater specification for a non-running engine.
    c. If the oil temperature is outside of the expected range, refer to FC 145 to troubleshoot an above-normal coolant temperature.
13. Damaged or incorrectly installed piston cooling nozzles
    a. Inspect capscrew and piston cooling nozzle for damage.
    b. Check for leaks and improper seating.
14. Inaccurate or blocked oil pressure sensor
    a. Connect a properly calibrated mechanical oil pressure gauge to the engine at the plug on top of the oil filter head.
    b. Connect InPower.
    c. While engine is stopped, compare the oil pressure reading on the service tool to the reading on the mechanical oil pressure gauge.
    d. Only proceed if engine troubleshooting has been completed. Do not attempt to start the engine if there is doubt about oil pressure.
    e. Start the generator set.
    f. Compare the oil pressure reading on the service tool to the reading on the mechanical oil pressure gauge.
15. Fault simulation enabled or the threshold set too high
    a. Connect to the control with InPower and ensure that the fault simulation for LOP is not enabled.
    b. Using the electronic service tool, verify that the fault threshold is **not** within the normal operating range for the oil pressure sensor.

4.18 Code 144 - Engine Coolant Temperature OOR Low (Warning)

Logic:

Engine coolant temperature signal voltage is out of range - shorted low.

NOTICE
The E-controls manual applies to several applications. See the wiring diagrams provided with the generator set or in APPENDIX for appropriate pin numbers.

Diagnosis and Repair:

For the troubleshooting procedure, refer to DTC 118 in the E-Controls Service Manual.

4.19 Code 145 - Engine Coolant Temperature OOR High (Warning)

Logic: Engine coolant temperature signal voltage is out of range - shorted high.

Diagnosis and Repair:

For the troubleshooting procedure, refer to DTC 117 in the E-Controls Manual, which applies to several applications. See the drawings provided with the generator set or the wiring diagrams appendix for the appropriate pin numbers.

4.20 Code 146 - Engine Coolant Temperature Above Normal (Warning)

Logic: Engine coolant temperature has exceeded the warning threshold (220 °F [105 °C]) for high coolant temperature

Possible Causes:

1. High ambient temperature
2. Coolant level below specification
3. Damaged or obstructed cooling system components
4. Inaccurate coolant temperature sensor
5. Fault simulation feature enabled
6. Faulty thermostat
7. Malfunctioning water pump
8. Air or combustion gases entering the cooling system

Diagnosis and Repair

1. High ambient temperature
   a. Measure the air temperature entering the air intake louver of the generator set enclosure if enclosed, or cooling air to the radiator if not enclosed.
   b. Verify the expected cooling system ambient temperature capability.
   c. Inspect for recirculation of cooling discharge air into the generator set enclosure air inlet or the area surrounding the radiator cooling air inlet.
2. Coolant level below specification
   a. Inspect the engine, cooling system, and surrounding area for external coolant leaks.
      i. Repair as required.

   b. Verify the coolant level is correct.
      i. Add coolant as necessary.
3. Damaged or obstructed cooling system components
   a. Inspect the radiator, charge air cooler (if used), and other cores (if used).
      i. Inspect for damaged fins.
      ii. Inspect for dirt, debris or obstructions.
      iii. Remove the blockage.
   b. Inspect the fan shroud for damage and clearance.
      i. Repair or replace the shroud if damaged.
   c. Inspect the fan belt(s) for damage, wear, and proper tension. Inspect the pulleys and belt tensioner for damage or wear.
      i. Repair or replace the parts that are damaged or worn.
   d. Inspect the radiator cap and gasket for damage and proper pressure operation.
      i. Replace the radiator cap if it is not operating correctly.
   e. Inspect the upper and lower radiator hoses for collapse, distortion, or fluid leaks.
      i. Replace the hose(s) if damaged or worn.
   f. Inspect the cooling system components for internal contaminates (dirt, scale, or sludge) and clean as required.
      i. Open the radiator cap and inspect for contaminated coolant and scale.
      ii. Flush the cooling system per the engine service manual.
4. Inaccurate coolant temperature sensor
   a. Measure the coolant temperature near the sender and compare it to the coolant temperature displayed on the control panel.
   b. Verify the temperature sender resistance and compare it to the specification.
      i. Disconnect the main harness connector from the coolant temperature sensor.
      ii. Measure the resistance between the coolant temperature signal pin and the coolant temperature sensor return pin.

TABLE 18. ENGINE COOLANT TEMP (ECT) CALIBRATION

Degrees Fahrenheit	Degrees Celsius	Ohms
266	130	278
248	120	375

Degrees Fahrenheit	Degrees Celsius	Ohms
230	110	494
221	105	568
212	100	657
203	95	764
194	90	892
185	85	1,045
176	80	1,229
158	70	1,720
140	60	2,450
122	50	3,560
77	25	10,000
32	0	33,650
-13	-25	138,100
-40	-40	361,100

If the temperature differs from the unit display by more than 8 °F (13 °C), replace the sensor.

c. Verify the continuity of temperature sender leads. Harness lead resistance should be less than 0.5 Ohm for each lead from the connection to the PCC control board connector.

d. Repair or replace faulty components or wiring.

5. Fault simulation feature enabled
    a. Connect InPower.
    b. Verify that the fault simulation is disabled for the engine coolant temperature sensor by connecting to the PCC via InPower.
6. Faulty thermostat
    a. Refer to the Coolant Thermostat Troubleshooting section.
7. Malfunctioning water pump
    a. replace the water pump. Refer to the Water Pump Removal and Installation section.
8. Air or combustion gases entering the cooling system
    a. Refer to the engine service manual.

4.21 Code 151 - Engine Coolant Temperature High (Shutdown)

Logic: The engine coolant temperature has exceeded the alarm (shutdown) threshold for high coolant temperature.

Diagnosis and Repair

For the troubleshooting procedure, refer to DTC 217 in the E-Controls Manual, which applies to several applications. See the drawings provided with the generator set or the wiring diagrams appendix for the appropriate pin numbers.

4.22 Code 153 - Intake Manifold Temperature OOR High (Warning)

Logic:

Engine intake manifold temperature sensor signal is out of range – shorted high.

NOTICE
The E-controls manual applies to several applications. See the wiring diagrams provided with the generator set or in APPENDIX for appropriate pin numbers.

Diagnosis and Repair:

For the troubleshooting procedure, refer to DTC 113 in the E-Controls Manual.

4.23 Code 154 - Intake Manifold Temperature OOR Low (Warning)

Logic:

Engine intake manifold temperature sensor signal is out of range – shorted low.

NOTICE
The E-controls manual applies to several applications. See the wiring diagrams provided with the generator set or in APPENDIX for appropriate pin numbers.

Diagnosis and Repair:

For the troubleshooting procedure, refer to DTC 112 in the E-Controls Manual.

4.24 Code 155 - Intake Manifold Temperature High (Shutdown)

Logic: The engine intake manifold temperature has exceeded 95 °C (203 °F) for greater than 10 seconds.

Diagnosis and Repair:

For the troubleshooting procedure, refer to DTC 127 in the E-Controls Manual, which applies to several applications. See the drawings provided with the generator set or the wiring diagrams appendix for the appropriate pin numbers.

4.25 Code 234 - Engine Speed High (Shutdown)

Logic:

Engine speed signals indicate an engine speed greater than the shutdown threshold.

Possible Causes:

1. Faulty Hall Effect (HE) sensor connections and wiring
2. Faulty HE sensor
3. Fault simulation feature is enabled
4. Incorrect threshold setting
5. Incorrect settings on the ECM
6. Incorrect calibrations in the PowerCommand control (PCC)
7. Flywheel teeth number is incorrectly set in the PCC or E-Controls
8. Engine speed is higher than shutdown threshold

Diagnosis and Repair:

1. Faulty HE sensor connections and wiring
    a. Inspect the HE sensor and the main harness connector pins.
        i. Disconnect the main harness connector from the HE sensor.
        ii. Inspect for corroded, bent, broken, pushed back, expanded, or loose pins.
        iii. Inspect for evidence of moisture in or on the connector.
            A. Dry the connectors with Cummins electronic cleaner, Part Number 3824510.
        iv. Inspect for missing or damaged connector seals.
        v. Inspect for dirt or debris in or on the connector pins.
        vi. Inspect the wiring for any damage or shorting.

   b. Check for 5V at the 5V supply pin of the harness, and ground at the ground pin.
      i. If one or both are not present, repair or replace the harness.
   c. Check continuity from the signal lead of the sensor to the ECM (see wiring diagrams for ECM pin-outs).
      i. If there is not continuity, repair or replace the harness.

2. Faulty HE sensor
   a. Disconnect the main harness connector from the HE sensor.
   b. Remove the sensor from the flywheel housing, clean and inspect it for damage. If damaged, replace the HE sensor, as well as inspect the flywheel and starter.
   c. Check for continuity across all three of the pins. If one or more pins are open, replace the HE Sensor.
   d. If an oscilloscope is available, with sensor connected to the wiring harness, measure the voltage across the ground and output lead (ground and signal) while cranking the engine. A clean square wave should appear. If not, replace the HE sensor.
3. Fault simulation feature is enabled
   a. Connect the InPower service tool.
   b. Verify that the fault simulation is not enabled for the engine speed sensor by connecting to the PCC.
4. Incorrect threshold setting
   a. Use the service tool to connect to the PCC and verify fault threshold settings; then compare them to the specifications. The threshold setting values are:
      - Overspeed Trip Level (60 Hz) = 2250
      - Secondary Overspeed Trip Speed (60 Hz) = 2250
   b. Recalibrate the PCC to reset the threshold settings.
5. Incorrect settings on the ECM
   a. Check that the max allowed governed speed is consistent with the PCC.
   b. Verify that the HE sensor is communicating with the ECM with the E-Controls service tool.
6. Incorrect calibrations in the PowerCommand control (PCC)
   a. Using the display or the InPower service tool, verify the calibration in the PCC.
      i. If the calibration in the PCC matches the latest calibration on the InCal website, then the calibration is correct. If it does not, update the calibration to the latest.
      ii. Verify that the HE sensor feature is enabled in calibration.

7. Flywheel teeth number is incorrectly set in the PCC or E-Controls
    a. Make sure that the correct number of flywheel teeth is set in the PCC and E-Controls.
        i. Use InPower and the E-controls GCP to ensure that both the PCC and E-controls have the correct number of teeth. These generator sets have 60 evenly spaced teeth, with 2 removed.
8. Engine speed is higher than shutdown threshold
    a. The engine speed governor is not operating correctly. Verify that the throttle plate can move freely. Clean or repair as required.

4.26 Code 256 - Ambient Temperature OOR Low (Warning)

Logic:

Ambient temperature signal voltage is out of range – shorted low.

Possible Causes:

1. Faulty ambient temperature sensor connections
2. Faulty ambient temperature sensor
3. Incorrect controller calibrations

Diagnosis and Repair:

1. Faulty ambient temperature sensor connections
    a. Inspect the ambient temperature sensor and the main harness connector pins.
        i. Disconnect the main harness connector from the ambient temperature sensor.
        ii. Inspect for corroded pins, bent or broken pins, pushed back or expanded pins.
        iii. Inspect for evidence of moisture in or on the connector.
            A. Dry the connectors with Cummins electronic cleaner, Part Number 3824510.
        iv. Inspect for missing or damaged connector seals.
        v. Inspect for dirt or debris in or on the connector pins.
2. Faulty ambient temperature sensor
    a. Check the resistance of the sensor.
        i. Disconnect the main harness connector from the ambient temperature sensor.

ii. Measure the resistance between the ambient temperature sensor signal pin and the ambient temperature sensor return pin. Sensor resistance varies linearly with temperature: 700 Ohms at 0 °F, and 1100 Ohms at 100 °F (+/- 3%).

3. Incorrect controller calibrations

   a. Using the display or the InPower service tool, verify the calibration in the PCC.

      i. If the calibration in the PCC matches the latest calibration on the InCal website, then the calibration is correct. If it does not, update the calibration to the latest.

4.27 Code 286 - CAN Address Conflict Failure (Warning)

Logic: There are two or more devices on the network use the same source address.

NOTICE
The E-controls manual applies to several applications. See the wiring diagrams provided with the generator set or in APPENDIX for appropriate pin numbers.

Diagnosis and Repair:

1. For the troubleshooting procedure, refer to DTC 1628 in the E-Controls Manual.

   a. If another Cummins device is found to have the same slave address, refer to that service manual for that device to change the slave address.

4.28 Code 359 - Fail to Start

This indicates that the engine failed to start after the expiration of crank time.

Possible Causes:

1. Fuel system issues
2. Incorrect starter disconnect speed

Diagnosis and Repair:

1. Fuel system issues

   a. Inspect fuel lines and fuel connections for leaks.

      i. Repair if leaks are found. Refer to the Fuel System section.

   b. The manual fuel shutoff (FSO) valve is closed.

      i. Open the valve.

   c. The FSO valve solenoids or circuit are malfunctioning.
      i. Check the FSO valve solenoids and circuit.
      ii. Correct or replace as necessary.
2. Incorrect starter disconnect speed
   a. Connect to the control via the InPower service tool. Make sure Starter Disconnect Speed is set to 450 RPM.

4.29 Code 415 - Engine Oil Pressure Low (Shutdown)

Logic: Engine oil pressure is below the low oil pressure shutdown threshold (less than 10 psig for more than 2 seconds).

NOTICE
This is an ECM driven fault. The corresponding DTC is 524.

NOTICE
The generator set uses either a normally open switch type (two wire) or a sensor type (three wire) pressure sensor. See the Wiring Diagrams appendix for pressure sensor connections.

Possible Causes:

1. Lubricating oil level is low
2. External leak
3. Fault simulation is enabled or the threshold is set too high
4. Coolant temperature is above specification
5. Lubricating oil does not meet specifications
6. Lubricating oil is contaminated with coolant or fuel
7. Oil pressure sensor is inaccurate or blocked
8. Engine angularity during operation exceeds specification
9. Incorrect lubricating oil cooler is installed
10. Lubricating oil pump is faulty
11. Main oil pressure regulator is faulty
12. Lubricating oil suction or transfer tube is loose or broken
13. Piston cooling nozzles are damaged or are not installed correctly
14. Lubricating oil filter plumbing is not routed correctly

Diagnosis and Repair:

1. Lubricating oil level is low
    a. Check the oil level. Add or drain oil, if necessary.
2. External leak
    a. Inspect the engine and surrounding area for external oil leaks.
    b. Tighten the capscrews, pipe plugs, and fittings.
    c. Replace gaskets that show signs of oil leaks.
3. Fault simulation is enabled or the threshold is set too high
    a. Connect to the control with InPower and ensure that the fault simulation for LOP (Low Oil Pressure) is not enabled.
    b. Using the electronic service tool, verify that the fault threshold is not within the normal operating range for the oil pressure sensor (greater than 20 - 65 psig).
4. Coolant temperature is above specification
    a. On the display or using the InPower service tool, read the engine coolant temperature.
    b. Compare the coolant temperature against the expected coolant temperature for that engine model (less than 221 °F [105 °C]).
    c. If the coolant temperature is outside of the expected range, refer to DTC 217 in the E-Controls manual.
5. Lubricating oil does not meet specifications
    a. Verify lubricating oil meets the specifications as described in the Model Specifications section.
    b. Verify alternative oil and additives were not added during the oil life.
    c. Verify the age of the lubricating oil.
    d. If necessary, take an oil sample. Refer to oil analysis technique bulletins for instructions on how to take an oil sample.
6. Lubricating oil is contaminated with coolant or fuel
    a. Damaged head gasket
    b. Damaged intake gasket
7. Oil pressure sensor is inaccurate or blocked
    a. Connect a mechanical oil pressure gauge of known good quality and calibration to the engine at one of the plugs on top of the oil filter head.
    b. Connect InPower.
    c. While engine is stopped, compare the oil pressure reading on the service tool to the reading on the mechanical oil pressure gauge.
    d. Only proceed if engine troubleshooting has been completed. Do not attempt to start the engine if there is doubt about oil pressure.

   e. Start the generator set.
   f. Compare the oil pressure reading on the service tool to the reading on the mechanical oil pressure gauge. Oil pressure should be greater than 15 psig (low oil pressure warning level).

8. Engine angularity during operation exceeds specification
   a. Verify container is level or near level.
9. Incorrect lubricating oil cooler is installed
   a. Check if the correct lubricating oil cooler part number is installed. Verify against the appropriate parts manual.
10. Lubricating oil pump is faulty
    a. Ensure that oil pump turns freely.
       i. Mark the angle of the oil pump shaft.
       ii. Remove the front gear cover. The oil pump should spin freely. Repair or replace as necessary.
       iii. Re-align the oil pump shaft with the mark made earlier.
    b. Inspect the lubricating oil pump gears for chips, cracks, or excessive wear.
    c. Check side clearances on the oil pump gears. Refer to the Engine Operation & Maintenance Manual for QSJ5.9G.
    d. If debris is suspected of having gone through the pump, drain the oil, and inspect the pump. Replace as necessary.
    e. Inspect the rear cover plate for scoring and grooves.
    f. Inspect the pump housing for damage and excessive wear.
11. Main oil pressure regulator is faulty
    a. Inspect the plunger and plunger bore for nicks or scratches.
    b. Verify the plunger moves freely in the bore.
    c. Repair or replace as necessary.
12. Lubricating oil suction or transfer tube is loose or broken
    a. Inspect lubricating oil suction tube or transfer tube for leaks. Visually inspect for cracks, kinks, or tears.
    b. Inspect the capscrews for signs of leaks.
    c. Inspect the gaskets and o-rings for signs of damage, excessive wear or pinching.
13. Piston cooling nozzles are damaged or are not installed correctly
    a. Inspect capscrew and piston cooling nozzle for damage.
    b. Check for leaks and improper seating.
14. Lubricating oil filter plumbing is not routed correctly
    a. Inspect the lubricating oil filter plumbing.

b. Compare plumbing to appropriate parts manual, repair or replace as necessary.

4.30 Code 427 - CAN Data Link Degraded

Logic:

Communication between the engine control module (ECM) and the generator set control is severed.

Possible Causes:

1. The engine ECM has lost power or failed
2. The CAN datalink has failed

Diagnosis and Repair:

1. The engine ECM has lost power or failed
    a. The Emergency (E-Stop) button, if installed, is a closed relay when it is pulled out (inactive), and is an open relay when pressed (active). The E-Stop button disables power to the keyswitch input on the engine ECM when it is pressed (active); and CAN-LINK communication will stop.

    Make sure that the E-Stop is not active on the control:

    i. Pull out (inactivate) the E-Stop button.

    ii. Reset the E-Stop button.

    iii. Press the Off button on the Operator Panel.

    iv. Press the Reset button.

    v. Select Manual or Auto as required.

    b. Make sure that the E-Stop button is functioning correctly:

    i. Measure the outputs of the E-Stop (Normally Open and Normally Closed contacts).

    ii. Make sure that the outputs switch state correctly when engaged and disengaged.

    iii. Replace the switch if faulty.

    c. Check the wiring from the baseboard.

    d. The keyswitch control relay is a normally open relay. Make sure that B+ is available at the relay input, then measure the voltage output.

    - If there is a B+ at both the input and output of the keyswitch control relay, the relay is not faulty.
    - If B+ is noted at the input but not at the output of the keyswitch control relay, replace the relay.

e. Connect to the engine ECM with E-Controls GCP Display or 4G Display to verify that the ECM is functioning properly and is communicating with the CAN-LINK network.

i. Refer to the Engine Control Module (ECM) section. If the ECM is faulty, replace it.

2. The CAN datalink has failed

a. There is a defective datalink harness connection, or open circuit.

i. Inspect the datalink harness and connector pins from J11-20 to J1939+ and from J11-19 to J1939-.

ii. Check the shield ground connection at J11-17.

b. Check the terminating resistors.

i. With connector J11 disconnected from the baseboard and the engine datalink connection disconnected from the ECM control, measure resistance between pins J11-19 and J11-20 (60 Ohms is satisfactory).

ii. If resistance is not 60 Ohms, check the terminating resistors. Each of the two terminating resistors should be 120 Ohms; replace them if they are not 120 Ohms.

4.31 Code 441 - Low Battery Voltage

Logic:

Battery voltage is low.

Possible Causes:

1. Damaged battery cable connections
2. Low battery voltage
3. Discharged or defective battery
4. Bad battery ground connection
5. Damaged accessory wiring at B+
6. Faulty engine DC alternator
7. Battery voltage (12 VDC) does not match calibration
8. Battery charger (if equipped) is not adjusted and/or is not functioning properly

Diagnosis and Repair:

1. Damaged battery cable connections

a. Inspect the battery cable connections for loose connections and/or corrosion, and repair if necessary.

2. Low battery voltage

a. Using DVM, measure the battery voltage from the positive (+) terminal to the negative (-) terminal.

   b. If it is not within 11.0 to 14.2 V recharge the battery.

3. Discharged or defective battery
   a. Check the electrolyte level (if possible).
   b. Replenish the electrolyte level if low and recharge the battery (if possible). The specific gravity of a fully charged lead acid battery is approximately 1.26 at 80 °F (27 °C).
   c. If the battery is not able to hold adequate voltage, replace the battery.
4. Bad battery ground connection
   a. Inspect the battery ground connection.
      i. Disconnect the engine harness.
      ii. Measure the resistance from the negative (-) battery terminal to the engine block ground.
      iii. If the resistance is more than 1 Ohm, repair the battery ground connection.
5. Damaged accessory wiring at B+
   a. Check for add-on or accessory wiring at the positive (+) terminal of the battery.
      i. Starting at the positive (+) terminal, follow any add-on or accessory wiring and examine the wire(s) for damaged insulation or an installation error that can cause supply wire to be shorted to the engine block.
6. Faulty engine DC alternator
   a. Check the engine DC alternator.
   b. If the normal charging voltage is not 12-14 VDC then troubleshoot the DC alternator.
      i. Inspect alternator for signs of damage or excessive heat. If damaged, replace the DC alternator.
      ii. Check belt tension, and adjust the position of the DC alternator to ensure that the belt is properly tensioned and not slipping on the pulley.
      iii. If belt is properly tensioned, but still slips on the DC alternator pulley, remove the fan belt from the pulley, and spin the DC alternator by hand. It should spin freely and easily. If not, replace the DC alternator.
      iv. If the alternator still does not produce 12-14 VDC, replace the alternator.
7. Battery voltage (12 VDC) does not match calibration
   a. Verify the battery voltage in the calibration.
   b. Verify the DC voltage selection in the control calibration matches the generator set system DC voltage (12 VDC).

8. Battery charger (if equipped) is not adjusted and/or is not functioning properly
    a. Verify that the battery charger is adjusted properly.
    b. Verify that the battery charger is functioning properly.

4.32 Code 442 - High Battery Voltage

Logic:

Battery voltage is high.

Possible Causes:

1. A 12 VDC battery is connected but the charger is set for 24 VDC
2. Faulty engine DC alternator
3. Fault threshold is incorrect

Diagnosis and Repair:

1. A 12 VDC battery is connected but the charger is set for 24 VDC
    a. Adjust the battery charger to 12 VDC.
    b. Verify the battery selection and charger voltage selection match the requirements.
2. Faulty engine DC alternator
    a. Check the engine DC alternator.
    b. If the normal charging voltage is not 12-14 VDC, then troubleshoot the DC alternator.
        i. Inspect alternator for signs of damage or excessive heat. If damaged, replace the DC alternator.
        ii. Check belt tension, and adjust the position of the DC alternator to ensure that the belt is properly tensioned and not slipping on the pulley.
        iii. If belt is properly tensioned, but still slips on the DC alternator pulley, remove the fan belt from the pulley, and spin the DC alternator by hand. It should spin freely and easily. If not, replace the DC alternator.
        iv. If the alternator still does not produce 12-14 VDC, replace the alternator.
3. Fault threshold is incorrect
    a. Check the fault threshold values 16 V, 60 seconds.

4.33 Code 781 - ECM CAN Datalink Has Failed

Logic:

Communication between the Engine Control Module (ECM) and the generator set control is cut off.

Possible Causes:

1. The ECM has lost power or failed
2. The CAN datalink has failed

Diagnosis and Repair:

1. The ECM has lost power or failed
   a. The Emergency Stop (E-Stop) button, if installed, is a closed relay when it is pulled out (not active), and open relay when pressed (active). The E-Stop button disables power to the keyswitch input on the ECM when it is pressed (active), and CAN-LINK communication will stop. Make sure that the E-Stop is not active on the control:
      i. Pull out (inactivate) the Emergency Stop button.
      ii. Reset the Emergency Stop button.
      iii. Press the Off button on the operator panel.
      iv. Press the Reset button.
      v. Select Manual or Auto as required.
   b. Make sure that the Emergency Stop button is functioning correctly.
      i. Measure the outputs of the E-Stop (Normally Open and Normally Closed contacts).
      ii. Make sure that the outputs switch state correctly when engaged and disengaged.
      iii. Replace the switch if faulty.
   c. Check the wiring from the baseboard.
   d. The keyswitch control relay is a normally open relay. Make sure that B+ is available at the relay input, then measure the voltage output.
      - If there is a B+ at both the input and output of the keyswitch control relay, the relay is not faulty.
      - If B+ is noted at the input but not at the output of the keyswitch control relay, replace the relay.
   e. Connect to the ECM with E-Controls GCP, to verify that the ECM is functioning properly and is communicating with the CAN-LINK network.
      i. If CAN-LINK communications is disabled, enable CAN-LINK.
      ii. Inspect the ECM for bent or damaged pins. Repair as necessary.
      iii. Ensure that connectors are securely connected.
      iv. Inspect the CAN datalink, as specified in the next troubleshooting step.
      v. If none of the previous steps resolve the issue, replace the ECM.

2. The CAN datalink has failed
    a. There is a defective datalink harness connection, or open circuit.
        i. Inspect the Datalink harness and connector pins from J11-20 to J1939+ and from J11-19 to J1939-.
        ii. Check the shield ground connection at J11-17.
    b. Check the terminating resistors.
        i. With connector J11 disconnected from the baseboard and the engine datalink connection disconnected from the ECM control, measure resistance between pins J11-19 and J11-20 (60 Ohms is satisfactory).
        ii. If the resistance is not 60 Ohms, check the terminating resistors. Each of the two terminating resistors should be 120 Ohms; replace if not 120 Ohms.

4.34 Code 1117 - ECM Power Lost

Logic:

This indicates that "keyswitch" to the Engine Control Module (ECM) was not removed for 30 seconds before removing battery power to the ECM (removing connectors or battery cable).

Possible Causes:

1. ECM power lost

Diagnosis and Repair:

1. ECM power lost
    a. To reset, press the Off button, press the Emergency Stop button, and wait 30 seconds.

4.35 Code 1244 - Engine Normal Shutdown

Logic:

The engine has received a normal shutdown request.

Possible Causes:

1. The generator set is going through a normal shutdown.

Diagnosis and Repair:

1. The generator set is going through a normal shutdown.
    a. The generator set is going through a normal shutdown and there are no active shutdown fault(s) in the ECM for at least 2 seconds.

4.36 Code 1245 - Engine Shutdown Fault

Logic:

An engine shutdown fault has occurred in the Engine Control Module (ECM), and no other active shutdown faults exist on the PCC.

Possible Cause:

1. Event/fault code 1245 is activated by another active shutdown fault in the ECM

Diagnosis and Repair:

1. Event/fault code 1245 is activated by another active shutdown fault in the ECM
   a. Connect to the ECM with E-Controls GCP Display or 4G Display to determine the actual shutdown fault that is generating event/fault code 1245.
   b. Troubleshoot the shutdown fault(s).

4.37 Code 1246 - CAN Unknown Engine Fault

Logic: The PCC received an unknown message from the ECM.

Possible Cause:

1. ECM/engine fault

Diagnosis and Repair:

1. ECM/engine fault
   a. Refer to the E-Controls service tool.

4.38 Code 1248 - Engine Warning

Logic:

An engine warning fault has occurred in the Engine Control Module (ECM), and there are no active warning faults on the PCC.

Possible Cause:

1. Another active warning fault in the ECM activates event/fault code 1248

Diagnosis and Repair:

1. Another active warning fault in the ECM activates event/fault code 1248
   a. Connect to the ECM with E-Controls GCP Display or 4G Display to determine the actual warning fault that is generating event/fault code 1248.
   b. Troubleshoot the shutdown fault(s).

4.39 Codes 1311 and 1312 - Customer Input #1 and #2 (Warning or Shutdown)

Logic:

The nature of the fault is an optional customer selection. Examples of inputs: Low Fuel Day Tank, Water In Fuel, Ground Fault, Low Starting Hydraulic Pressure, Low Starting Air Pressure, etc.

Each of the fault functions can be programmed using the InPower service tool, as follows:

- Enable/disable input (default: enable)
- Status, Warning, or Shutdown (default: #1-None, #2-Warning and #3-Warning)
- Active closed or open (default: closed [ground])

Change the display name using up to 19 characters (default: #1-Customer Fault 1, #2-Ground Fault, #3-Low Fuel).

Possible Cause:

1. Fault condition exists at customer inputs
2. External wiring problem
3. Incorrect fault function settings are programmed into the control calibration

Diagnosis and Repair:

1. Fault condition exists at customer inputs
2. External wiring problem
    a. Disconnect the signal lead from TB1 and reset the control.
        i. Configure input 1 - TB1-12
        ii. Configure input 2 - TB1-14
    b. Disconnect the signal wire from the relevant customer sensor. Check resistance to GND at TB1-12 (fault 1311) or TB1-14 (fault 1312). If there is a continuity, repair or replace the harness.
    c. If the message goes away, the external wiring has a short circuit. Check for any grounding of either input because that activates the fault.
3. Incorrect fault function settings are programmed into the control calibration
    a. Verify that control values match the parameters necessary for fault detection.

4.40 Code 1317 - Low Coolant Level (Warning or Shutdown)

Logic: This fault is used when an optional coolant level sensor is installed. The nature of the fault is an optional customer selection. The fault function can be programmed (using the InPower service tool), as follows:

- Enable/disable input (default: enable)
- Status, Warning, or Shutdown (default: #1-None, #2 and #3-Warning)
- Active closed or open (default: closed [ground])

- Change the display name using up to 19 characters (default: #1- Customer Fault 1, #2-Ground Fault, #3-Low Fuel).

Possible Causes:

1. Low coolant
2. Faulty coolant level sensor connections
3. Faulty coolant level sensor
4. Incorrect calibration settings for the Low Coolant fault in the control
5. Faulty control board

Diagnosis and Repair:

1. Low coolant
    a. Stop the engine and allow the engine to cool down.
    b. Visually inspect and verify that the engine coolant is at the appropriate level.
    c. If the coolant level is too low, add coolant per specifications.
2. Faulty coolant level sensor connections
    a. Inspect the coolant level sensor and the main harness connector pins.
        i. Disconnect the main harness connector from the coolant level sensor.
        ii. Inspect for:
            A. Corroded, bent, broken, pushed back, or expanded pins
            B. Evidence of moisture in or on the connector
            C. Missing or damaged connector seals
            D. Dirt or debris in or on the connector pins
            E. Wiring for any damage or shorting
3. Faulty coolant level sensor
    a. Check sender operation.
        i. Remove the connector from the sensor.
        ii. Verify battery power at pin C of the sensor harness plug (Sig P-9 lead into connector). If B+ is not present, check Fuse F1; repair or replace the harness.
        iii. Verify ground at pin B of the sensor harness plug (Sig P-11 lead into connector). If ground is not present, repair or replace the harness.
        iv. Verify continuity of pin D of sensor harness plug (Sig P-10 lead into connector) and the J20-17 connector. If continuity is not present, repair or replace the harness.
        v. With the sensor out of coolant:
            A. Provide power to sensor pin C, and ground at pin B.

B. With a multimeter in diode/continuity test mode, connect the red meter lead to pin D and black to ground.

- The meter indication should be "continuity". If this indication is not present, the sensor is defective.

vi. With the sensor in coolant:

A. Provide power to sensor pin C, and ground at pin B.

B. With a multimeter in diode/continuity test mode, connect the red meter lead to pin D and black to ground.

- The meter indication should *not* be "continuity". If this indication is present, the sensor is defective.

4. Incorrect calibration settings for the Low Coolant fault in the control
   - Verify calibration setting for Configurable Input #3 as "Fault Active State Selection = Active Closed".
5. Faulty control board
   - If the sender, harness and control settings are acceptable, replace the baseboard.

4.41 Code 1318 - Low Fuel (Warning or Shutdown)

Logic: This fault is used when an optional low fuel level switch is installed. The nature of the fault is an optional customer selection. The fault function can be programmed using the InPower service tool, as follows:

Fault Function	Default
Enable/disable input	Enable
Status, Warning, or Shutdown	#1-None, #2-Warning and #3-Warning
Active closed or open	Closed (ground)

Change the display name using up to 19 characters (default: #1-Customer Fault 1, #2-Ground Fault, #3-Low Fuel).

Possible Causes:

1. Low fuel pressure
2. Faulty or inoperable switch
3. No actual fault; external wiring problem
4. Incorrect fault function settings are programmed into the control calibration

Diagnosis and Repair:

1. Low fuel pressure
   - Measure the fuel pressure at the fuel pump inlet.

2. Faulty or inoperable switch
   - Remove the switch and verify proper switch operation. If either of the following conditions is not demonstrated, the switch is defective:
     - When the float is at the bottom of the switch, the wires must show continuity.
     - When the float is raised, the wires must show an open circuit.
3. No actual fault; external wiring problem
   a. Disconnect the signal lead from TB1 and reset the control.
   b. Disconnect the signal wire from the fuel level switch. Check resistance to GND at the J20-18 harness wire or on the back of the annunciator (if equipped). If there is continuity, repair or replace the harness.
   c. If the message goes away, the external wiring has a short circuit. Check for any grounding of either input, which activates the fault.
4. Incorrect fault function settings are programmed into the control calibration
   - Verify that control values match the parameters necessary for fault detection.

4.42 Code 1417 - Power Down Failure

Logic:

The PCC has failed to go to sleep.

Possible Cause:

1. Incorrect calibrations in PowerCommand controls
2. Faulty baseboard

Diagnosis and Repair:

1. Incorrect calibrations in PowerCommand controls
   a. Using the display or the InPower Service tool, verify the calibration in the PCC.
      i. If the calibration in the PCC matches the latest calibration on the InCal website, then the calibration is correct. If it does not, update the calibration to the latest.
2. Faulty baseboard
   a. Remove power (B+) from the PCC for 5 to 10 seconds and reconnect B+ to the PCC.
      i. If the PCC fails to go to sleep after power is cycled from the PCC and the PCC shows event/fault code 1417 again, replace the baseboard.

4.43 Code 1433 - Local E-Stop

Logic:

The state of the Local Emergency Stop (E-Stop) has been changed.

Possible Causes:

1. The local E-Stop button has been activated
2. Faulty connection or faulty E-Stop switch

Diagnosis and Repair:

1. The Local E-Stop button has been activated
    a. Reset the Local E-Stop:
        i. Pull the Local E-Stop button out.
        ii. Press the Off button.
        iii. Press the Reset button.
        iv. Select Manual or Auto as required.
2. Faulty connection or faulty E-Stop switch
    a. Verify that the E-Stop button is working properly. The E-Stop button is a closed contact when it is pulled out (not active), and an open contact when pressed (active).
        i. Check for an open circuit condition in the connection and/or wiring from the Local E-Stop switch to the PCC. A ground connection to the Local E-Stop control input (J25-2 Input; J25-6 Ground) disables the E-Stop alarm. An open circuit should activate the E-Stop alarm.

4.44 Code 1434 - Remote E-Stop

Logic:

The state of the Remote Emergency Stop has been changed.

Possible Causes:

1. The Remote Emergency Stop button has been activated
2. Jumper not installed in control
3. Faulty connection or faulty Emergency Stop switch

Diagnosis and Repair:

1. The Remote Emergency Stop button has been activated
    a. Reset the Remote Emergency Stop.
        i. Pull the Remote Emergency Stop button out.
        ii. Press the Off button.
        iii. Press the Reset button.
        iv. Select Manual or Auto as required.
2. Jumper not installed in control
    a. Install the missing jumper between TB1-16 Input and TB1-15 Ground.

3. Faulty connection or faulty Emergency Stop switch
   a. Check the Emergency Stop button, and verify that it is working properly. The Emergency Stop button is a closed relay when it is pulled out (not active), and an open relay when pressed (active).
      i. Verify the connection and/or wiring from the Remote Emergency Stop switch to the PCC for an open circuit condition. A ground connection to the Remote E-Stop control input (TB1-16 Input; TB1-15 Ground) disables the Emergency Stop alarm. An open circuit should activate the Emergency Stop alarm.

4.45 Code 1435 - Low Coolant Temperature (Warning)

Logic:

The engine coolant temperature is below the low coolant temperature warning threshold.

Possible Causes:

1. Threshold is set too high
2. Coolant heater(s) is/are not operating properly
3. Low ambient temperature

NOTICE
In applications where the ambient temperature falls below 40 °F (4 °C), the Low Coolant Temp may be indicated even though the coolant heaters are operating.

Diagnosis and Repair:

1. Threshold is set too high
   a. Verify that the LCT Warning Threshold is set to 50 °F (10 °C).
2. Coolant heater(s) is/are not operating properly
   a. Make sure that the coolant heater(s) is/are connected properly to a power supply.
      i. Check for open circuits in the wiring.
      ii. Make sure that the power supply of the coolant heater is working properly.
   b. Measure the temperature of the coolant. If the coolant temperature is close to the ambient temperature when the ambient air temperature is below the coolant heater thermostat setting, replace the coolant heater(s).

3. Low ambient temperature
    a. If the coolant heater(s) is/are working properly and the radiator has enough coolant, but the ambient temperature around the generator set is very cold (less than 40 °F [4 °C]), the coolant heaters might not have the capability to keep the coolant temperature above the low coolant temperature warning threshold. This could be an application issue and will need to be further investigated.

4.46 Code 1438 - Fail to Crank (Shutdown)

Logic:

The engine failed to crank after the generator control received a start signal.

Possible Causes:

1. Dead or weak battery
2. Failed starter
3. Failed starter solenoid
4. Failed starter relay
5. Engine or rotor is locked or binding

Diagnosis and Repair:

1. Dead or weak battery
    a. Verify battery voltage is at least 12 VDC (24 VDC where applicable).
    b. Charge or replace the battery as necessary.
2. Failed starter
    a. Press the Reset/Fault Acknowledge button on the display.
    b. Attempt to start the generator and test for B+ at the starter supply lug.
    c. If B+ is present at the starter supply lug, the starter could be defective.
3. Failed starter solenoid
    a. Press the Reset/Fault Acknowledge button on the display.
    b. Check wiring for continuity between the terminal on the starter relay and start solenoid SW terminal. Resistance should be less than 5 Ohms.
    c. Attempt to start the generator set and test for B+ at SW terminal of the starter solenoid.
    d. Check wiring for continuity between the solenoid COM terminal and B+ lug of the battery. Resistance should be less than 1 Ohm.
    e. Attempt to start the generator set and test for B+ at the solenoid output lug.
    f. If B+ is not present, the starter solenoid is defective.

4. Failed starter relay

    a. Check wiring for continuity between the terminal on the starter relay and J20-13 control board terminal. Resistance should be less than 1 Ohm.

    b. Check wiring for continuity between the terminal on the starter relay and J20-15 control board terminal. Resistance should be less than 1 Ohm.

    c. Check for B+ at the terminal on the starter relay.

    d. Attempt to start the generator set and test for B+ at the terminal on the starter relay.

    e. Check wiring for continuity between the terminal on the starter relay and ground. Resistance should be less than 1 Ohm.

    f. Attempt to start the generator and test for B+ at the terminal on the starter relay.

    g. If B+ is not present, the starter relay is defective.

5. Engine or rotor is locked or binding

    a. Verify that the generator can rotate freely by barring the engine over by hand. If the generator set cannot be turned over, identify the source of the bind, and repair as necessary.

NOTICE
Do not use the alternator fan to rotate the engine.

4.47 Code 1442 - Weak Battery

Logic:

This fault occurs when the engine is starting (cranking) and the voltage of the battery drops below the Weak Battery Voltage Threshold (8 V) for the time set in the Weak Battery Voltage Set Time (2 seconds).

Possible Causes:

1. Weak or discharged battery
2. Battery connections are loose or dirty
3. Insufficient battery charging voltage
4. Faulty engine DC alternator
5. Faulty harness
6. Weak Battery Voltage Threshold is set too high

Diagnosis and Repair:

1. Weak or discharged battery

    a. Measure the voltage of the battery with a voltmeter. Battery voltage should be 12 VDC or greater.

   b. If the battery voltage is low, check the electrolyte level in the battery (if possible). Replenish the electrolyte level if low and recharge the battery; the specific gravity for a fully charged lead acid battery is approximately 1.26 at 80 °F (27 °C).

   c. If the battery cannot hold adequate voltage, replace the battery.

2. Battery connections are loose or dirty

   a. Clean and tighten battery terminals and battery cable connectors. If the battery cable connectors are cracked or worn out, replace them.

3. Insufficient battery charging voltage

   a. Make sure that the battery charger (if applicable) is charging the battery at an acceptable rate. Adjust the charge rate if the rate is below the recommendation of the manufacturer.

   b. If the battery located far from the battery charger, make sure that a proper wire size is used to compensate for voltage drop.

4. Faulty engine DC alternator

   a. Check the engine DC alternator.

   b. If normal charging voltage is not 12-14 VDC, then troubleshoot the DC alternator.

      i. Inspect alternator for signs of damage or excessive heat. If damaged, replace the DC alternator.

      ii. Check belt tension, and adjust the position of the DC alternator to ensure that the belt is properly tensioned and not slipping on the pulley.

      iii. If belt is properly tensioned, but still slips on the DC alternator pulley, remove the fan belt from the pulley, and spin the DC alternator by hand. It should spin freely and easily. If not, replace the DC alternator

      iv. If the alternator still does not produce 12-14 VDC, replace the alternator.

5. Faulty harness

   a. Measure the battery voltage at the battery terminals.

   b. Measure the battery voltage at the baseboard input.

   c. Measure the voltage at:

      - B+ (J20-9, J20-10, J20-20, and J20-21) and
      - B- (negative) input (J20-1, J20-2, J20-4, J20-7, J20-12)

   d. If the voltage at the battery terminals and the control is not the same, check the harness and replace it if necessary.

6. Weak Battery Voltage Threshold is set too high

   a. Make sure that the Weak Battery Voltage Threshold is set to the specified values (8 V, 2 seconds).

4.48 Code 1446 - High AC Voltage

Logic:

One or more of the phase voltages has exceeded the High AC Voltage Threshold (110% of nominal voltage, 10 seconds).

Possible Causes:

1. High AC Voltage Threshold is set too low
2. Faulty PCC control board (AVR circuit)
3. Improper connections at generator output terminals
4. Faulty PMG (if used)
5. Engine speed/frequency surge

Diagnosis and Repair:

1. High AC Voltage threshold is set too low
   a. Verify parameter settings.
2. Faulty PCC control board (AVR circuit)
   a. Measure the output at J17-1 and J17-2 on the PCC board. The output should be at 3 - 30 VDC when the generator set is operating at “No Load".
      i. If the voltage output of J17-1 and J17-2 is constantly above 30 VDC at no load, then the AVR portion of the baseboard is faulty. Replace the baseboard.
3. Improper connections at generator output terminals
   a. Compare connections in the generator to the wiring schematic.
   b. Correct according to the appropriate schematic if necessary.
4. Faulty PMG (if used)
   a. Start the generator set and run at rated speed. Measure the voltages at the terminals P2 (J18-1) and P3 (J18-2). These should be balanced and within the range of 60 Hz generators 190 to 220 V.
5. Engine speed/frequency surge
   a. Refer to fault codes 234 and 1449 for diagnosis.

4.49 Code 1447 - Low AC Voltage (Shutdown)

Logic:

One or more of the phase voltages has dropped below the Low AC Voltage Threshold (85%) for more than the specified amount of time (10 seconds).

Possible Causes:

1. Incorrect threshold setting or AVR settings
2. Overload

3. Improper connections at generator output terminals
4. Incorrect voltage sense or setup wiring connection
5. Faulty PCC board (AVR circuit)
6. Faulty rotating rectifier assembly (diodes CR1 through CR6)
7. Low residual magnetism in excitation coil

Diagnosis and Repair:

1. Incorrect threshold setting or AVR settings
   a. Verify factory settings have not changed. Contact factory service support for original settings.
2. Overload
   a. Make sure that the load on the generator set does not exceed the generator set kW rating.
   b. If the generator set is producing correct voltage with no load, but shutting down on under voltage when the generator set picks up certain loads, the undervoltage shutdowns are being caused by the load. Motors, Uninterruptible Power Supply (UPS), Variable Frequency Drive (VFD), Medical Diagnostic Imagining Equipment, Fire Pumps and certain types of lighting have a considerable and different influence on a generator and might require starting these loads when there is a minimum load on the generator set.
   c. Revisit the generator set sizing process to make sure that the generator set is correctly sized for the application, especially if new loads have been introduced into the system. Refer to the T-030 manual.
3. Improper connections at generator output terminals
   a. Check connections.
      i. Compare connections in generator to wiring schematic.
      ii. Correct according to the appropriate schematic as needed.
4. Incorrect voltage sense or setup wiring connection
   a. Verify that the voltage sensing inputs J22-1, J22-2, J22-3, and J22-4 are connected to L1, L2, L3, and L0 respectively.
   b. Verify that excitation inputs J18-1 and J18-2 are connected to the correct generator terminals.
5. Faulty PCC board (AVR circuit)
   a. Connect the InPower service tool.
   b. Start the generator set.
   c. Using the InPower service tool, verify that the AC voltage output is greater than residual.
   d. If the AC voltage output is residual, using the InPower service tool, verify that the AVR is enabled.

   e. Inspect the generator control harness connector pins for voltage sense and field connections.
   f. Turn off the generator set.
   g. Visually inspect harness for corroded pins, bent or broken pins, pushed back or expanded pins.
6. Faulty rotating rectifier assembly (diodes CR1 through CR6)
   a. Check each diode. Refer to the Alternator Performance Troubleshooting section.
7. Low residual magnetism in excitation coil
   a. The excitation coil may need to be flashed:
      i. Remove the Field Coil+ and Field Coil- leads from the alternator.
      ii. Using a 12 VDC supply:
         A. Touch the positive supply terminal to Field Coil+ and the negative supply terminal to Field Coil-.
         B. Remove after brief contact.
         C. Repeat three times.
      iii. Reconnect the Field Coil+ and Field Coil- leads to the alternator.
      iv. Reset the control.
      v. Restart the generator set.

4.50 Code 1448 - Underfrequency

Logic:

The frequency has dropped below the Underfrequency Threshold (6 Hz) for the time set in the Underfrequency Delay parameter (10 seconds).

Possible Causes:

1. Overrides are enabled
2. Underfrequency threshold is set too high
3. Overload
4. Engine governor problem

Diagnosis and Repair:

1. Overrides are enabled
   a. Connect with the InPower service tool.
   b. Make sure that the Alternator LX-N overrides are not enabled. If required, disable the Alternator LX-N overrides.
2. Underfrequency threshold is set too high
   a. Verify the Underfrequency Threshold and Underfrequency Time Delay set values.

3. Overload
   a. Make sure that the load on the generator set does not exceed the generator set kW rating.
   b. If the generator set is producing correct voltage with no load, but is shutting down on under voltage when the generator set picks up certain loads, the under voltage shutdowns are being caused by the load. Motors, Uninterruptible Power Supply (UPS), Variable Frequency Drive (VFD), Medical Diagnostic Imagining Equipment, Fire Pumps, and certain types of lighting have a considerable and different influence on a generator and might require starting these loads when there is a minimum load on the generator set. Refer to the T-030 manual.
   c. Revisit the generator set sizing process to make sure that the generator set is correctly sized for the application, especially if new loads have been introduced into the system.
4. Engine governor problem
   a. Verify that the wiring to the throttle body actuator works correctly. Correct if faulty.
   b. Verify that the throttle shaft and plate are free to move. Clean or repair if necessary.

4.51 Code 1449 - Overfrequency

Logic:

The frequency has gone above the Overfrequency Threshold (6 Hz) for the time that is registered in the Overfrequency Delay (10 seconds).

Possible Causes:

1. Overfrequency threshold is set too low
2. Engine governor problem

Diagnosis and Repair:

1. Overfrequency threshold is set too low
   a. To access the Overfrequency configuration menu on the operator panel, go to **Setup > Genset Setup > Volt Protection**.
   b. Verify that the Overfrequency Threshold and Overfrequency Time Delay are per specification. Refer to the list to see the default value for Overfrequency.
2. Engine governor problem
   a. Verify that the wiring to the throttle body actuator works correctly. Correct if faulty.
   b. Verify that the throttle shaft and plate are free to move. Clean or repair if necessary.

4.52 Code 1471 - High AC Current (Warning)

Logic:

The generator output current has exceeded the warning limit threshold (110%) for greater than the set time limit (60 seconds).

Possible Causes:

1. Short
2. Overload
3. Incorrect CTs, CT connections, or CT setup
4. Incorrect CT harness connections
5. Incorrect rating setup
6. Fault override enabled
7. Parameter set incorrectly

Diagnosis and Repair:

1. Short
   a. Inspect the load cables and the AC harness connections.
   b. Disconnect the AC harness from the load cables.
   c. Inspect the AC harness and board connector pins.
   d. Visually inspect for corroded pins, bent or broken pins, and/or pushed back or expanded pins.
   e. Check for a short circuit of the harness to engine block ground.
2. Overload
   a. Make sure that the load on the generator set does not exceed the generator set kW rating.
   b. If the generator set is producing correct frequency with no load, but shutting down on underfrequency when the generator set picks up certain loads, the underfrequency shutdowns are being cause by the load. Motors, Uninterruptible Power Supply (UPS), Variable Frequency Drive (VFD), Medical Diagnostic Imagining Equipment, Fire Pumps, and certain types of lighting have a considerable and different influence on a generator and might require starting these loads when there is a minimum load on the generator set.
   c. Revisit the generator set sizing process to make sure that the generator set is correctly sized for the application, especially if new loads have been introduced into the system. Refer to the T-030 manual.
3. Incorrect CTs, CT connections, or CT setup
   a. Check that the correct CT(s) has/have been installed.
   b. Check that CT connections are secure.
   c. Check that the CTs are installed correctly.

   d. Connect the InPower service tool.
   e. Verify that the correct CT ratio has been used. Adjust the setting if necessary.
   f. Check and correct connections for any bent pins, sockets, dirt, etc.
4. Incorrect CT harness connections
   a. Measure the resistance of the CT harness on each pin.
   b. Disconnect connector P12 from the control board and CTs.
   c. Measure the resistance of each pin on the CT harness connector to engine block ground. Resistance should be open or infinite.
   d. Verify that the CT harness plug wiring is correct. Verify continuity between pin pairs as follows:
      - P12-1 (CT1) to P12-4 (CT1-COM)
      - P12-2 (CT2) to P12-5 (CT2-COM)
      - P12-3 (CT3) to P12-6 (CT3-COM)
   e. Re-terminate connections if necessary.
5. Incorrect rating setup
   a. Connect the InPower service tool.
   b. Verify the generator set rating is set correctly. Adjust settings if necessary.
6. Fault override enabled
   a. Connect the InPower service tool and make sure that the fault is not enabled.
   b. If InPower is not available, cycle power to the control:
      i. Press the Emergency Stop (E-Stop) button (if installed) and wait 30 seconds.
      ii. Disconnect and disable the stand alone battery charger (if installed).
      iii. Disconnect the battery (disconnect the negative first).
      iv. Leave the controller without power for 1 minute.
      v. In the following order: Reconnect the battery, enable the stand alone battery charger, pull out the E-Stop button, and reset the control.
7. Parameter set incorrectly
   a. Verify fault threshold values in calibration.

4.53 Code 1472 - High AC Current (Shutdown)

Logic:

The generator output current has exceeded the Shutdown set limit (150%) for greater than the set time limit (10 seconds).

Possible Causes:

1. Short
2. Overload
3. Incorrect CTs, CT connections, or CT setup
4. Incorrect CT harness connections
5. Incorrect rating setup
6. Fault override enabled
7. Parameter set incorrectly

Diagnosis and Repair:

1. Short or overload
   a. Inspect the load cables and the AC harness connections.
   b. Disconnect the AC harness from the load cables.
   c. Inspect the AC harness and board connector pins.
   d. Visually inspect for corroded pins, bent or broken pins, and pushed back or expanded pins.
   e. Check for a short circuit of the harness to engine block ground.
2. Overload
   a. Make sure that the load on the generator set does not exceed the generator set kW rating.
   b. If the generator set is producing correct frequency with no load, but shutting down on underfrequency when the generator set picks up certain loads, the underfrequency shutdowns are being cause by the load. Motors, Uninterruptible Power Supply (UPS), Variable Frequency Drive (VFD), Medical Diagnostic Imagining Equipment, Fire Pumps, and certain types of lighting have a considerable and different influence on a generator and might require starting these loads when there is a minimum load on the generator set.
   c. Revisit the generator set sizing process to make sure that the generator set is correctly sized for the application, especially if new loads have been introduced into the system. Refer to the T-030 manual.
3. Incorrect CTs, CT connections, or CT setup
   a. Check that correct CTs have been installed.
   b. Check that CT connections are secure.
   c. Check that CTs are installed correctly.
   d. Connect the InPower service tools.
   e. Verify the correct CT ratio has been used. Adjust the setting if necessary.
   f. Check and correct connections for any bent pins, sockets, dirt, etc.

4. Incorrect CT harness connections
    a. Measure the resistance of the CT harness on each pin.
    b. Disconnect connector P12 from the control board and CTs.
    c. Measure the resistance of each pin on the CT harness connector to engine block ground. Resistance should be open or infinite.
    d. Verify the CT harness plug wiring is correct. Verify that continuity between pins pairs is as follows:
        - P12-1 (CT1) to P12-4 (CT1-COM)
        - P12-2 (CT2) to P12-5 (CT2-COM)
        - P12-3 (CT3) to P12-6 (CT3-COM)
    e. Re-terminate connections if necessary.
5. Incorrect rating setup
    a. Connect the InPower service tool and make sure that the fault is not enabled.
    b. Verify the generator set rating is set correctly.
    c. Verify CT ratings in the control are set correctly. Adjust settings if necessary.
6. Fault override enabled
    a. Connect with the InPower service tool and make sure that the fault is not enabled.
    b. If InPower is not available, cycle power to the control:
        i. Press the Emergency Stop (E-Stop) button (if installed) and wait 30 seconds.
        ii. Disconnect and disable the stand alone battery charger (if installed).
        iii. Disconnect the battery (disconnect the negative first).
        iv. Leave the controller without power for 1 minute.
        v. In the following order: Reconnect the battery, enable the stand alone battery charger, pull out the E-Stop button, and reset the control.
7. Parameter set incorrectly
    a. Verify the fault threshold values in the calibration.

4.54 Code 1853 - Annunciator Input 1 Fault

Logic:

Customer fault 1 (input 1, LED 1) on the universal annunciator is active.

Possible Cause:

1. Condition for which "Annunciator Input #1" is configured for is active
2. Incorrectly configured or wiring issue

3. Faulty annunciator

Diagnosis and Repair:

1. Condition for which "Annunciator Input #1" is configured for is active
   a. Check the condition for which "Annunciator Input #1" has been configured for. For example, if "Annunciator Input #1" was configured to become active when the fuel level is low, check the fuel level and add fuel if needed. After the issue is resolved, press the Reset button on the operator panel in order to clear the fault. If the fault does not clear, go to the next step.

Configurable Parameter	Option 1 (Default)	Option 2
Negative or Positive Input 1 Activation	Negative Input (Ground Input)	Positive Input (B+ Input)
Inverting Active Hardware Signals	Do Not Invert	Invert

2. Incorrectly configured or wiring issue
   a. Customer input 1 on the universal annunciator can be configured to conform to different applications. Below are two configurations that have an impact on how input 1 becomes active:
      - *Negative or positive Input 1 activation:* Allows the user to activate with a negative (ground) or positive (B+) input; the default setting is a negative (ground) input.
      - *Inverting active hardware signals:* Input 1 has the capability to be inverted. If annunciator input 1 is set to inverted, then an active hardware signal will be considered inactive and an inactive signal will be considered active; the default is set to non-inverted.

   b. When set to default, event/fault code 1853 (customer input 1) becomes active when there is a ground input at TB1-1 on the back of the universal annunciator.
   c. Make sure that the universal annunciator is correctly configured; for setup and configuration instructions, refer to the universal annunciator operator's manual.
   d. Check the wiring at TB1-1 and make sure that customer input 1 is wired correctly. Depending on the configuration of the annunciator shown in step 1, make sure that there is not a short or open circuit at the TB1-1 connection.
   e. Check the sender, relay, or device that is activating Input 1 on the universal annunciator. Replace if faulty.
3. Faulty annunciator
   a. If the wiring and configuration is satisfactory, replace the universal annunciator.

4.55 Code 1854 - Annunciator Input 2 Fault

Logic:

Customer fault 2 (Input 2, LED 2) on the universal annunciator is active.

Possible Cause:

1. Condition for which "Annunciator Input #2" is configured for is active
2. Incorrectly configured or wiring issue
3. Faulty annunciator

Diagnosis and Repair:

1. Condition for which "Annunciator Input #2" is configured for is active
   a. Check the condition for which "Annunciator Input #2" has been configured for. For example, if "Annunciator Input #2" was configured to become active when the fuel level is low, check the fuel level and add fuel if needed. After the issue is resolved, press the Reset button on the operator panel in order to clear the fault. If the fault does not clear, go to the next step.

Configurable Parameter	Option 1 (Default)	Option 2
Negative or Positive Input 2 Activation	Negative Input (Ground Input)	Positive Input (B+ Input)
Inverting Active Hardware Signals	Do Not Invert	Invert

2. Incorrectly configured or wiring issue
   a. Customer input 2 on the universal annunciator can be configured to conform to different applications. Below are two configurations that have an impact on how Input 2 becomes active:
      - *Negative or positive Input 2 activation:* Allows the user to activate with a negative (ground) or positive (B+) input; the default setting is a negative (ground) input.
      - *Inverting active hardware signals:* Input 2 has the capability to be inverted. If annunciator input 2 is set to inverted, then an active hardware signal will be considered inactive and an inactive signal will be considered active; the default is set to non-inverted.

   b. When set to default, event/fault code 1854 (customer input 2) becomes active when there is a ground input at TB1-2 on the back of the universal annunciator.
   c. Make sure that the universal annunciator is correctly configured; for setup and configuration instructions, refer to the universal annunciator operator's manual.
   d. Check the wiring at TB1-2 and make sure that customer input 2 is wired correctly. Depending on the configuration of the annunciator in step 1, make sure that there is not a short or open circuit at the TB1-2 connection.

e. Check the sender, relay, or device that is activating input 2 on the universal annunciator. Replace if faulty.

3. Faulty annunciator

a. If the wiring and configuration is satisfactory, replace the universal annunciator.

4.56 Code 1855 - Annunciator Input 3 Fault

Note: The nature of the annunciator fault is an optional configurable selection.

Logic:

Customer fault 3 (input 3, LED 3) on the universal annunciator is active.

Possible Cause:

1. Condition for which "Annunciator Input #3" is configured for is active
2. Incorrectly configured or wiring issue
3. Faulty annunciator

Diagnosis and Repair:

1. Condition for which "Annunciator Input #3" is configured for is active

   a. Check the condition for which "Annunciator Input #3" has been configured for. For example, if "Annunciator Input #3" was configured to become active when the fuel level is low, check the fuel level and add fuel if needed. After the issue is resolved, press the Reset button on the operator panel in order to clear the fault. If the fault does not clear, go to the next step.

Configurable Parameter	Option 1 (Default)	Option 2
Negative or Positive Input 3 Activation	Negative Input (Ground Input)	Positive Input (B+ Input)
Inverting Active Hardware Signals	Do Not Invert	Invert

2. Incorrectly configured or wiring issue

   a. Customer input 3 on the universal annunciator can be configured to conform to different applications. Below are two configurations that have an impact on how input 3 becomes active.

      - Negative or positive Input 3 activation: Allows the user to activate with a negative (ground) or positive (B+) input; the default setting is a negative (ground) input.
      - Inverting active hardware signals: Input 3 has the capability to be inverted. If annunciator input 3 is set to inverted, then an active hardware signal will be considered inactive and an inactive signal will be considered active; the default is set to non-inverted.

b. When set to default, event/fault code 1855 (customer input 3) becomes active when there is a ground input at TB1-3 on the back of the universal annunciator.

c. Make sure that the universal annunciator is correctly configured; for setup and configuration instructions, refer to the universal annunciator operator's manual.

d. Check the wiring at TB1-3 and make sure that customer input 3 is wired correctly. Depending on the configuration of the annunciator, make sure that there is not a short or open circuit at the TB1-3 connection.

e. Check the sender, relay, or device that is activating Input 3 on the universal annunciator, replace if faulty.

3. Faulty Annunciator

   a. If the wiring and configuration is satisfactory, replace the universal annunciator.

4.57 Code 1944 - Annunciator Configuration Error (Warning)

Logic: More than one network device is configured to activate one of the annunciator output relays.

Possible Causes:

1. Bad network configuration
2. Bad device on network

Diagnosis and Repair

1. Bad network configuration

   a. Check the setup of devices on the network against duplicate use of the same annunciator relay output.

2. Bad device on network

   a. Troubleshoot the network for malfunctioning devices.

4.58 Code 2118 - Fuel Pressure Low

Logic:

This fault is used when an optional low fuel pressure switch is installed. The nature of the fault is an optional customer selection. The fault function is programmed (using the InPower service tool), as follows:

- *Function:* Low Fuel Pressure Switch (default: Disabled)
- *Fault Level Response:* Warning (default: #1-None, #2-Warning and #3-Warning)

- *Fault Active State Selection:* Active Closed (default: Active Closed)
- *Display Name:* LOW FUEL PRESSURE

Possible Causes:

1. Low fuel pressure
2. Faulty fuel pressure switch connections
3. Faulty fuel pressure switch
4. Incorrect fuel system selected in control
5. Faulty control board

Diagnosis and Repair:

1. Low fuel pressure
   a. Check fuel supply and change as required.
2. Faulty fuel pressure switch connections
   a. Inspect the fuel pressure switch and the harness connectors.
   b. Disconnect the harness connector from the fuel pressure switch.
   c. Inspect for corroded pins, bent or broken pins, pushed back or expanded pins.
   d. Inspect for evidence of moisture in or on the connector.
   e. Inspect for dirt or debris in or on the connector pins.
   f. Inspect the wiring for any damage or shorting.
3. Faulty fuel pressure switch
   a. Check switch operation.
   b. Turn off the fuel supply to the unit, and vent fuel in the line. Check for continuity across the two leads of the switch. The circuit should be open.
   c. Turn fuel supply to the unit on, and check for continuity across the two leads of the switch. The circuit should be closed
4. Incorrect fuel system selected in control
   a. Verify fuel system selection in control menu. Refer to the Converting the Fuel System Type section.
5. Faulty control board
   a. If the sender, harness and control settings are acceptable, the baseboard is defective. Replace it.

4.59 Code 2335 - Excitation Fault (Loss of AC Sense)

Logic:

The control has lost voltage sensing or has lost zero cross sensing.

Possible Causes:

1. Incorrect configuration
2. Bad fuse
3. Bad wire harness or wrong connections
4. Low residual magnetism in excitation coil
5. Excitation coil is defective
6. Incorrect generator set setup
7. Bad control board
8. Short circuit

Diagnosis and Repair:

1. Incorrect configuration
    a. Make sure that values for the Low of AC Voltage Threshold (85%) and Low of AC Voltage Time Delay (10 seconds) are correct in calibration.
2. Bad fuse
    a. Check the fuse F5 (10 Amp).
    b. Replace if necessary.
3. Bad wire harness or wrong connections

⚠ CAUTION
Excessive voltage is possible during testing. Make sure your meter can handle alternator full voltage.

a. Check electrical continuity between the following locations. If resistance is greater than 1 Ohm, repair or replace the harness:
- J22 Pin 4 and the terminal marked N on the alternator terminal block (identified as Sense N on the generator wiring diagram)
- J22 Pin 3 and the terminal marked W on the alternator terminal block (identified as Sense W on the generator wiring diagram)
- J22 Pin 2 and the terminal marked V on the alternator terminal block (identified as Sense V on the generator wiring diagram)
- J22 Pin 1 and the terminal marked U on the alternator terminal block (identified as Sense U on the generator wiring diagram)

b. Check continuity between the following leads. If resistance is greater than 1 Ohm, repair or replace the harness.
- J17 Pin 1 and Field Coil + (F1)
- J17 Pin 2 and Field Coil - (F2)

c. Check continuity between the following leads. If resistance is greater than 1 Ohm, repair or replace the harness:

- J18 Pin 1 and the terminal marked Shunt 1 on the alternator terminal block or PMG terminal marked P2
- J18 Pin 2 and the terminal marked Shunt 2 on the alternator terminal block or PMG terminal marked P3

d. Make sure that the inline connectors in the wiring harness are connected properly.

4. Low residual magnetism in excitation coil

   a. Flash the excitation coil:

      i. Remove Field Coil+ and Field Coil- leads from the alternator.

      ii. Using a 12 VDC supply, touch the positive supply terminal to Field Coil+ and the negative supply terminal to Field Coil-. Remove after brief contact. Repeat three times.

      iii. Reconnect Field Coil+ and Field Coil- leads to the alternator.

      iv. Reset the control, and restart the generator set.

5. Excitation coil is defective

   a. Refer to the Alternator Performance Troubleshooting section.

6. Incorrect generator set setup

   a. Verify that the generator set is capable of reaching the rated speed.

7. Bad control board

   a. Replace the control board module after performing all other steps.

8. Short circuit

   a. If none of the previous debugging steps solve the problem, then the shutdown may be due to a short circuit on the main output lines of the alternator. Inspect the main output lines from the alternator for mis-wire, faulty wire, or any other signs of short circuit.

4.60 Code 2676 - Alternator Frequency Conflict (Shutdown)

Logic: The Alternator Line Frequency and Alternator Excitation Frequency do not match.

Possible Causes:

1. Incorrect setting
2. Bad wire harness or wrong connections
3. Bad control board
4. Bad alternator

Diagnosis and Repair:

1. Incorrect setting
   a. Check the Alternator Line Frequency Gain trim using the operator panel or the InPower service tool.
      - When Shunt is selected, a gain of 1 is the default.
      - When PMG is selected, a gain of 2 is the default.

   b. Measure the Alternator Line Frequency (J22-1 to J22-4).
   c. Measure the Alternator Excitation Frequency (J18-1 to J18-2).
   d. Calculate the Alternator Excitation Frequency value using the following equation:

      *Alternator Line Frequency * Alternator Line Frequency Gain = Alternator Excitation Frequency*

   e. Compare the Alternator Excitation Frequency that was *measured* to the Alternator Excitation Frequency that was *calculated*.
   f. Check the voltage sense leads and exciter power lead for open circuits or short circuits.

2. Bad wire harness or wrong connections

⚠ CAUTION
Excessive voltage is possible during testing. Make sure your meter can handle alternator full voltage.

   a. Check continuity between the following leads; if resistance is greater than 1 Ohm, repair or replace the harness:
      - J17 Pin 1 and Field Coil + (F1)
      - J17 Pin 2 and Field Coil **-** (F2)

   b. Make sure that the inline connectors in the wiring harness are connected properly.

3. Bad control board
   - Replace the control board.

4. Bad alternator
   - Replace the alternator.

4.61 Code 2677 - Fail to Stop (Shutdown)

Logic:

The generator set continues to run after receiving shutdown command from the controller.

Possible Causes:

1. Stuck fuel shutoff (FSO) valve

Diagnosis and Repair:

1. Stuck fuel shutoff (FSO) valve
   a. Check keyswitch operation and make sure it is not stuck closed. Use a multimeter and check continuity across the relay (K3-1 and K3-4). With the Emergency stop pressed, the relay should be open.
   b. Check for a stuck FSO valve. Check the FSO relay and related wiring. Check that the FSO is not mechanically stuck. (The controller shuts off the fuel supply valves only or the spark plug supply.)
   c. If issue persists, consult DTC 1181 in the E-Controls manual.

4.62 Code 2729 - IO Module Lost (Warning)

Logic: There is an intermittent data link between the I/O module and the PCC control (Aux 101 I/O Module option) and no input fault levels were set to Shutdown.

Possible Causes:

1. Incorrect wiring
2. I/O settings misconfigured

Diagnosis and Repair:

1. Incorrect wiring
   a. The connection between AUX 101 and PCC 1302 is incorrect. Make sure there is proper wiring.
      - PCC 1302 TB1-1 – PCC Net A (+) to AUX 101 J1-3
      - PCC 1302 TB1-2 – PCC Net B (-) to AUX 101 J1-4
      - PCC 1302 TB1-3 – B+ Return to AUX 101 J14-2
      - PCC 1302 TB1-5 – Customer Fused B+ to AUX 101 J14-1
      - PCC 1302 TB15-5 – System Wake-up to AUX 101 J1-5
2. I/O settings misconfigured
   a. If no AUX 101 is connected to PCC 1302, connect to the InPower service tool.
      - Go to **Adjustments > System I/O Adjustment > Output Relays**. Make sure System IO Board Enable is disabled.
      - Go to **Adjustments > System I/O Adjustment**. Make sure no inputs or outputs are configured as enabled.

