Writing Sample 1a and 1b

Overview

These two documents should be considered in tandem as they are a product of the most structured and regulated environments where I've been a technical writer. These documents were built using Arbortext and DocZone, respectively, widely considered among the more technologically complex authoring tools. While my pure writing skills are not the focus of this writing sample, most technical writers in large organizations understand that the field requires that the writer be well-versed in these complex authoring tools and methodologies.

In a virtual walkthrough, I'll be able to point out how XML is used to produce the PDF outputs. I was the lead writer on both projects, with each manual requiring extensive edits and updates. I'll be able to explain how chunks of text, tables, or images found within the published PDFs are held as individual files in an authoring library or content management system. Bookmaps were created from the library, pulling all of the XML file topics together to create the published manuals. As a technical writer, I was tasked with managing the required edits within the authoring environment, reusing topic files, creating new files as necessary, checking them out to make edits, checking them in to solidify the changes, and make them part of the ever-growing puzzle that is technical writing in the digital world.

I'll look to demonstrate my pure writing skills in my other submitted samples, but I think it's important to show the Google hiring team that I've used complex tools as a technical writer for multiple best-in-field organizations. Reviewers should also note that these manuals are written to meet very strict FDA and ISO requirements. Regulatory bodies are involved and considered in every bit of published content produced by the technical writers of these companies.

Writing Sample Considerations

1. How much of the content did you write? Choose one: Other (explain).
    a. If you wrote only portions of the document, tell us which portions you wrote.

As mentioned above, these projects were assigned to bring documentation in alignment with product updates. That said, as technical writer, I touched/edited every section of the manual including front and back covers, front matter, warnings and cautions, body text, tables, images, appendices, etc. As a whole, these documents represent a giant undertaking by the writer, who, in addition to the core responsibilities of technical information editing and publishing, must also navigate inputs from engineering groups, regulatory groups, and beyond.

2. Does the document represent your original writing, or is it existing content that you revised?

Both. When managing updates in an XML authoring environment topic reuse is prioritized. Any content from previous related manuals that was still true for the product being updated would be preserved in the new manual. However, any chunk of text that was held in its own XML file that required updating, the standard practice was to duplicate that file and rename it specifically for the project you were working on. Under this practice, I as the writer am leveraging existing content to write original, project-specific content.

3. Where did you get the information to write the document?

In the case of the Boston Scientific manual, our primary source of information would come directly from Engineering or may be delivered by a project manager in the form of a spreadsheet. Often the writer has to obtain the information on their own accord by searching organizational databases (Windchill, Matrix, etc.) to find the latest released design document or artwork. I also must consider packaging engineering and localization (translations) teams to learn where the product is sold and include appropriate regional labeling, such as the marks found on the back cover. Additionally, the documents are bound by different regulatory bodies, and must meet those requirements (CE marks, FDA, ISO). Staying on top of regulatory requirements was an ongoing duty of the Technical Writing team with information constantly being subject to changes or updates.

4. Was the document edited by other people for grammar and style? Choose one:
    a. ▸ Light editing. If so, who edited the document?

My answer to this question is that the documents would be scrutinized *heavily*, but hopefully edited lightly. By that I mean that we had layers of self-editing, followed by peer editing before a document was to be submitted to the publishing process through the content management system where it was reviewed by several organizational stakeholders who'd only sign-off and move the document forward if their own criteria were met. As Technical Writer, I'm representing myself and my department when I put something out for review, so I and my team go through painstaking review to catch any of our own errors before they reach eyes outside of our department. We had a variety of standard practices in place from traditional line editing and proofreading, PDF "redline" comparison tools, pre-reviews, peer reviews, etc.

5. Share how you obtained any code samples.

N/A

6. Was a company style guide used to write this document?

Yes. The structured authoring environment exists on top of a departmental template adhering to the specifications of a style guide. Typically, the Technical Communications department style guide would differ from the wider company style guide.

7. Provide any additional useful context for the sample, such as deadlines, achievements, etc. If you edited the content after it was published, what changes did you make and why?

All documentation projects had deadlines, usually associated with project milestones or "gates." Project management has been a big part of my technical writing experience and typically I've achieved success in my roles and have been trusted to lead both product updates as well as new product introductions.

8. Was this document part of a larger documentation set?
    a. ▸ If so, what was the larger documentation set and how much of it did you own?

