Installation Manual

Generator Set

VTA28-G5/G6 Engine with PowerCommand® 1.2 or 3.3 Control

C600 D6
C600 D6 (Spec F)
C700 D5
C700 D5 (Spec F)
C825 D5A
C825 D5A (Spec F)

English
Original Instructions
10-2023
A043C345 (Issue 2)

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1 IMPORTANT SAFETY INSTRUCTIONS

SAVE THESE INSTRUCTIONS. This manual contains important instructions that should be followed during installation and maintenance of the generator set and batteries.

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.

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 with specific generator sets. In the event that this manual has been supplied in isolation, contact your authorized distributor.

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

1.2.1 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 can cause severe personal injury or death.

Do not operate equipment when fatigued, or after consuming any alcohol or drug.

⚠ 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

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.

⚠ 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

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.

⚠ 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 use combustible liquids like ether.

⚠ 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

Fire Hazard

Materials drawn into the generator set are a fire hazard. Fire can cause severe burns or death.

Make sure the generator set is mounted in a manner to prevent combustible materials from accumulating under the unit.

⚠ WARNING

Fire Hazard

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. Repair oil leaks promptly.

⚠ WARNING

Fall Hazard

Falls can result in severe personal injury or death.

Make sure that suitable equipment for performing tasks at height are used in accordance with local guidelines and legislation.

⚠ WARNING

Fire Hazard

Materials drawn into the generator set are a fire hazard. Fire can cause severe burns or death.

Keep the generator set and the surrounding area clean and free from obstructions.

⚠ WARNING

Pressurized System

Pressurized systems can rupture/leak which can result in severe personal injury or death.

Use appropriate lock out/tag out safety procedures to isolate from all energy sources before performing any service tasks. Use PPE.

⚠ WARNING

Confined Areas

Confined spaces or areas with restricted access or potential to entrap can cause severe personal injury or death.

Use appropriate lock out/tag out safety procedures to isolate from all energy sources. Use PPE. Follow site specific lone worker protocols/permits to work.

⚠ CAUTION

Manual Handling Heavy Objects

Handling heavy objects can cause severe personal injury.

Use appropriate lifting equipment and perform tasks with two people where doing so would make completion of the task safe.

⚠ CAUTION

Power Tools and Hand Tools

Tools can cause cuts, abrasions, bruising, puncture injuries.

Only trained and experienced personnel should use power tools and hand tools. Use PPE.

⚠ CAUTION

Sharp Edges and Sharp Points

Projecting corners/parts may cause cuts, abrasions and other personal injury.

Use PPE. Be aware of sharp edges and corners/sharp points. Cover/protect them.

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.

1.3.1 Moving Parts Can Cause Severe Personal Injury or Death

- Keep hands, clothing, and jewelry away from moving parts. 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.
- 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.
- If any adjustments must be made while the unit is running, use extreme caution around hot manifolds, moving parts, etc.

1.3.2 Positioning of Generator Set

The generator set should be placed on level ground with adequate open space around it. The immediate area around the generator set should be free of any flammable material.

NOTICE

Access or service doors must be closed and locked before repositioning, and they must remain locked during transportation and siting.

NOTICE

The generator set is capable of operating at inclines of up to +/– 2.5 degrees.

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 jewelry 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 *Locking the Generator Set Out of Service* 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 jewelry 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.

1.4.1 NFPA Equivalent Standards

BS EN 12601:2010 Reciprocating internal combustion engine driven generating sets — Safety. International Relationships EN 12601:2010 Identical BS EN 60204-1:2006+A1:2009 Safety of machinery. Electrical equipment of machines. General requirements. International Relationships EN 60204-1:2006 Identical, IEC 60204-1:2005 Modified.

1.4.2 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.

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.

1.5.1 Spillage

Any spillage that occurs during fueling, oil top-off, or oil change must be cleaned up before starting the generator set.

1.5.2 Fluid Containment

NOTICE
Where spillage containment is not part of a Cummins supply, it is the responsibility of the installer to provide the necessary containment to prevent contamination of the environment, especially water courses and sources.

Fluid containment is incorporated into the base of the generator set, it must be inspected at regular intervals. Any liquid present should be drained out and disposed of in accordance with local health and safety regulations. Failure to perform this action may result in spillage of liquids which could contaminate the surrounding area.

Any other fluid containment area must also be checked and emptied, as described above.

1.5.3 Do Not Operate in Flammable and Explosive Environments

Flammable vapor can cause an engine to overspeed 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.

1.6.1 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 Decommissioning and Disassembly

NOTICE

Decommissioning and disassembly of the generator set at the end of its working life must comply with local guidelines and legislation for disposal/recycling of components and contaminated fluids. This procedure must only be carried out by suitably trained and experienced service personnel. For more information contact your authorized distributor.

2 Introduction

⚠ WARNING

Hazardous Voltage

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

Make sure that only a trained and experienced electrician makes generator set electrical output connections, in accordance with the installation instructions and all applicable codes.

⚠ WARNING

Electrical Generating Equipment

Faulty electrical generating equipment can cause severe personal injury or death.

Generator sets must be installed, certified, and operated by trained and experienced persons in accordance with the installation instructions and all applicable codes.

2.1 About This Manual

The purpose of this manual is to provide the users with sound, general information. It is for guidance and assistance with recommendations for correct and safe procedures, which may from time to time be updated. It is the user's responsibility to ensure they are aware of any updates to this guidance before commencing operational activities. Cummins shall not be liable for any operational consequences arising as a result of not following the guidance outlined in this manual, nor for any discretionary actions taken by the user in response to recommendations outlined in this manual.

The information contained within the manual is based on information available at the time of going to print. In line with Cummins 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**).

Users are respectfully advised that, in the interests of good practice and safety, it is their responsibility to employ competent persons to carry out any installation work. Consult your authorized distributor for further installation information. It is essential that the utmost care is taken with the application, installation, and operation of any engine due to their potentially hazardous nature. Careful reference should also be made to other Cummins literature. A generator set must be operated and maintained properly for safe and reliable operation.

For further assistance, contact your authorized distributor.

2.1.1 Additional Installation Manual Information

The purpose of this manual is to provide the Installation Engineer with sound, general information for the installation of the generator set. Refer to the Generator Set Operator Manual for additional information which must also be read before operating the set.

This manual provides installation instructions for the generator set models listed on the front cover. This includes the following information:

- Mounting Recommendations - for fastening the generator set to a base and space requirements for normal operation and service.
- Mechanical and Electrical Connections - covers most aspects of the generator set installation.
- Prestart - checklist of items or procedures needed to prepare the generator set for operation.
- Installation Checklist - reference checks upon completion of the installation.

This manual does not provide application information for selecting a generator set or designing the complete installation. If it is necessary to design the various integrated systems (fuel, exhaust, cooling, etc.), additional information is required. Review standard installation practices. For engineering data specific to the generator set, refer to the Specification and Data Sheets. For application information, refer to Application Manual T-030, "Liquid Cooled Generator Sets." To find this manual online:

1. Go to **powersuite.cummins.com**
2. Click on "Login" on the Home page.
3. Click on "Library".
4. Click on "Technical Documents".
5. Click on "Technical information".
6. Click on "Liquid Cooled Genset Application Manual".

2.2 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	HMI	Human-Machine Interface
ADCS	Advanced Digital Control System	LCD	Liquid Crystal Display
ASTM	American Society for Testing and Materials (ASTM International)	LED	Light-Emitting Diode
AVR	Automatic Voltage Regulator	MIL STD	Military Standard
CB	Circuit Breaker	NATO	North Atlantic Treaty Organization
CT	Current Transformer	NFPA	National Fire Protection Agency
DC	Direct Current	NO	Normally Open
DCS	Digital Control System	PT	Potential Transformer
ECM	Engine Control Module	OOR	Out of Range
EMI	Electromagnetic interference	PCC	PowerCommand™ Control
EN	European Standard	PPE	Personal Protective Equipment
ESD	Electro Static Discharge	PWM	Pulse-Width Modulation
E-Stop	Emergency Stop	RMS	Root Mean Square
Genset	Generator Set	SAE	Society of Automotive Engineers
GFCI	Ground Fault Circuit Interrupter	SW_B+	Switched B+
GFI	Ground Fault Interrupter	USB	Universal Serial Bus
GND	Ground		

2.3 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.

⚠ CAUTION

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)

The relevant manuals appropriate to your generator set are also available, the document numbers below are English language versions (other languages are available):

- Operator Manual for VTA28-G5/G6 with PC 1.2 (A046W365)
- Operator Manual for VTA28-G5/G6 with PC 3.3 (A043C344)
- Installation Manual for VTA28-G5/G6 with PC 1.2 and PC 3.3 (A043C345)
- Service Manual for VTA28-G5/G6 with PC 1.2 and PC 3.3 Control (A046W373)
- Engine Operation & Maintenance Manual for VTA28 (3379052)
- Engineering Application Manual *T-030: Liquid Cooled Generator Sets* (A040S369)
- Parts Manual for VTA28-G5/G6 with PC 3.3 (A047E394)
- Recommended Spares List (RSL) for C600 D6 (A046V193)
- Recommended Spares List (RSL) for C700 D5 (A046V194)
- Recommended Spares List (RSL) for C825 D5A (A046V196)
- Standard Repair Times - BL Family (0900-0900)
- Warranty Administration Manual (4021290)
- Global Commercial Warranty Statement (A028U870)

Contact your authorized distributor for more information regarding related literature for this product.

2.4 After Sales Services

Cummins offers a full range of maintenance and warranty services.

2.4.1 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.

2.4.2 Warranty

For details of the warranty coverage for your generator set, refer to the Global Commercial 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 resources 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 warranty. Contact your authorized service provider.

2.4.2.1 Warranty Limitations

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

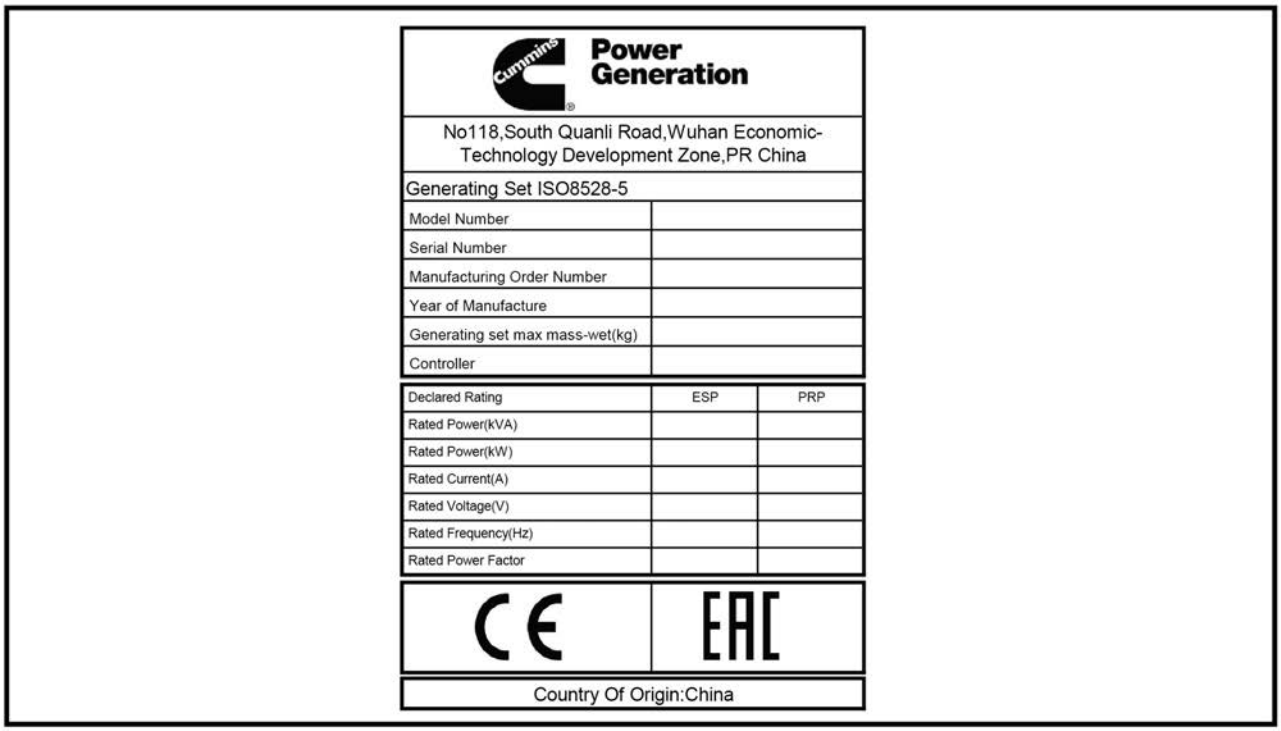
3 System Overview

This section provides an overview of the generator set.

3.1 Generator Set Identification

Each generator set is provided with a nameplate similar to that shown below. The nameplate provides information unique to the generator set.

3.1.1 Nameplate



Power Generation

No118,South Quanli Road,Wuhan Economic-Technology Development Zone,PR China

Generating Set ISO8528-5	
Model Number	
Serial Number	
Manufacturing Order Number	
Year of Manufacture	
Generating set max mass-wet(kg)	
Controller	

Declared Rating	ESP	PRP
Rated Power(kVA)		
Rated Power(kW)		
Rated Current(A)		
Rated Voltage(V)		
Rated Frequency(Hz)		
Rated Power Factor		

CE EAC

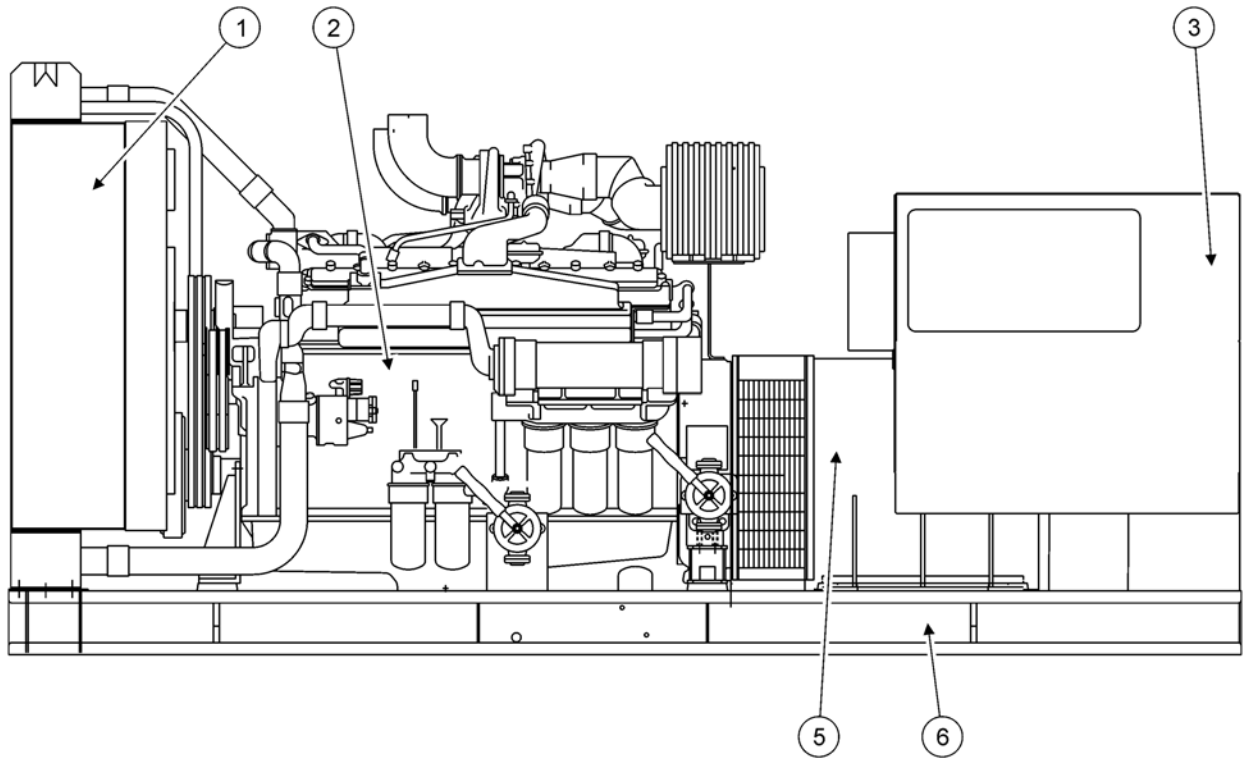
Country Of Origin:China

FIGURE 1. TYPICAL GENERATOR SET NAMEPLATE

3.2 Generator Set Components

The main components of a typical VTA28 engine generator set are shown below, and referred to within this section.

There are various options listed although they may not be available for all models.



No	Description	No	Description
1	Radiator		(Not indicated)
2	Engine		Battery and Tray
3	Controller		Alarm Module
4	Battery (Other Side)		Battery Charger
5	Alternator		Engine Coolant Heater
6	Bed Frame		Alternator Heater

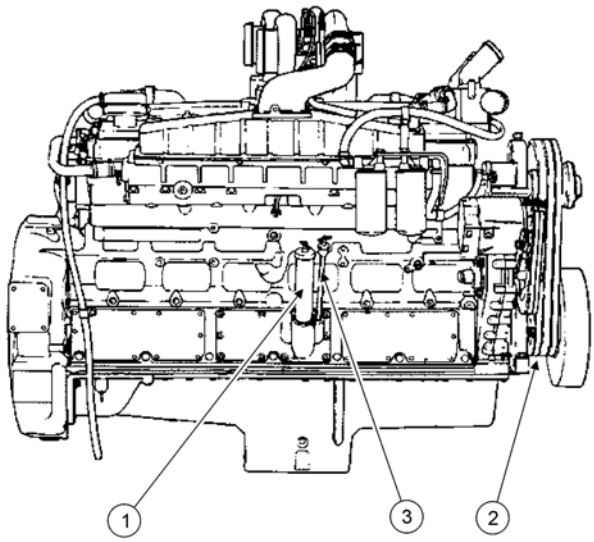
FIGURE 2. TYPICAL VTA28 ENGINE GENERATOR SET

3.3 Generator Set Rating

For details of the generator set rating, refer to the generator set nameplate. For operation at temperatures or altitudes above those stated on the nameplate, a derate may be necessary.

3.4 Engine

For additional engine specific information, refer to the relevant engine manual for your generator set.



No.	Description
1	Oil filler cap
2	Fan belt
3	Dipstick

FIGURE 3. TYPICAL ENGINE COMPONENTS (VTA28)

3.5 Sensors

Various generator set parameters are measured by sensors, and the resulting signals are processed by the control board.

Engine-mounted sensors monitor a number of different systems, including:

- Oil Pressure Sensor
- Cooling System Temperature Sensor
- Magnetic Speed Pickup Unit (MPU)
- Coolant Level sensor

3.6 Normal Duty Air Cleaner

This shows the normal duty air cleaner.

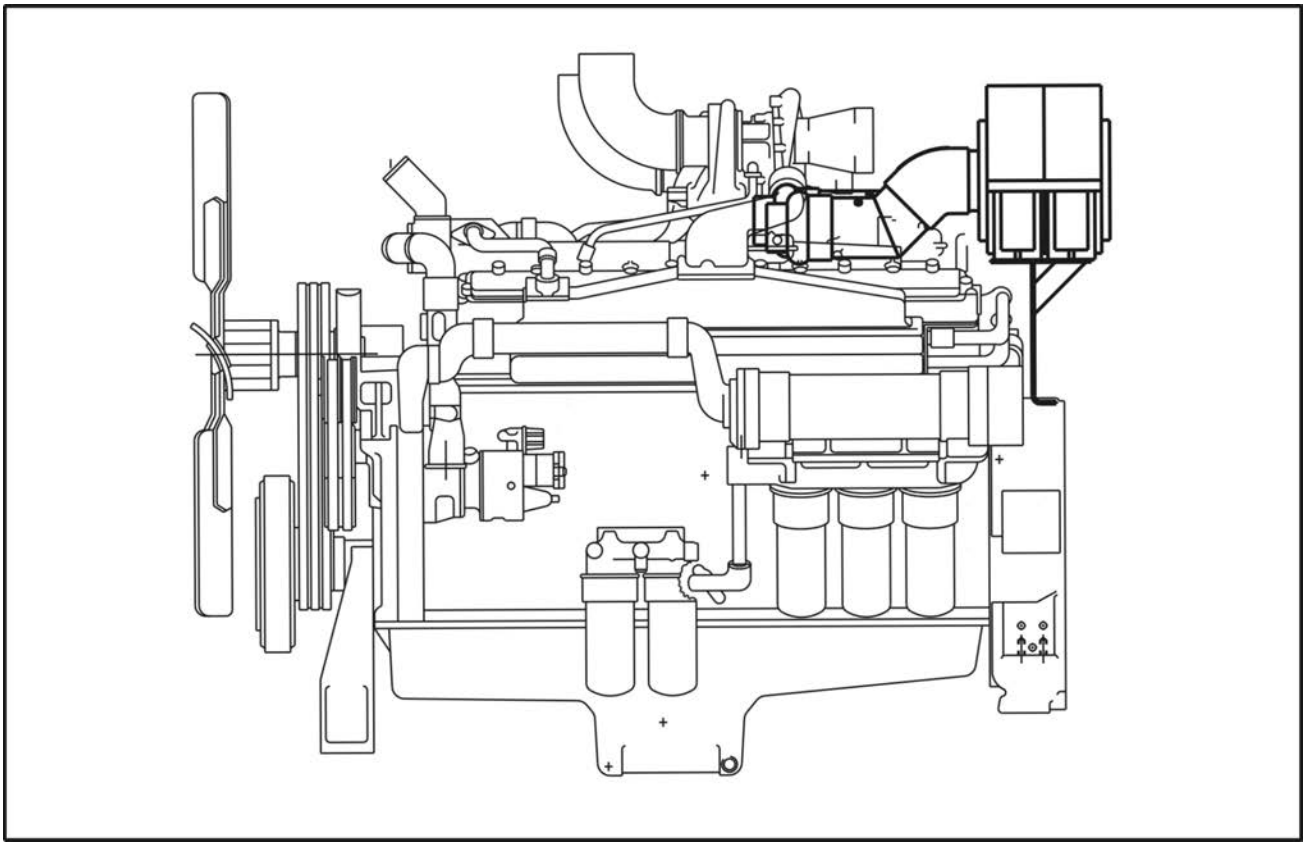


FIGURE 4. NORMAL AIR CLEANER ASSEMBLY

3.7 System Options

3.7.1 Alternator Heater

An alternator heater is used to help keep the alternator free of condensation when the generator set is not running. During cool and humid conditions, condensation can form within an alternator, creating flashing and shock hazards.

3.7.2 Annunciators

The annunciator's lamps and alarm indicate the operating status and fault conditions of an emergency power system. For more information, see **Section 9.8 on page 60**.

3.7.3 Coolant Heater

NOTICE
Operating the heater or heaters when the coolant system has been drained, or there is a suspicion that the coolant is frozen, can result in equipment damage. **Always make sure the coolant is not frozen and the radiator is filled to the recommended level before energizing the heater or heaters.**

A coolant heater keeps the engine coolant warm when the engine is shut down. It heats and circulates the coolant within the engine. This reduces start-up time and lessens engine wear caused by cold starts. It is electrically operated and thermostatically controlled.

3.7.4 Control Box Heater

A control box heater provides a means of humidity and temperature control of the control box interior. It protects the components when the generator set is subjected to varying ambient air conditions during extended periods of non-use. For more information on heater components and wiring, see **Section 9.10 on page 61**.

3.7.5 Heavy Duty Air Cleaner

The heavy duty air cleaner assembly is used in dusty environments. The air cleaner includes of a primary and a safety element. The rubber breather tube on the bottom of each filter canister should be checked periodically to make sure it is free of dust an dirt.

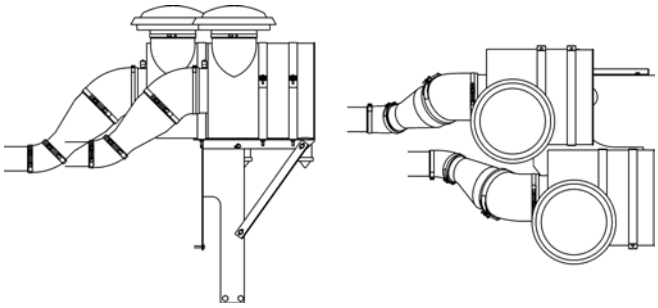


FIGURE 5. HEAVY DUTY AIR CLEANER ASSEMBLY

3.7.6 Fuel Transfer Pump

A fuel transfer pump and control can be installed when a sub-base or an in-skid day tank is provided. For more information, see **Section 9.4 on page 57**.

3.7.7 Battery Charger

3.7.7.1 Mains (Utility) Powered Battery Charger

⚠ CAUTION
Disconnect the battery charger before isolating the battery. Failure to do so can result in voltage spikes high enough to cause equipment damage and personal injury.

This unit maintains the battery in a fully charged condition without over-charging. The unit also provides rapid charging, when necessary, at a current up to the rated output.

The charger's electronic control circuit allows the charger to be left in circuit during engine cranking and to operate in parallel with the charge alternator.

The charger will supply current to the battery system until the battery terminal voltage becomes equal to the set float voltage, at which point only a trickle charge current is present. When the battery becomes discharged due to a load being present and the terminal voltage falls, the charger will again supply current to restore the voltage of the battery to the float voltage.

3.7.7.2 Battery Charger - 5 Amp and 10 Amp Wall-Mounted (Option)

The 5 Amp and 10 Amp Battery Chargers are of the constant voltage, current limited type, designed for charging vented or sealed lead acid and nickel cadmium batteries. They are also capable of supplying a standing load whilst simultaneously maintaining the battery to its fully charged state. It is designed to be left in circuit during cranking and to operate in parallel with the charge alternator mounted on the engine.

The chargers are supplied loose for wall mounting.

Features:

- Boost charge facility
- Charge fail facility
- Short circuit protected
- Reverse power protected
- Constant voltage
- Current limited
- RF suppression

3.7.7.2.1 Boost

As the charge cycle commences, current is limited to the maximum allowable by the electronic control circuitry. As the battery becomes increasingly charged, the current demanded by the battery reduces proportionally, until the battery terminal float voltage equals the reference voltage of the charger at which point the charger maintains a trickle charge only, which is insufficient to either overcharge the battery or cause “gassing” effects.

A Boost Charge facility enables the constant voltage of the charger to be increased, allowing charge time to be reduced and periodic equalization of battery cells to take place.

Boost charge commences on the operation of the Boost switch located on the front panel of the unit.