4.63 Code 2731 - IO Module Lost (Shutdown)

Logic: Indicates an intermittent data link between the I/O module and the PCC control (Aux 101 I/O Module option) and at least one input fault level was set to Shutdown.

Possible Causes:

1. Incorrect wiring
2. I/O settings misconfigured

Diagnosis and Repair:

1. Incorrect wiring
   a. The connection between AUX 101 and PCC 1302 is incorrect. Make sure there is proper wiring.
      - PCC 1302 TB1-1 – PCC Net A (+) to AUX 101 J1-3
      - PCC 1302 TB1-2 – PCC Net B (-) to AUX 101 J1-4
      - PCC 1302 TB1-3 – B+ Return to AUX 101 J14-2
      - PCC 1302 TB1-5 – Customer Fused B+ to AUX 101 J14-1
      - PCC 1302 TB15-5 – System Wake-up to AUX 101 J1-5
2. I/O settings misconfigured
   a. If no AUX 101 is connected to PCC 1302, connect to InPower.
      i. Go to **Adjustments > System I/O Adjustment > Output Relays**. Make sure System IO Board Enable is disabled.
      ii. Go to **Adjustments > System I/O Adjustment**. Make sure no inputs or outputs are configured as enabled.

4.64 Code 2897 - Factory Memory Block Corrupt

Logic: The control has detected a corrupted memory block.

Possible Cause:

1. Defective memory block

Diagnosis and Repair:

1. Defective memory block
   a. Connect to device using InPower version 10.0 or greater.
   b. In InPower, right click on the device, and select Initial Calibration (Recover Device) from the menu that appears.
   c. If the capture file for the device is available, select "overlay capture file". If not, select feature codes.
      - Feature codes can be found on the nameplate of the device, located on the alternator housing.

d. If the problem persists, contact the factory for support.

4.65 Code 2898 - Periodic or Fault Memory Block Corrupt

Logic: The control has detected a corrupted memory block.

Possible Cause:

1. Defective memory block

Diagnosis and Repair:

1. Defective memory block
   a. Connect to the device using InPower version 10.0 or greater.
   b. In InPower, right click on the device, and select Initial Calibration (Recover Device) from the menu that appears.
   c. If the capture file for the device is available, select "overlay capture file". If not, select feature codes.
      - Feature codes can be found on the nameplate of the device, located on the alternator housing.
   d. If the problem persists, contact the factory for support.

4.66 Code 2899 - User Memory Block Corrupt

Logic: The control has detected a corrupted memory block.

Possible Cause:

1. Defective memory block

Diagnosis and Repair:

1. Defective memory block
   a. Connect to the device using InPower version 10.0 or greater.
   b. In InPower, right click on the device, and select Initial Calibration (Recover Device) from the menu that appears.
   c. If the capture file for the device is available, select "overlay capture file". If not, select feature codes.
      - Feature codes can be found on the nameplate of the device, located on the alternator housing.
   d. If the problem persists, contact the factory for support.

4.67 Code 2911 - Trim Memory Block Corrupt

Logic: The control has detected a corrupted memory block.

Possible Cause:

1. Defective memory block

Diagnosis and Repair:

1. Defective memory block
   a. Connect to the device using InPower version 10.0 or greater.
   b. In InPower, right click on the device, and select Initial Calibration (Recover Device) from the menu that appears.
   c. If the capture file for the device is available, select "overlay capture file". If not, select feature codes.
      - Feature codes can be found on the nameplate of the device, located on the alternator housing.
   d. If the problem persists, contact the factory for support.

4.68 Code 2964 - Intake Air Temperature Higher than Expected

Logic: The manifold air temperature exceeds 94 °C (200 °F) for more than 60 seconds, while the engine is running (DTC 111 active).

Possible Causes:

1. Exhaust air entering intake
2. TMAP sensor failure

Diagnosis and Repair:

1. Exhaust air entering intake
   a. Inspect the exhaust system for leaks. Check the exhaust manifold gaskets, turbo gasket (if equipped), and exhaust tubing for holes or escaping exhaust. Replace the faulty component(s) if necessary.
   b. The unit is not properly ventilated. Make sure that the unit is greater than 5 feet from any obstruction.
      - For units located inside of a structure, make sure that exhaust gases do not exit within 5 feet of the intake for the structure or generator set.
      - For enclosed sets, make sure that there are no objects blocking the exhaust opening on the top of the enclosure, or objects that may redirect exiting airflow towards the intake end of the unit.
2. TMAP sensor failure
   a. Remove TMAP sensor from the intake manifold, and expose it to ambient air.
   b. Make sure that the tip is well away from the engine or other heat/cold sources.

c. Connect using the E-controls service tool, and monitor the manifold air temperature. Compare that to the known ambient air temperature.

d. Check for continuity across leads 1 and 2 of the TMAP sensor. If the circuit is open, replace the TMAP sensor.

4.69 Code 2972 - Field Overload (Shutdown)

Logic:

If the time that the Field AVR Duty Cycle is operating at maximum output is longer than the time in the “Max Field Time" parameter, event/fault code 2972 will become active.

Possible Causes:

⚠ CAUTION
Excessive voltage is possible during testing. Make sure your meter can handle alternator full voltage.

1. Voltage sensing into the baseboard is too low, or there is an open/short circuit
2. Application issue

Diagnosis and Repair:

1. Voltage sensing into the baseboard is too low, or there is an open/short circuit
   a. Measure the voltage going into the baseboard at L1 = J22-1, L2 = J22-2, L3 = J22-3, and LN = J22-4 (for single phase applications use L1, L2 and LN). If the generator set control is not sensing voltage, it will try to overcompensate by maxing out the AVR output.
      i. If the voltage going into the control board is zero, or less than the Nominal Voltage calibration, then the wiring from the alternator to the baseboard for an open circuit or short circuit.
   b. Measure the output of the AVR at J17-1 and J17-2 while turning the generator set on. The output should be at least 30 VDC when the generator set is starting, but the voltage should decrease significantly when the generator set builds up voltage.
      i. If the output of J17-1 and J17-2 is constantly high or is locked in, then the AVR portion of the PCC is faulty. Replace the baseboard if the AVR is faulty.
2. Application issue
   a. If the generator set runs adequately with no load or some load but as soon as additional load is applied, the generator set shuts down on “Field Overload", then this might be an application issue (load issue, generator set undersized, etc.).

4.70 Code 5134 - Unknown Shutdown at Idle

Logic:

Engine is not getting a proper fuel supply.

Possible Causes:

1. Fuel supply issue

Diagnosis and Repair:

1. Fuel supply issue
    a. Check that there is a proper supply of fuel to the engine.

4.71 Code 5365 - Fault Code on Secondary Source (Information that the Fueling Has Been Shifted to Secondary Source)

Logic:

This fault is used when an optional low fuel pressure switch is installed and the generator set is set up for dual fuel operation. The nature of the fault is an optional customer selection. The fault function is programmed (using the InPower service tool), as follows:

- *Low Fuel Pressure Switch Active State Selection:* Active Closed
- *Function:* Low Fuel Pressure Switch (default: Disabled)
- *Fault Level Response:* Warning (default: #1-None, #2-Warning and #3-Warning)
- *Fault Active State Selection:* Active Closed (default: Active Closed)
- *Gas Fuel Type:* Dual

Possible Causes:

1. Low primary fuel pressure
2. Faulty fuel pressure switch connections
3. Faulty fuel pressure switch
4. Incorrect calibration settings for the Low Fuel Pressure fault in the control
5. Faulty control board

Diagnosis and Repair:

1. Low primary fuel pressure
    a. Check fuel supply. Diagnose and fix as required.
    b. Check fuel valve connections and operation. Diagnose and fix as required.

2. Faulty fuel pressure switch connections
    a. Inspect the fuel pressure switch and the harness connectors.
        i. Disconnect the harness connector from the fuel pressure switch.
        ii. Inspect for corroded, bent or broken tabs on the fuel pressure switch.
        iii. Inspect for evidence of moisture in or on the harness connectors.
        iv. Inspect for dirt or debris in or on the harness connectors.
        v. Inspect the wiring for any damage or shorting.
3. Faulty fuel pressure switch
    a. Check switch operation.
        i. Remove the connector from the fuel pressure switch.
        ii. Verify battery power on the sensor harness connector that plugs into tab NO on the fuel pressure switch. If B+ not present, repair or replace the harness.
        iii. Verify ground on the sensor harness connector that plugs into tab C on the fuel pressure switch. If ground is not present, repair or replace the harness.
4. Incorrect calibration settings for the Low Fuel Pressure fault in the control
    a. Verify calibration setting for Low Fuel Pressure Switch Active State Selection = Active Closed.
    b. Verify calibration setting for Configurable Input #3 Function = Low Fuel Pressure Switch.
    c. Verify calibration setting for Configurable Input #3 Fault Active State Selection = Active Closed.
5. Faulty control board
    a. If the sender, harness and control settings are acceptable, the baseboard is defective. Swap the control board.

4.72 Code 5669 - Engine Combustion (Shutdown)

Logic:

Rapid rate of increase of intake manifold temperature detected.

Possible Causes:

1. Intake manifold over-pressurization event
2. Faulty TMAP sensor
3. Faulty engine harness

Diagnosis and Repair:

1. Intake manifold overpressurization event
   a. Inspect the hose couplings between the compressor outlet and intake manifold.
      i. Inspect the hose couplings for damage.
      ii. Inspect the clamps for damage.
   b. Inspect the turbocharger (if used).
      i. Externally inspect the turbocharger for damage.
      ii. Inspect for loose or missing bolts on the compressor housing.
   c. Inspect the mixer.
      i. Remove the air cleaner and confirm there are no loose pieces within the mixer.
2. Faulty TMAP sensor
   a. For the troubleshooting procedure, refer to DTC 127 in the E-Controls manual.
3. Faulty engine harness
   a. Inspect the engine harness and the connector pins.
      i. Disconnect the engine harness connector from the extension harness.
      ii. Inspect for corroded pins, bent or broken pins, pushed back or expanded pins.
      iii. Inspect for evidence of moisture in or on the connector.
      iv. Inspect for missing or damaged connector seals.
      v. Inspect for dirt or debris in or on the connector pin.
      vi. Disconnect the harness from the ECM and sensor.
      vii. Measure the resistance in each pin from ECM to sensor. Resistance should be 5 Ohms or less.
      viii. Repair or replace the harness as necessary.

4.73 Code 6518 - Cold Start Idle Active (Event)

Logic:

Cold Start Idle is required to avoid turbo failures at cold temperatures due to a lack of lube oil circulation. Cold Start Idle runs the generator set at idle speed to warm up the lube oil before the generator set reaches rated speed. When Cold Start Idle is active, an event is generated. This condition exists for up to 2 minutes after start when the ambient temperature is below 20 °F (-6.7 °C). (See the Cold Start Idle Time Table below.) When the generator set reaches rated speed, Cold Start Idle will be deactivated.

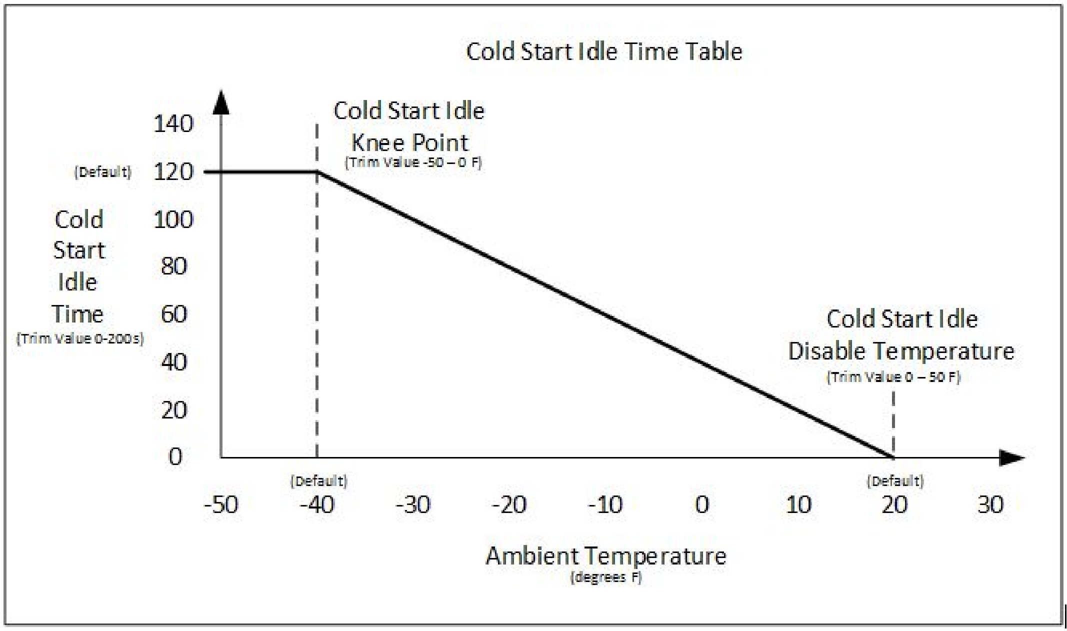


FIGURE 25. COLD START IDLE TIME TABLE

5 Fuses and Relays

5.1 Fuses and Relays

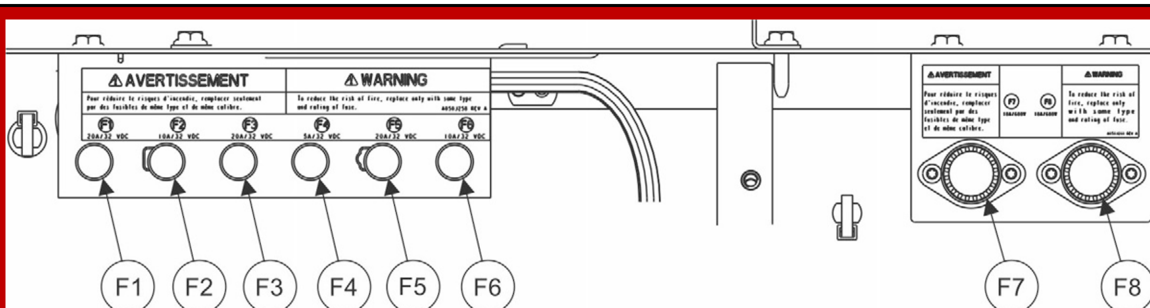
⚠ WARNING

Accidental starting of a generator set can cause severe personal injury or death. Be sure to isolate the battery to prevent accidental starting while working on the generator set.

⚠ CAUTION

Use of an incorrect fuse or relay can damage the generator set. Use replacement fuses and relays of the correct amperage.

5.2 Fuse and Relay Box



Fuse	Amps	Volts	Description
F1	20	32 VDC	1302 Control B+
F2	10	32 VDC	Key SW, Alt Flash, LCL, Fuel sol, HMI B+
F3	20	32 VDC	ECM Vbat B+
F4	5	32 VDC	Electronic Pressure Regulator (90 Pin ECM Only)
F5	20	32 VDC	Switched Ignition B+
F6	10	32 VDC	Customer Switched B+
F7	10	600 VAC	AC input, Shunt/PMG
F8	10	600 VAC	AC input, Shunt/PMG

5.3 Fuse and Relay Replacement

1. Disconnect the negative (-) cable from the battery first.

2. Remove the positive (+) cable from the battery.
3. Remove the fuse or relay box cover.
4. Remove the faulty fuse or relay.
5. Check the fuse or relay for continuity. If the fuse or relay shows an open circuit, replace the fuse or relay.
6. Install a new fuse or relay. The new fuse or relay must be of the same amperage and voltage as the old fuse or relay.
7. Replace the fuse or relay box cover.
8. Connect the positive (+) cable to the battery first.
9. Connect the negative (-) cable to the battery.
10. Start the generator set to see if the fault condition is fixed.
11. If the replaced fuse or relay becomes open again, troubleshoot to find the fault. Replace the fuse or relay after the fault has been repaired.

6 Engine Control Module (ECM)

6.1 Engine Control Module (ECM)

The Engine Control Module (ECM) monitors signal inputs from engine sensors to control the fuel metering and speed of the engine (see the figure below). The ECM also provides diagnostic control over the engine and fuel system. The PCC controls the starting and stopping sequence of the engine through the ECM.

In the event of an engine fault, the ECM provides a signal output via the CAN datalink to the PCC. If the ECM triggers an engine shutdown, the PCC displays an engine shutdown or service fault. The PCC will display an additional fault to determine the root cause of the engine shutdown. If no additional fault is displayed in the PCC, the engine fault code can be determined by connecting to the ECM with the Global Control Platform (GCP) Display or 4G service tool. For service tool information, see the Service Tool Manual (A043D529).

For more information, see the following EControls, Inc. publications:

- Light Duty Fuel System Service Manual Supplement (A035C596)
- *If applicable:* Global Control Platform (GCP) Engine Display Interface Software (EDIS) Training Manual (A035C608)
- *If applicable:* 4G Software Operator Manual (A052G024)

All of these manuals can be found in QuickServe OnLine (QSOL).

The wiring harness and GCP or 4G Display software required to perform engine diagnostics are available from your authorized distributor.

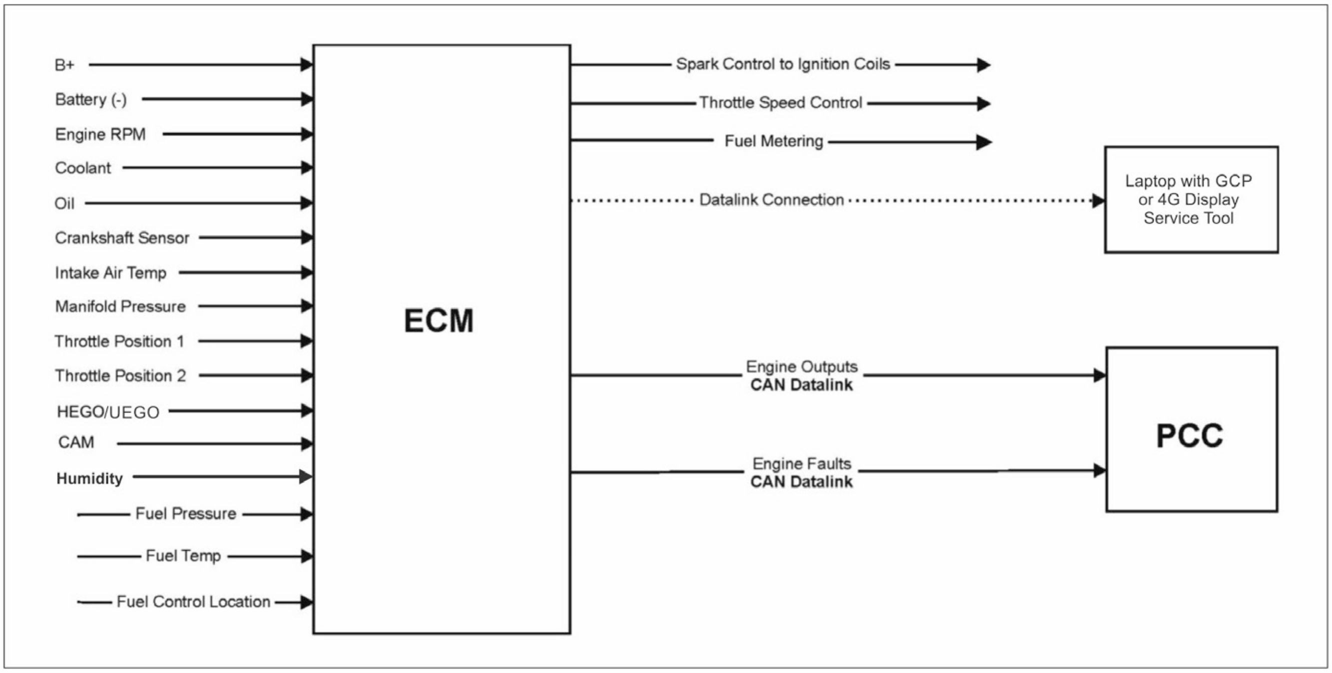


FIGURE 26. ECM INPUTS AND OUTPUTS

6.2 Keyswitch Control

The keyswitch input to the ECM remains active during all controller modes other than when the Sleep Mode is active or the Emergency Stop is engaged. The PCC sends a start signal to the ECM via the Keyswitch Relay and the Start Relay. When the PCC detects a start command, both relays become charged, sending the start signal to the ECM, causing the engine to crank.

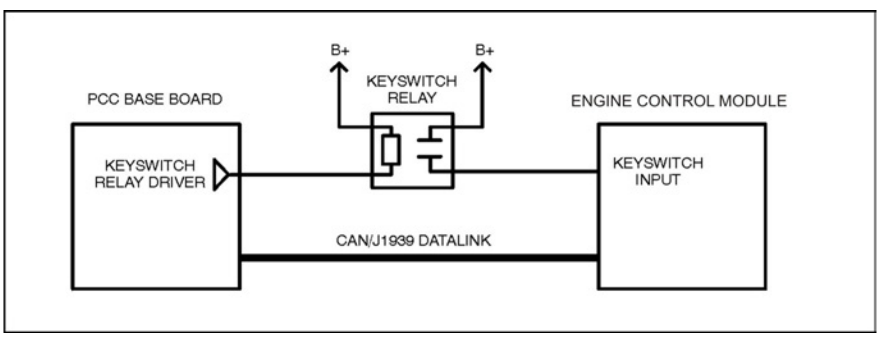


FIGURE 27. CONTROL SYSTEM BLOCK DIAGRAM

6.3 Reprogram ECM

1. Obtain the latest revision of ECM calibration from the InCal website at *www.cumminspower.com/en/services*. Refer to Instruction Sheet G755.
2. Save the file on a laptop.

3. Make sure the generator set is stopped, is off (that is, in Off mode), and the breaker is in the open position.
4. If the unit is connected to a fuel supply, shut off the fuel supply.
5. Connect to the ECM to the laptop using an EControls GCP E-Com USB interface cable (part number A047A982).
6. Log in using one of the following passwords:

Tool	Password
GCP	DD3F-OSHY-VJLV-IPGC
4G	GLTX-0BIS-534R-SVUX

7. Open the GCP Display or 4G service tool.
8. Use the pull-down **File** menu on the upper left of GCP Display or 4G screen and select **Reprogram Target**. See the figure below.

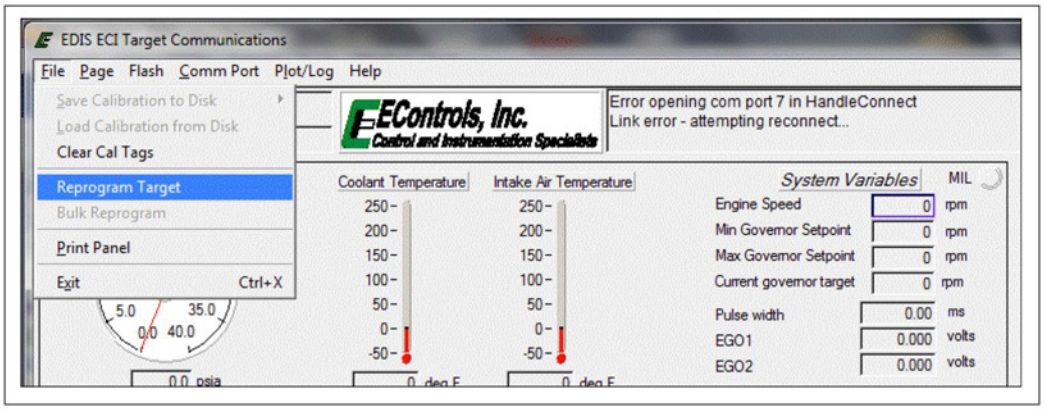


FIGURE 28. PULL DOWN REPROGRAM TARGET SELECTION

9. Select file to download (.MOT file). See the figure below.

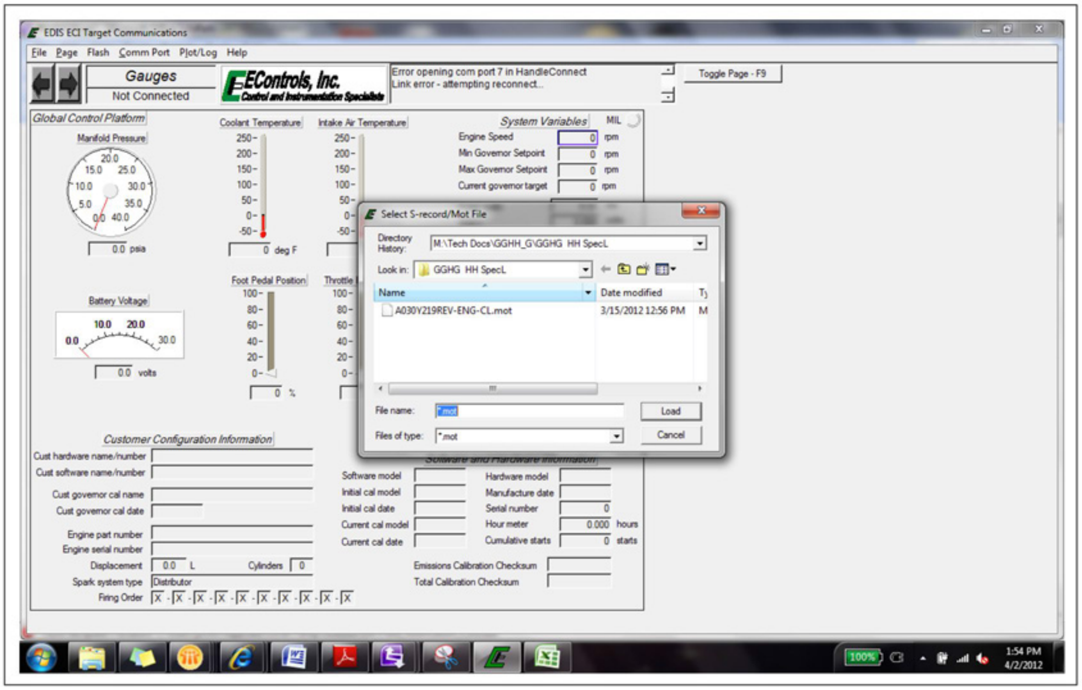


FIGURE 29. MOT FILE

10. The status bar displays the calibration status.

11. Confirm in the lower left hand corner of the "Gauges" page that the new calibration is loaded. See the figure below.

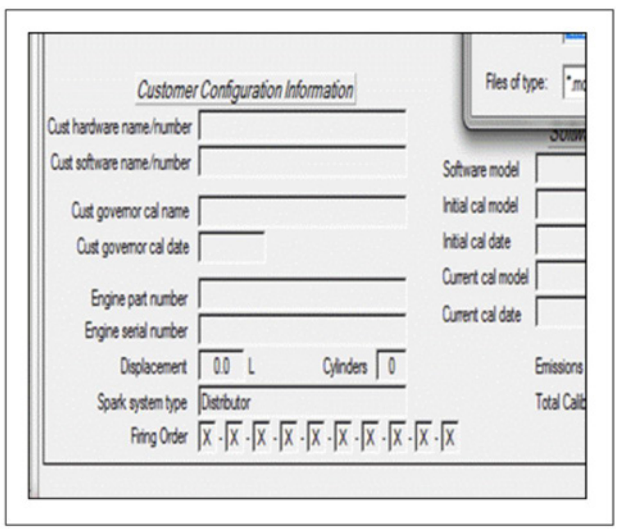


FIGURE 30. ECM UPDATE DOWNLOAD CONFIRMATION

6.4 Viewing Engine Faults

Fault information can be viewed using the GCP Display and 4G service tools. See the Reprogram ECM section for login information. The GCP Display and 4G service tools are available from Cummins. The GCP Display and 4G software each consists of several pages of display information. All fault and diagnostic information is managed through the Faults page. Interaction includes viewing fault messages, downloading fault data (fault snapshot and flight data recorder), and erasing faults from memory.

Faults are separated into two categories, Active and Historic. Active faults are active in real-time and historic faults have been generated at some instance in time that may or may not be active in real-time. When a fault becomes active, it is immediately logged as historic and a snapshot and flight data log is saved. **Figure 31** shows an example of the fault page when an active fault has been generated. Notice that the fault is present in both the active and historic lists and the malfunction indicator lamp (MIL) has been illuminated. **Figure 32** shows an example of the fault page with a historic fault stored in memory.

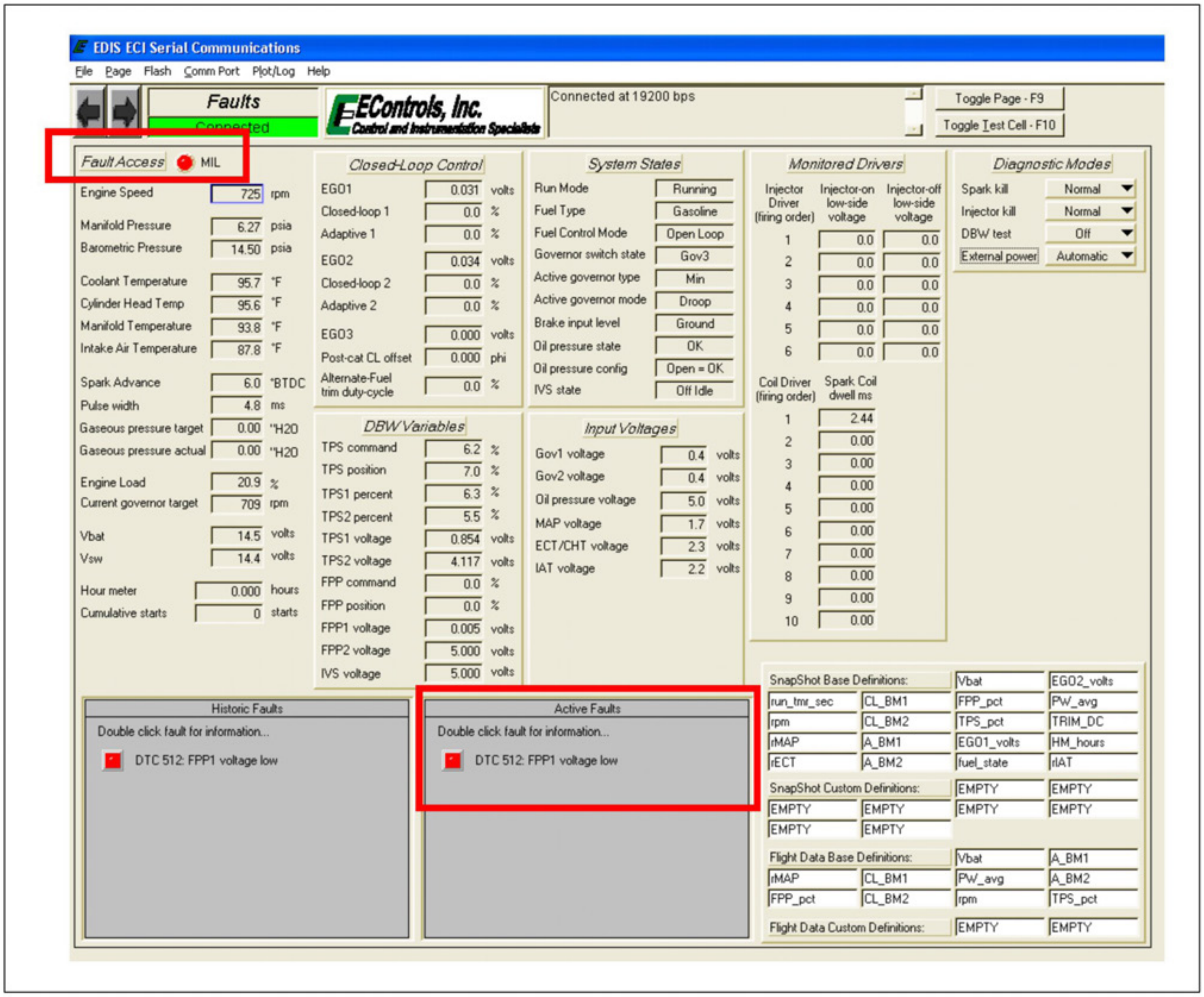


FIGURE 31. FAULTS PAGE WITH ACTIVE FAULT MESSAGE

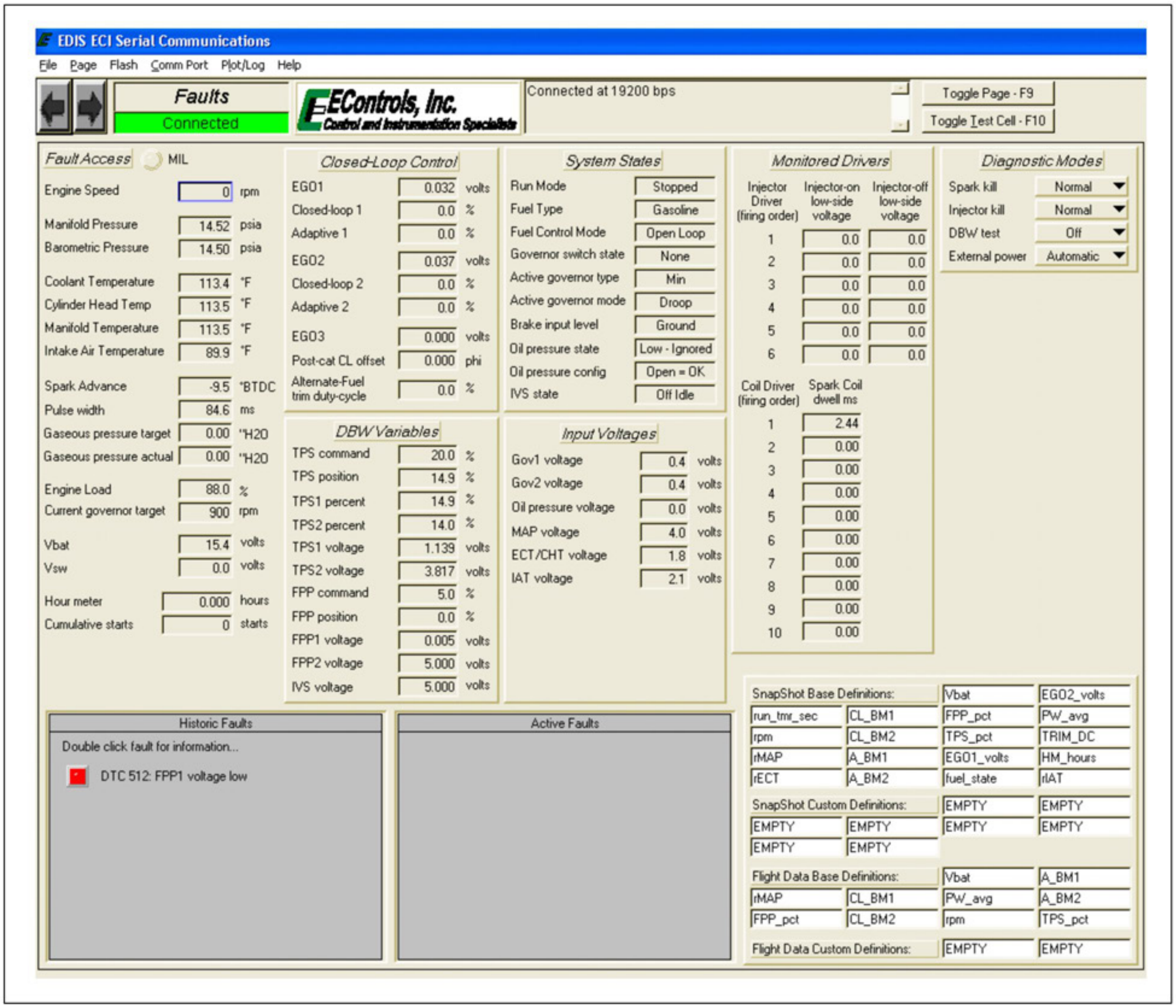


FIGURE 32. FAULTS PAGE WITH HISTORIC FAULT MESSAGE

When an engine fault occurs, a fault snapshot (FSS) and flight data recorder (FDR) are logged within the ECM.

Fault snapshot is data recorded at the instant the fault is triggered. This data is only logged for the first eight (8) faults on the first occurrence of each fault. The fault snapshot is a sample of data taken at the instance the fault triggered. The fault snapshot is stored in the EEPROM and is retained even when battery power has been lost.

The flight data recorder is ten seconds of recorded data, eight (8) seconds prior to the fault and two (2) seconds following the fault. This data is saved for the first two occurrences of the fault. Flight data recorder data is saved in the RAM, and will be erased if the ECM loses battery power.

Both sets of data are accessed from the Historic Fault Information interface and can be saved to the PC upon retrieval.

6.5 Accessing Fault Information

Fault information can be accessed by double left-clicking the fault LED in the historic fault list. This produces the Historic Fault Information interface shown in the image below. From this interface the user can interpret a diagnostic trouble code (DTC) message, identify whether or not the fault occurred during the current start cycle, identify if the fault caused the engine to shut down, determine how many start cycles have occurred since the fault was last active, and view snapshot and flight data.

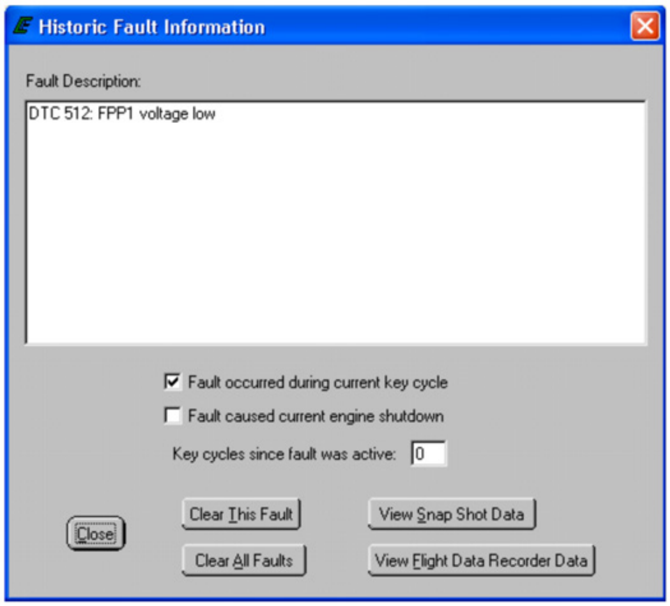


FIGURE 33. HISTORIC FAULT INFORMATION INTERFACE

The table below outlines the options displayed in the Historic Fault Information screen. Historic faults are not overwritten if the same fault becomes active, storing data from the original active fault.

TABLE 19. HISTORIC FAULT INFORMATION INTERFACE FUNCTIONS

Fault Description Message Box	Customized Text that References the DTC Flash Code and Describes the Fault
Fault During Key Cycle Checkbox	Informs that the fault occurred during the current key-on event.
Fault Caused Engine Shutdown Checkbox	Informs that the fault caused the engine to shutdown.
Key Cycles Since Fault Active Indicator	Displays the amount of key-on events since the fault was last active.
Clear This Fault Button*	Erases the selected historic fault from the ECM.
Clear All Faults Button*	Erases all historic faults from the ECM.

Fault Description Message Box	Customized Text that References the DTC Flash Code and Describes the Fault
View Snap Shot Data Button	Retrieves a data “snap shot” from the ECM for variables defined in the base and custom snapshot variable definition lists.
View Flight Data Recorder Data Button	Retrieves a 10-second data strip chart (8 seconds prior, 2 seconds after fault trigger) from the ECM for variables defined in the base and custom flight data recorder definition lists. An example.
Close Button	Exits the Historic Fault Information interface. DOES NOT cancel or clear any faults.
* Snapshot and flight data recorder data for historic faults is erased if the fault is cleared from memory.	

The image below is an example of a fault snapshot after View Fault Snapshot is selected. Data is presented in two columns, base and custom variables. When retrieved, the FSS data may be saved to the PC in text format with an *.fss* extension. A FSS saved to a PC may be reviewed in any ASCII based software program.

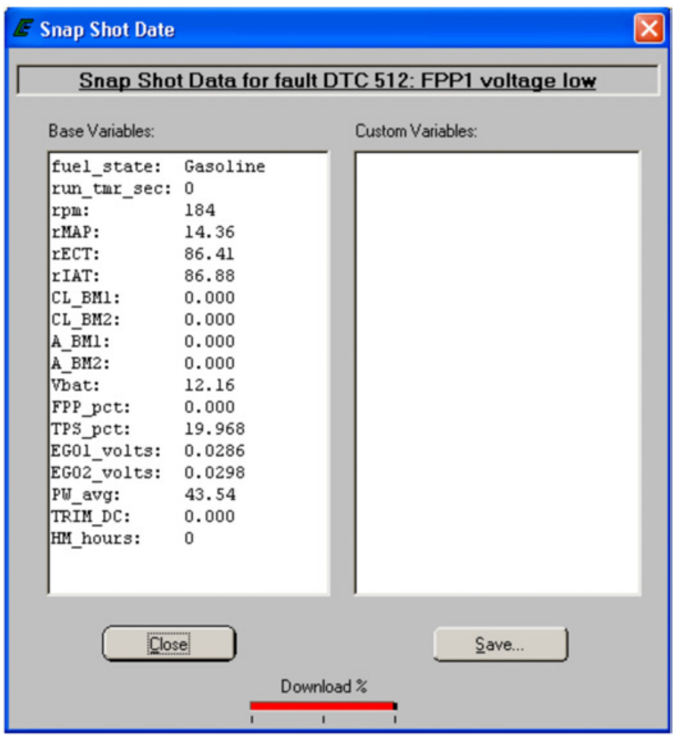


FIGURE 34. SNAPSHOT DATA INTERFACE

The image below shows the Flight Data Recorder interface after View Flight Data Recorder is selected. The FDR captures a ten second (eight seconds prior and two seconds after generating the fault) strip of data for base and custom variables. FDR data is presented in an interface similar to the Plot interface for a quick graphical presentation. From this interface, the FDR data may be saved to the PC in text, tab-delimited format with an *.fdr* file extension. When saved to a PC, FDR data may be reviewed using any graphical post-processing software capable of handling tab-delimited formatting.

FIGURE 35. FLIGHT DATA RECORDER INTERFACE

For more information regarding the GCP Display or 4G service tools, refer to the following documents:

- *If applicable:* Global Control Platform (GCP) Engine Display Interface Software (EDIS) Training Manual
- *If applicable:* 4G Software Operator Manual (A052G024)

6.6 ECM Fault Codes

NOTICE
The EControls manual applies to several applications. See the wiring diagrams provided with the generator set or the Wiring Diagrams appendix for appropriate pin numbers.

DTC Code	Description	Models	
		C45 N6, C50 N6, C60 N6	C70 N6, C80 N6, C100 N6
16	Crank and/or Cam Could Not Synchronize During Start[1]	■	■
107	MAP low voltage	■	■

DTC Code	Description	Models	
		C45 N6, C50 N6, C60 N6	C70 N6, C80 N6, C100 N6
108	MAP High Pressure	■	■
111	IAT higher than expected Stage 1	■	■
112	IAT low voltage	■	■
113	IAT high voltage	■	■
116	ECT higher than expected Stage 1	■	■
117	ECT / CHT low voltage	■	■
118	ECT / CHT high voltage	■	■
121	TPS1 % lower than TPS2 %[2]	■	■
122	TPS1 Signal Voltage Low[2]	■	■
123	TPS1 Signal Voltage High[2]	■	■
127	IAT higher than expected Stage 2	■	■
129	BP low pressure	■	■
134	EGO1 open / lazy (HO2S1)	■	
187	FT gaseous fuel extremely low		■
187	FT gaseous fuel low		■
188	FT gaseous fuel high		■
217	ECT higher than expected 2	■	■
219	Max govern speed override		■
221	TPS1 % higher than TPS2 %[2]	■	■
222	TPS2 Signal Voltage Low[2]	■	■
223	TPS2 Signal Voltage High[2]	■	■
336	Crank Input Signal Noise[3]	■	■
337	Loss of Crankshaft Input Signal[3]	■	■
341	Camshaft Input Signal Noise	■	■
342	Loss of Camshaft Input Signal	■	■
359	Fuel run-out longer than expected	■	■
520	Oil pressure low stage 1 (sender)	■	■
521	Oil pressure high (sender)		■
522	Oil pressure sender low voltage	■	■
523	Oil pressure sender high voltage	■	■

DTC Code	Description	Models	
		C45 N6, C50 N6, C60 N6	C70 N6, C80 N6, C100 N6
524	Oil Pressure Low[4]	■	■
562	Battery Voltage (VBat) Low[5]	■	■
563	Battery Voltage (VBat) High[5]	■	■
601	Microprocessor Failure - Flash	■	■
604	Microprocessor Failure - RAM	■	■
606	Microprocessor Failure - COP	■	■
642	Sensor Supply Voltage 1 Low (5Vext1)	■	■
643	Sensor Supply Voltage 1 High (5Vext1)	■	■
685	Relay coil open		■
686	Relay control ground short		■
687	Relay coil short to power		■
1111	Fuel rev limit		■
1112	Spark rev limit		■
1113	RPM higher than expected		■
1151	Closed Loop High (LPG)	■	■
1152	Closed Loop Low (LPG)	■	■
1153	Closed Loop High (Natural Gas)	■	■
1154	Closed Loop Low (Natural Gas)	■	■
1161	Adaptive Learn High (LPG)	■	■
1162	Adaptive Learn Low (LPG)	■	■
1163	Adaptive Learn High (NG)	■	■
1164	Adaptive Learn Low (NG)	■	■
1171	MegaJector/EPR delivery pressure higher than expected[6]	■	■
1172	MegaJector/EPR delivery pressure lower than expected[6]	■	■
1173	MegaJector/EPR comm lost[7]	■	■
1174	MegaJector/EPR voltage supply high[8]	■	■
1175	MegaJector/EPR voltage supply low[8]	■	■
1176	MegaJector/EPR internal actuator fault detection	■	■

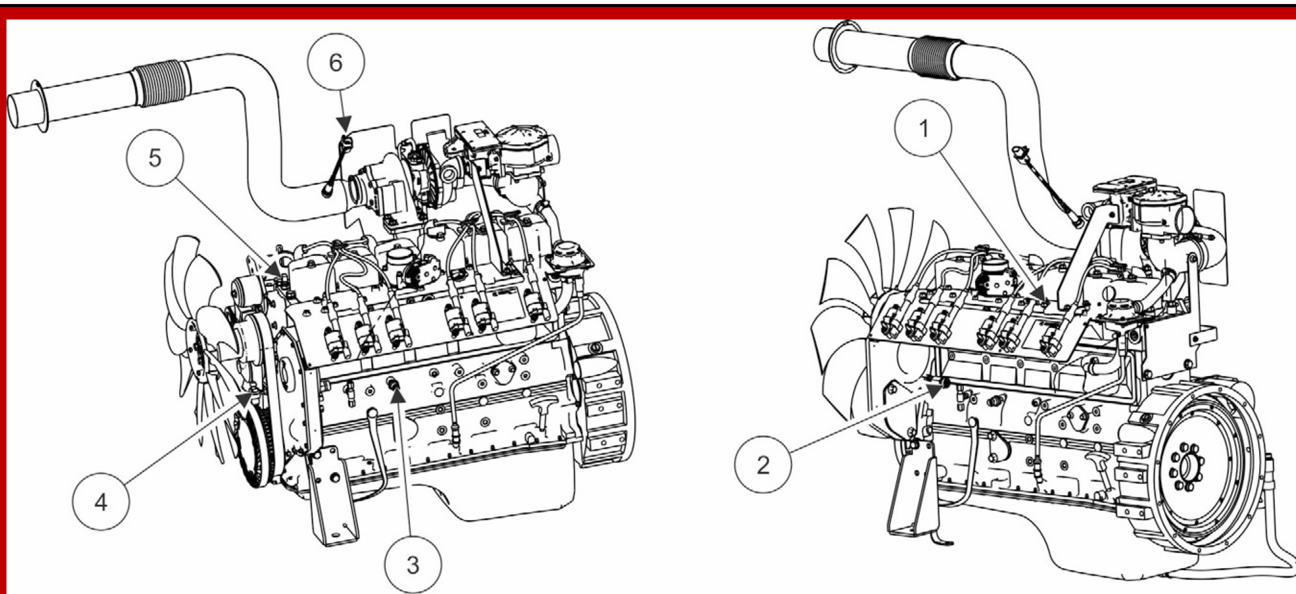
DTC Code	Description	Models	
		C45 N6, C50 N6, C60 N6	C70 N6, C80 N6, C100 N6
1177	MegaJector/EPR internal circuitry fault detection	■	■
1178	MegaJector/EPR internal comm fault detection	■	■
1183	MegaJector autozero / lockoff failed	■	
1612	Microprocessor Failure - RTI 1	■	■
1613	Microprocessor Failure - RTI 2	■	■
1614	Microprocessor Failure - RTI 3	■	■
1615	Microprocessor Failure - A/D	■	■
1616	Microprocessor Failure - Interrupt	■	■
1626	CAN1 Tx failure	■	■
1627	CAN1 Rx failure	■	■
1628	CAN1 address conflict failure	■	■
1673	Calibration Configuration Error		■
1674	Hardware ID Failure		■
2111	Unable to reach lower TPS	■	■
2112	Unable to reach higher TPS	■	■
2135	TPS1/2 simultaneous voltages out of range	■	■
2229	BP high pressure[9]	■	■
8901	UEGO1 internal processor fault		■
8902	UEGO1 heater supply high voltage		■
8904	UEGO1 cal resistor voltage high		■
8910	UEGO1 sense cell voltage high		■
8914	UEGO1 sense cell slow to warm up		■
8916	UEGO1 sense cell impedance high		■
9999	RPM higher than expected	■	
9999	DBW drive current high		■
9999	Envirotech receipt lost[10]		■
9999	Lockoff open / ground short		■
9999	Lockoff short to power		■
9999	UEGO1 heater open / ground short		■
9999	UEGO1 heater short to power		■

DTC Code	Description	Models	
		C45 N6, C50 N6, C60 N6	C70 N6, C80 N6, C100 N6
9999	UEGO1 internal supply voltage low		■

[1]Hall-Effect sensor on crankshaft and camshaft
[2]TPSs are potentiometers, with 1 starting "low" at 0 Ohms
[3]Hall-Effect sensor used
[4]Inspect the sensor
[5]VDC
[6]EPR is integrated in the ECM in some units.
[7]EPR is integrated in the ECM in some units. If this fault occurs, replace the ECM/EPR module.
[8]Make sure the pressure regulator valve moves freely. If so, replace the ECM/EPR module.
[9]psig
[10]Humidity sensor used

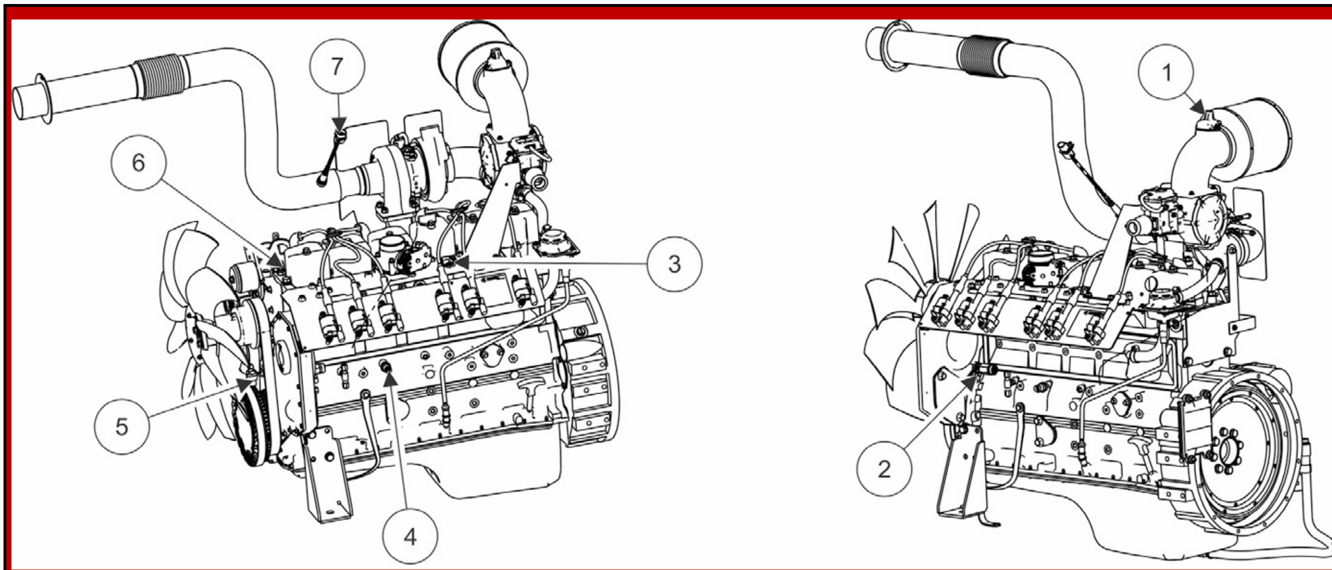
7 Sensors

The following figures shows the location of the sensors or senders to which the PCC responds.



No.	Description	No.	Description
1	Temperature Manifold Absolute Pressure (TMAP) Sensor	4	Crankshaft Position (CKP) Sensor
2	Camshaft Position (CMP) Sensor	5	Engine Coolant Temperature (ECT) Sensor
3	Oil Pressure Sensor	6	Heated Exhaust Gas Oxygen (HEGO) Sensor

FIGURE 36. SENSOR LOCATIONS (C45 N6, C50 N6, C60 N6 MODELS)



No.	Description	No.	Description
1	Humidity Sensor	5	Crankshaft Position (CKP) Sensor
2	Camshaft Position (CMP) Sensor	6	Engine Coolant Temperature (ECT) Sensor
3	Temperature Manifold Absolute Pressure (TMAP) Sensor	7	Universal Exhaust Gas Oxygen (UEGO) Sensor
4	Oil Pressure Sensor		

FIGURE 37. SENSOR LOCATIONS (C70 N6, C80 N6, C100 N6 MODELS)

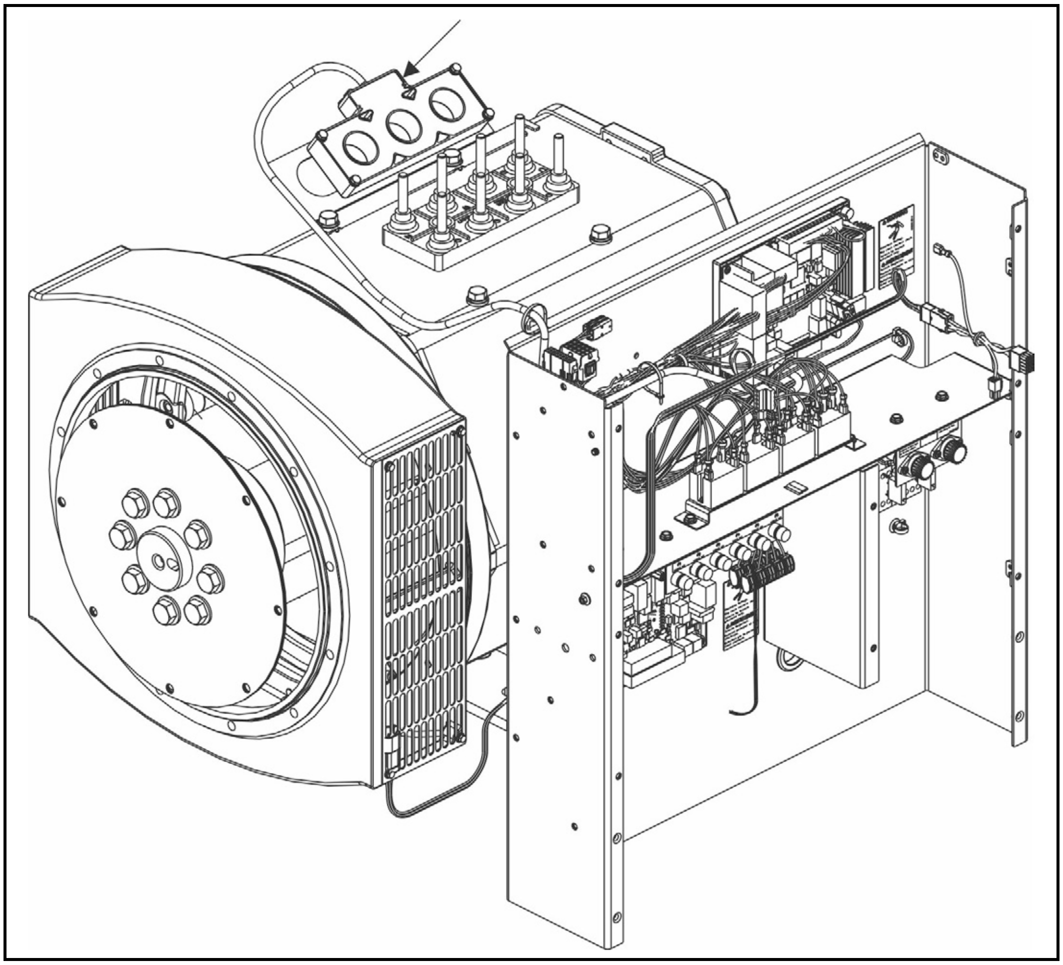


FIGURE 38. CURRENT TRANSFORMER ASSEMBLY

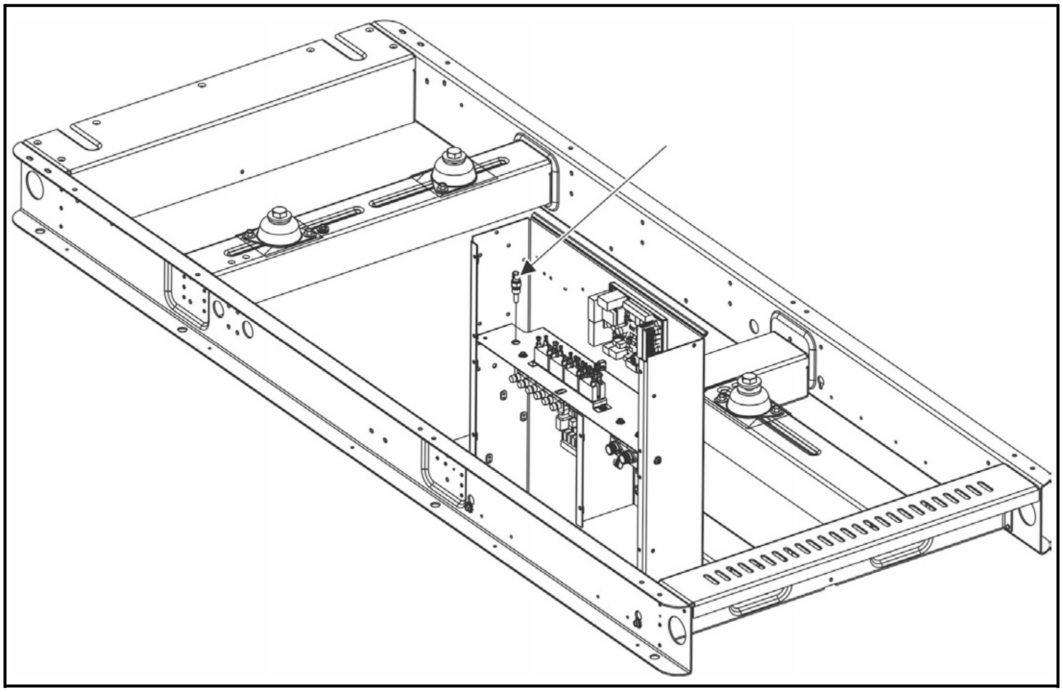


FIGURE 39. AMBIENT AIR TEMPERATURE SENSOR

7.2 Oil Pressure Sensor

The oil pressure sensor is a normally open switch. When engine oil pressure falls below 6 PSI, the switch closes. Once the ECM detects that the switch is grounded it sends a shutdown signal to the engine. The ECM will allow the engine to be restarted but will continue to send a shutdown signal if the pressure remains below 6 PSI.

7.3 Engine Coolant Temperature (ECT) Sensor

The ECM monitors the engine coolant temperature though the ECT sensor mounted on the engine. The ECM uses this sensor input to make corrections in fueling and to protect the engine from overheating during normal operation.

TABLE 20. COOLANT TEMPERATURE SENSOR RESISTANCE

Temperature (°F)	Temperature (°C)	Resistance (Ohms)
266	130	278
248	120	375
230	110	494
221	105	568
212	100	657

Temperature (°F)	Temperature (°C)	Resistance (Ohms)
203	95	764
194	90	892
185	85	1,045
176	80	1,229
158	70	1,720
140	60	2,450
122	50	3,560
77	25	10,000
32	0	33,650
-13	-25	138,100
-40	-40	361,100

7.4 Crankshaft Position (CKP) Sensor

The crankshaft position sensor (CKP) is used to determine engine RPM and crankshaft position. The CKP uses a Hall Effect type sensor which generates a square wave form. The CKP is located next to the trigger wheel mounted on the end of the crankshaft. The trigger wheel contains 60 teeth spaced 6 degrees apart with two teeth missing. By magnetically locating the empty space on each revolution, the ECM can determine the position of the crankshaft and engine speed.

7.5 Camshaft Position (CMP) Sensor

The camshaft position sensor (CMP) is a Hall Effect type sensor. The CMP is used to determine when cylinder 1 reaches its compression stroke. The ECM uses this information to control fuel delivery to the proper cylinder.

7.6 Heated Exhaust Gas Oxygen (HEGO) Sensor

The Heated Exhaust Gas Oxygen Sensor (HEGO), also referred to as an O_2 sensor, is mounted before the catalyst in the exhaust system. The HEGO monitors the amount of oxygen in the exhaust system versus ambient conditions and generates a voltage output relative to the reading. This information is used to determine a rich or lean condition in the engine. In the event of a rich mixture, the typical HEGO output is 0.8 to 0.9 VDC. In the event of a lean mixture, the voltage drops to between 0.1 to 0.3 VDC. The ECM communicates with the HEGO, and adjusts the fuel system to maintain the proper air/fuel mixture. At a perfectly balanced mixture the HEGO should produce approximately 0.45 VDC.

7.7 Universal Exhaust Gas Oxygen (UEGO) Sensor

The Universal Exhaust Gas Oxygen Sensor (UEGO), also referred to as an O_2 sensor, is mounted in the exhaust system after the turbocharger and before a catalyst if equipped. The UEGO monitors the amount of oxygen in the exhaust system versus ambient conditions by determining the pumping current needed to maintain a constant output voltage from a monitoring chamber. Positive pumping current indicates a lean air to fuel (AFR) ratio, and negative pumping current indicates a rich AFR. The scale of the pumping current indications of how lean or rich the operation is relative to a stoichiometric condition. The ECM uses the UEGO sensor output signal to adjust the fuel system to maintain the proper air to fuel mixture.

7.8 Additional Sensors

<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>Throttle Position Sensor (TPS)</td><td rowspan="2">The ECM monitors the TPS (which is internal to the throttle body) and the TMAP sensor to maintain fuel control and emissions. For more information on the TPS, see the Electronic Throttle Body (ETB) section.</td></tr>
<tr><td>Temperature Manifold Absolute Pressure (TMAP) Sensor</td></tr>
<tr><td>Humidity Sensor</td><td>C70, C80 and C100 models only: This value is reported in the ECM where the calibration adjusts to optimize combustion performance for all ambient humidity conditions. The humidity sensor measures the relative humidity, inlet air temperature and barometric pressure of the intake air used for combustion, and sends this information to the ECM via the CAN network. The sensor is located on top of the air intake elbow. It uses four wires: two for 5V voltage supply and return, and two for CAN communication. If the sensor malfunctions, an error code will appear in the ECM as an unidentified engine fault on the generator display.</td></tr>
<tr><td>Integrated Electronic Pressure Regulator (IEPR)</td><td rowspan="2">See the IEPR/DEPR section.</td></tr>
<tr><td>Direct Acting Pressure Regulator (DEPR)</td></tr>
<tr><td>Low Fuel Pressure Sensor</td><td>This sensor is optional on single fuel system and standard on dual fuel systems. When the fuel pressure falls below 5” w.c.:
Single fuel system: The switch will trigger a warning message on the generator display.
Dual fuel system: The switch will change fuel sources to the secondary fuel (LP vapor).</td></tr>
</table>

Name	Description
Current Transformer	This sensor measures the main alternator electrical current. Its output signal feeds into the PC 1.1 or PC 2.3 control for calculating ampacity, and generator set power, as well as overload and short circuit safety shutdowns.
Ambient Air Temperature Sensor	This sensor senses the air temperature near the generator set. Its output signal feeds into the PC 1.1 or PC 2.3 control to adjust engine idle speed and warm-up time when temperatures are less than 20 °F.

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8 SAE J1939 CAN (Controlled Area Network)

8.1 SAE J1939 CAN (Controlled Area Network)

The following section describes the function and operation of the J1939 Controlled Area Network (CAN) datalink, as it applies to this generator set. The engine control module (ECM) communicates to the generator set controller (PCC) over this network.

CAN communications follow the SAE J1939 communication protocol standard. The CAN datalink is based on a main trunk no more than 131 feet (40 meters) long and with 30 devices that is terminated by a 120 Ohm resistor at each end. Stubs no longer than 3.3 feet (1 meter) extend from the main trunk to each module in the bus.

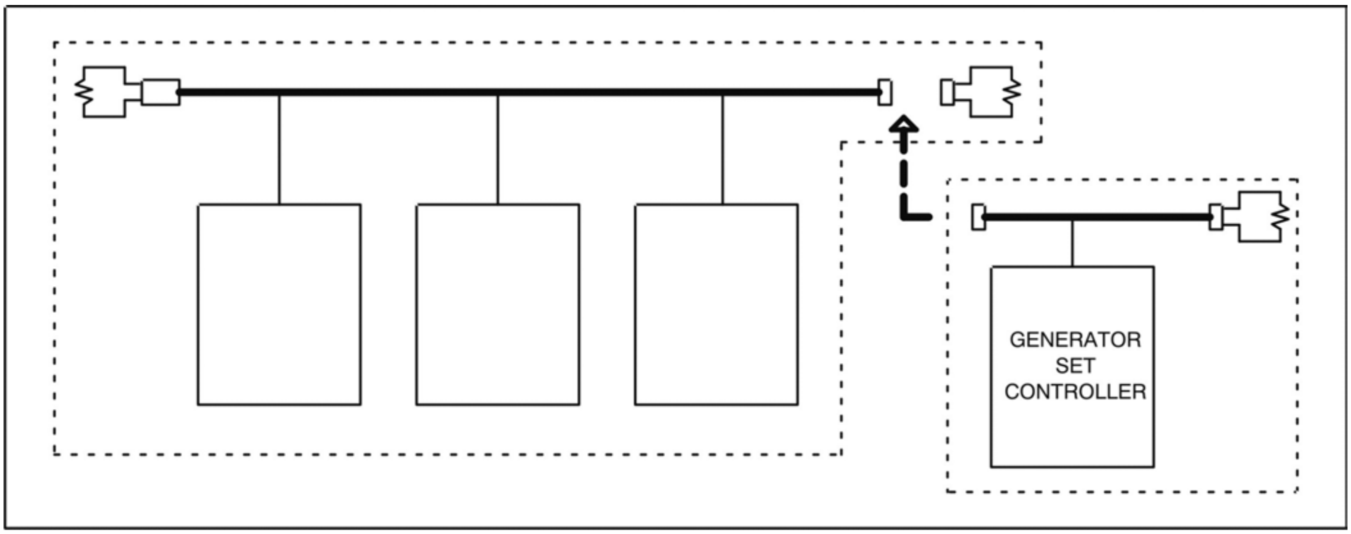

FIGURE 40. CAN DATALINK

8.2 CAN Datalink Signals

The CAN datalink carries the binary signal between the ECM (Engine Control Module) and the PCC controller. The binary signal is expressed by a change in voltage. The table below shows how the generator set controller distinguishes between the voltage signals.

TABLE 21. CAN DATALINK VOLTAGE DIFFERENTIALS

Signal	0	1
J1939 High (+)	2.5 V	3.5 V
J1939 Low (-)	2.5 V	1.5 V

Signal	0	1
Voltage Differential	0 V	2 V

The CAN datalink transmits the signal at 250 KBaud, or 250 kilobits per second. Hence, it is possible for the voltages on J1939 High (+) and J1939 Low (-) to change 250,000 times per second.

The figures below show examples of good and bad datalink signals, on a high-resolution oscilloscope. The bad signal is caused by termination problems (no termination, wrong termination, or bad termination).