Yes, in the example of the Cummins Power Generation manual, product updates would usually require edits to our three types of manuals, the Installation, Operation, and Service manuals. There was a different intended audience for each type of manual and we'd approach the writing differently for each end user.

Boston Scientific

PHYSICIAN'S LEAD MANUAL

RELIANCE 4–FRONT™

Pace/Sense and Defibrillation Lead

Integrated Bipolar DF4-LLHH and DF4-LLHO Connectors

Tined Fixation

Single Shock Coil with GORE™ Coating

REF 0654, 0682, 0683

Dual Shock Coils with GORE™ Coating

REF 0655, 0685, 0686

Single Shock Coil with Silicone In-Fill

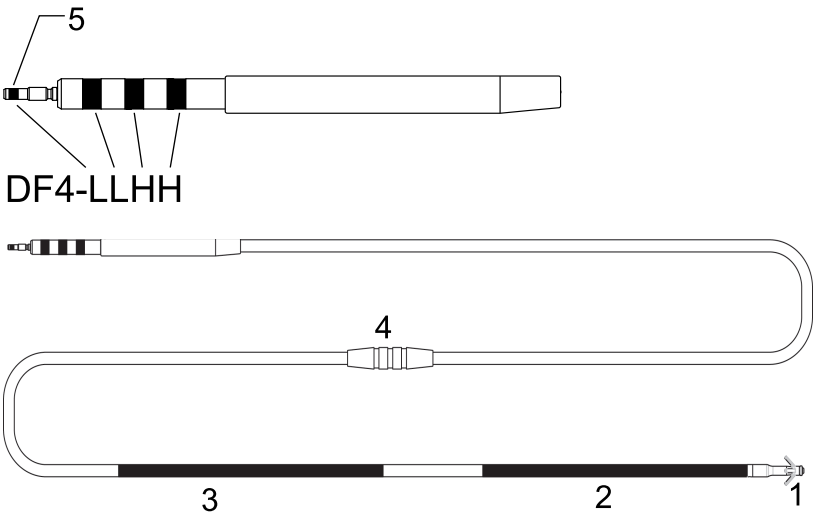
REF 0650, 0662, 0663

Dual Shock Coils with Silicone In-Fill

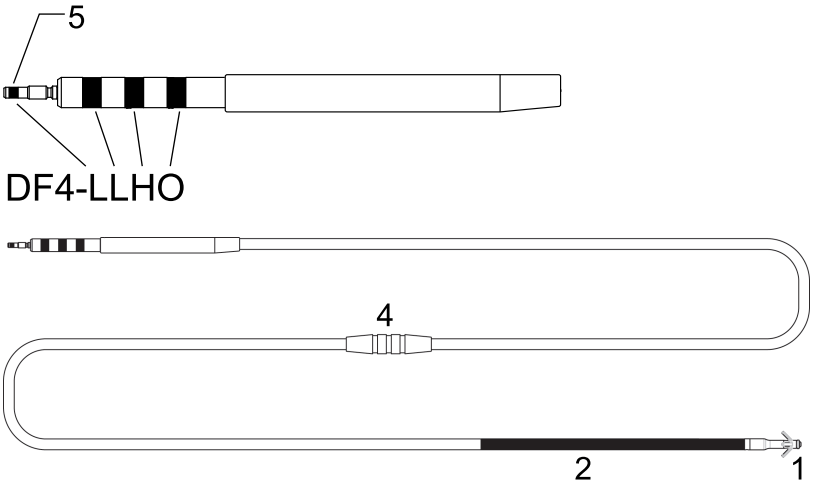
REF 0651, 0636, 0665

Table of Contents

DUAL COIL models, DF4–LLHH connector, Tined fixation



SINGLE COIL models, DF4–LLHO connector, Tined fixation



1. Distal steroid-eluting pace/sense electrode (cathode)
2. Proximal pace/sense coil (anode), distal defibrillating coil
3. Proximal defibrillating coil (dual coil models only)
4. Suture sleeve
5. Terminal pin insertion indicator

INFORMATION FOR USE

Device Description

The Boston Scientific Corporation RELIANCE 4-FRONT defibrillator lead is a 7.3 French (8F introducer), transvenous, steroid-eluting, integrated bipolar, DF-4 compatible lead intended for permanent sensing, pacing, and defibrillation when used with a compatible Implantable Cardioverter Defibrillator (ICD) or Cardiac Resynchronization Therapy Defibrillator (CRT-D). The RELIANCE 4-FRONT lead family offers active and passive fixation models, single and dual coil models, and silicone filled or GORE™ coated defibrillator coil models.