3.7.7.2.1.1 Controls and Indicators

The following controls are provided:

- **Power On/Off** - Switches the unit On/Off
- Boost - A boost charge enables the constant voltage of the charger to be increased, allowing charge time to be reduced and periodic equalization of battery cells to take place. Boost charge is obtained when the Boost switch is placed in the **On** position. In the **Off** position, boost charging does not take place.

NOTICE
The charger should not be left in the Boost position for excessive periods or gassing of the battery occurs.

The following indicators are provided:

- Power On - This indicator illuminates when the Power switch is in the On power and AC power is supplied to the unit.
- Charge Current Meter - This indicates the output current of the battery charger in amps.

3.7.7.2.2 Specifications - 5 Amp and 10 Amp

Description	Specifications
Supply Voltage	90–305 V (L-N)
Frequency Range	48–64 Hz (L-N)
DC Output	10 A DC at 12 V and 24 V DC*
Ripple and Noise	< 1%
Efficiency	> 86%
Regulation Line	< 0.5%
Regulation Load	2%
Temperature Sensor Input	PT1000
Charge Failure Relay	3 A at 30 V DC volt free relay
Operating Temperature Range	–30–55 °C (–22–131 °F)
Operating Temperature Range (Derate to Output)	–30–80 °C (–22–176 °F)
Dimensions Overall	170 x 305 x 116 mm (6.7 x 12 x 4.6 in)
* Configurable for use as a 5 Amp Charger	

3.7.7.3 Battery Charger – 5 Amp/24 Volt

NOTICE
It is the sole responsibility of the Customer to provide the power supply and means to isolate the power supply to the battery charger.

NOTICE
The AC power supply must be installed using the correctly sized conductors with appropriate overcurrent and ground fault protection to comply with local electrical codes and regulations.

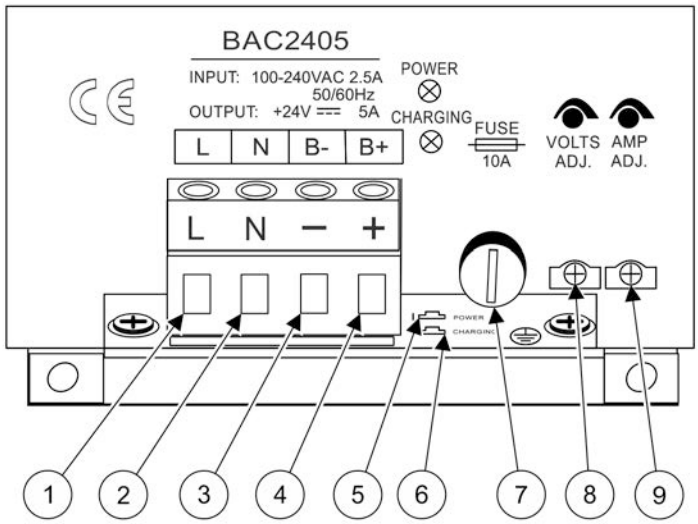
The 5 Amp Battery Charger is of the constant voltage, current limited type, designed for charging vented or sealed lead acid and nickel cadmium batteries. They are also capable of supplying a standing load while simultaneously maintaining the battery at a fully charged state. It is designed to be left in the circuit during cranking and to operate in parallel with the charging alternator mounted on the engine.

3.7.7.3.1 Features

- Wide input voltage.
- Automatic two–stage charging process, constant current and constant voltage.
  - Constant current type: when the battery terminal voltage falls below the pre-set value, charging current will be constant.
  - Constant voltage type: when the battery terminal voltage exceeds the pre-set value, charging current will decrease with the rising of terminal voltage until the pre-set current value is reached.

    When the charging current value falls below 0.5 A and the constant voltage value is reached, the battery is fully charged (charging indicator will extinguish).

- Built-in current protective circuit for short-circuit protection and reverse connection protection. The output fuse may blow when the output terminal of battery charger shorted, or the battery connection is reversed. The charger green LED lights up but output terminal without voltage outputting. Rewire and replace the fuse to return to normal.
- Adjustable current and voltage.
  - Voltage adjustment: When adjust voltage on site, battery need to be disconnected with battery charger, and then adjust the voltage potentiometer (VOLT) to the appropriate value while measuring the charger output voltage.
  - Current adjustment: Connect the battery charger with battery, measuring charging current under 25.0 VDC charging voltage, and then adjust the current potentiometer (AMP) to the appropriate value. Current also can be estimated according to the scale of the current potentiometer.
- Separate LED power and charging indicators.



No.	Description	No.	Description
1	Line (L) Input Connector	6	Power LED Indicator (Lit when charger is operating normally)
2	Neutral (N) Input Connector	7	Output Fuse, Rated 10A
3	Battery Negative Output Connector	8	Charging Voltage Potentiometer
4	Battery Positive Output Connector	9	Charging Amperage Potentiometer
5	Charging LED Indicator (Lit when charging current is >0.5 A)		

FIGURE 6. BATTERY CHARGER COMPONENTS

3.7.7.3.2 Specifications

TABLE 1. POWER SUPPLY

Nominal Operation Voltage	100–240 VAC

Operation Frequency	50/60 Hertz

TABLE 2. CHARGE OUTPUT

Output Voltage	27.6 VDC (±1%)
Rated Charging Current	5 A (±2%)
Maximum Output Power	135 W

TABLE 3. GENERAL

Operating Temperature	-30°C to 55°C (-22°F to 131°F)
Storage Temperature	-40°C to 85°C (-40°F to 185°F)
Dimensions	143 mm x 96 mm x 55 mm (5.63 in x 3.78 in x 2.17 in)

3.7.7.4 Battery Circuits

For generator set specific information, refer to the drawings and circuit diagrams provided with your generator set.

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4 Installation Overview

These installation recommendations apply to typical installations with standard model generator sets. Whenever possible, these recommendations also cover factory designed options or modifications. However, because of the many variables in any installation, it is not possible to provide specific recommendations for every situation. If there are any questions not answered by this manual, contact your nearest authorized distributor for assistance.

4.1 Application and Installation

A power system must be carefully planned and correctly installed for proper operation. This involves two essential elements.

- **Application** (as it applies to generator set installations) refers to the design of the complete power system that usually includes power distribution equipment, transfer switches, ventilation equipment, mounting pads, cooling, exhaust, and fuel systems. Each component must be correctly designed so the complete system will function as intended. Application and design is an engineering function generally done by specifying engineers or other trained specialists. Specifying engineers or other trained specialists are responsible for the design of the complete power system and for selecting the materials and products required.
    - Generator sets are designed and manufactured for specific environments.
        - Open generator sets are designed for use inside a building or plant where they will not be subjected to extreme environments.
        - Enclosed generator sets are designed for use outside, with features designed to enable operation in a wide range of climates.
- **Installation** refers to the actual set-up and assembly of the power system. The installers set up and connect the various components of the system as specified in the system design plan. The complexity of the system normally requires the special skills of qualified electricians, plumbers, sheet-metal workers, etc. to complete the various segments of the installation. This is necessary so that all components are assembled using standard methods and practices.

4.2 Safety Considerations

The generator set has been carefully designed to provide safe and efficient service when properly installed, maintained, and operated. However, the overall safety and reliability of the complete system is dependent on many factors outside the control of the generator set manufacturer. To avoid possible safety hazards, make all mechanical and electrical connections to the generator set exactly as specified in this manual. All systems external to the generator (fuel, exhaust, electrical, etc.) must comply with all applicable codes. Make certain all required inspections and tests have been completed and all code requirements have been satisfied before certifying the installation is complete and ready for service.

⚠ WARNING

Fall Hazard

Falls can result in severe personal injury or death.

Make sure that suitable equipment for performing tasks at height are used in accordance with local guidelines and legislation.

4.3 Standby Heating Devices

Cummins requires installing standby generator sets (life safety systems) with engine jacket water coolant heaters in order to ensure a 10 second start. Jacket water coolant heaters are also recommended in prime and continuous applications where time and load acceptance is to be minimized.

The jacket water coolant heater provided by Cummins rated to provide the above requirements in ambient temperatures as low as 4 °C (40 °F). Although most Cummins generator sets will start in temperatures down to –32 °C (–25 °F) when equipped with engine jacket water coolant heaters, it might take more than 10 seconds to warm the engine before a load can be applied when ambient temperatures are below 4 °C (40 °F).

On generator sets equipped with a graphic display, the **Low Coolant Temperature** message, in conjunction with illumination of the Warning LED, is provided to meet the current requirements. The engine cold sensing logic initiates a warning when the engine jacket water coolant temperature falls below 21 °C (70 °F). In applications where the ambient temperature falls below 4 °C (40 °F), or there exists a high amount of cold airflow, the jacket water coolant heater may not provide the necessary heating. Under these conditions, although the generator set may start, it may not be able to accept load within 10 seconds. When this condition occurs, check the coolant heaters for proper operation. If the coolant heaters are operating properly, other precautions may be necessary to warm the engine before applying a load.

4.4 Product Modifications

Agency certified products purchased from Cummins comply only with those specific requirements and as noted on company product specification sheets. Subsequent modifications must meet commonly accepted engineering practices and/or local and national codes and standards. Product modifications must be submitted to the local authority having jurisdiction for approval.

4.5 InPower Service Tool

InPower™ is a PC-based service tool used to:

- Make adjustments to the controls trims and settings.
- Perform diagnostics and monitoring.
- Create a capture file of the controls trims and settings.
- Update control calibrations (InPower PRO version).

NOTICE
Refer to the InPower User Guide for specifics.

InPower Adjustment Feature

The adjustment feature allows you to make adjustments to generator set parameters, calibrations and settings. There are several groups of adjustment parameters.

NOTICE
Not all generator sets will have the same adjustments available.

InPower Capture File Description

InPower provides a method of extracting (capturing) a device's parameter values. Capturing saves device information in a file that is identified with a .CAP extension.

Capture files are used to store a copy of the generator set's parameter values. During generator set installation, it is suggested that a capture file be made before and after changes are made to the generator set operating parameters. This information can be very useful when troubleshooting the generator set (determine if parameters/settings have been modified after installation) and when replacement of the base board is necessary. The capture file can be used as a template to write the previous settings to the new base board software.

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5 Specifications

5.1 Generator Set Specifications

TABLE 4. C600 D6, C700 D5 & C700D5 SPEC F, C825D5 (SPEC F), C825 D5A & C825D5A SPEC F SPECIFICATIONS

MODELS	C600 D6, C700 D5 & C700D5 Spec F, C825D5 (Spec F), C825 D5A & C825D5A Spec F	
Engine Cummins Diesel Series	VTA28-G5/G6	
Generator kW Rating	See generator set nameplate for rating information.	
Engine Fuel Connection Inlet/Outlet Thread Size	Refer to generator get outline drawing supplied with generator	
Maximum Weight	5760 kg (12699 lb) wet - Open Set	
Fuel Max. Fuel Inlet Restriction Max. Fuel Return Restriction Fuel Pump Flow Rate	101 mmHg (4 inHg) 165 mmHg (6.5 inHg) 337 L/hr (89 US gal/hr)	
Exhaust Outlet Size Max. Allowable Back Pressure Exhaust Flow at Rated Load Exhaust Gas Temperature	1500 RPM 5 in. NB 10.2 kPa 4340 cfm (2048 L/s at standby) 507 °C (944 °F) standby	1800 RPM 5 in. NB 10.2 kPa 5040 cfm (2379 L/s at standby) 507 °C (944 °F)
Electrical System Starting Voltage Battery Group Number CCA (minimum) Cold Soak @ 0 °F (-18 °C)	24 Volts DC 31 1400 A at 0 °F to 32 °F (-18 °C to 0 °C)	
Cooling System Capacity	C825D5 (Spec F), C825 D5A & C825D5A Spec F 181 L (49 US gal) 40 °C	C600 D6, C700 D5 & C700D5 Spec F 167 L (44 US gal) 40 °C 178 L (47 US gal) 50 °C
Lubricating System Oil Capacity with Filters	84 L (22.3 US gal)	

5.2 Engine Fuel Consumption

TABLE 5. ENGINE FUEL CONSUMPTION L/HR (GAL/HR) AT 1500 RPM (50 HZ)

Model	C700 D5, C700D5 (Spec F)	C825D5 (Spec F), C825 D5A, C825D5A (Spec F)
Engine	**VTA28-G5**	**VTA28-G6**
Engine Performance Data at 50Hz - Standby/Full Load	**154 (33.8)**	**162 (35.6)**
Engine Performance Data at 50Hz - Prime/Full Load	**140 (30.8)**	**147 (32.3)**
Refer to Data Sheets for other applications. In line with the CPGK policy of continuous improvement these figures are subject to change.		

TABLE 6. ENGINE FUEL CONSUMPTION L/HR (GAL/HR) AT 1800 RPM (60 HZ)

Model	C600 D6
Engine	**VTA28-G5**
Engine Performance Data at 60Hz - Standby/Full Load	**173 (38)**
Engine Performance Data at 60Hz - Prime/Full Load	**154 (33.8)**
Refer to Data Sheets for other applications. In line with the CPGK policy of continuous improvement these figures are subject to change.	

6 Installing the Generator Set

Generator set installations must be engineered so that the generator set will function properly under the expected load conditions. Use these instructions as a general guide only. Follow the instructions of the consulting engineer when locating or installing any components. The complete installation must comply with all local and state building codes, fire regulations, and other applicable regulations.

Requirements to be considered prior to installation are:

- Level mounting surface
- Adequate cooling air
- Adequate fresh induction air
- Non-combustible mounting surface
- Electrical connections

⚠ CAUTION

Depending on your location and intended use, ensure that international, national or local laws and regulations regarding Air Quality Emissions have been observed and complied with. Be sure to consult local pollution control or air quality authorities before completing your construction plans.

6.1 Location

⚠ 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.

⚠ WARNING

Incorrect installation

Incorrect installation of the generator set, service or parts replacement, can result in severe personal injury, death, and/or equipment damage.

Service personnel must be trained and experienced to perform electrical and mechanical component installation.

NOTICE

Depending on your location and intended use, additional laws and regulations may require for you to obtain an air quality emissions permit before beginning installation of your generator set. Be sure to consult local pollution control or air quality authorities before completing your construction plans.

Generator set location is decided mainly by related systems such as ventilation, wiring, fuel, and exhaust. The set should be located as near as possible to the main power service entrance. Exhaust gases must not be able to enter or accumulate around inhabited areas.

Provide a location away from extreme ambient temperatures and protect the generator set from adverse weather conditions.

Use the following information to locate the generator set for optimal operating conditions:

Surface: Concrete or compacted gravel with the generator set resting on solid, poured concrete blocks, or timber blocks spaced at reasonable intervals around the perimeter of the generator set.

Leveling: Level the generator set from side-to-side within 3.5°, and end-to-end within 2.5°.

Placement:

- Generator sets should be a minimum of 5 m (16.4 ft) apart to allow for adequate access.
- Make sure that the air inlets are not obstructed by surrounding trees, buildings, or other obstructions.
- Make sure noise distribution (to prevent echoing) is kept to a minimum.
- Consider exhaust for immediate neighbors.
- The prevailing wind direction should be considered so that the engine combustion air inlet is upwind and the exhaust discharge is downwind.
- The immediate area around the proposed location of the mounting surface should be evaluated for proper drainage so that moisture run-off is sufficient to prevent ponding around the unit(s).

6.2 Mounting

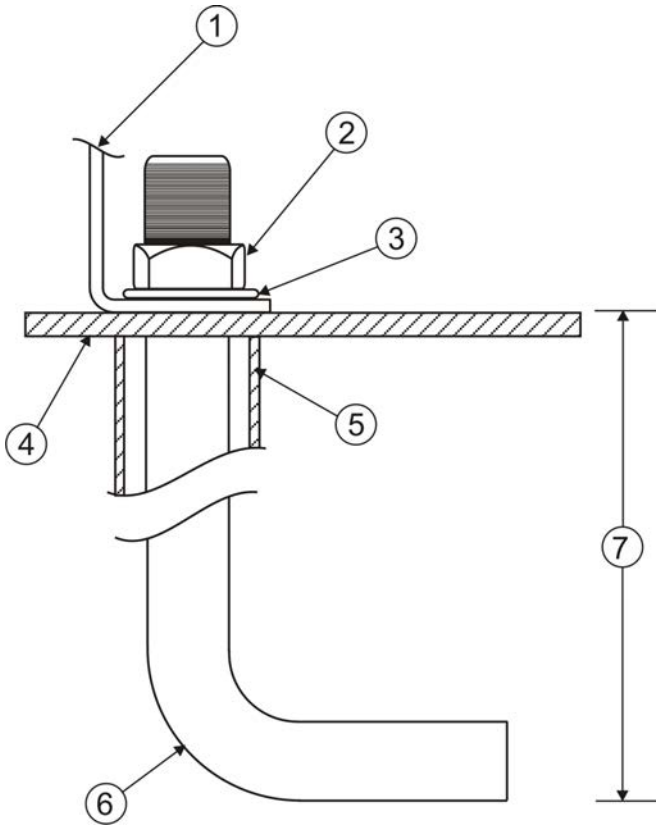
Generator sets are mounted on a steel skid that provides proper support. The engine-generator assembly is isolated from the skid frame by rubber mounts that provide adequate vibration isolation for normal installations. Where required by building codes or special isolation needs, generator sets may be mounted on rubber pads or mechanical spring isolators.

NOTICE
The use of unapproved isolators may result in harmful resonances and may void the generator set warranty.

Mount the generator set on a substantial and level base such as a concrete pad. A non-combustible material must be used for the pad.

Use 16 mm ($^{5}/_{8}$ in) or anchored mounting bolts to secure the generator set bedframe to the base. Use a flat washer and hexagonal nut for each bolt (see **Figure 7**). The 38 x 152 mm (1½ x 6 in) pipe inserted over the mounting bolts allows minor adjustment of the bolts to align them to the holes in the bedframe.

The fixing centers for the mounting bolts can be found on the generator set *Outline Drawing*.



No.	Description	No.	Description
1	Generator Bedframe Flange	5	38 mm x 152 mm Pipe (1½ inch x 6 inch)
2	Hexagonal Nut	6	Mounting Bolt Set in Concrete
3	Flat or Bevel Washer	7	305 mm (12 inch)
4	Mounting Base on Concrete		

FIGURE 7. BOLT DIAGRAM

6.3 Access to Generator Set

Generally, at least 1 meter (3.3 ft) of clearance should be provided on all sides of the generator set for maintenance and service access. (Increase clearance by width of door if optional housing is used.) A raised foundation or slab of 152 mm (6 inches) or more above floor level will make servicing easier. Lighting should be adequate for operation, maintenance and service operations and should be connected on the load side of the transfer switch so that it is available at all times.

6.4 Rigging Instructions

⚠ WARNING

Heavy Load

Incorrect lifting or repositioning can cause severe personal injury or death.

Do not lift the generator set by attaching to the engine or alternator lifting points. Do not stand under or near the generator set when lifting.

⚠ WARNING

Heavy Load

Incorrect lifting or repositioning can cause severe personal injury or death.

Make sure that only suitably trained and experienced personnel transport and handle generator sets and associated components.

1. Consult the generator set outline drawing for weight and center-of-gravity information.
2. Attach cables from the lifting lugs to a spreader bar. Never make the spreader bar cable attachment points wider than the attachment points on the skid or the bars. Make sure cables do not touch any other part of the generator set other than the skid.

NOTICE

Spreader bar cable attach points width "Y" must never be wider than skid cable attach points "X." Distance "X" is the narrowest width.

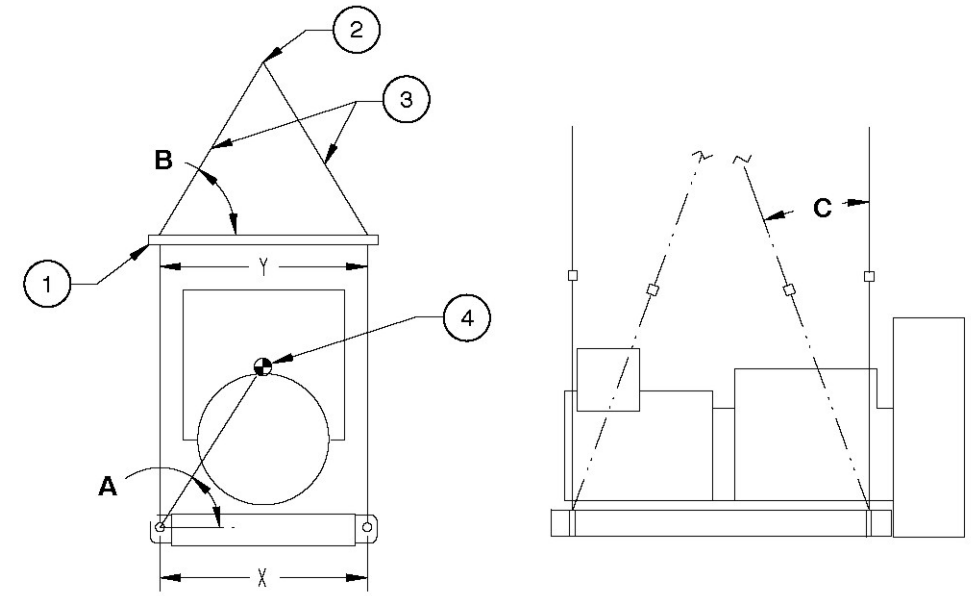
NOTICE

Angle B must be slightly greater than angle A. Angle B should be as close to 90 degrees as possible to provide a stable lift.

3. With pedestal box (not shown), the spreader bars (front and back) should be used to clear the pedestal box and the attachment cables must be as vertical as possible.

NOTICE

The lifting angle (angle C) must not exceed 20° from vertical.



No.	Description	No.	Description
A	Angle A	1	Spreader Bar
B	Angle B	2	Lifting Point
C	Angle C (20° Maximum)	3	Lifting Cables
X	The Narrowest Width (On the Skid)	4	Center of Gravity
Y	This Distance Must be Less than Distance "X"		

FIGURE 8. RIGGING

6.5 Moving the Generator Set

⚠ WARNING

Heavy Load

Incorrect lifting or repositioning can cause severe personal injury or death.

Make sure that only suitably trained and experienced personnel transport and handle generator sets and associated components.

⚠ WARNING

Heavy Load

Incorrect lifting or repositioning can cause severe personal injury or death.

Do not lift the generator set by attaching to the engine or alternator lifting points. Do not stand under or near the generator set when lifting.

⚠ WARNING

Mechanical Hazard

Failed components may be ejected or operate incorrectly which can cause severe personal injury or death.

Do not climb the generator set; this may damage critical parts.

NOTICE

Make sure that any shipping brackets supplied with the generator set are fitted, before moving the generator set. Failure to install the shipping brackets before moving may result in damage to the generator set.

NOTICE

Access or service doors must be closed and locked before repositioning, and they must remain locked during transportation and siting.

It is essential that there are sufficient trained and experienced personnel in attendance to make sure the lifting and transportation of the generator set is undertaken in a safe and appropriate manner, and in accordance to local guidelines and legislation.

Before lifting the generator set, lifting points, angle of slings, mass, access to intended site, and the distance of movement should all be taken into account when organizing a suitable crane/hoist. Consult the generator set information supplied with the generator set for details of dimensions and mass.

- Make sure the fuel tank is empty.
- Make sure that the crane operating area is able to support the mass of the crane and the generator set.
- Make sure the equipment used for lifting is adequate to support the weight of the generator set.
- Attach the lifting device to the lifting points only using suitable shackles, chains, and spreader bars.
- Slowly tighten the slings. Inspect the lifting attachments before commencing a full lift to make sure they are attached correctly.
- Hoist the generator set slowly using the indicated lifting points only.
- Guide the generator set with ropes at a safe distance to prevent uncontrolled rotation when positioning the generator set.
- Move the generator set to the desired location and place in position, bringing the set down slowly.
- Loosen the slings; unhook and remove the shackles.

6.6 Transportation

⚠ WARNING

Transportation and handling of generator sets must only be undertaken by suitably trained and experienced personnel who are familiar with the transport of these items.

⚠ WARNING

Do not lift the generator set by attaching to the engine or alternator lifting points. Improper handling of the generator set may cause serious damage to the generator set and its components and can result in severe personal injury or death.

⚠ WARNING

On a containerized generator set, the doors must be locked before re-positioning and must remain locked during transportation and siting.

- Ensure the generator set is prepared for transport. If necessary drain fluids and ensure that acid or fumes do not leak from the battery (where applicable).

- If the generator set is transported over along distances, protect it against environmental influences by sealing it in a plastic cover or similar.
- For lifting procedures, see **Section 6.5 on page 33**.
- Ensure the generator set is secured to the vehicle with suitable securing straps. Wooden chocks and pallets alongside the securing straps can prevent movement during transportation.
- If required, attached impact indicators to the generator set. Upon delivery, check these impact indicators and contact the transport company immediately if an impact has been detected. Impacts can cause serious damage to the generator set and its components.
- Ensure that the generator set cannot turn over during transportation.
- Do not overload the transport vehicle. Under no circumstances should the generator set be started while inside a truck.
- Lifting eyes where fitted are to be checked at regular intervals to ensure they are damage free and tight.

6.6.1 Lifting using a Fork Lift

If a forklift is to be used to move the containerized generator set, the forks must be inserted under the base of the container. The forklift pockets must only be used to lift an empty container. Refer to the General Arrangement drawings for further reference information including the Centre of Gravity.

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7 Mechanical Connections

The generator set mechanical system installation includes connecting the fuel, exhaust, ventilation, and cooling systems. Before starting any type of fuel installation, all pertinent state and local codes must be complied with and the installation must be inspected before the unit is put in service.

7.1 Fuel System

Cummins engines normally use a diesel fuel specified to ASTM No. 2 or BS 2869:2010+A1:2011 (*Fuel oils for agricultural, domestic and industrial engines and boilers. Specification.)*

In all fuel system installations, cleanliness is of the utmost importance. Make every effort to prevent entrance of moisture, dirt, or contaminants of any kind into the fuel system. Clean all fuel system components before installing.

NOTICE
A fuel filter/strainer/water separator of 100-120 mesh or equivalent (approximately 150 microns nominal) must be fitted between either the main tank and day tank or between the main tank and the engine.

Use only compatible metal fuel lines to avoid electrolysis when fuel lines must be buried. Buried fuel lines must be protected from corrosion.

⚠ CAUTION
Never use galvanized or copper fuel lines, fittings, or fuel tanks. Condensation in the tank and lines combines with the sulfur in diesel fuel to produce sulfuric acid. The molecular structure of the copper or galvanized lines or tanks reacts with the acid and contaminates the fuel.

An electric solenoid valve in the supply line is recommended for all installations and required for indoor automatic or remote starting installations. Connect the solenoid wires to the generator set “Switched B+” circuit to open the valve during generator set operation.