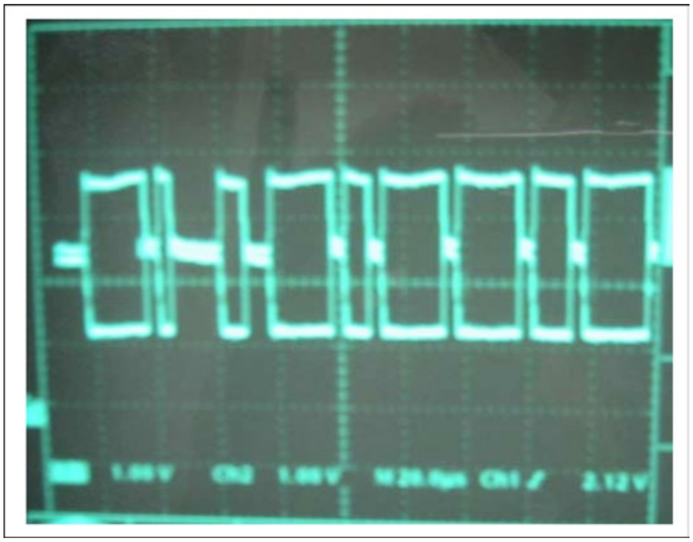

FIGURE 41. CAN DATALINK: GOOD SIGNAL

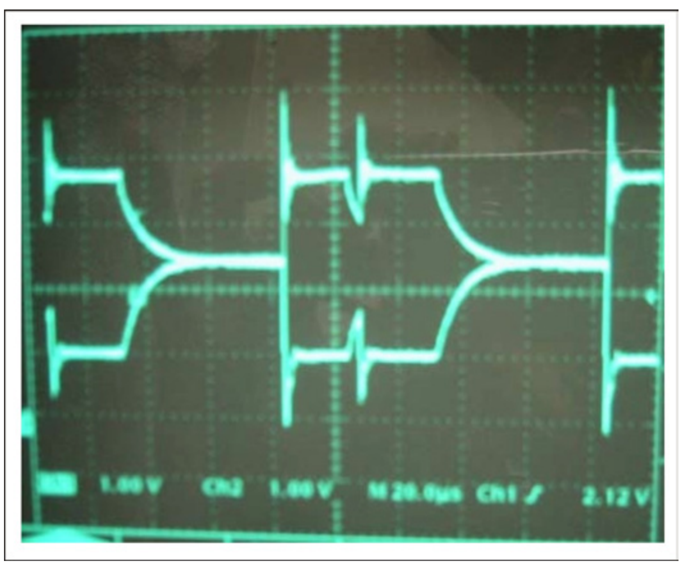

FIGURE 42. CAN DATALINK: BAD SIGNAL

8.3 J11 Connections

The CAN datalink connects to the PCC baseboard via connector J11. J11 pin connections are identified in the table below.

TABLE 22. CONNECTOR J11

Description	Pin
CAN +	20
CAN -	19
CAN Shield	17
Keyswitch +	22
Keyswitch -	21

The PCC uses this data to display engine status (sensor, warning and shutdown conditions). The datalink must remain active at all times. If not, the PCC will detect the inactive datalink and display a datalink error shutdown condition.

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9 Fuel System

9.1 Fuel System Adjustments

NOTICE
Read the warranty statement provided with the generator set for US Environmental Protection Agency (EPA) restrictions on servicing specific components.

9.2 Adaptive Learn Function

The following information applies to C70 N6, C80 N6, and C100 N6 models only:

Adaptive learn is an engine ECM function that allows the generator set to "learn" its environment. There are small differences in the performance of each engine and fuel system component, so the ECM uses inputs from the engine sensors to adjust running conditions to operate more consistently for each individual generator set.

NOTICE

The generator set must be run with no active faults under load (that is, transfer switch connected to maximum customer load available) until the engine reaches a temperature of 175 °F (80 °C) to allow the adaptive learn function to initialize whenever changing the programming in an ECM or replacing any of the components below:

- **Engine internals (including cylinder head assembly, pistons, crankshaft, etc.)**
- **Throttle body**
- **ECM**
- **Universal Exhaust Gas Oxygen (UEGO) sensor**
- **Temperature Manifold Absolute Pressure (TMAP) sensor**
- **Turbocharger**
- **Humidity sensor**
- **Engine coolant temperature (ECT) sensor**
- **Fuel mixer**
- **Direct Electronic Pressure Regulator (DEPR)**

9.3 Fuel System Drawings

The engine is equipped with a fuel mixer to run on natural gas or propane vapor.

⚠ WARNING

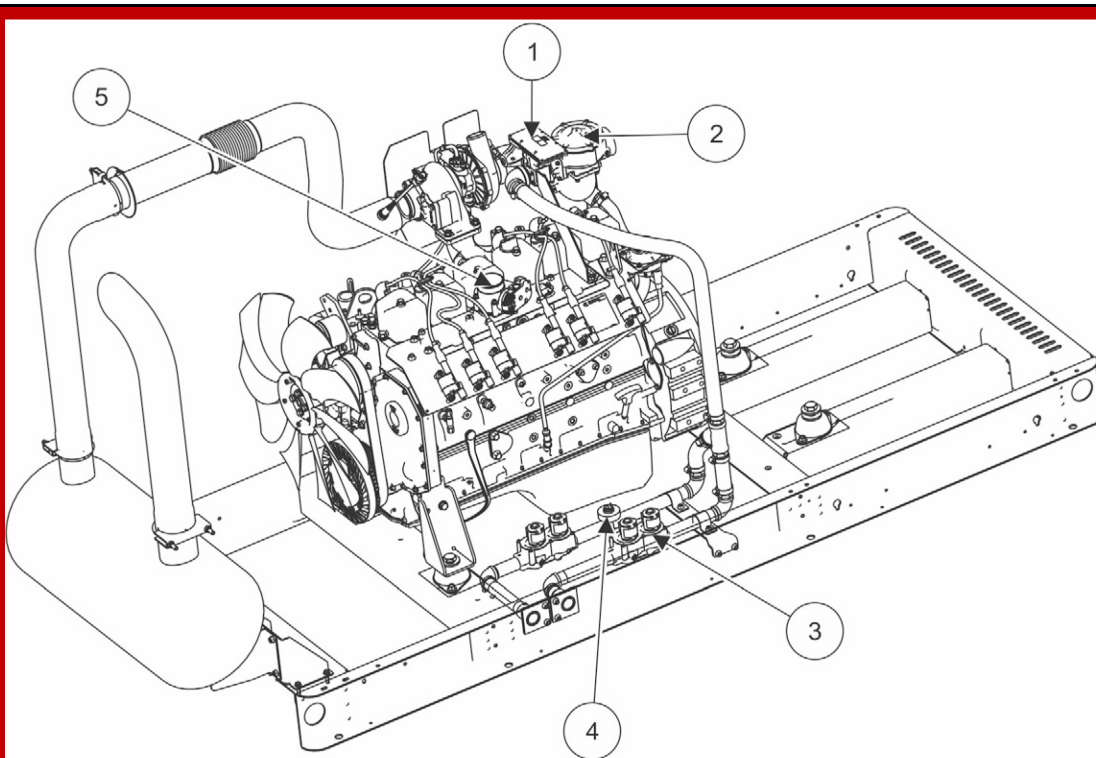
Gaseous fuels are flammable and explosive. They can cause severe personal injury or death. Do not allow cigarettes, flame, pilot lights, arcing switches, or electrical equipment near gaseous fuel ventilations. Keep an ABC-type multi-purpose fire extinguisher available.

⚠ CAUTION

Do not attempt to correct power by adjusting fuel system before determining that the engine and the ignition system are functioning properly. Be sure to check if there is air cleaner restriction due to dirt accumulation.

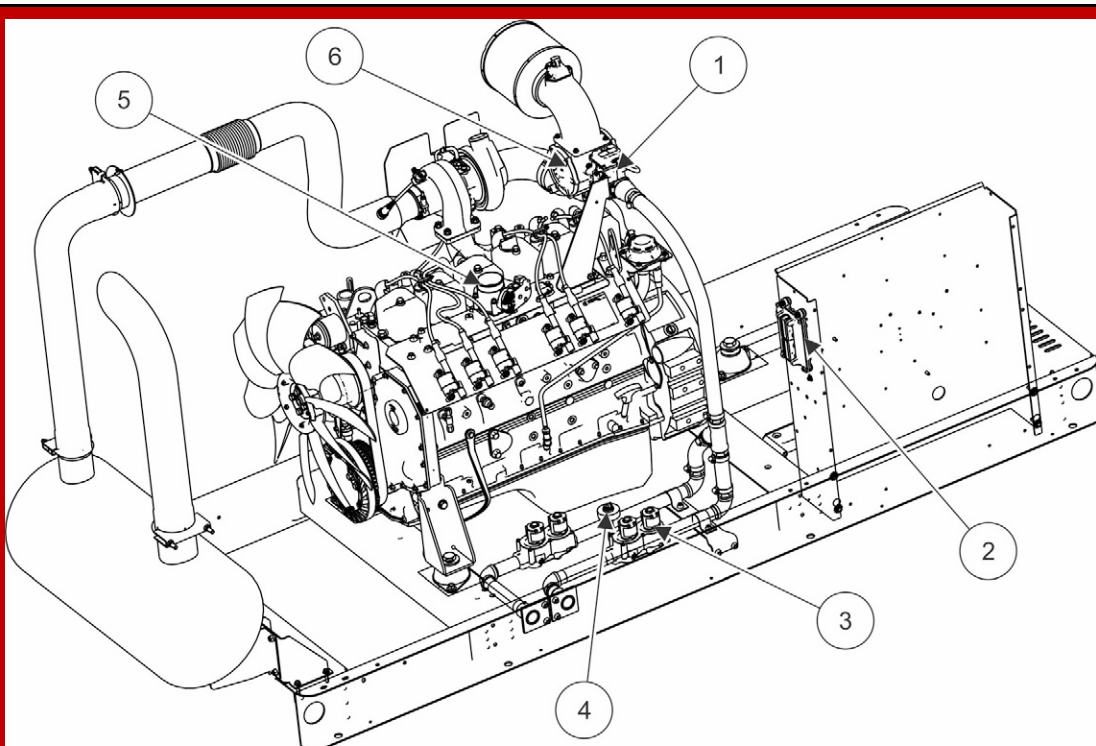
NOTICE

The dual fuel option is shown in each image, but there is also a single fuel option for both systems.



No.	Description	No.	Description
1	Integrated Electronic Pressure Regulator (IEPR)	4	Fuel Pressure Sensor (Option on Single Fuel)
2	Mixer	5	Throttle Body
3	Fuel Solenoid		

FIGURE 43. DUAL FUEL NATURAL GAS AND PROPANE VAPOR FUEL SYSTEM (MODELS C45, C50, C60)



No.	Description	No.	Description
1	Direct Acting Electronic Pressure Regulator (DEPR)	4	Fuel Pressure Sensor (Option on Single Fuel)
2	ECM	5	Throttle Body
3	Fuel Solenoid	6	Mixer

FIGURE 44. DUAL FUEL NATURAL GAS AND PROPANE VAPOR FUEL SYSTEM (MODELS C70, C80, C100)

9.4 Fuel Pressure Requirements

The minimum pressure refers to supply pressure under rated load (maximum gas flow).

Make sure that pipeline quality gas is used.

For the required fuel pressure supply range for propane vapor or natural gas, see the Model Specifications section.

9.5 Fuel System Components and Operation

This generator set is equipped for natural gas.

Converting the Fuel System Type

For single-fuel systems, the generator set leaves the factory configured for natural gas. No mechanical parts are required for fuel conversion. To convert the fuel system type, configure the control.

1. Enter the Fuel System Menu.
    a. From any Info Menu, hold down the up and down arrows simultaneously for two seconds. The Service Menu appears.
    b. Select **Setup Menus**.
    c. Enter the password **574** on the Password screen. The Setup Menu appears.
    d. Select **Genset Service**.
    e. Select **Genset**.
    f. Advance through the screens until the Fuel System Setup Menu appears.
2. Update the Fuel System Type on the Fuel System Setup Menu. See the figure below.
    a. Press **Adjust** on the Fuel System Menu.
    b. Edit the Fuel System using the horizontal arrow key. Change the field value by using the +/- keys.

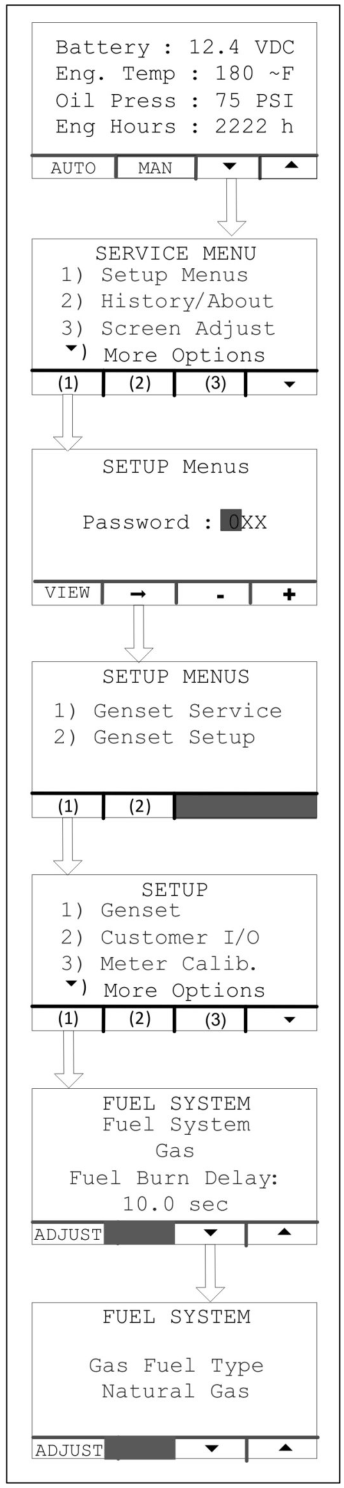


FIGURE 45. FUEL SYSTEM TYPE

3. Update the Gas Fuel Type on the Fuel System Menu.
   a. When changing the Fuel System, a second Fuel System Menu is enabled. Advance to this menu by pressing the down arrow after saving any changes.
   b. Press **Adjust** on the Fuel System Menu.
   c. Edit the Gas Fuel Type by using the horizontal arrow key. See the figure below.

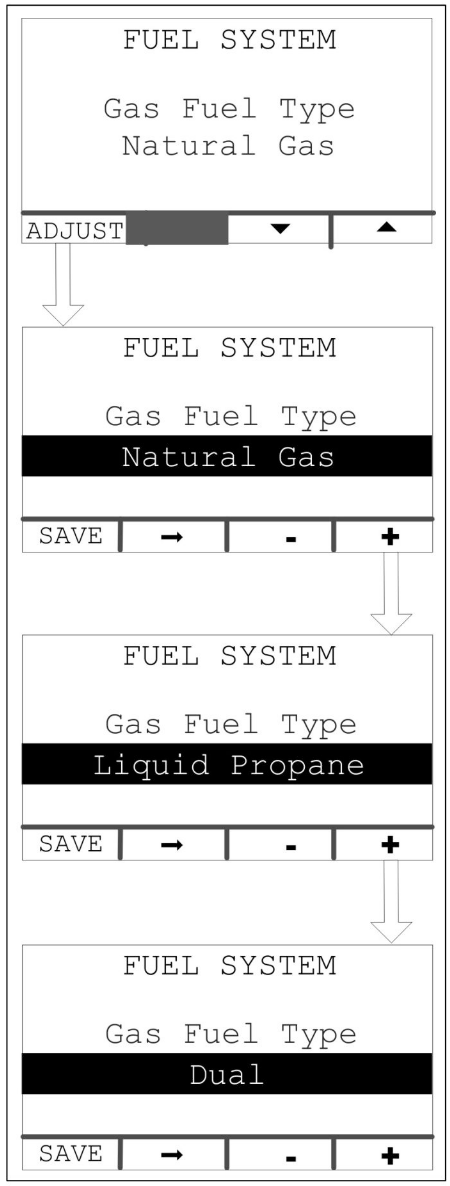


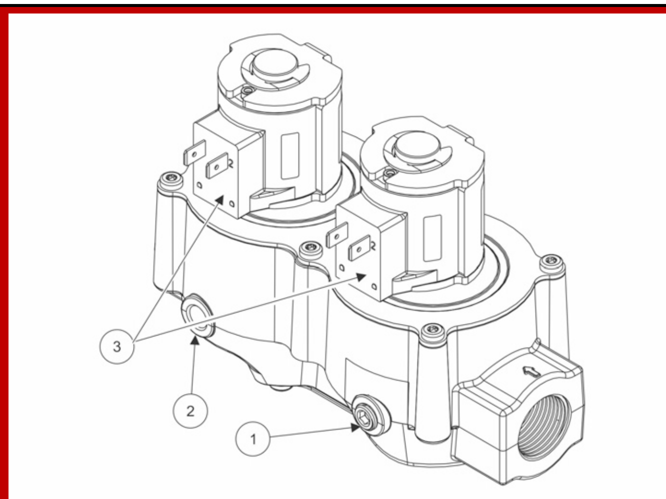
FIGURE 46. GAS FUEL TYPE

   d. Change the field value to Natural Gas, Liquid Propane, or Dual by using the +/- keys.
   e. Select **Save** to save the changes.

Fuel Shutoff Solenoid Valve

When the engine is cranking or running, an electronic signal is sent to the solenoid, which opens the valve permitting fuel to flow to the pressure regulator and mixer. When the engine is stopped, fuel is sealed off within the valve.

There are two pressure ports on each side of the solenoid. The inlet and outlet valve flange also include a pressure port. The two in-line pressure ports on the valve body side correspond to each flange pressure port. The corresponding side and flange ports will give the same pressure reading. The top valve body side pressure port measures the pressure between the two shut-off valves. This port is used to determine if the first valve is leaking.



No.	Description	No.	Description
1	Inlet Pressure Port	3	Power Plug
2	Outlet Pressure Port		

Note: Test port threads are G-1/8" and not 1/8" NPT. For test purposes only, a 1/8" ISO male to 1/8" NPT female adapter may be used.

FIGURE 47. FUEL SHUTOFF SOLENOID VALVE

Fuel Shutoff Solenoid Troubleshooting

If the generator set does not start, first determine if both valves are in good condition before adjusting the fuel system.

1. Disconnect the terminals between the wire harness going to the valve assembly and the engine harness.
2. Check for voltage at the solenoid coils. Use a multi-meter to measure 12 VDC between the B+ wire and ground of the engine harness.
    - If no voltage is measured, check for blown fuses or bad wiring while cranking.

- If voltage is less than or equal to 10.2 VDC, check for bad wiring or low battery voltage.
- If voltage is greater than 10.2 VDC, check for correct solenoid operation

3. Check for solenoid operation.
   a. While holding onto the solenoid, apply 12 VDC to a coil on one of the solenoids.
   b. Listen and feel for the solenoid to activate.
   c. Repeat applying the voltage a few times to be sure the solenoid operates.
   d. Repeat these steps for all solenoids.
   e. If either solenoid does not activate, use a multi-meter to measure resistance of the coil. The resistance should be 11 Ohms.
      - If the resistance is not 11 Ohms, replace the solenoid.
      - If the resistance is 11 Ohms, replace the gas valve assembly.
4. Check for fuel leaks at the solenoid. With a soapy water solution, check pipe threads and areas around the base of the solenoid for gas leakage.
   - If a pipe thread is showing bubbles, tighten the pipe connection.
   - If anywhere on the gas valve shows bubbles or leakage, replace the complete gas valve assembly.

Coil Assembly Replacement

To remove the coil assembly:

1. Loosen the knob lock screw and remove the knob.
2. Loosen the power plug lock screw and remove the power plug.
3. Pull straight up to remove the coil assembly from the solenoid body.

To reinstall the coil assembly:

1. Insert the coil assembly into the solenoid body.
2. Replace the power plug and tighten the power plug lock screw.
3. Replace the knob and tighten the knob lock screw.

Integrated Electronic Pressure Regulator (IEPR)/Direct Acting Pressure Regulator (DEPR)

The IEPR/DEPR used on US emission certified engines is a critical part of the certified emissions system and does not require any periodic adjustment.

The IEPR/DEPR is connected directly to the mixer on all certified engines. The IEPR/DEPR is the primary fuel control device, used to maintain both performance and emissions control. The IEPR/DEPR contains an internal computer, which communicates with the ECM via CAN datalink.

The IEPR/DEPR precisely controls the fuel flow to deliver the correct Air Fuel ratio to the engine. The IEPR/DEPR also contains fuel pressure and temperature sensors, which provide input to the ECM for fuel calculation.

If the IEPR/DEPR detects a fault within the system, it will send the information to the ECM. Depending on the type of fault, the ECM may command the IEPR/DEPR to change fueling, limit fuel delivery or in some cases shut down the engine.

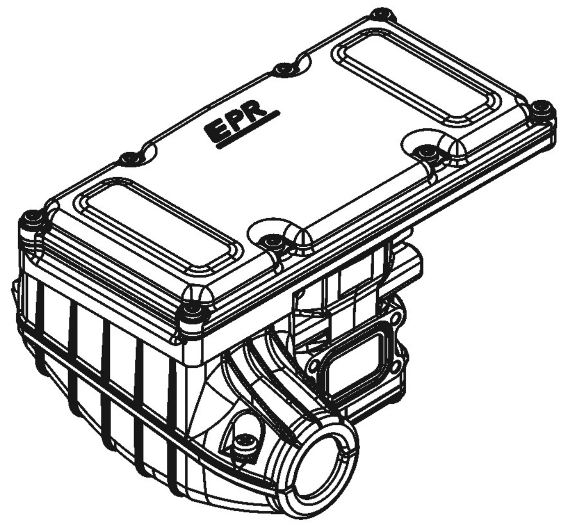


FIGURE 48. INTEGRATED ELECTRONIC PRESSURE REGULATOR (IEPR)/DIRECT ACTING PRESSURE REGULATOR (DEPR)

Mixer Assembly

The mixer acts as the secondary fuel metering device, and delivery device, in the emission control system. The mixer utilized on USA emission certified engines is a critical part of the certified emission system and does not require any periodic adjustment and does not have any external or internal adjustments.

The mixer is a completely self-controlled air-fuel metering device. It is an air valve design, utilizing a constant pressure drop to draw fuel into the mixer from cranking to full load. The mixer is mounted to the air-inlet ahead of the throttle control device.

When the engine begins to crank, it draws in air. With the air valve covering the inlet, negative pressure builds. This creates a vacuum which is referred to as an air valve vacuum (AVV). The amount of AVV is a direct result of the throttle position. At low engine speed the AVV is low and the air valve position is low, thus creating a small venturi. The IEPR/DEPR maintains the precise fuel control to the mixer, despite the air valve position.

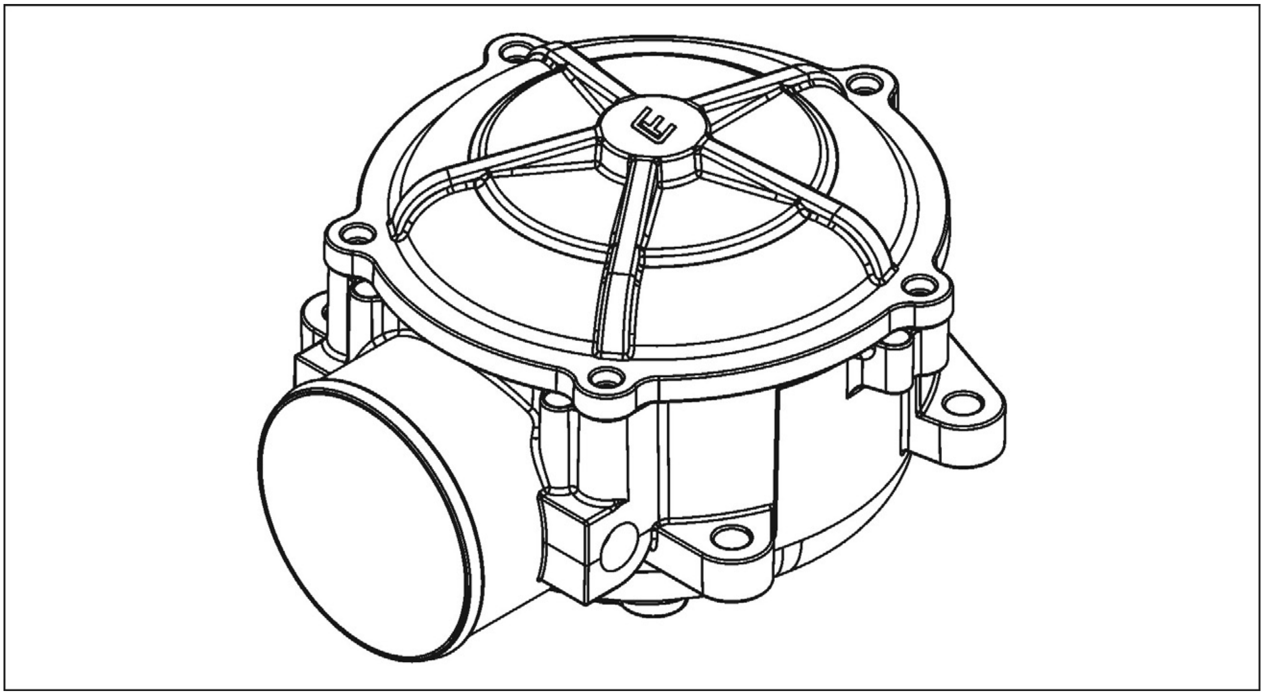


FIGURE 49. MIXER ASSEMBLY

Electronic Throttle Body (ETB)

The Electronic Throttle Body (ETB) is connected to the intake manifold of the engine. The ETB control device uses an electronic motor connected to the throttle shaft. When the engine is running, the ECM sends an electrical signal to the ETB motor, to increase or decrease the angle of the throttle blade, thus increasing or decreasing the air fuel mixture flow to the engine.

The fuel system uses an electronic signal, Drive By Wire (DBW), to control engine speed. The ECM determines speed and load control. Defaults programmed into the ECM software and the throttle position sensors allow the ECM to maintain safe operating control over the engine.

The ETB also incorporates two internal Throttle Position Sensors (TPS) which provide output signals to the ECM. The ECM uses TPS information to correct speed and load control, as well as emission control and engine protection.

The ETB used on US emission certified engines does not require any periodic adjustment.

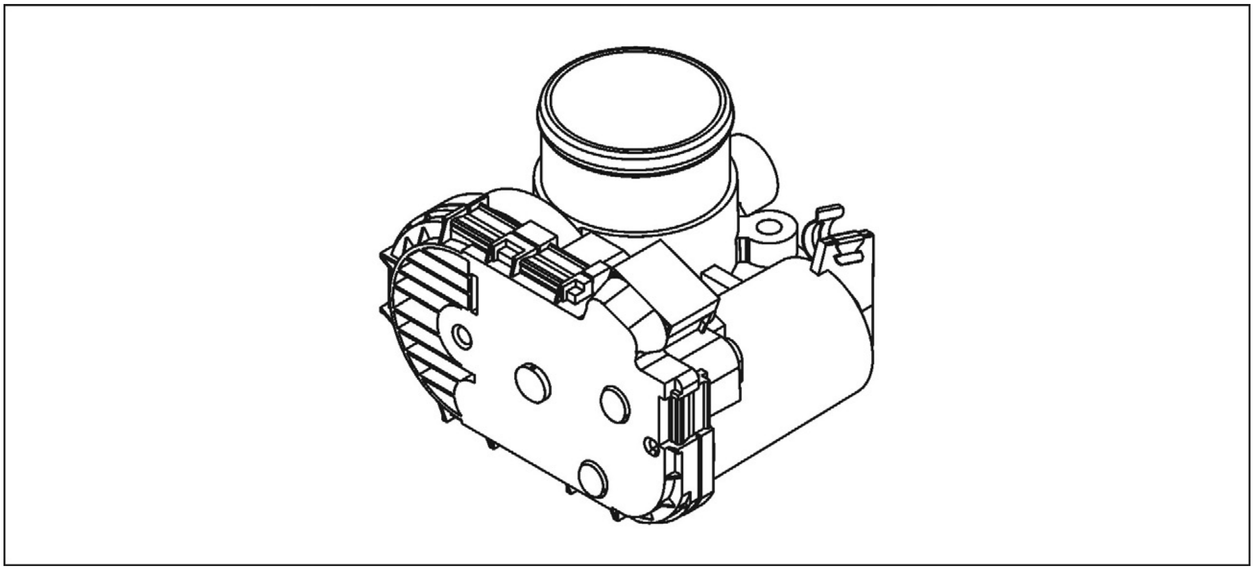


FIGURE 50. ELECTRONIC THROTTLE BODY (ETB)

10 Exhaust System

10.1 Overview

NOTICE
Read the warranty statement provided with the generator set for US Environmental Protection Agency (EPA) restrictions on servicing specific components.

The exhaust system is comprised of up to three active components - the turbocharger (if equipped), the oxygen sensor, and the muffler/catalytic converter (if equipped) - in addition to manifold(s) and piping connecting the components.

10.2 Oxygen Sensor

During normal operation, the oxygen sensor monitors the oxygen content of the exhaust gases and sends a voltage signal to the ECM. The ECM monitors this voltage. The oxygen sensor has a heating element incorporated into the sensor to aid in the warm-up to the proper operating temperature and to maintain that temperature.

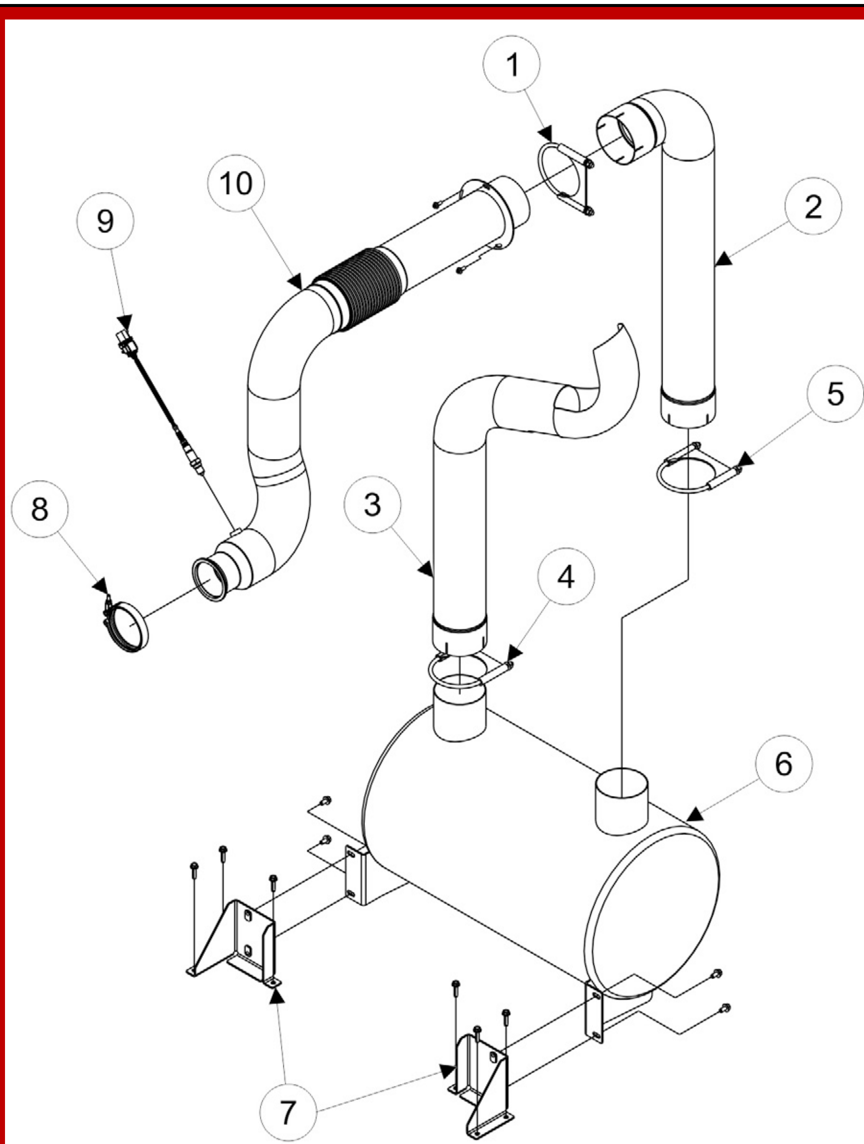
The oxygen sensor produces no voltage when it is below its normal operating temperature of about 600 °F (315.5 °C). During this warm-up period, the ECM operates in an open-loop fuel control mode. It does not use the oxygen sensor signal. Instead, the ECM controls fuel metering based on other inputs and its own program. Refer to the Sensors section for more information.

Proper operation of the oxygen sensor depends on three conditions:

- *Good electrical connections:* The low voltages generated by the sensor require good, clean connections which should be checked whenever a sensor problem is suspected or indicated.
- *Outside air supply:* The sensor needs proper exhaust circulation to the internal portion of the sensor and proper air circulation to the external portion of the sensor. Whenever the sensor is installed, make sure the air passages are not restricted.
- *Proper operating temperature:* The ECM will not react to the sensor signal until the sensor reaches approximately 600 °F (315.5 °C). This factor must be considered when evaluation the performance of the sensor.

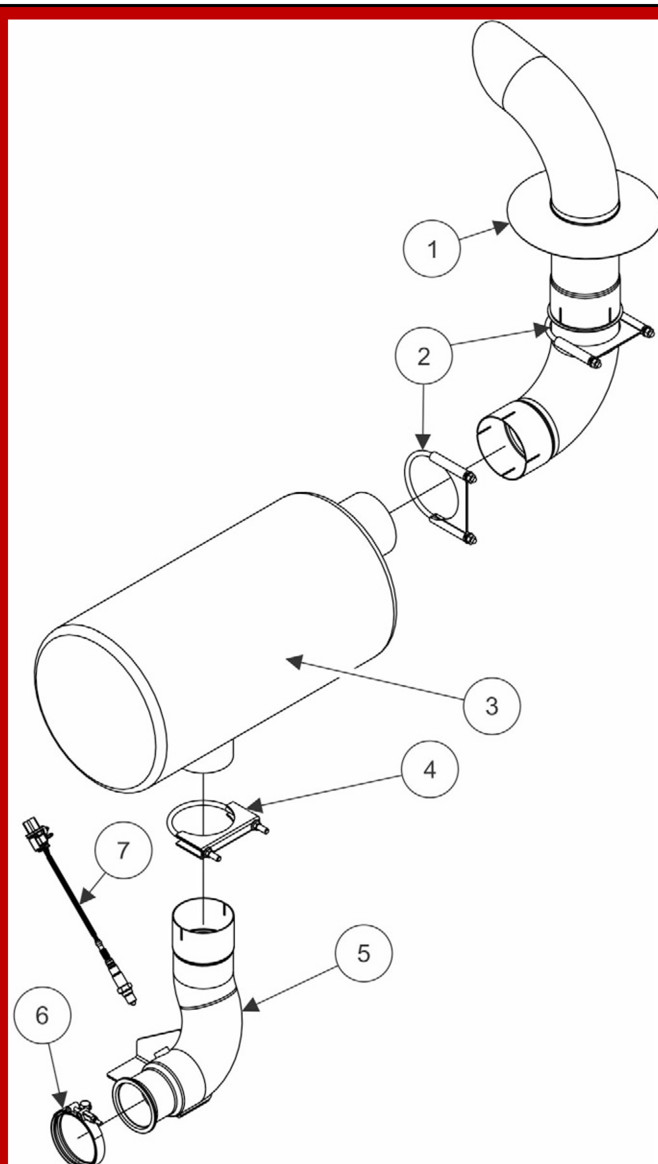
Your authorized Cummins Inc. distributor can monitor fuel system/oxygen sensor operation using the GCP Display service tool and the ECM.

10.3 Exhaust System Graphic



No.	Description	No.	Description
1	Exhaust Stack	6	Muffler
2	Exhaust Clamp	7	Muffler Bracket
3	Exhaust Pipe	8	Vee Band Clamp
4	Clamp	9	Oxygen Sensor
5	Exhaust Clamp	10	Exhaust Pipe

FIGURE 51. EXHAUST SYSTEM FOR SOUND ENCLOSURE



No.	Description	No.	Description
1	Muffler	5	Oxygen Sensor
2	Exhaust Clamp	6	Clamp
3	Exhaust Pipe	7	Exhaust Stack
4	Vee Band Clamp		

FIGURE 52. EXHAUST SYSTEM FOR WEATHER ENCLOSURE

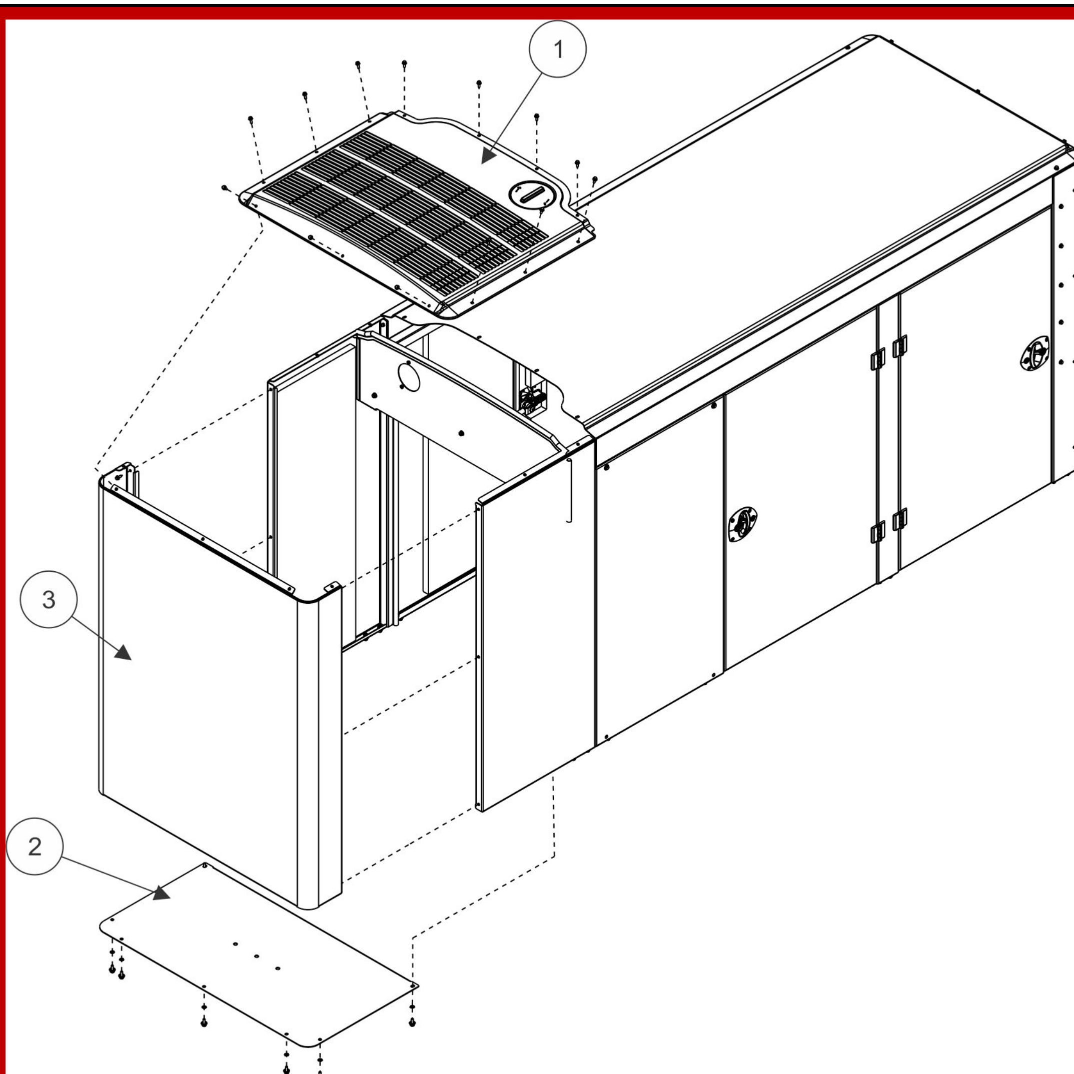
10.4 Muffler Removal and Installation

⚠ WARNING
Hot Exhaust Components

Exhaust pipes and mufflers are very hot and can cause severe personal injury or death from direct contact or from fire hazard.

Allow the muffler to cool down before removing.

1. Remove the muffler:
    a. Remove the exhaust pipe coming from the bulkhead to the muffler.
    b. Remove the muffler.



No.	Description	No.	Description
1	Enclosure Roof	3	Outlet Cover
2	Enclosure Panel (Bottom)		

FIGURE 53. ENCLOSURE REMOVAL

2. Install the muffler:

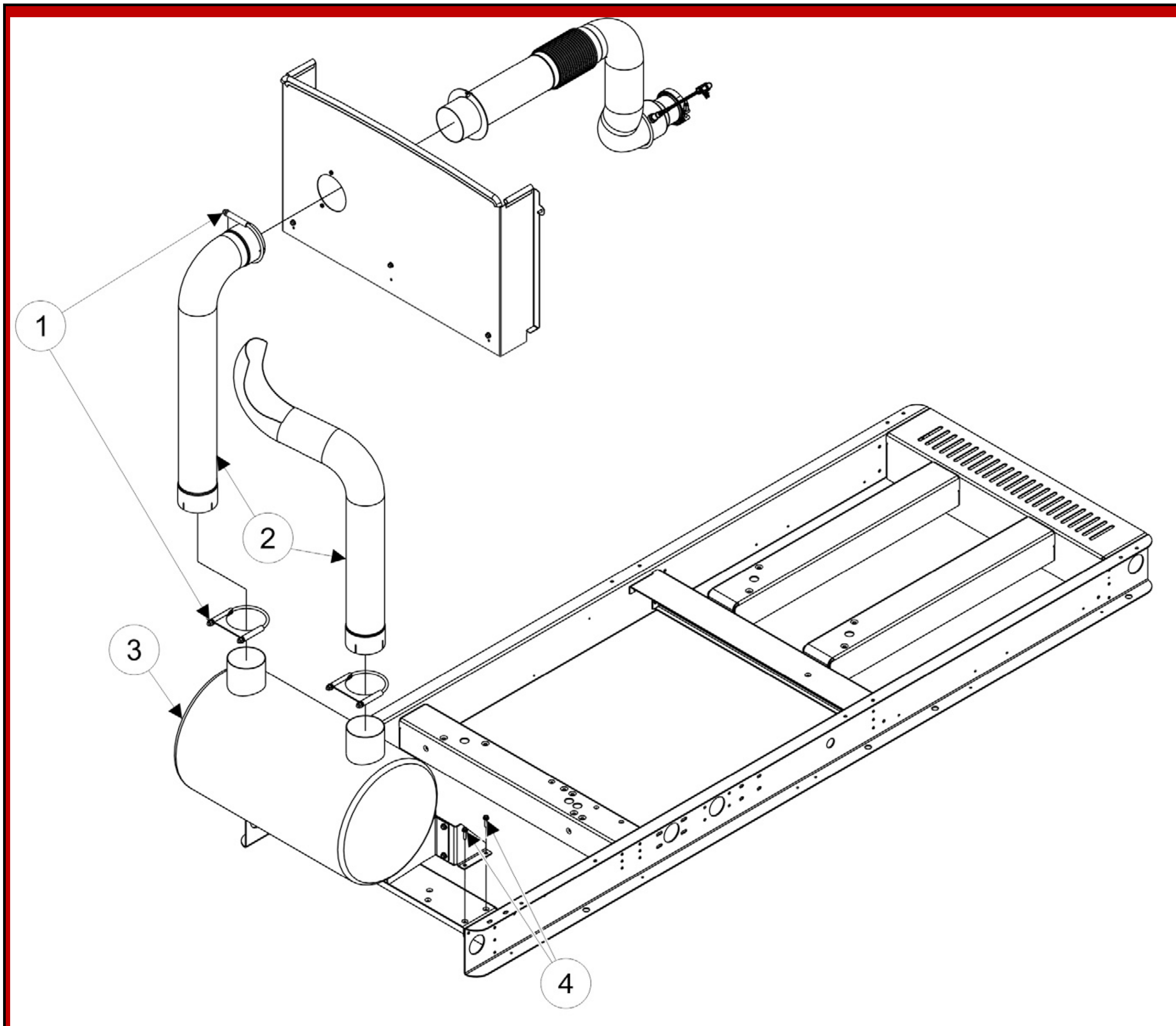
   a. *Sound enclosure only:*

      i. Place the two mounting brackets on the skid and attach them with 3 bolts each. Torque values: 24 - 29 Nm (17.7 - 21.4 ft-lb)

      ii. Attach the exhaust pipe coming from the engine so that the muffler bolt holes line up with the mounting bracket bolt holes.

      iii. Attach the muffler to the mounting brackets with 2 bolts in each bracket. Torque values: 24 - 29 Nm (17.7 - 21.4 ft-lb).

b. Attach the muffler exhaust pipe. Tighten the clamp. Torque values: 41 - 49 Nm (30 - 36 ft-lb).

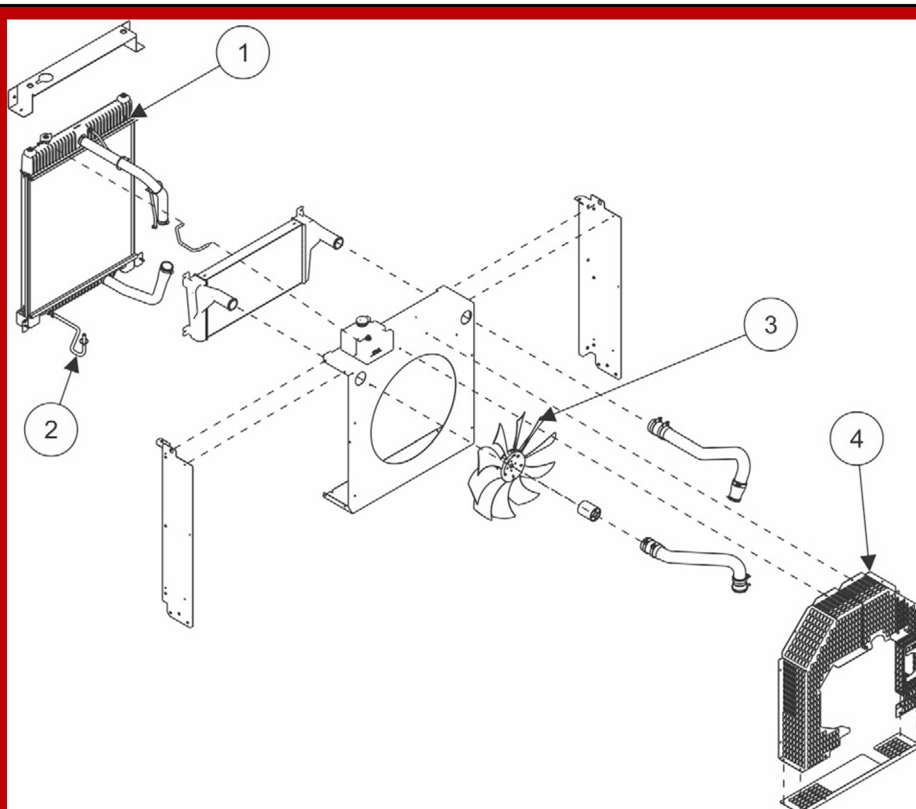


No.	Description	No.	Description
1	Clamps (2)	3	Muffler (Silencer)
2	Exhaust Pipes (2)	4	Bolts

FIGURE 54. MUFFLER INSTALLATION

11 Cooling System

11.1 Cooling System Components



No.	Description	No.	Description
1	Radiator Guard	4	Fan
2	Radiator	5	Fan Guard
3	Coolant Drain		

FIGURE 55. COOLING SYSTEM FOR GENERATOR SET WITH QSJ5.9G ENGINE

11.2 Cooling System Maintenance

This section provides information on cleaning the radiator and updated information regarding bearings that has been provided by our supplier to enable efficient and prolonged life of the equipment.

NOTICE
The following information regarding the correct choice and fitting of hose clamps has also been provided by our supplier to assist and guide the user.

Cooling Fan Drive Belt Maintenance

⚠ CAUTION

The belt tensioner is spring-loaded and must be pivoted away from the drive belt. Pivoting in the wrong direction can result in damage to the belt tensioner.

1. Lift the tensioner to remove the drive belt.

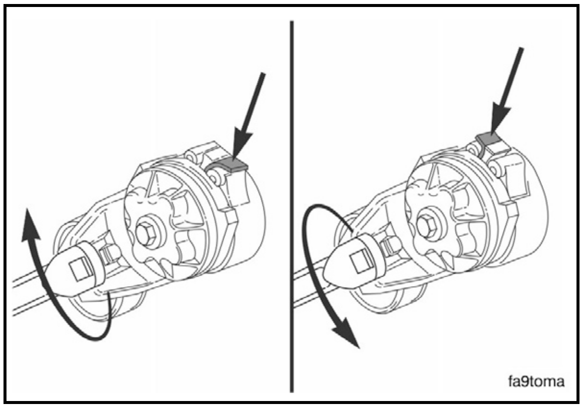


FIGURE 56. LIFT THE TENSIONER TO REMOVE THE BELT

2. The belt tensioner winds in the direction that the spring tang is bent over the tensioner body. Loosen the tension on the belt by rotating the tensioner to wind the spring tighter.

⚠ CAUTION

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

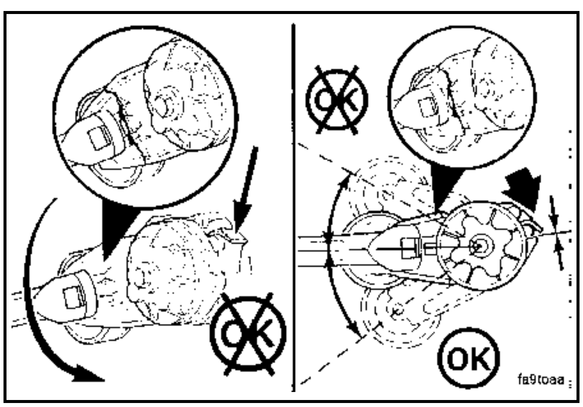


FIGURE 57. DO NOT USE EXCESSIVE FORCE

3. Inspect the drive belt for:
   - Cracks
   - Glazing
   - Tears or cuts
   - Hardening
   - Excessive wear

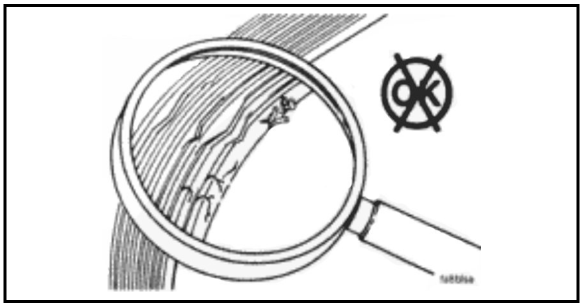


FIGURE 58. INSPECT THE DRIVE BELT

4. Lift the tensioner to install the drive belt.

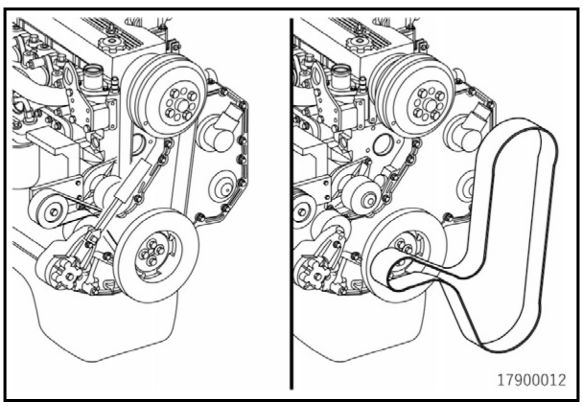


FIGURE 59. LIFT THE TENSIONER

Cleaning

Cleaning Radiator Cores Using Pressurized Water Equipment

NOTICE
In specific dust-laden environments, this procedure should not be used as the initial cleaning operation. Instead, follow the procedure in the *Dust Laden Environments* section.

On enclosed generator sets with removable end panel(s), remove the end panel(s) to assist in the cleaning of the radiator. Refer to the Remove Enclosure End Panel sub-section in the Exhaust System section.

Inspect the exterior of the radiator for obstructions. During the service life of a radiator, a buildup of foreign matter can obstruct the flow of air through the radiator cores, reducing the cooling capability. To ensure the continued efficiency of the radiator, the core will require cleaning.

For thorough cleaning, pressure wash in the opposite direction to the airflow.

⚠ CAUTION
Do not use cleaners that contain ammonia to clean the radiator or charge air cooler. Ammonia will damage the core.

The recommended equipment for cleaning a radiator core is an industrial pressure washer, but it must be used in the correct manner because misuse can reduce the performance of the core. Protect the generator set from any over spray during this procedure.

To be effective, it is recommended that a hot water washer be used.

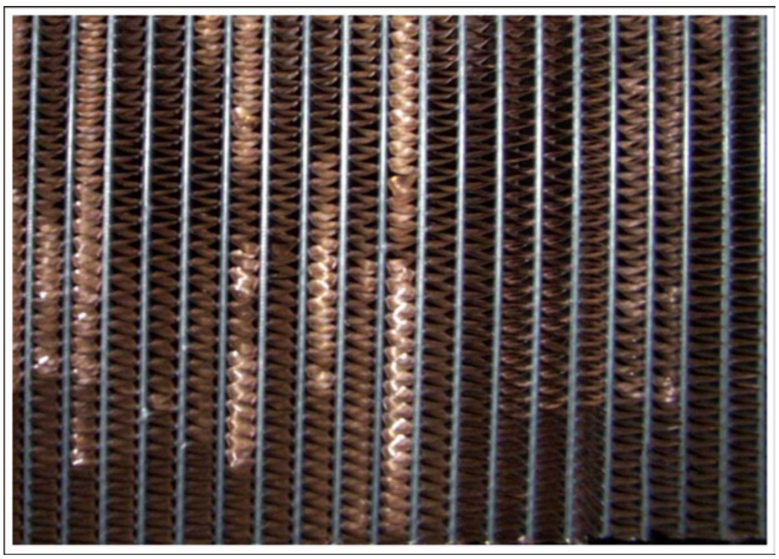


FIGURE 60. FINS DAMAGED BY PRESSURE WASHING AT ACUTE ANGLES TO CORE FACE

⚠ WARNING
Wear PPE when cleaning the radiator core with a pressure washer or compressed air. Verify appropriate PPE is worn for the cleaning materials being used. Respiratory protection must be worn when cleaning the radiator with compressed air.

⚠ CAUTION
Follow all codes and standards regarding collection and disposal of cleaning materials used to clean the radiator.

⚠ CAUTION

With the pressures involved, it is important that the distance between the core face and the nozzle is a minimum of 18 inches (450 mm); otherwise, damage may occur.

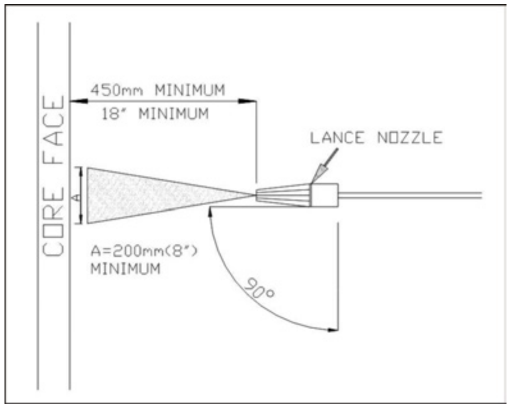


FIGURE 61. PRESSURE WASHER NOZZLE POSITIONING

⚠ CAUTION

Most industrial pressure washers work at pressures of around 1500 psi to 3000 psi (103 bar to 206 bar). It is very important that, when washing a core in this way, the lance is kept at a right angle to the core.

⚠ CAUTION

If your pressure washer works above 3000 psi, make sure the gap between the nozzle and the core face is increased; otherwise, fin damage will occur.

NOTICE

Always follow the pressure washer manufacturer's Health and Safety Guidelines.

Replace the end panel(s) where necessary. Refer to the Install Enclosure End Panel sub-section in the Exhaust System section.

Dust Laden Environments

Specific Instructions for the Cleaning of Radiator Cores Used in an Environment Subjected to Crushed Aggregate or Ceramic Dust Contamination

On enclosed generator sets with removable end panel(s), remove the end panel(s) to assist in the cleaning of the radiator.

Inspect the exterior of the radiator for obstructions. During the service life of a radiator, a buildup of foreign matter can obstruct the flow of air through the radiator cores, reducing cooling capability. To maintain the efficiency of the radiator, the core will require cleaning.

Unless the radiator can be dismantled and the core treated in a professional caustic immersion cleaning system, the radiator should not be “wet” cleaned. This is because of the tendency of this type of contamination to coalesce and become extremely difficult to remove.

The correct procedure is to regularly blow through the entire core area with low pressure compressed air (against the direction of cooling airflow). It is very important to ensure that resultant debris blown from the core is subsequently removed and disposed of before engine start-up. An industrial vacuum cleaner will achieve this requirement. In most installations, it will be necessary to remove cowls and guarding.

To prevent damage to fins and resultant loss of cooling, it is important to ensure that the air gun used is maintained at right angles to the core face.

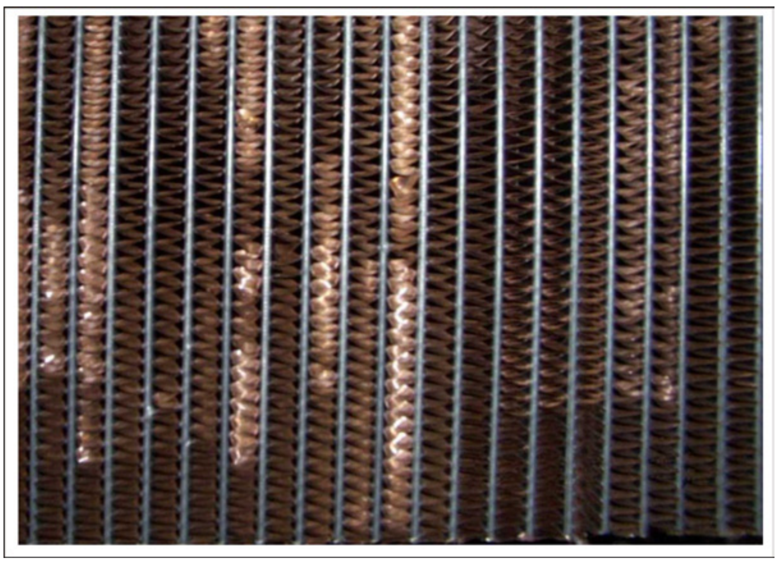


FIGURE 62. FINS DAMAGED BY COMPRESSED AIR AT ACUTE ANGLES TO CORE FACE

After this procedure has been effectively carried out with only the lightest of dust remaining, follow it immediately (if necessary) by cleaning the radiator cores using pressurized water equipment.

Replace the end panel(s) where necessary.

NOTICE
It is vitally important that the core is thoroughly dried before start-up.

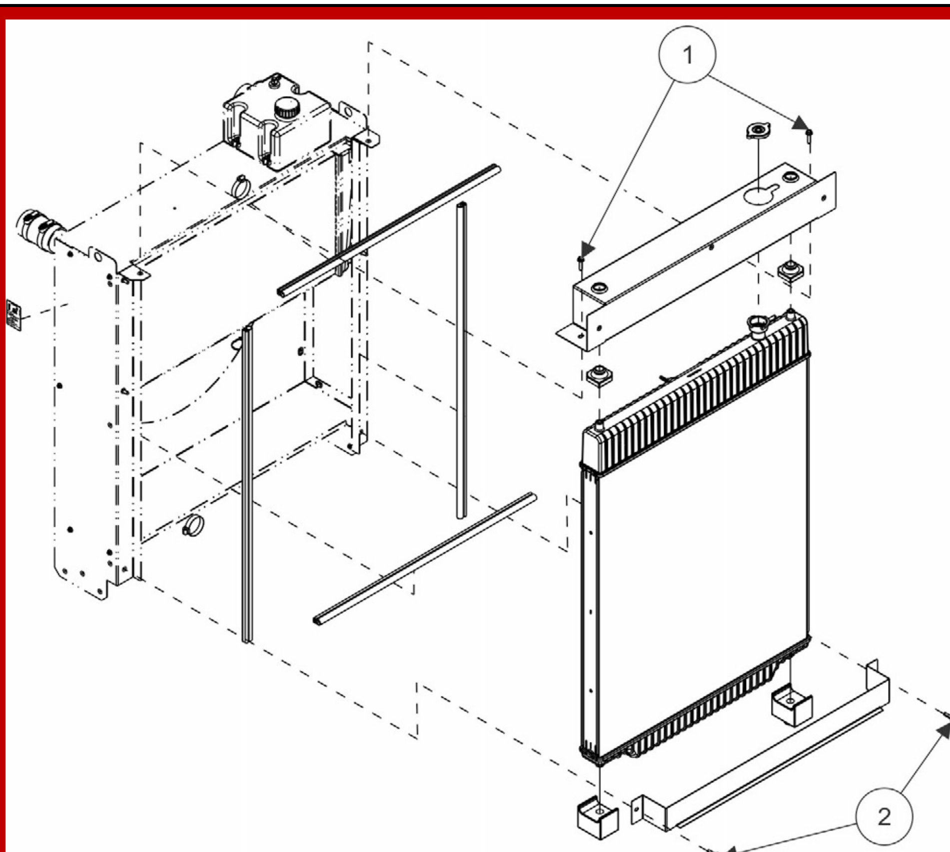
11.3 Radiator Assembly Removal and Installation

RADIATOR REMOVAL

1. Drain the coolant.
2. Remove the enclosure doors, roof panel above radiator, and exhaust end cap.

NOTICE
If you are removing the radiator as part of the Engine Removal and Installation section, also remove the second roof panel.

3. Remove the muffler and fan guards.
4. If required, remove the muffler braces from the skids before removing the alternator.
5. Remove the radiator.
   a. Remove the top two bolts as shown below.



No.	Description	No.	Description
1	Top Bolts	2	Bottom Bolts

FIGURE 63. REMOVE THE TOP TWO BOLTS

b. Remove the 2 horizontal bottom bolts as shown above.

c. Carefully pull the radiator away from the engine to prevent damage to the bottom seal.

RADIATOR INSTALLATION

1. Re-install the radiator.
   a. Carefully move the radiator back towards the engine to prevent damage to the bottom seal.
   b. Re-install the 2 horizontal bottom bolts as shown above.
   c. Re-install the 2 top bolts as shown above.
2. If required, re-install the muffler braces from the skids.
3. Re-install the muffler and fan guards.
4. Re-install the enclosure doors, roof panel above radiator, and exhaust endcap.
5. Re-fill the coolant.

11.4 Water Pump Removal and Installation

⚠ WARNING

Coolant is toxic. If not reused, dispose of in accordance with local environmental regulations.

1. Drain the coolant.
2. Remove the drive belt. Refer to the Cooling Fan Drive Belt section.

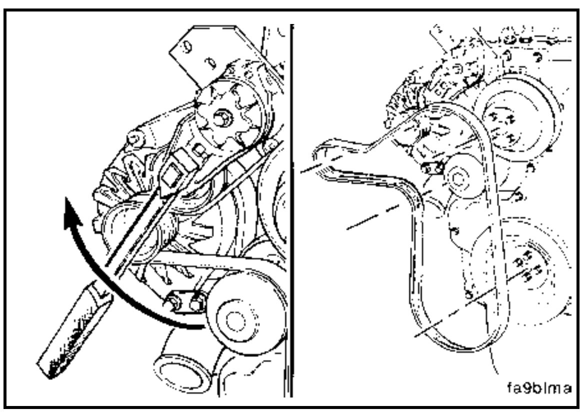


FIGURE 64. REMOVE THE DRIVE BELT

3. Remove the two 13 mm capscrews and water pump.

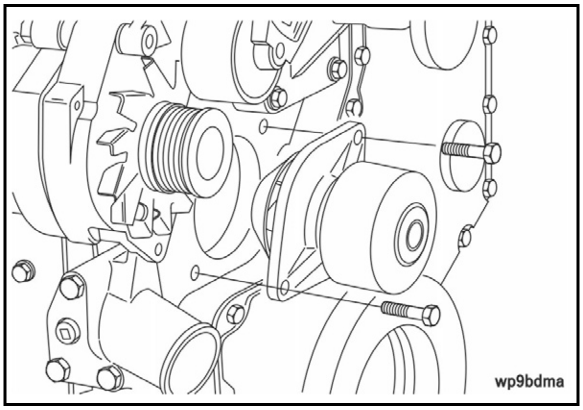


FIGURE 65. REMOVE THE CAPSCREWS AND WATER PUMP

4. Clean the sealing surface on the cylinder block.

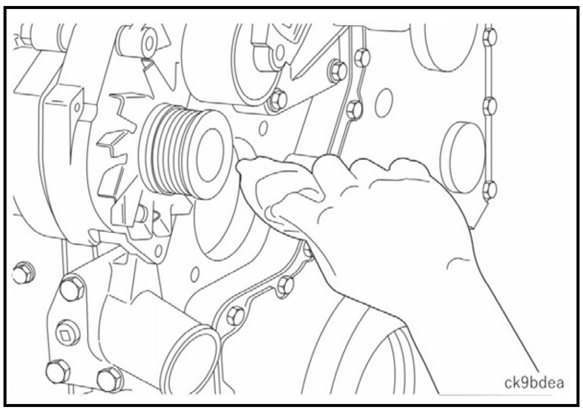


FIGURE 66. CLEAN THE CYLINDER BLOCK SEALING SURFACE

5. Clean the o-ring sealing surface on the water pump housing.

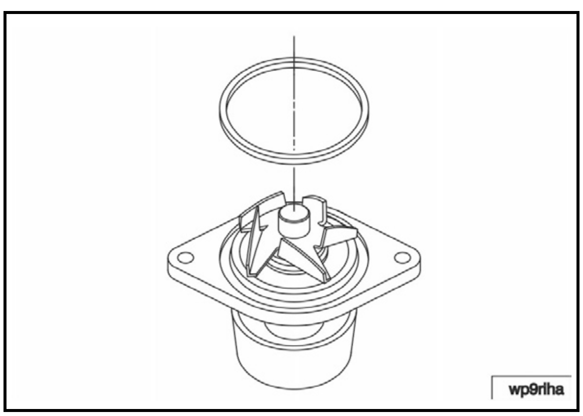


FIGURE 67. CLEAN THE O-RING SEALING SURFACE

6. Install the o-ring onto the water pump housing.
7. Install the new sealing ring into the pump groove. See **Figure 67**.

8. Install the water pump. See **Figure 65**. Torque value: 18 ft-lb (24 Nm), 13 mm.
9. Using a 3/8-in square drive, lift the tensioner and install the belt. Refer to the Cooling Fan Drive Belt section.

NOTICE
If it is difficult to install the drive belt (for example, the belt seems too short), position the belt over the grooved pulleys first. Then, while holding the tensioner up, slide the belt over the water pump pulley.

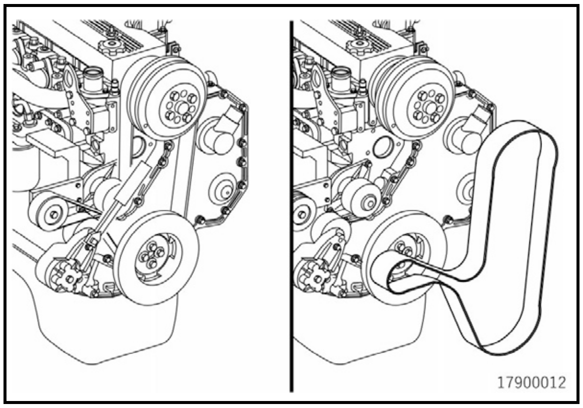


FIGURE 68. INSTALL THE BELT

10. Fill the cooling system.

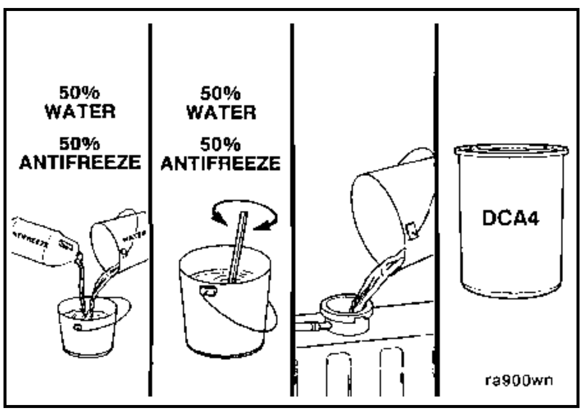


FIGURE 69. FILL THE COOLING SYSTEM

11. Install the pressure cap.
12. Operate the engine and check for coolant leaks. Engine temperature: 180 °F (80 °C).

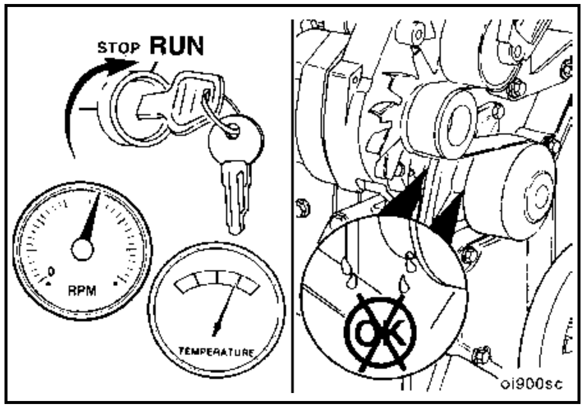


FIGURE 70. CHECK FOR COOLANT LEAKS

11.5 Thermostat Removal and Installation

1. Removal:
   a. Disconnect the negative battery cable.
   b. Remove the accessory drive belt.
   c. Drain the coolant.
   d. Disconnect the upper radiator hose.
   e. Remove the alternator mounting capscrew, loosen the alternator link capscrew and lower the alternator.
   f. Remove three capscrews, the thermostat housing, lifting bracket, thermostat, and thermostat seal.
   g. Clean the mating surfaces.
2. Installation:
   a. Make sure to position the rubber seal the same way it was removed.
   b. Install the thermostat, thermostat seal, thermostat housing, gasket, lifting bracket, and three capscrews. Torque to 17.7 ft-lb (24 Nm).
   c. Install the alternator.
      - Torque the mounting capscrew (upper) to 17.7 ft-lb (24 Nm).
      - Torque the alternator link capscrew (lower) to 32 ft-lb (43 Nm).
   d. Install the accessory drive belt.