This lead family has the following characteristics:

- Endocardial cardioversion/defibrillation and pace/sense lead—intended for chronic delivery of cardioverting/defibrillating shocks, and bipolar pacing and sensing capabilities; implanted within the superior vena cava, right atrium, and right ventricle.
- 4-FRONT integrated bipolar connector—intended to be connected to a device with a DF4-LLHH port, which accepts either a DF4-LLHH or DF4-LLHO lead. It is configured with in-line contacts and labeled as DF4-LLHH or DF4-LLHO, described below:
  - DF4: indicates the lead contains high voltage contacts[1]
  - L: indicates a connection to a low-voltage pace/sense electrode; first L (terminal pin)—distal pace/sense electrode; second L (proximal ring contact)—proximal pace/sense electrode
  - H: indicates a connection to a high-voltage defibrillation electrode; first H (middle ring contact)—distal coil electrode; second H (distal ring contact)—proximal coil electrode (dual-coil models)
  - O: indicates an inactive distal ring contact (single-coil models)

  NOTE: *RELIANCE 4-FRONT leads with the DF4-LLHH/LLHO label are equivalent and are compatible with a device containing either a GDT-LLHH or DF4-LLHH port.*
- Tip electrode—serves as the cathode for intracardiac right ventricular pacing/sensing and uses an IROX coated electrode which may improve pacing performance. Lower and more consistent pacing thresholds may increase the pacing longevity of the pulse generator.
- Coil electrodes—the distal coil electrode and the proximal coil electrode (for dual-coil models) serve as the anode and cathode during cardioversion/defibrillation shocks. The distal coil also serves as the anode for pacing and sensing.
- GORE™ expanded polytetrafluoroethylene (ePTFE)-covered coils[2] —the ePTFE covering prevents tissue ingrowth around and between the coil filars.

1. DF4 refers to the international standard ISO 27186:2010.
2. GORE is a trademark of W.L. Gore and Associates.

- IROX-coated tip electrode—the tip electrode is coated with IROX (iridium oxide) to increase the microscopic surface area.
- Steroid-eluting—upon exposure to body fluids, the steroid elutes from the lead to help reduce tissue inflammation response at the distal electrode. The steroid suppresses the inflammatory response believed to cause threshold rises typically associated with implanted pacing electrodes. Lower thresholds are desirable because they can increase pacing safety margins and reduce pacing energy requirements, potentially increasing pulse generator longevity. The nominal dose and structure of the steroid are listed in the specifications (Table 5 Specifications (Nominal) on page 29).
- Radiopaque suture sleeve—the radiopaque suture sleeve is visible under fluoroscopy and is used to secure, immobilize, and protect the lead at the venous entry site after lead placement. The window feature is designed to aid compression of the sleeve onto the lead during suturing.
- Tined—silicone rubber tines located proximal to the distal pacing electrode provide fixation to the wall of the heart.
- Lead body—the isodiametric lead body contains one conductor for pacing/sensing. Dual-coil models have two conductors for defibrillation and single-coil models have one conductor for defibrillation. The lead conductors are coated and insulated in separate lumens within the silicone rubber lead body. A second layer of silicone covers the lead body to provide additional insulation and a uniform body diameter. A layer of polyurethane covers the proximal area of the lead body to provide additional abrasion protection in the implantation pocket. The suture sleeve and terminal boot molding are fabricated from molded silicone rubber.
- Lubricious coating—the lead has a proprietary coating that makes the surface more lubricious. This reduces both the static and dynamic coefficients of friction, and makes the lead feel and handle like polyurethane while providing the reliability of silicone.
- Stylet delivery method—the design consists of an open-lumen conductor coil to enable lead delivery using a stylet. Refer to the stylet information ("Stylets" on page 12).

Related Information

Instructions in the lead manual should be used in conjunction with other resource material, including the applicable pulse generator physician's manual and instructions for use on any implant accessories or tools.