Separate fuel return lines to the day tank or supply tank must be provided for each generator set in a multiple-set installation to prevent the return lines of idle sets from being pressurized. Fuel return lines must not contain a shutoff device. Engine damage will occur if the engine is run with the return fuel lines blocked or restricted.

⚠ CAUTION
Never install a shutoff device in fuel return line(s). If fuel return line(s) is blocked or exceeds fuel restriction limit, engine damage will occur.

7.1.1 Fuel Return Restrictions (or Pressure) Limit

Fuel return drain restriction (consisting of friction head and static head) between the engine injector return line connection and the fuel tank must not exceed the limit stated in the model-specific generator set *Specification Sheet*.

7.1.2 Fuel Line Connections

⚠ WARNING

Combustible Liquid

Fuel leaks are a fire and explosion hazard which can cause severe personal injury or death.

Always use flexible tubing between the engine and fuel supply to avoid line failure and leaks due to vibration. The fuel system must meet all application codes.

⚠ WARNING

Combustible Liquid

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

Do not route fuel lines near electrical wiring.

⚠ WARNING

Hot Surface

Hot surfaces can ignite fuel. Ignited fuel is a fire and explosion hazard which can cause severe burns or death.

Do not route fuel lines near hot exhaust parts.

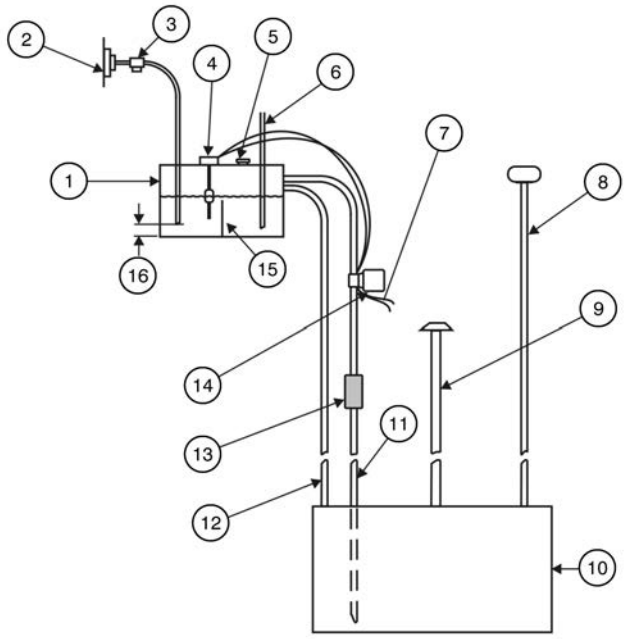
NOTICE

Fuel lines must be routed and secured to maintain a 12.7 mm (½ inch) minimum clearance from electrical wiring and a 51 mm (2 inches) minimum clearance from hot exhaust parts.

Flexible lines for connecting between the engine and the skid mounted fuel tank (if fitted) are supplied as standard equipment.

Flexible lines for connecting between the engine and an external fuel supply must be used between the engine fuel system, and the fuel supply and return lines to protect the fuel system from damage caused by vibration, expansion, and contraction.

For additional information refer to T-030 Application Manual.



No.	Description	No.	Description
1	Day Tank/Skid Mounted Fuel Tank	9	Fill Pipe
2	Engine Fuel Pump	10	Main Fuel Tank
3	Shut Off Valve	11	Supply Line
4	Float Switch	12	Larger Overflow Line 120 Mesh Fuel Strainer
5	Vented Fill Cap	13	120 Mesh Fuel Strainer
6	Injector Fuel Return Line	14	Fuel Transfer Pump Electric Motor Driven
7	Connect to AC Output	15	Baffle
8	Vent Pipe	16	25.4 mm (1 inch) Clearance

FIGURE 9. TYPICAL FUEL SUPPLY INSTALLATION

7.1.3 Engine Fuel Connections

Identification tags are attached to the fuel supply line and fuel return line connections. All models require a fuel return line from the injectors to the tank.

7.1.3.1 PowerBox Generator Sets

NOTICE
On PowerBox enclosed generator sets, the optional fuel tanks are supplied with fuel feed and spill return lines between the fuel tank and the engine.

7.1.4 Supply Tank

The fuel supply tank, day tank, or other reservoir must be arranged so that the highest fuel level does not exceed the maximum height above the fuel injectors specified for the engine. The lowest level must not fall below the specified lift height of the engine fuel lift pump. In critical start applications, the lowest level should not be less than 150 mm (6 inches) above the engine fuel pump inlet to make sure there is no air in the fuel line during startup. Provisions must be made for draining or pumping out water.

For critical start applications, where generator sets are paralleled or must satisfy emergency start-time requirements, it is recommended that a fuel tank or reservoir be located such that the lowest possible fuel level is not less than 150 mm (6 in) above the fuel pump inlet. This will prevent air from accumulating in the fuel line while the generator set is in standby, eliminating the period during startup when it has to be purged.

Locate the fuel tank as close as possible to the generator set and within the restriction limitations of the fuel pump.

Install a fuel tank that has sufficient capacity to supply the generator set depending on its application:

- Continuous power
- Prime power
- Standby power

Refer to the Engine Fuel Consumption section for fuel consumption data.

If the fuel inlet restriction exceeds the defined limit due to the distance/customer-supplied plumbing between the generator set and the main fuel tank, a transfer tank (sometimes referred to as a day tank) and auxiliary pump will also be required. If an overhead main fuel tank is installed, a transfer tank and float valve will be required to prevent fuel head pressures from being placed on the fuel system components.

For additional information on the size and installation of a supply tank for the application, consult your local authorized Cummins distributor or dealer.

7.1.5 Fuel Inlet Pressure/Restriction Limit

Engine performance and fuel system durability is compromised if the fuel inlet pressure or restriction limits are not adhered to. Fuel inlet pressure or restriction must not exceed the limits stated in the model-specific generator set *Specification Sheet*.

7.1.6 Day Tank

Some generator set installations may include a fuel day tank. They are used when fuel inlet restriction limits cannot be met, or the supply tank is overhead and presents problems of high fuel head pressure for the fuel inlet and return lines.

7.1.6.1 Supply Tank Lower Than Engine

⚠ WARNING

Combustible Liquid

Spilled fuel is a fire and explosion hazard which can cause severe personal injury or death.

Provide an overflow line to the supply tank from the day tank.

NOTICE

The supply tank top must be below the day tank top to prevent siphoning from the fuel supply to the day tank.

With this installation, the day tank is installed near the generator set, below the fuel injection system and within the fuel inlet restriction limit. Install a fuel transfer pump, to pump fuel from the supply tank to the day tank. A float switch in the day tank controls operation of the auxiliary fuel pump.

Provide a return line from the engine injection system return connection to the day tank. Plumb the return line to the bottom of day tank as shown in **Figure 9 on page 39**. Provide a day tank overflow line to the supply tank in case the float switch fails to shut off the fuel transfer pump.

7.1.6.2 Supply Tank Higher Than Engine

With this installation, the day tank is installed near the generator set, above the fuel injection system and within the fuel return restriction limit. Include an automatic fuel shutoff valve in the fuel line between the fuel supply tank and the day tank to stop fuel flow when the generator set is off.

Provide a return line from the engine injection system return connection to the day tank. Plumb the return line to the bottom of day tank as shown in **Figure 9 on page 39**.

NOTICE
Spilled fuel can create environmental hazards. Check local requirements for containment and prevention of draining to sewer and ground water.

7.1.7 Fuel Transfer Pump Installation

⚠ WARNING
Combustible Liquid ***Fuel leaks are a fire and explosion hazard which can cause severe personal injury or death.*** ***Make sure that only trained and experienced personnel install and service the generator set in accordance with applicable codes.***

NOTICE
Do not smoke near fuel and keep flames, sparks, pilot lights, arcing switches and equipment, and other sources of ignition well away.

A fuel transfer pump and control are available as an option when a sub-base or an in-skid day tank is provided. The automatic control operates the fuel pump to maintain a reservoir of fuel in the day tank.

7.2 Exhaust System

Pipe exhaust gases to the outside of any enclosure. Locate the exhaust outlets away from any air inlets to avoid gases re-entering the enclosure. Exhaust installations are subject to various detrimental conditions such as extreme heat, infrequent operation, and light loads. Regularly inspect the exhaust system both visually and audibly to see that the entire system remains fume tight and safe for operation.

⚠ WARNING
Inhalation of exhaust gasses can result in severe personal injury or death. Use extreme care during installation to provide a tight exhaust system. Terminate exhaust pipes away from enclosed or sheltered areas, windows, doors, and vents.

For indoor installation, the exhaust system should use sealed joint type fittings where possible to provide a tight exhaust system. Use of slip type fittings (secured with a clamp) may allow leakage of exhaust gases into the building if not fitted correctly fitted. Check to make sure there are no exhaust leaks.

Use an approved thimble (see **Figure 10 on page 43**) where exhaust pipes pass through wall or partitions. Insulated wall/roof thimbles are used where exhaust pipes pass through a combustible roof or wall. This includes structures, such as wood framing or insulated steel decking, etc. Uninsulated wall/roof thimbles are used where exhaust pipes pass through a non-combustible wall or roof, such as concrete. Where applicable, refer to NFPA 37, Section 6-3, *Stationary Combustion Engines and Gas Turbines,* for accepted design practices. Build according to the code requirements in effect at the installation site.

⚠ WARNING

Hot exhaust pipes can start a fire and cause severe injury or death if improperly routed through walls. Use an approved thimble where exhaust pipes pass through wall or partitions.

⚠ WARNING

Inhalation of exhaust gases can result in severe personal injury or death. Do not use exhaust heat to warm a room, compartment, or storage area.

Rain caps are available for the discharge end of vertical exhaust pipes. The rain cap clamps onto the end of the pipe and opens due to exhaust discharge force from the generator set. When the generator set is stopped, the rain cap automatically closes, protecting the exhaust system from rain, snow, etc.

Use a section of flexible exhaust pipe between the engine and remainder of exhaust system. Support the exhaust system to prevent weight from being applied to engine exhaust outlet elbow/turbocharger connection.

⚠ CAUTION

Weight applied to the engine manifold can result in turbocharger damage. Support the silencer and exhaust piping so no weight or stress is applied to the engine exhaust elbow.

The exhaust system design should meet local code requirements.

NOTICE

Liability for injury, death, damage, and warranty expense due to use of unapproved silencers or modifications to the exhaust system becomes the responsibility of the person installing the unapproved silencer or performing the modification. Contact your authorized distributor for approved exhaust system parts.

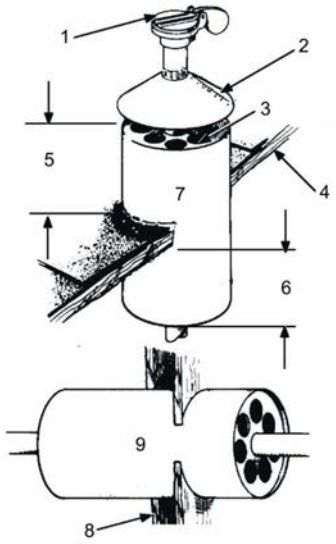
Avoid sharp bends by using sweeping, long radius elbows and provide adequate support for the silencer and tailpipe. Pitch a horizontal run of exhaust pipe downward (away from engine) to allow any moisture condensation to drain away from the engine. If an exhaust pipe must be turned upward, install a condensation trap at the point where the rise begins see **Figure 11 on page 43**.

Shield or insulate exhaust lines if there is danger of personal contact. Allow at least 305 mm (12 inches) of clearance if the pipes pass close to a combustible wall or partition. Before installing insulation on exhaust system components, check the exhaust system for leaks while operating the generator set under full load and correct all leaks.

⚠ WARNING

Exhaust pipes are very hot and they can cause severe personal injury or death from direct contact or from fire hazard. Shield or insulate exhaust pipes if there is danger of personal contact or when routed through walls or near other combustible materials.

Refer to Application Manual T-030, "Liquid Cooled Generator Sets" for more detailed information about sizes of exhaust system pipes and fittings.



No.	Description	No.	Description
1	Rain Cap	6	230 mm (9 inches)
2	Drip Cap	7	Vertical Alignment
3	Holes in End of Inner Sleeve	8	Wall or Partition
4	Roof	9	Horizontal Alignment
5	230 mm (9 inches)		

FIGURE 10. MOUNTING EXHAUST THIMBLE

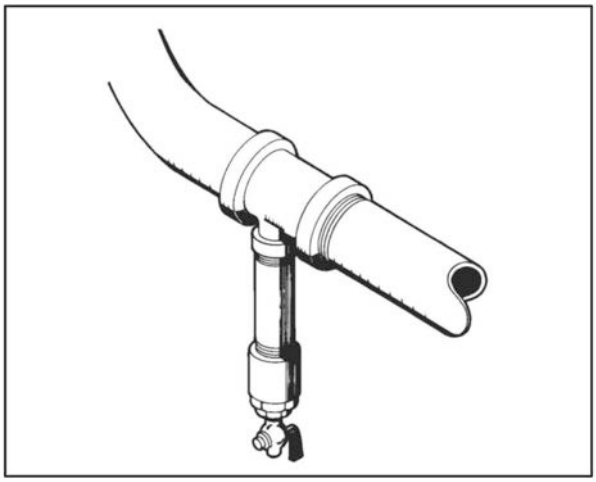


FIGURE 11. CONDENSATION TRAP

7.2.1 PowerBox Exhaust

NOTICE
PowerBox enclosed generator sets have an integral exhaust system discharging at high level.

7.3 Ventilation and Cooling

⚠ WARNING

Toxic Gases

Engine and radiator cooling air may carry carbon monoxide gas, which 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.

Generator sets create considerable heat that must be removed by proper ventilation.

Generator sets in factory-mounted housings for outdoor installation are designed for proper cooling and ventilation.

Indoor installations require careful design with respect to cooling and ventilation. In an indoor installation, all radiator cooling air must be discharged to the out-of-doors. Duct adapter kits are available.

Outdoor installations normally rely on natural air circulation but indoor installations need properly sized and positioned vents for required airflow.

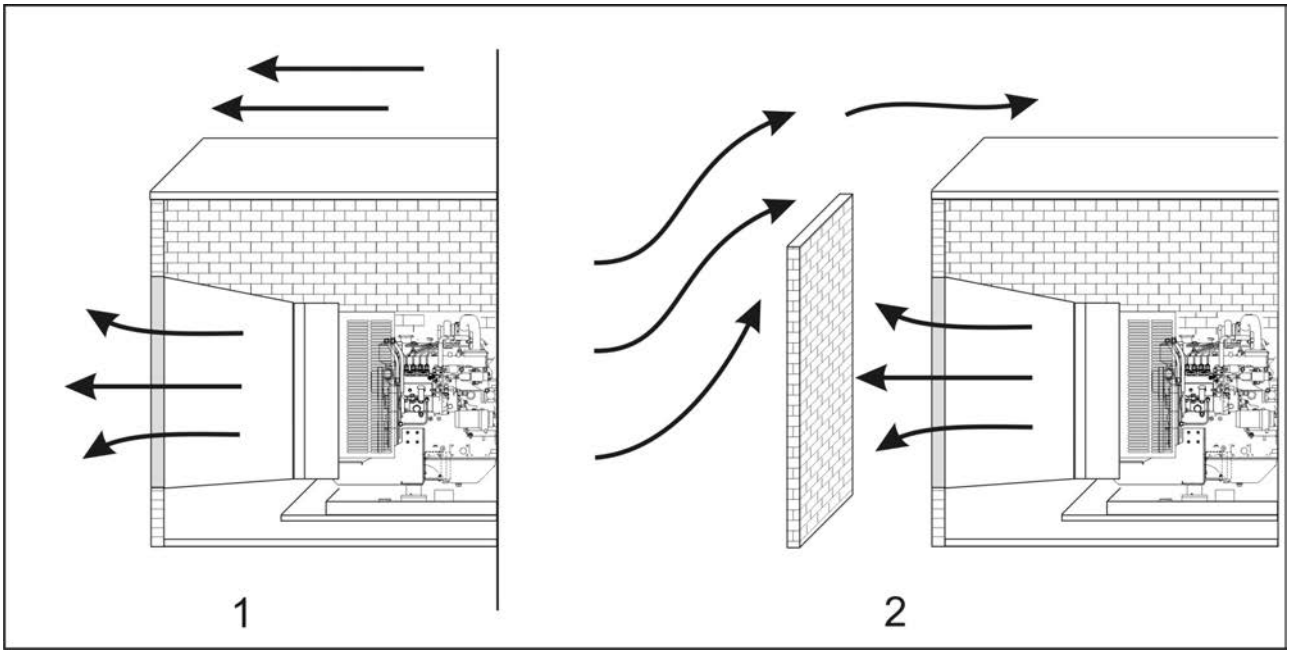
Transfer the stray voltage from the cooling system to the ground through the skid.

7.4 Vents and Ducts

1. For indoor installations, locate vents so incoming air passes through the immediate area of the installation before exhausting. Install the air outlet higher than the air inlet to allow for convection air movement.
2. Size the vents and ducts so they are large enough to allow the required flow rate of air.
3. Wind will restrict free airflow if it blows directly into the air outlet vent. Locate the outlet vent so the effects of wind are eliminated, or if the outlet vent cannot be located as mentioned, install a wind barrier. See **Figure 12**.

NOTICE

The "free area" of ducts must be as large as the exposed area of the radiator. Refer to the generator set Specification Sheet for the airflow requirements and allowed airflow restriction.



No.	Description	No.	Description
1	Prevailing Wind Away from Air Outlet Vent	2	Prevailing Wind Towards Air Outlet Vent, Wind Barrier Installed

FIGURE 12. WIND BARRIER

7.5 Dampers

Dampers or louvers protect the generator set and equipment room from the outside environment. Their operation of opening and closing should be controlled by operation of the generator set.

In cold climates, the radiator exhaust air can be recirculated to modulate the ambient air temperature in the generator set room. This will help the generator set warm up faster, and help to keep fuel temperatures higher than the cloud point of the fuel. If recirculation dampers are used, they should be designed to 'fail closed', with the main exhaust dampers open, so that the generator set can continue to operate when required. Designers should be aware that the generator set room operating temperature will be very close to the outdoor temperature, and either not route water piping through the generator set room, or protect it from freezing.

7.6 Air Inlet and Outlet Openings

Louvers and screens over air inlet and outlet openings restrict air flow and vary widely in performance.

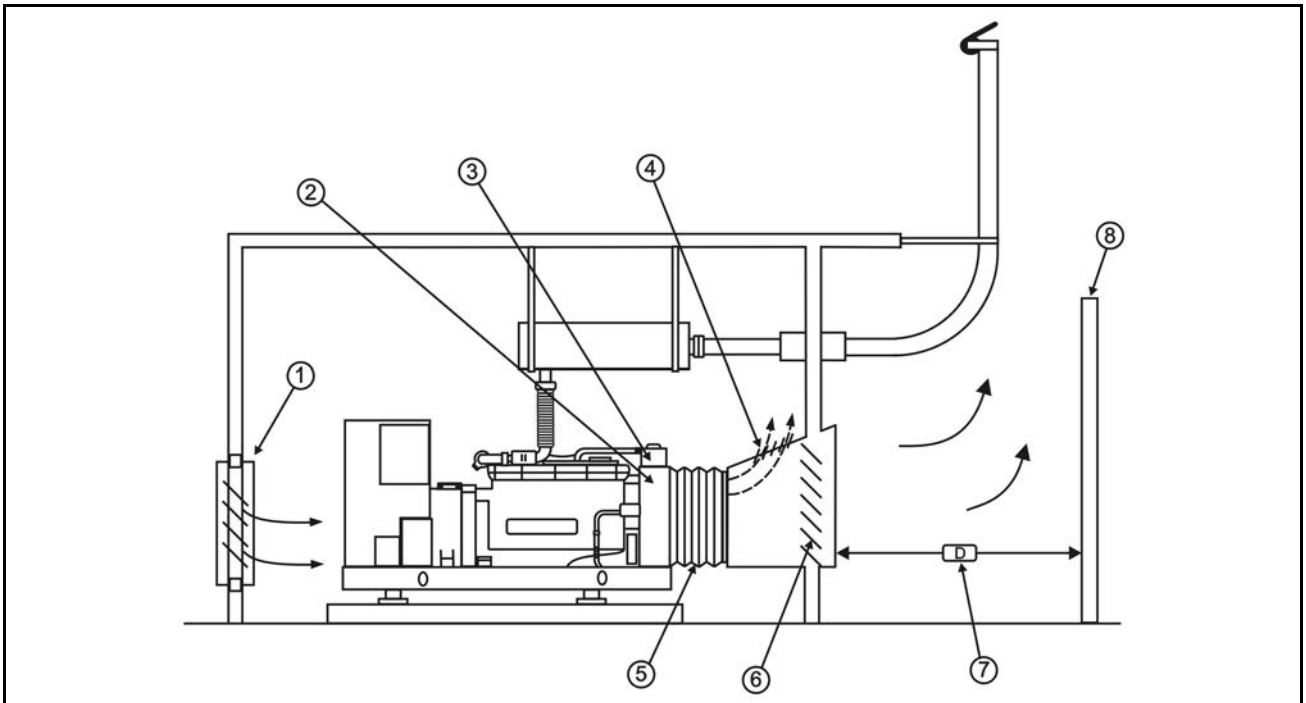
A louver assembly with narrow vanes, for example, tends to be more restrictive than one with wide vanes. The effective open area specified by the louver or screen manufacturer should be used.

Radiator set cooling air is drawn past the control end of the set by a pusher fan that blows air through the radiator. Locate the air inlet to the rear of the set. Make the inlet vent opening 1.5 times larger than the radiator area.

Locate the cooling air outlet directly in front of the radiator and as close as possible. The outlet opening must be at least as large as the radiator area. Length and shape of the air outlet duct should offer minimum restriction to airflow.

A flexible duct connector must be provided at the radiator to prevent exhaust air recirculation around the radiator, to take up generator set movement and vibration, and to prevent transmission of noise. Attach the flexible duct using screws and nuts so that the duct can be removed for maintenance purposes. Before installing the duct, remove the radiator core guard.

Enclosed generator sets are primarily designed to work in an open environment. When considering installing an enclosed generator set in an enclosed environment specific application factors must be considered (air flow, exhaust gas extraction, fuel supply and storage, etc.). For advice, contact the Application Engineering Group at Cummins.



No.	Description	No.	Description
1	Cool Air Inlet Damper	5	Flexible Duct Connector
2	Engine Driven Fan	6	Hot Air Outlet Damper
3	Radiator	7	Distance Should Not be Less Than Height of Radiator
4	Thermostat Controlled Re-Circulating Damper	8	Wind/Noise Barrier

FIGURE 13. TYPICAL OPEN GENERATOR SET INSTALLATION

8 DC Control Wiring

⚠ WARNING

Electric Shock Hazard

Voltages and currents present an electrical shock hazard that can cause severe burns or death.

Avoid contact with the voltage sense and bus sense leads; voltages of up to 600 VAC may still be present. These voltages could be live even when the generator set is switched off.

⚠ WARNING

Electric Shock Hazard

Voltages and currents present an electrical shock hazard that can cause severe burns or death.

Make sure all power is off before performing control wire installation.

⚠ WARNING

Electric Shock Hazard

Voltages and currents present an electrical shock hazard that can cause severe burns or death.

To prevent accidental electrocution, stand on a clean dry wooden platform or clean rubber insulating mat, make sure your clothing and shoes are dry, remove all jewelry, and use tools with insulated handles.

The generator set control box contains connection points for remote control and monitor options.

NOTICE

Always run control circuit wiring in a separate metal conduit from the AC power cables to avoid inducing currents that could cause problems within the control.

Use cable ties to keep control wiring away from sharp edges and AC power cables within the control housing.

NOTICE

Stranded copper wire must be used for all customer connections to the control panel. Solid copper wire may break due to the generator set vibration.

Use flexible conduit for all wiring connections to the generator set.

8.1 TB1 Remote Monitor / Control Connections

Customer monitor/control connections are attached to terminal block TB1. Optional equipment, such as sensing devices used to monitor generator set operation, remote start/stop switches, etc. are also attached to TB1.

Available options will vary between controller models.

8.2 PowerCommand 3.3 Customer Connections

Refer to **Section A.1 on page 72** for information on customer connections.

8.2.1 Configurable Outputs

Each output has normally-open contacts. The contacts can be used to control small devices, indicator lamps, or relays.

The contacts are programmed to energize by entering a code number for the desired event.

NOTICE

Using the InPower service tool or accessing the Setup submenus is required to modify the customer outputs. Contact an authorized distributor for assistance.

8.2.1.1 Contact Ratings for Configurable Outputs

TABLE 7. CONTACT RATINGS FOR CONFIGURABLE OUTPUTS

Description	Value
Maximum Voltage	30 VDC
Maximum Current	3.5 Amps

8.2.2 Remote Start

⚠ WARNING

Automated Machinery

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

Make sure that the generator set cannot be started accidentally or remotely before starting work on the generator.

NOTICE

Remote start terminals should only be used for a remote application. Remote start terminals are not to be shorted if the remote start function is not intended to be used.

When the control is in Auto/Remote mode, grounding this input initiates the engine cranking and start sequence. This circuit must be opened to permit resetting a shutdown condition with the Reset input. (The remote stop is actually the removal of the remote start signal to the control.)

8.2.3 Configurable Inputs

Grounding any one of these inputs activates the corresponding warning or shutdown sequence.

External sensing equipment must be connected to the designated digital input.

The nature of the fault is an optional customer selection. Example inputs: Low Coolant Level, Low Fuel Level, Ground Fault, etc.

NOTICE

The InPower service tool or access to the Setup submenus is required to modify the customer fault inputs. Contact your authorized distributor for assistance.

8.2.4 Remote Emergency Stop

Opening this input causes an immediate shutdown. Emergency stop must be reset at the remote panel, then at the front panel.