11.6 Fan Spacer and Pulley Maintenance

⚠ WARNING

When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

⚠ WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

1. Remove the cooling fan drive belt. Refer to the Cooling Fan Drive Belt section.
2. Remove the four fan capscrews, fan, and spacer.
3. Remove the fan pulley.

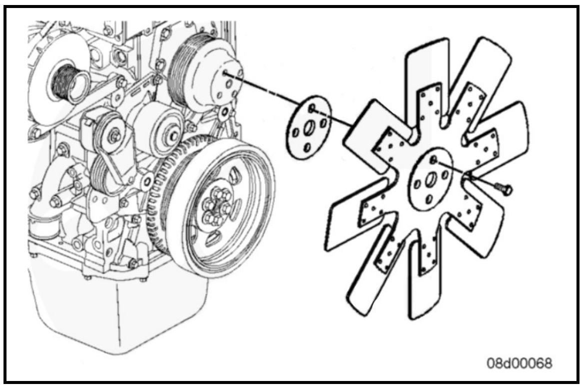


FIGURE 71. EXAMPLE OF FAN PULLEY REMOVAL

4. Clean the fan pulley with solvent and dry with compressed air.

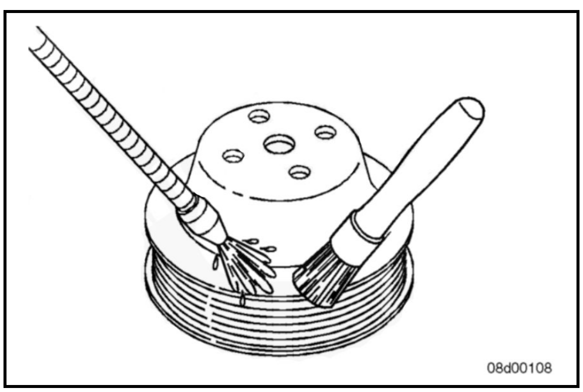


FIGURE 72. CLEAN THE FAN PULLEY

5. Inspect the fan pulley for cracks near the bolt holes and for damage at the drive belt contact surface.
    - If damage is found on the fan pulley, the fan hub must also be inspected.

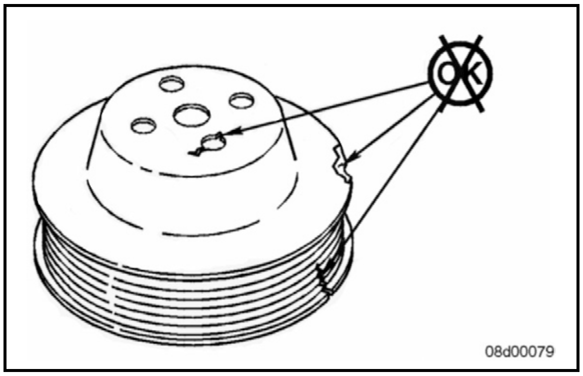


FIGURE 73. INSPECT THE FAN PULLEY

6. Install the fan pulley.
7. Install the spacer, fan, and fan capscrews. Torque value: 34.7 - 42.0 ft-lb (47 - 57 Nm).
8. Install the drive belt. Refer to the Cooling Fan Drive Belt section.
9. Operate the engine and check for proper operation.

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12 Engine and Accessories

12.1 Cylinder Block Assembly

Front Crankshaft Seal Maintenance

The front crankshaft seal is mounted in the front gear cover. A double-lipped Teflon® seal is used. The sealing surface on the crankshaft must be clean and free of lubricating oil during assembly.

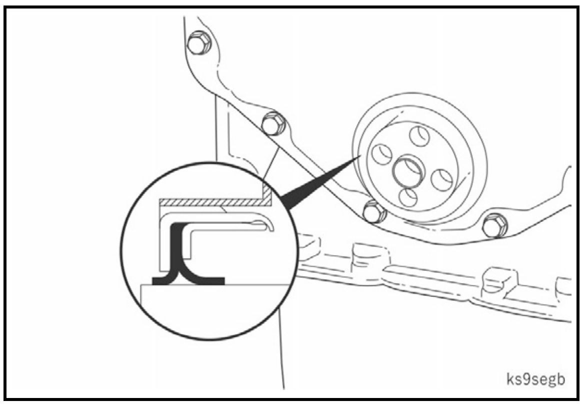


FIGURE 74. FRONT CRANKSHAFT SEAL

1. To make the drive belt removal easier, loosen the vibration damper.
2. Remove the drive belt. Refer to the Cooling Fan Drive Belt Maintenance section.

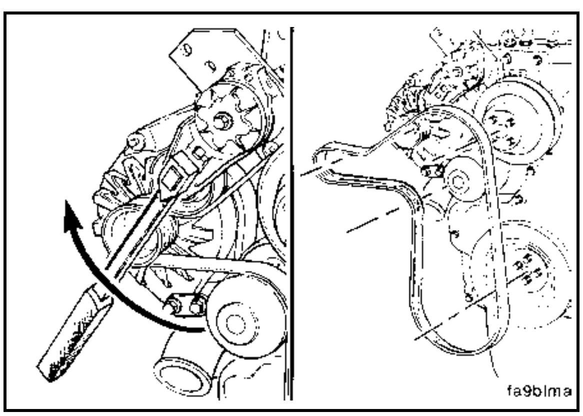


FIGURE 75. REMOVE THE DRIVE BELT

3. Remove the vibration damper and crankshaft sensor tone wheel. Refer to the Rubber Vibration Damper Maintenance section.

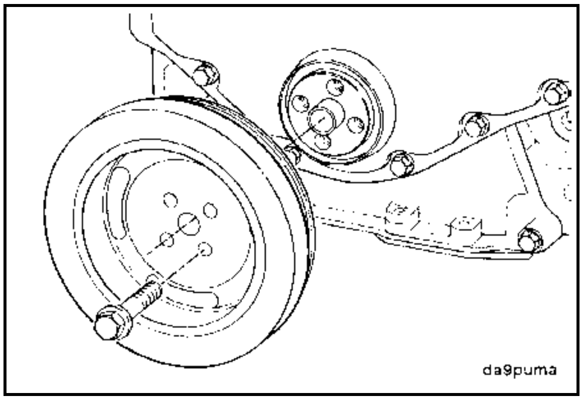


FIGURE 76. REMOVE THE VIBRATION DAMPER

4. Remove the front gear cover. Refer to the Front Gear Cover Removal and Installation section.

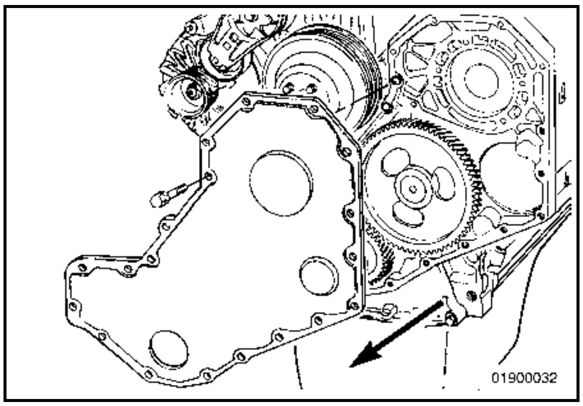


FIGURE 77. REMOVE THE FRONT GEAR COVER

5. While supporting the gear cover, remove the oil seal from the gear cover.

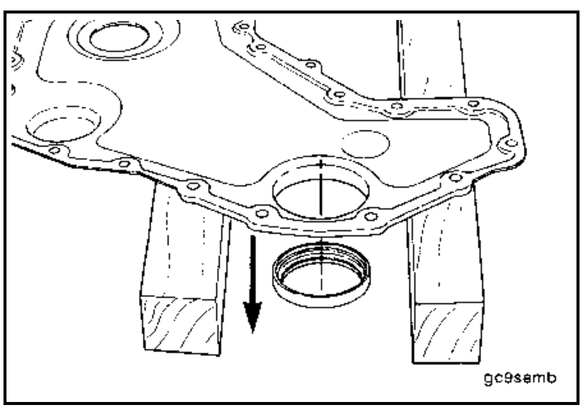


FIGURE 78. REMOVE THE OIL SEAL

6. Drive the oil seal from the backside of the cover toward the front side of the cover.

7. Clean the gear cover seal bore and the crankshaft surface of all oil, dirt, and seal residue.

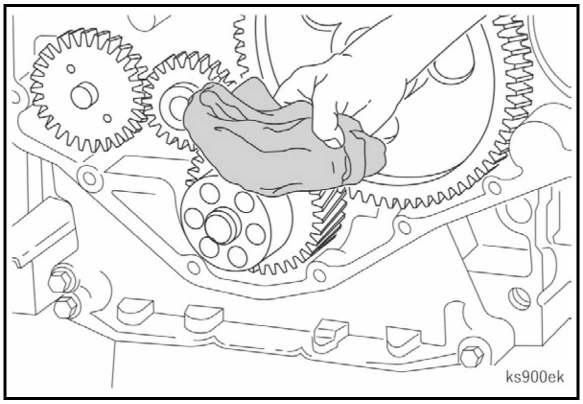


FIGURE 79. CLEAN THE BORE AND THE CRANKSHAFT SURFACE

8. Inspect the crankshaft for excessive wear.

NOTICE
If the crankshaft has excessive wear, a service wear sleeve is available.

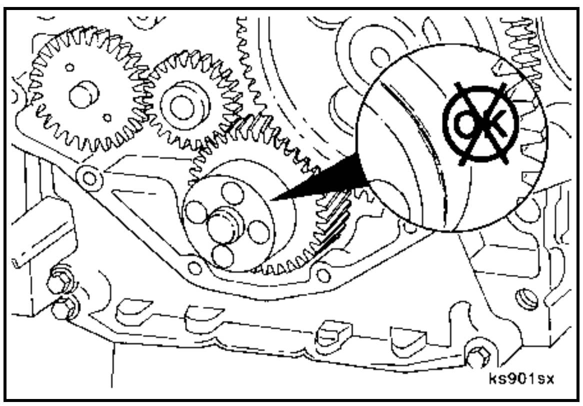


FIGURE 80. INSPECT THE CRANKSHAFT

9. Leave the plastic pilot installation tool in the lubricating oil seal.
10. Position the seal on the Oil Seal Installation Tool (Part Number 3824498) with the lubricating oil seal dust lip facing outward.

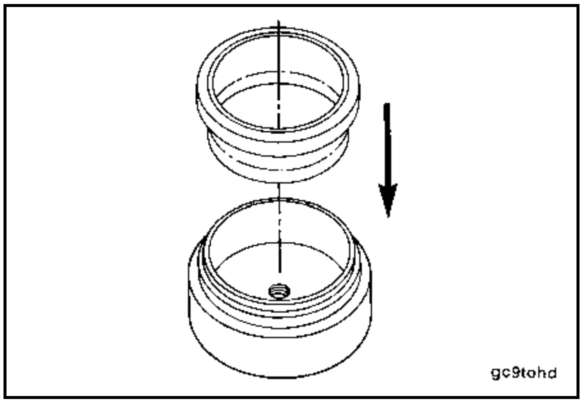


FIGURE 81. POSITION THE SEAL

11. Apply a bead of Loctite™ 277, or equivalent, to the outside diameter of the seal before installation.

NOTICE
Properly support the front cover lubricating oil seal flange to prevent damage to the lubricating oil seal and front cover.

12. Press the lubricating oil seal into the front cover from the backside of the cover toward the front side of the cover.

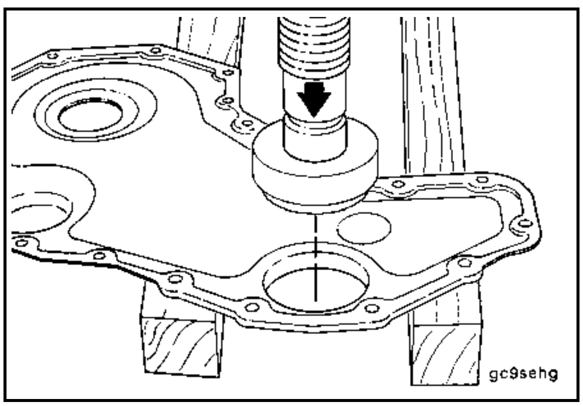


FIGURE 82. PRESS THE SEAL INTO THE FRONT COVER

13. Press the lubricating oil seal until the service tool bottoms against the front cover.
14. Apply a thin bead of Three-Bond™ to the cover side of the front cover gasket only.

NOTICE
Do not remove the plastic seal pilot tool from the lubricating oil seal at this time. Use the plastic seal pilot tool to guide the seal on the crankshaft.

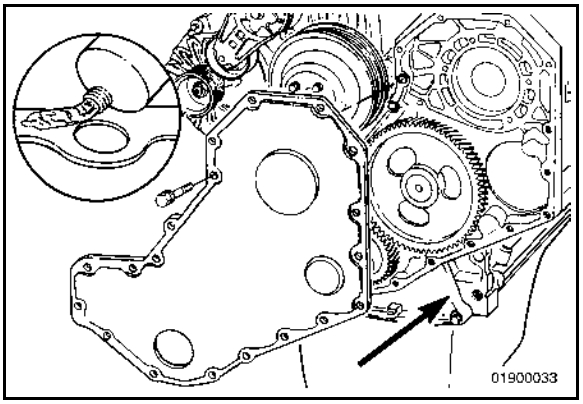


FIGURE 83. APPLY A BEAD TO THE COVER SIDE OF THE FRONT GASKET

15. Install the gasket and front gear cover on the engine. Refer to the Front Gear Cover Removal and Installation section.

NOTICE
The front gear cover capscrews must be tightened within 15 minutes of applying the sealant on the gasket.

16. Tighten the front gear cover mounting capscrews.

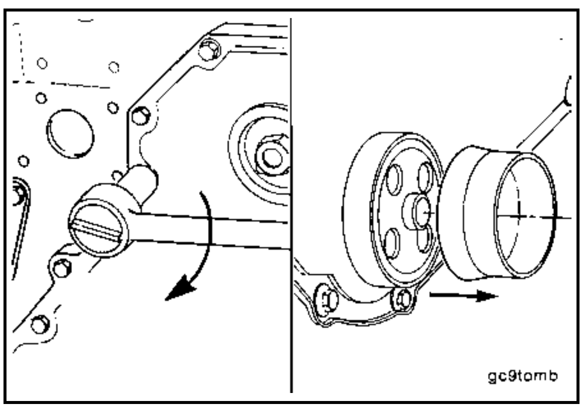


FIGURE 84. TIGHTEN THE FRONT GEAR COVER MOUNTING CAPSCREWS

17. Remove the plastic pilot tool from the crankshaft. Torque value: 18 ft-lb (24 Nm).
18. Install the vibration damper. Do not tighten the capscrews to the correct torque value at this time. Refer to the Rubber Vibration Damper Maintenance section or the Viscous Vibration Damper Maintenance section, whichever is applicable.

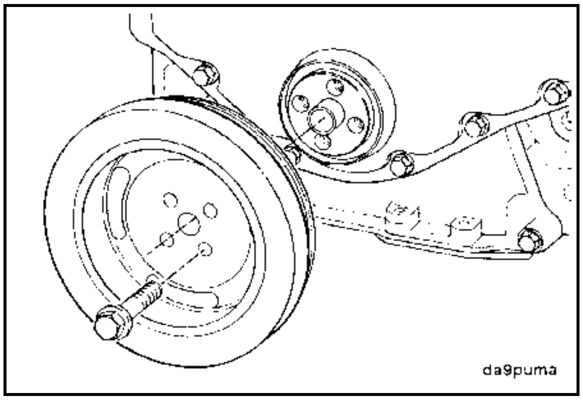


FIGURE 85. INSTALL THE DAMPER

19. Install the drive belt. Refer to the Cooling Fan Drive Belt Maintenance section.

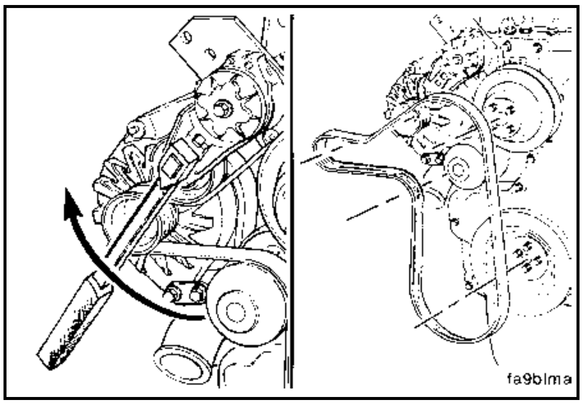


FIGURE 86. INSTALL THE DRIVE BELT

20. Tighten the vibration damper capscrews. Torque value: 92 ft-lb (125 Nm).

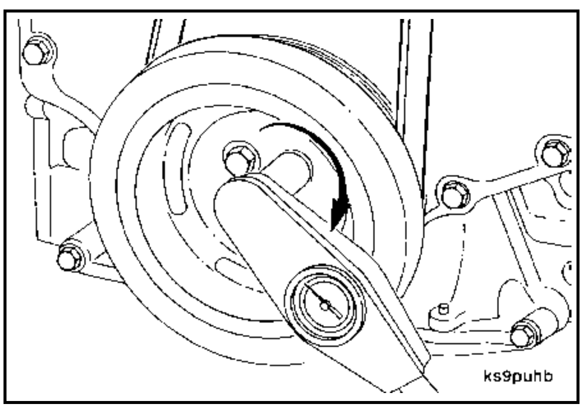


FIGURE 87. TIGHTEN THE DAMPER CAPSCREWS

Rear Crankshaft Seal Maintenance

1. Remove the alternator. Refer to the Alternator Removal and Installation section.

2. Remove the flywheel. Refer to the Flywheel Maintenance section.

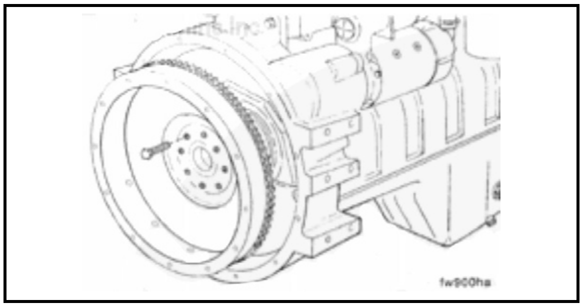


FIGURE 88. REMOVE THE FLYWHEEL

3. Using a 1/8 drill, drill two holes 180° apart into the seal carrier.

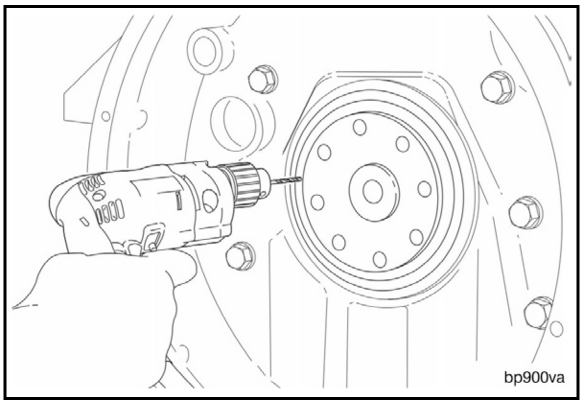


FIGURE 89. DRILL TWO HOLES INTO THE SEAL CARRIER

4. Using a slide hammer dent puller for No. 10 sheet metal screws, remove the rear seal.

⚠ CAUTION
The seal lip and the sealing surface on the crankshaft must be free from all oil residue to reduce the possibility of seal leaks.

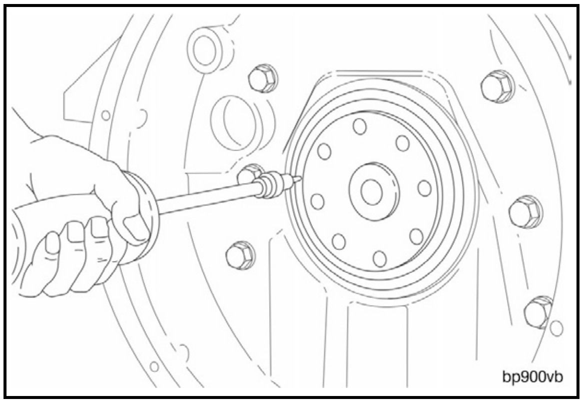


FIGURE 90. REMOVE THE REAR SEAL

5. Clean and dry the rear crankshaft sealing surface.

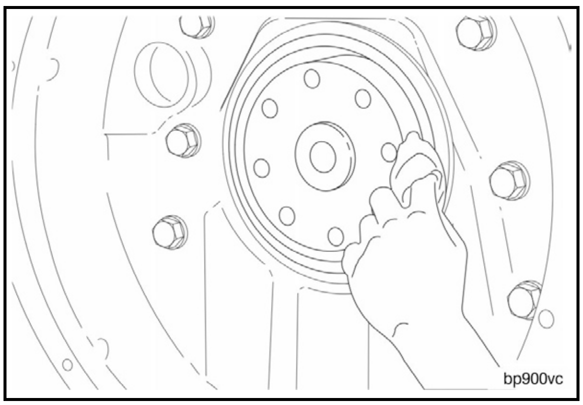


FIGURE 91. CLEAN AND DRY THE SEALING SURFACE

6. Install the seal pilot, which is provided in the replacement kit, onto the crankshaft. Push the seal onto the pilot and crankshaft.

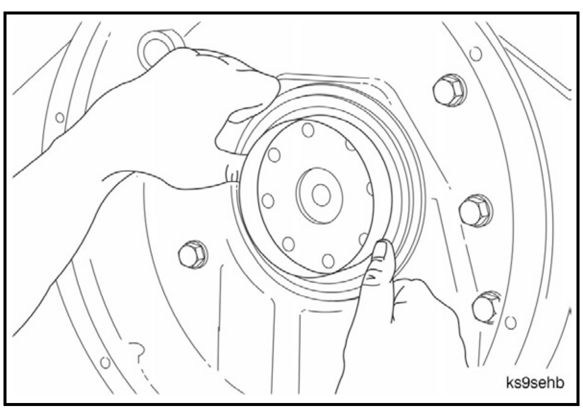


FIGURE 92. INSTALL THE SEAL PILOT

7. Remove the seal pilot.

NOTICE

For installation, the lubricating oil seal requires a mild soap on the outside diameter of the seal case.

8. Use the alignment tool (Wear Sleeve Installation Tool, Part No. 3824078) to install the seal to the correct depth in the housing.
9. Use a hammer to drive the seal into the housing until the alignment tool stops against the housing.
10. Hit the tool at 12-, 3-, 6-, and 9-o'clock positions to drive the seal evenly and to prevent bending of the seal carrier.

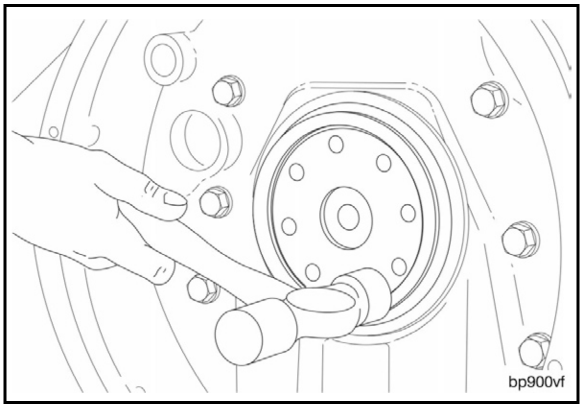


FIGURE 93. DRIVE THE SEAL EVENLY

11. Install the flywheel. Refer to the Flywheel Maintenance section.
12. Tighten the capscrews in the sequence as shown in the figure below. Refer to the Cooling Fan Drive belt section. Torque value: 101 ft-lb (137 Nm), 19 mm.

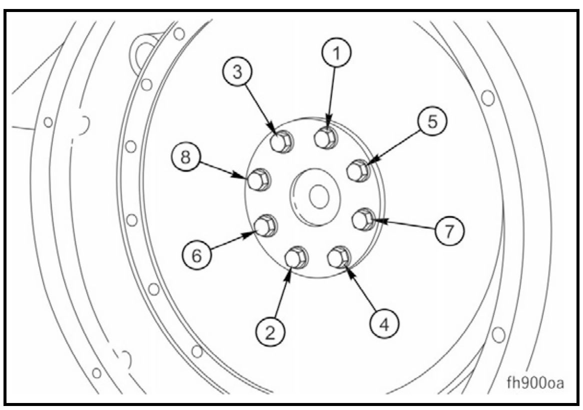


FIGURE 94. INSTALL THE FLYWHEEL

13. Attach the alternator and drive disc. Refer to the Alternator Removal and Installation section.

Front Gear Cover Removal and Installation

1. Remove the drive belt. Refer to the Cooling Fan Drive Belt Maintenance section.

NOTICE
Removal is easier if the vibration damper is loosened before removing the belt.

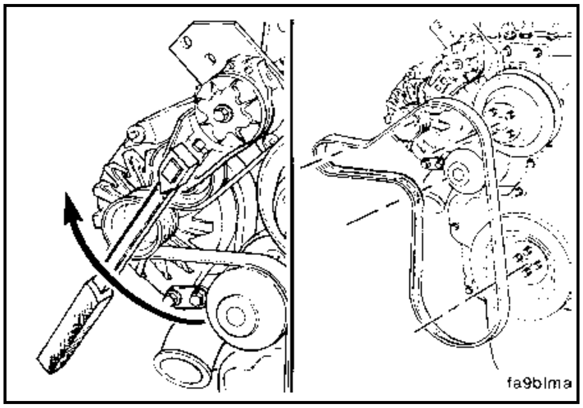


FIGURE 95. REMOVE THE DRIVE BELT

2. Remove the vibration damper. Refer to the Rubber Vibration Damper Maintenance section.

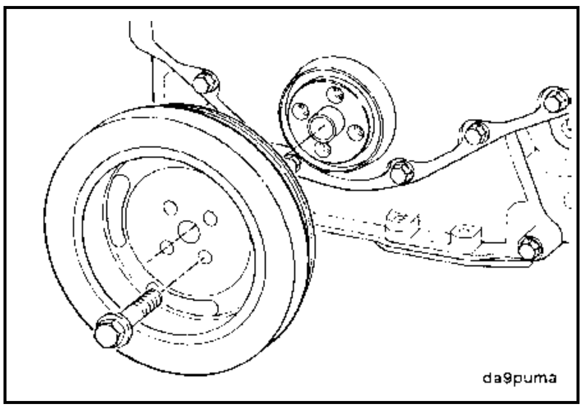


FIGURE 96. REMOVE THE VIBRATION DAMPER

3. Remove the fan hub pulley. Refer to the Fan Spacer and Pulley Maintenance section.

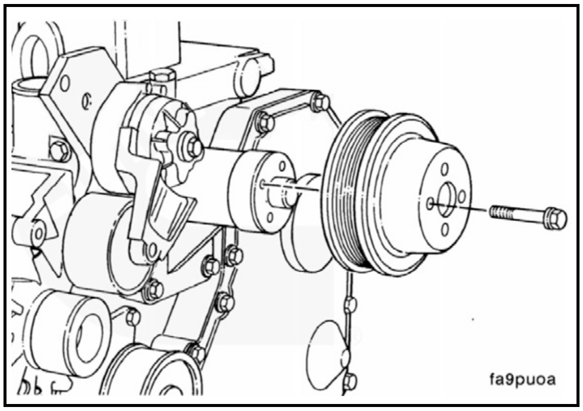


FIGURE 97. REMOVE THE FAN HUB PULLEY

4. Remove the front gear cover.

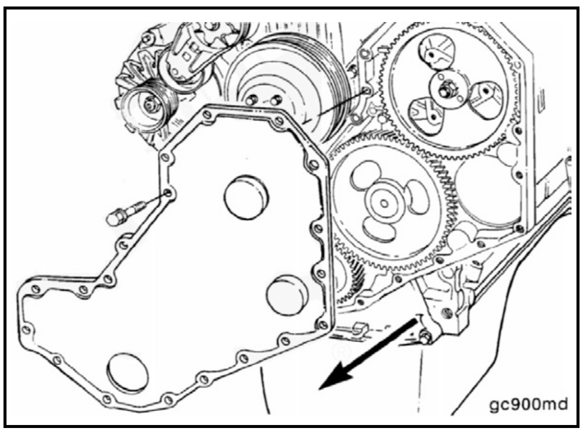


FIGURE 98. REMOVE THE FRONT GEAR COVER

5. Clean the gear cover and gear housing gasket surface.

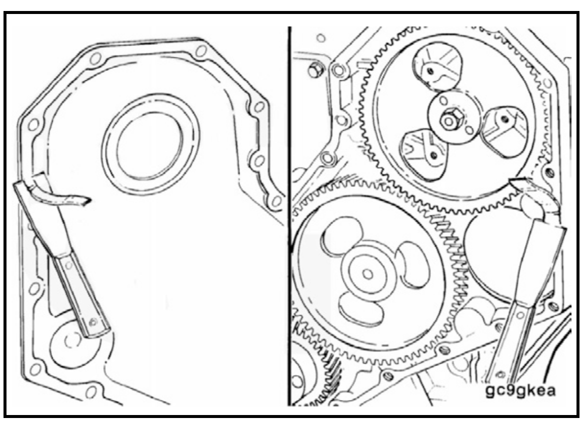


FIGURE 99. CLEAN THE GEAR COVER AND GEAR HOUSING GASKET SURFACE

6. Inspect the gear cover for cracks or damage.

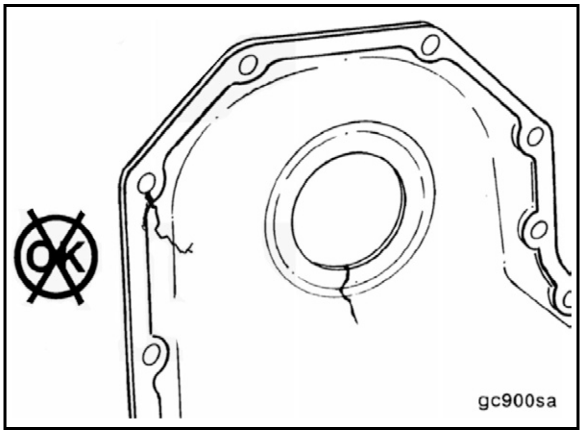


FIGURE 100. INSPECT THE GEAR COVER

7. Make sure the crankshaft is clean, dry, and oil-free before installing the gear cover. Failure to clean the sealing surface properly can result in an oil leak.

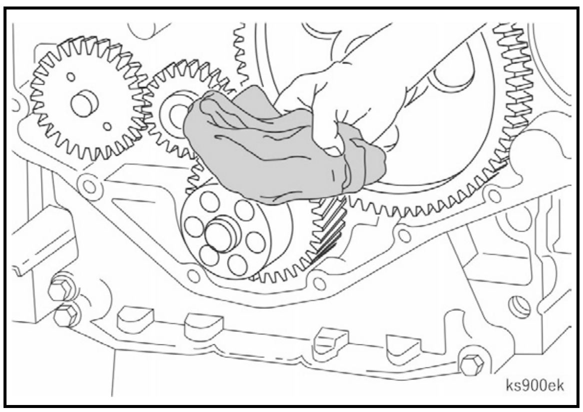


FIGURE 101. MAKE SURE THE CRANKSHAFT IS CLEAN AND DRY

8. Install a new seal in the gear cover. Refer to the Front Crankshaft Seal section.

NOTICE
Install three guide pins, Part Number 3164977, to improve alignment of the front cover and front seal to the gear housing and crankshaft.

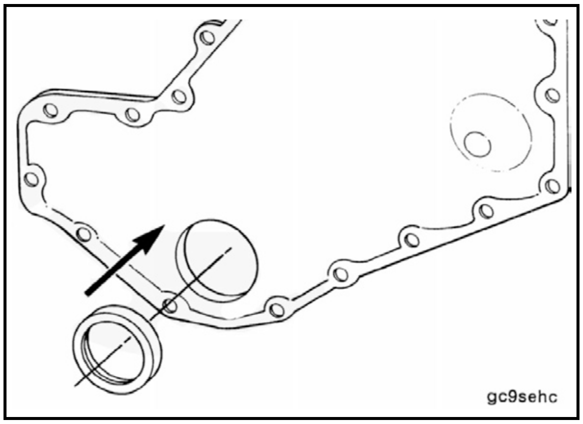


FIGURE 102. INSTALL A NEW SEAL

9. Apply a thin bead of Three Bond™ to the cover side of the front cover gasket only.

NOTICE
Do not remove the plastic seal pilot tool from the lubricating oil seal at this time. Use the plastic seal pilot tool to guide the seal on the crankshaft.

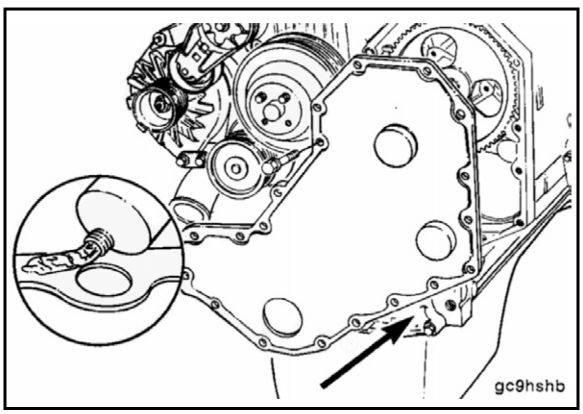


FIGURE 103. APPLY THREE BOND

10. Install the gasket and front cover on the engine.
11. Tighten the front cover capscrews. Torque value: 212 in-lb (24 Nm), 10 mm.

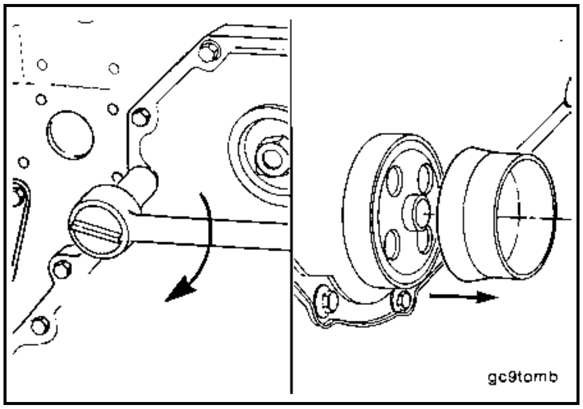


FIGURE 104. TIGHTEN THE FRONT COVER CAPSCREWS

12. Remove the plastic pilot tool from the crankshaft.
13. Install the vibration damper. See **Figure 96**. Also, refer to the Rubber Vibration Damper Maintenance section.

NOTICE
Do not tighten the capscrews to the correct torque specification at this time.

14. Install the fan hub pulley. Refer to the Fan Spacer and Pulley Maintenance section.
15. Install the drive belt using a 3/8-inch square drive. See **Figure 95**. Also refer to the Cooling Fan Drive Belt Maintenance section.

NOTICE
If difficulty is experienced installing the drive belt (that is, the belt seems too short), position the belt over the grooved pulleys first. Then, while holding the tensioner up, slide the belt over the water pump pulley.

16. Tighten the vibration damper capscrews. Torque value: 92 ft-lb (125 Nm), 15 mm.

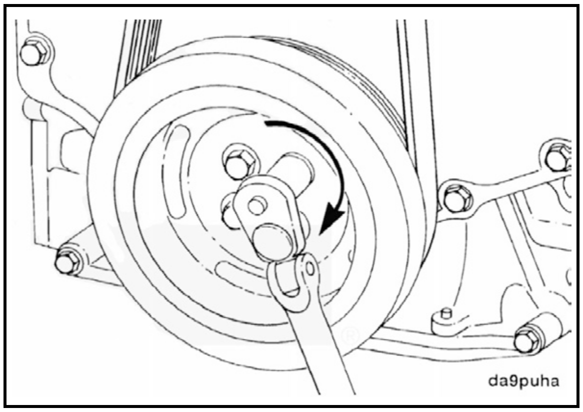


FIGURE 105. TIGHTEN THE VIBRATION DAMPER CAPSCREWS

Rubber Vibration Damper Maintenance

⚠ WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

⚠ WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

⚠ WARNING

Wear protective gloves when handling parts that have been heated to reduce the possibility of personal injury.

1. Make sure the generator set is disabled.
    a. Press the STOP button on the operator panel to make sure the control is in the Off mode.
    b. If equipped, activate the E-stop button.
    c. If equipped, disconnect the battery charger. Remove any other electrical supply sources.
    d. Disconnect the negative (-) cable from the battery and secure it from contacting the battery terminals to prevent accidental starting.
2. Remove the fan drive belt. Refer to the Cooling Fan Drive Belt Maintenance section.
3. Remove the vibration damper and crankshaft speed indicator ring.

NOTICE

The crankshaft speed indicator ring is part of the vibration damper assembly and should not be removed from the vibration damper itself.

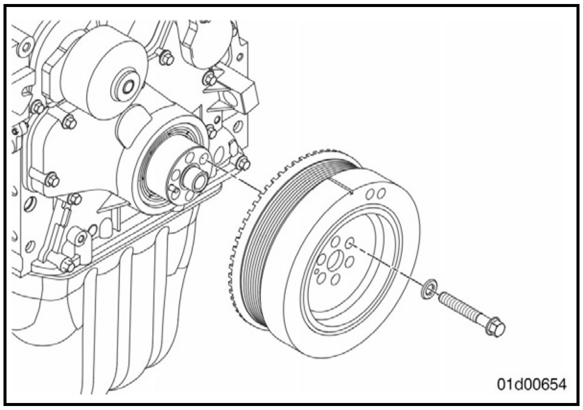


FIGURE 106. REMOVE THE DAMPER AND CRANKSHAFT SPEED INDICATOR RING

4. Use soapy water to clean any oil from the vibration damper and crankshaft speed indicator ring.

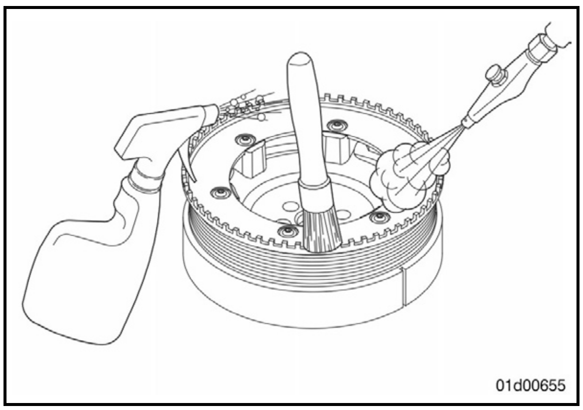


FIGURE 107. CLEAN OIL FROM THE DAMPER AND CRANKSHAFT SPEED INDICATOR RING

5. Dry the vibration damper/crankshaft speed indicator ring with compressed air.
6. Inspect the crankshaft speed indicator ring for missing teeth, cracks, or damaged surfaces. If any damage is found, the crankshaft speed indicator ring must be replaced, along with the whole damper assembly.

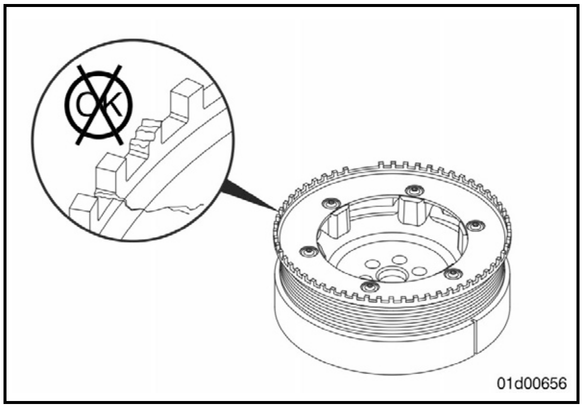


FIGURE 108. INSPECT THE CRANKSHAFT SPEED INDICATOR RING

7. Check the mounting web for cracks.

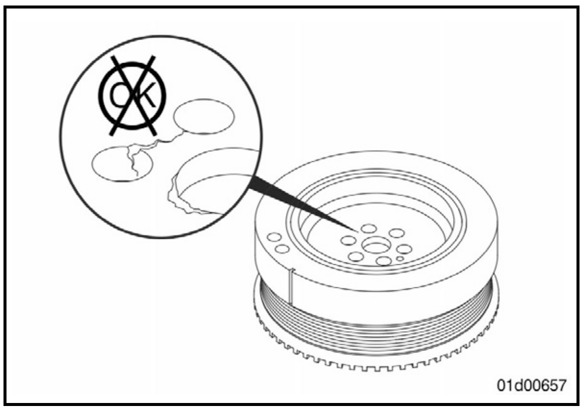


FIGURE 109. CHECK THE MOUNTING WEB

8. Check the alignment marks on the inner and outer rings.
9. Check the index lines (A) on the damper hub (B) and the inertia member (C). If the lines are more than 1/16 in (1.59 mm) out of alignment, replace the damper.

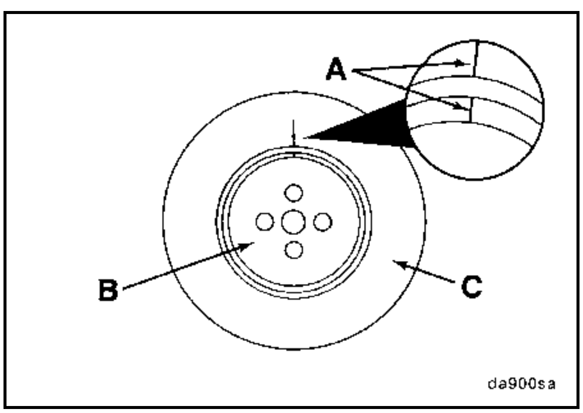


FIGURE 110. CHECK THE INDEX LINES

10. Inspect the vibration damper hub for cracks. If the hub is cracked, replace the damper.
11. Inspect the rubber member for deterioration. If pieces of rubber are missing or if the elastic member is more than 1/8 in (3.18 mm) below the metal surface, replace the damper.

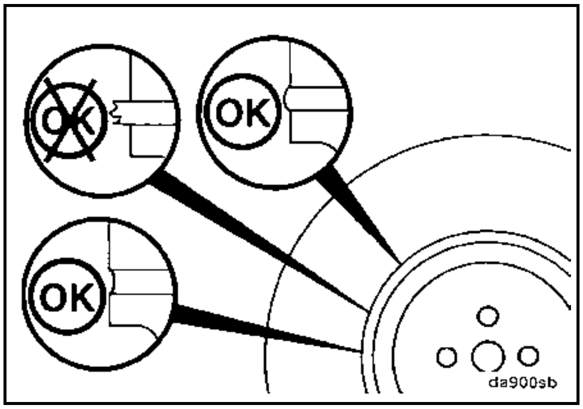


FIGURE 111. INSPECT THE RUBBER MEMBER

12. Check for forward movement of the damper ring on the hub. If any movement is detected, replace the damper.
13. Align the crankshaft speed indicator ring and vibration damper with the index pin located on the nose of the crankshaft.

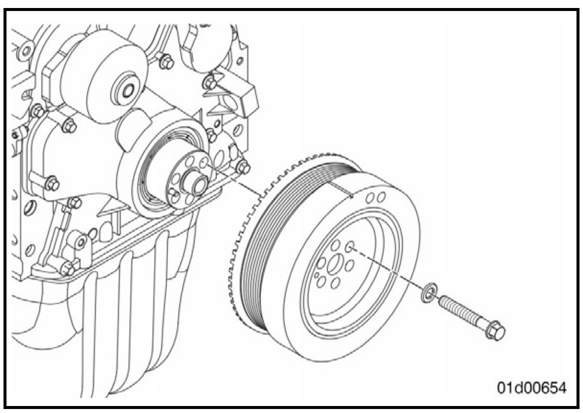


FIGURE 112. ALIGN THE CRANKSHAFT SPEED INDICATOR AND DAMPER WITH THE INDEX PIN

14. Lubricate the capscrews with clean engine oil.
15. Install the vibration damper and crankshaft speed indicator ring.
16. Tighten the six vibration damper capscrews in a criss-cross pattern. Torque value: 37 ft-lb (50 Nm); rotate 90°.
17. Install the fan drive belt. Refer to the Cooling Fan Drive Belt Maintenance section.
18. Connect the negative (–) cable to the battery.

19. Operate the engine and check for noise and proper operation.

12.2 Cylinder Head Maintenance

⚠ WARNING

Fuel is flammable. Keep all cigarettes, flames, pilot lights, arcing equipment, and switches out of the work area and areas sharing ventilation to reduce the possibility of severe personal injury or death when working on the fuel system.

⚠ WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

⚠ WARNING

Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

⚠ WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 120 °F (50 °C) before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

⚠ WARNING

This component or assembly weighs greater than 50 lb (23 kg). To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

⚠ WARNING

When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

⚠ WARNING

Use skin and eye protection when handling caustic solutions to reduce the possibility of personal injury.

⚠ WARNING

Wear protective eye covering while cleaning carbon deposits to reduce the possibility of eye injury.

⚠ WARNING

Use eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

⚠ WARNING

Wear protective clothing and safety glasses or a face shield while cleaning. Machining debris can cause personal injury.

⚠ CAUTION

Do not lay the cylinder head on the combustion deck. This can damage the cylinder head deck.

⚠ CAUTION

Do not use caustic or acidic solutions to clean the cylinder head capscrews. Use of these solutions can cause corrosion.

⚠ CAUTION

Be sure the gasket is correctly aligned with holes in the cylinder block. If the gasket is not aligned correctly, engine damage can result.

OVERVIEW

The cylinder head is a one-piece, cross-flow design with two valves per cylinder. The head has integrally cast valve guides and hardened valve seat surfaces that can be repaired by a certified Cummins Inc. distributor using the appropriate service parts.

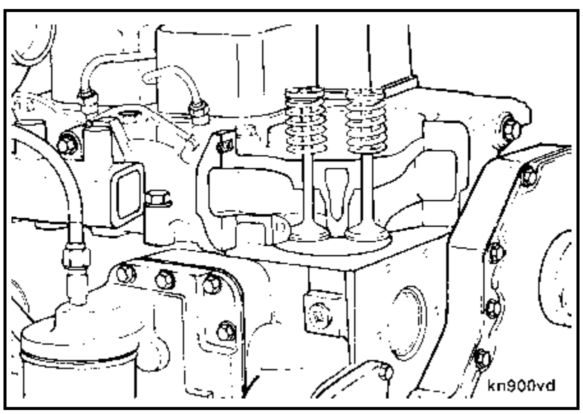


FIGURE 113. CYLINDER HEAD

The cylinder head has a cast intake manifold, a thermostat housing, and an internal water bypass.

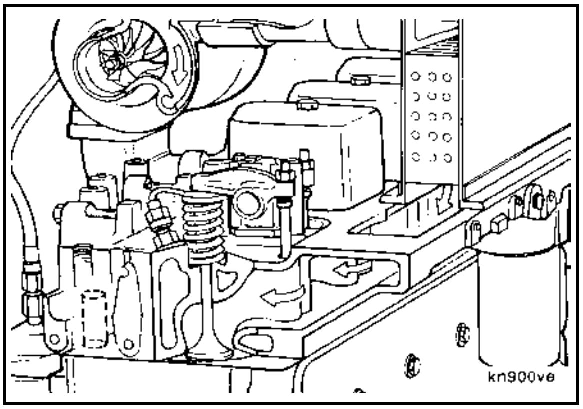


FIGURE 114. CYLINDER HEAD CAST INTAKE MANIFOLD, THERMOSTAT HOUSING, AND WATER BYPASS

Separate pedestals for each cylinder are to support and route oil to the rocker levers.

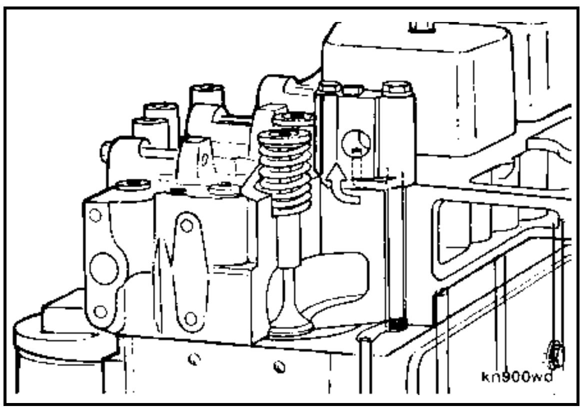


FIGURE 115. CYLINDER HEAD PEDESTALS

The cylinder head gasket is a specialized metal design with a printed o-seal on both sides around the water holes. An embossment in the gasket seals the cylinder bores. The gasket also provides orifices to control coolant flow.

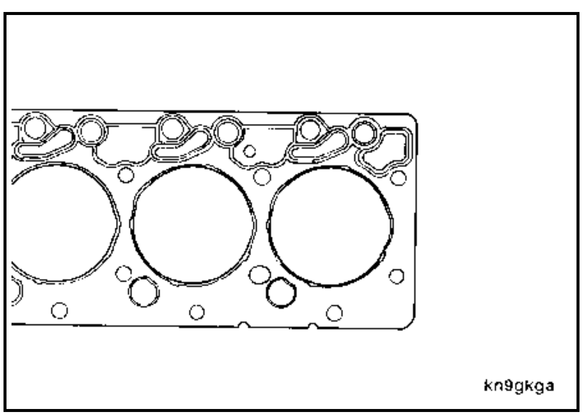


FIGURE 116. CYLINDER HEAD GASKET

INITIAL CHECK

A compression leak to the coolant will normally be detected by loss of coolant as the coolant is blown from the cooling system.

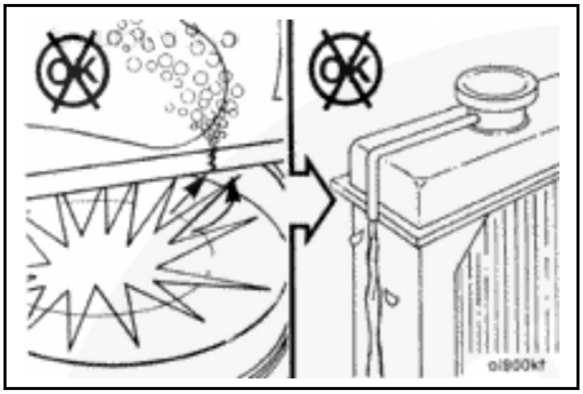


FIGURE 117. LOSS OF COOLANT

The sound emitted from the overhead can indicate a valve train problem. Loose rocker levers will clatter. A squeaking noise can mean lack of lubrication for the adjusting screw and the push rod socket.

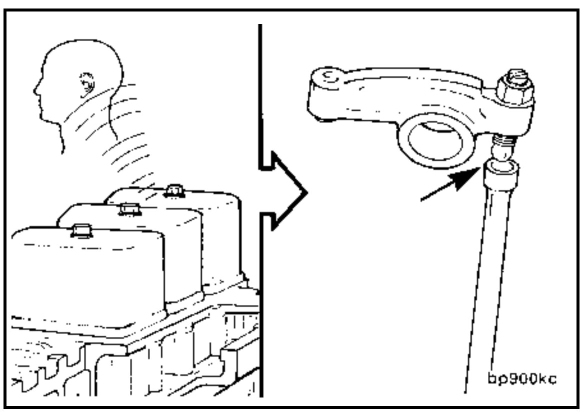


FIGURE 118. SOUND INDICATIONS OF PROBLEMS

Valve leakage is often audible from the intake and exhaust manifolds.

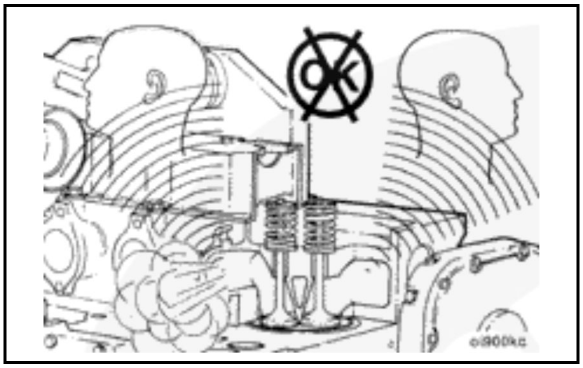


FIGURE 119. VALVE LEAKAGE SOUND FROM THE MANIFOLDS

If the compression is low on one or more nonadjacent cylinders and the pressure cannot be increased by oiling the rings, improper valve sealing is to be suspected.

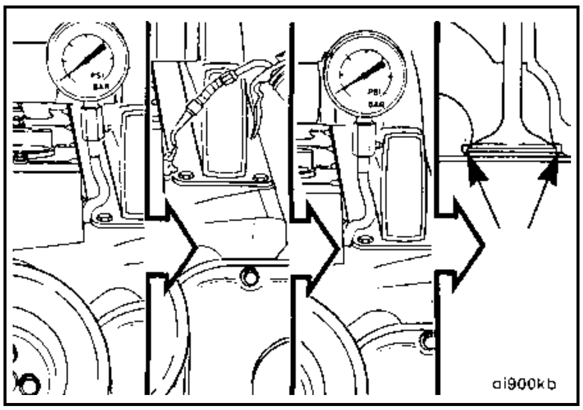


FIGURE 120. DIAGNOSING IMPROPER VALVE SEALING

PREPARATION

1. Make sure the generator set is disabled.
   a. Press the STOP button on the operator panel to make sure the control is in the Off mode.
   b. If equipped, activate the E-stop button.
   c. If equipped, disconnect the battery charger. Remove any other electrical supply sources.
   d. Remove AC power to the customer’s AC connections.
   e. Disconnect the negative (-) cable from the battery and secure it from contacting the battery terminals to prevent accidental starting.
2. Turn the vehicle's main fuel shutoff valve OFF.
3. Disconnect the battery cables. Refer to the equipment manufacturer's service information.
4. Drain the coolant.
5. Remove the radiator hoses.

6. Remove the turbocharger.
7. Remove the exhaust manifold.
8. Remove the spark plug wires. Refer to the Spark Plug section.
9. Remove the spark plugs. Refer to the Spark Plug section.
10. Remove the ignition coil bracket and ignition coil assembly.
11. Remove the rocker lever covers.
12. Remove the rocker levers. Refer to the Rocker Levers Removal section.
13. Remove the intake manifold cover.
14. Remove the drive belt. Refer to the Cooling Fan Drive Belt Maintenance section.
15. Remove the belt tensioner and bracket. Refer to the Cooling Fan Drive Belt Maintenance section.
16. Remove the fan hub assembly and pulley.
17. Remove the alternator bracket mounting capscrews and pivot the alternator away from the engine. Refer to the DC (Battery Charging) Alternator section.
18. Remove the thermostat and thermostat housing assembly. Refer to the Coolant Thermostat Troubleshooting section.

REMOVAL

1. Remove the cylinder head capscrews in the sequence illustrated.

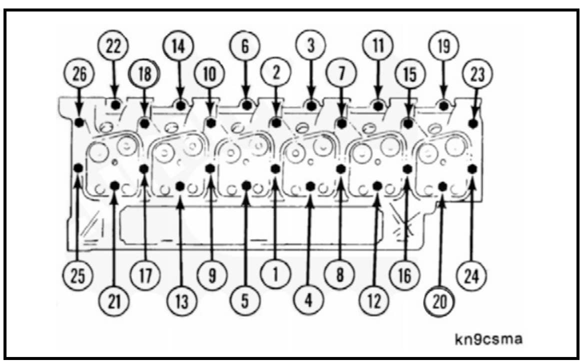


FIGURE 121. REMOVAL ORDER OF CAPSCREWS

2. Remove the cylinder head and gasket from the cylinder block. Be sure that the head is removed in a direct upward direction. The 6 cylinder head weight is 113 lb (51.3 kg).

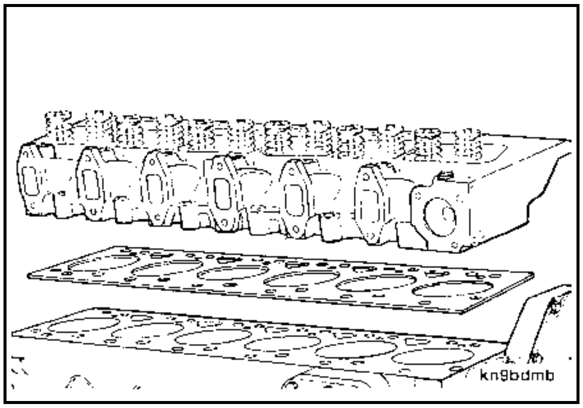


FIGURE 122. REMOVE THE CYLINDER HEAD AND GASKET

CLEAN AND INSPECT

1. Scrape the gasket material from all gasket surfaces on the block and head.

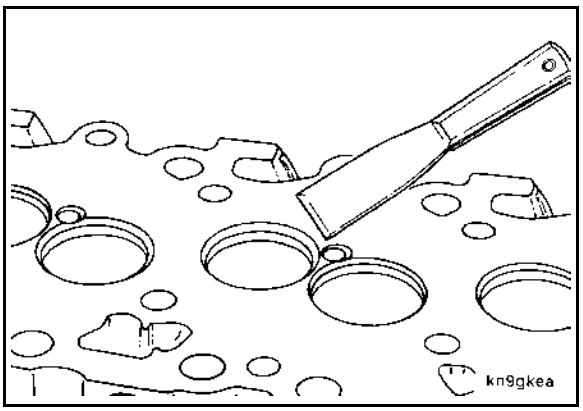


FIGURE 123. SCRAPE THE GASKET MATERIAL

2. Clean the buildup of deposits from the coolant passages. Excessive deposits can be cleaned in an acid tank, but the expansion plugs must first be removed.

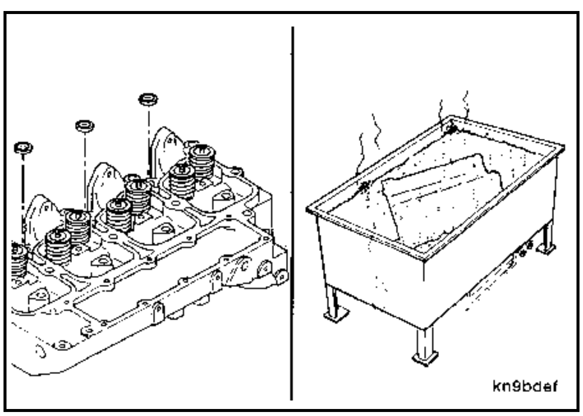


FIGURE 124. REMOVE DEPOSIT BUILDUPS

3. Clean the cylinder head combustion deck with a Scotch-Brite™ pad, or an equivalent cleaning pad, and diesel fuel or solvent.

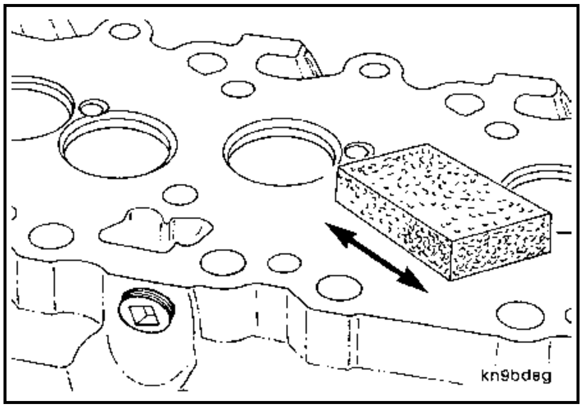


FIGURE 125. CLEAN THE CYLINDER HEAD COMBUSTION DECK

4. Inspect the area within 1/8-inch of the firing ring diameter. Any wear that can be felt with a fingernail within the 1/8-inch area is unacceptable, making the cylinder head not reusable. Wear beyond this 1/8-inch area will have no effect on future combustion sealing and the usability of the cylinder head.
5. Clean carbon deposits from the valve pockets with a high-quality steel wire wheel installed in a drill or a die grinder.

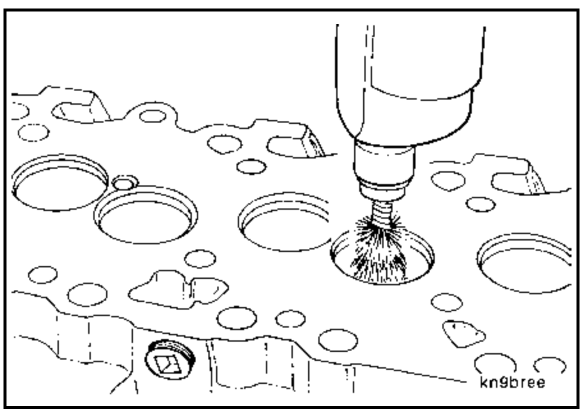


FIGURE 126. REMOVE CARBON DEPOSITS

NOTICE
An inferior-quality wire wheel will lose steel bristles during operation, thus causing additional contamination.

6. Wash the cylinder head in a hot, soapy water solution.

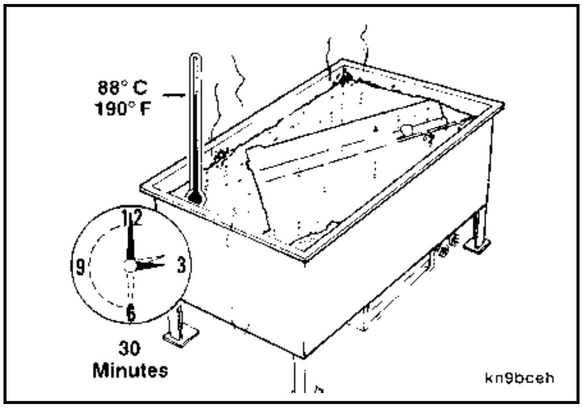


FIGURE 127. WASH THE CYLINDER HEAD

7. After rinsing, use compressed air to dry the cylinder head.
8. Using a petroleum-based solvent to clean the capscrews, clean the capscrews thoroughly with a wire brush or a soft wire wheel, or use a nonabrasive bead blast to remove deposits from the shanks and threads.

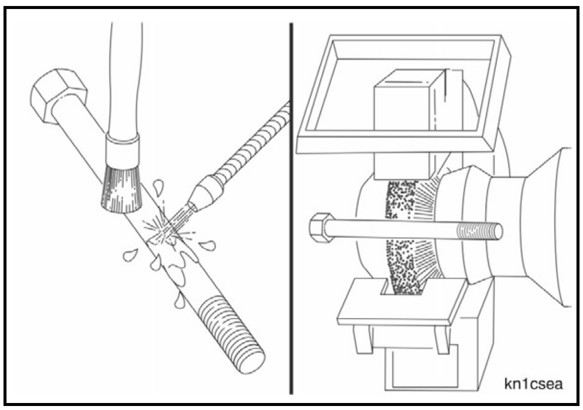


FIGURE 128. CLEAN THE CAPSCREWS

9. Use a straightedge and feeler gauge to measure the overall flatness of the cylinder block. The overall flatness, end-to-end and side-to-side, must not exceed 0.003 in (0.075 mm).

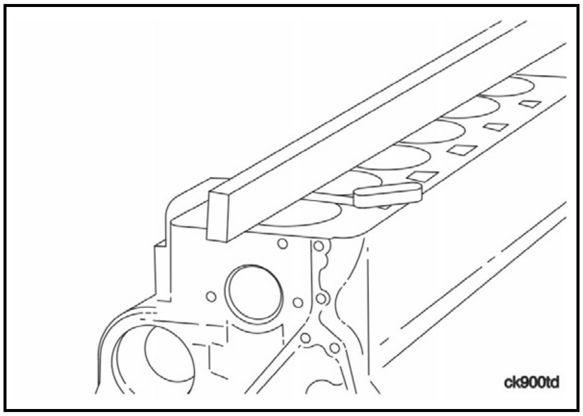


FIGURE 129. MEASURE THE FLATNESS OF THE CYLINDER BLOCK

10. Inspect the combustion deck for any localized dips or imperfections. If present, the cylinder block head deck must be ground.
11. The following guidelines apply only to cracks extending from the spark plug bore to the intake valve seats. (Replace cylinder heads that exhibit valve bridge cracks in any other location.)
    - If the crack does not extend into the valve seat, the cylinder head is reusable.

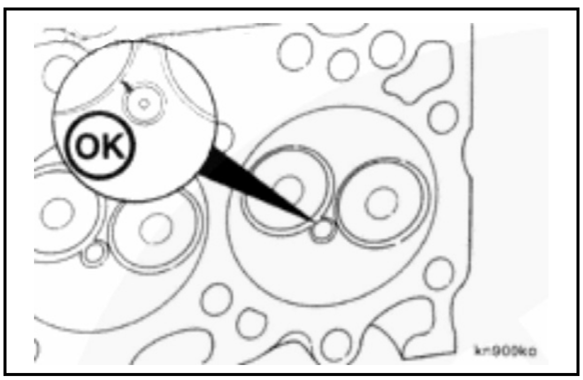


FIGURE 130. REUSABLE CYLINDER HEAD

    - If the crack extends into or through the valve seat, the cylinder head must be repaired by installing a valve seat insert. Contact your Cummins Inc. distributor for information.

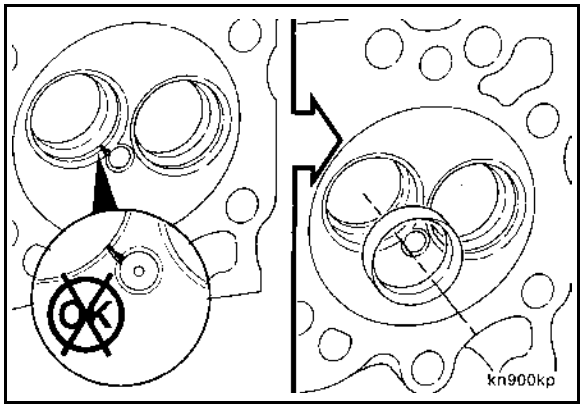


FIGURE 131. CYLINDER HEAD CRACK THAT NEEDS REPAIR

12. Use a straightedge and a feeler gauge to measure the cylinder head combustion surface for flatness.

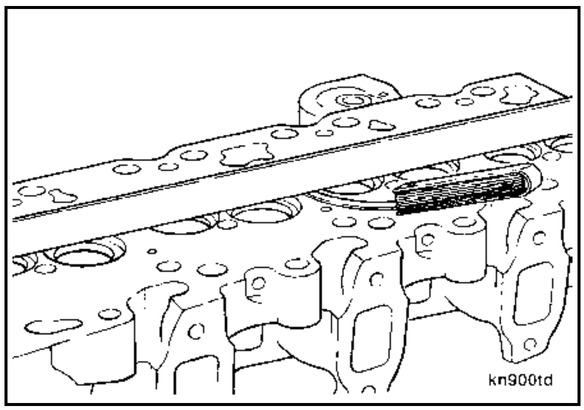


FIGURE 132. MEASURE THE CYLINDER HEAD COMBUSTION SURFACE

TABLE 23. CYLINDER HEAD FLATNESS MAXIMUM VALUES

	Max
End-to-End	0.012 in (0.305 mm)
Side-to-Side	0.003 in (0.076 mm)

13. Use a flap wheel or a rotating disk of Scotch-Brite to remove the dirt, debris, and rust from the exhaust manifold mounting surface.

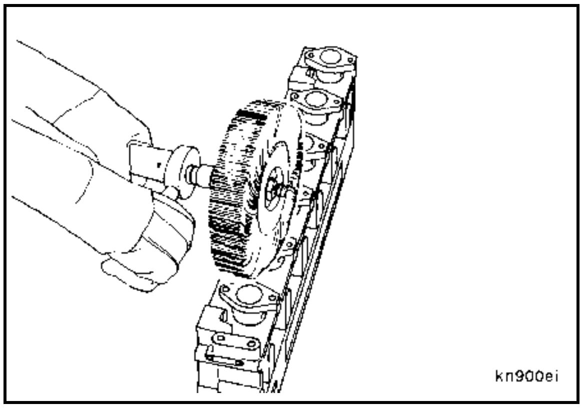


FIGURE 133. CLEAN THE EXHAUST MANIFOLD MOUNTING SURFACE

NOTICE
If the exhaust manifold mounting surface of the cylinder head is not flat within a maximum of 0.008 in (0.20 mm), the mounting surface must be machined.