For additional reference information, go to www.bostonscientific-elabeling.com.

INTENDED AUDIENCE

This literature is intended for use by professionals trained or experienced in device implant and/or follow-up procedures.

Indications and Usage

This Boston Scientific lead is indicated for use as follows:

- Intended for pacing, rate-sensing, and delivery of cardioversion and defibrillation shocks when used with a compatible pulse generator

Contraindications

Use of this Boston Scientific lead is contraindicated for the following patients:

- Patients who have a unipolar pacemaker
- Patients with a hypersensitivity to a maximum single dose of 1.1 mg dexamethasone acetate
- Patients with mechanical tricuspid heart valves

WARNINGS

General

- **Labeling knowledge.** Read this manual thoroughly before implantation to avoid damage to the pulse generator and/or lead. Such damage can result in patient injury or death.
- **For single patient use only.** Do not reuse, reprocess, or resterilize. Reuse, reprocessing, or resterilization may compromise the structural integrity of the device and/or lead to device failure which, in turn, may result in patient injury, illness, or death. Reuse, reprocessing, or resterilization may also create a risk of contamination of the device and/or cause patient infection or cross-infection, including, but not limited to, the transmission of infectious disease(s) from one patient to another. Contamination of the device may lead to injury, illness, or death of the patient.
- **Backup defibrillation protection.** Always have external defibrillation equipment available during implant and electrophysiologic testing. If not terminated in a timely fashion, an induced ventricular tachyarrhythmia can result in the patient's death.
- **External-source rescue shocks.** Do not use any component of the lead system to assist in delivery of external-source rescue shocks or extensive tissue damage could occur.
- **Resuscitation availability.** Ensure that an external defibrillator and medical personnel skilled in CPR are present during post-implant device testing should the patient require external rescue.
- **Lead fracture.** Lead fracture, dislodgment, abrasion, or an incomplete connection can cause a periodic or continual loss of pacing or sensing or both.

  This could possibly result in arrhythmia nondetection, oversensing of rate, inappropriate delivery of a pulse generator shock, or inadequate delivery of converting energy.

Handling

- **Excessive flexing.** Although pliable, the lead is not designed to tolerate excessive flexing, bending, or tension. This could cause structural weakness, conductor discontinuity, and/or lead dislodgment.
- **Do not kink leads.** Do not kink, twist, or braid the lead with other leads as doing so could cause lead insulation abrasion damage or conductor damage.
- **Handling the lead without Connector Tool.** Use caution handling the lead terminal when the Connector Tool is not present on the lead. Do not directly contact the lead terminal with any surgical instruments or electrical connections such as PSA (alligator) clips, ECG connections, forceps, hemostats, and clamps. This could damage the lead terminal, possibly compromising the sealing integrity and result in loss of therapy or inappropriate therapy.
- **Handling the terminal while tunneling.** Do not contact any other portion of the lead terminal, other than the terminal pin, even when the lead cap is in place.

Implant Related

- **Separate defibrillation electrode.** In order to deliver defibrillation therapy, the single-coil models must be implanted with an additional defibrillation electrode. It is recommended to use the pectorally implanted defibrillator pulse generator that uses the metallic housing as a defibrillation electrode.
- **Only use Connector Tool for electrical connections.** For DF4-LLHH or DF4-LLHO leads, only use the Connector Tool for electrical connections to pacing system analyzers or similar monitors. Do not attach alligator clips directly to the lead terminal or damage could occur.
- **Obtain appropriate electrode position.** Take care to obtain appropriate electrode position. Failure to do so may result in higher defibrillation thresholds or may render the lead unable to defibrillate a patient whose tachyarrhythmia(s) might otherwise be convertible by a pulse generator system.
- **Proper connections.** When connecting the lead to the pulse generator, it is very important that proper connections are made. The terminal pin must be inserted beyond the setscrew block to enable a proper connection. Visualization of the terminal pin insertion indicator beyond the setscrew block may be used to confirm that the terminal pin is fully inserted into the pulse generator port. Evaluation of the electrical performance of the lead after connection to the pulse generator is the final confirmation of full insertion. An improper connection could result in loss of therapy or inappropriate therapy.

Post-Implant

- **Diathermy.** Do not subject a patient with an implanted pulse generator and/or lead to diathermy since diathermy may cause fibrillation, burning of the myocardium, and irreversible damage to the pulse generator because of induced currents.