8.3 Run Relays (K10, K11, K13, K14, K15, K19, K20, K21)

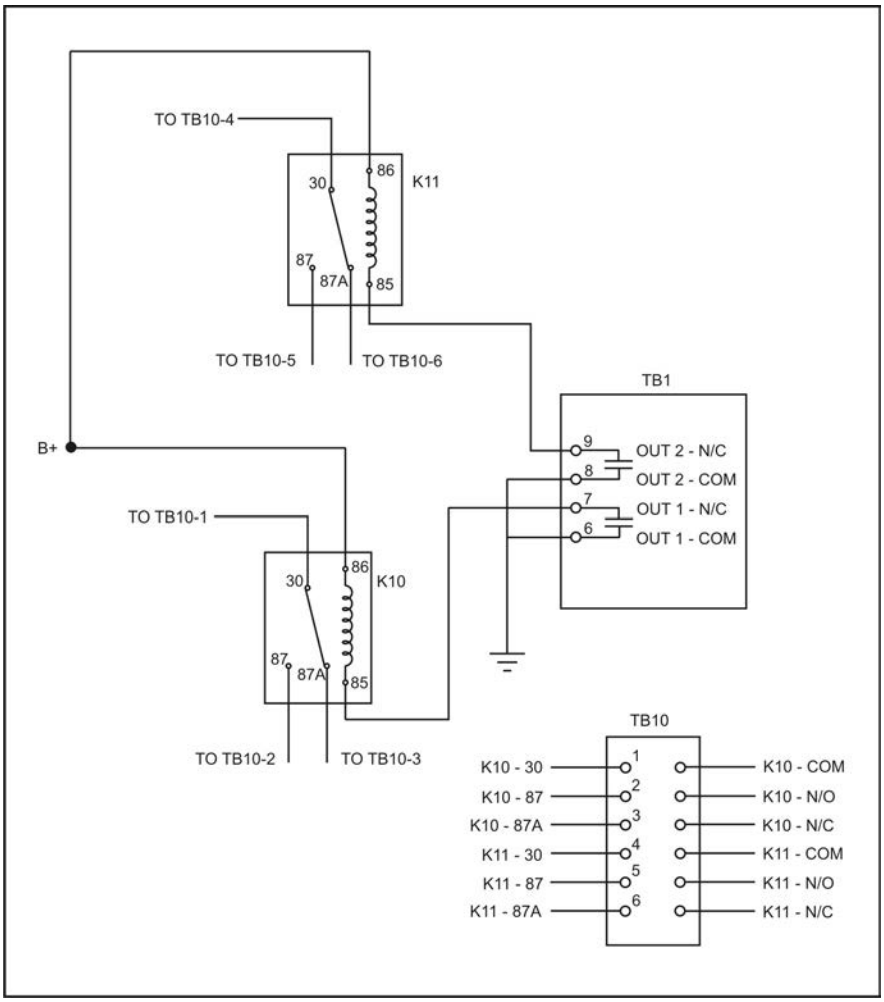
Optional run relays are mounted inside the control box. The single-pole, double-throw run relays are used for customer connections to control auxiliary equipment such as fans, pumps, and motorized air dampers.

The run relays are energized when the generator set control receives a start signal.

The contacts are rated:

- 20 Amps resistive at 30 VDC
- 15 Amps inductive at 30 VDC

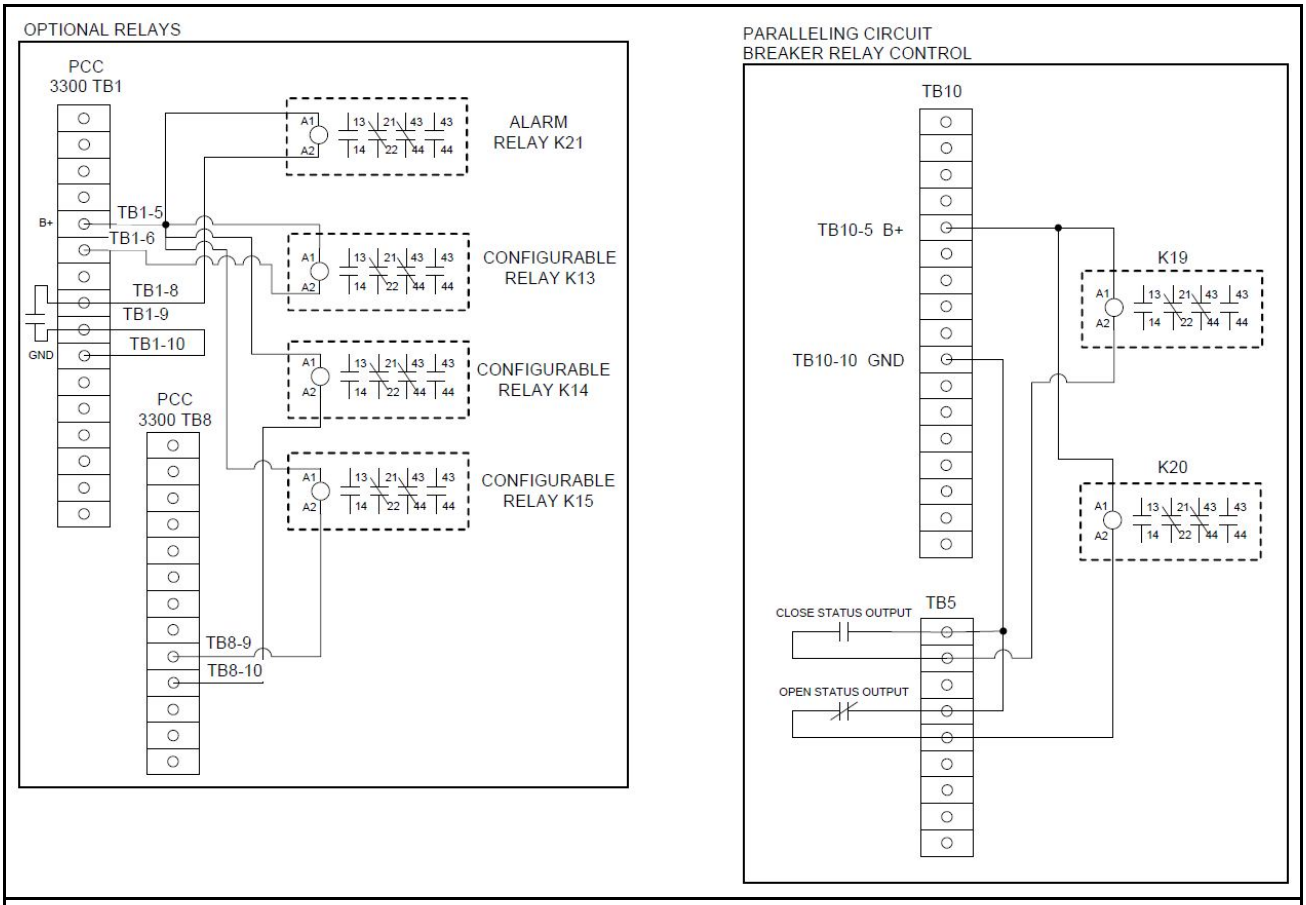
TABLE 8. OPTIONAL RUN RELAYS (K10, K11)



Legend:

COM = Common
N/O = Normally Open
N/C = Normally Closed
TB = Terminal Block

TABLE 9. OPTIONAL RUN RELAYS (K13, K14, K15, K19, K20, K21)



Legend:

COM = Common
N/O = Normally Open
N/C = Normally Closed
TB = Terminal Block
GND = Ground
B+ = Battery Posistive

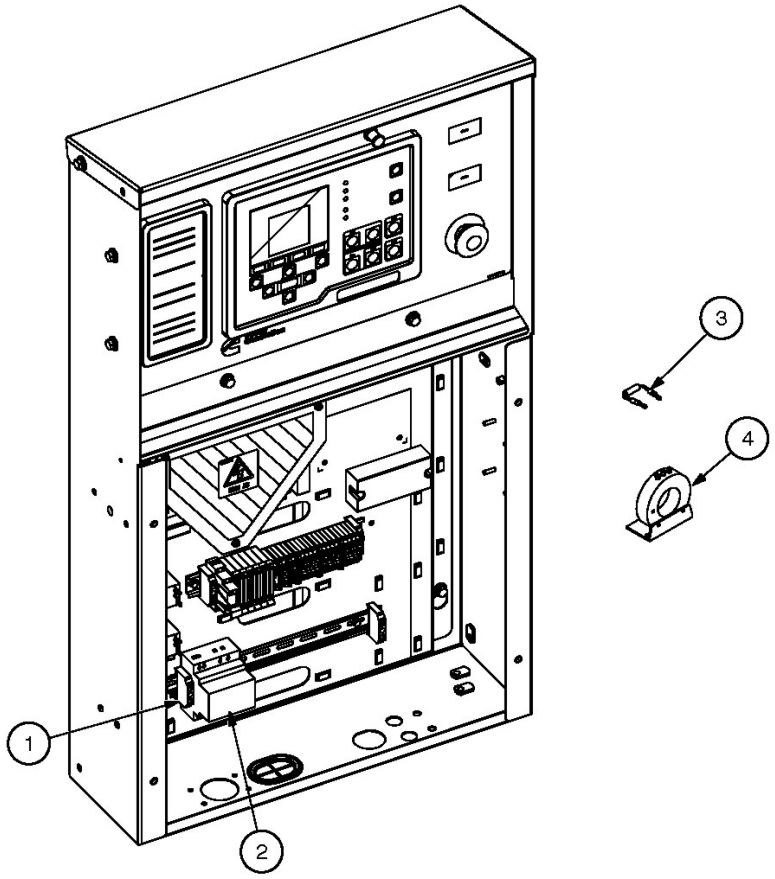
8.4 Ground Fault Relays

A Ground Fault Relay (GFR) continuously monitors the neutral-to-ground connection and activates a fault alarm when the connection is broken. During generator set operation, the relay continuously monitors the line-to-neutral and activates a fault alarm when a ground fault is sensed.

A control reset will clear the fault at the control panel and will also reset the ground fault relay.

8.4.1 Ground Fault Relay with Local Current Transformer

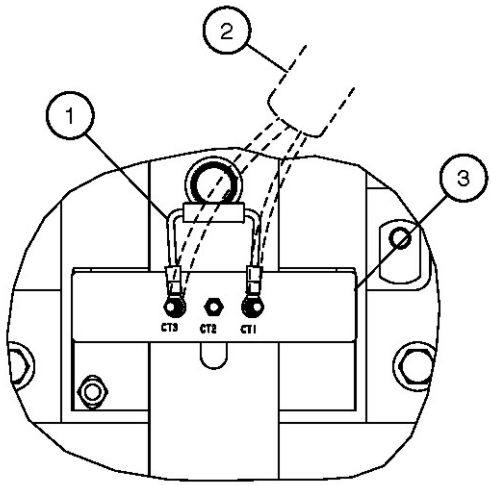
The ground fault relay with a local Current Transformer (CT) is used on generator sets that have their neutrals bonded to ground internally in the circuit breaker or entrance enclosure. The ground bonding jumper is connected between the neutral (L0) bus bar and the equipment grounding bus and passes through the ground fault sensing CT which drives the GFI relay. Generator sets with this feature power separately derived systems via 4-pole transfer switches that switch the neutral conductor as well as the three phases.



No.	Description	No.	Description
1	Terminal End Bracket	3	CT Meter Harness with Resistor
2	Ground Fault Relay	4	Current Transformer

FIGURE 14. GROUND FAULT RELAY USED WITH LOCAL CURRENT TRANSFORMER

For installations with a local current transformer, the current transformer is mounted inside the control box. The meter harness with resistor is installed on the transformer. The relay harness is connected from the relay to the current transformer.



No.	Description	No.	Description
1	CT Meter Harness with Burden Resistor	3	Current Transformer
2	Relay Harness		

FIGURE 15. GROUND FAULT METER HARNESS

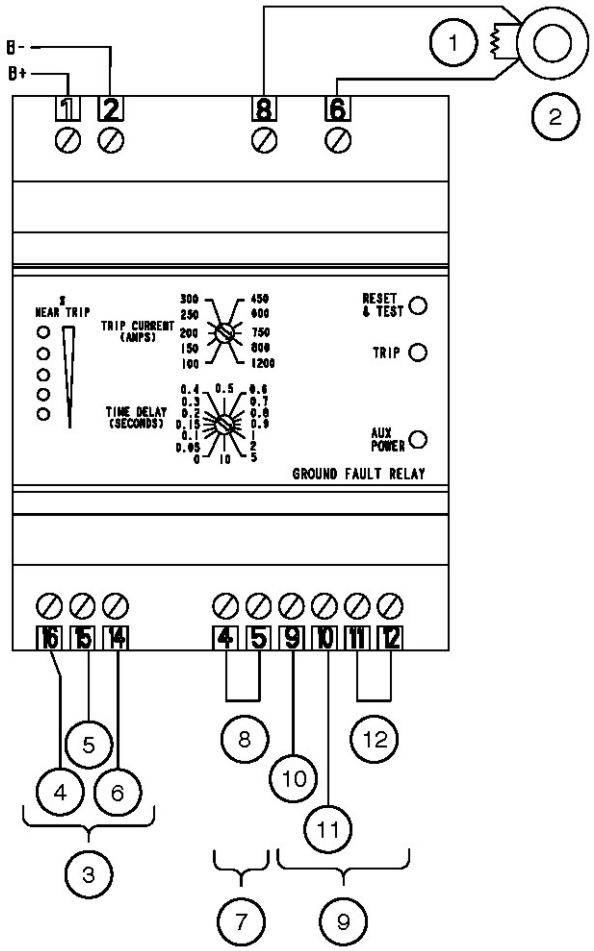
8.4.2 Ground Fault Relay Installation

Refer to the following figure when making wiring connections. The connection points on the ground fault relay that are used include:

- GFR-1 - B+
- GFR-2 - B–
- GFR-6 to CT3
- GFR-8 to CT1
- GFR-14 (Signal) to TB1-14
- GFR-15 (Signal Return) to TB1-15

The two leads connected from GFR-14 and GFR-15 to TB1-14 and 15 are configurable inputs.

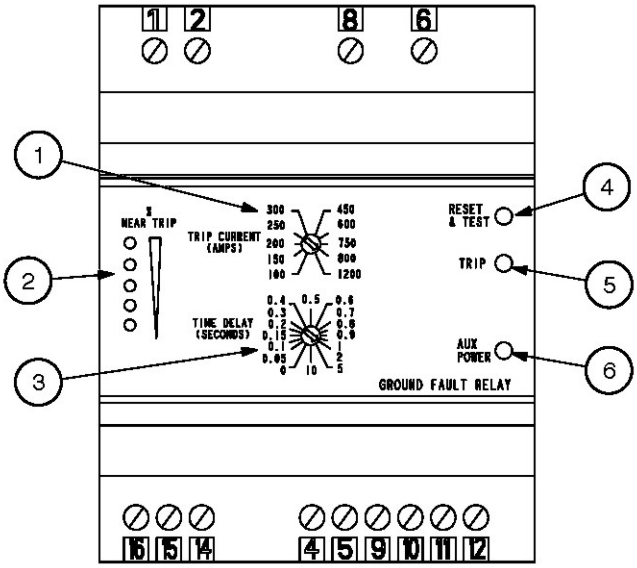
The maximum AC terminal voltage for the ground fault relay is 600 VAC. The supply voltage is 12-48 VDC. The continuous current is 5 amps.



No.	Description	No.	Description
1	Burden Resistor	7	Optional
2	Current Transformer	8	Link for Latching Relay
3	Output Signal	9	Not Used
4	N.O.	10	Analogue +
5	Com.	11	Output –
6	N.C.	12	Link for 200µ Shunt

FIGURE 16. GROUND FAULT RELAY WIRING CONNECTIONS

The relay has a time delay setting of zero to ten seconds and a current setting of 100 to 1200 amperes. Adjust the Current and Time Delay controls on the ground fault relay to the customer's specifications.



No.	Description	No.	Description
1	Trip Current Control	4	Reset and Test Button
2	Percent Near Trip Indicators	5	Trip Indicator
3	Time Delay Control	6	Auxiliary Power Indicator

FIGURE 17. GROUND FAULT RELAY

9 AC Electrical Connections

⚠ WARNING

Arc Flash and Shock Hazard

Voltages and currents present an electrical shock hazard that can cause severe burns or death.

Make sure that only service personnel who are trained and experienced perform electrical and mechanical component installations. The AC sensing harness and other cabling will become energized when the generator set is in operation.

⚠ 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

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

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

Electric Shock Hazard

Voltages and currents present an electrical shock hazard that can cause severe burns or death.

Avoid contact with the voltage sense and bus sense leads; voltages of up to 600 VAC may still be present. These voltages could be live even when the generator set is switched off.

This section provides the procedure that is used to connect the AC electrical system of the generator set.

Before making any AC electrical connections, make certain the generator set cannot be accidentally started. Make sure the Operator Panel is in OFF mode. Turn off or remove AC power from the battery charger and then remove the negative (**–**) battery cable from the set starting battery using an insulated wrench.

If the generator set is being installed in an application where it may parallel with other generators or utility sources, the generator set control system may be energized from an external source. Lock out tag out any external source that can provide AC power to the generator set.

NOTICE

Ventilate the battery area before working on or near battery. Wear goggles. Stop the generator set and disconnect the battery charger before disconnecting battery cables. Disconnect negative (–) cable first and reconnect last using an insulated wrench.

Connecting the generator set AC electrical system involves:

- Installation of transfer switch
- Installation or verification of paralleling switchboard
- Generator output voltage selection
- Load cable connection
- Standard and optional AC equipment connections (e.g., control box heater, coolant heater, etc.).

For all output connections, including when field connection is made at the alternator terminations, installation should be completed with conductors of appropriate size, type, and rating specified in local codes (or UL). For UL compliant installations, use conductor size, X AWG, 75 °C or 90 °C copper wire, 600V. Where X AWG is the conductor size specified by the local electrical code for 75 °C at the rated output current for the generator set. Use copper conductors only. For non-UL compliant installations, use cable sizes, composition, and rating per local codes. Strain relief, bending space, raceway, and other installation features should be completed in compliance with local code.

Local regulations often require that wiring connections be made by a licensed electrician, and that the installation be inspected and approved before operation. All connections, wire sizes, materials used, etc. must conform to the requirements of electrical codes in effect at the installation site.

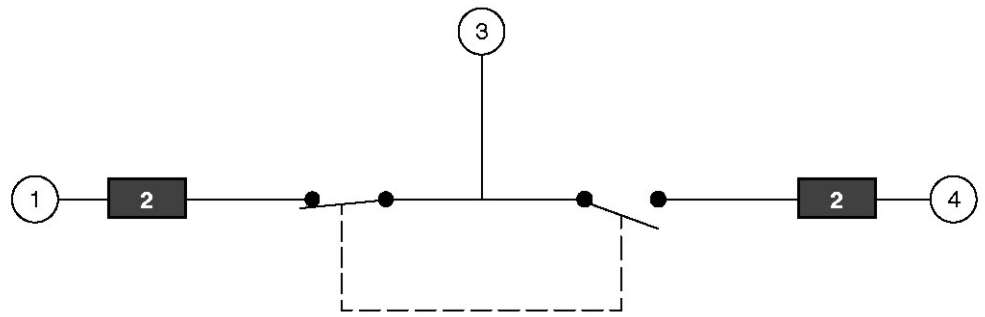
Before starting the generator set, check to make sure that all electrical connections are secure, and that all wiring is complete. Replace and secure any access panels that have been removed during installation. Check that the load cables from the generator set are properly connected.

NOTICE

Backfeed to a utility system can cause electrocution or property damage. Do not connect to any building electrical system except through an approved device and after the building main switch is opened.

9.1 Transfer Switch

A transfer switch must be used for switching the load from the normal power source to the generator set (see **Figure 18**). Follow the installation instructions provided with the transfer switch when connecting the load and control wiring.



No.	Description	No.	Description
1	Normal Power Source	3	Load
2	Overcurrent Protective Device	4	Emergency Power Source

FIGURE 18. TYPICAL LOAD TRANSFER FUNCTION

9.2 Load Connections

NOTICE

Flexible conduit and stranded conductors must be used for connections to take up movement of the generator set.

Do not change circuit breaker in absence of authorized operator. Connect with your nearest Cummins Authorized Distributor for genuine Cummins part information.

All loads are connected to the alternator by bolting stranded load wires to the appropriate terminals on the alternator reconnection terminal block or circuit breaker lugs. The terminals are marked U, V, W, and N to indicate the line and neutral connections. (Reference: U, V, and W correspond with L1, L2 and L3; and N with L0 respectively). See **Appendix C on page 87** for details about the following:

- Load connections
- Conduit
- Cable Size

9.3 Load Balancing

When connecting loads to the generator set, balance the loads so that the current flow from each line terminal (L1, L2, and L3) is about the same. This is especially important if both single phase and three phase loads are connected. Any combination of single phase and three phase loading can be used as long as each line current is about the same, within 10 percent of median value and no line current exceeds the name plate rating of the generator. Check the current flow from each line after connections by observing the Operator Panel ammeter.

9.4 Fuel Transfer Pump Installation

⚠ WARNING

Combustible Liquid

Fuel leaks are a fire and explosion hazard which can cause severe personal injury or death.

Make sure that only trained and experienced personnel install and service the generator set in accordance with applicable codes.

NOTICE

Do not smoke near fuel and keep flames, sparks, pilot lights, arcing switches and equipment, and other sources of ignition well away.

A fuel transfer pump and control are available as an option when a sub-base or an in-skid day tank is provided. The automatic control operates the fuel pump to maintain a reservoir of fuel in the day tank.

9.4.1 Fuel Transfer Pump Control AC Connections

See the wiring diagrams provided with your generator set when making connections at the fuel pump control.

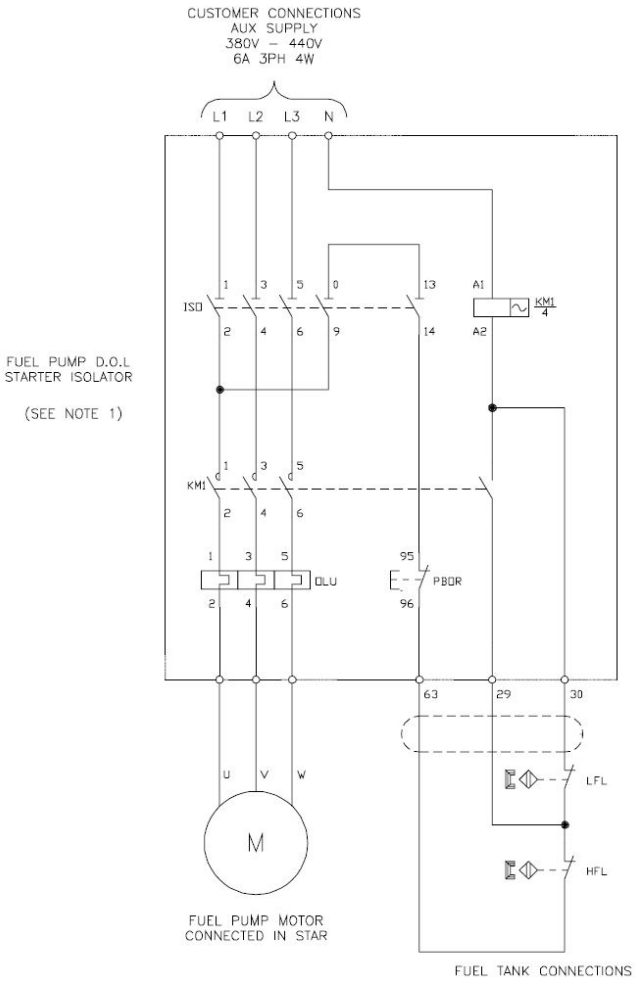


FIGURE 19. FUEL PUMP CONTROL TERMINAL BOARD

9.5 Current Transformers

Current transformers (CTs) reduce high voltage currents (AC) to enable safe monitoring.

9.5.1 Current Transformer Installation Requirements

Current transformers (CTs) reduce high voltage currents (AC) to enable safe monitoring.

The CT has a dot on one side. This dot must be facing toward the alternator reconnection terminal block (conventional current flowing into the dot). A dot is also used to indicate pin 1 of the CT.

Route the load lead through the appropriate CT. See the Alternator Reconnection Drawing section.

The CTs have dual secondaries (3 pins):

- The CT secondary wire marked 1 is connected to pin 1 of the CT.
- The CT secondary wire marked 2/3 is connected to pin 3 for low voltage generator sets.

9.6 Coolant Heater Connection

NOTICE

The coolant heater must not be operated while the cooling system is empty or damage to the heater will occur.

A coolant heater keeps the engine coolant warm when the engine is shut down. It heats and circulates the coolant within the engine. This reduces start-up time and lessens engine wear caused by cold starts. It is electrically operated and thermostatically controlled.

Refer to **Appendix A** for electrical connections.

9.6.1 Coolant Heater Specifications

The coolant heaters are designed to allow the generator set to start and pick up load within 10 seconds in a 40 °F (4.4 °C) environment. In colder ambient temperature environments the starting time may be longer.

An installation may include one of two types of coolant heaters.

- 4990 watt at nominal voltage - This coolant heater is used in an environment where the minimum temperature is 40 °F (4 °C).
- 6420 watt at nominal voltage - This coolant heater is used in an environment where the temperature is less than 40 °F (4 °C).

The coolant heater is set up for a 240 V configuration.

9.7 Alternator Heater Connection

⚠ WARNING

Electric Shock Hazard

Voltages and currents present an electrical shock hazard that can cause severe burns or death.

Water or moisture inside an alternator increases the possibility of flashing and electrical shock. Do not use an alternator which is not dry inside and out.

An alternator heater(s) is used to help keep the alternator free of condensation when the generator set is not running. During cool and humid conditions, condensation can form within an alternator, creating flashing and shock hazards.

Connect the heater(s) terminals to a source of power that will be on during the time the engine is not running. Be sure the supply voltage and circuit amperage is correct for the heater element rating.

9.7.1 Alternator Heater Specifications

The 240V alternator heater is used with HC5 and HC6 alternators.