14. Inspect the exhaust manifold mounting surface of the cylinder head.

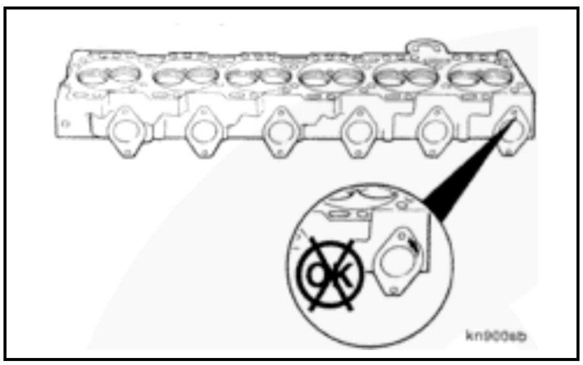


FIGURE 134. INSPECT THE EXHAUST MANIFOLD MOUNTING SURFACE

15. Use a straight edge and a feeler gauge to measure the flatness of the exhaust manifold mounting surface.

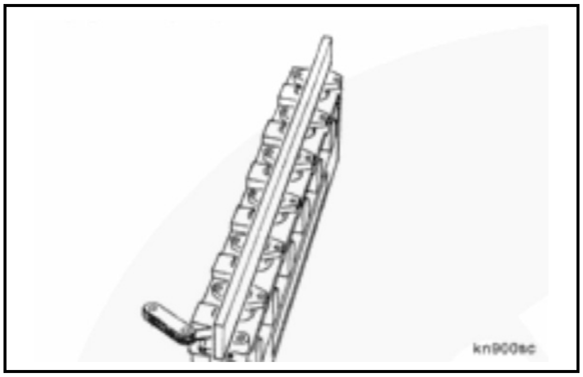


FIGURE 135. MEASURE THE FLATNESS OF THE EXHAUST MANIFOLD MOUNTING SURFACE

NOTICE
A maximum of 0.02 in (0.5 mm) can be machined from the exhaust manifold mounting surface of the cylinder head. If grooves or pits are deeper than 0.02 in (0.5 mm), the mounting surface cannot be restored by machining.

16. Inspect the cylinder head capscrews for damaged threads, corroded surfaces, or a reduced diameter (due to capscrew stretching).

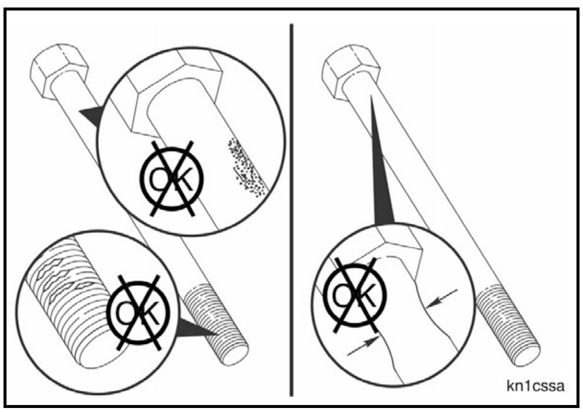


FIGURE 136. INSPECT THE CYLINDER HEAD CAPSCREWS

Do not reuse cylinder head capscrews under the following conditions:

- Visible corrosion or pitting exceeds 0.155 in² (1 cm²) in area
    - Acceptable: 3/8 x 3/8 inch
    - Unacceptable: 1/2 x 1/2 inch
- Visible corrosion or pitting exceeds 0.005 in (0.12 mm) in depth

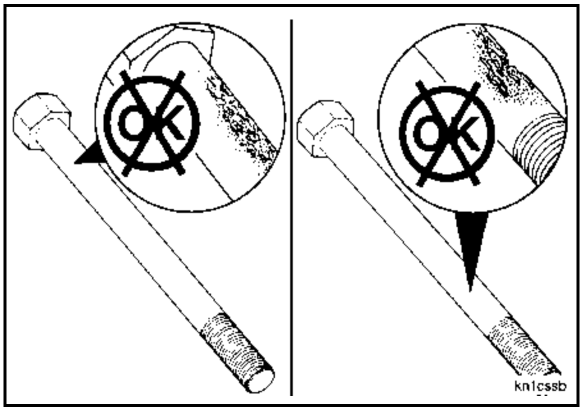


FIGURE 137. VISIBLE CORROSION AND PITTING IN AREA AND DEPTH

- Visible corrosion or pitting is located within 1/8 in (3.2 mm) of the fillet or the threads

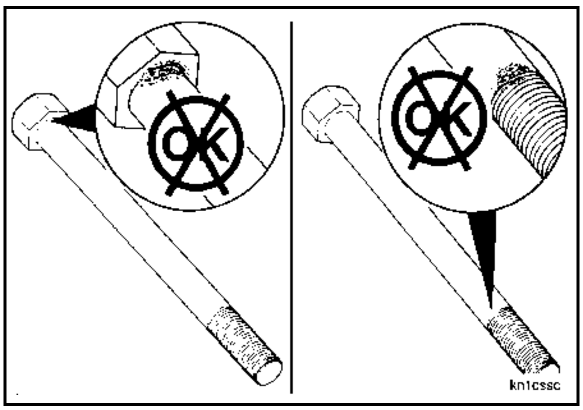


FIGURE 138. VISIBLE CORROSION AND PITTING NEAR THE FILLET AND THREADS

- Stretched beyond "free-length" maximum. Refer to the measurement procedure below:

NOTICE
If the capscrews are not damaged, they can be reused throughout the life of the engine unless the specified "free length" is exceeded.

  - Use a capscrew length gauge (Part Number 3823921 or equivalent), to check the capscrew free length. Place the head of the capscrew in the appropriate slot with the flange against the base of the slot. If the end of the capscrew touches the foot of the gauge, the capscrew is too long and must be discarded.

TABLE 24. CAPSCREW FREE LENGTH

	Length
Short (Maximum)	2.815 in (71.5 mm)
Medium (Maximum)	4.807 in (122.1 mm)
Long (Maximum)	7.201 in (182.9 mm)

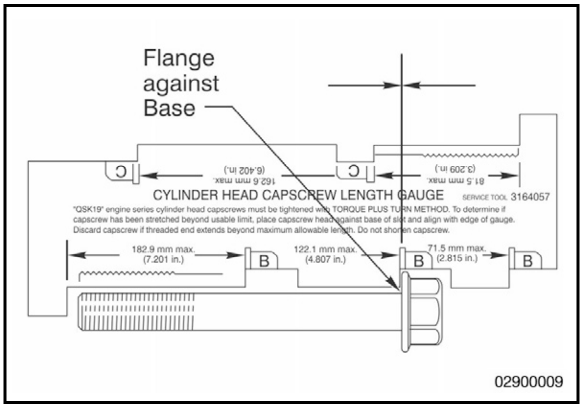


FIGURE 139. ACCEPTABLE CAPSCREW FREE LENGTH (SHOWING FLANGE AGAINST THE BASE)

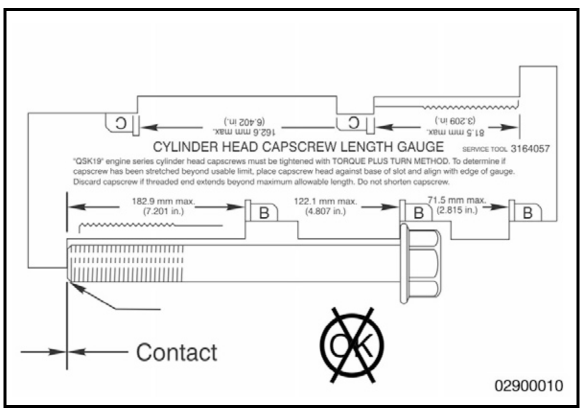


FIGURE 140. UNACCEPTABLE CAPSCREW LENGTH

INSTALL

1. Position a new cylinder head gasket over the dowels. “TOP” and the part number must be facing up on the gasket.

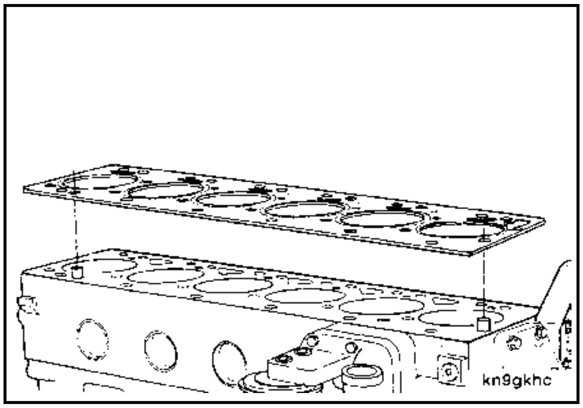


FIGURE 141. POSITION THE NEW CYLINDER HEAD GASKET OVER THE DOWELS

2. Carefully put the cylinder head straight down onto the cylinder block and seat it onto the dowels. The 6 cylinder head weight is 113 lb (51.3 kg).

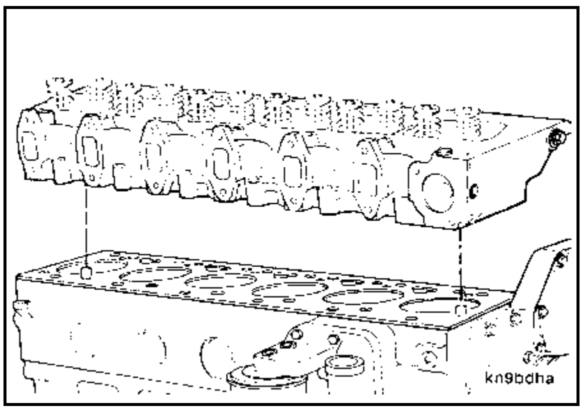


FIGURE 142. POSITION AND SEAT THE CYLINDER BLOCK

3. Position the push tubes into the valve tappets.

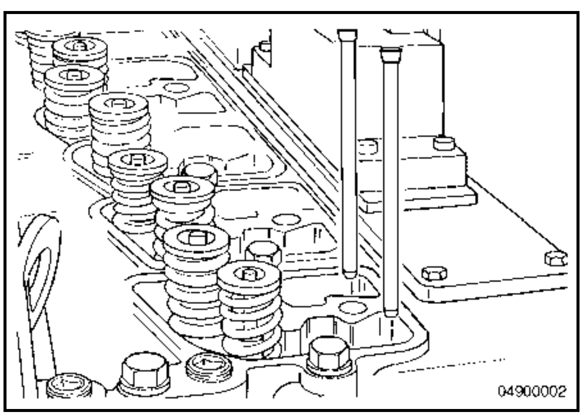


FIGURE 143. POSITION THE PUSH TUBES INTO THE VALVE TAPPETS

4. Lubricate the push tube sockets with clean lubricating engine oil.

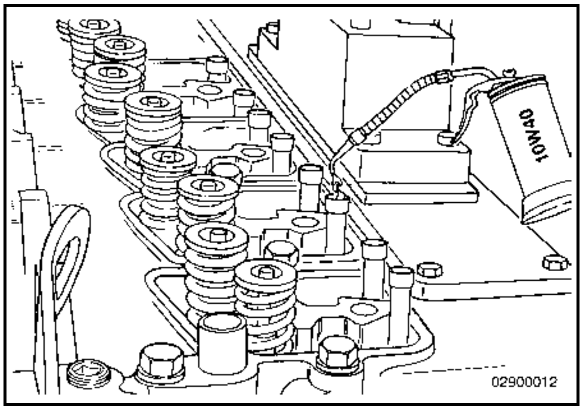


FIGURE 144. LUBRICATE THE PUSH TUBE SOCKETS

5. Lubricate the valve stems with clean gas engine lubricating oil.

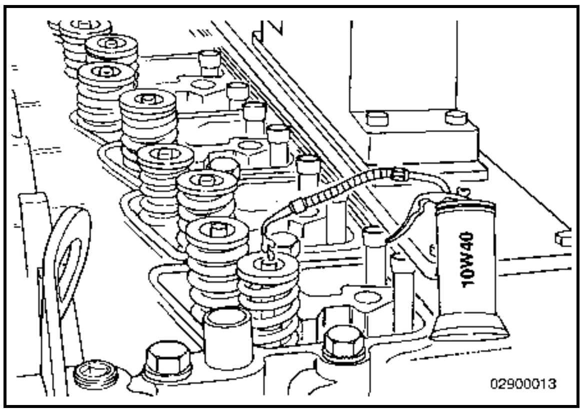


FIGURE 145. LUBRICATE THE VALVE STEMS

6. Completely loosen the rocker lever adjusting screws.

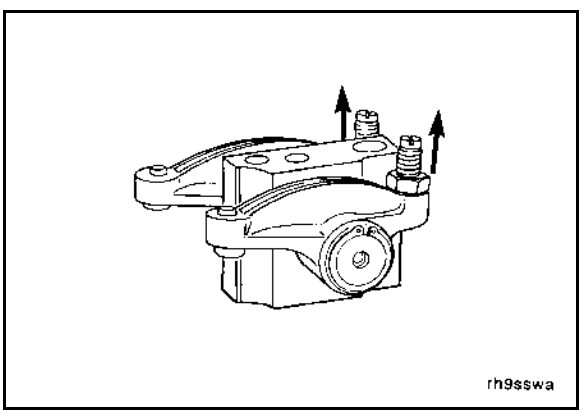


FIGURE 146. LOOSEN THE ROCKER LEVER ADJUSTING SCREWS

7. Install the pedestals.

NOTICE
The rocker lever pedestals are aligned with dowels.

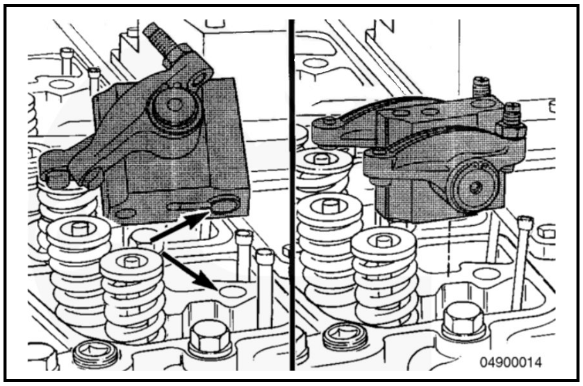


FIGURE 147. INSTALL THE PEDESTALS

8. Lubricate the 8 mm pedestal capscrew threads and under the capscrew heads with clean lubricating engine oil.

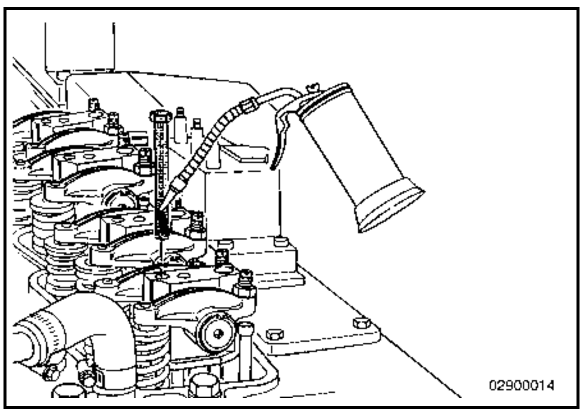


FIGURE 148. LUBRICATE THE 8 MM PEDESTAL CAPSCREW THREADS AND UNDER THE CAPSCREW HEADS

9. Install the capscrews finger-tight.
10. Lubricate the 12 mm pedestal/head capscrew bolt threads and under the capscrew heads with clean lubricating engine oil.

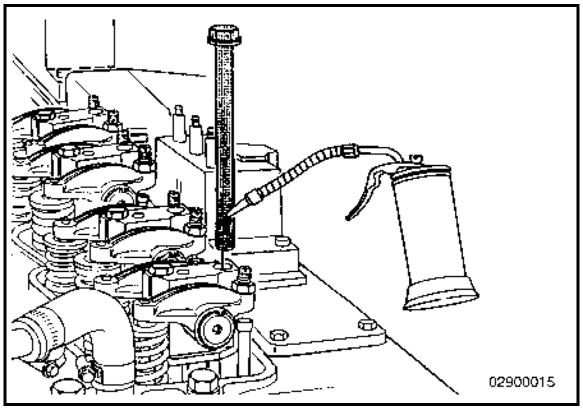


FIGURE 149. LUBRICATE THE 12 MM THE PEDESTAL/HEAD CAPSCREW BOLT THREADS AND UNDER THE CAPSCREW HEADS

11. Install the capscrews finger-tight.
12. Lubricate the threads and under the heads on the remaining cylinder head capscrews with clean gas engine lubricating oil.

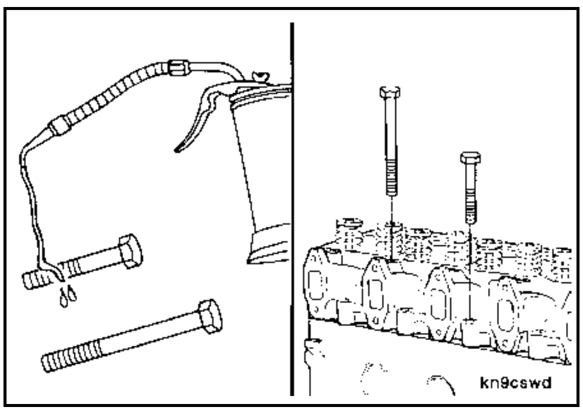


FIGURE 150. LUBRICATE THE REMAINING CYLINDER HEAD CAPSCREWS AND UNDER THE CAPSCREW HEADS

13. Install capscrews in the cylinder head and finger-tighten.
14. Tighten the cylinder head using the following steps:
    a. As shown in the figure below, tighten all 26 cylinder head capscrews. Torque value: 66 ft-lb (90 Nm).

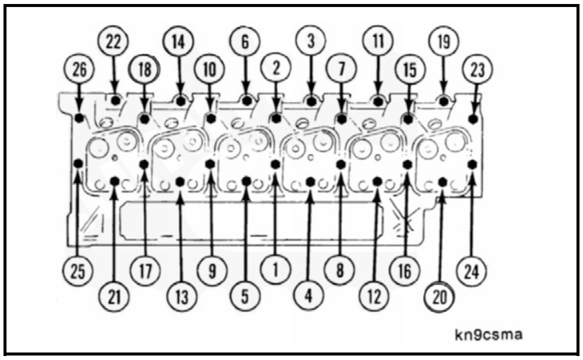


FIGURE 151. TIGHTEN CYLINDER HEAD CAPSCREWS

b. As shown in the figure below, tighten the six long capscrews only (numbers 4, 5, 12, 13, 20, and 21). Torque value: 89 ft-lb (120 Nm).

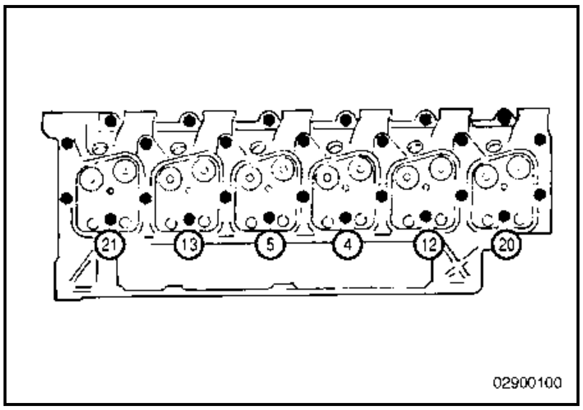


FIGURE 152. TIGHTEN THE LONG CAPSCREWS

c. Tighten the short capscrews (numbers 1 through 3; 6 through 11; 14 through 19; and 22 through 26) because of cylinder head relaxation and to obtain proper cylinder head torque requirements. Torque value: 66 ft-lb (90 Nm).

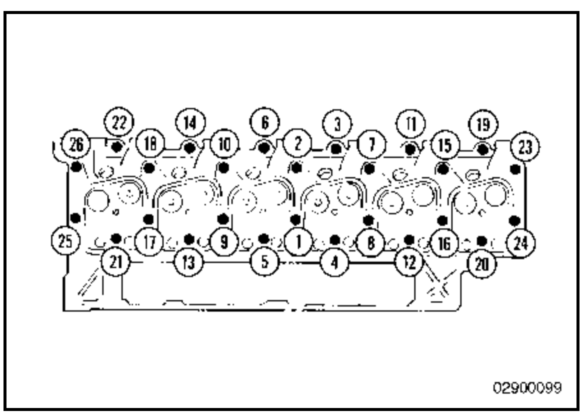


FIGURE 153. TIGHTEN THE SHORT CAPSCREWS

d. Re-tighten the six long capscrews only (numbers 4, 5, 12, 13, 20, and 21) as shown in Figure 152. Re-tightening is necessary due to cylinder head relaxation and to obtain proper cylinder head torque requirements. Torque value: 89 ft-lb (120 Nm).

e. Perform the following steps:

   i. As shown in the figure below, turn the capscrew 90° as indicated on the capscrew head.

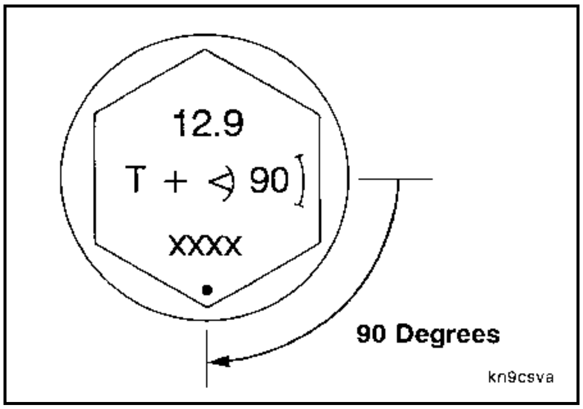
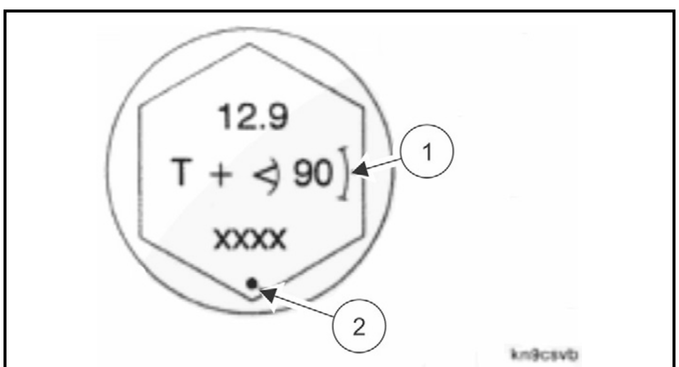


FIGURE 154. TURN THE CAPSCREW 90°

   ii. To turn the capscrew to the desired angle accurately, align the capscrew with the small “dot” and “window” that are marked on the capscrew head, or use recommended torque angle gauge Part Number 3823878 (or equivalent torque angle gauge for 3/4-in [19 mm] drive).



No.	Description	No.	Description
1	Window	2	Dot

FIGURE 155. ALIGN THE CAPSCREW WITH THE DOT AND WINDOW

   iii. Mark the cylinder head adjacent to the dot on the capscrew head. This mark will serve as an indexing aid.

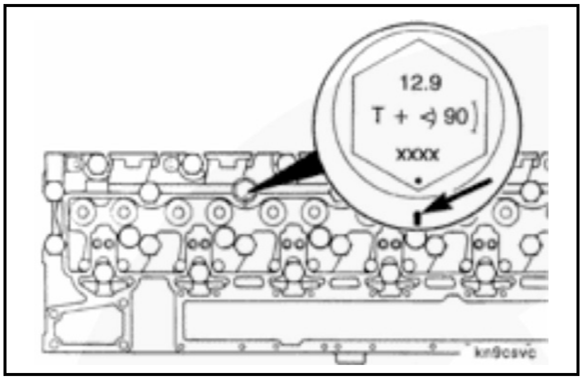


FIGURE 156. MARK THE CYLINDER HEAD ADJACENT TO THE DOT

iv. Rotate the capscrew until the mark that has been made on the cylinder head falls into the window on the capscrew head.

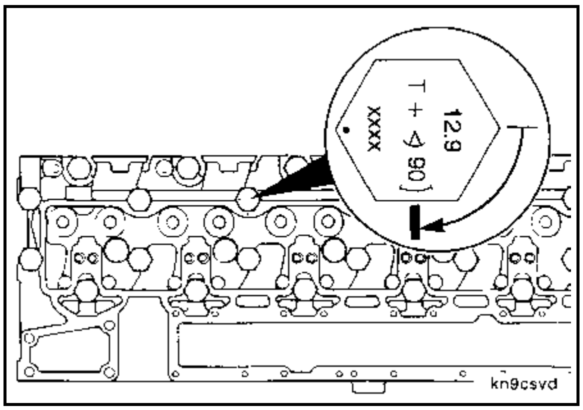


FIGURE 157. ROTATE THE CAPSCREW UNTIL THE MARK FALLS INTO THE WINDOW

v. Use a permanent marker to mark the socket corresponding to one of the flats of the socket hex.

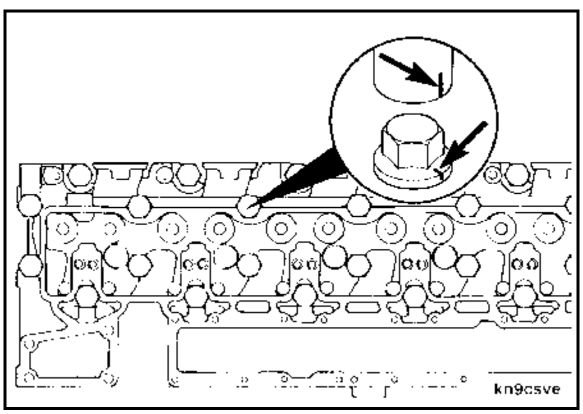


FIGURE 158. MARK THE SOCKET

vi. After torque has been applied, mark the cylinder head at the location of the dot. See **Figure 156**.

vii. Position the socket on the capscrew such that the mark on the socket is at the same point as the window on the capscrew.

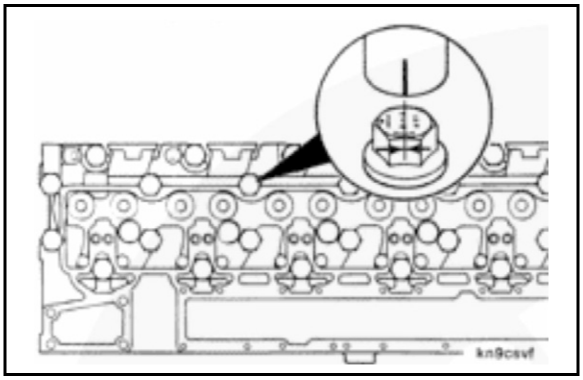


FIGURE 159. POSITION THE CAPSCREW SOCKET

viii. Turn the socket until the mark on the socket aligns with the mark on the cylinder head.

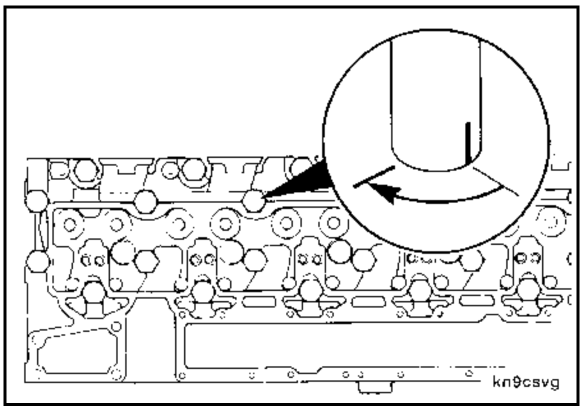


FIGURE 160. TURN THE SOCKET UNTIL THE SOCKET MARK ALIGNS WITH THE CYLINDER HEAD MARK

15. Tighten the 8 mm pedestal capscrews. Torque value: 18 ft-lb (24 Nm).

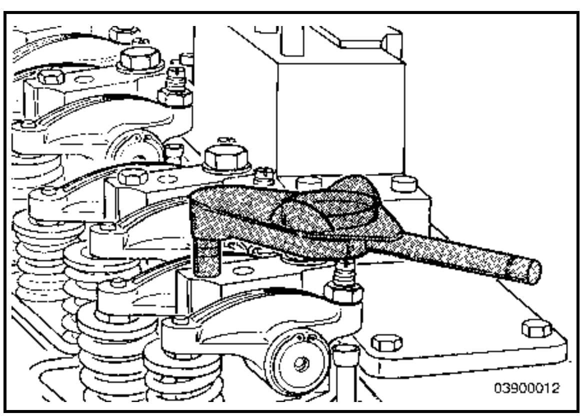


FIGURE 161. TIGHTEN THE 8 MM PEDESTAL CAPSCREWS

COMPLETION

1. Adjust the overhead. Refer to the Overhead Set section.
2. Install the rocker levers. Refer to the Rocker Levers section.
3. Install the rocker lever covers. Tighten the capscrews. Torque value: 18 ft-lb (24 Nm).
4. Install the intake manifold cover.
5. Install the ignition coils and bracket assembly. Refer to the Engine Removal and Installation Torque Values section.
6. Install the spark plugs. Refer to the Spark Plug section.
7. Install the spark plug wires. Refer to the Spark Plug section.
8. Install the exhaust manifold. Refer to the Engine Removal and Installation Torque Values section.
9. Install the turbocharger. Refer to the Engine Removal and Installation Torque Values section.
10. Install the thermostat and thermostat housing assembly. Refer to the Coolant Thermostat section.
11. Install the fan hub assembly and pulley.
12. Install the belt tensioner and bracket. Refer to the Cooling Fan Drive Belt Maintenance section.
13. Install the alternator and alternator bracket. Refer to the DC (Battery Charging) Alternator section
14. Install the drive belt. Refer to the Cooling Fan Drive Belt Maintenance section.
15. Install the radiator hoses. Refer to the Engine Removal and Installation Torque Values section.
16. Fill the cooling system.
17. Connect the battery cables. Refer to the equipment manufacturer's service information.
18. Make sure the generator set is enabled.
    a. Reconnect the negative (-) cable to the battery.
    b. Reconnect AC power to the customer’s AC connections.
    c. If equipped, reconnect the battery charger. Reconnect any other electrical supply sources.
    d. If equipped, deactivate the E-stop button.
    e. Press the START button on the operator panel to make sure the control is in the ON mode.
19. Turn the vehicle's main fuel shutoff valve ON.
20. Operate the engine and check for leaks.

12.3 Rocker Levers

Overhead Set

General Information

NOTICE
Cummins highly recommends that any service or maintenance work be performed by qualified technicians.

This section provides general information for diagnosing overhead set component malfunctions (rocker lever, valve stem, push tube, tappet, and camshaft).

The rocker lever group consists of the rocker lever assemblies, rocker assembly oil manifold, valve cover, and crankcase breather.

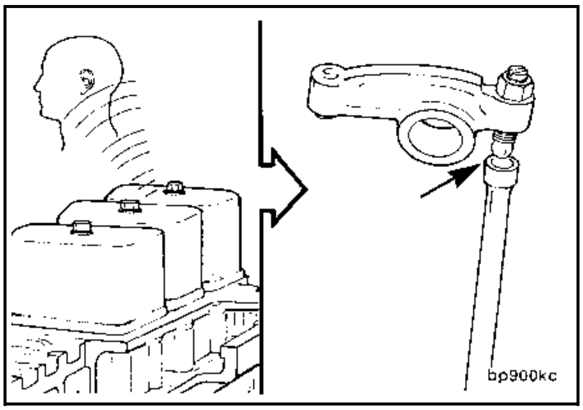


FIGURE 162. ROCKER LEVER GROUP

Each cylinder of the engine has a separate rocker lever assembly. The pedestal support has drillings to route the oil flow to the shaft and levers.

The rocker levers are push tube actuated and use an adjusting screw to control the clearance between the rocker lever and valve stem. The rocker levers do not use a bushing in the bore for the rocker lever shaft. The rocker lever must be replaced if the bore is damaged or worn beyond the specification limit.

The ball end of the push tube fits into the ball socket in the tappet. The other end of the push rod has a ball socket in which the ball end of the rocker lever adjusting screw operates.

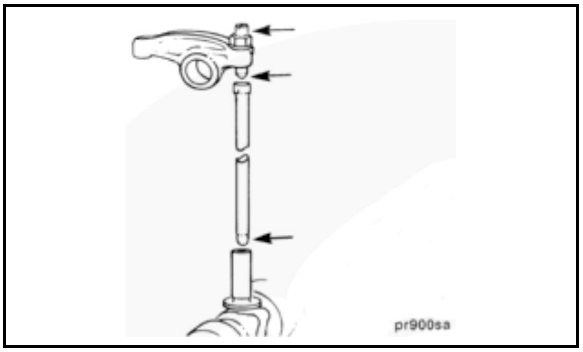


FIGURE 163. ENDS OF THE PUSH TUBE

NOTICE
The phosphorous and zinc levels in mid-range natural gas engine oils help in the lubricating of sliding tappets.

Excessive valve lash can indicate a worn valve stem, push tube, valve tappet, or rocker lever.

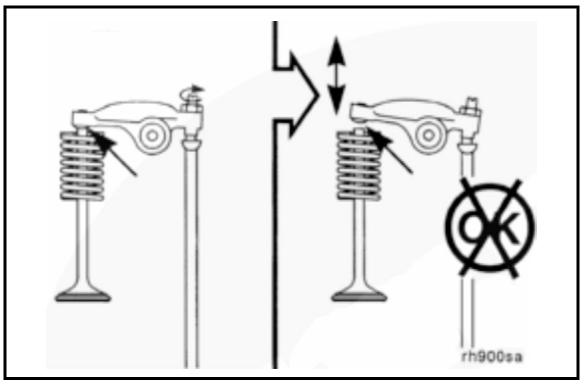


FIGURE 164. EXCESSIVE VALVE LASH

Loose rocker levers and the need to reset the valve clearance frequently can also indicate camshaft lobe or tappet wear. If an inspection of the rocker levers, valve stems, and push tubes does not show wear, then the tappet and/or camshaft lobe wear can be suspected. If tappet and/or camshaft wear is suspected, contact your Cummins distributor for service.

A severely damaged camshaft journal(s) can generate metal chips that will be found in the lubricating oil pan and oil filter.

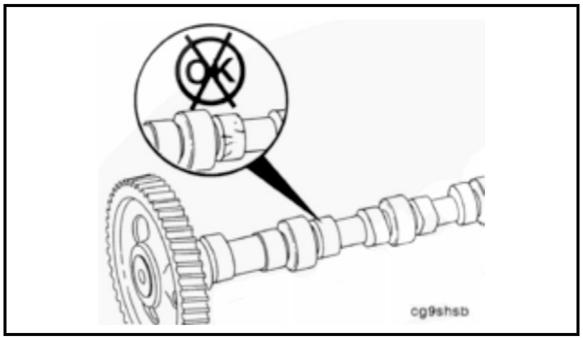


FIGURE 165. DAMAGED CAMSHAFT

NOTICE

As the clearance between the camshaft bushing(s) and camshaft journal(s) increases, oil pressure and volume will decrease, causing damage to the camshaft and tappets.

Valve Clearance Adjustment

NOTICE

All valve adjustments must be made when the engine is cold, and stabilized coolant temperatures are at 140 °F (60 °C) or below.

1. Remove the rocker lever cover capscrews, insulators, and spacers from the cover.

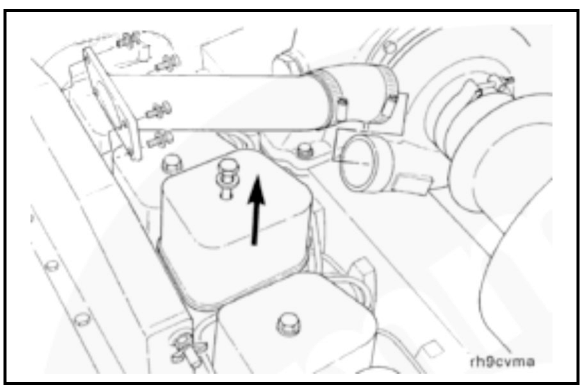


FIGURE 166. REMOVE ROCKER LEVER COMPONENTS

2. Locate top dead center for cylinder Number 1.
3. Rotate the engine (clockwise when facing the damper) until the cylinder Number 6 (for 6 cylinder) intake rocker arm starts to open the intake valve.
4. Wiggle the rocker arm while barring the engine; when the rocker arm gets tight, stop barring.

NOTICE

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

- **Intake Clearance: 0.012 in (0.305 mm)**
- **Exhaust Clearance: 0.024 in (0.610 mm)**

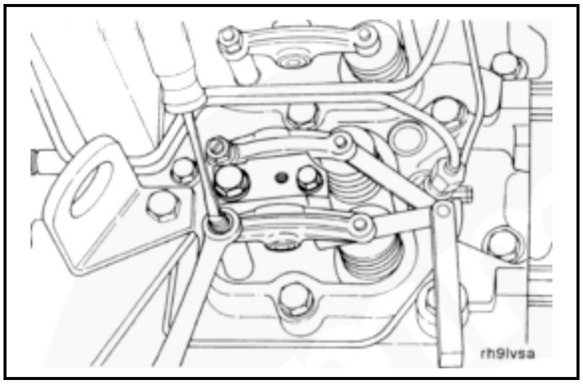


FIGURE 167. WIGGLE THE ROCKER ARM

5. Set only the valves indicated by the arrows in the figure below (E = exhaust, I = intake).

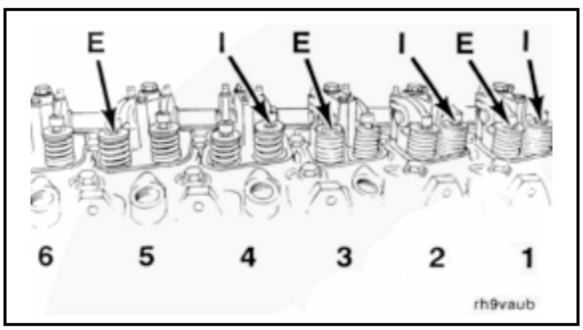


FIGURE 168. SET THE VALVES INDICATED

6. Holding the locknut steady with the wrench, adjust the valve clearance with the screwdriver or Allen wrench.
7. Tighten the locknut and measure the valve lash again. Torque value: 18 ft-lb (24 Nm).
8. Mark the pulley, and rotate the crankshaft 360°.

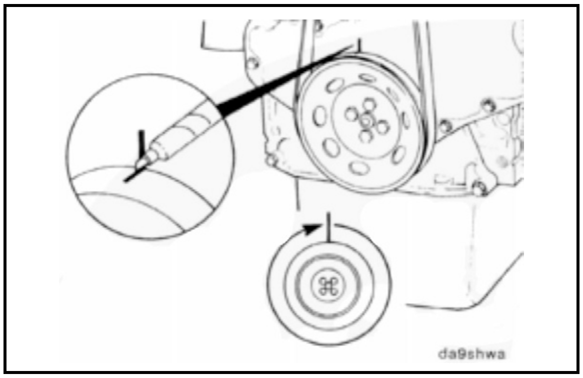


FIGURE 169. MARK THE PULLEY AND ROTATE THE CRANKSHAFT 360°

9. Adjust the valves as indicated in the figure below. Set only the valves indicated by the arrows in the figure (E = exhaust, I = intake). Do not set valves that are not indicated. Torque value: 18 ft-lb (24 Nm).

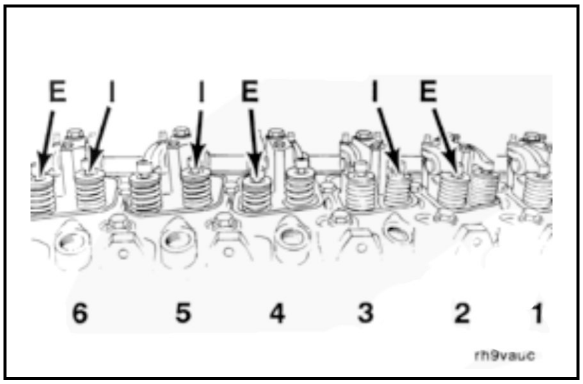


FIGURE 170. ADJUST THE VALVES INDICATED

10. Install the rocker lever covers, and tighten the capscrews. Torque Value: 18 ft-lb (24 Nm). Refer to the Rocker Lever section.

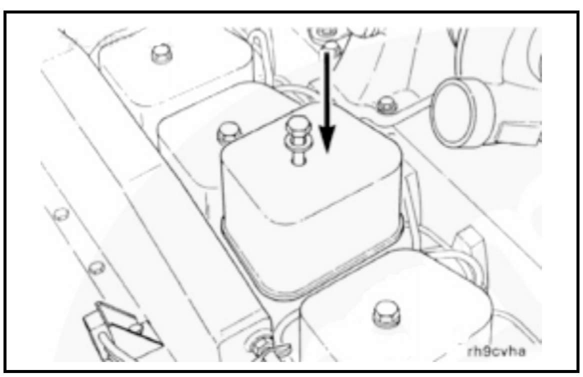


FIGURE 171. INSTALL THE ROCKER LEVER COVERS

Rocker Lever Cover Maintenance

⚠ WARNING
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause bodily injury.

1. Remove the rocker lever covers.

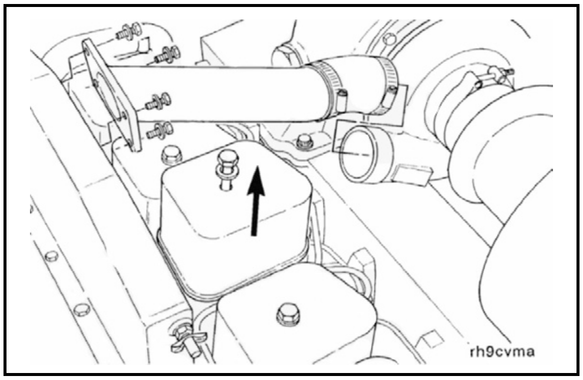


FIGURE 172. REMOVE THE ROCKER LEVER COVERS

2. Clean the rocker lever covers with a strong solution of detergent in hot water.
3. Dry the rocker lever covers with compressed air.

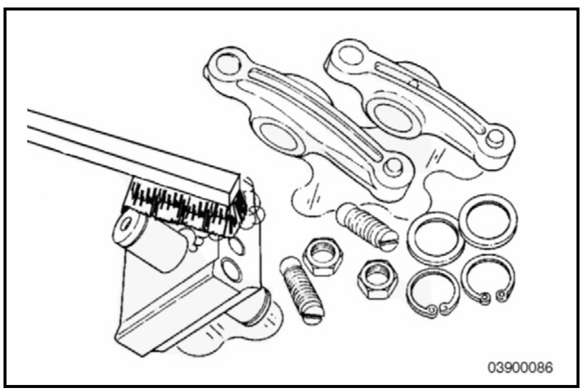


FIGURE 173. DRY WITH COMPRESSED AIR

4. Check the rocker lever covers for cracks.

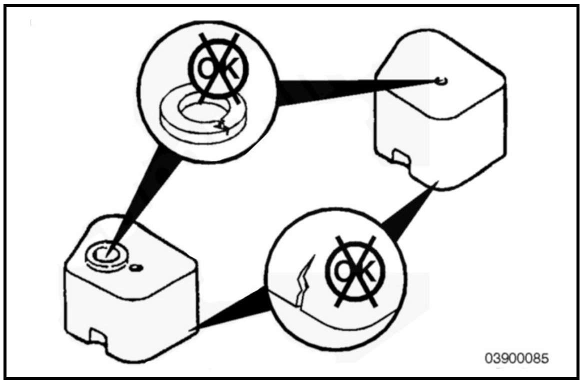


FIGURE 174. CHECK THE ROCKER LEVER COVERS FOR CRACKS

5. Install the rocker lever covers.
6. Tighten the capscrews. Torque value: 18 ft-lb (24 Nm); 15 mm.

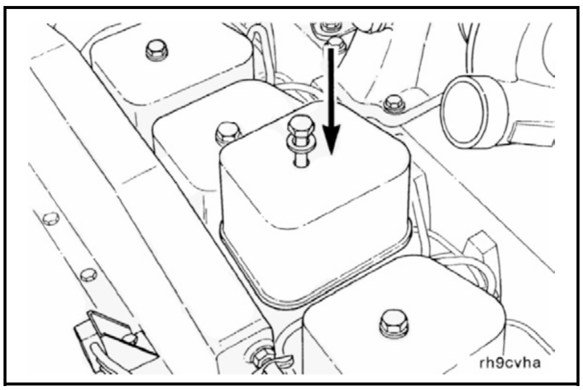


FIGURE 175. TIGHTEN THE CAPSCREWS

Rocker Lever Removal

1. Remove the rocker lever covers.

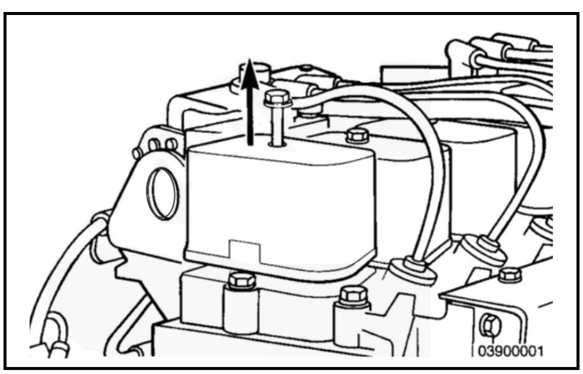


FIGURE 176. REMOVE THE ROCKER LEVER COVERS

2. Loosen the adjusting screw locknuts. Loosen the adjusting screws until they stop. (14 mm)

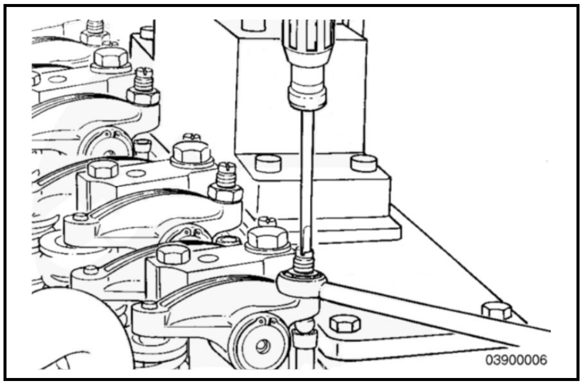


FIGURE 177. LOOSEN THE ADJUSTING SCREW LOCKNUTS AND SCREWS

3. Remove the capscrews from the rocker lever pedestals. Remove the pedestals and rocker lever assemblies.

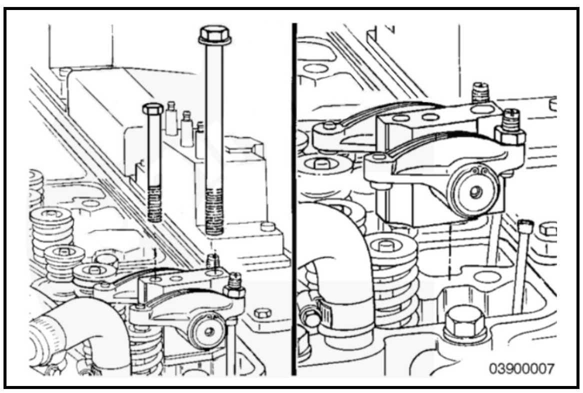


FIGURE 178. REMOVE THE CAPSCREWS, PEDESTALS, AND ROCKER LEVER ASSEMBLIES

4. Mark the push tubes to identify their location.
5. Remove the push tubes.

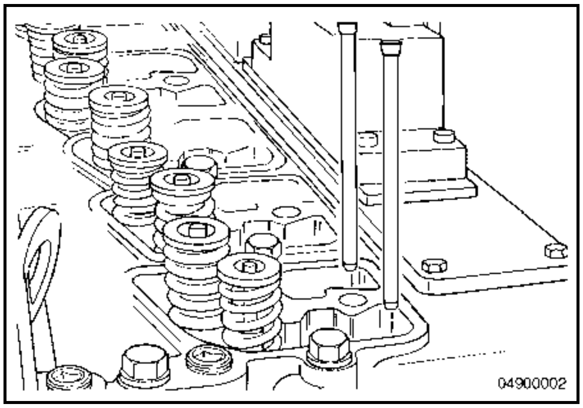


FIGURE 179. REMOVE THE PUSH TUBES

Rocker Lever Installation

1. Install the push tubes as marked during removal.
2. Make sure the dowel rings in the pedestals are installed into the dowel bores.

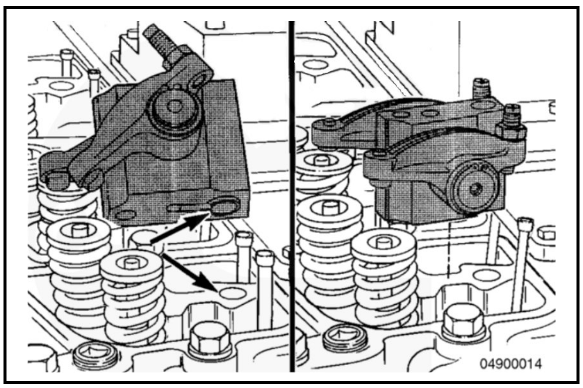


FIGURE 180. DOWEL RINGS INSTALLED INTO DOWEL BORES

3. Inspect all pedestal capscrews for proper length using Service Tool Part Number 3823921.

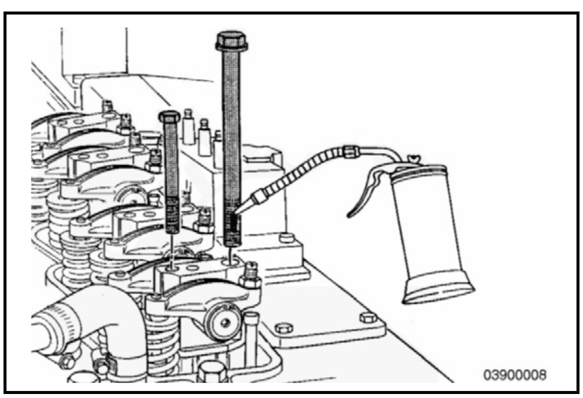


FIGURE 181. INSPECT THE PEDESTAL CAPSCREWS

4. Use clean engine oil to lubricate the threads and under the heads of the capscrews.
5. Install the capscrews into the pedestals:
    a. Tighten the 12 mm pedestal/cylinder head capscrews to 66 ft-lb (90 Nm).

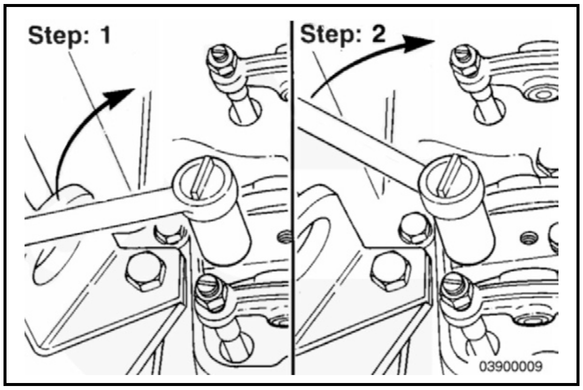


FIGURE 182. TIGHTEN THE 12 MM PEDESTAL/CYLINDER HEAD CAPSCREWS

    b. Tighten the 8 mm pedestal/cylinder head capscrews to 90 ft-lb (120 Nm); 188 mm.
    c. After the 12 mm pedestal/cylinder head capscrews have been tightened to 90 ft-lb (120 Nm), rotate the 12 mm pedestal/cylinder head capscrews an additional 90°.

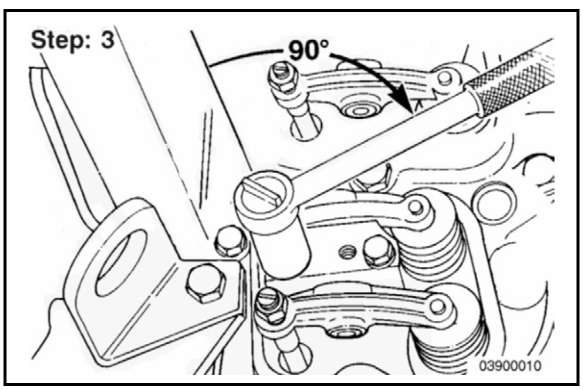


FIGURE 183. ROTATE THE 12 MM PEDESTAL/CYLINDER HEAD CAPSCREWS

6. Tighten the 8 mm pedestal capscrews. Torque value: 18 ft-lb (24 Nm); 13 mm.

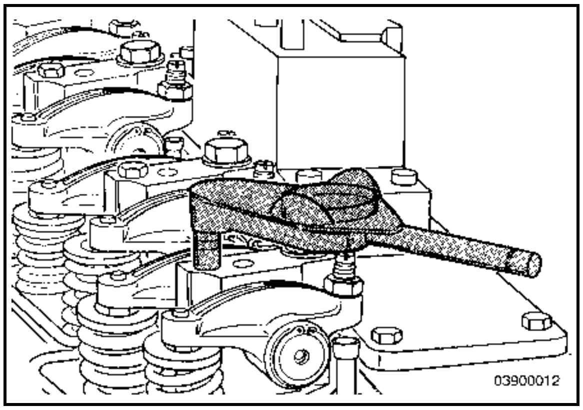


FIGURE 184. TIGHTEN THE 8 MM PEDESTAL CAPSCREWS

7. Adjust the valve lash. Refer to the Overhead Set section.

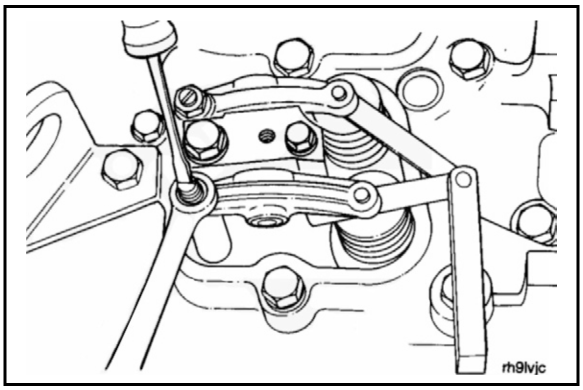


FIGURE 185. ADJUST THE VALVE LASH

8. Install the rocker lever covers. Torque value: 18 ft-lb (24 Nm); 15 mm.

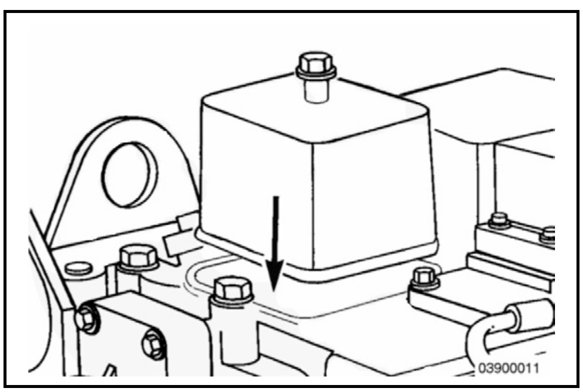


FIGURE 186. INSTALL THE ROCKER LEVER COVERS

12.4 Push Tube or Rod Maintenance

1. Remove the rocker lever cover(s). Refer to the Rocker Lever Covers section.
2. Remove the rocker levers. Refer to the Rocker Lever section.
3. Remove the push tubes.

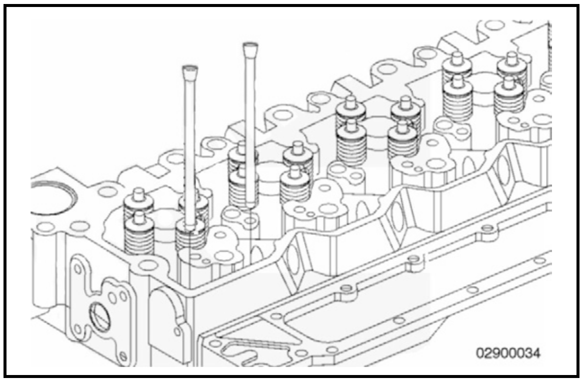


FIGURE 187. REMOVE THE PUSH TUBES

4. Clean the push tubes in hot, soapy water.

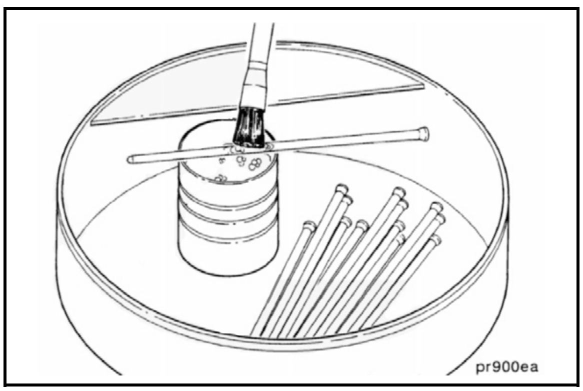


FIGURE 188. CLEAN THE PUSH TUBES

5. Check the push tube ball and socket for signs of scoring. Check for cracks where the ball and the socket are pressed into the tube.

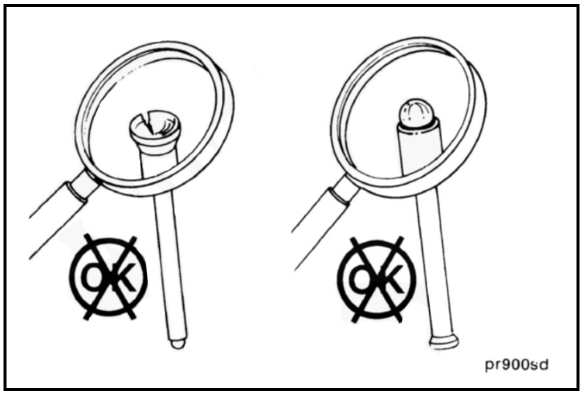


FIGURE 189. CHECK THE PUSH TUBE BALL AND SOCKET FOR SCORING AND CRACKS

6. Check the push tubes for roundness and straightness.

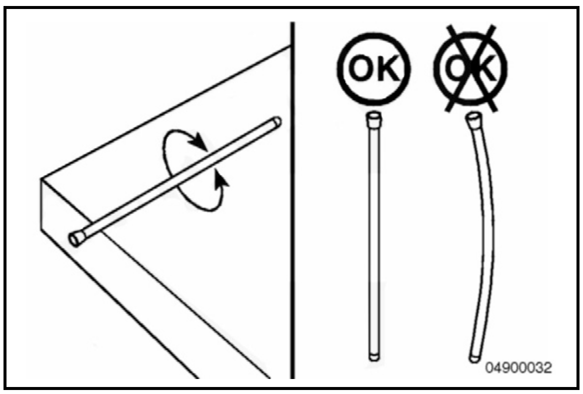


FIGURE 190. INSPECT THE PUSH TUBES

7. Install the push tubes into the sockets of the valve tappets. Lubricate the push tube sockets with clean lubricating engine oil.

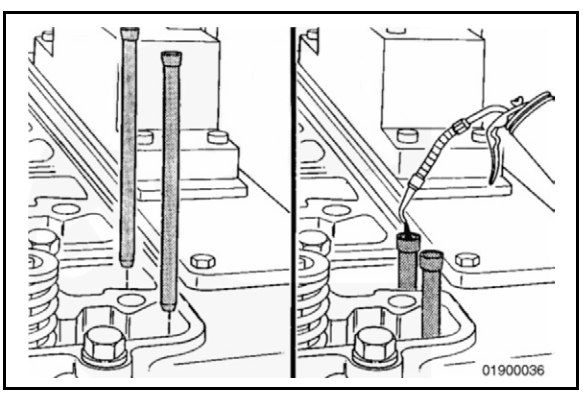


FIGURE 191. INSTALL THE PUSH TUBES AND LUBRICATE THE PUSH TUBE SOCKETS

8. Install the rocker levers. Refer to the Rocker Lever section.

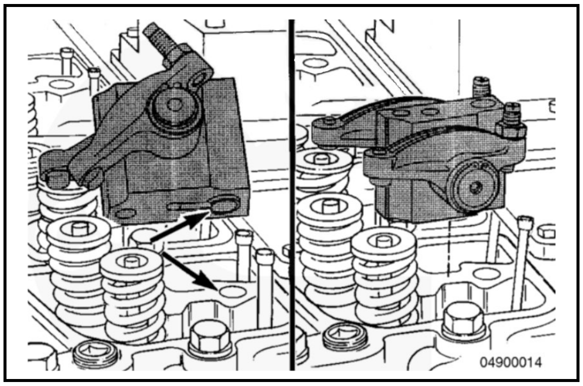


FIGURE 192. INSTALL THE ROCKER LEVERS

9. Adjust the valves. Refer to the Valve Adjustment section.

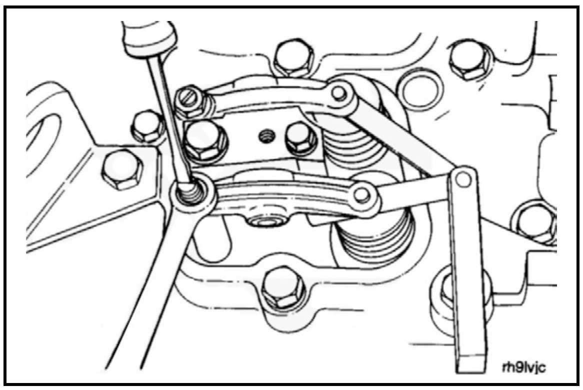


FIGURE 193. ADJUST THE VALVES

10. Install the valve covers. Torque value: 18 ft-lb (24 Nm); 15 mm.

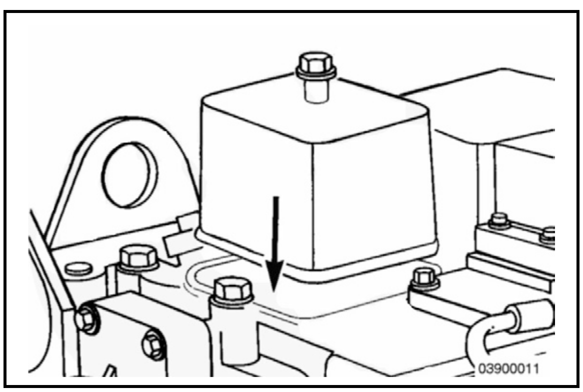


FIGURE 194. INSTALL THE VALVE COVERS

12.5 Flywheel Maintenance

⚠ WARNING

The component weighs 51 lb (23 kg) or more. To avoid personal injury, use a hoist or get assistance to lift the component.

⚠ WARNING

When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.

⚠ WARNING

Compressed air used for cleaning should not exceed 30 psi (207 kPa). Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause bodily injury.

⚠ WARNING

When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to avoid personal injury.

⚠ WARNING

Do not use a cracked or resurfaced flywheel. These can break, causing serious personal injury or property damage.

1. Remove the alternator. Refer to the Alternator Removal and Installation section.

   NOTICE

   Use the barring tool (Part No. 3824591) to hold the flywheel, which will prevent rotation.

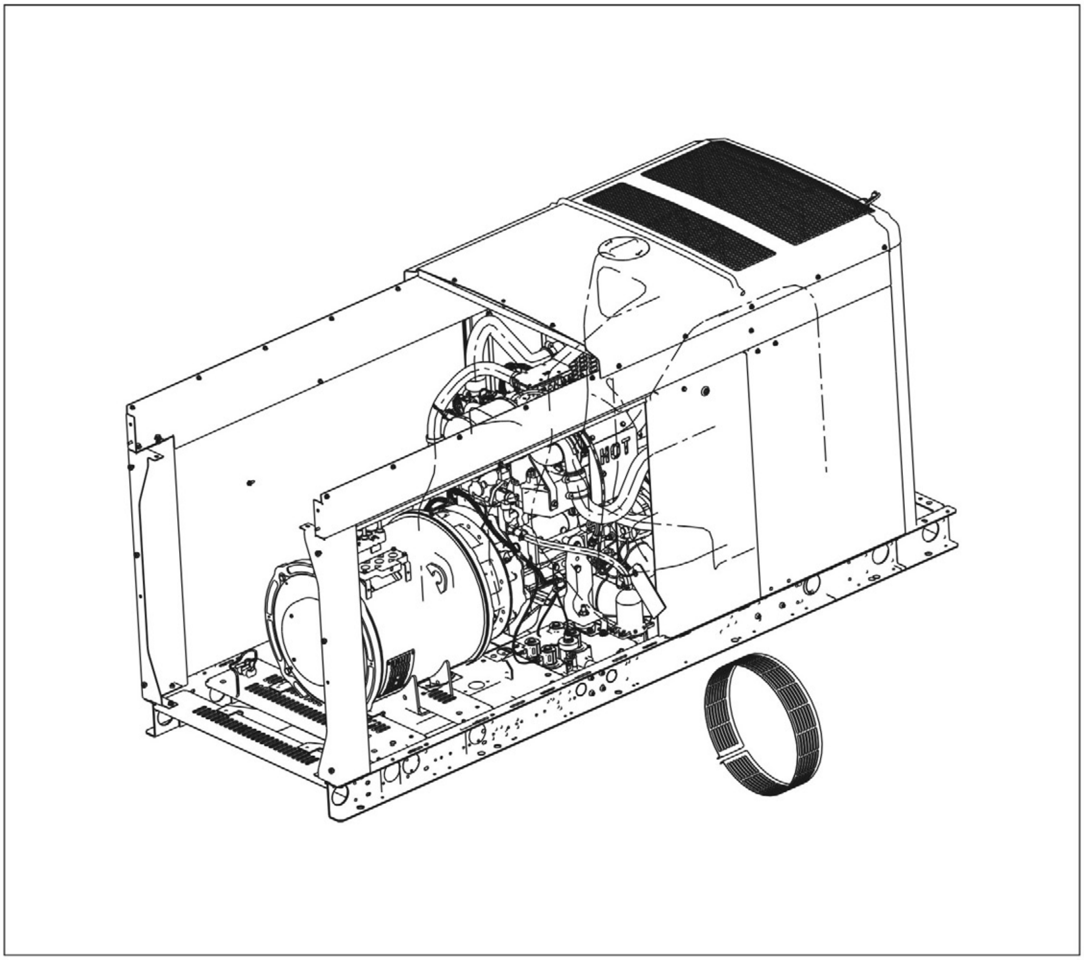


FIGURE 195. REMOVE THE ALTERNATOR

2. Remove two capscrews 180° apart.

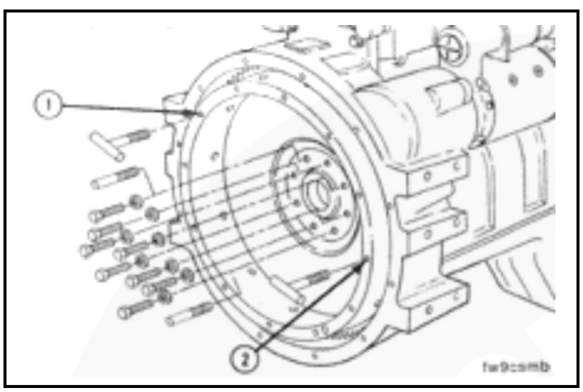


FIGURE 196. REMOVE TWO CAPSCREWS

3. Install two M12 x 1.25 x 90-mm guide pins.
4. Determine the capscrew thread design and size, and install two t-handles (3/8-16 thread) in the flywheel at points 1 and 2.
5. Remove the remaining six flywheel mounting capscrews.

6. Remove the flywheel from the guide pins.

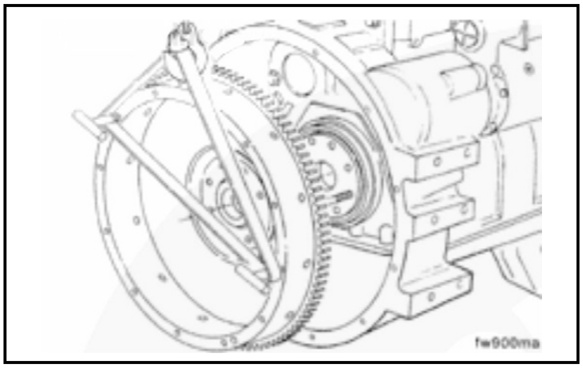


FIGURE 197. REMOVE THE FLYWHEEL

7. Use a wire brush to clean the crankshaft pilot bore.

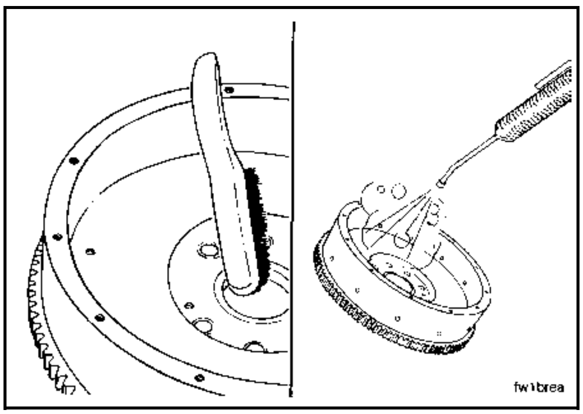


FIGURE 198. USE A WIRE BRUSH TO CLEAN THE BORE

8. Use steam or solvent to clean the flywheel.
9. Dry with compressed air.
10. Inspect the flywheel for cracks, nicks and burrs.

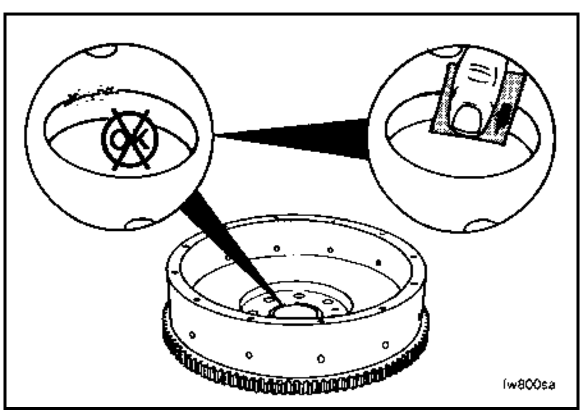


FIGURE 199. INSPECT THE FLYWHEEL FOR CRACKS, NICKS AND BURRS

11. Use a Scotch-Brite™ 7448 pad (or equivalent) to remove small nicks and burrs.
12. Inspect the flywheel ring gear teeth for cracks and chips. If the ring gear teeth are cracked or broken, replace the flywheel. Proceed to Step 19.