PRECAUTIONS

Clinical Considerations

- **Dexamethasone acetate.** It has not been determined whether the warnings, precautions, or complications usually associated with injectable dexamethasone acetate apply to the use of a low concentration, highly localized, controlled-release device. Refer to the Physicians' Desk Reference™ [3] for a listing of potentially adverse effects.

Sterilization and Storage

- **If package is damaged.** The blister trays and contents are sterilized with ethylene oxide gas before final packaging. When the pulse generator and/or lead is received, it is sterile provided the container is intact. If the packaging is wet, punctured, opened, or otherwise damaged, return the pulse generator and/or lead to Boston Scientific.
- **Storage temperature.** Store at 25°C (77°F). Excursions are permitted between 15°C to 30°C (59°F to 86°F). Transportation spikes are permitted up to 50°C (122°F).
- **Use by date.** Implant the pulse generator and/or lead before or on the USE BY date on the package label because this date reflects a validated shelf life. For example, if the date is January 1, do not implant on or after January 2.

Handling

- **Do not immerse in fluid.** Do not wipe or immerse the tip electrode in fluid. Such treatment will reduce the amount of steroid available when the lead is implanted.
- **Chronic repositioning.** Optimum threshold performance might not be achieved if the lead is chronically repositioned because the steroid can be depleted.
- **Protect from surface contamination.** The lead uses silicone rubber which can attract particulate matter, and therefore, must always be protected from surface contamination.
- **Lubricants.** Do not apply oil-based lubricants to the ePTFE-covered shocking coils or it may affect electrical performance.
- **No mineral oil on lead tip.** Mineral oil should never come in contact with the lead tip electrode. Mineral oil on the tip may inhibit tissue ingrowth and conduction.
- **Ensure suture sleeve position.** Ensure the suture sleeve remains proximal to the venous entry site and near the terminal boot molding throughout the procedure until it is time to secure the lead.

3. Physicians' Desk Reference is a trademark of Thomson Healthcare Inc.

Implantation

- **Evaluate patient for surgery.** There may be additional factors regarding the patient's overall health and medical condition that, while not related to device function or purpose, could render the patient a poor candidate for implantation of this system. Cardiac health advocacy groups may have published guidelines that may be helpful in conducting this evaluation.
- **Lead compatibility.** Prior to implantation, confirm the lead-to-pulse generator compatibility. Using incompatible leads and pulse generators can damage the connector and/or result in potential adverse consequences, such as undersensing of cardiac activity or failure to deliver necessary therapy.
- **Line-powered equipment.** Exercise extreme caution if testing leads using line-powered equipment because leakage current exceeding 10 µA can induce ventricular fibrillation. Ensure that any line-powered equipment is within specifications.
- **Do not bend the lead near the lead-header interface.** Insert the lead terminal straight into the lead port. Do not bend the lead near the lead-header interface. Improper insertion can cause insulation or connector damage.
- **Vein pick.** The vein pick is not intended either for puncturing the vein or for dissecting tissue during a cutdown procedure. Be sure that the vein pick does not puncture the insulation of the lead. This could prevent proper lead function.
- **Do not bend lead with stylet in place.** Do not bend the lead with a stylet in place. Bending the lead could damage the conductor and insulation material.
- **Tools applied to distal end.** Do not apply tools to the distal end of the lead because lead damage could occur. Avoid holding or handling the distal tip of the lead.
- **Curving the stylet.** Do not use a sharp object to curve the distal end of a stylet. Do not curve a stylet while it is in the lead. If a curved stylet is preferred, gently curve a straight stylet before inserting it into the lead to avoid damage to the stylet and lead.
- **Do not implant lead under clavicle.** When attempting to implant the lead via a subclavian puncture, do not introduce the lead under the medial one-third region of the clavicle. Damage or chronic dislodgment to the lead is possible if the lead is implanted in this manner. If implantation via the subclavian vein is desired, the lead must enter the subclavian vein near the lateral border of the first rib to avoid entrapment by the subclavius muscle or ligamentous structures associated with the narrow costoclavicular region. It has been established in the literature that lead fracture can be caused by lead entrapment in such soft tissue structures

as the subclavius muscle, costocoracoid ligament, or the costoclavicular ligament.[4]