9.8 Annunciators

9.8.1 PowerCommand Universal Annunciator

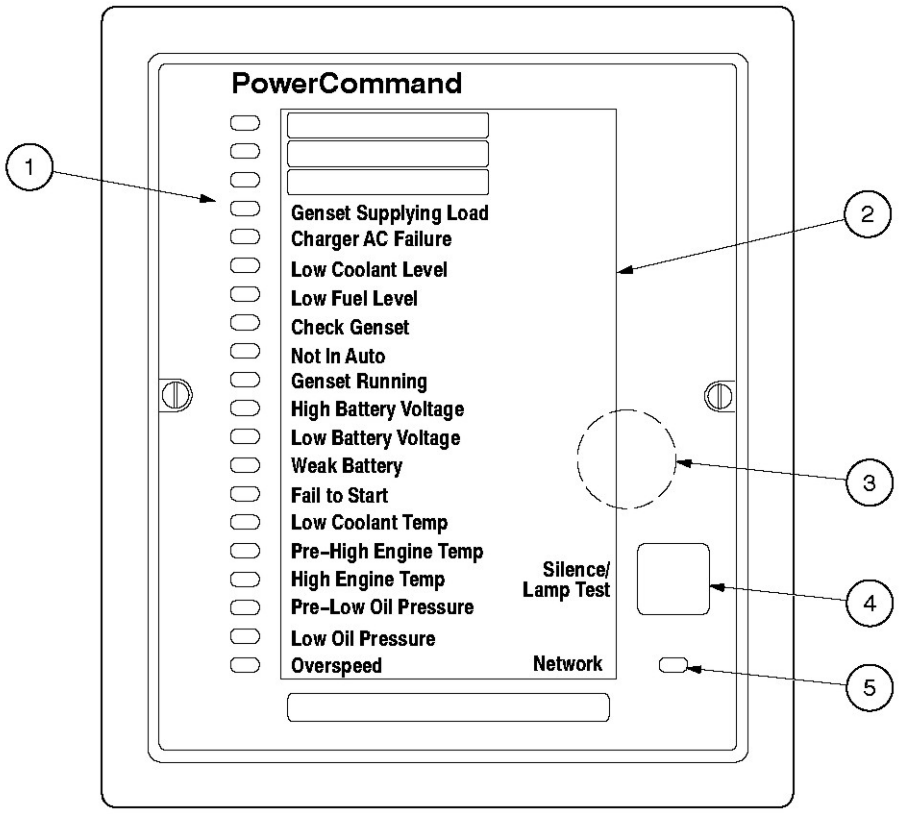
A universal annunciator provides lamps and a horn to annunciate the operating status and fault conditions of an emergency power system. It is designed for connection to either a 12 VDC or a 24 VDC control system. It can be configured to be either a positive or negative signal device.

Two versions of the PowerCommand universal annunciator are available.

- Panel Mounted
- Panel with Enclosure

The universal annunciator can communicate using either a PCCNet or a Modbus network.

Refer to the PowerCommand Universal Owners Manual for more information.



No.	Description	No.	Description
1	System Status Lamps	4	Silence/Lamp Test Button
2	Insert Card	5	Network Status Lamp
3	Horn		

FIGURE 20. ANNUNCIATOR COMPONENTS

9.9 Battery Charger

9.9.1 Mains (Utility) Battery Charger - Wall Mounted

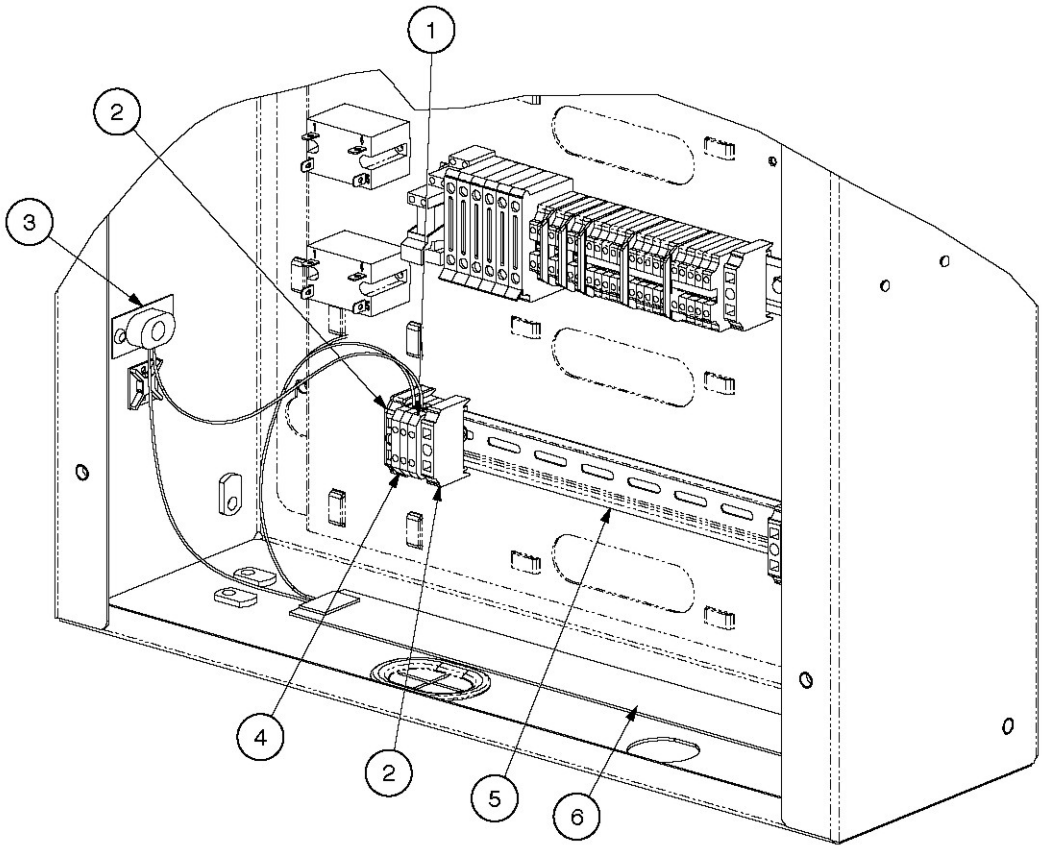
Mains (utility) powered battery chargers, which are wall mounted, are available in 5 and 10 amp ratings, dependent on the generator set configuration. For more information, see the Battery Charger section of the generator set Operator Manual.

9.10 Control Box Heater

9.10.1 Control Box Heater Installation

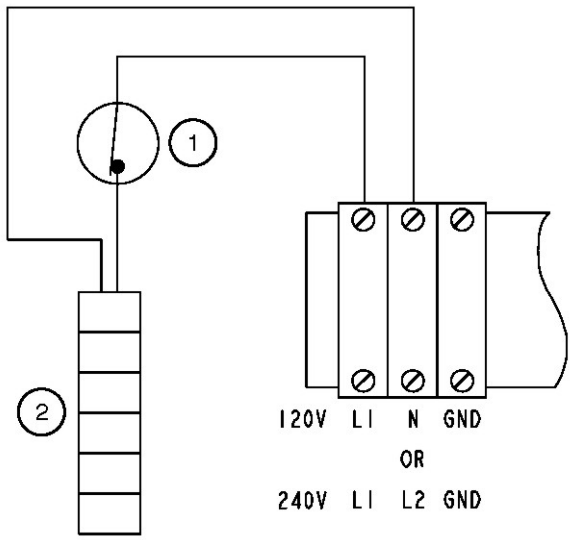
A thermostat controlled heater is installed inside the control cabinet. The heater may be attached to the bottom or the side of the control box. **Figure 21** shows a typical heater. **Figure 22** shows typical heater wiring.

The heater power cord must be connected to a grounded outlet.



No.	Description	No.	Description
1	Terminal Block (Ground)	4	Terminal Block
2	Terminal Endplate	5	Terminal DIN Rail
3	Thermostat	6	Flexible Heater Pad

FIGURE 21. TYPICAL CONTROL BOX HEATER



No.	Description	No.	Description
1	Thermostat	2	Heater

FIGURE 22. TYPICAL HEATER WIRING DIAGRAM

9.11 Grounding

⚠ WARNING

Electric Shock Hazard

Voltages and currents present an electrical shock hazard that can cause severe burns or death.

Make sure that only service personnel who are trained and experienced perform electrical and mechanical component installations. Bonding and grounding must be done properly. All metallic parts that could become energized under abnormal conditions must be properly grounded.

The following is a brief description of system and equipment grounding of permanently installed AC generators within a facility wiring system.

NOTICE

It is important to follow the requirements of the local electrical code.

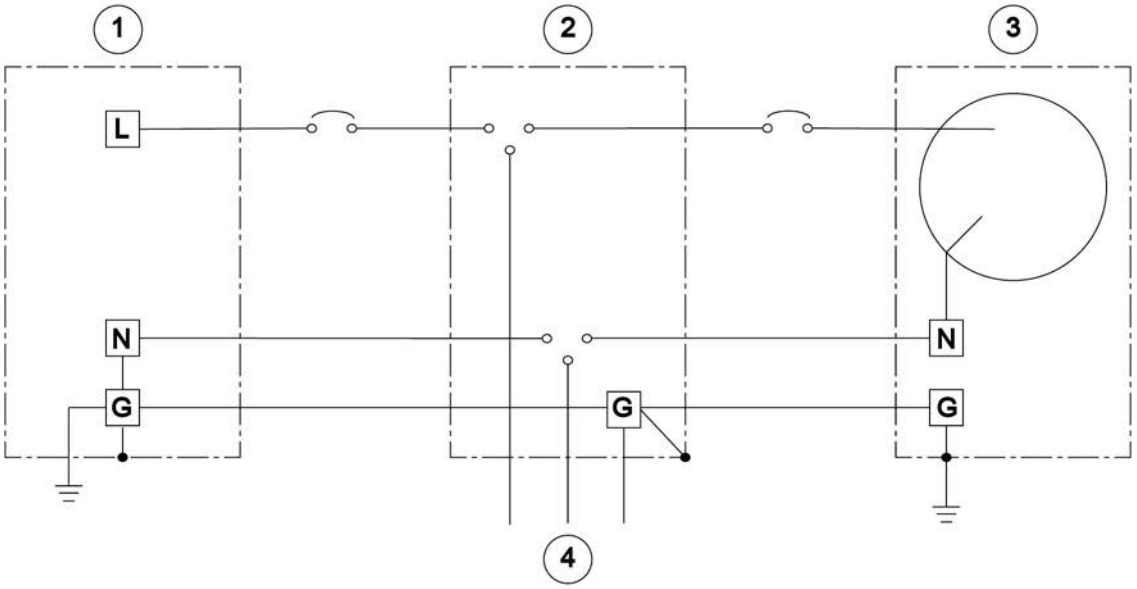
NOTICE

A UL-listed grounding electrode terminal within its ratings and suitable for the application must be installed and labeled "Grounding Electrode Terminal" for UL compliance.

Figure 23, Figure 24 and Figure 25 illustrate typical system grounding for a 2-pole, 3-pole, and 4-pole Automatic Transfer Switch (ATS). In the 2-pole and 3-pole ATS, note that the generator neutral is connected to the ATS and is NOT bonded to ground at the generator. In the 4-pole ATS system, a grounding electrode conductor and a bonding jumper are used to connect the generator neutral to ground.

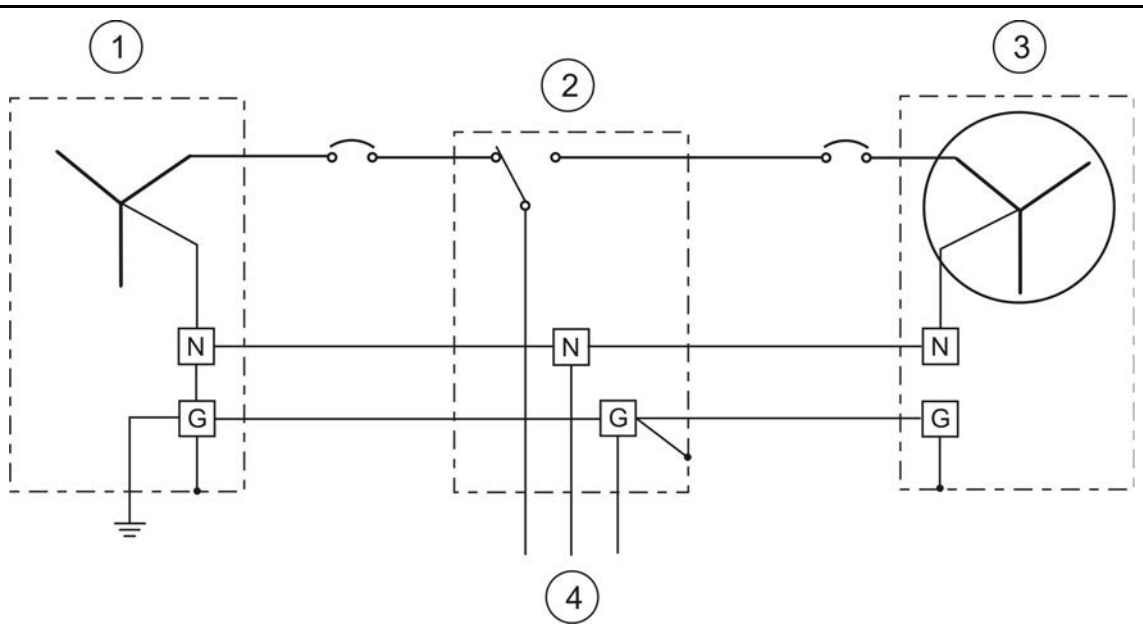
Make sure the generator set is grounded to earth in one location only. On generator sets without a circuit breaker, ground to the point indicated on the top of the generator. On generator sets with circuit breakers, use the ground lug provided in the circuit breaker box.

The grounding electrode terminal is not provided. Make sure UL listed terminals are used, are sized for the generator set ratings, and are suitable for the application.



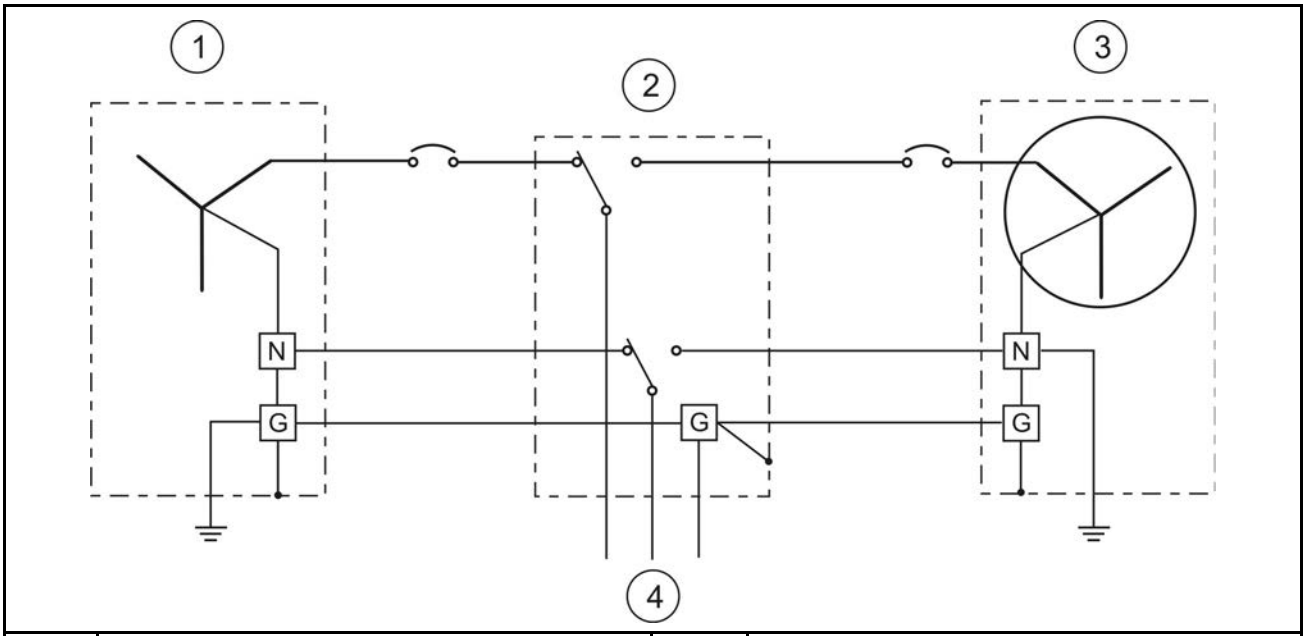
No.	Description	No.	Description
1	Service Entrance	3	Generator Set
2	2-Pole ATS	4	Load

FIGURE 23. TYPICAL SYSTEM - ONE-PHASE, THREE WIRE UTILITY, TWO-POLE ATS



No.	Description	No.	Description
1	Service Entrance	3	Generator Set
2	3-Pole ATS	4	Load

FIGURE 24. TYPICAL SYSTEM - THREE-PHASE, FOUR WIRE UTILITY, THREE-POLE ATS



No.	Description	No.	Description
1	Service Entrance	3	Generator Set
2	4-Pole ATS	4	Load

FIGURE 25. TYPICAL SYSTEM - THREE-PHASE, FOUR WIRE UTILITY, FOUR-POLE ATS

10 Pre-Start Preparation

⚠ 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.

Before an initial start of the generator set, complete the Installation Checklist, see **Chapter 11 on page 67**.

10.1 Electrical System

Verify all electrical connections are secure and all wiring is complete and inspected. Replace and secure any access panels that may have been removed during installation.

10.2 Battery Connections - 12 Volt / 24 Volt

⚠ WARNING

Accidental starting of the generator set can cause severe personal injury or death. Make sure that the PowerCommand® Control is in the OFF mode before connecting the battery cables.

Starting the unit requires a 12 volt or 24 volt battery. Connect positive battery cable before connecting negative battery cable to prevent arcing.

Service the batteries as necessary. If an automatic transfer switch is installed without a built-in charge circuit, connect a separate battery charger. Proper selection and maintenance of batteries and battery chargers is essential for system reliability.

⚠ WARNING

Ignition of explosive battery gases can cause severe personal injury or death. Always connect negative (–) battery cable last to prevent arcing.

⚠ WARNING

Ventilate battery area before working on or near battery. Arcing at battery terminals, light switch or other equipment, flame, pilot lights and sparks can ignite battery gas. Do not smoke, or switch trouble light ON or OFF near battery. Discharge static electricity from body before touching batteries by first touching a grounded metal surface.

10.3 Starting

Refer to the generator set Operator manual for important safety precautions and recommended procedures for starting the generator set and verifying proper operation. Start the generator set and verify all engine and generator set menus are displaying the correct values.

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11 Installation Checklist

11.1 Checklist

Tick	General Items
	Generator set wattage capacity is sufficient to handle maximum anticipated load.
	At least 3 feet (914.4 mm) of clearance (or greater for housing door) is provided around the entire generator set for service and ventilation.
	The generator set is located in an area not subject to flooding.
	All operating personnel have read and are familiar with the generator set Operator manual, all health and safety procedures, warnings, cautions, precautions, and the other documentation supplied with the generator set.
	All operators have been thoroughly briefed on preventative maintenance procedures.
	All operators have read and understand all important safety instructions.
	Generator Set Support
	The floor, roof, or earth on which the generator set rests is strong enough and will not allow shifting or movement. Observe local codes on soil bearing capacity due to freezing and thawing.
	The generator set is properly supported and retained to an approved base
	The supporting base is large enough and is of non-combustible material, extending 6 inches (152.4 mm) all around the generator set.
	Cooling Air Flow
	Generator set air inlet is faced into direction of strongest, prevailing winds.
	Air inlet openings are unrestricted and are at least 1 to $1^{1}/_{2}$ times larger than air outlet area.
	Cooling air outlet is on downwind side of building (if not, wind barrier is constructed).
	Proper ducting material (sheet metal, canvas) is used between radiator and air outlet.
	Diesel Fuel System (if applicable)
	Fuel tanks meet or exceed all Local, State, or National codes (if applicable).
	Fuel lines are properly installed, supported, and protected against damage.
	The fuel filters have been installed.
	Approved flexible fuel line is installed between the main fuel supply and the generator set's fuel system near the generator set, to protect it against damage caused by vibration, expansion, and contraction.
	Strainer or fuel screen (100 to 200 mesh) is installed in the fuel supply line to protect the fuel lift pump, day tank transfer pump, or float valve seat from fuel tank debris (if applicable).
	The fuel filter assembly shipped with the generator set is installed and operational (if applicable).
	Fuel supply shutoff valves are installed to prevent fuel flow in case of leaks.
	No shutoff valves are installed on engine fuel return line (if applicable).
	External fuel pumps are connected and operational at all times - generator set started or shut down (if applicable).
	Fuel tanks are filled with the correct grade / type of fuel (if applicable).
	Fuel system is properly primed.

	No fuel leaks are found in supply line or engine fuel system.
	Exhaust System
	The breather tube routing is set up to blow the fumes away from the generator set (if applicable)
	Operators are thoroughly briefed on the dangers of carbon monoxide gas.
	If the installation includes a heavy duty air cleaner, it has been installed.
	Areas around generator set are well ventilated. No possibility of exhaust fumes entering building doors, windows, or intake fans.
	Exhaust gases are piped safely outside and away from building.
	The correct length of approved rigid pipe is connected to the generator set flexible pipe using approved securing methods with no weight resting on engine exhaust components. There are no bends in flex section.
	Condensation drain is provided in lowest section of exhaust piping.
	Exhaust piping is insulated to guard against burns to personnel.
	Exhaust piping passing through walls or ceilings have approved fire-proof materials and are in compliance with all codes.
	Exhaust piping is large enough in diameter to prevent excessive back pressure on engine.
	Verify that the pyrometer meters are functioning.
	AC and DC Wiring
	For bottom entry circuit breaker installations, the cable chute has been installed (if applicable).
	Wire sizes, insulation, conduits and connection methods all meet applicable codes.
	AC and DC wires are separated in their own conduit to prevent electrical induction.
	All load, line and generator connections are well made and correct.
	Flexible conduit is used between the generator and the building or surrounding structure.
	Check phase rotation.
	Generator Set Pre-Start
	Generator set engine is properly serviced with oil and coolant.
	Battery charger is installed using the appropriate cable size and is operational.
	Battery charger is configured for the proper DC battery voltage, battery type, and float voltage.
	Batteries are properly installed, serviced and charged.
	Battery temperature sensor is connected and operational (if applicable).
	Engine coolant heater is connected and operational.
	All generator set covers and safety shields are installed correctly.
	All fuel and coolant shutoff valves are operational.
	Radiator fan and other external moving parts including drive belts are unrestricted.
	On PowerBox enclosed generator sets, the end doors are open and latched back.

12 Manufacturing Facilities

U.S. and CANADA	EMEA, CIS	BRAZIL
Cummins Inc. 1400 73rd Ave. NE Minneapolis, MN 55432 USA	Cummins Inc. Royal Oak Way South Daventry Northamptonshire NN11 8NU United Kingdom	Rua Jati, 310, Cumbica Guarulhos, SP 07180-900 CNPJ: 43.2201.151/0001-10 Brazil
Toll Free 1-800-CUMMINS™ (1-800-286-6467) Fax +1 763-574-5298	Phone +44 1327 88-6453 Fax +44 1327 88-6125	Phone 0800 286 6467
CHINA	**INDIA**	**ASIA PACIFIC**
Cummins Inc. No.118 South Quanli Road , Wuhan Economic& Technological Development Zone , Hubei, P.R.China 430058	Cummins Inc. Plot No B-2, SEZ Industrial Area, Village-Nandal & Surwadi, Taluka-Phaltan Dist- Satara, Maharashtra 415523 India	Cummins Sales and Service Singapore Pte Ltd 85 Tuas South Avenue 1 Singapore 637419
Phone + 86 (27) 8421 4008 Fax + 86 (27) 8421 4804	Phone +91 021 66305514	Fax +65 6265 6909
LATIN AMERICA	**MEXICO**	
3350 Southwest 148th Ave. Suite 205 Miramar, FL 33027 USA	Eje 122 No. 200 Zona Industrial San Luis Potosi, S.L.P. 78395 Mexico	
Phone +1 954 431 551 Fax +1 954 433 5797	Phone +52 444 870 6700 Fax +52 444 824 0082	

12.1 How to Obtain Service

When a product requires servicing, contact the nearest Cummins service provider. To locate the distributor, go to **www.cummins.com/support** and select Find a Sales or Service Location. When contacting the service provider, always supply the complete model, specification, and serial number as shown on the nameplate.

12.1.1 Locating a Distributor

In the U.S. and Canada

To easily locate the nearest certified distributor/dealer for Cummins generator sets in your area, or for more information, contact us at 1-800-CUMMINS™ (1-800-286-6467) or visit **www.cummins.com/support**.

If unable to contact a distributor using the automated service, consult the Internet.

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

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

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.

A.1 Customer Connections

Customer connections are listed in the wiring diagrams. See **Appendix A**.