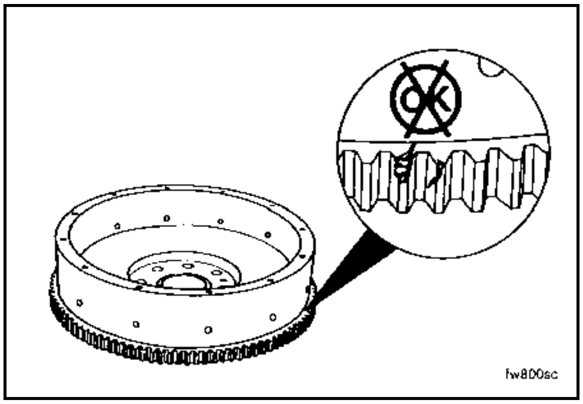


FIGURE 200. INSPECT THE FLYWHEEL RING GEAR TEETH

13. Use the barring tool (Part No. 3824591) to rotate the crankshaft one complete revolution. The flywheel must not show excessive runout.

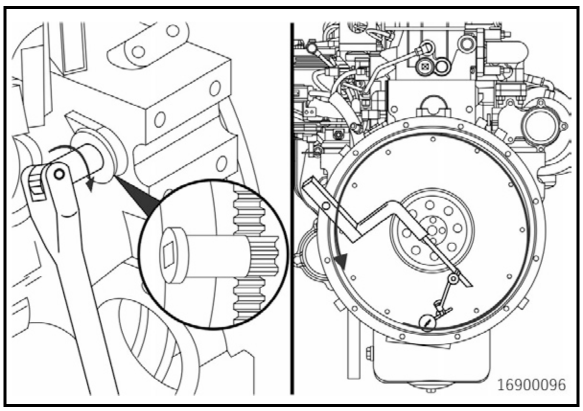


FIGURE 201. ROTATE THE CRANKSHAFT

14. Measure the flywheel runout at four equal points on the flywheel.

NOTICE
Be sure to push the flywheel toward the front of the engine to remove the crankshaft end clearance each time a point is measured.

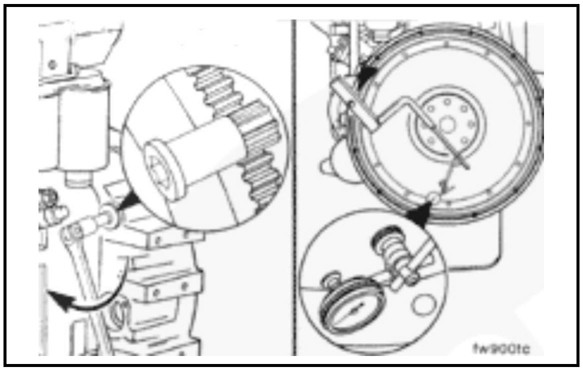


FIGURE 202. MEASURE THE FLYWHEEL RUNOUT

15. Check the total indicator reading (TIR). Verify that it does not exceed the specifications in the table below:

Flywheel Radius (A)	Runout Tolerance for Flywheel Face Radius
8 in (203 mm)	0.008 in (0.203 mm)
10 in (254 mm)	0.010 in (0.254 mm)
12 in (305 mm)	0.012 in (0.305 mm)
14 in (356 mm)	0.014 in (0.356 mm)
16 in (406 mm)	0.016 in (0.406 mm)

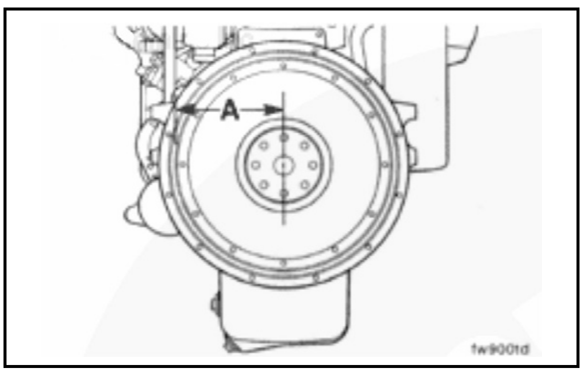


FIGURE 203. CHECK THE TIR

16. If the flywheel face runout is not within specifications:

    a. Remove the flywheel.

    b. Check for nicks, burrs, or foreign material between the flywheel mounting surface and crankshaft flange.

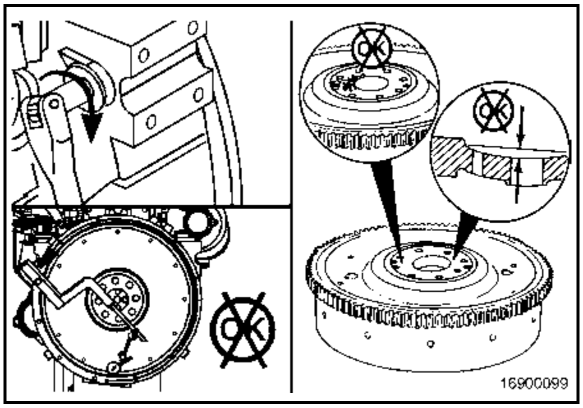


FIGURE 204. REMOVE THE FLYWHEEL AND INSPECT BETWEEN THE FLYWHEEL MOUNTING SERVICE AND CRANKSHAFT FLANGE

17. Install the alternator. Refer to the Alternator Removal and Installation section.
18. Inspect the rear face of the crankshaft and flywheel mounting flange for cleanliness and raised nicks or burrs.

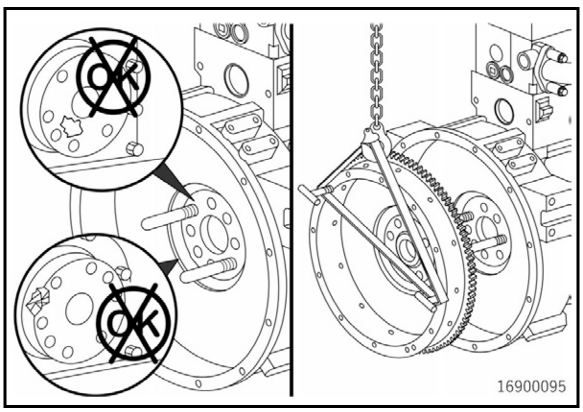


FIGURE 205. INSPECT THE REAR FACE OF THE CRANKSHAFT AND FLYWHEEL MOUNTING FLANGE

19. Install the flywheel on the guide pins.
20. Lubricate the threads of the capscrews and the surface of the washers with clean lubricating engine oil.

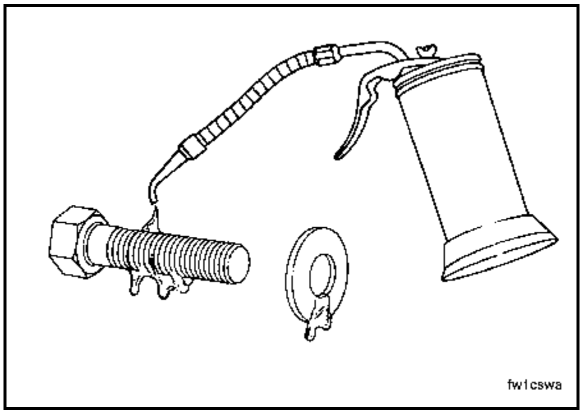


FIGURE 206. LUBRICATE CAPSCREW THREADS AND WASHER SURFACES

21. Install the six capscrews.
22. Remove the t-handles and guide pins.

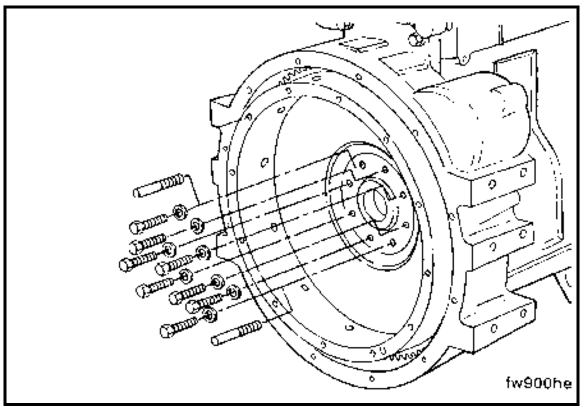


FIGURE 207. REMOVE THE T-HANDLES AND GUIDE PINS

23. Install the remaining capscrews into the holes from which the guide pins were removed.
24. Using the barring tool (Part No. 3824591) to hold the crankshaft, tighten the flywheel capscrews in a star pattern. Torque value: 101 ft-lb (137 Nm), 18 mm.

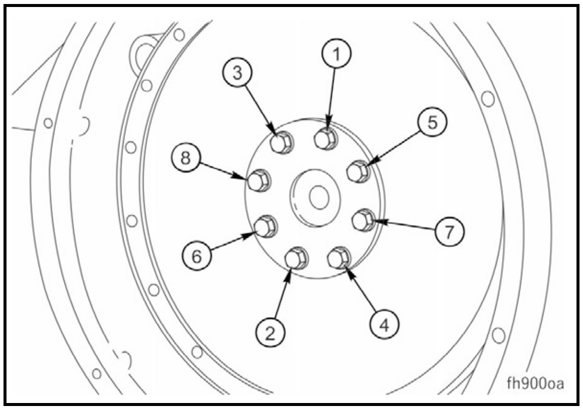


FIGURE 208. USE THE BARRING TOOL TO HOLD THE FLYWHEEL AND TIGHTEN THE CAPSCREWS

25. Refer to the equipment manufacturer's procedures to install the transmission.

12.6 Engine Removal and Installation

1. Make sure the generator set is disabled.
   a. Press the STOP button on the operator panel to make sure the control is in the Off mode.
   b. If equipped, activate the E-stop button.
   c. If equipped, disconnect the battery charger. Remove any other electrical supply sources.
   d. Remove AC power to the customer's AC connections.
   e. Disconnect the negative (-) cable from the battery and secure it from contacting the battery terminals to prevent accidental starting.
2. Drain engine oil and coolant.
3. Shut off the generator fuel supply.
4. Remove:
   - Enclosure doors, roof panels and exhaust endcap
   - Fan guards
   - Muffler
   - Radiator for access to fan hub
   - Fan and fan hub
   - Heavy-duty air cleaner assembly (if present) and brackets
   - Charge air cooler piping (if present)
   - Disconnect oxygen sensor from engine harness
   - Exhaust pipe from turbocharger to bulkhead

5. Disconnect:
   - Fuel hose from IEPR/DEPR
   - Mixer from turbocharger inlet
   - Crankshaft position sensor
   - Camshaft sensor
   - TMAP sensor plug from engine harness
   - Humidity sensor plug (lean burn sets only)
   - Throttle body engine harness plug
   - Crankcase breather hose between crankcase breather valve and air intake
   - Crankcase breather drain hose from oil pan
   - Crankcase breather intake hose from crankcase breather on crankcase cover
   - Engine harness at IEPR/DEPR plug (56 or 90 pin connector)
6. Remove the fuel system, air filter assembly (IEPR/DEPR, mixer, throttle body), and brackets.
7. Remove the engine coolant heater hose.
8. Disconnect the spark plug wires and remove the shields from the spark plugs.
9. Disconnect the ignition coils from the engine harness.
10. Remove the ignition coil mounting bracket with the crankcase breather and ignition coils in place.
11. Turbocharger models only:
    a. Remove the throttle body from the intake manifold.
    b. Disconnect the turbocharger oil drain and supply lines.
    c. Disconnect and remove the turbocharger.
12. Remove the exhaust manifold.
13. Remove the upper and lower radiator hoses from the engine.
14. Disconnect the coolant level switch (if present) from the engine harness.
15. Remove all wiring connections from the starter. Use zip ties (or something similar) to keep the multiple terminal connections together for reassembly.
16. If option code E154-2 (extreme cold weather package) appears on the option code label on the generator set, perform the following steps:
    a. Remove the starter bolts with a 17 mm 12-pt. socket wrench.
    b. Remove the starter.

NOTICE

The new engine comes with the standard starter installed; if there is an extreme cold weather starter on the old engine, you will need to install it on the new engine.

17. Disconnect the following:
    - Coolant temperature sender
    - Oil pressure sender
    - Fuel solenoid connections
    - Any remaining engine harness to engine connections
18. Remove the engine harness from the engine.
19. Remove the intake manifold.
20. Install the engine lifting bracket into the right-most intake manifold bolt holes in the engine block, as shown below.

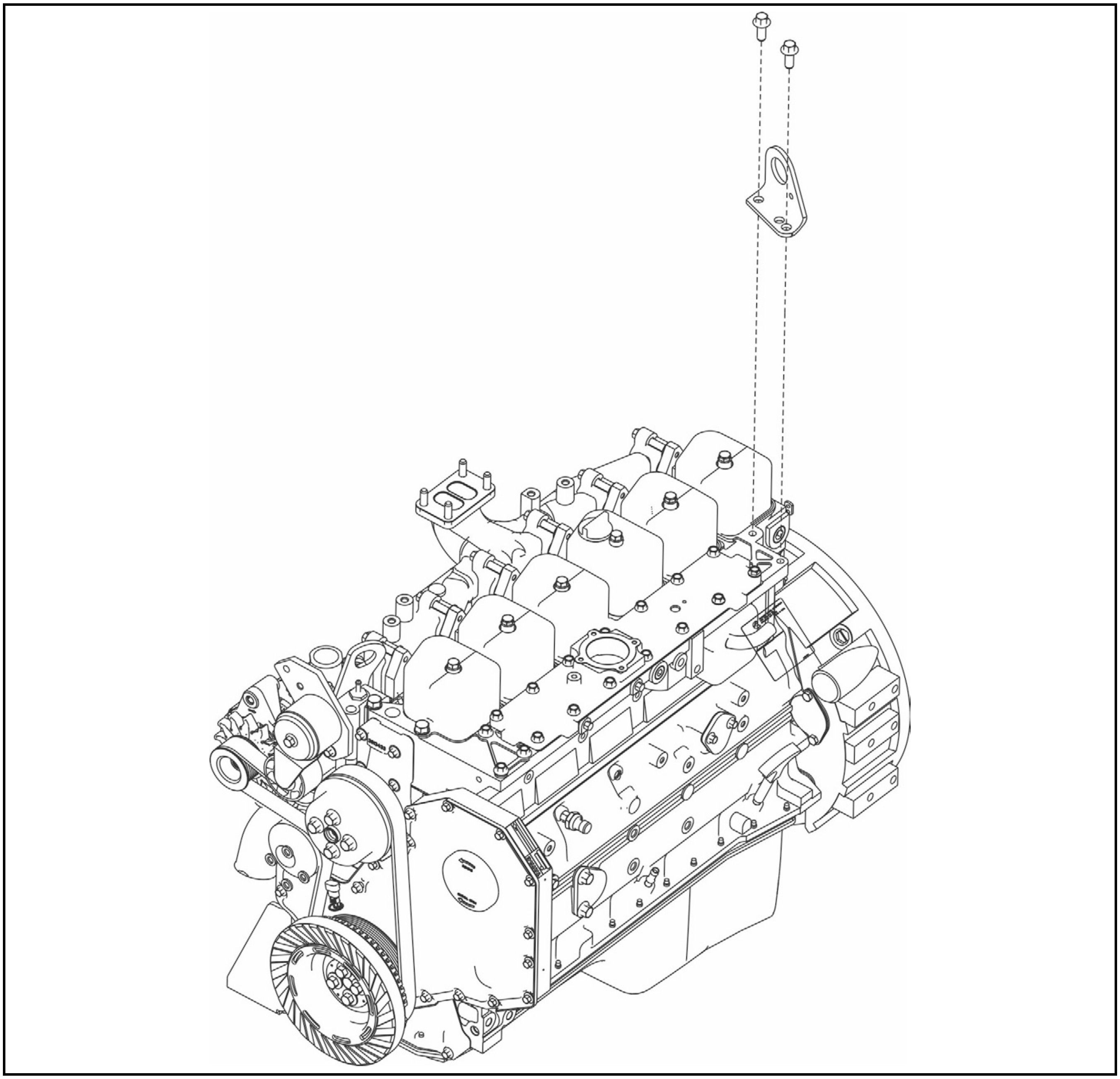


FIGURE 209. INTAKE MANIFOLD BOLTS AND BOLT HOLES

21. Support the engine and alternator separately at the flywheel housing to alternator connection before disconnecting the engine from the alternator.

⚠ CAUTION
Alternator rotor to stator contact can damage windings and cause failure of the alternator. Protect rotor and stator windings by inserting a thin flexible spacer between the rotor and stator before disconnecting from the flywheel housing or flywheel.

22. Remove the alternator access guards from the flywheel housing.
23. Remove the bolts that connect the alternator drive disc to the flywheel.
24. Gently lower the rotor onto the stator.
25. Remove the bolts that connect the flywheel housing to the alternator housing.
26. Use the two engine lifting brackets to safely support the engine on a lift or hoist while removing the engine isolator brackets from the engine.
27. Remove one engine isolator bracket from the skid to allow the engine to swing away from the skid.
28. Lower the engine to a properly supported position. Remove the following components from the engine block:
    - Crankshaft sensor
    - Camshaft sensor
    - Oil pressure sensor
    - Coolant temperature sensor
    - Crankcase breather drain fitting
    - Coolant heater fittings
    - Turbocharger oil supply fitting from oil filter head
    - Turbocharger oil drain hose and mounting clip
    - Engine block ground strap
    - Engine harness mounting clips
    - Remaining engine isolator bracket

ENGINE INSTALLATION

1. On the new engine block, install the following components that were previously removed:
    - Intake manifold with new gasket
    - Crankshaft sensor
    - Camshaft sensor
    - Oil pressure sensor*
    - Coolant temperature sensor*
    - Crankcase breather drain fitting
    - Coolant heater fittings*
    - Turbocharger oil supply line fitting at oil filter head
    - Turbocharger oil drain fitting into the oil pan*
    - Engine block ground strap
    - Engine harness mounting clips
    - Both engine isolator brackets

*Use sealing adhesive.

2. Safely lift the engine onto the skid using the two engine lifting brackets.
3. Support the flywheel end of the engine to align it with the alternator rotor and housing.
4. Lift the rotor and align the drive disc bolt holes to the flywheel bolt holes, removing the spacer that was inserted between the rotor and the stator.
5. Install the bolts that connect the alternator drive disc to the flywheel. See the Generator Set Coupling section for the tightening procedure.
6. Install the bolts that connect the flywheel housing to the alternator housing.
7. Install the alternator access guards on the flywheel housing.
8. Remove the engine lifting bracket as shown in the figure below from the intake manifold bolt holes in the engine block as shown in Figure 209.
9. Re-install the intake manifold bolts.
10. Attach the engine harness to the engine. Make sure that the harness routing is free from sharp edges and pinch points.
11. Connect the following:
    - Coolant temperature sender
    - Oil pressure sender
    - Fuel solenoid connections
12. If option code E154-2 (extreme cold weather package) appears on the option code label on the generator set, perform the following steps:
    a. Remove the starter from the new engine.
    b. Install the old starter onto the new engine.
    c. Install the starter bolts with a 17 mm 12-pt. socket wrench.
13. Connect all starter wiring connections. (Remove any zip ties first.)
14. Connect the coolant level switch to the engine harness (if present).
15. Attach the upper and lower radiator hoses to the engine.
16. Turbocharged models only:
    a. Install the turbocharger onto the exhaust manifold using a new gasket.
    b. Connect the turbocharger oil drain and supply lines. Use a new oil drain gasket at the turbocharger.
        - When connecting the turbo outlet to the expander hose clamp, do the following:
            i. Open the screw until it stops at the D-nut.

NOTICE
The minimum gap for a D-nut is 3 mm. A gap of 3 - 8 mm is typical for this product.

   ii. Set the window latch to the tightest position. Three windows open is typical for this product.

   c. Install the throttle body in the intake manifold. Install a new gasket between the throttle body and the intake manifold.

17. Install the ignition coil mounting bracket with the crankcase breather and ignition coils in place.
18. Connect the ignition coils to the engine harness.
19. Connect the spark plug wires to the spark plugs and install the spark plug shields.
20. Install the engine coolant heater hose.
21. Install the fuel system, air filter assembly (IEPR/DEPR, mixer, throttle body), and brackets.
22. Connect:
    - Fuel hose to IEPR/DEPR
    - Mixer to turbocharger inlet
    - Crankshaft position sensor
    - Camshaft sensor
    - TMAP sensor plug to engine harness
    - Humidity sensor plug (lean burn sets only)
    - Throttle body engine harness plug
    - Crankcase breather hose between crankcase breather valve and air intake
    - Crankcase breather drain hose to oil pan
    - Crankcase breather intake hose to crankcase breather on crankcase cover
    - Engine harness at IEPR/DEPR plug (56 or 90 pin connector)
    - Any remaining engine harness to engine connections
23. Install:
    - Enclosure doors, roof panels and exhaust endcap
    - Fan guards
    - Muffler
    - Radiator for access to the fan hub
    - Fan and fan hub
    - Heavy-duty air cleaner assembly (if present) and brackets
    - Charge air cooler piping (if present)
    - Oxygen sensor to the engine harness
    - Exhaust pipe from the turbocharger to the bulkhead
24. Turn on the generator fuel supply.

25. Fill with engine oil and coolant.
26. Connect the generator battery. Connect the negative terminal last.
27. Connect and turn on AC accessory power from customer AC connection terminals.
28. Test run the generator.

TABLE 25. ENGINE REMOVAL AND INSTALLATION TORQUE SPECIFICATIONS

Components	Torque Value
Engine Lifting Bracket Service Part Bolts	34.7 - 42.0 ft-lb (47 - 57 Nm)
Coolant Heater Hose Fitting into Adapter at Head	Use sealant. Tighten to 1-1/2 to 2-1/2 turns past finger tight.
Upper Coolant Heater Fitting into Head	Use sealant. 7.2 - 8.8 ft-lb (9.8 - 11.9 Nm)
Coolant Heater Fitting near Breather	Use sealant. 7.2 - 8.8 ft-lb (9.8 - 11.9 Nm)
Coolant Outlet Hose at Thermostat Housing (Upper Radiator Hose)	2.0 - 2.5 ft-lb (2.8 - 3.4 Nm)
Coolant Inlet Hose at Block (Lower Radiator Hose)	2.0 - 2.5 ft-lb (2.8 - 3.4 Nm)
Engine Ground Strap Bolts	17.7 - 21.4 ft-lb (24 - 29 Nm)
Engine Isolator Mount to Engine Block Bolts	60.5 - 73.8 ft-lb (82 - 100 Nm)
Alternator Air Outlet Screen Bolts	5.9 - 7.2 ft-lb (8 - 9.7 Nm)
Alternator Cover Adaptor Bolts	5.9 - 7.2 ft-lb (8 - 9.7 Nm)
Alternator Drive Disc to Engine Flywheel Bolts	34.7 - 42.0 ft-lb (47 - 57 Nm)
Alternator Housing to Flywheel Housing Bolts	34.7 - 42.0 ft-lb (47 - 57 Nm)
Starter Bolts	27.3 - 32.5 ft-lb (37 - 49 Nm)
Clip for Oil Drain Hose	60.5 - 73.8 ft-lb (82 - 100 Nm)
Battery Cable Bolts	60.5 - 73.8 ft-lb (82 - 100 Nm)

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13 Alternators

13.1 General Description

The UC22/27 range of alternators has a brushless rotating field design, available from 240VAC to 600VAC, 60Hz, and built to meet BS5000 Part 3 and international standards.

All of the UC22/27 range are self-excited as standard with excitation power derived from the main output windings.

A permanent magnet generator (PMG) powered excitation system is available as an option.

13.2 Air Flow

Make sure that the air inlets and outlets are not obstructed when the alternator is running.

13.3 Humid Conditions

The water carrying capacity of air depends on temperature. If the air temperature falls below its saturation point, dew may form on the windings, reducing the electrical resistance of the insulation. In humid conditions, additional protection may be required even if the alternator is fitted inside an enclosure. Anti-condensation heaters are supplied on request.

13.4 Anti-Condensation Heaters

⚠ DANGER
Live Electrical Conductors ***Live electrical conductors can cause serious injury or death by electric shock and burns.*** ***To prevent injury and before removing covers over electrical conductors, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.***

Power to the anti-condensation heater is supplied from a separate source. Anti-condensation heaters raise the air temperature around the windings to deter condensation forming in humid conditions when the alternator is not operating. Best practice is to energize the heaters automatically when the alternator is off.

13.5 Alternator Removal and Installation

ALTERNATOR REMOVAL

1. Make sure the generator set is disabled.
    a. Press the STOP button on the operator panel to make sure the control is in the Off mode.
    b. If equipped, activate the E-stop button.
    c. If equipped, disconnect the battery charger. Remove any other electrical supply sources.
2. Remove AC power to the customer’s AC connections.
3. Disconnect the negative (-) cable from the battery and secure it from contacting the battery terminals to prevent accidental starting.
4. Remove the enclosure doors and roof panel above alternator (in preparation for lifting the alternator).
5. Remove the enclosure intake endcap.
6. Remove the electrical "dome" over the alternator.
7. Clearly mark and remove all wiring on the output side of the connection block. Do NOT remove stator leads from the connection block.
8. If present, disconnect PMG or EBS wiring.
9. Remove the wiring harness mounting clips from the alternator housing.
10. Support the engine and alternator separately at the flywheel housing to alternator connection before disconnecting the engine from the alternator.

⚠ CAUTION
Alternator rotor to stator contact can damage windings and cause failure of the alternator. Protect rotor and stator windings by inserting a thin flexible spacer between the rotor and stator before disconnecting from the flywheel housing or flywheel.

11. Remove the alternator access guards from the flywheel housing.
12. Remove the bolts that connect the alternator drive disc to the flywheel.
13. Gently lower the rotor onto the stator (with the spacer in place).
14. Remove the bolts that connect the flywheel housing to the alternator housing.
15. Safely support the alternator on a lift or hoist before removing the alternator isolator bracket bolts.
16. Ensure all wiring and wiring harnesses have been disconnected and moved out of the way.
17. Install lifting points onto the alternator.
18. Safely lift the alternator by hooks or shackles attached to the lifting points (lugs or eyes) provided, so that the alternator is out of the way.

ALTERNATOR INSTALLATION

1. Safely lift the alternator into position.

> ⚠ **WARNING**
>
> ***Falling Mechanical Parts***
>
> ***Falling mechanical parts can cause serious injury or death by impact, crushing, severing or trapping.***
>
> ***To prevent injury and before lifting the alternator:***
>
> - ***Do not lift the complete generator set by the alternator lifting fixtures.***
> - ***Keep the alternator horizontal when lifting.***
> - ***Fit drive end and non-drive end transit fittings to single bearing alternators to keep the main rotor in the frame.***

2. Before coupling, remove the drive end (DE) transit arrangement.
3. Safely lift the alternator by hooks or shackles attached to the lifting points (lugs or eyes) provided. A label attached to a lifting point (shown below) shows the correct lifting arrangement.
   - Use chains of sufficient length, and a spreader bar if necessary, to make sure that the chains are vertical when lifting.
   - Make sure that the capacity of the lifting equipment is sufficient for the alternator mass shown on the label.

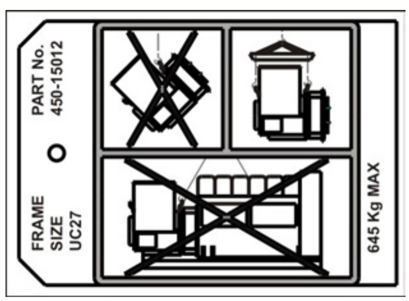


FIGURE 210. LIFTING LABEL

4. Support the engine and alternator separately at the flywheel housing to alternator connection before reconnecting the engine to the alternator.
5. Remove the spacer (or transit bar if this is a new alternator) from between the rotor and the stator.
6. Install the bolts that connect the alternator drive disc to the flywheel. Torque value: 34.7 - 42.0 ft-lb (47 - 57 Nm).
7. Couple the alternator by following the procedure in the **Single Bearing** section. For more information, see the **Generator Set Coupling** section.
8. Install the bolts that connect the flywheel housing to the alternator housing. Torque value: 34.7 - 42.0 ft-lb (47 - 57 Nm).

9. After coupling, remove the non-drive end (NDE) transit bar.
10. Install the alternator access guards on the flywheel housing.

⚠ CAUTION
Alternator rotor to stator contact can damage windings and cause failure of the alternator. Protect rotor and stator windings by inserting a thin flexible spacer between the rotor and stator before disconnecting from the flywheel housing or flywheel.

11. Re-attach the wiring harness mounting clips to the alternator housing.
12. If present, reconnect PMG or EBS wiring.
13. Install all wiring on the output side of the connection block. Make sure connections are made exactly as they were marked when the alternator was removed.

⚠ CAUTION
Incorrect alternator connections may cause catastrophic damage to the alternator and/or generator controls.

14. Ensure that the wiring harness has been reinstalled properly.
15. Install the electrical "dome" over the alternator. Torque bolts to 7.4 - 8.9 ft-lb (10 - 12 Nm).
16. Install the enclosure intake endcap. Torque values:
    - Bolts that mount to the skid: 6.6 - 8.1 ft-lb (9 - 11 Nm)
    - All other enclosure panel bolts: 4.4 - 5.9 ft-lb (6 - 8 Nm)
17. Install the enclosure roof panel above the alternator, using the torque values identified in the previous step.
18. Install the enclosure doors.
19. Reconnect the negative (-) cable to the battery.
20. Restore AC power to the customer's AC connections.
21. Test run the generator set.

13.6 Bearings

Bearing Life

Factors that reduce bearing life or lead to bearing failure include:

- Adverse operating conditions and environment
- Stress caused by misalignment of the generator set
- Vibration from the engine that exceeds the limits in BS 5000-3 and ISO 8528-9

- Long periods (including transportation) when the alternator is stationary and subjected to vibration can cause false brinelling wear (flats on the balls and grooves on the races)
- Humid or wet conditions that cause corrosion and deterioration of the grease by emulsification.

Sealed Bearings

Inspect sealed-for-life bearings periodically. Check for signs of wear, fretting or other detrimental features. Damage to seals, grease leakage or discoloration of the bearing races indicate that the bearing may need to be replaced.

Generator Set Coupling

⚠ WARNING
Moving Mechanical Parts ***Moving mechanical parts during generator set coupling can cause serious injury by crushing, severing or trapping.*** ***To prevent injury, keep arms, hands and fingers away from mating surfaces when coupling the generator set.***

NOTICE
Do not attempt to rotate the alternator rotor by levering against the vanes of the cooling fan. The fan is not designed to withstand such forces and will be damaged.

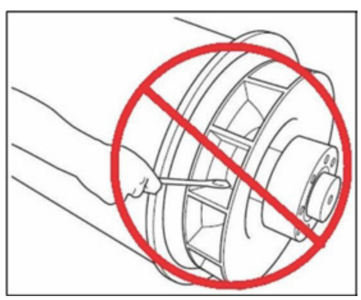


FIGURE 211. DO NOT ROTATE THE ALTERNATOR ROTOR USING THE COOLING FAN VANES.

Efficient operation and long component life depend on minimizing mechanical stresses on the alternator. When coupled in a generator set, misalignment and vibration interactions with the prime mover engine can cause mechanical stress.

Generator sets need a substantial flat continuous bedplate to suit the installation site floor loading, with engine and alternator mounting pads to make a firm base for accurate alignment. The height of all mounting pads must be within 0.25 mm for skid mounting, 3 mm for non-adjustable anti-vibration mounts (AVM) or 10 mm for adjustable height AVMs. Use shims to a level base. The rotational axes of alternator rotor and engine output shaft must be coaxial (radial alignment) and perpendicular to the same plane (angular alignment). The axial alignment of the alternator and engine coupling must be within 0.5 mm, to allow for thermal expansion without unwanted axial force on the bearings at operating temperature.

Vibration can occur by flexing of the coupling. The alternator is designed for a maximum bending moment not exceeding 140 kgm (1000 ft-lb). Check the maximum bending moment of the engine flange with the engine manufacturer.

Close-coupling of alternator and engine can increase the rigidity of the generator set. The generator set builder must supply guarding for open-coupled applications.

To prevent rust during transit and storage, the alternator frame spigot, rotor coupling plates and shaft extension have been treated with a rust preventive coating. Remove this before coupling the generator set.

To prevent movement of the rotor during transport, single bearing alternators without a permanent magnet alternator (PMG) have a non-drive end (NDE) transit bracket fitted. Remove the NDE cover, remove the NDE transit bracket and fasteners, and then refit the NDE cover before coupling the generator set.

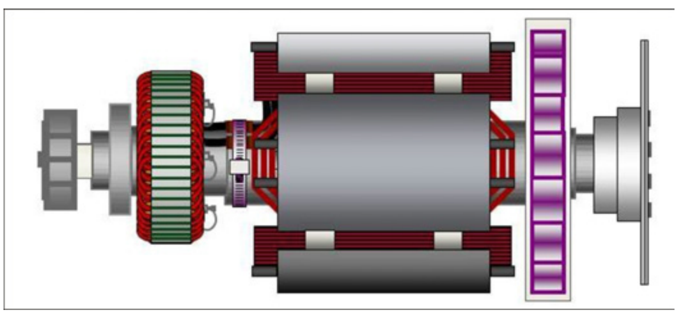


FIGURE 212. SINGLE BEARING ALTERNATOR ROTOR SHOWING COUPLING DISCS BOLTED TO DRIVE END COUPLING HUB (AT RIGHT)

Single Bearing

⚠ WARNING

Falling Mechanical Parts

Falling mechanical parts can cause serious injury or death by impact, crushing, severing or trapping.

To prevent injury and before lifting the alternator:

- ***Do not lift the complete generator set by the alternator lifting fixtures.***
- ***Keep the alternator horizontal when lifting.***
- ***Fit drive end and non-drive end transit fittings to single bearing alternators to keep the main rotor in the frame.***

1. Remove the drive end transit bracket that keeps the rotor in place during transport.
2. Remove the air outlet covers from the drive end of the alternator to access the coupling and adaptor bolts.
3. Make sure the coupling discs are concentric with the adaptor spigot.
4. Fit two alignment dowels into flywheel bolt holes 180 degrees apart to help align the disc and the flywheel.
5. Lift and offer the alternator to the engine, barring the engine over by hand to align discs and flywheel.
6. Engage the alignment dowels into coupling disc bolt holes and push the alternator towards the engine until the coupling discs are against the flywheel face.

NOTICE

Do not pull the alternator to the engine using bolts through the flexible discs.

7. Fit the adaptor bolts, using heavy gauge washers under the heads. Tighten the adapter bolts evenly around the adapter.
8. Check the torque of each bolt in a clockwise direction around the bolt circle to ensure all the bolts are tight. Refer to the engine manufacturer's manual for correct tightening torque.
9. Remove the alignment dowels. Fit the coupling bolts, using heavy gauge washers under the heads.
10. Tighten the bolts to fix the coupling disc to the flywheel, in the sequence shown in Figure 213 on page 284.
11. Check the torque of each bolt in a clockwise direction around the bolt circle to ensure all the bolts are tight.
12. If a PMG is not fitted, remove the NDE transit bracket.

13. Replace all covers.

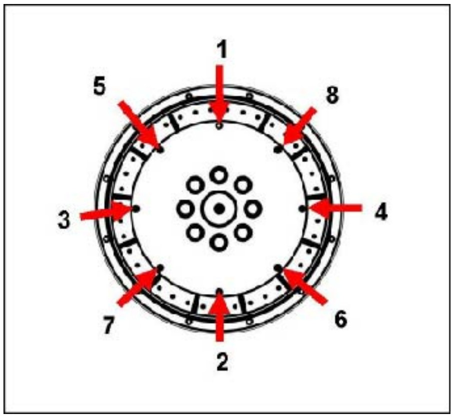
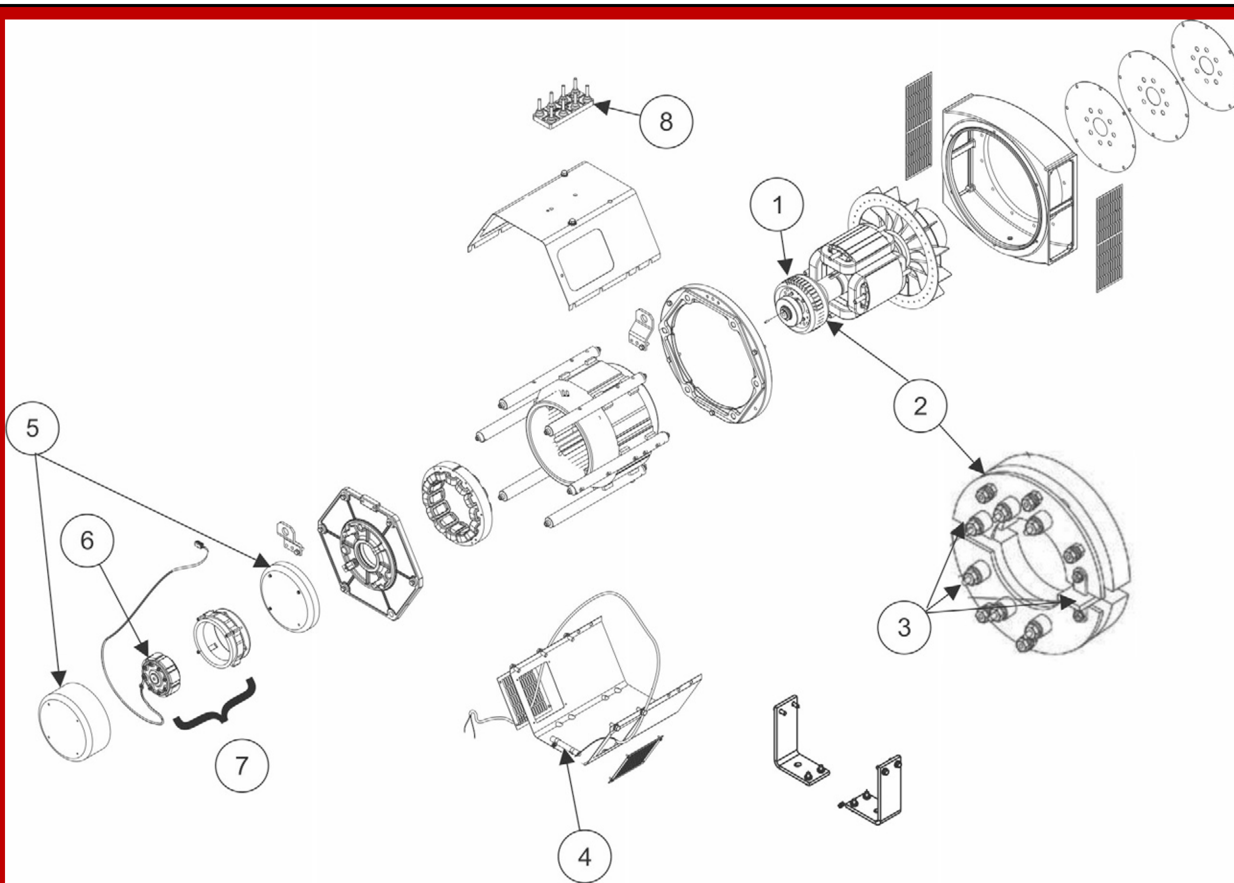


FIGURE 213. FIXING SEQUENCE

NOTICE
The following image is for reference only.



No.	Description	No.	Description
1	NDE Bearing Kit	5	PMG Cover (Cover Included in Kit [#7])
2	Rotating Rectifier Assembly	6	Current PMG Rotor/Stator Repair Kit
3	Diode FRW/REV and Varistor Kit	7	Complete PMG Upfit
4	Heater	8	Main Terminal Board

FIGURE 214. UC SINGLE BEARING ALTERNATOR PARTS

13.7 Rectifier System

Introduction

The rectifier converts alternating current (AC) induced in the exciter rotor windings into direct current (DC) to magnetize the main rotor poles. The rectifier comprises two semicircular annular positive and negative plates, each with three diodes. In addition to connecting to the main rotor, the DC output of the rectifier also connects to a varistor. The varistor protects the rectifier from voltage spikes and surge voltages that may be present on the rotor under various loading conditions of the alternator.

Diodes provide a low resistance to current in one direction only: Positive current will flow from anode to cathode, or another way of viewing it is that negative current will flow from cathode to anode.

The exciter rotor windings are connected to 3 diode anodes to form the positive plate and to 3 diode cathodes to form the negative plate to give full wave rectification from AC to DC. The rectifier is mounted on, and rotates with, the exciter rotor at the non-drive end (NDE).

Safety

⚠ DANGER
Live Electrical Conductors
Live electrical conductors can cause serious injury or death by electric shock and burns.
To prevent injury and before removing covers over electrical conductors, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

⚠ DANGER
Rotating Mechanical Parts
Rotating mechanical parts can cause serious injury or death by crushing, severing or trapping.
To prevent injury and before removing covers over rotating parts, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

Test and Replace Rectifier System Component Requirements

TABLE 26. TEST AND REPLACE RECTIFIER SYSTEM COMPONENT REQUIREMENTS

Personal Protective Equipment (PPE)	Wear appropriate PPE.
Consumables	Loctite 241 thread locking adhesive
	Dow Corning silicone heat sink compound type 340 or similar
Parts	Full set of three anode lead diodes and three cathode lead diodes (all from the same manufacturer)
	One metal-oxide varistor

Tools	Multimeter
	Insulation tester
	Torque wrench

Test and Replace Varistor

1. Inspect the varistor, (if fitted).
2. Record varistor as faulty if there are signs of overheating (discoloration, blisters, melting) or disintegration.
3. Disconnect one varistor lead. Store fastener and washers.
4. Measure the resistance across the varistor. Good varistors have a resistance greater than 100 MΩ.
5. Record the varistor as faulty if the resistance is short circuit or open circuit in either direction. (Some multimeters will read O.L. at high resistance levels. Please be aware of the limits of your tools.)
6. If the varistor is faulty, replace it and replace all diodes.
7. Reconnect and check that all leads are secure, washers fitted and fasteners tight.

Test and Replace Diodes

NOTICE
Do not tighten a diode above the stated torque. The diode will be damaged.

1. Disconnect the lead of one diode where it joins the windings at the insulated terminal post. Store fastener and washers.
2. Measure the voltage drop across the diode in the forward direction, using the diode test function of a multimeter.
3. Measure the resistance across the diode in the reverse direction, using the 1000 VDC test voltage of an insulation tester.
4. Diode is faulty if the voltage drop in the forward direction is outside the range 0.3 to 0.9 VDC, or the resistance is below 20 MΩ in the reverse direction.
5. Repeat the tests for the five remaining diodes.
6. If any diode is faulty, replace the full set of six diodes (same type, same manufacturer):
   a. Remove diode(s).
   b. Apply a small amount of heat sink compound **only** to the base of the replacement diode(s), not the threads.
   c. Check polarity of diode(s).
   d. Screw each replacement diode into a threaded hole in the rectifier plate.

e. Apply 2.6 to 3.1 Nm (23 to 27.4 in-lb) torque to give good mechanical, electrical and thermal contact.

f. Replace the varistor.

7. Reconnect and check that all leads are secure, washers fitted and fasteners tight.

13.8 Windings

Introduction

NOTICE

To avoid equipment damage, disconnect all control wiring, ECM, and customer load leads from alternator winding connections before conducting these tests.

NOTICE

The integrated Automatic Voltage Regulator (AVR) on the generator set control contains electronic components which would be damaged by high voltage applied during insulation resistance tests. The generator set control must be disconnected before doing any insulation resistance test.

Temperature sensors must be grounded to earth before doing any insulation resistance test.

Damp or dirty windings have a lower electrical resistance and could be damaged by insulation resistance tests at high voltage. If in doubt, test the resistance at low voltage (500 V) first.

Alternator performance depends on good electrical insulation of the windings. Electrical, mechanical and thermal stresses, and chemical and environmental contamination, cause the insulation to degrade. Various diagnostic tests indicate the condition of insulation by charging or discharging a test voltage on isolated windings, measuring current flow, and calculating the electrical resistance by Ohm's law.

When a DC test voltage is first applied, three currents can flow:

- **Capacitive Current:** To charge the winding to the test voltage (decays to zero in seconds),
- **Polarizing Current:** To align the insulation molecules to the applied electric field (decays to near-zero in ten minutes), and
- **Leakage Current:** Discharge to earth where the insulation resistance is lowered by moisture and contamination (increases to a constant in seconds).

For an insulation resistance test, a single measurement is made one minute after a DC test voltage is applied, when capacitive current has ended. For the polarization index test, a second measurement is made after ten minutes. An acceptable result is where the second insulation resistance measurement is at least double the first, because the polarization current has decayed. In poor insulation, where leakage current dominates, the two values are similar. A dedicated Insulation Tester takes accurate, reliable measurements and may automate some tests.

Safety

⚠ DANGER

Live Electrical Conductors

Live electrical conductors can cause serious injury or death by electric shock and burns.

To prevent injury and before removing covers over electrical conductors, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

⚠ WARNING

Live Electrical Conductors

Live electrical conductors at the winding terminals after an insulation resistance test can cause serious injury or death by electric shock or burns.

To prevent injury, discharge the windings by shorting to earth through an earthing rod for at least 5 minutes.

Requirements

TABLE 27. WINDING TEST REQUIREMENTS

Requirement	Description
Personal Protective Equipment (PPE)	Wear mandatory site PPE.
Consumables	None
Parts	None
Tools	Insulation test meter
	Multimeter
	Milliohm meter or microohm meter
	Clamp ammeter
	Infrared thermometer
	Earth rod

Test the Insulation Resistance of Windings

NOTICE

The alternator must not be put into service until the minimum insulation resistance is achieved.

TABLE 28. TEST VOLTAGE AND MINIMUM ACCEPTABLE INSULATION RESISTANCE FOR NEW AND IN-SERVICE ALTERNATORS

Component	Test Voltage (V)	Minimum Insulation Resistance at 1 Minute (MΩ)	
		New	In-Service
Main Stator	500	10	5
Exciter Stator	500	10	5
Exciter Rotor, Rectifier & Main Rotor Combined	500	10	5

1. Inspect the windings for mechanical damage or discoloration from overheating. Clean the insulation if there is hygroscopic dust and dirt contamination.
2. For main stators:
   a. Disconnect the neutral to earth conductor (if equipped).
   b. Connect together the three leads of all phase windings (if possible).
   c. Apply the test voltage from the table between any phase lead and earth.
   d. Measure the winding insulation resistance after 1 minute (IR_{1min}). Disconnect all control wiring and customer load leads from the alternator winding connections before conducting these tests.
   e. Discharge the test voltage with an earth rod for 5 minutes.
   f. If the measured insulation resistance is less than the minimum acceptable value, dry the insulation, and then repeat the method.
   g. If minimum resistance is not above listed, replace the main stator.
   h. Reconnect neutral to earth conductor (if equipped).
3. For exciter stators, and combined exciter and main rotors:
   a. Connect together both ends of the winding (if possible).
   b. Apply the test voltage from the table between the winding and earth.
   c. Measure the winding insulation resistance after 1 minute, IR_{1min}. Insulation should be measured with winding temperatures of 20 °C.
   d. Discharge the test voltage with an earth rod for 5 minutes.
   e. If the measured insulation resistance is less than the minimum acceptable value, dry the insulation, and then repeat the method.

f. Repeat the method for each winding.
g. If minimum resistance is not above listed, replace the exciter stator.
h. Remove the connections made for testing.

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Appendix A. Wiring Diagrams

Table of Contents

The drawings included in this section are representative. For current complete information, refer to the drawing package that was shipped with the unit.

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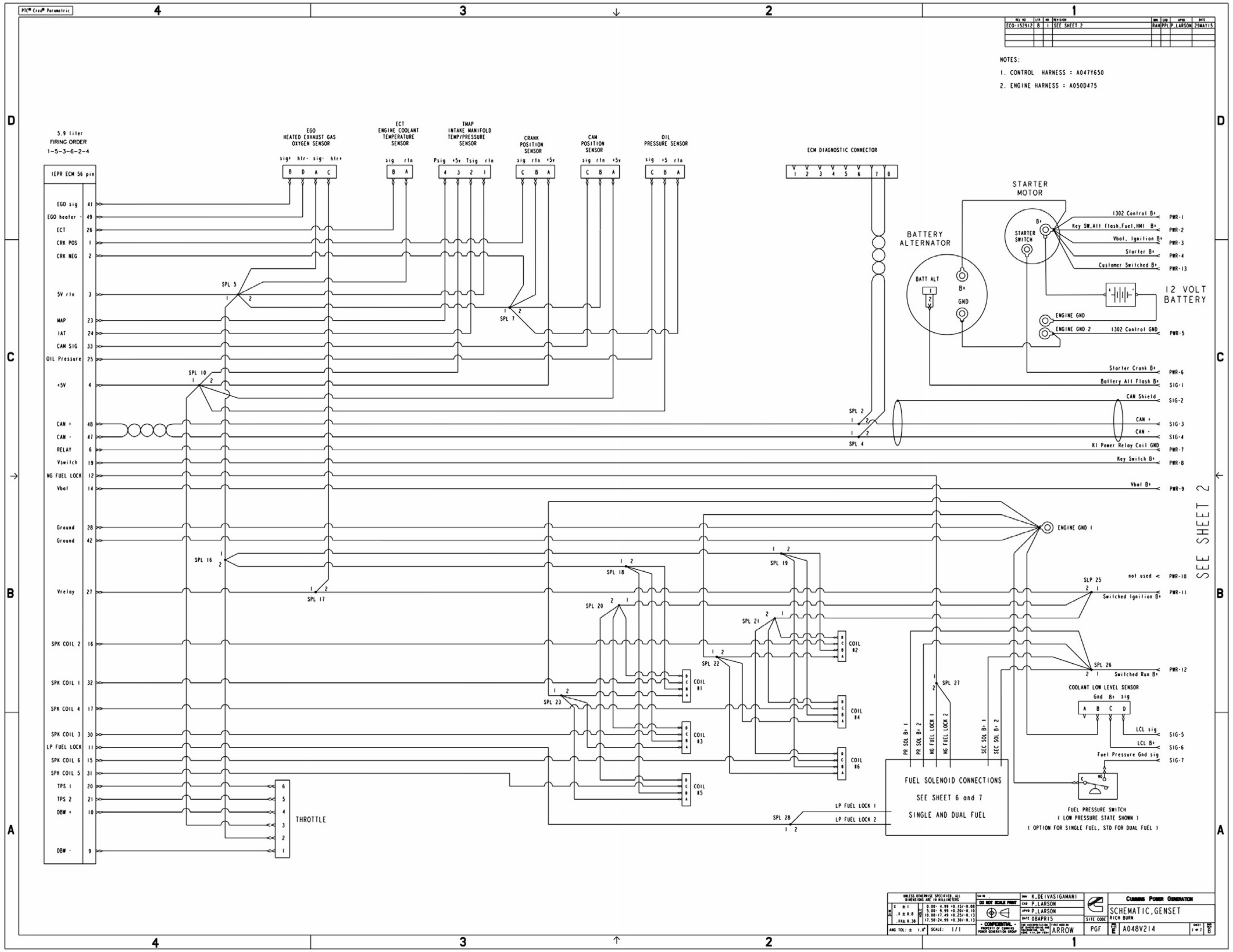


FIGURE 215. WIRING DIAGRAM FOR PCC 1302 (56 PIN ECM) (SHEET 1 OF 7)

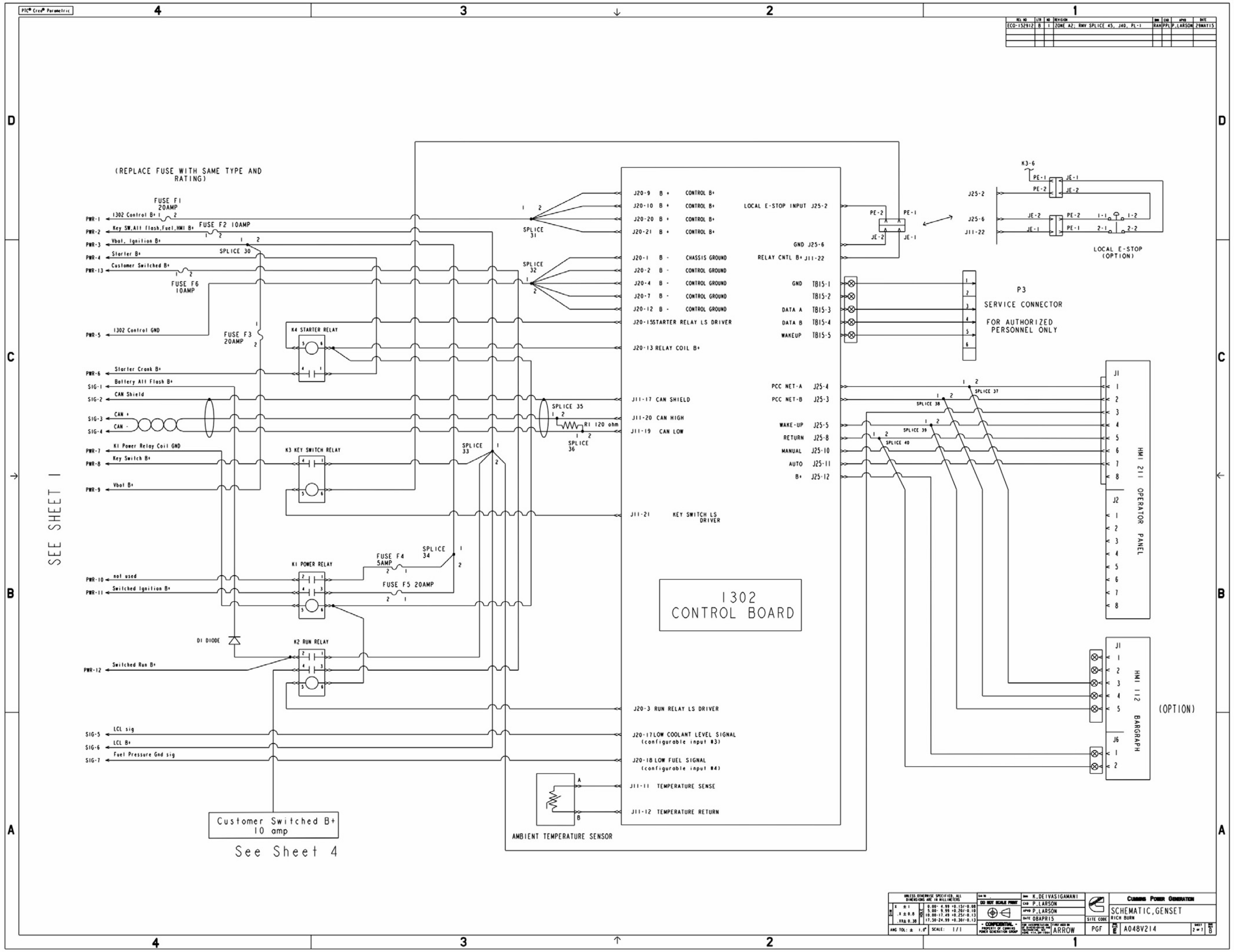


FIGURE 216. WIRING DIAGRAM FOR PCC 1302 (56 PIN ECM) (SHEET 2 OF 7)

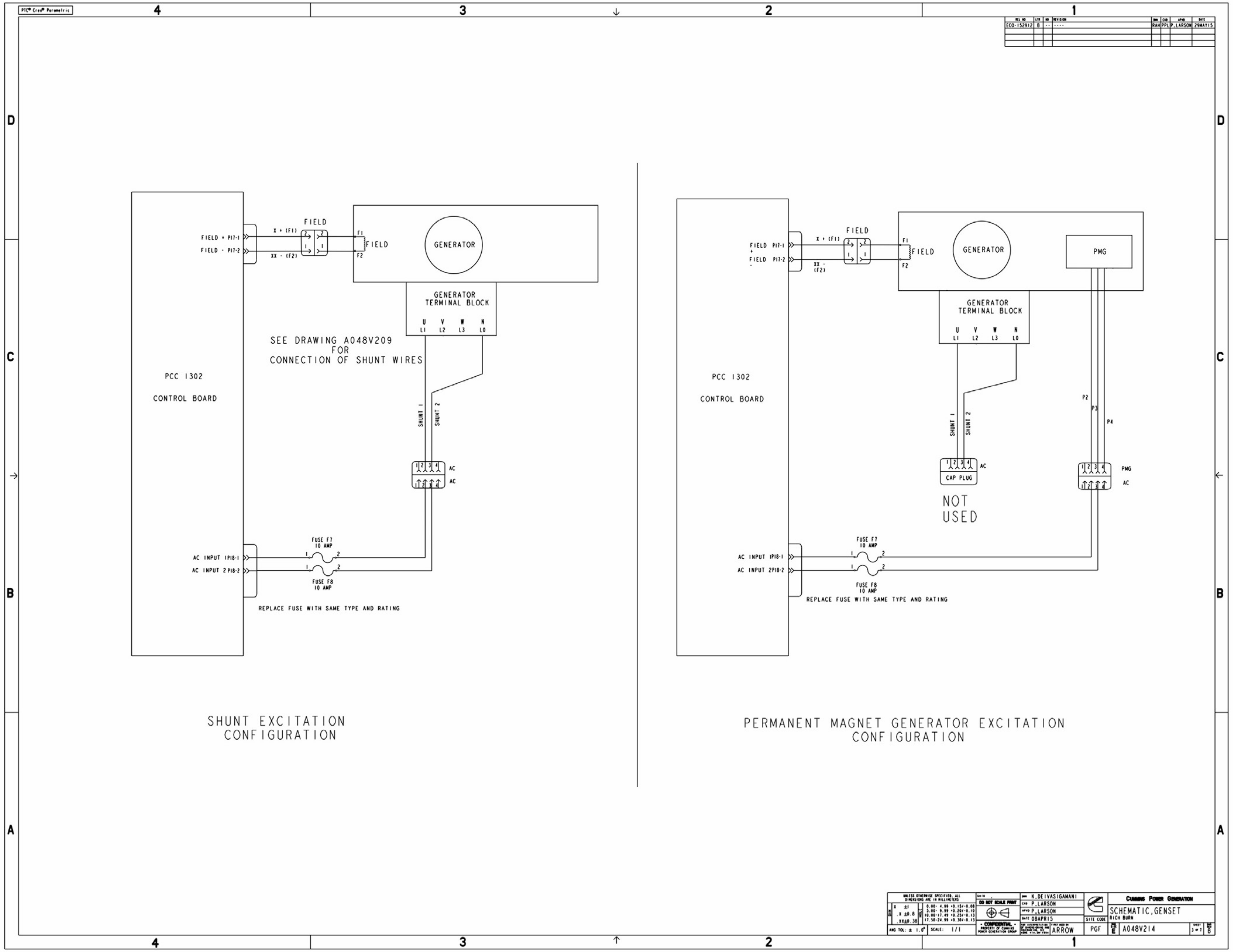
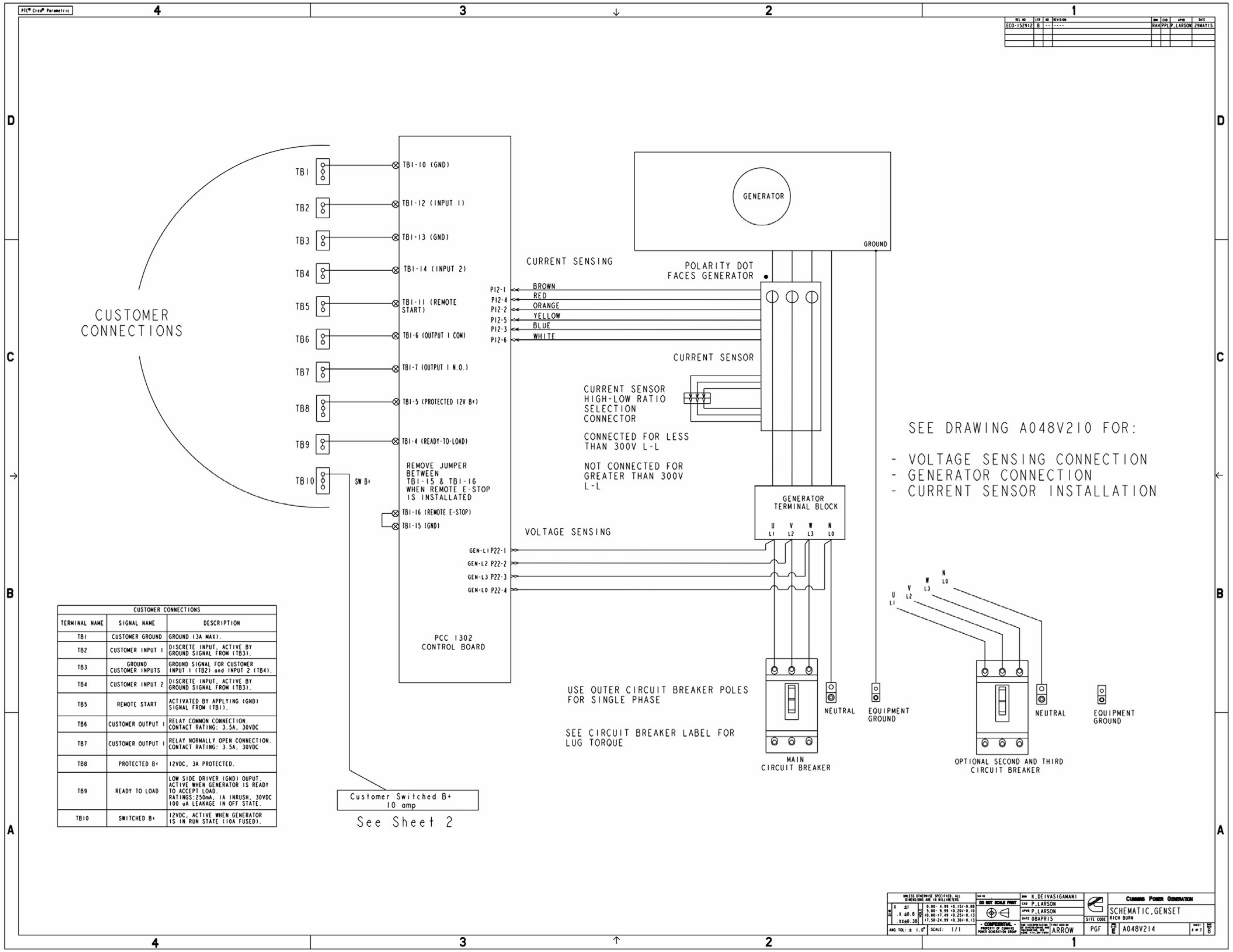


FIGURE 217. WIRING DIAGRAM FOR PCC 1302 (56 PIN ECM) (SHEET 3 OF 7)



CUSTOMER CONNECTIONS		
TERMINAL NAME	SIGNAL NAME	DESCRIPTION
TB1	CUSTOMER GROUND	GROUND (3A MAX).
TB2	CUSTOMER INPUT 1	DISCRETE INPUT, ACTIVE BY GROUND SIGNAL FROM (TB3).
TB3	GROUND CUSTOMER INPUTS	GROUND SIGNAL FOR CUSTOMER INPUT 1 (TB2) and INPUT 2 (TB4).
TB4	CUSTOMER INPUT 2	DISCRETE INPUT, ACTIVE BY GROUND SIGNAL FROM (TB3).
TB5	REMOTE START	ACTIVATED BY APPLYING (GND) SIGNAL FROM (TB1).
TB6	CUSTOMER OUTPUT 1	RELAY COMMON CONNECTION. CONTACT RATING: 3.5A, 30VDC
TB7	CUSTOMER OUTPUT 1	RELAY NORMALLY OPEN CONNECTION. CONTACT RATING: 3.5A, 30VDC
TB8	PROTECTED B+	12VDC, 3A PROTECTED.
TB9	READY TO LOAD	LOW SIDE DRIVER (GND) OUPUT. ACTIVE WHEN GENERATOR IS READY TO ACCEPT LOAD. RATINGS:250mA, 1A INRUSH, 30VDC 100 uA LEAKAGE IN OFF STATE.
TB10	SWITCHED B+	12VDC, ACTIVE WHEN GENERATOR IS IN RUN STATE (10A FUSED).