- **Electrode distance from pacemaker.** For patients with bipolar cardiac pacemakers, the lead pace/sense electrode (the tip electrode and distal coil electrode) should be placed as far as possible from the pacemaker electrodes to avoid cross-sensing between the defibrillator pulse generator and the pacemaker.
- **Lead dislodgment.** Should dislodgment occur, immediate medical care is required to resolve the electrode position and minimize endocardial trauma.
- **Compatible delivery tools.** Only use compatible delivery tools to deliver the lead because using incompatible delivery tools may cause lead damage or patient injury.
- **Inaccurate rate counting.** R-wave amplitudes of less than the recommended value can cause inaccurate rate counting in the chronic state, possibly resulting in failure to sense a tachyarrhythmia or misdiagnosis of a normal rhythm as abnormal. Signal durations that exceed the programmed refractory period of the pulse generator can cause inaccurate rate sensing which may cause inappropriate behavior.
- **Avoid tight stricture.** When ligating the vein, avoid stricture that is too tight. A tight stricture might damage the insulation or sever the vein. Avoid dislodging the distal tip during the anchoring procedure.
- **Do not suture directly over lead.** Do not suture directly over the lead body, as this may cause structural damage. Use the suture sleeve to secure the lead proximal to the venous entry site to prevent lead movement.
- **Use caution to remove suture sleeve.** Avoid removing or cutting the suture sleeve from the lead. If removal of the suture sleeve is necessary, use caution as lead damage can occur.
- **Use of multiple suture sleeves has not been evaluated.** Use of multiple suture sleeves has not been evaluated and is not recommended.
- **Tunnel the lead.** Tunnel the lead from the chest area to the pulse generator implant site. Do not tunnel the lead from the pulse generator implant site to the chest area because this can damage the electrodes or lead body or both by permanently stretching the lead.
- **Excessive tension on lead.** When tunneling the lead, take precautions not to place excessive tension on the lead. This can cause either structural weakness and/or conductor discontinuity.
- **Re-evaluate the lead after tunneling.** After tunneling, re-evaluate the lead to verify that no significant change in signals or damage to the lead has occurred during the tunneling procedure. Reattach the Connector Tool and repeat the steps in Evaluating Lead Performance.

4. Magney JE, et al. Anatomical mechanisms explaining damage to pacemaker leads, defibrillator leads, and failure of central venous catheters adjacent to the sternoclavicular joint. PACE. 1993;16:445–457.

Hospital and Medical Environments

- **Electrocautery.** Electrocautery may induce ventricular arrhythmias and/or fibrillation, and may cause asynchronous pacing, inhibited pacing, inappropriate shocks, and/or a reduction in pulse generator pacing output possibly leading to loss of capture.

  If electrocautery is medically necessary, observe the following to minimize risk to the lead. Also, refer to pulse generator labeling for device programming recommendations and additional information about minimizing risk to the patient and system.

  - Avoid direct contact between the electrocautery equipment and the pulse generator or leads.
  - Keep the path of the electrical current as far away as possible from the pulse generator and leads.
  - If electrocautery is performed on tissue near the device or leads, monitor pre- and post- measurements for sensing and pacing thresholds and impedances to determine the integrity and stability of the system.
  - Use short, intermittent, and irregular bursts at the lowest feasible energy levels.
  - Use a bipolar electrocautery system where possible.

- **Radio frequency (RF) ablation.** RF ablation may induce ventricular arrhythmias and/or fibrillation, and may cause asynchronous pacing, inhibition of pacing, inappropriate shocks, and/or a reduction in pulse generator pacing output possibly leading to loss of capture. RF ablation may also cause ventricular pacing up to the Maximum Tracking Rate (MTR) and/or changes in pacing thresholds. Additionally, exercise caution when performing any other type of cardiac ablation procedure in patients with implanted devices.

  If RF ablation is medically necessary, observe the following to minimize risk to the lead. Also, refer to pulse generator labeling for device programming recommendations and additional information about minimizing risk to the patient and system.

  - Avoid direct contact between the ablation catheter and the pulse generator and leads. RF ablation close to the lead electrode may damage the lead-tissue interface.
  - Keep the path of the electrical current as far away as possible from the pulse generator and leads.
  - If RF ablation is performed on tissue near the device or leads, monitor pre- and post-measurements for sensing and pacing thresholds and impedances to determine the integrity and stability of the system.