A.2 VTA28G5/G6 Wiring Diagram with PowerCommand 1.2 Control

A044V045	A3	AUTOCAD

REL NO	LTR	NO	REVISION	DR	CHKR	APPROVED	DATE
ECO-131152	A	1	PRODUCTION RELEASE	YS	AL	AW	17DEC12

PowerCommand 1.2 FOR VTA28 HYDRO MECHANICAL GENSET

PAGE	TITLE	DESCRIPTION
1	INDEX	COVER PAGE
2	WIRING DIAGRAM	SCHEMATIC, ELECTRICAL CONNECTIONS
3	GENSET LOCATION, GENSET	DEVICE LOCATIONS ON GENSET

DO NOT SCALE PRINT	TOLERANCE UNLESS STATED ALL DIMENSIONS IN MM DIM: X = ±0.5, X.X = ±0.3, X.XX = ±0.15	SIM TO –	DRAWN YONGLE SHI		CUMMINS POWER GENERATION
		COMPID FORM	CHECK ANDY LIU		
		THIRD ANGLE PROJECTION	APPR AARON WANG		TITLE: DIAGRAM,SCHEMATIC
ANG TOL ± 1.0°	HOLE: 0.09 - 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	THIS DOCUMENT IS THE PROPERTY OF CUMMINS POWER GENERATION. IT CONTAINS PROPRIETARY AND CONFIDENTIAL INFORMATION WHICH MUST NOT BE DUPLICATED, USED OR DISCLOSED OTHER THAN EXPRESSLY AUTHORIZED BY CUMMINS POWER GENERATION OR ITS REPRESENTATIVE	DATE 17DEC12	SITE CODE	
DRAWN TO SCALE OF: NTS		FOR INTERPRETATION OF DIMENSIONING AND TOLERANCING, SEE BS 8888 PART 2	FIRST USED ON VTA28	PGC	DWG NO A044V045 · SHEET 1 OF 3 · DWG SIZE A3

FIGURE 26. SHEET 1 OF 3

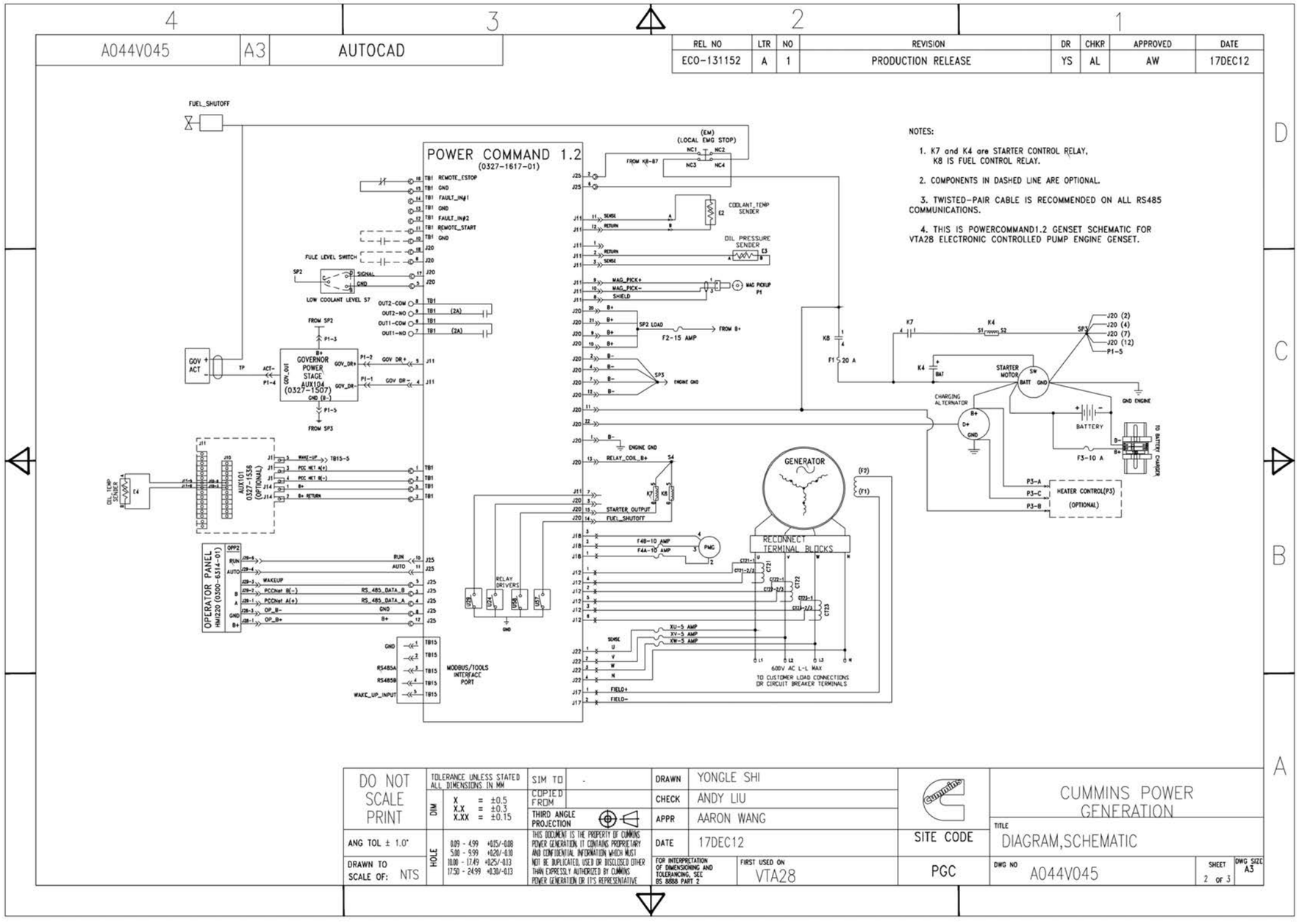

FIGURE 27. SHEET 2 OF 3

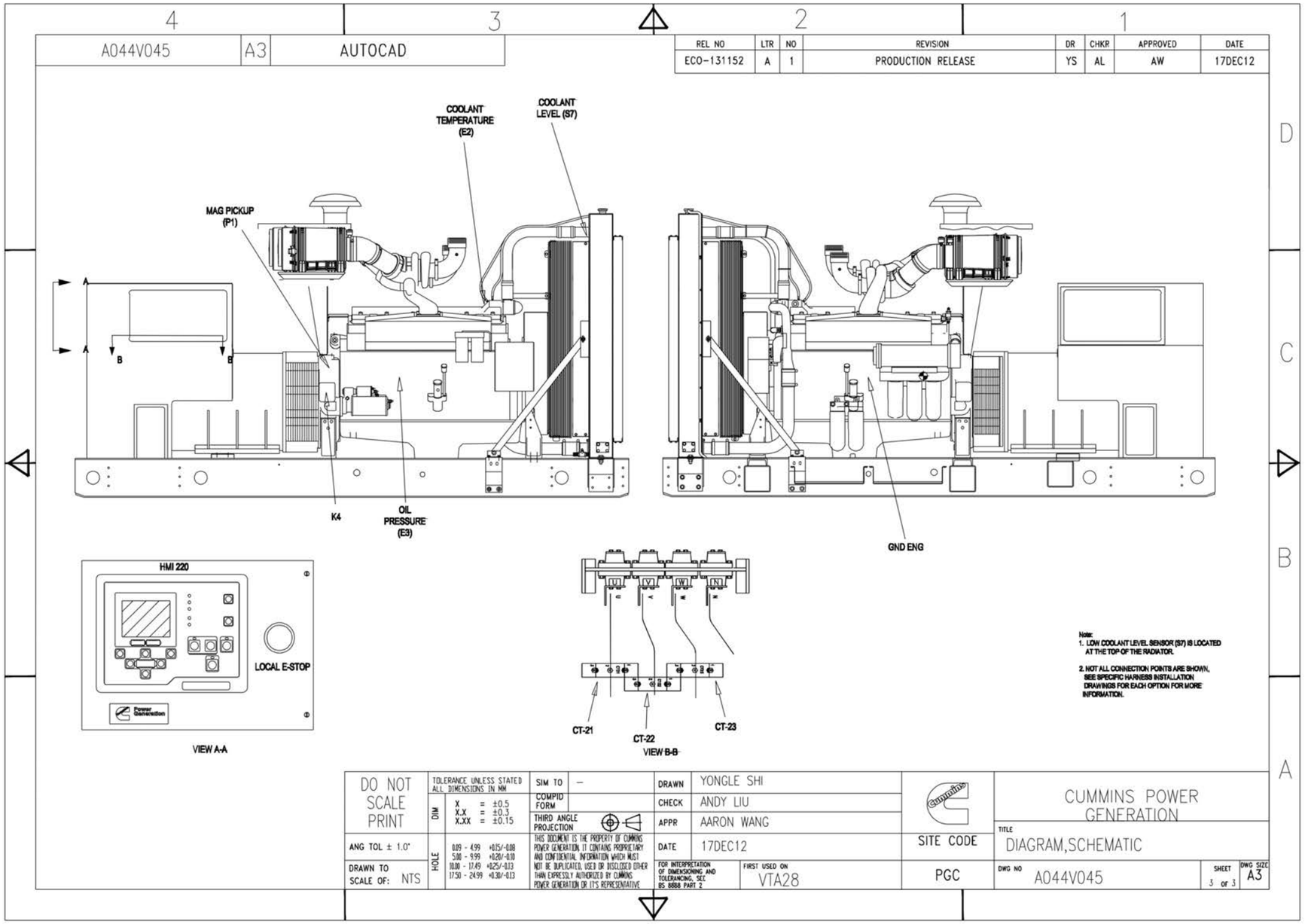

FIGURE 28. SHEET 3 OF 3

A.3 A035J417 - Wiring Diagram

A035J417	A1	CREO PARAMETRIC

REL NO	LTR	NO	REVISION	DR	CHKR	APPROVED	DATE
ECO-138139	E	1	SEE SHEET 7	BW	AM	A.SALVEY	25SEP13

PowerCommand 3.3 FOR VTA28 HYDRO MECHANICAL GENSET

PAGE	TITLE	DESCRIPTION
1	INDEX	COVER PAGE
2	WIRING DIAGRAM	SCHEMATIC,ELECTRICAL CONNECTIONS
3	GENSET LOCATION,GENSET	DEVICE LOCATIONS ON GENSET
4	LOCATION DIAGRAM	HC6 ALTERNATOR
5	LOCATION DIAGRAM	HC5 ALTERNATOR
6	OPTIONS	ACCESSORY CONNECTIONS
7	ADDITIONAL PINOUTS	ADDITIONAL PINOUT CONNECTIONS

Notes:
1. Fusing requirements for Arc flash protection for TB7 (Bus/Utility Voltage Sense)*:If your potential circuits have available incident energy > 1.2 Cal/cm2 or 5J/cm2 then you need to protect for arc flash in the lines feeding TB7**.
   Available Incident energy > 1.2 Cal/cm2 or 5J/cm2 is typically found when any of the the following is true:
   A) LL Voltage > 240Vac OR
   B) Paralleled OR
   C) Alternator size > 125kVA
2. Fusing requirements for Arc flash protection for TB7 (Bus/Utility Voltage Sense)*:If Available Incident energy is > 1.2 Cal/cm2 or 5J/cm2 then the use of current limiting fuses or other suitable means in the lines feeding J22 and TB7** are needed.
   The following suggested current limiting fuses will accomplish this:
   A) Fuse rating: 600Vac, 0.5A, AIC=200kA, fast acting, current limiting, Class CC (e.g. Ferraz Shawmut ATMR 1/2 or equiv.)
   B) Use 600Vac rejection type fuse holder with AIC=200kA rating, e.g. Ferraz Shawmut 30323R or equiv.
   C) Fuses must be placed near the voltage source.
   * Per NFPA 70E and Cummins Electrical Safety Policy.
   **Fusing protecting the circuit feeding TB7 must also meet all local code requirements.
3. For enclosure-container wiring diagrams refer to the following drawings.
   0630-2941
   0630-3613
   0630-3080
   0630-2867
   0630-2868
   0630-2873
4. Where 'PCC3300' is used, 'PCC3300 MLD' also applies.

DO NOT SCALE PRINT	SIM TO -	DRAWN N.SCHOTTLER	CUMMINS POWER GENERATION		
	COPIED FROM -	CHECK N.SCHOTTLER		TITLE	
	THIRD ANGLE PROJECTION	APPR T.AJAYI		SITE CODE	DIAGRAM,SCHEMATIC
	DATE 01APR11	FIRST USED ON VTA28		PGK	DWG NO A035J417 SHEET 1 of 7 A1