FIGURE 218. WIRING DIAGRAM FOR PCC 1302 (56 PIN ECM) (SHEET 4 OF 7)

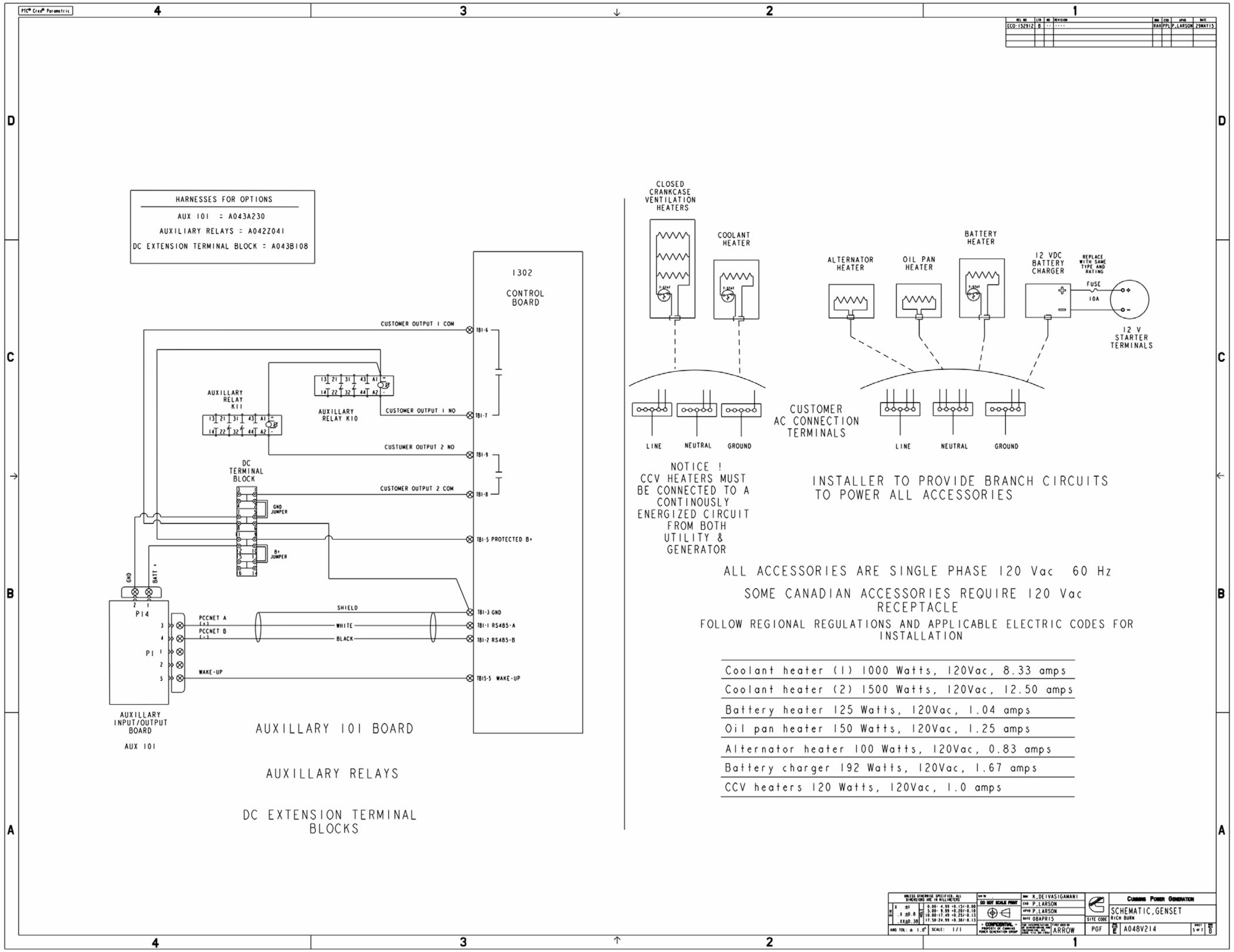


FIGURE 219. WIRING DIAGRAM FOR PCC 1302 (56 PIN ECM) (SHEET 5 OF 7)

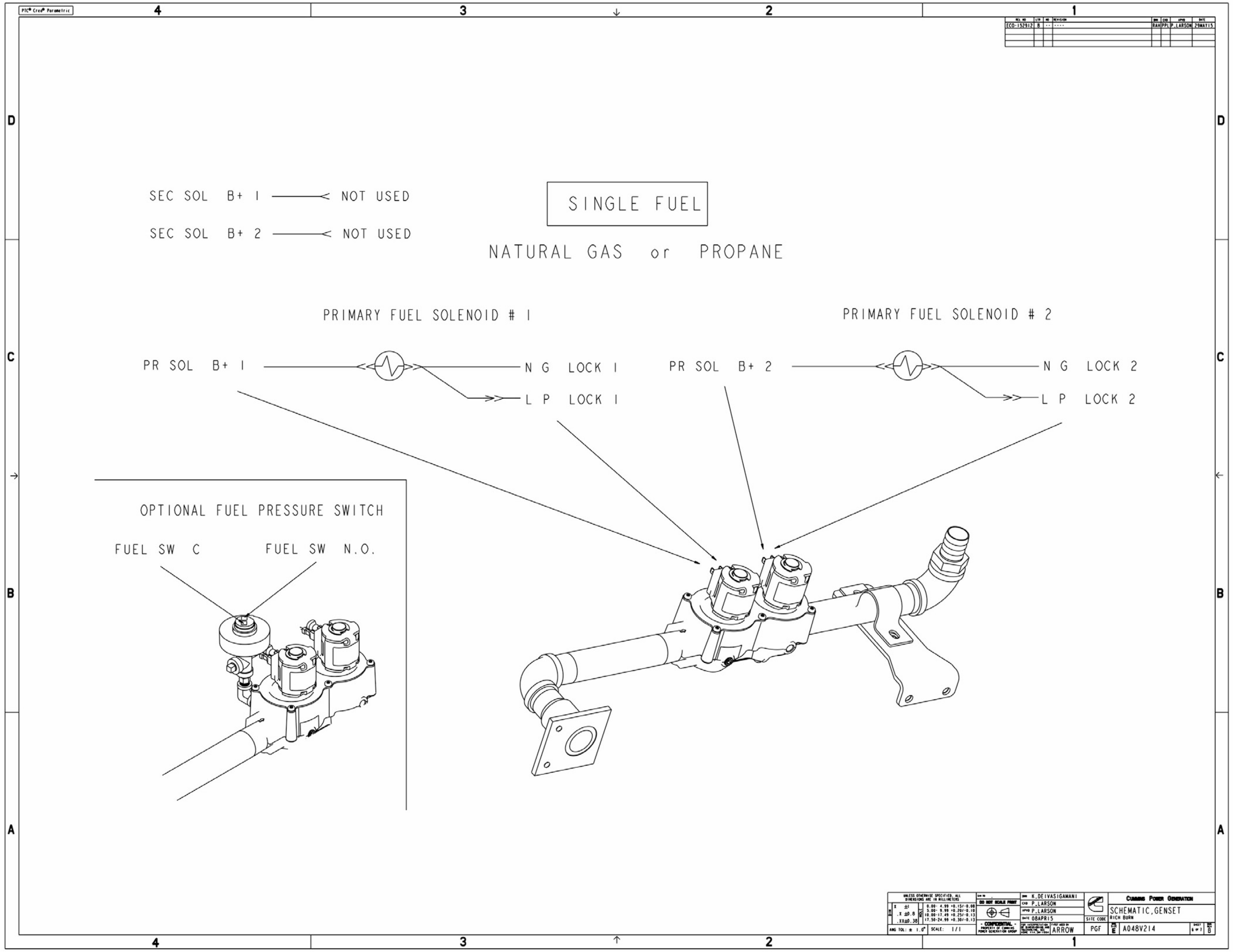


FIGURE 220. WIRING DIAGRAM FOR PCC 1302 (56 PIN ECM) (SHEET 6 OF 7)

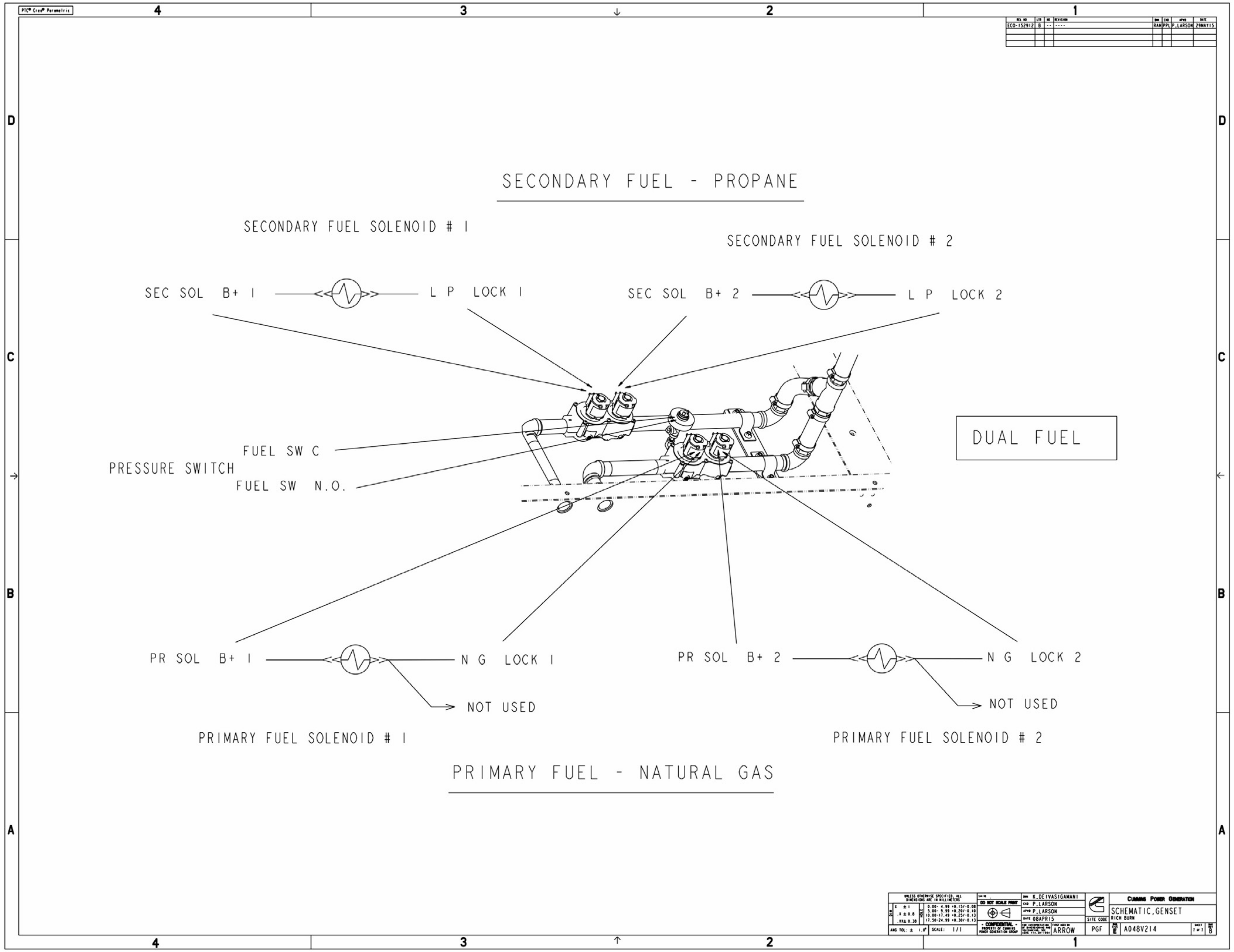


FIGURE 221. WIRING DIAGRAM FOR PCC 1302 (56 PIN ECM) (SHEET 7 OF 7)

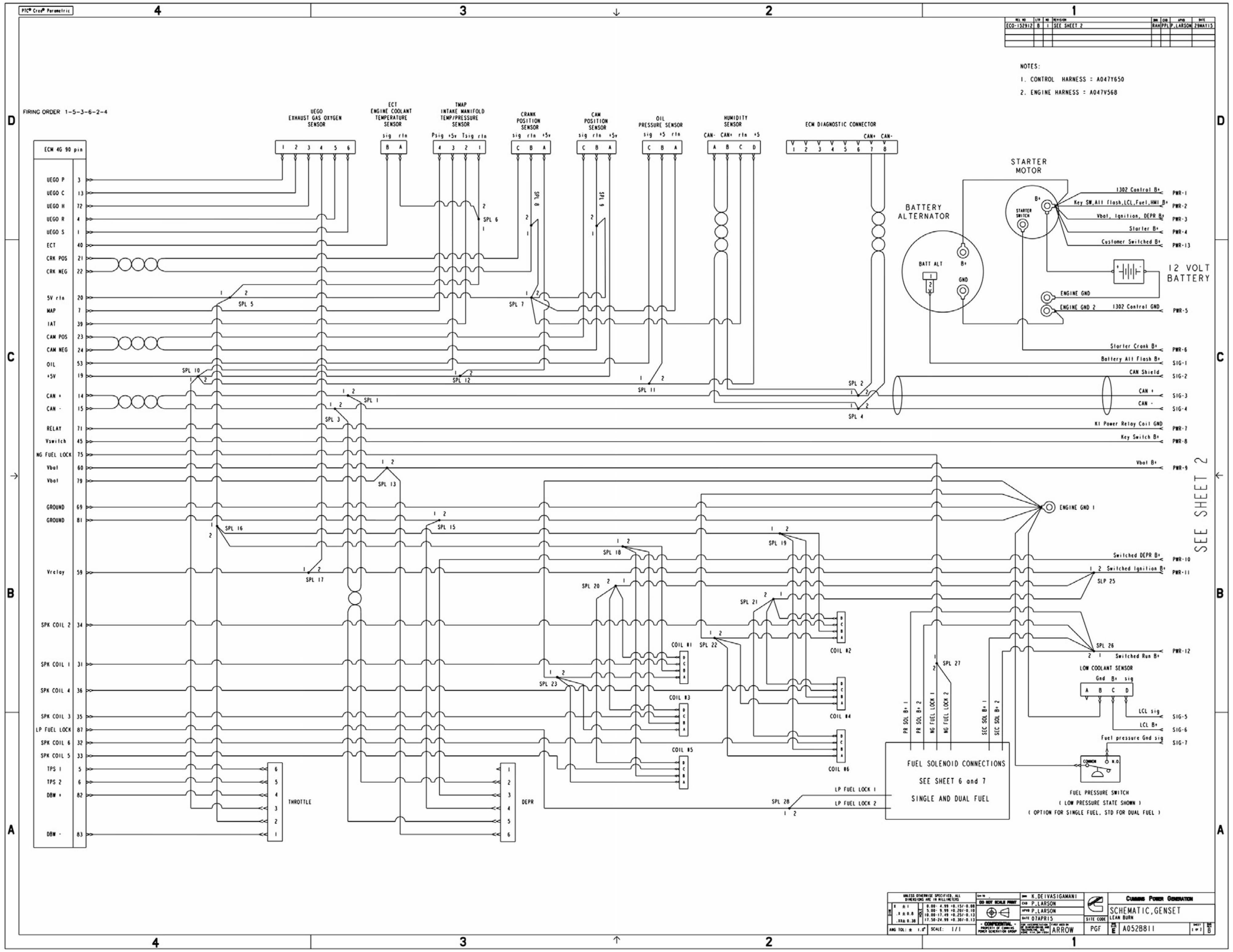


FIGURE 222. WIRING DIAGRAM FOR PCC 1302 (90 PIN ECM) (SHEET 1 OF 7)

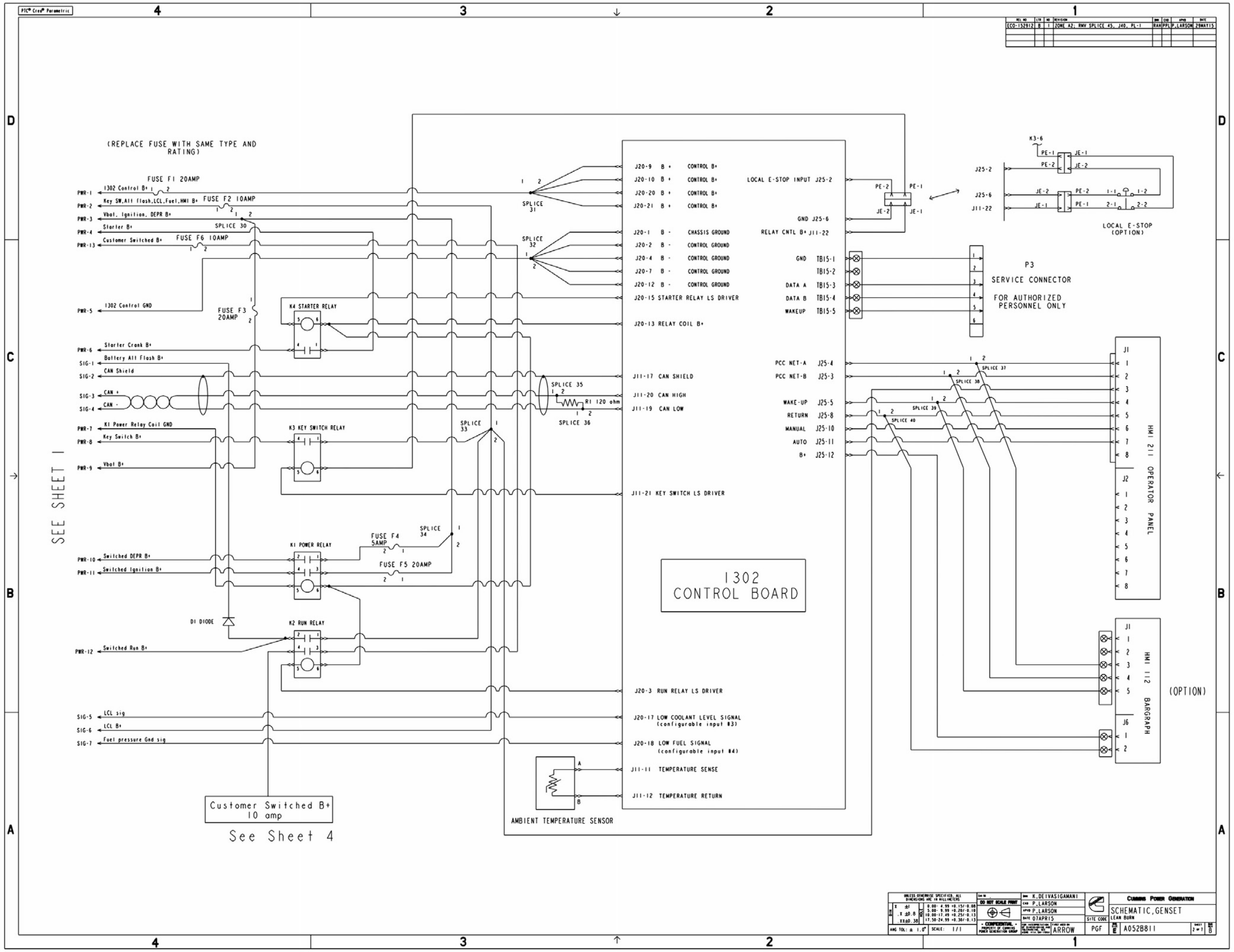


FIGURE 223. WIRING DIAGRAM FOR PCC 1302 (90 PIN ECM) (SHEET 2 OF 7)

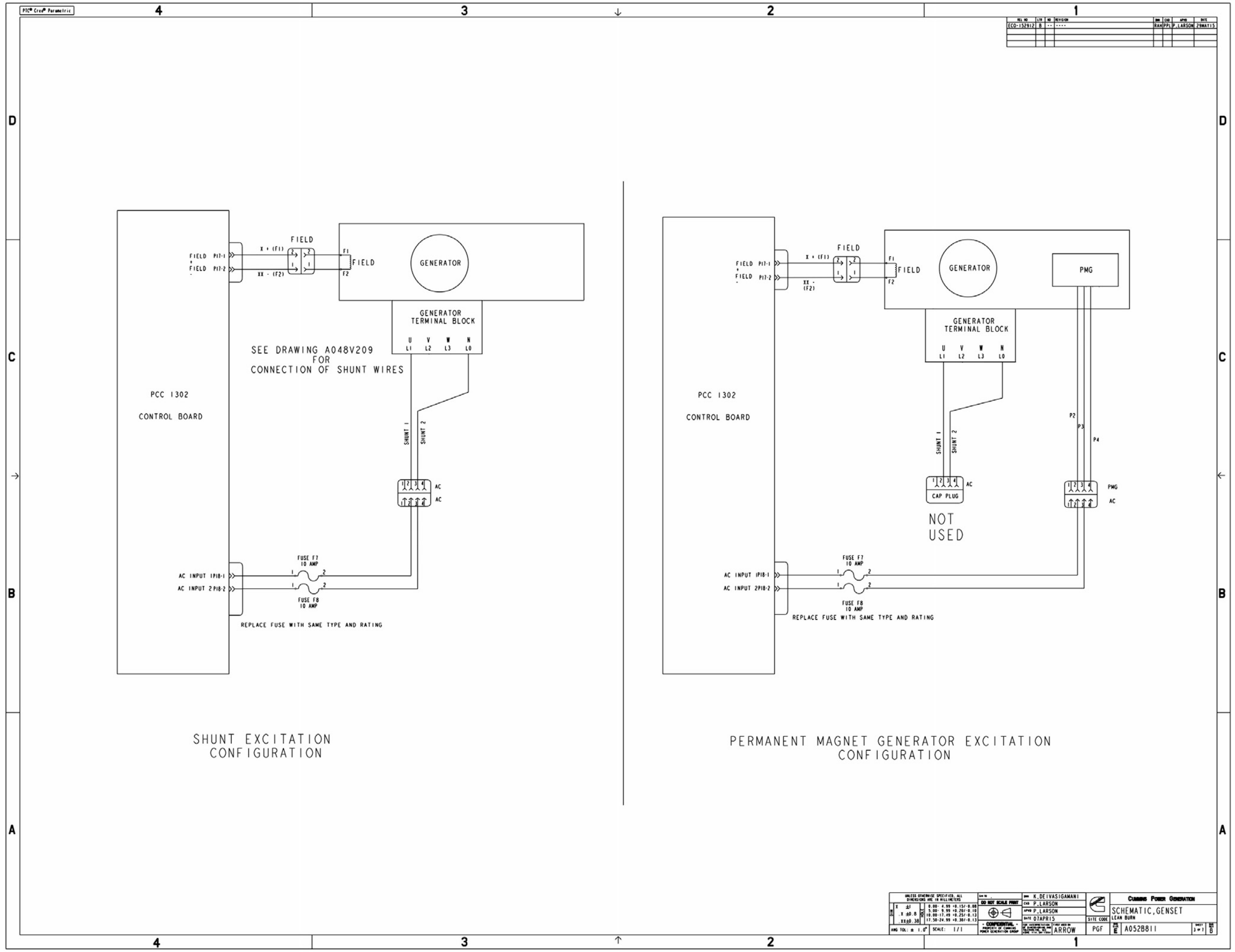
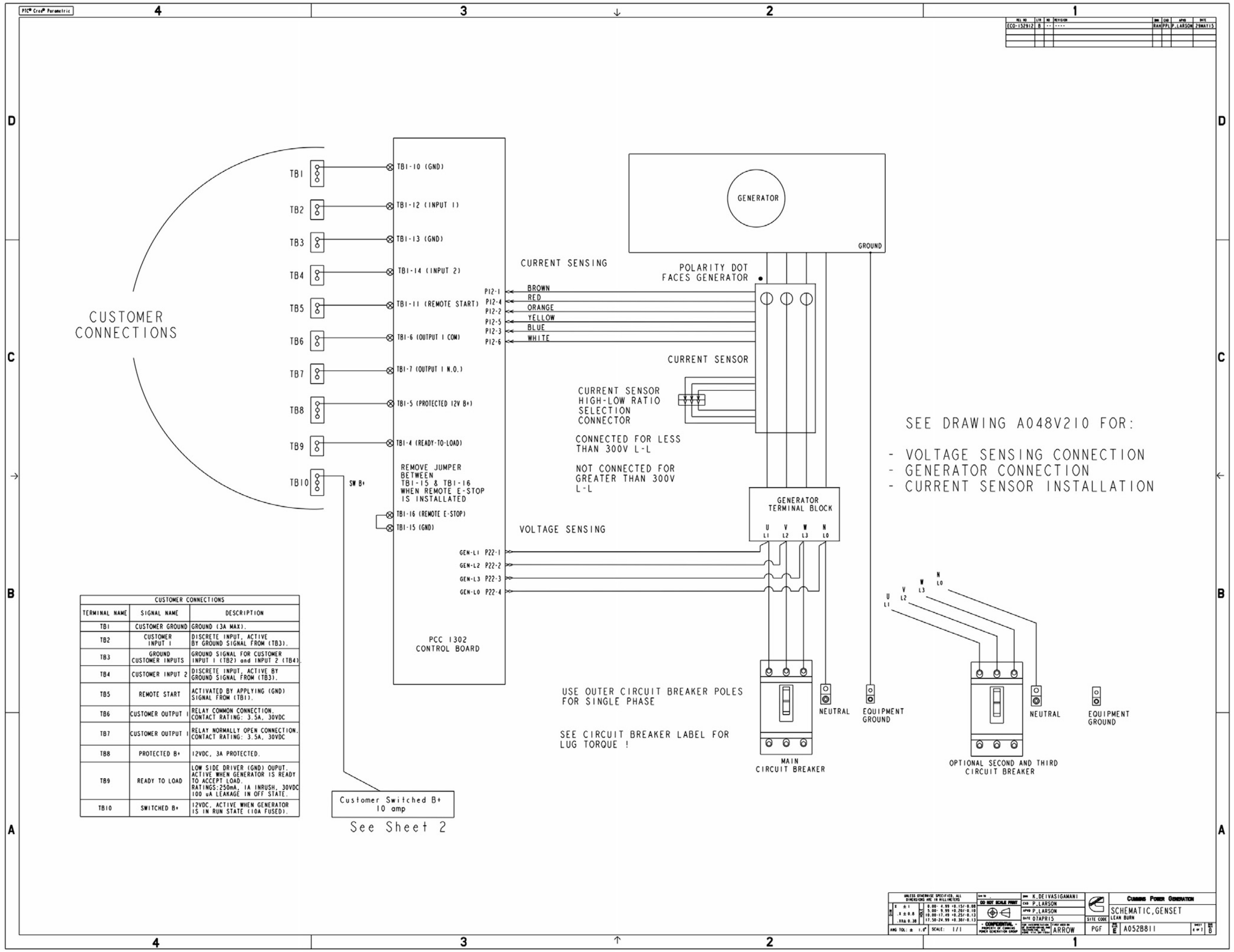


FIGURE 224. WIRING DIAGRAM FOR PCC 1302 (90 PIN ECM) (SHEET 3 OF 7)



CUSTOMER CONNECTIONS		
TERMINAL NAME	SIGNAL NAME	DESCRIPTION
TB1	CUSTOMER GROUND	GROUND (3A MAX).
TB2	CUSTOMER INPUT 1	DISCRETE INPUT, ACTIVE BY GROUND SIGNAL FROM (TB3).
TB3	GROUND CUSTOMER INPUTS	GROUND SIGNAL FOR CUSTOMER INPUT 1 (TB2) and INPUT 2 (TB4).
TB4	CUSTOMER INPUT 2	DISCRETE INPUT, ACTIVE BY GROUND SIGNAL FROM (TB3).
TB5	REMOTE START	ACTIVATED BY APPLYING (GND) SIGNAL FROM (TB1).
TB6	CUSTOMER OUTPUT 1	RELAY COMMON CONNECTION. CONTACT RATING: 3.5A, 30VDC
TB7	CUSTOMER OUTPUT 1	RELAY NORMALLY OPEN CONNECTION. CONTACT RATING: 3.5A, 30VDC
TB8	PROTECTED B+	12VDC, 3A PROTECTED.
TB9	READY TO LOAD	LOW SIDE DRIVER (GND) OUPUT. ACTIVE WHEN GENERATOR IS READY TO ACCEPT LOAD. RATINGS:250mA, 1A INRUSH, 30VDC 100 uA LEAKAGE IN OFF STATE.
TB10	SWITCHED B+	12VDC, ACTIVE WHEN GENERATOR IS IN RUN STATE (10A FUSED).

FIGURE 225. WIRING DIAGRAM FOR PCC 1302 (90 PIN ECM) (SHEET 4 OF 7)

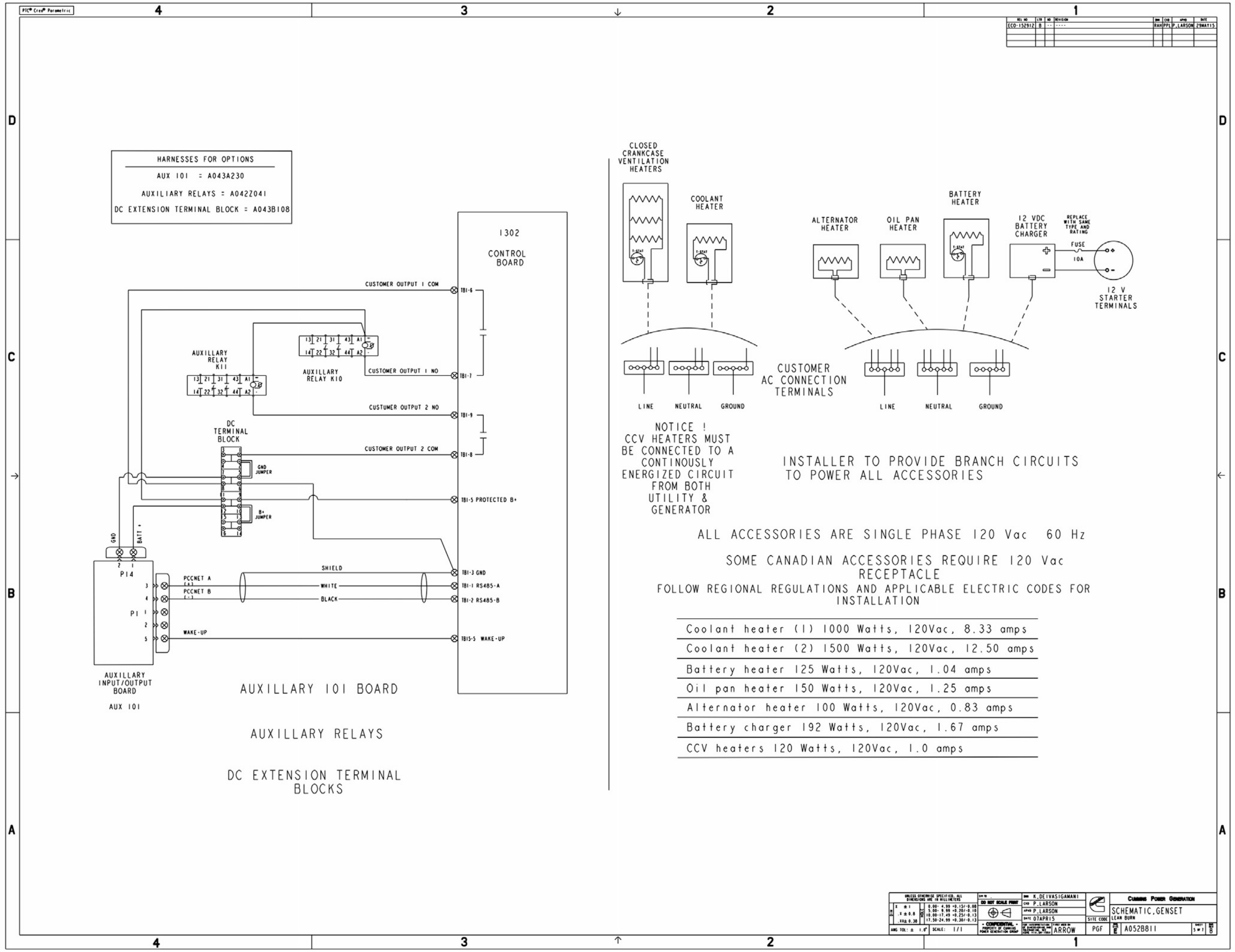


FIGURE 226. WIRING DIAGRAM FOR PCC 1302 (90 PIN ECM) (SHEET 5 OF 7)

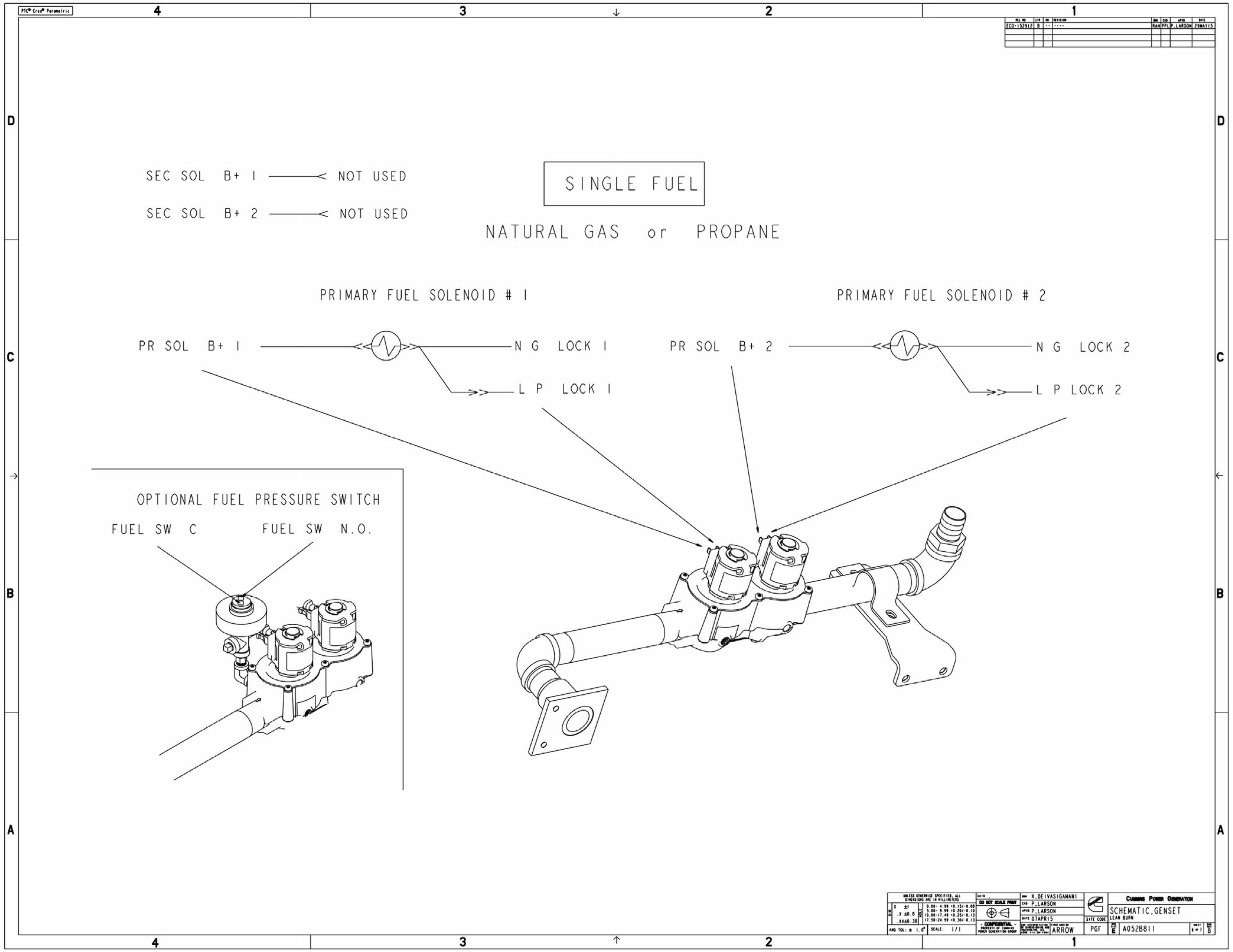


FIGURE 227. WIRING DIAGRAM FOR PCC 1302 (90 PIN ECM) (SHEET 6 OF 7)

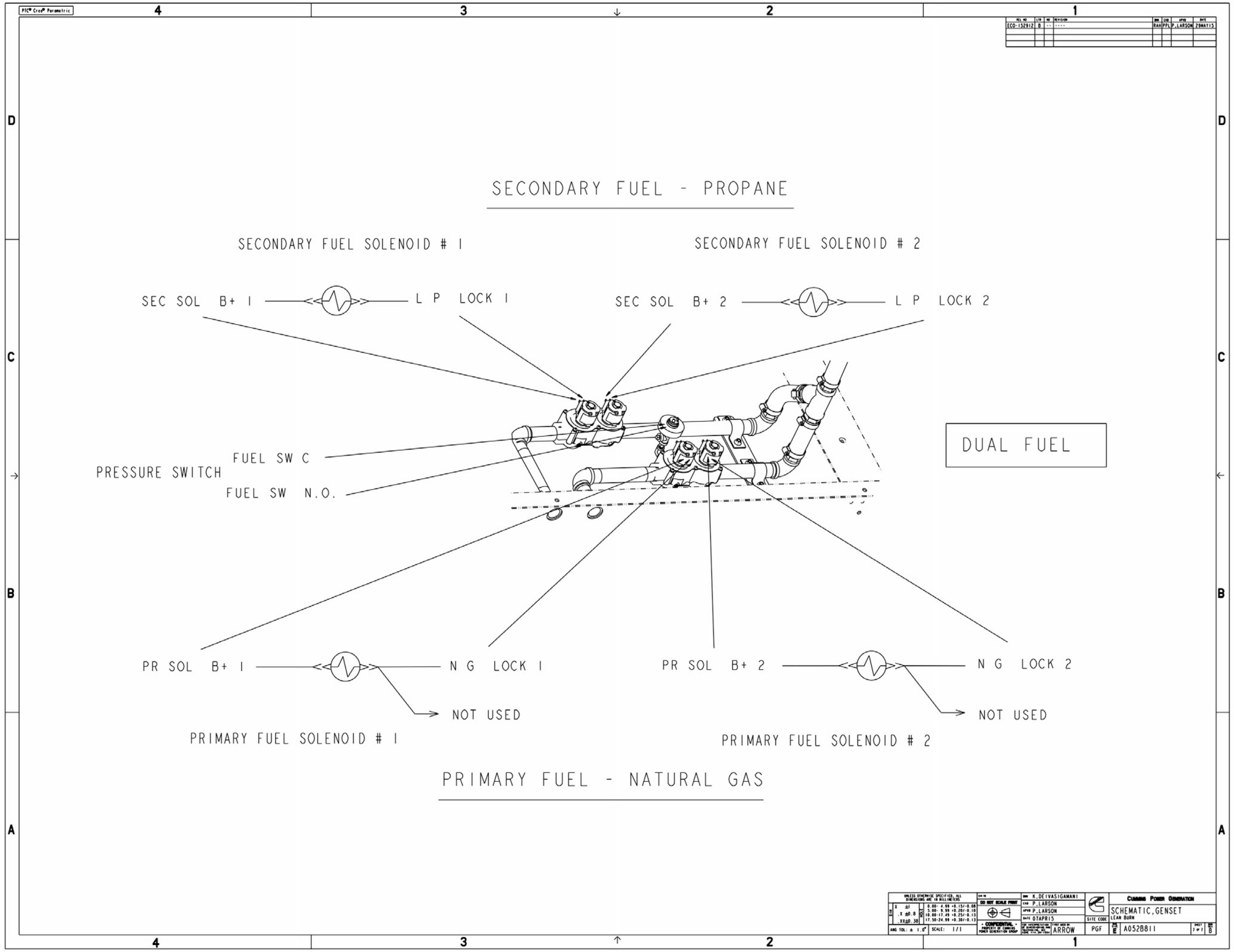


FIGURE 228. WIRING DIAGRAM FOR PCC 1302 (90 PIN ECM) (SHEET 7 OF 7)

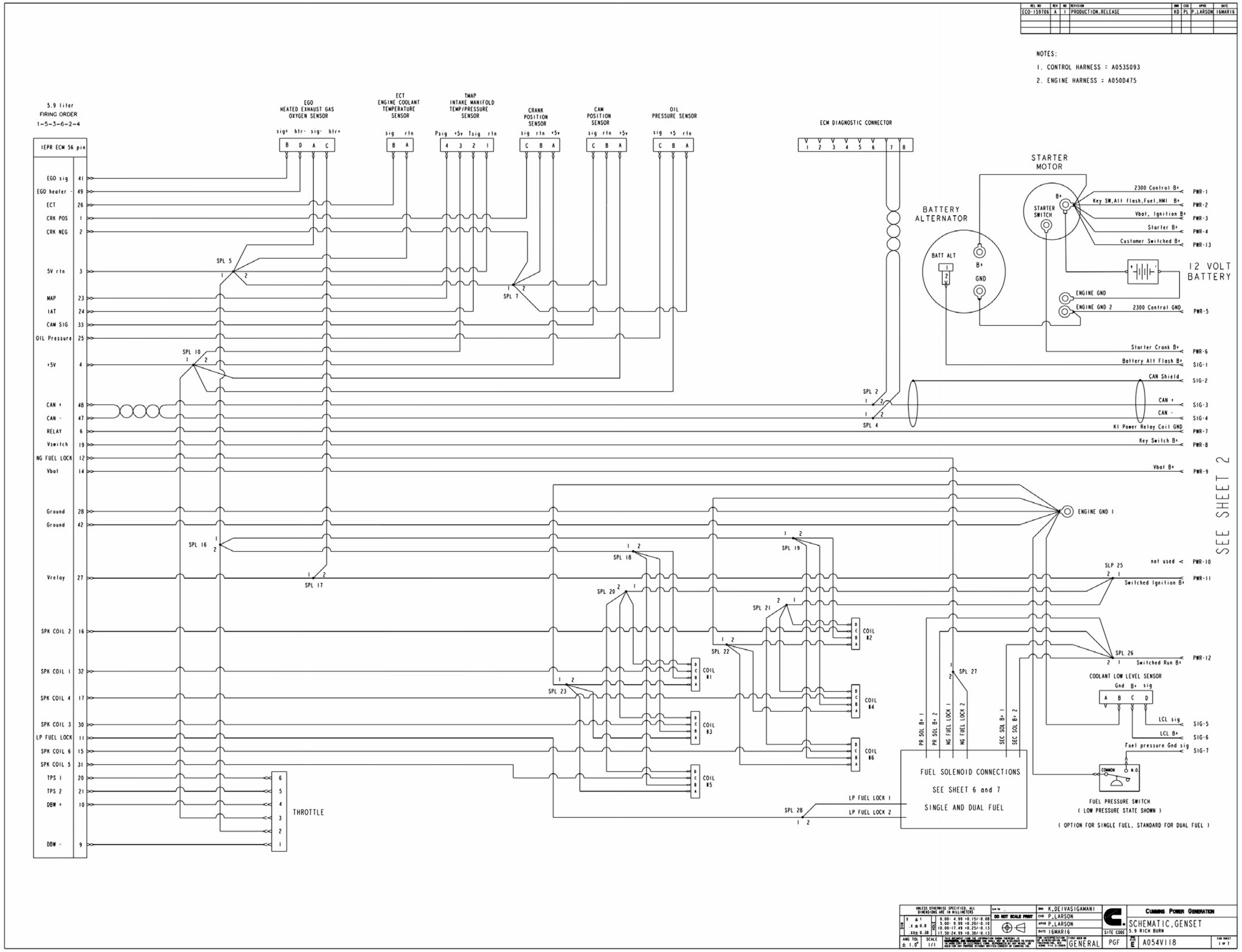


FIGURE 229. WIRING DIAGRAM FOR PCC 2300 (56 PIN ECM) (SHEET 1 OF 7)

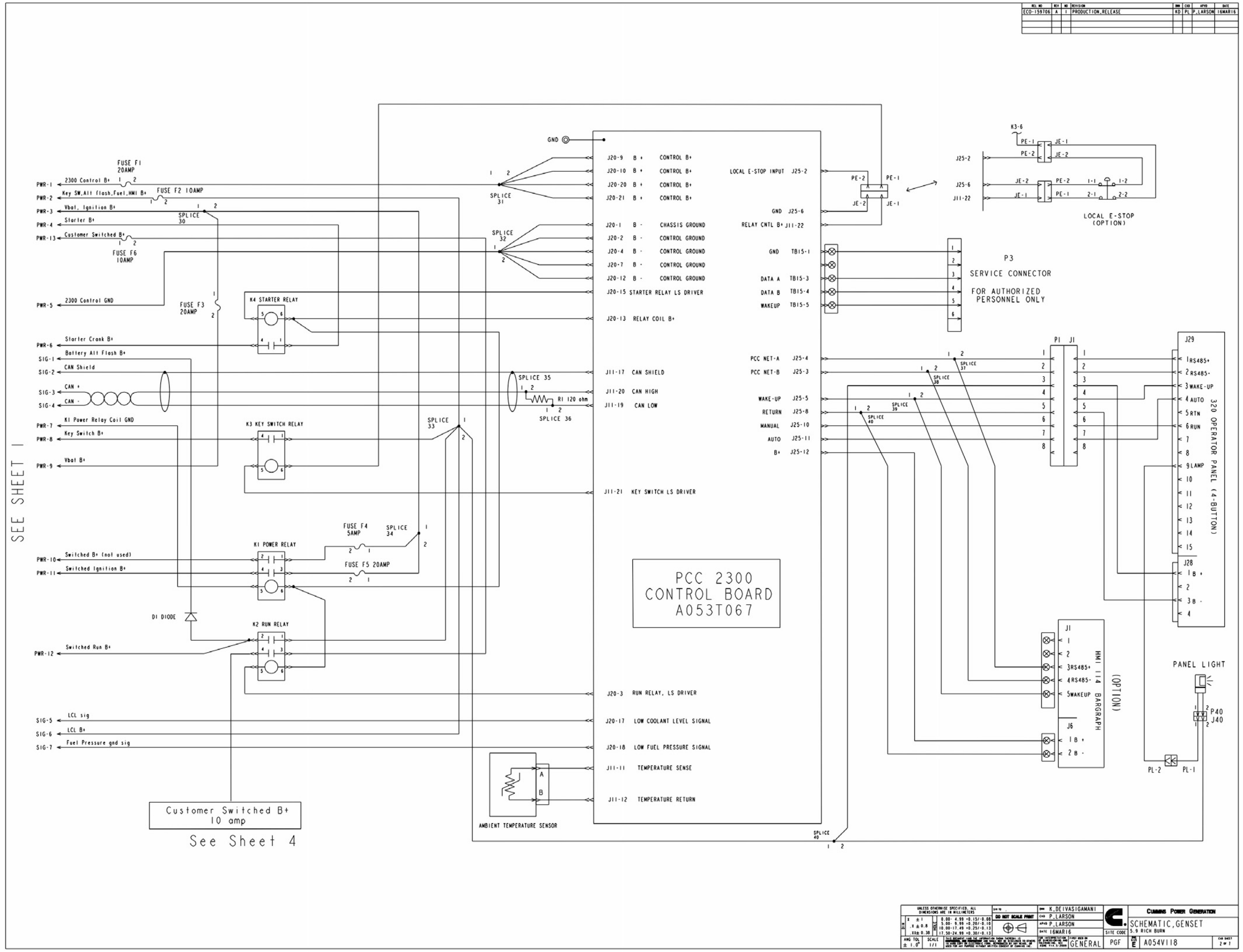


FIGURE 230. WIRING DIAGRAM FOR PCC 2300 (56 PIN ECM) (SHEET 2 OF 7)

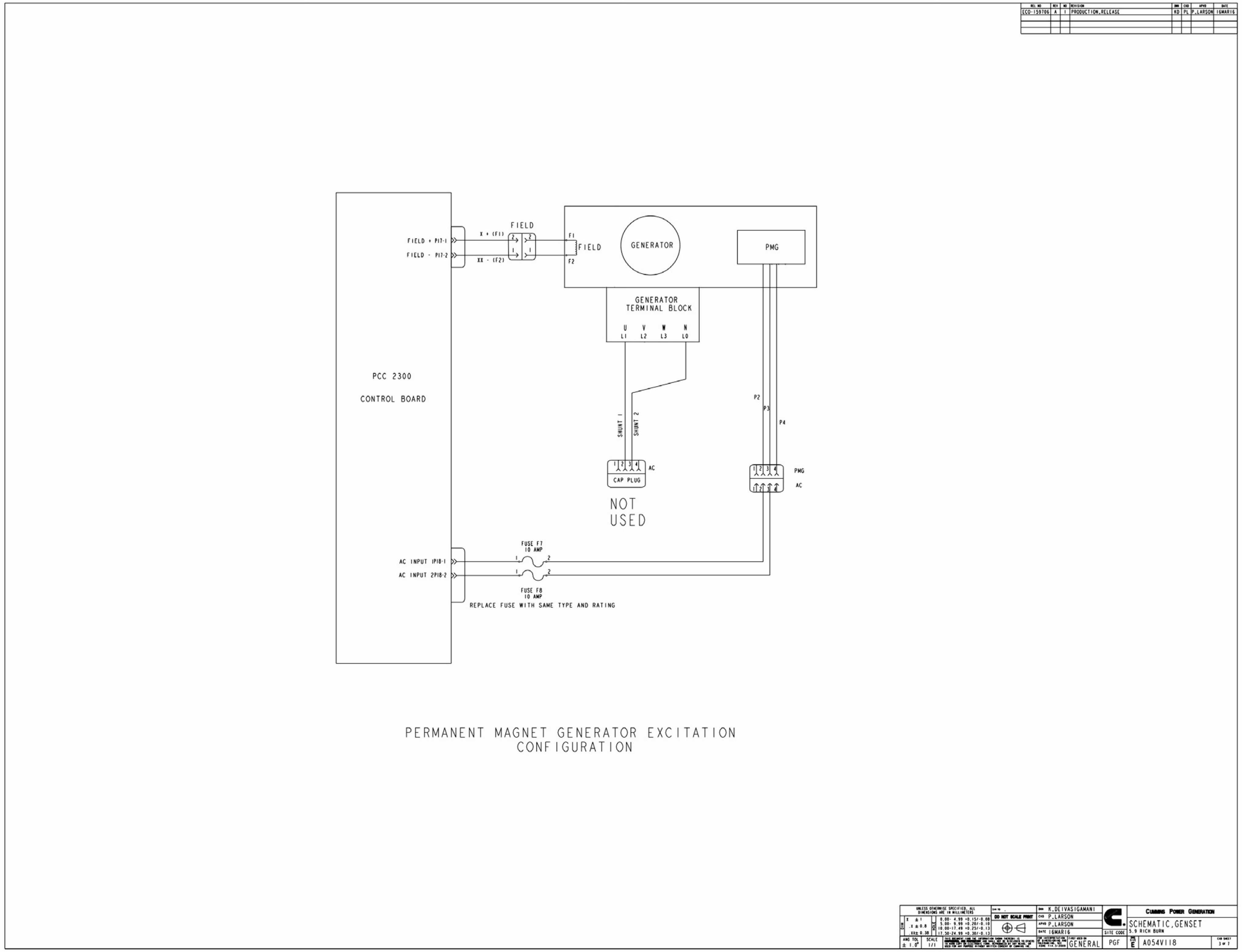
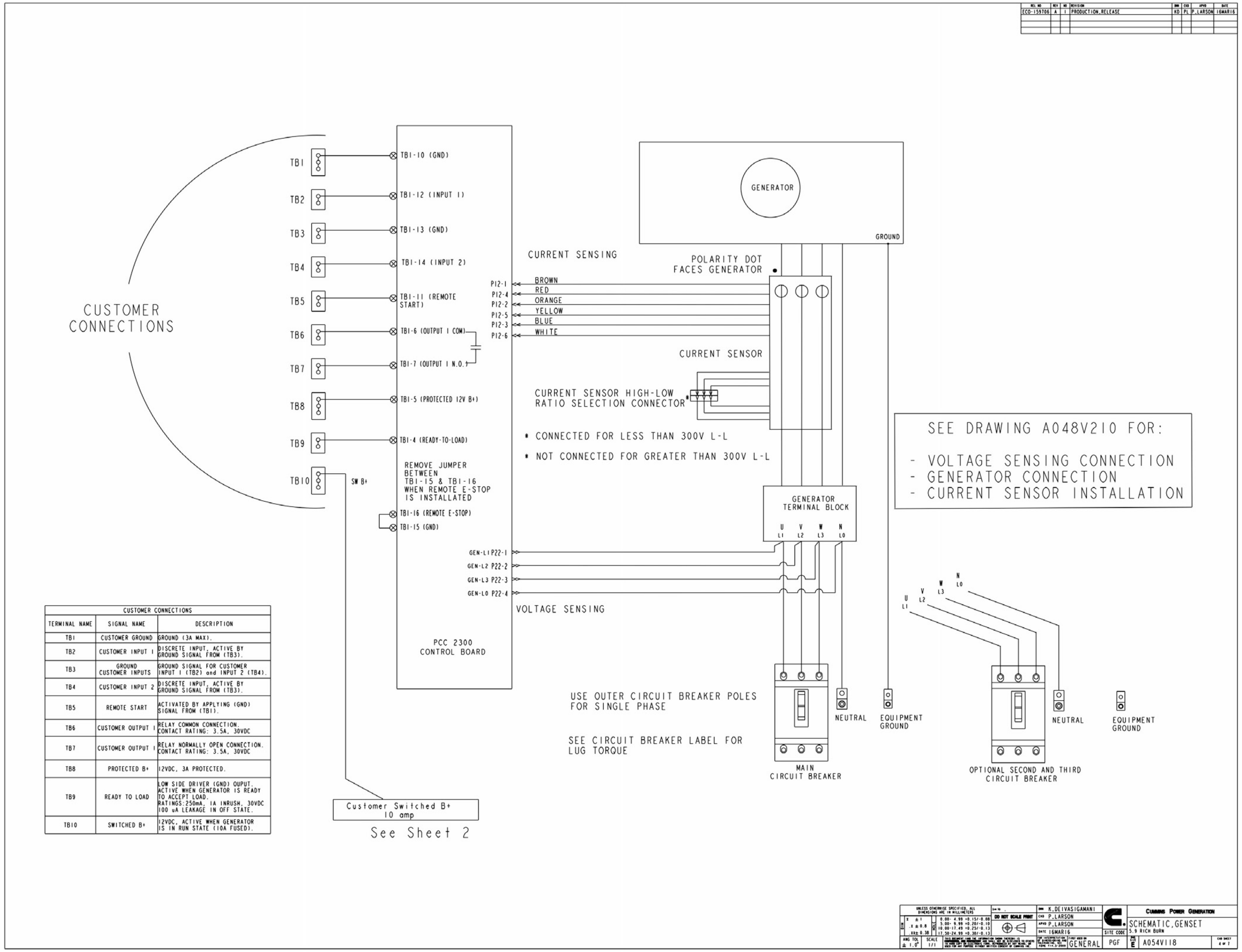


FIGURE 231. WIRING DIAGRAM FOR PCC 2300 (56 PIN ECM) (SHEET 3 OF 7)



CUSTOMER CONNECTIONS		
TERMINAL NAME	SIGNAL NAME	DESCRIPTION
TB1	CUSTOMER GROUND	GROUND (3A MAX).
TB2	CUSTOMER INPUT 1	DISCRETE INPUT, ACTIVE BY GROUND SIGNAL FROM (TB3).
TB3	GROUND CUSTOMER INPUTS	GROUND SIGNAL FOR CUSTOMER INPUT 1 (TB2) and INPUT 2 (TB4).
TB4	CUSTOMER INPUT 2	DISCRETE INPUT, ACTIVE BY GROUND SIGNAL FROM (TB3).
TB5	REMOTE START	ACTIVATED BY APPLYING (GND) SIGNAL FROM (TB1).
TB6	CUSTOMER OUTPUT 1	RELAY COMMON CONNECTION. CONTACT RATING: 3.5A, 30VDC
TB7	CUSTOMER OUTPUT 1	RELAY NORMALLY OPEN CONNECTION. CONTACT RATING: 3.5A, 30VDC
TB8	PROTECTED B+	12VDC, 3A PROTECTED.
TB9	READY TO LOAD	LOW SIDE DRIVER (GND) OUPUT. ACTIVE WHEN GENERATOR IS READY TO ACCEPT LOAD. RATINGS:250mA, 1A INRUSH, 30VDC 100 uA LEAKAGE IN OFF STATE.
TB10	SWITCHED B+	12VDC, ACTIVE WHEN GENERATOR IS IN RUN STATE (10A FUSED).

FIGURE 232. WIRING DIAGRAM FOR PCC 2300 (56 PIN ECM) (SHEET 4 OF 7)

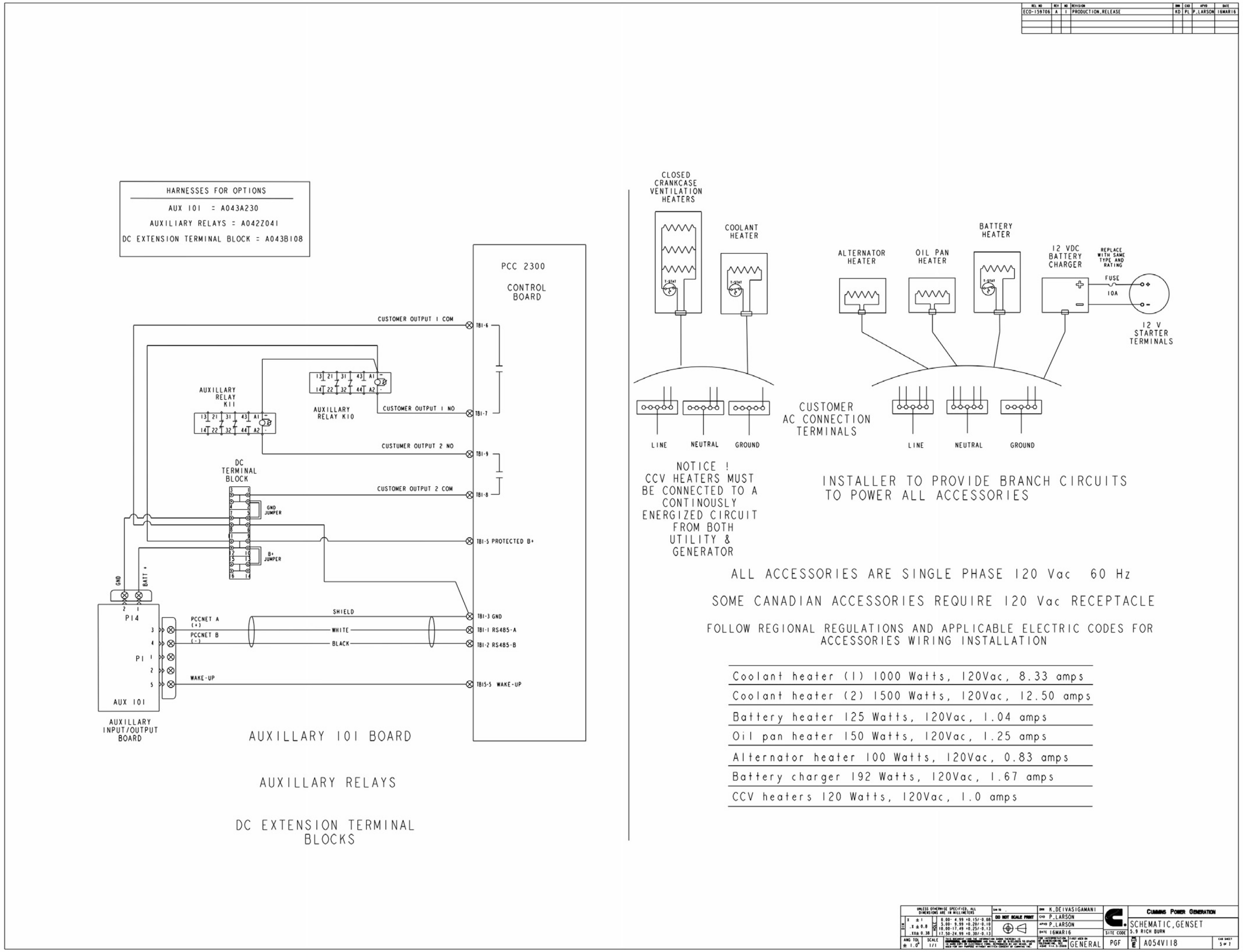


FIGURE 233. WIRING DIAGRAM FOR PCC 2300 (56 PIN ECM) (SHEET 5 OF 7)

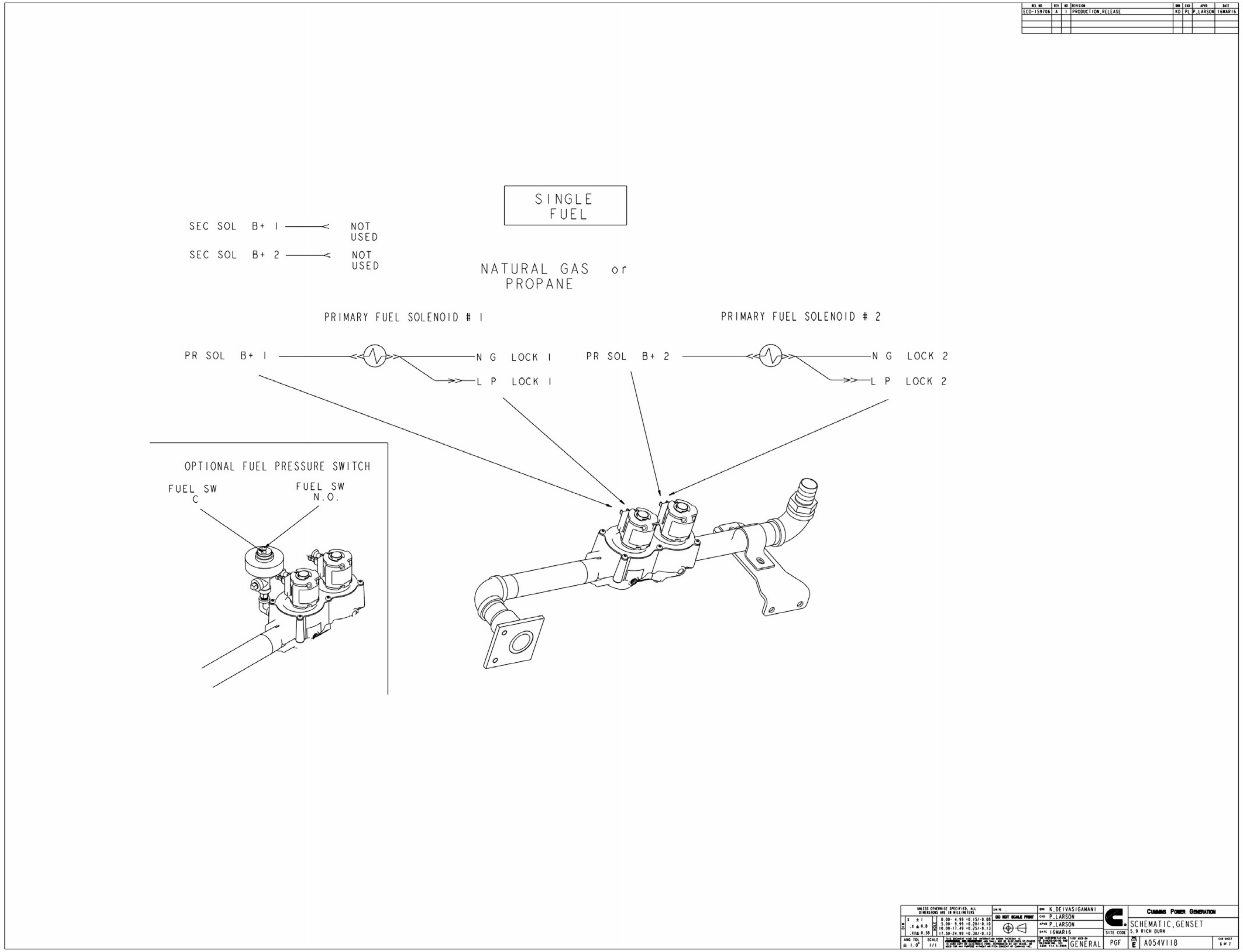


FIGURE 234. WIRING DIAGRAM FOR PCC 2300 (56 PIN ECM) (SHEET 6 OF 7)

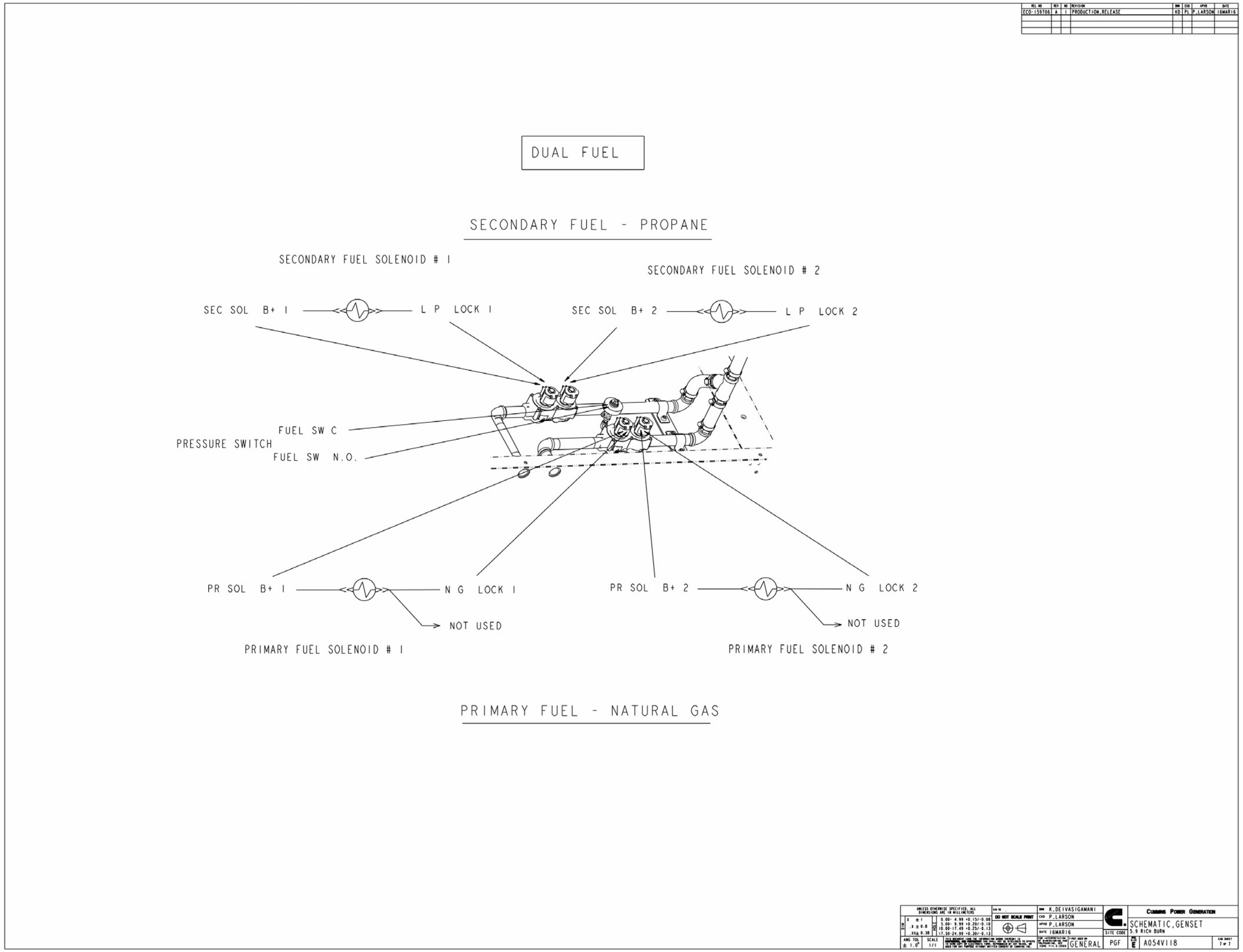


FIGURE 235. WIRING DIAGRAM FOR PCC 2300 (56 PIN ECM) (SHEET 7 OF 7)

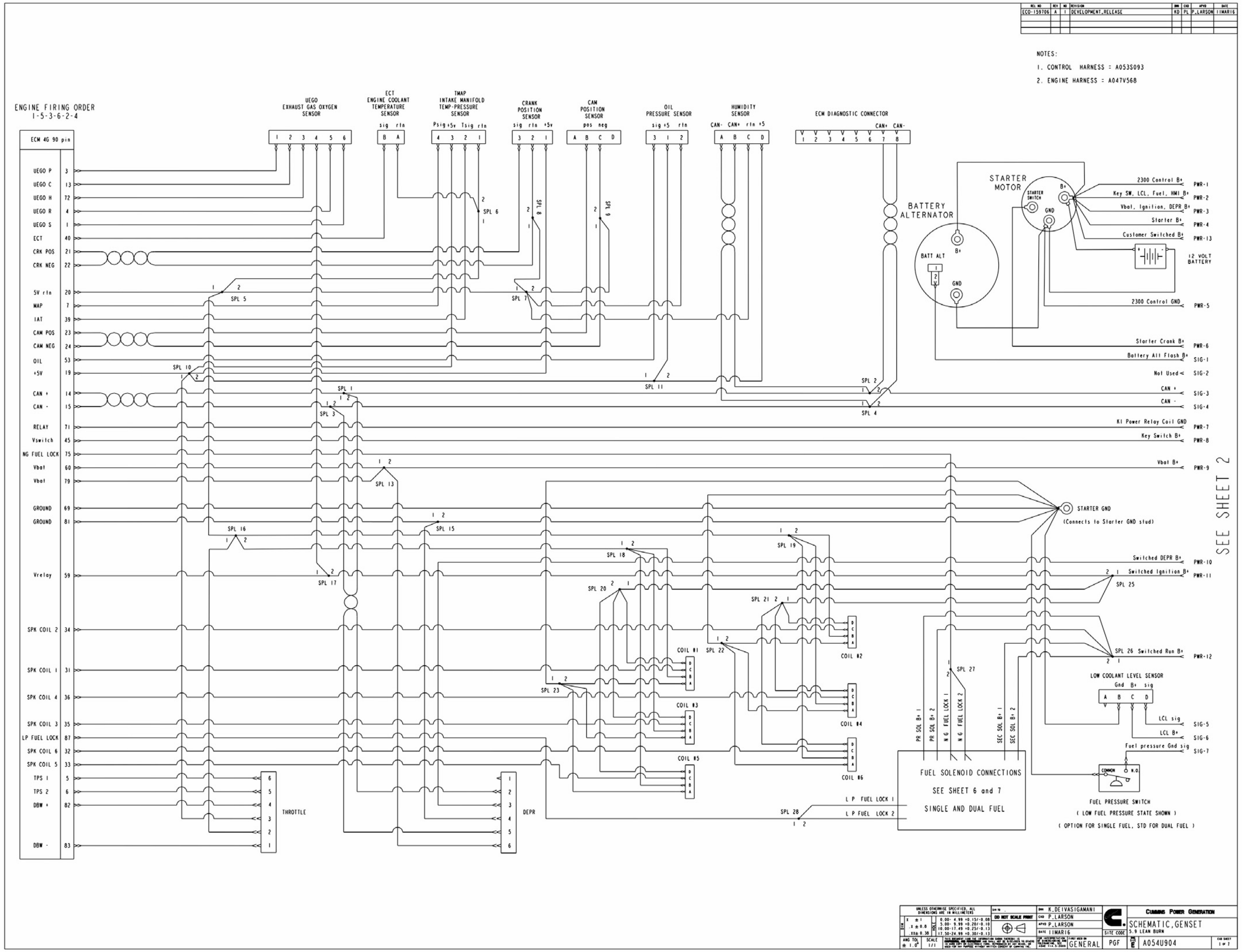


FIGURE 236. WIRING DIAGRAM FOR PCC 2300 (90 PIN ECM) (SHEET 1 OF 7)