FIGURE 29. SHEET 1 OF 7

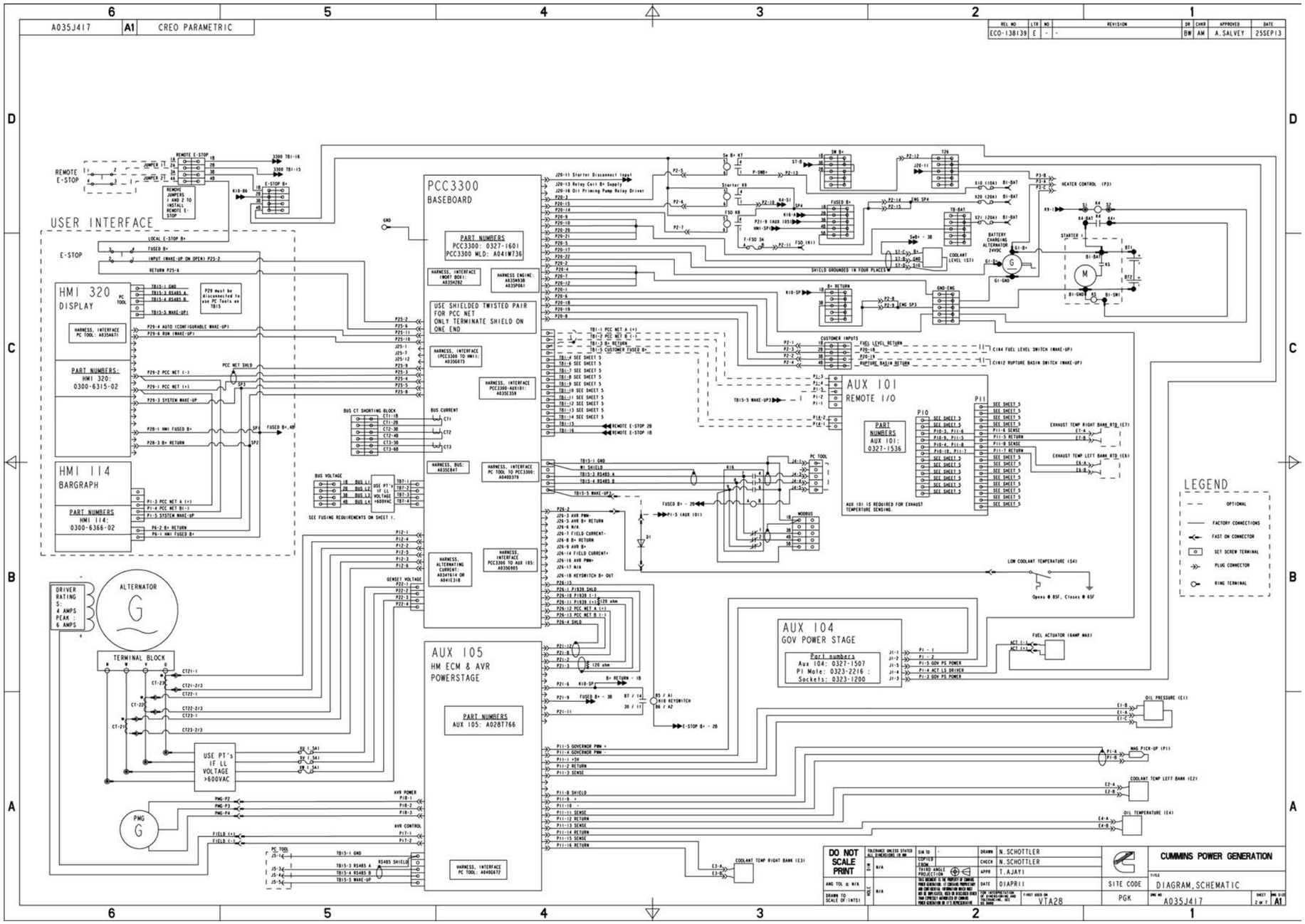

FIGURE 30. SHEET 2 OF 7

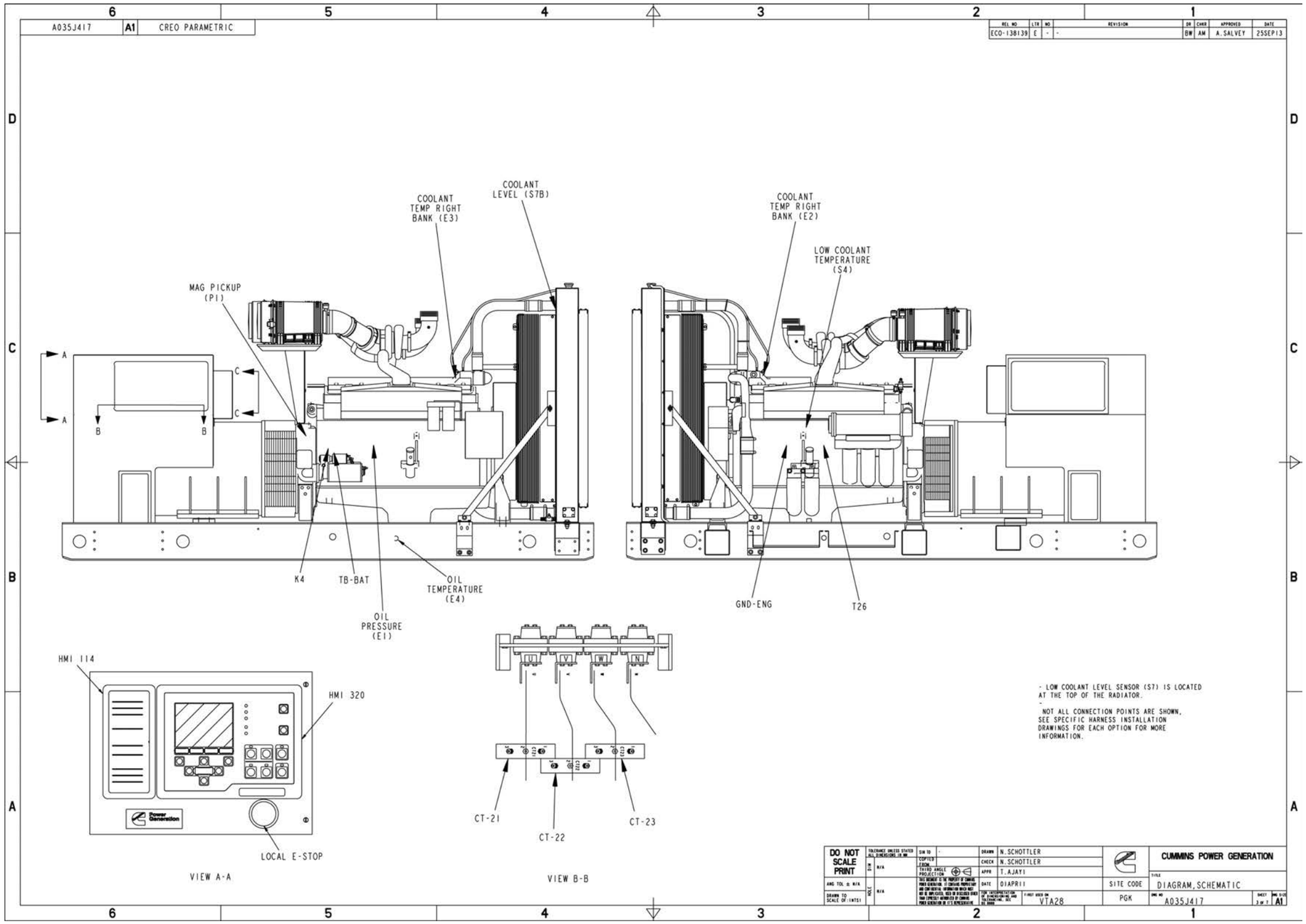

FIGURE 31. SHEET 3 OF 7

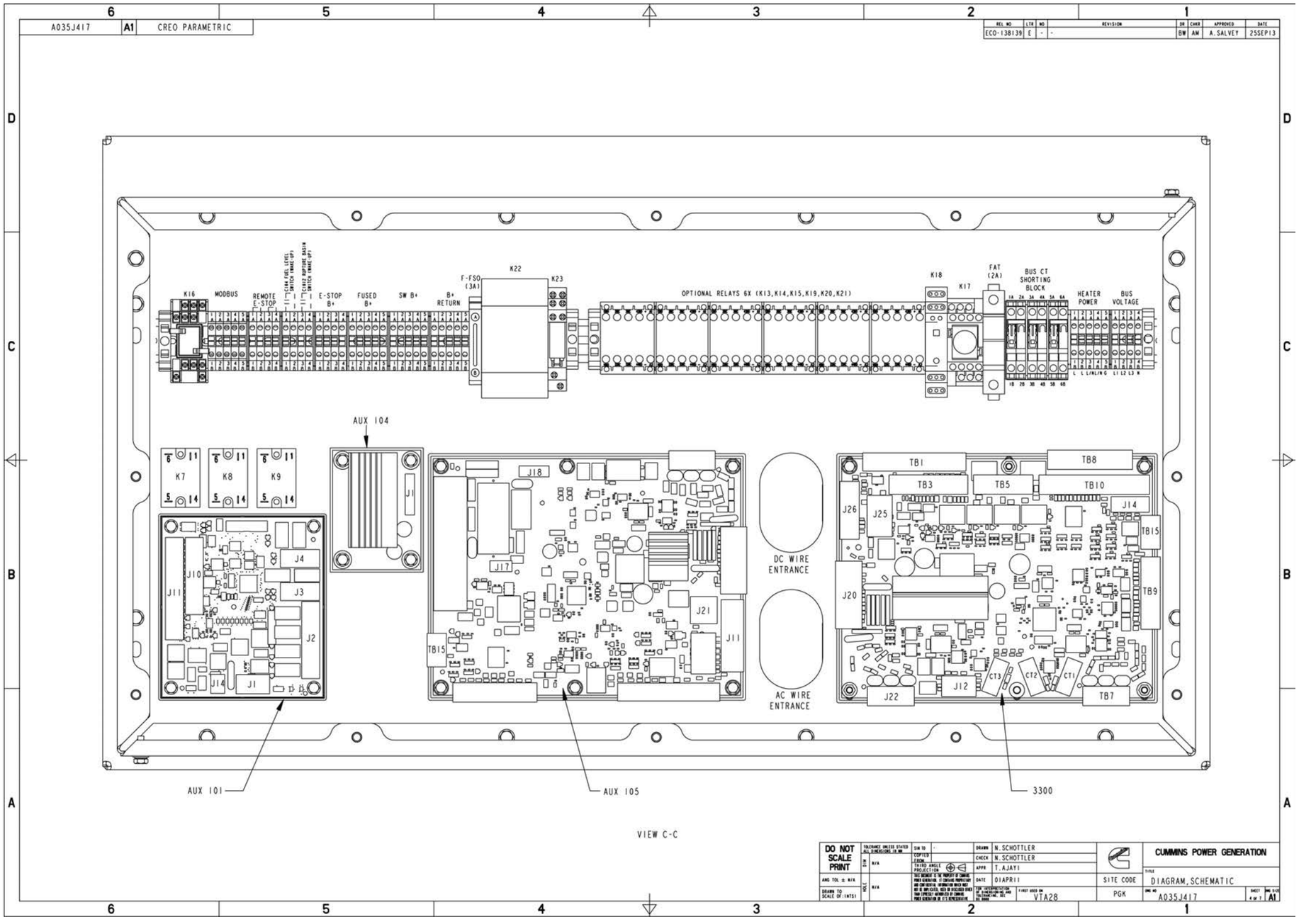

FIGURE 32. SHEET 4 OF 7

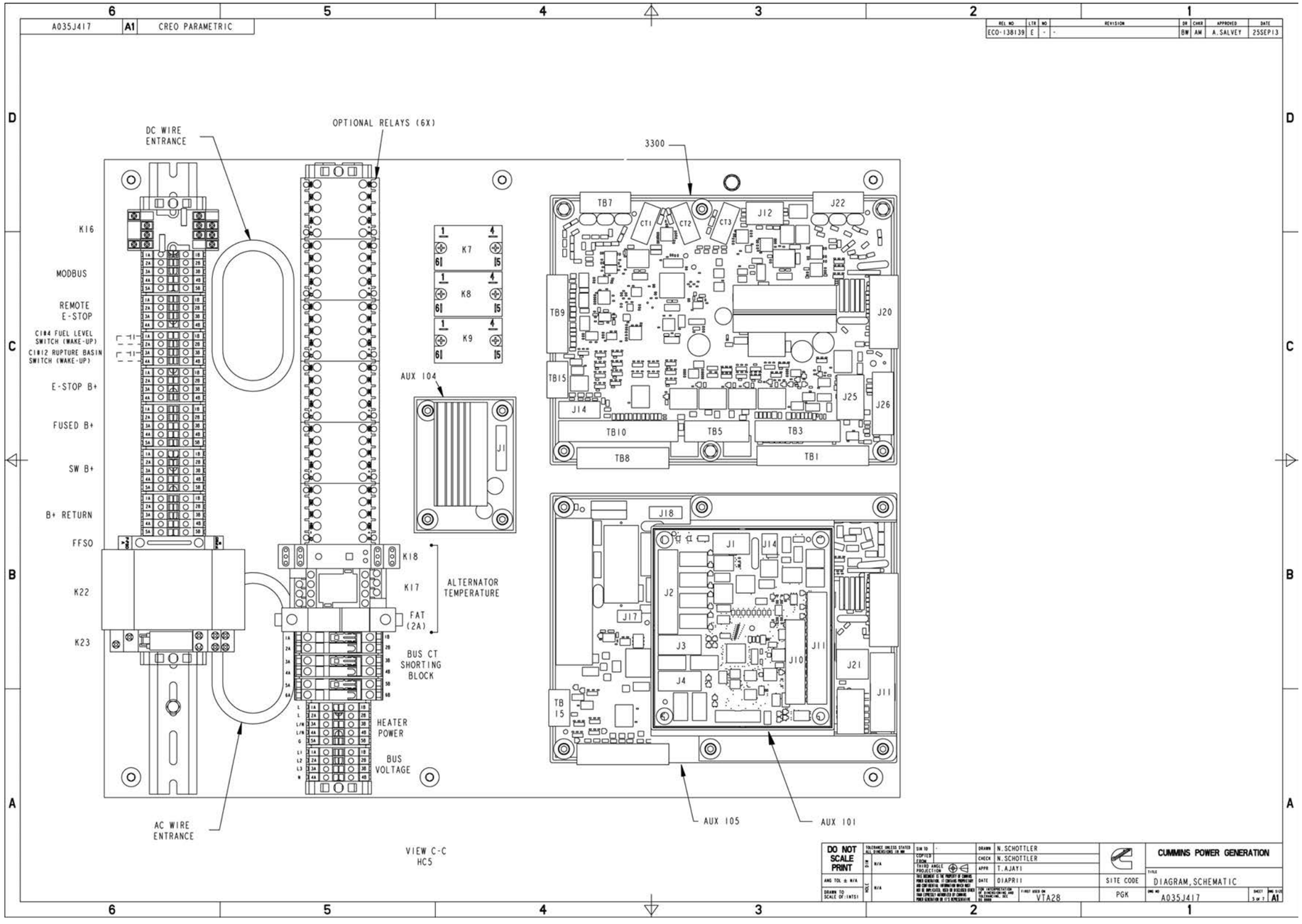

FIGURE 33. SHEET 5 OF 7

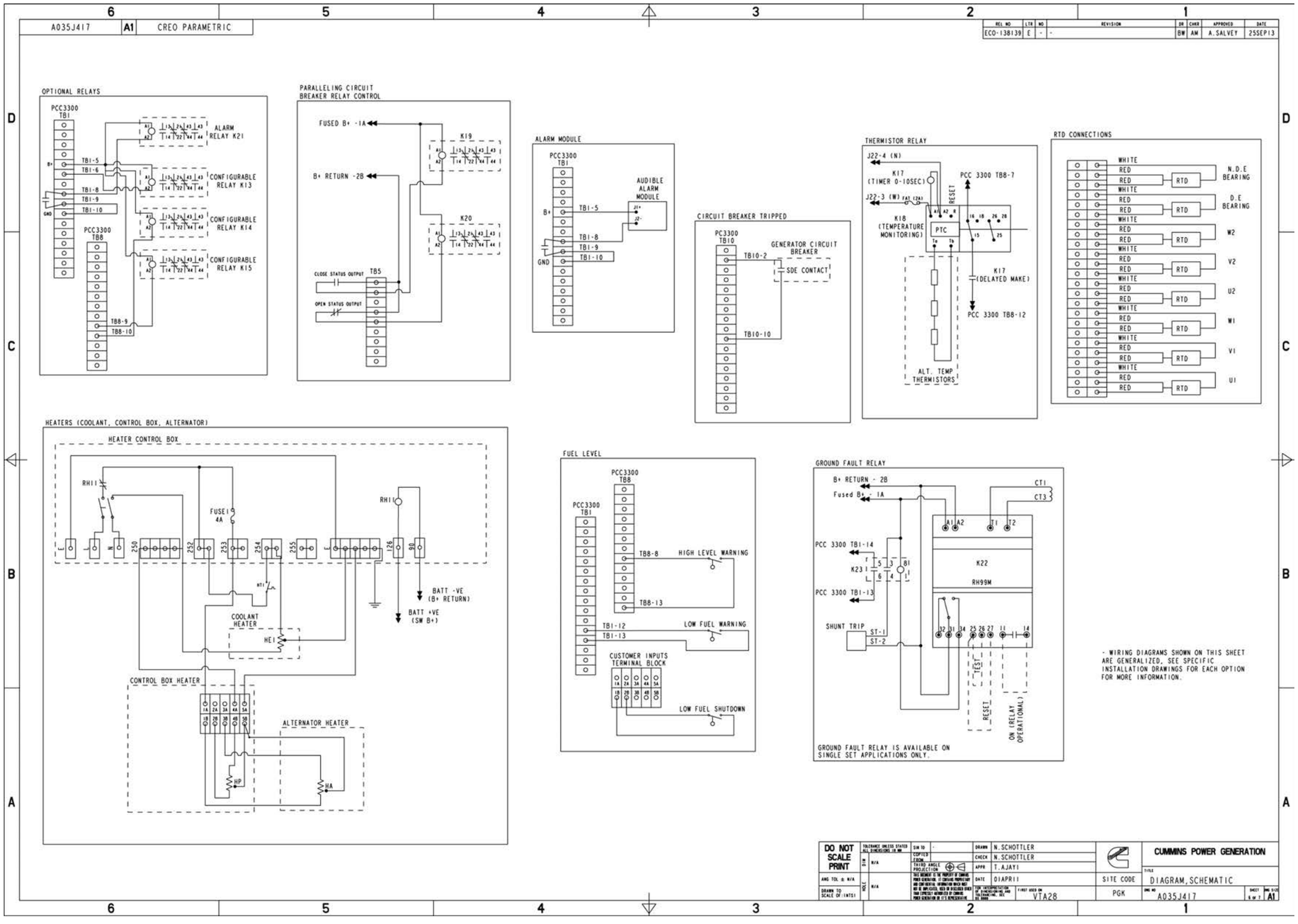

FIGURE 34. SHEET 6 OF 7

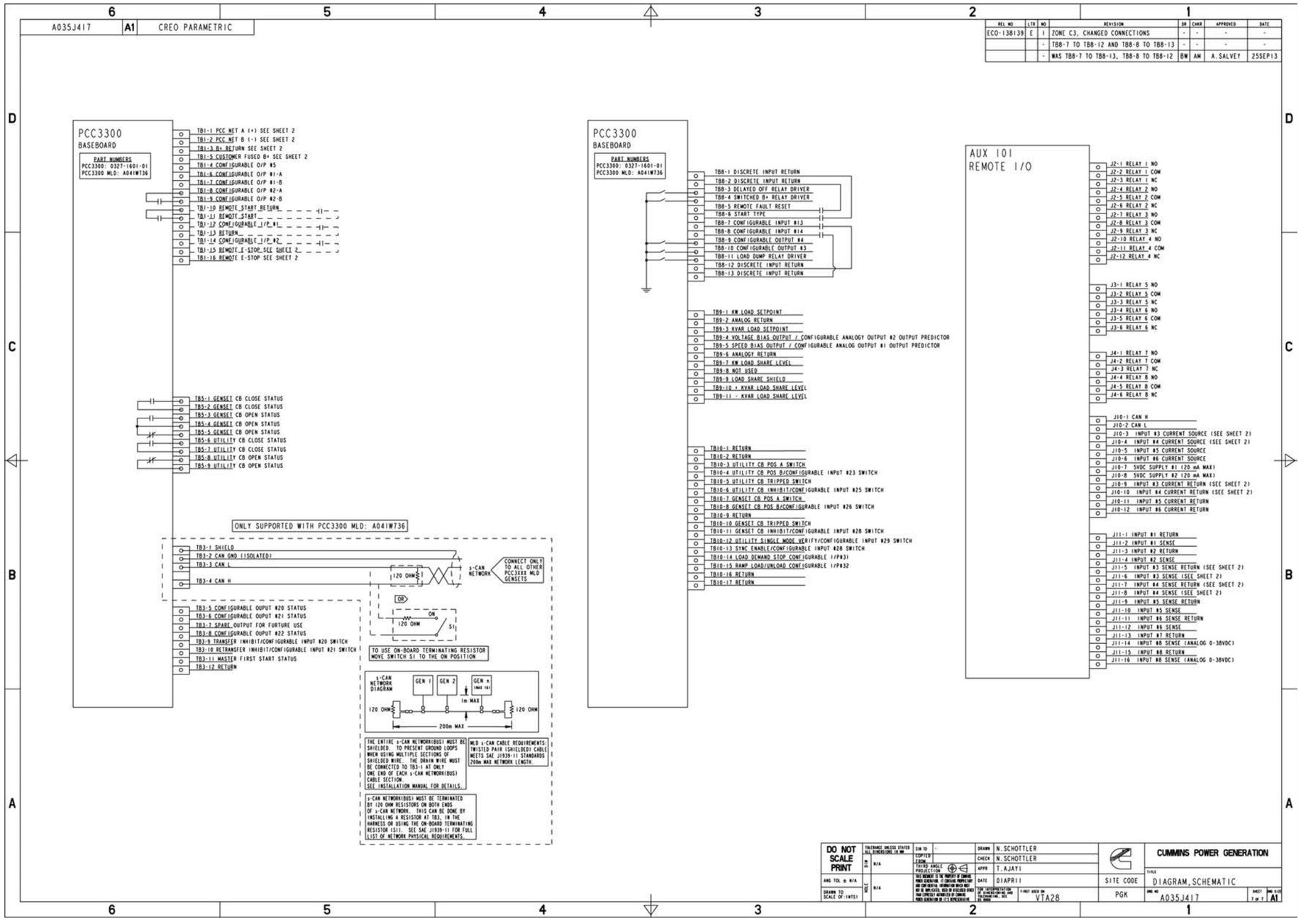

FIGURE 35. SHEET 7 OF 7

Appendix B. Alternator Reconnect Drawing

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.

B.1 XE7200 Reconnect

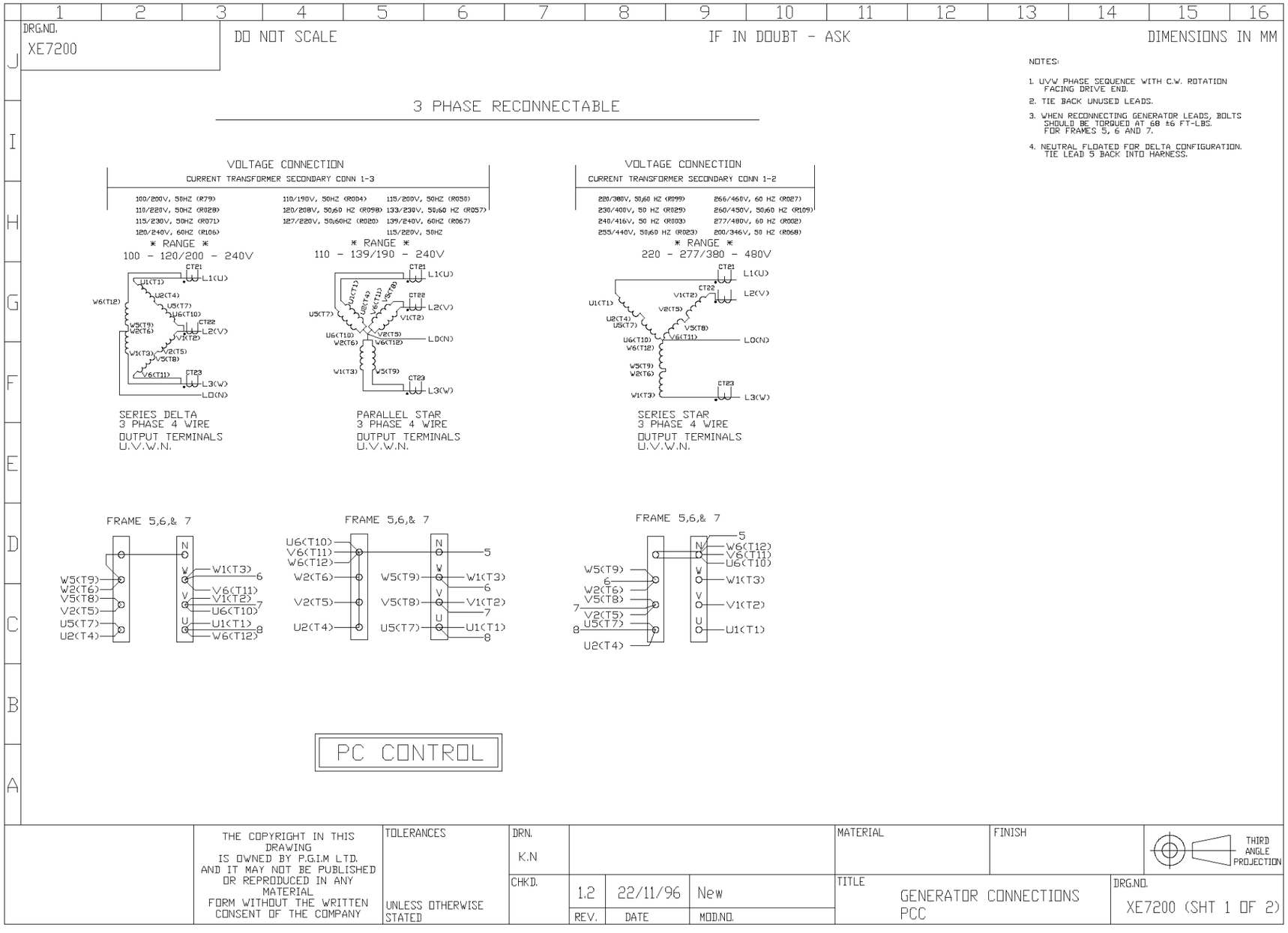

FIGURE 36. SHEET 1 OF 1

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Appendix C. Outline Drawings

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.

C.1 VTA28G5 Outline Drawing A041A446

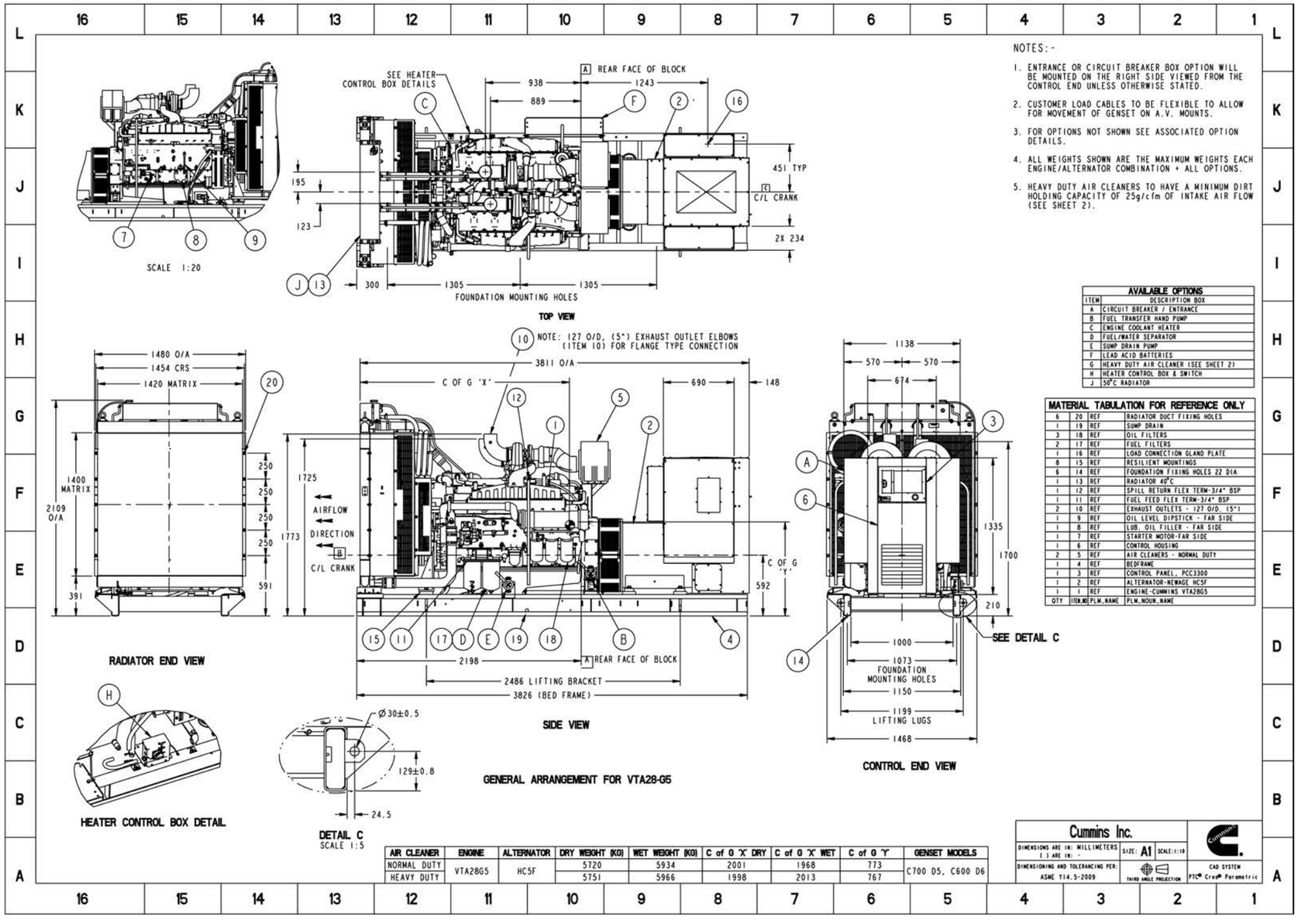


FIGURE 37. SHEET 1 OF 8

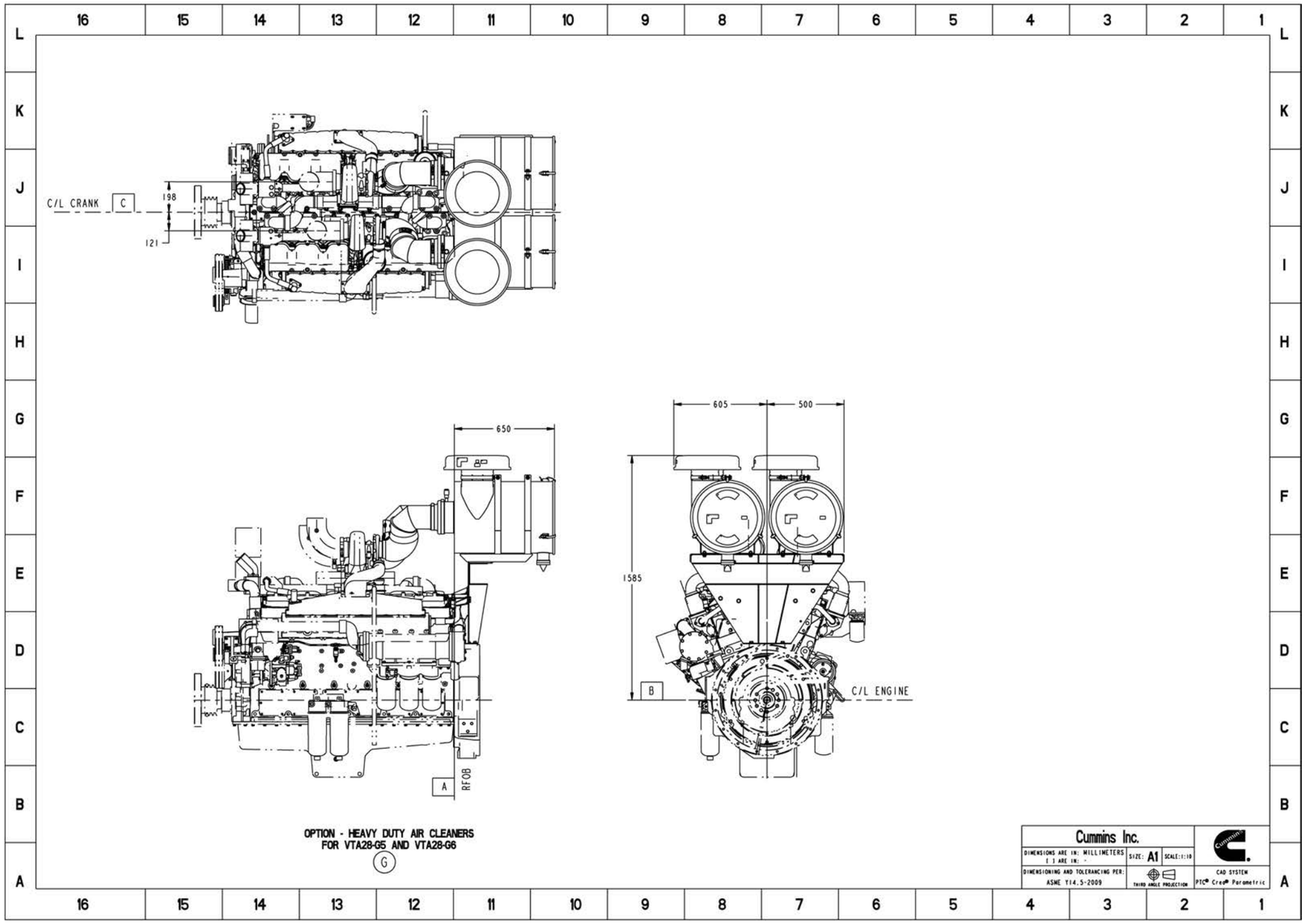


FIGURE 38. SHEET 2 OF 8

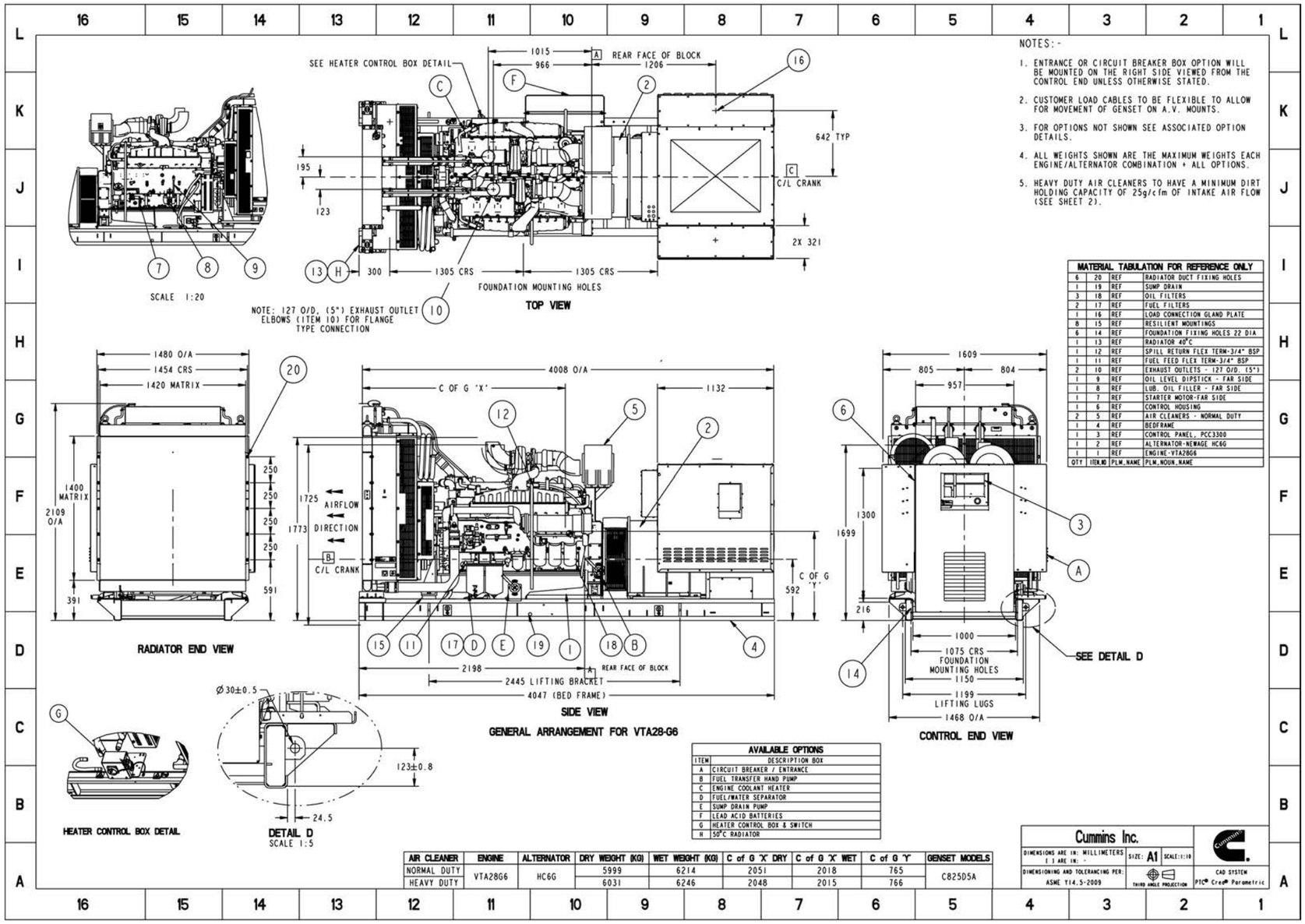
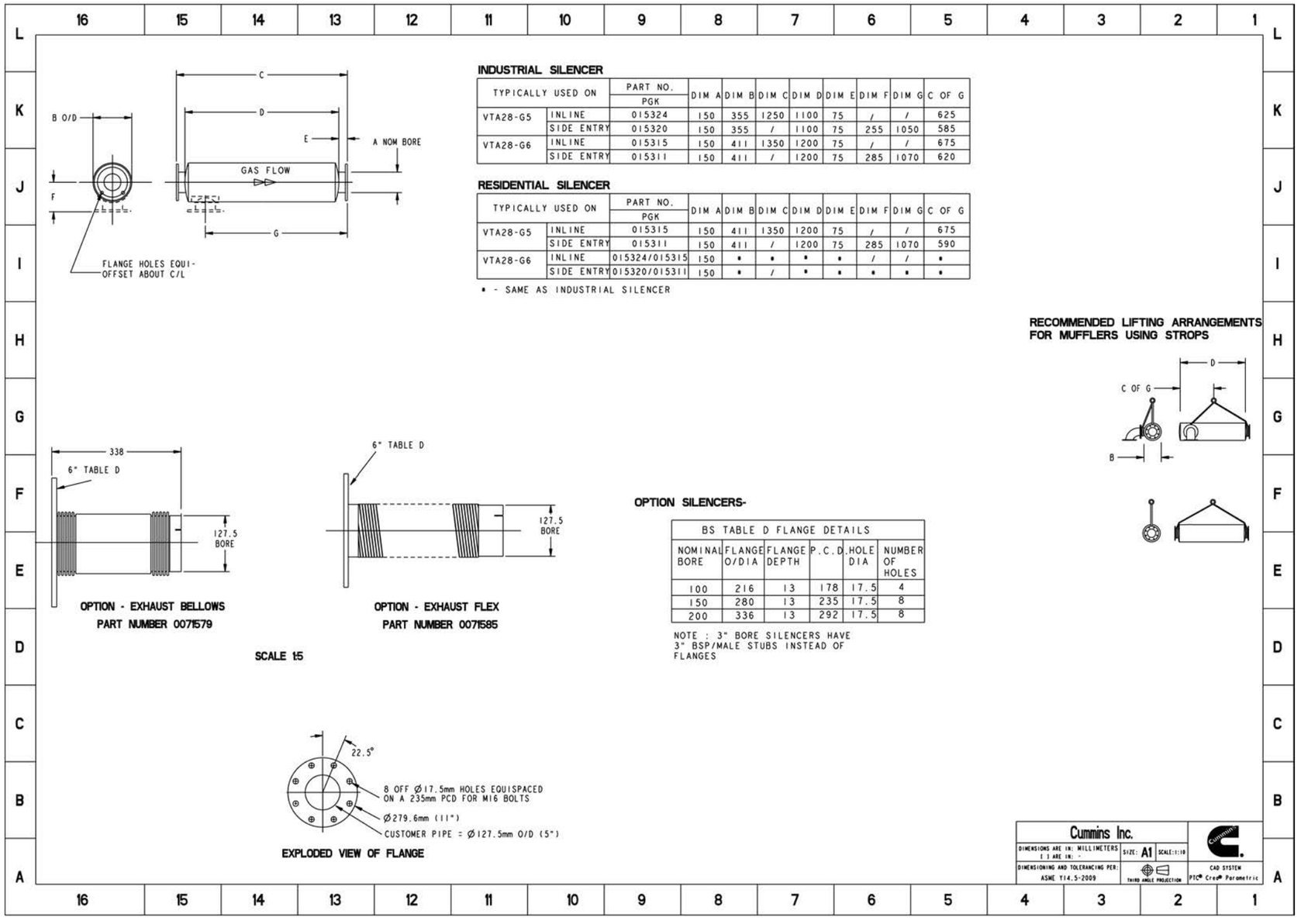


FIGURE 39. SHEET 3 OF 8



TYPICALLY USED ON		PART NO. PGK	DIM A	DIM B	DIM C	DIM D	DIM E	DIM F	DIM G	C OF G
VTA28-G5	INLINE	015324	150	355	1250	1100	75	/	/	625
	SIDE ENTRY	015320	150	355	/	1100	75	255	1050	585
VTA28-G6	INLINE	015315	150	411	1350	1200	75	/	/	675
	SIDE ENTRY	015311	150	411	/	1200	75	285	1070	620

TYPICALLY USED ON		PART NO. PGK	DIM A	DIM B	DIM C	DIM D	DIM E	DIM F	DIM G	C OF G
VTA28-G5	INLINE	015315	150	411	1350	1200	75	/	/	675
	SIDE ENTRY	015311	150	411	/	1200	75	285	1070	590
VTA28-G6	INLINE	015324/015315	150	*	*	*	*	/	/	*
	SIDE ENTRY	015320/015311	150	*	/	*	*	*	*	*

BS TABLE D FLANGE DETAILS					
NOMINAL BORE	FLANGE O/DIA	FLANGE DEPTH	P.C.D.	HOLE DIA	NUMBER OF HOLES
100	216	13	178	17.5	4
150	280	13	235	17.5	8
200	336	13	292	17.5	8

FIGURE 40. SHEET 4 OF 8

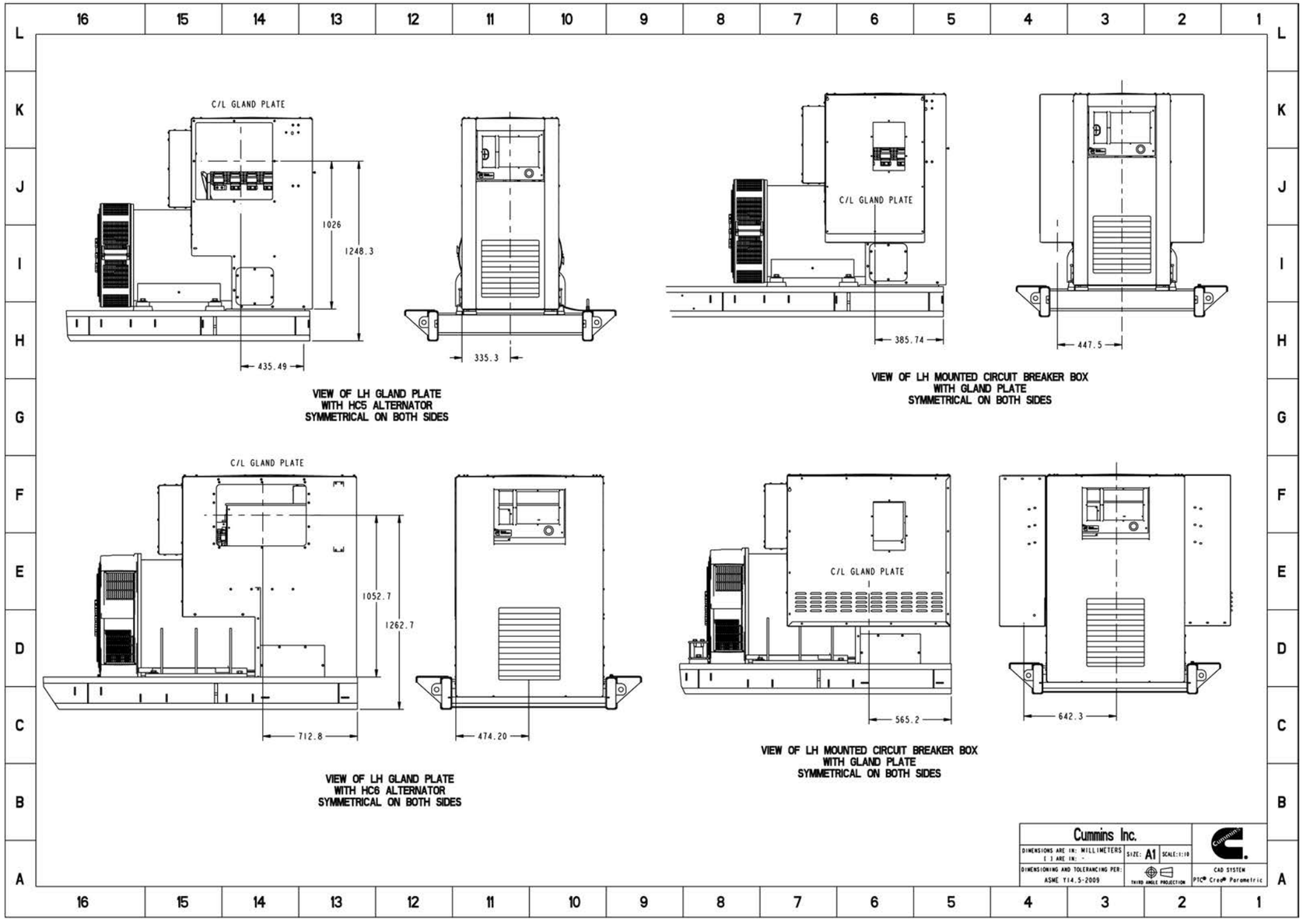


FIGURE 41. SHEET 5 OF 8

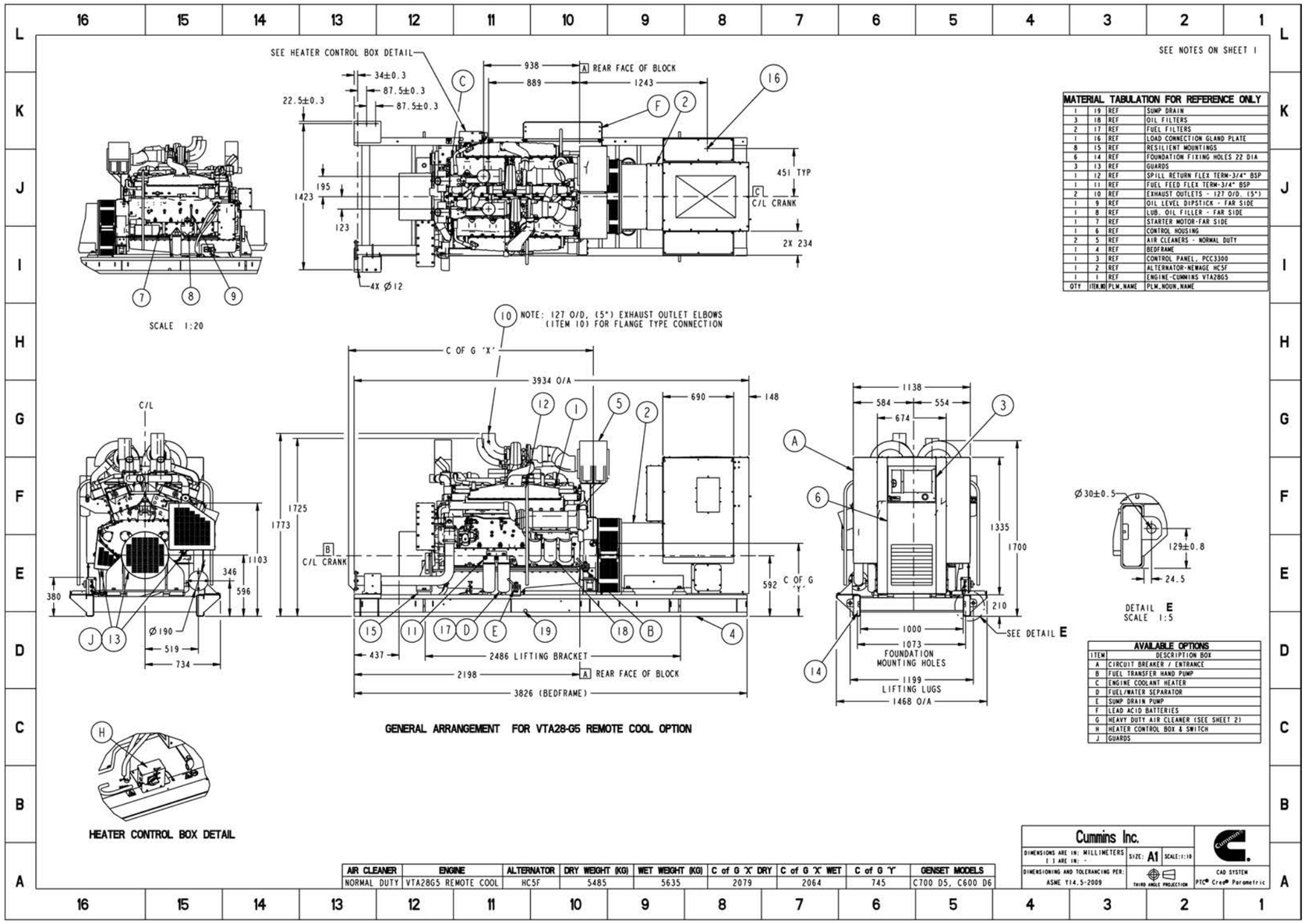


FIGURE 42. SHEET 6 OF 8

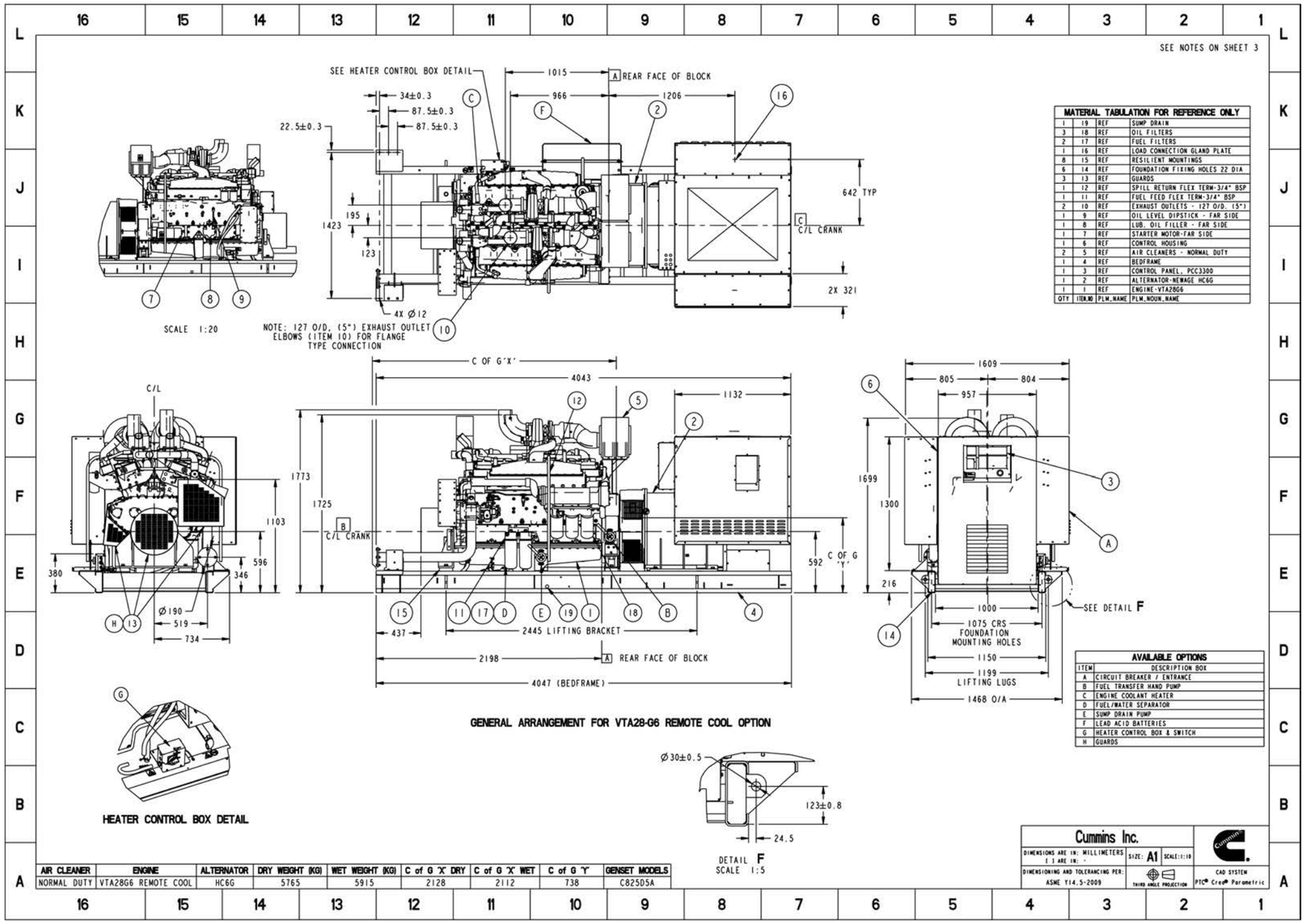


FIGURE 43. SHEET 7 OF 8

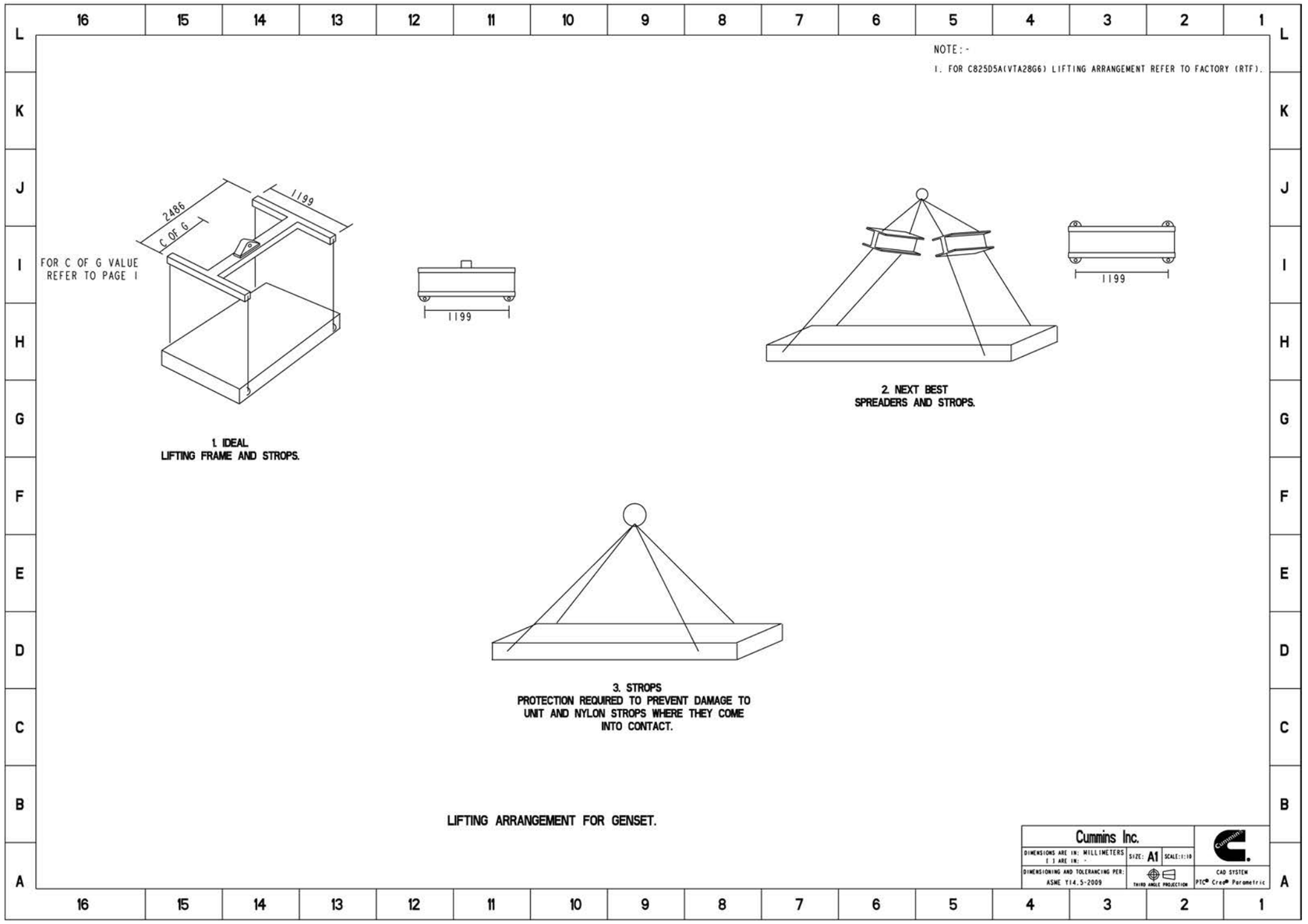


FIGURE 44. SHEET 8 OF 8

C.2 VTA28G6 Outline Drawing A045Z501

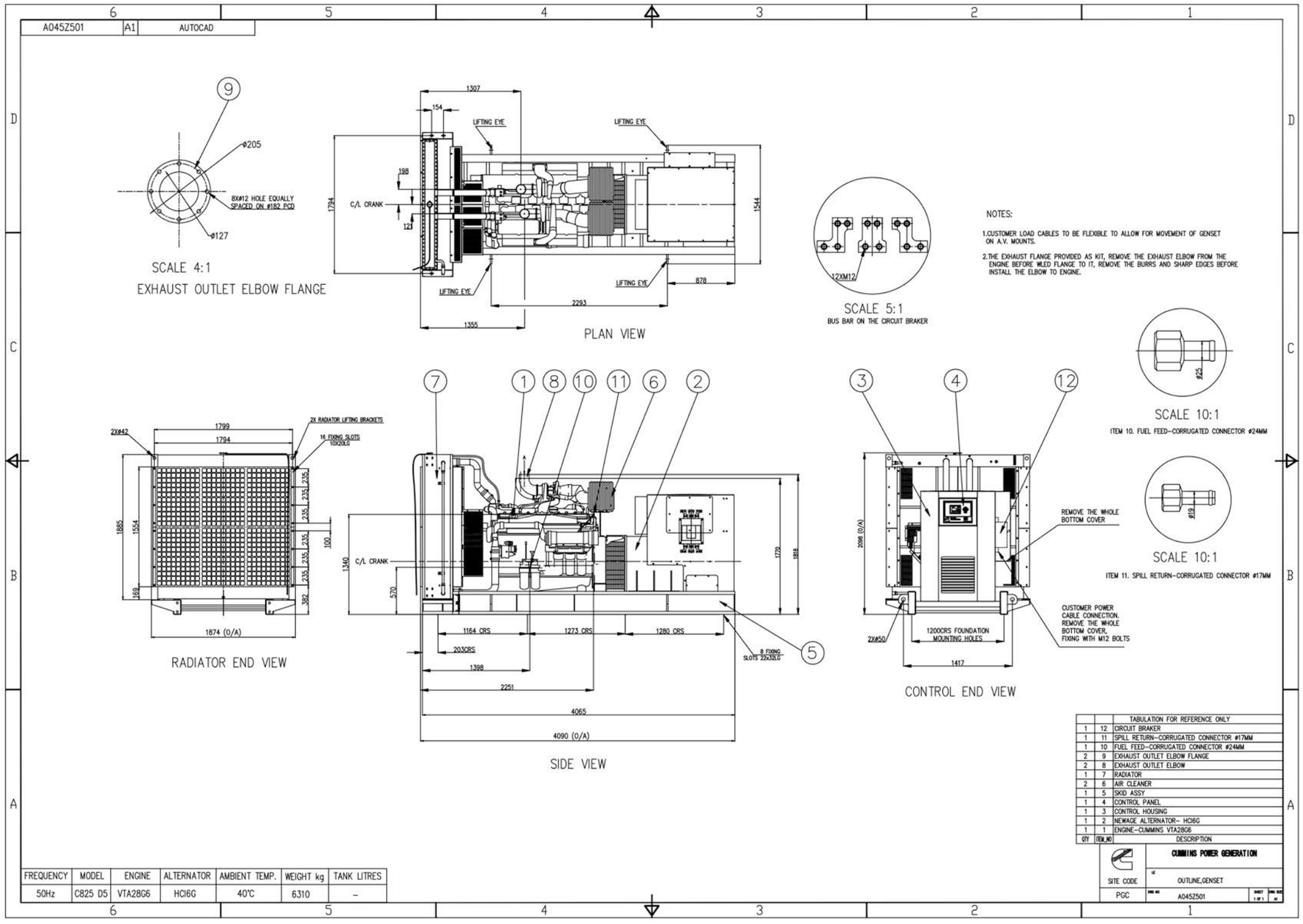


FIGURE 45. SHEET 1 OF 1

C.3 VTA28G5 Outline Drawing A045Z503

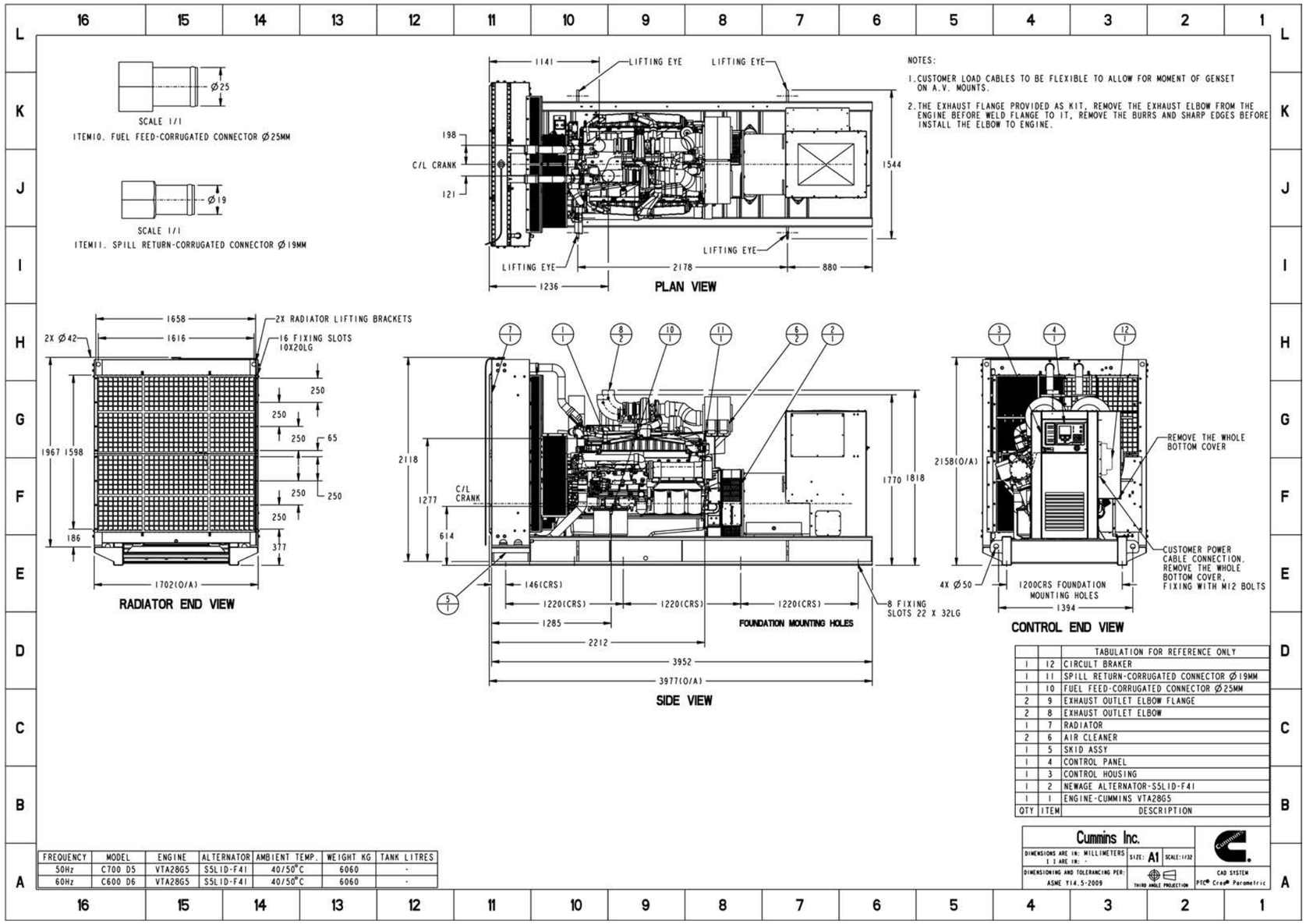


FIGURE 46. SHEET 1 OF 1

C.4 VTA28G6 Outline Drawing A074G716

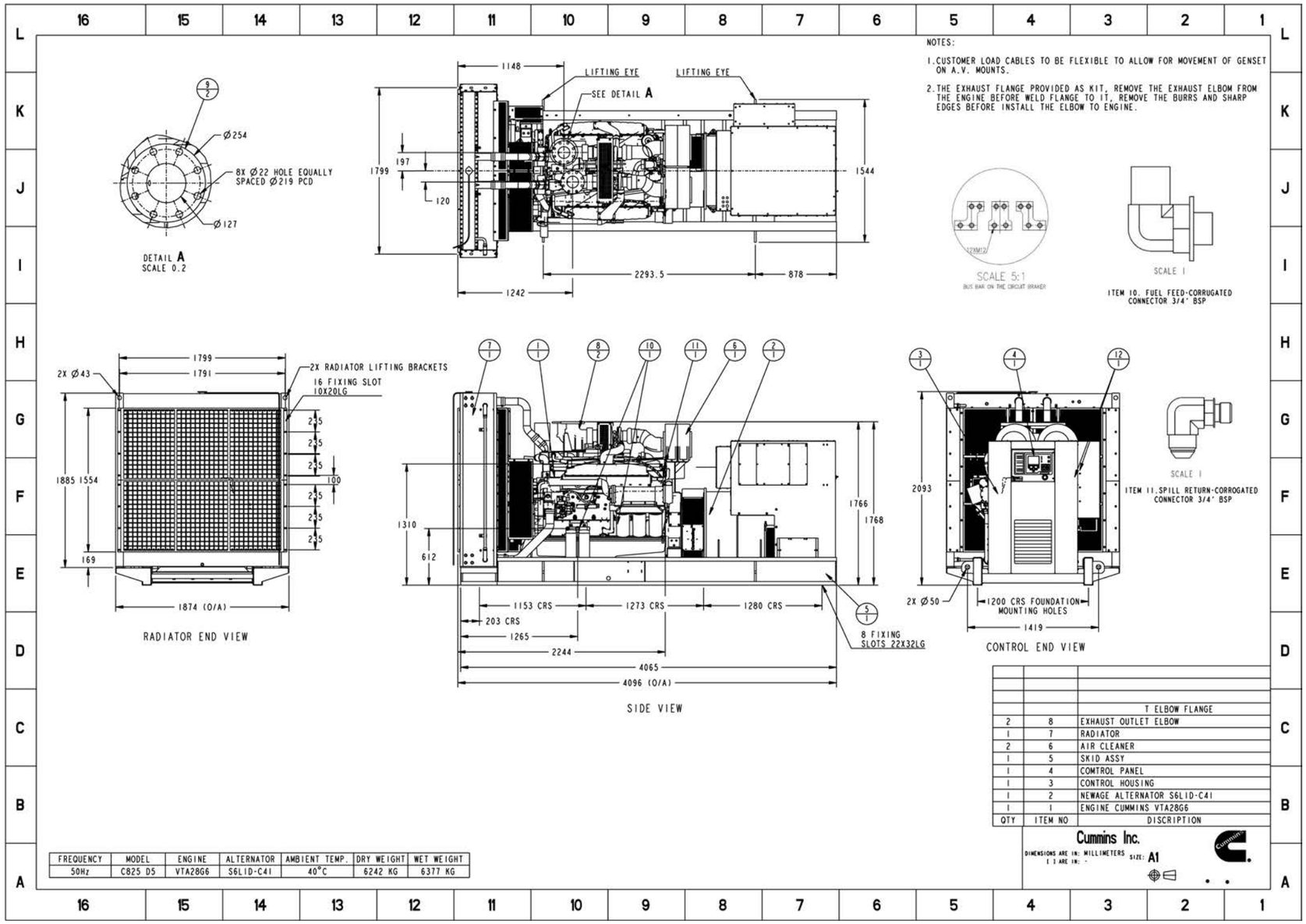


FIGURE 47. SHEET 1 OF 1

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