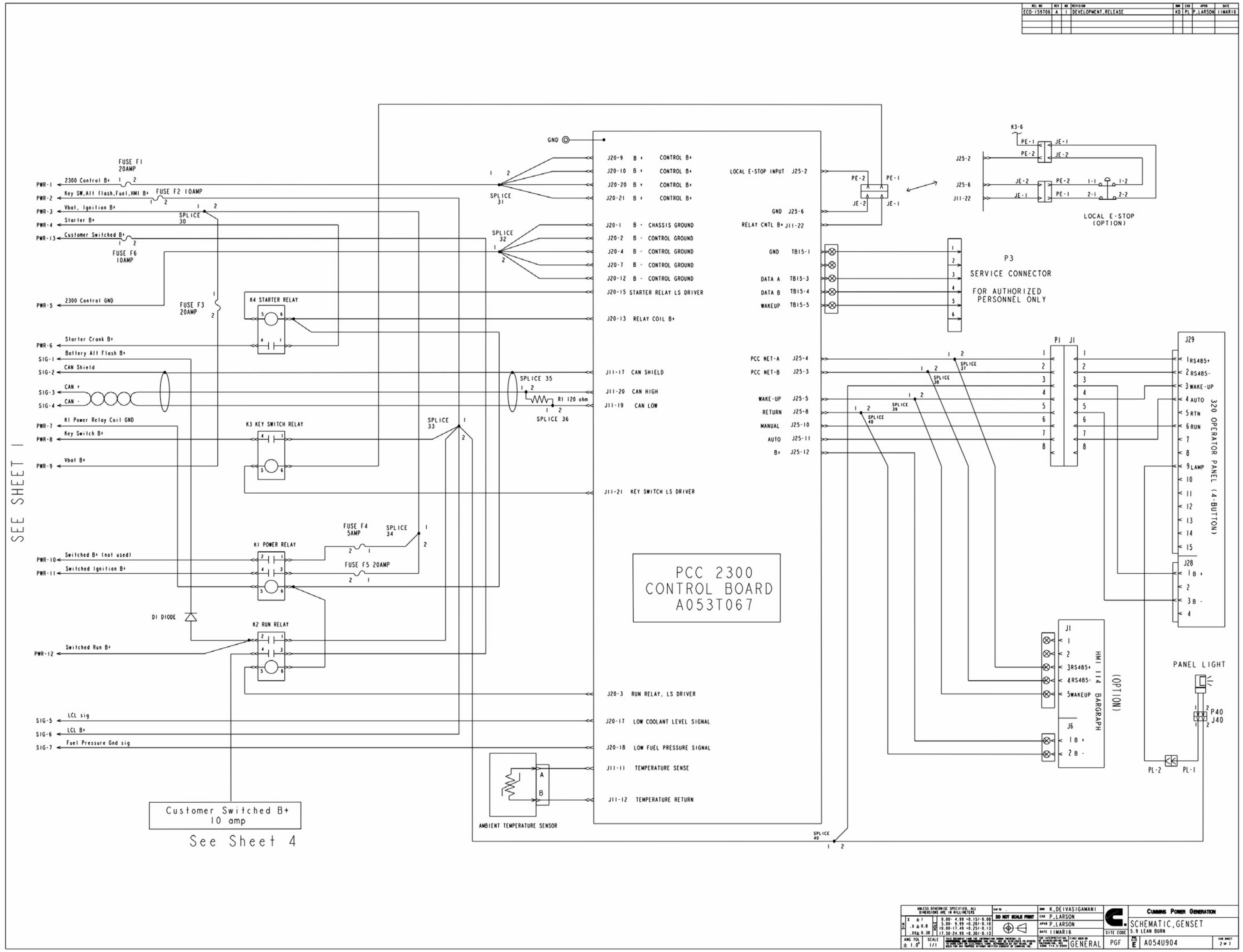


FIGURE 237. WIRING DIAGRAM FOR PCC 2300 (90 PIN ECM) (SHEET 2 OF 7)

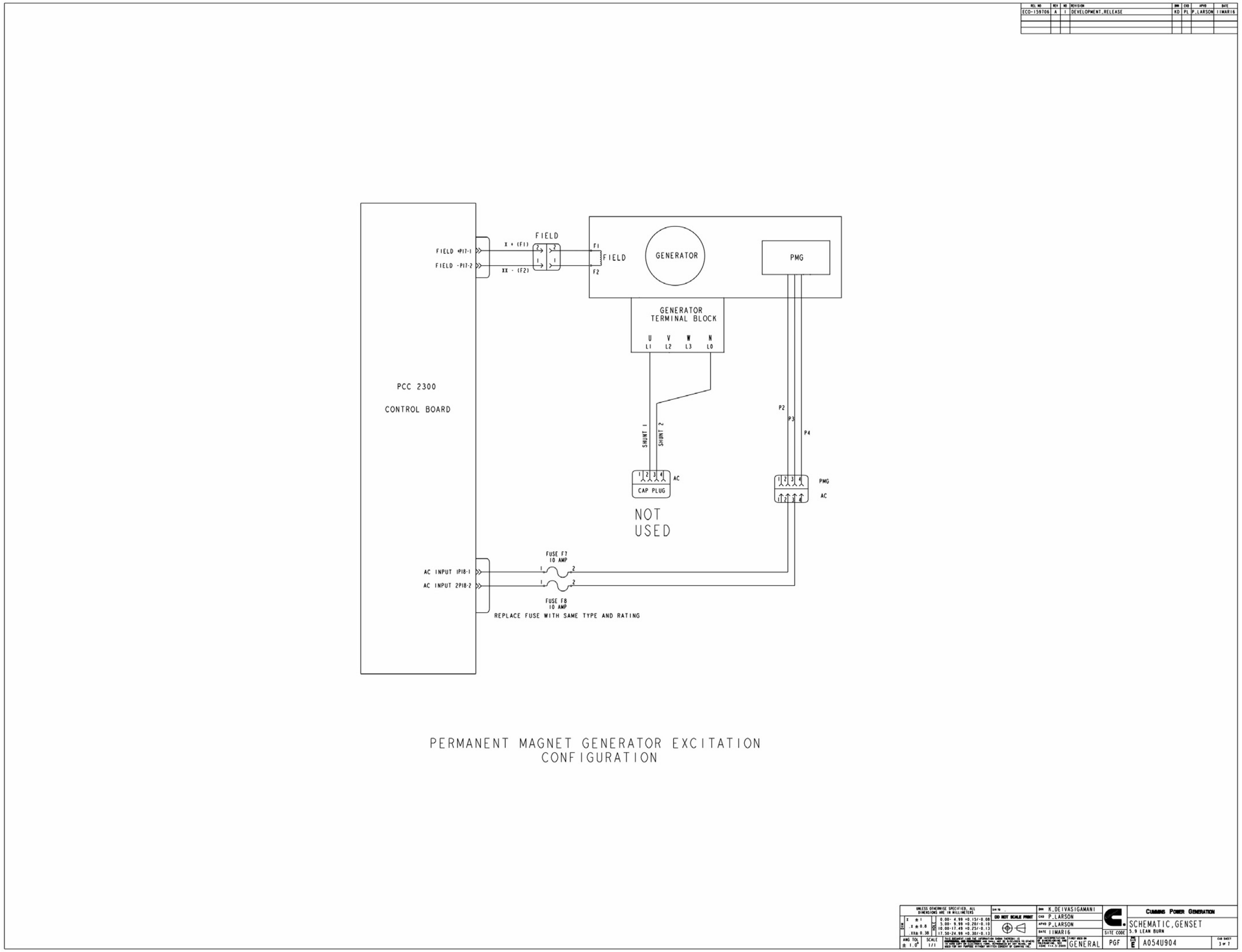
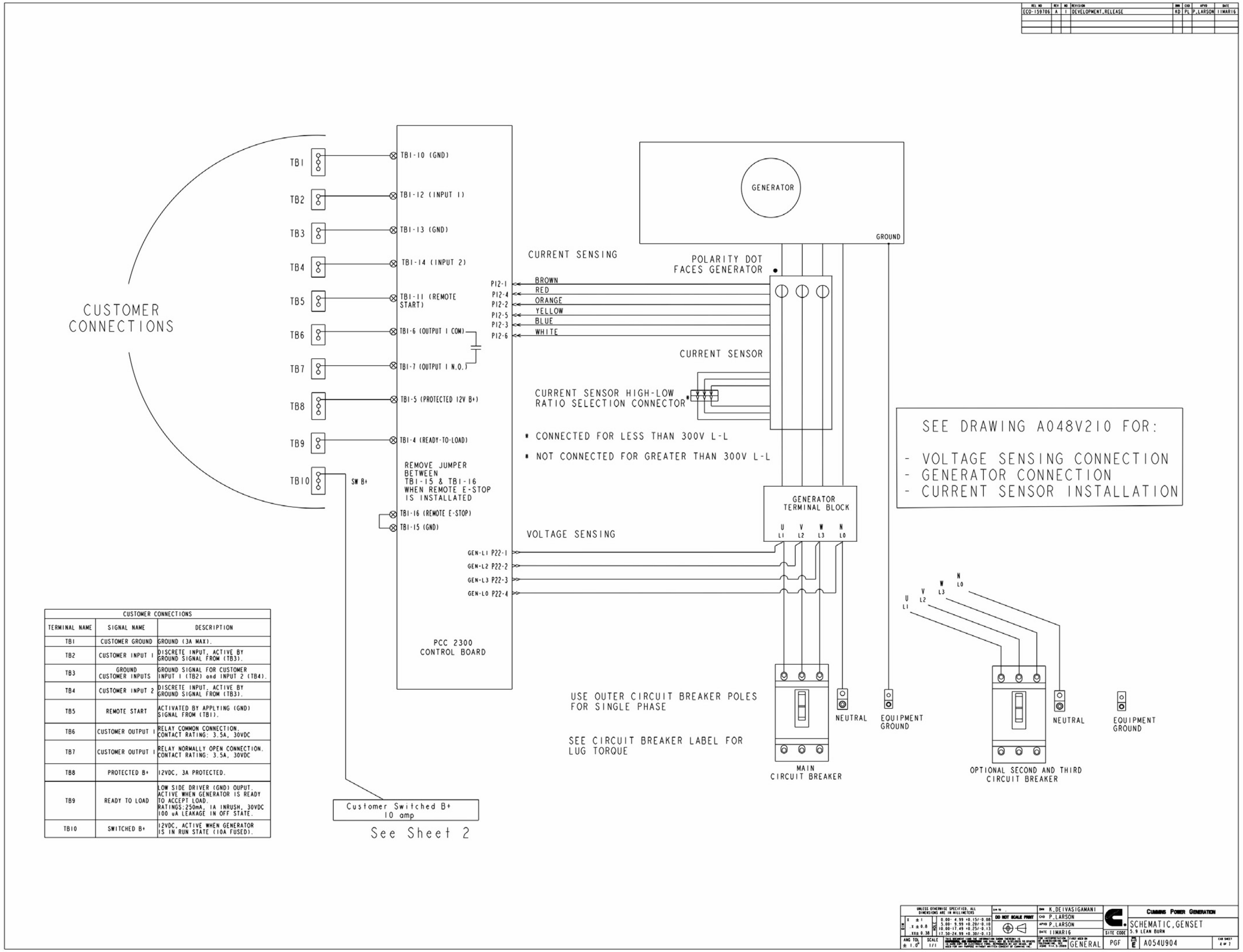


FIGURE 238.   WIRING DIAGRAM FOR PCC 2300 (90 PIN ECM) (SHEET 3 OF 7)



CUSTOMER CONNECTIONS		
TERMINAL NAME	SIGNAL NAME	DESCRIPTION
TB1	CUSTOMER GROUND	GROUND (3A MAX).
TB2	CUSTOMER INPUT 1	DISCRETE INPUT, ACTIVE BY GROUND SIGNAL FROM (TB3).
TB3	GROUND CUSTOMER INPUTS	GROUND SIGNAL FOR CUSTOMER INPUT 1 (TB2) and INPUT 2 (TB4).
TB4	CUSTOMER INPUT 2	DISCRETE INPUT, ACTIVE BY GROUND SIGNAL FROM (TB3).
TB5	REMOTE START	ACTIVATED BY APPLYING (GND) SIGNAL FROM (TB1).
TB6	CUSTOMER OUTPUT 1	RELAY COMMON CONNECTION. CONTACT RATING: 3.5A, 30VDC
TB7	CUSTOMER OUTPUT 1	RELAY NORMALLY OPEN CONNECTION. CONTACT RATING: 3.5A, 30VDC
TB8	PROTECTED B+	12VDC, 3A PROTECTED.
TB9	READY TO LOAD	LOW SIDE DRIVER (GND) OUPUT. ACTIVE WHEN GENERATOR IS READY TO ACCEPT LOAD. RATINGS:250mA, 1A INRUSH, 30VDC 100 uA LEAKAGE IN OFF STATE.
TB10	SWITCHED B+	12VDC, ACTIVE WHEN GENERATOR IS IN RUN STATE (10A FUSED).

FIGURE 239. WIRING DIAGRAM FOR PCC 2300 (90 PIN ECM) (SHEET 4 OF 7)

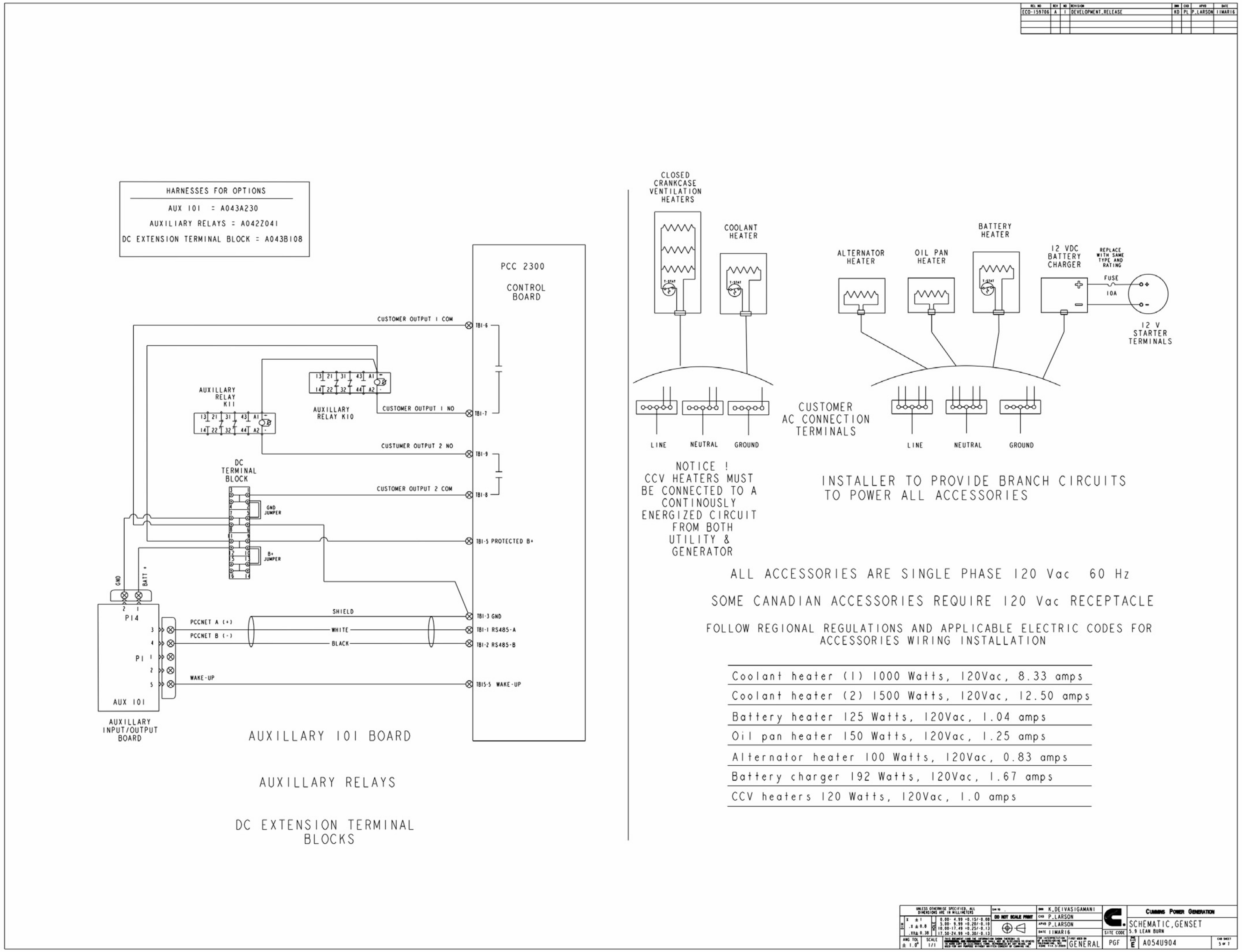


FIGURE 240. WIRING DIAGRAM FOR PCC 2300 (90 PIN ECM) (SHEET 5 OF 7)

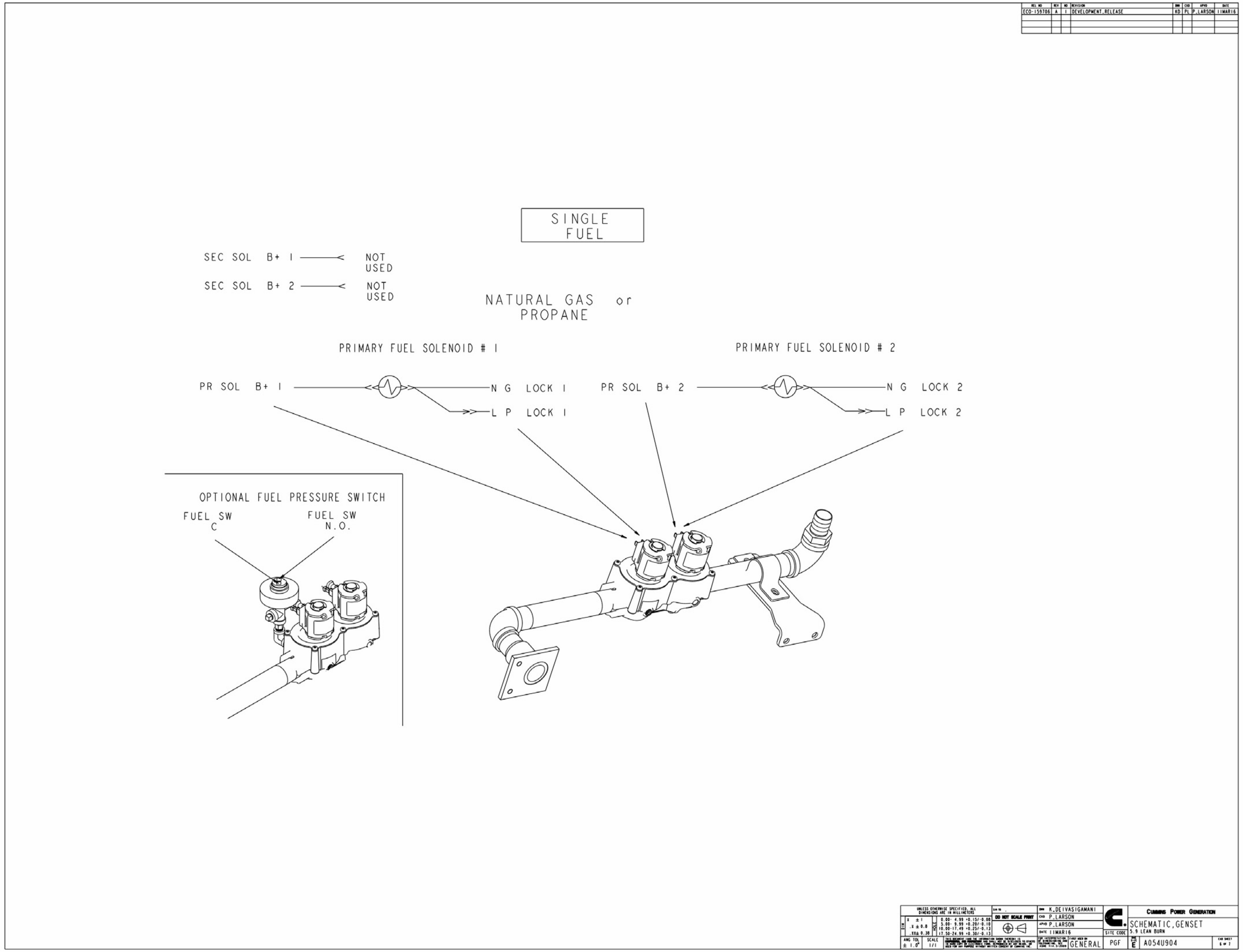


FIGURE 241. WIRING DIAGRAM FOR PCC 2300 (90 PIN ECM) (SHEET 6 OF 7)

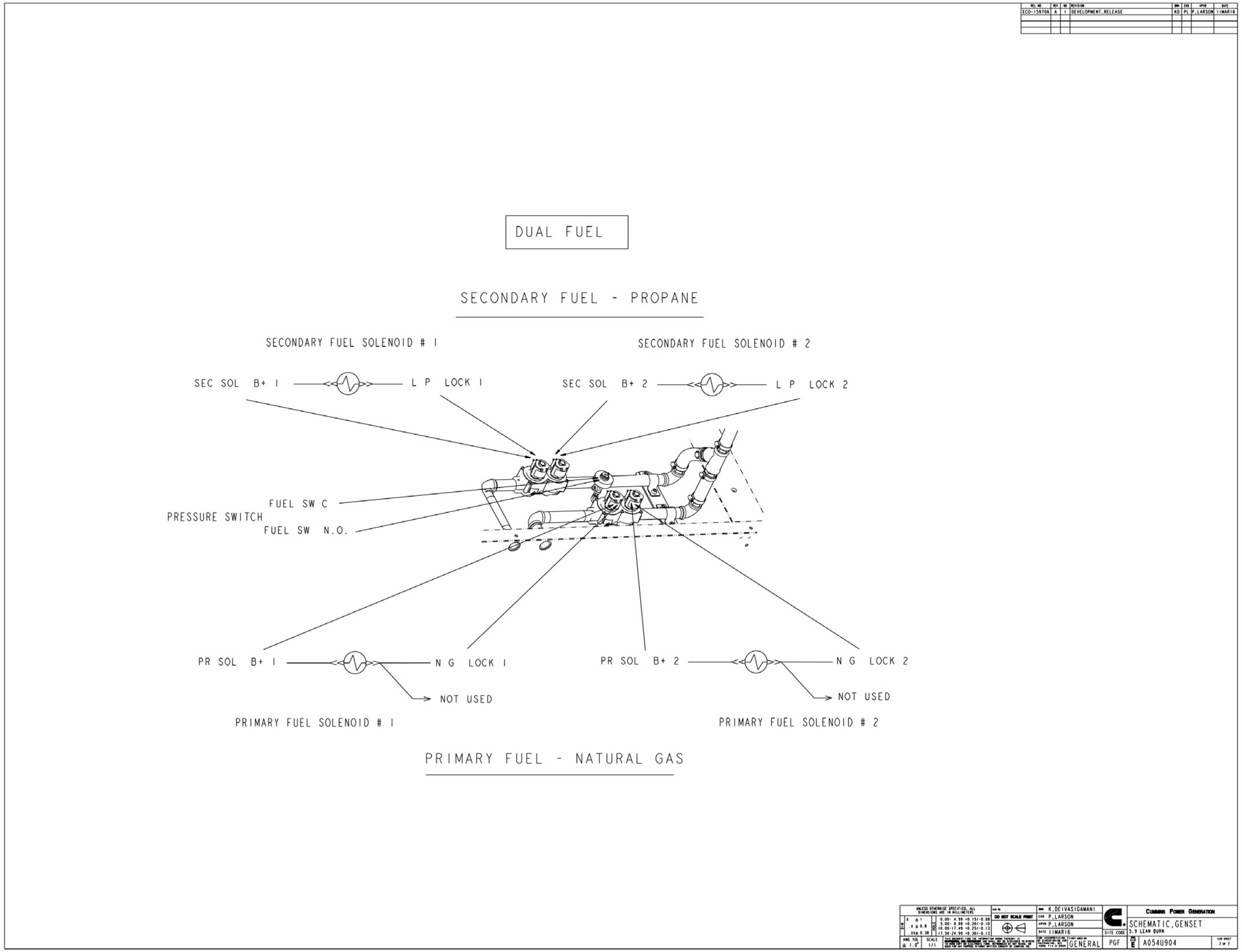
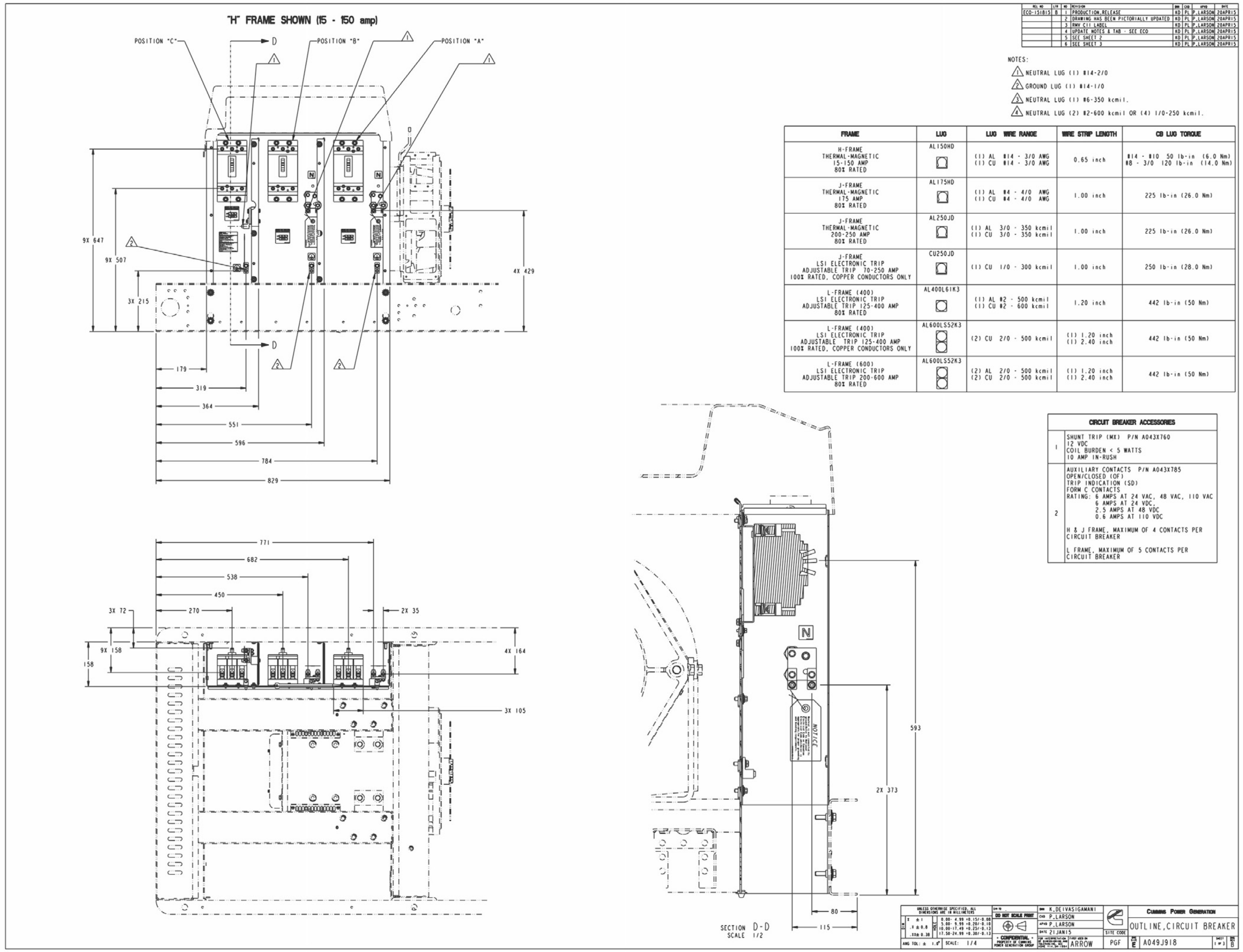


FIGURE 242.   WIRING DIAGRAM FOR PCC 2300 (90 PIN ECM) (SHEET 7 OF 7)



REL NO	LTR	NO	REVISION	DWN	CKD	APVD	DATE
ECO-151815	B	1	PRODUCTION RELEASE	KD	PL	P.LARSON	20APR15
		2	DRAWING HAS BEEN PICTORIALLY UPDATED	KD	PL	P.LARSON	20APR15
		3	RMV C11 LABEL	KD	PL	P.LARSON	20APR15
		4	UPDATE NOTES & TAB - SEE ECO	KD	PL	P.LARSON	20APR15
		5	SEE SHEET 2	KD	PL	P.LARSON	20APR15
		6	SEE SHEET 3	KD	PL	P.LARSON	20APR15

FRAME	LUG	LUG WIRE RANGE	WIRE STRIP LENGTH	CB LUG TORQUE
H-FRAME THERMAL-MAGNETIC 15-150 AMP 80% RATED	AL150HD	(1) AL #14 - 3/0 AWG (1) CU #14 - 3/0 AWG	0.65 inch	#14 - #10 50 lb-in (6.0 Nm) #8 - 3/0 120 lb-in (14.0 Nm)
J-FRAME THERMAL-MAGNETIC 175 AMP 80% RATED	AL175HD	(1) AL #4 - 4/0 AWG (1) CU #4 - 4/0 AWG	1.00 inch	225 lb-in (26.0 Nm)
J-FRAME THERMAL-MAGNETIC 200-250 AMP 80% RATED	AL250JD	(1) AL 3/0 - 350 kcmil (1) CU 3/0 - 350 kcmil	1.00 inch	225 lb-in (26.0 Nm)
J-FRAME LSI ELECTRONIC TRIP ADJUSTABLE TRIP 70-250 AMP 100% RATED, COPPER CONDUCTORS ONLY	CU250JD	(1) CU 1/0 - 300 kcmil	1.00 inch	250 lb-in (28.0 Nm)
L-FRAME (400) LSI ELECTRONIC TRIP ADJUSTABLE TRIP 125-400 AMP 80% RATED	AL400L61K3	(1) AL #2 - 500 kcmil (1) CU #2 - 600 kcmil	1.20 inch	442 lb-in (50 Nm)
L-FRAME (400) LSI ELECTRONIC TRIP ADJUSTABLE TRIP 125-400 AMP 100% RATED, COPPER CONDUCTORS ONLY	AL600LS52K3	(2) CU 2/0 - 500 kcmil	(1) 1.20 inch (1) 2.40 inch	442 lb-in (50 Nm)
L-FRAME (600) LSI ELECTRONIC TRIP ADJUSTABLE TRIP 200-600 AMP 80% RATED	AL600LS52K3	(2) AL 2/0 - 500 kcmil (2) CU 2/0 - 500 kcmil	(1) 1.20 inch (1) 2.40 inch	442 lb-in (50 Nm)

CIRCUIT BREAKER ACCESSORIES	
1	SHUNT TRIP (MX) P/N A043X760 12 VDC COIL BURDEN < 5 WATTS 10 AMP IN-RUSH
2	AUXILIARY CONTACTS P/N A043X785 OPEN/CLOSED (OF) TRIP INDICATION (SD) FORM C CONTACTS RATING: 6 AMPS AT 24 VAC, 48 VAC, 110 VAC 6 AMPS AT 24 VDC, 2.5 AMPS AT 48 VDC 0.6 AMPS AT 110 VDC H & J FRAME, MAXIMUM OF 4 CONTACTS PER CIRCUIT BREAKER L FRAME, MAXIMUM OF 5 CONTACTS PER CIRCUIT BREAKER

FIGURE 243. CIRCUIT BREAKER OUTLINE (SHEET 1 OF 3)

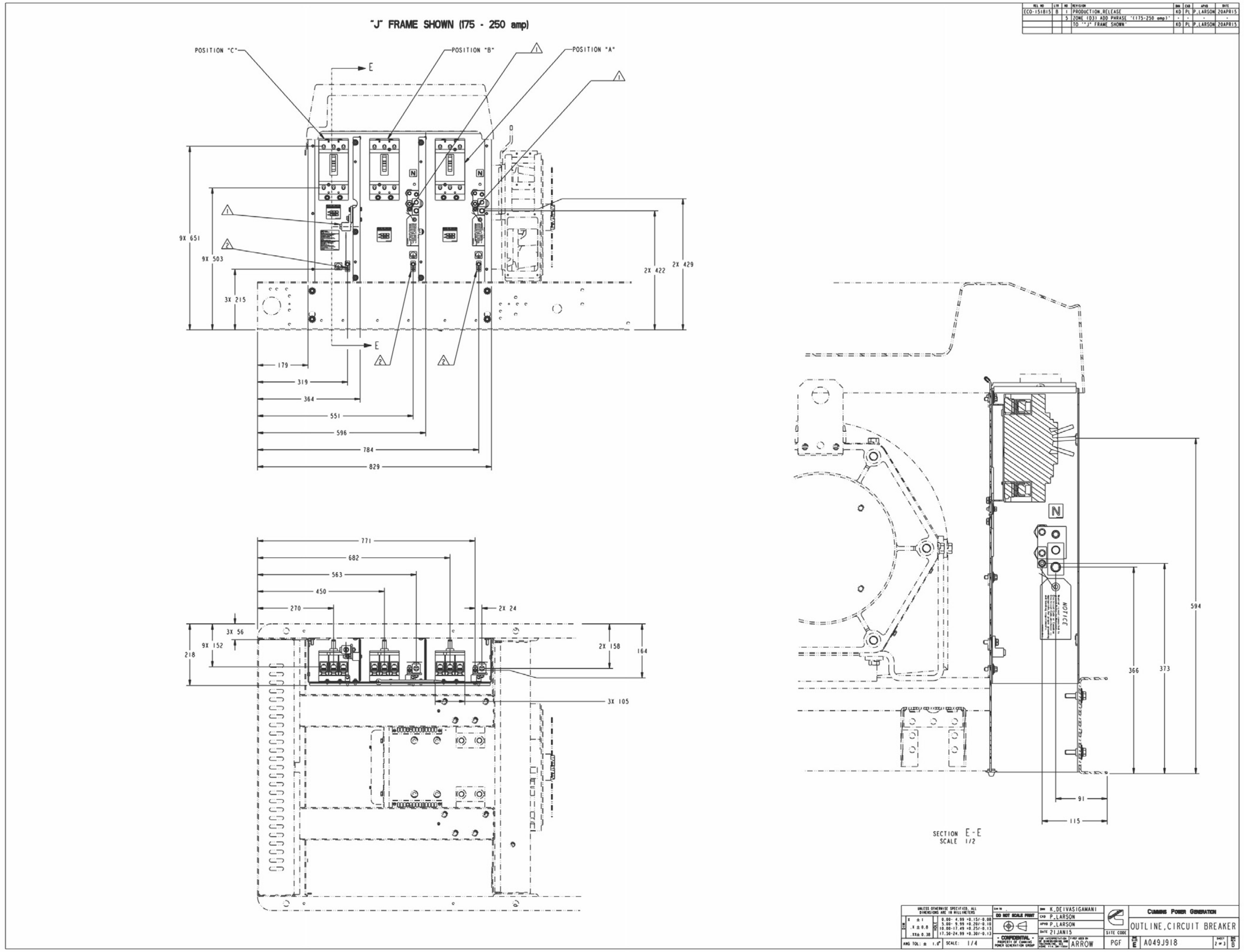


FIGURE 244. CIRCUIT BREAKER OUTLINE (SHEET 2 OF 3)

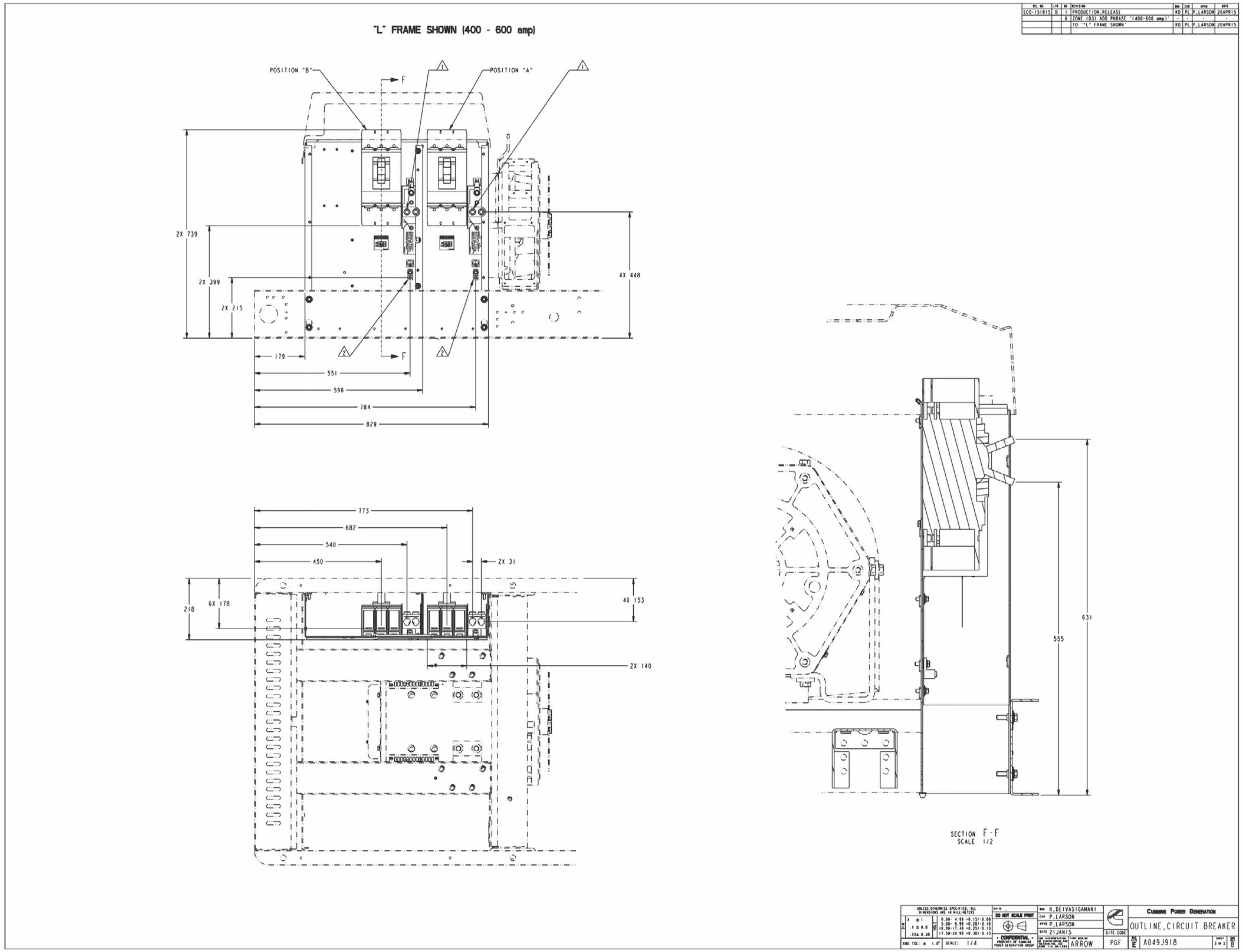


FIGURE 245. CIRCUIT BREAKER OUTLINE (SHEET 3 OF 3)

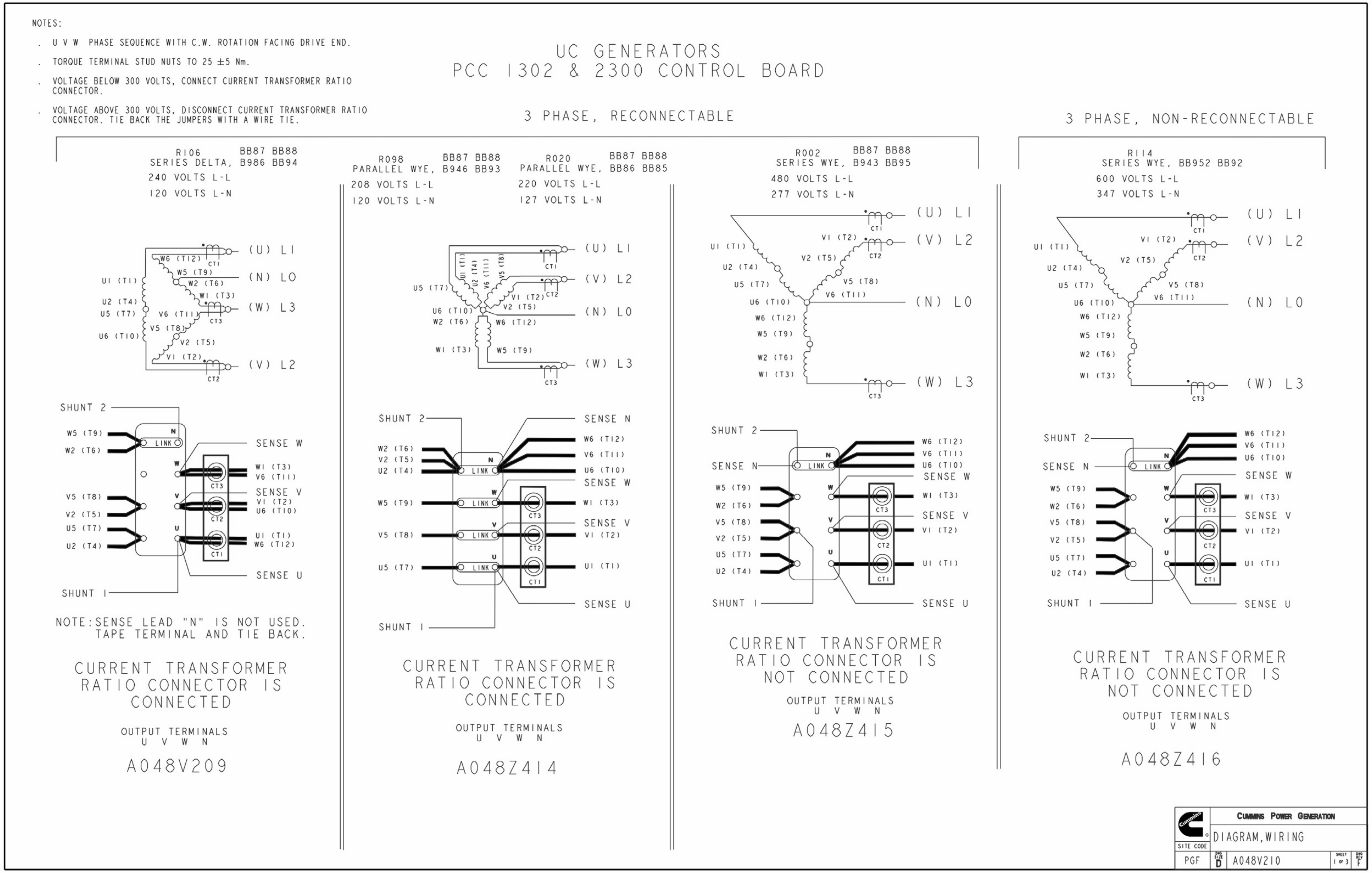


FIGURE 246. PCC 1302/2300 (SHEET 1 OF 3)

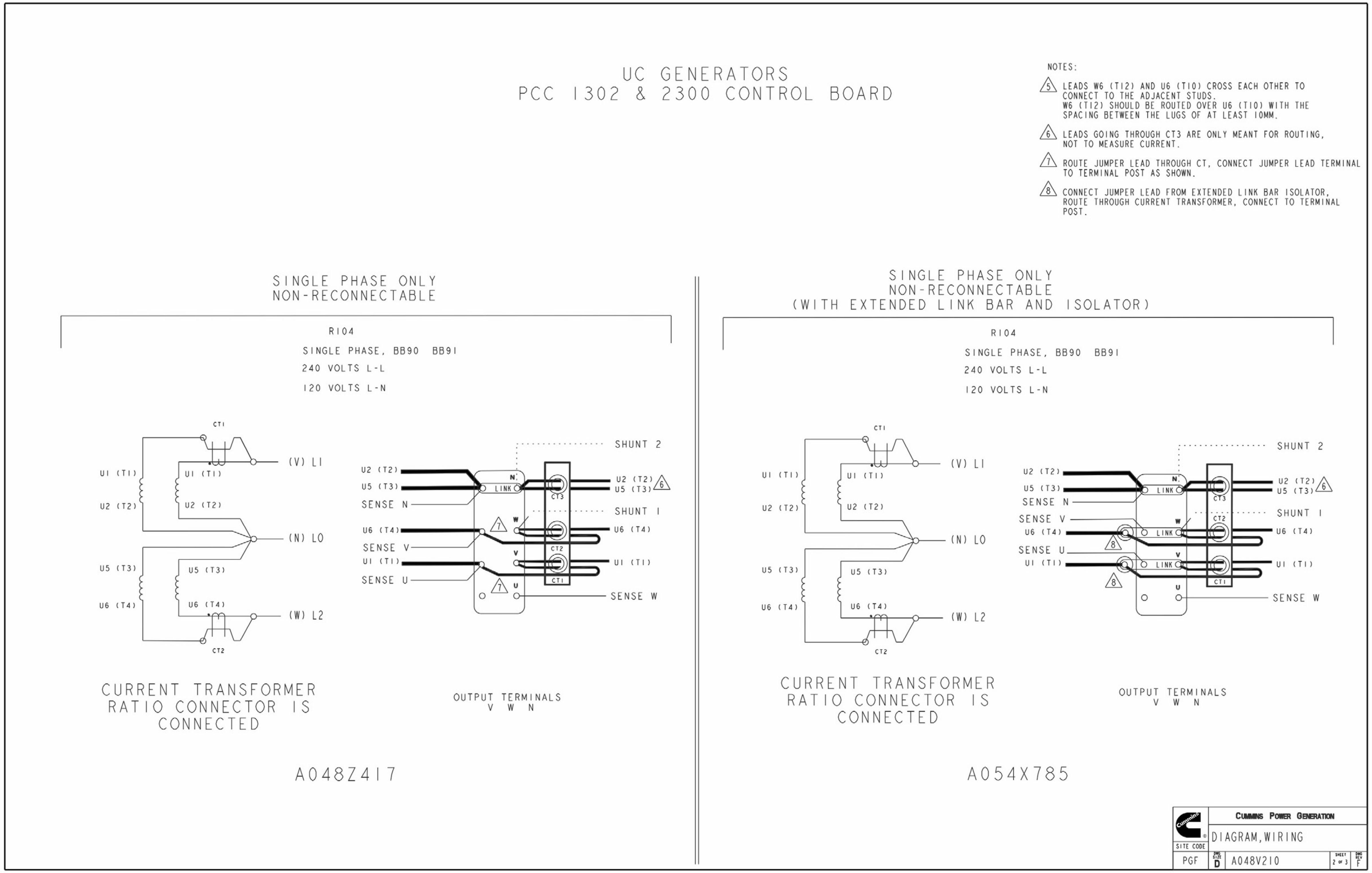


FIGURE 247. PCC 1302/2300 (SHEET 2 OF 3)

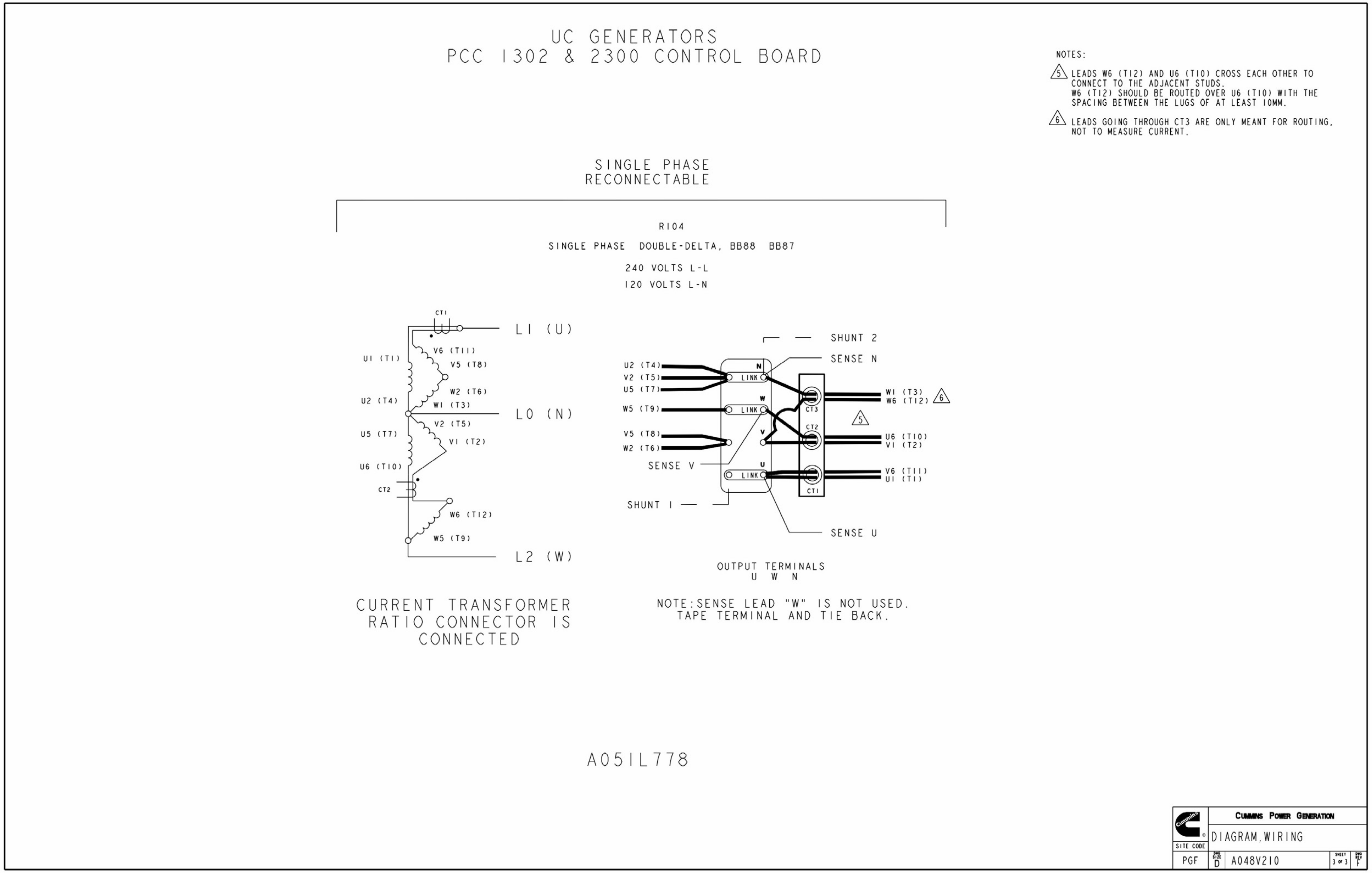
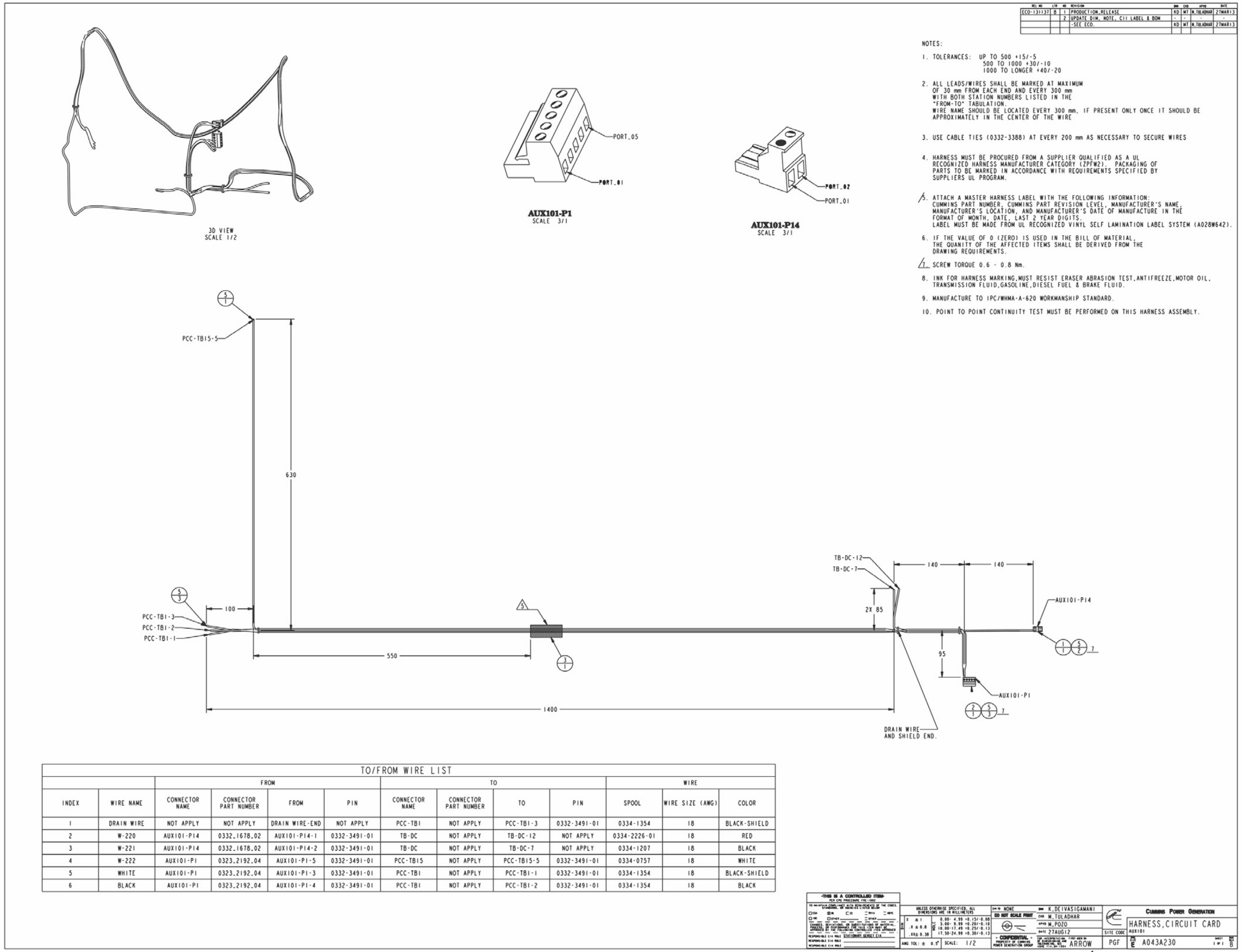


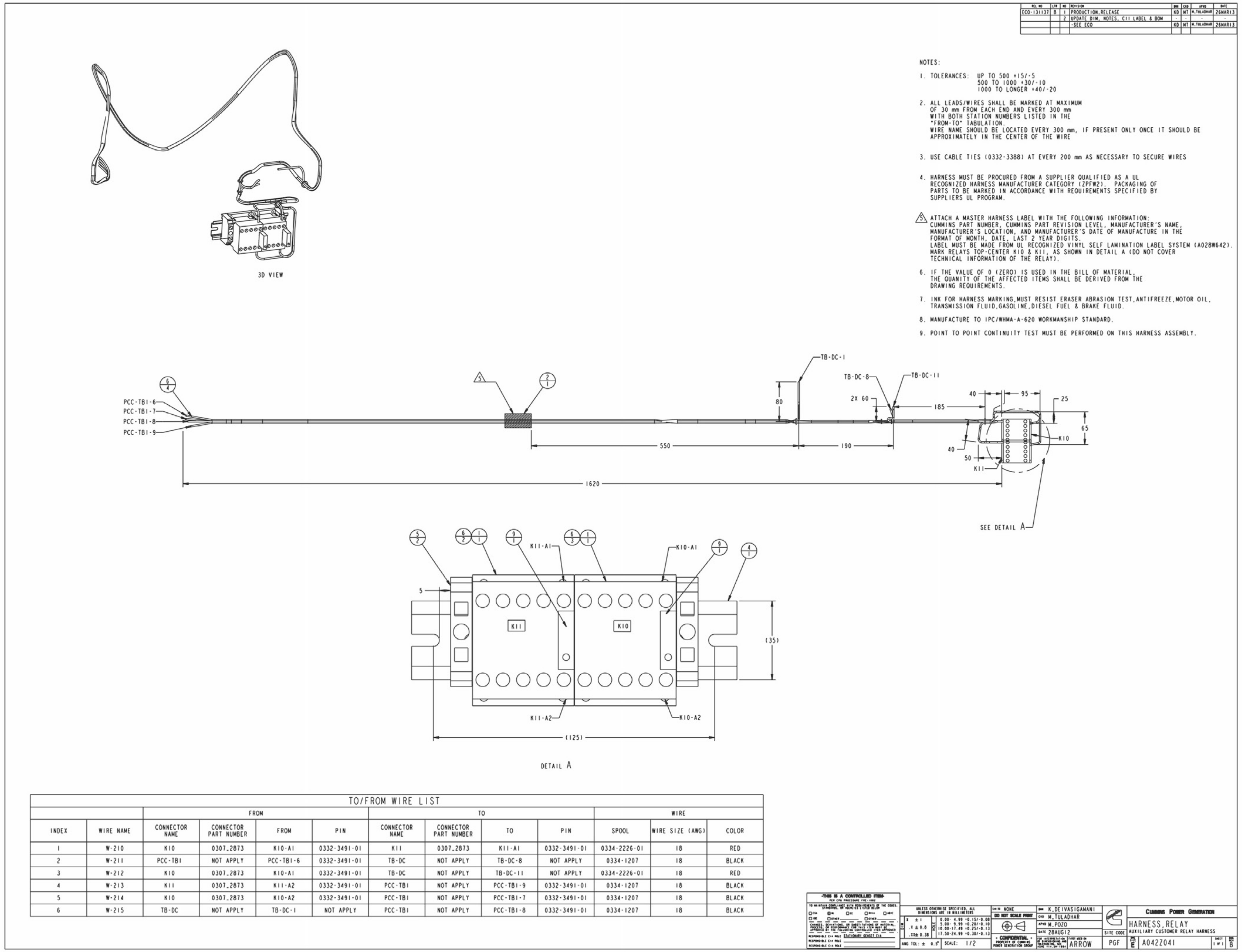
FIGURE 248. PCC 1302/2300 (SHEET 3 OF 3)



TO/FROM WIRE LIST

		FROM				TO				WIRE		
INDEX	WIRE NAME	CONNECTOR NAME	CONNECTOR PART NUMBER	FROM	PIN	CONNECTOR NAME	CONNECTOR PART NUMBER	TO	PIN	SPOOL	WIRE SIZE (AWG)	COLOR
1	DRAIN WIRE	NOT APPLY	NOT APPLY	DRAIN WIRE-END	NOT APPLY	PCC-TB1	NOT APPLY	PCC-TB1-3	0332-3491-01	0334-1354	18	BLACK-SHIELD
2	W-220	AUX101-P14	0332_1678_02	AUX101-P14-1	0332-3491-01	TB-DC	NOT APPLY	TB-DC-12	NOT APPLY	0334-2226-01	18	RED
3	W-221	AUX101-P14	0332_1678_02	AUX101-P14-2	0332-3491-01	TB-DC	NOT APPLY	TB-DC-7	NOT APPLY	0334-1207	18	BLACK
4	W-222	AUX101-P1	0323_2192_04	AUX101-P1-5	0332-3491-01	PCC-TB15	NOT APPLY	PCC-TB15-5	0332-3491-01	0334-0757	18	WHITE
5	WHITE	AUX101-P1	0323_2192_04	AUX101-P1-3	0332-3491-01	PCC-TB1	NOT APPLY	PCC-TB1-1	0332-3491-01	0334-1354	18	BLACK-SHIELD
6	BLACK	AUX101-P1	0323_2192_04	AUX101-P1-4	0332-3491-01	PCC-TB1	NOT APPLY	PCC-TB1-2	0332-3491-01	0334-1354	18	BLACK

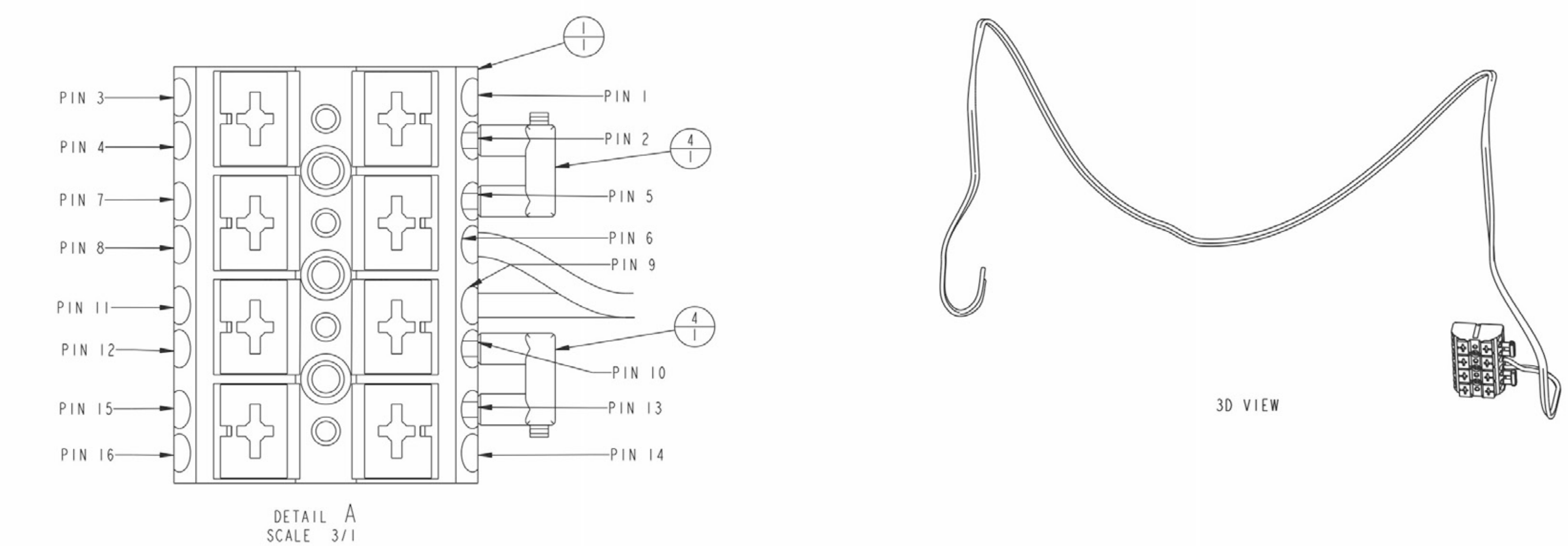
FIGURE 249. CIRCUIT CARD HARNESS (SHEET 1 OF 1)

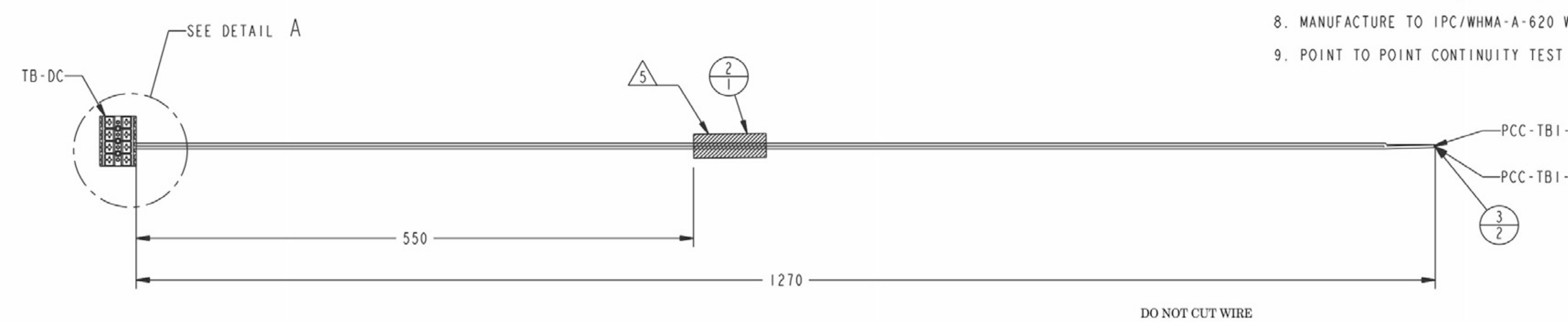


TO/FROM WIRE LIST												
		FROM				TO				WIRE		
INDEX	WIRE NAME	CONNECTOR NAME	CONNECTOR PART NUMBER	FROM	PIN	CONNECTOR NAME	CONNECTOR PART NUMBER	TO	PIN	SPOOL	WIRE SIZE (AWG)	COLOR
1	W-210	K10	0307_2873	K10-A1	0332-3491-01	K11	0307_2873	K11-A1	0332-3491-01	0334-2226-01	18	RED
2	W-211	PCC-TB1	NOT APPLY	PCC-TB1-6	0332-3491-01	TB-DC	NOT APPLY	TB-DC-8	NOT APPLY	0334-1207	18	BLACK
3	W-212	K10	0307_2873	K10-A1	0332-3491-01	TB-DC	NOT APPLY	TB-DC-11	NOT APPLY	0334-2226-01	18	RED
4	W-213	K11	0307_2873	K11-A2	0332-3491-01	PCC-TB1	NOT APPLY	PCC-TB1-9	0332-3491-01	0334-1207	18	BLACK
5	W-214	K10	0307_2873	K10-A2	0332-3491-01	PCC-TB1	NOT APPLY	PCC-TB1-7	0332-3491-01	0334-1207	18	BLACK
6	W-215	TB-DC	NOT APPLY	TB-DC-1	NOT APPLY	PCC-TB1	NOT APPLY	PCC-TB1-8	0332-3491-01	0334-1207	18	BLACK

FIGURE 250. RELAY HARNESS (SHEET 1 OF 1)

REL NO	LTR	NO	REVISION	DWN	CKD	APVD	DATE
ECO-131137	B	1	PRODUCTION RELEASE	KD	MT	M.TULADHAR	26MAR13
		2	UPDATE DIM, NOTES, C11 LABEL & BOM	-	-	-	-
			-SEE ECO.	KD	MT	M.TULADHAR	26MAR13





NOTES:

1. TOLERANCES: UP TO 500 +15/-5
   500 TO 1000 +30/-10
   1000 TO LONGER +40/-20
2. ALL LEADS/WIRES SHALL BE MARKED AT MAXIMUM OF 30 mm FROM EACH END AND EVERY 300 mm WITH BOTH STATION NUMBERS LISTED IN THE "FROM-TO" TABULATION. WIRE NAME SHOULD BE LOCATED EVERY 300 mm, IF PRESENT ONLY ONCE IT SHOULD BE APPROXIMATELY IN THE CENTER OF THE WIRE
3. USE CABLE TIES (0332-3388) AT EVERY 200 mm AS NECESSARY TO SECURE WIRES
4. HARNESS MUST BE PROCURED FROM A SUPPLIER QUALIFIED AS A UL RECOGNIZED HARNESS MANUFACTURER CATEGORY (ZPFW2). PACKAGING OF PARTS TO BE MARKED IN ACCORDANCE WITH REQUIREMENTS SPECIFIED BY SUPPLIERS UL PROGRAM.
5. ATTACH A MASTER HARNESS LABEL WITH THE FOLLOWING INFORMATION: CUMMINS PART NUMBER, CUMMINS PART REVISION LEVEL, MANUFACTURER'S NAME, MANUFACTURER'S LOCATION, AND MANUFACTURER'S DATE OF MANUFACTURE IN THE FORMAT OF MONTH, DATE, LAST 2 YEAR DIGITS. LABEL MUST BE MADE FROM UL RECOGNIZED VINYL SELF LAMINATION LABEL SYSTEM (A028W642).
6. IF THE VALUE OF 0 (ZERO) IS USED IN THE BILL OF MATERIAL, THE QUANITY OF THE AFFECTED ITEMS SHALL BE DERIVED FROM THE DRAWING REQUIREMENTS.
7. INK FOR HARNESS MARKING,MUST RESIST ERASER ABRASION TEST,ANTIFREEZE,MOTOR OIL, TRANSMISSION FLUID,GASOLINE,DIESEL FUEL & BRAKE FLUID.
8. MANUFACTURE TO IPC/WHMA-A-620 WORKMANSHIP STANDARD.
9. POINT TO POINT CONTINUITY TEST MUST BE PERFORMED ON THIS HARNESS ASSEMBLY.

TO/FROM WIRE LIST

		FROM				TO				WIRE			
INDEX	WIRE NAME	CONNECTOR NAME	CONNECTOR PART NUMBER	FROM	PIN	CONNECTOR NAME	CONNECTOR PART NUMBER	TO	PIN	SPOOL	WIRE SIZE (AWG)	LENGTH (REFERENCE ONLY) DO NOT CUT WIRE TO THIS LENGTH	COLOR
1	W-205	PCC-TB1	0323_1678_15	PCC-TB1-5	0332-3491-01	TB-DC	A043K557	TB-DC-9	NOT APPLY	0334-2226-01	18	1263	RED
2	W-206	PCC-TB1	0323_1678_15	PCC-TB1-3	0332-3491-01	TB-DC	A043K557	TB-DC-6	NOT APPLY	0334-1207	18	1250	BLACK

-THIS IS A CONTROLLED ITEM-
PER CPG PROCEDURE FRE-1002
TO MAINTAIN COMPLIANCE WITH REQUIREMENTS OF THE CODES, STANDARDS, OR AGENCIES LISTED BELOW
CSA · UL (X) · CE · RVIA · ABTC · IBC · OTHER · OTHER
CHANGES, DEVIATIONS, OR SUBSTITUTIONS OF MATERIAL, PROCESS, OR PERFORMANCE FOR THIS ITEM MUST BE APPROVED BY THE FOLLOWING CONTROLLED ITEM APPROVER
RESPONSIBLE CIA ROLE STATIONARY GENSET CIA
RESPONSIBLE CIA ROLE
RESPONSIBLE CIA ROLE

UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN MILLIMETERS
DIM: X ±1; .X ±0.8; .XX± 0.38
HOLE: 0.00- 4.99 +0.15/-0.08; 5.00- 9.99 +0.20/-0.10; 10.00-17.49 +0.25/-0.13; 17.50-24.99 +0.30/-0.13
ANG TOL: ± 0.5° SCALE: 5/8
SIM TO NONE
DO NOT SCALE PRINT
- CONFIDENTIAL - PROPERTY OF CUMMINS POWER GENERATION GROUP
DWN K_DEIVASIGAMANI
CKD M_TULADHAR
APVD M_POZO
DATE 28AUG12
FOR INTERPRETATION OF DIMENSIONING AND TOLERANCING, SEE ASME Y14.5M-1994
FIRST USED ON ARROW
SITE CODE PGF
CUMMINS POWER GENERATION
HARNESS,GENERATOR ELECTRICAL
2 WIRE HARNESS FOR B+,B- EXTENSION
DWG SIZE D A043B108 SHEET 1 OF 1 DWG REV B

FIGURE 251. GENERATOR ELECTRICAL HARNESS (SHEET 1 OF 1)

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Specifications are subject to change without notice.