- **Central line guidewire insertion.** Use caution when inserting guidewires for placement of other types of central venous catheter systems such as PIC lines or Hickman catheters in locations where pulse generator leads may be encountered. Insertion of such guidewires into veins containing leads could result in the leads being damaged or dislodged.

Follow-up Testing

- **Unsuccessful conversion testing.** Following an unsuccessful high-energy shock, miscounting of cardiac rate, delayed detection, or nondetection due to low amplitude VF signals, it may be necessary to reposition the lead.
- **Lead performance in chronic state.** For some patients, lead performance at implant may not predict performance in the chronic state. Therefore, it is strongly recommended that post-implant follow-up EP testing be performed should any change occur in lead performance. This testing should include at least one arrhythmia induction/conversion test of ventricular fibrillation.

Potential Adverse Events

Based on the literature and on pulse generator and/or lead implant experience, the following list includes the possible adverse events associated with implantation of products described in this literature:

- Air embolism
- Allergic reaction
- Arterial damage with subsequent stenosis
- Bleeding
- Bradycardia
- Breakage/failure of the implant instruments
- Cardiac perforation
- Cardiac tamponade
- Chronic nerve damage
- Component failure
- Conductor coil fracture
- Death
- Electrolyte imbalance/dehydration
- Elevated thresholds
- Erosion
- Excessive fibrotic tissue growth
- Extracardiac stimulation (muscle/nerve stimulation)
- Fluid accumulation
- Foreign body rejection phenomena
- Formation of hematomas or seromas
- Heart block
- Hemorrhage
- Hemothorax
- Inability to defibrillate or pace

- Inappropriate therapy (e.g., shocks and antitachycardia pacing [ATP] where applicable, pacing)
- Incisional pain
- Incomplete lead connection with pulse generator
- Infection including endocarditis
- Lead dislodgment
- Lead fracture
- Lead insulation breakage or abrasion
- Lead tip deformation and/or breakage
- Local tissue reaction
- Low amplitude VF signals
- Malignancy or skin burn due to fluoroscopic radiation
- Myocardial trauma (e.g., irritability, injury, tissue damage)
- Myopotential sensing
- Oversensing/undersensing
- Pericardial rub, effusion
- Pneumothorax
- Post-shock rhythm disturbances
- Pulse generator and/or lead migration
- Shunting current during defibrillation with internal or external paddles
- Syncope
- Tachyarrhythmias, which include acceleration of arrhythmias and early, recurrent atrial fibrillation
- Thrombosis/thromboemboli
- Valve damage
- Vasovagal response
- Venous occlusion
- Venous trauma (e.g., perforation, dissection, erosion)

Warranty Information

A limited warranty certificate for the lead is available. For a copy, contact Boston Scientific using the information on the back cover.

PRE- IMPLANT INFORMATION

Proper surgical procedures and techniques are the responsibility of the medical professional. The described implant procedures are furnished only for informational purposes. Each physician must apply the information in these instructions according to professional medical training and experience.

The lead is designed, sold, and intended for use only as indicated.

A major consideration choosing this lead family is that it does not require a thoracotomy. The physician should weigh its advantages against the patient's ability to withstand additional electrophysiology (EP) testing (arrhythmia induction and conversion test), and a possible thoracotomy, should the lead system prove ineffective.

Various factors, such as disease state or drug therapy, may necessitate repositioning of the defibrillation leads or substitution of one lead system for another in order to facilitate arrhythmia conversion. In some cases, reliable arrhythmia conversion may not be obtained with any leads at the available defibrillation or pulse generator defibrillation energy levels.

Bipolar pacemakers may be used with this lead family and pulse generator as long as the pacemaker and pulse generator do not interact, causing pulse generator nondetection or false detection. Refer to the pulse generator physician's manual for information about minimizing pacemaker interaction.

Surgical Preparation

Consider the following prior to the implantation procedure:

- Instrumentation for cardiac monitoring, imaging (fluoroscopy), external defibrillation, and lead signal measurements must be available during implant.
- Always isolate the patient from potentially hazardous leakage current when using electrical instrumentation.
- Sterile duplicates of all implantable items should be available for use if accidental damage or contamination occurs.

Items Included

The following items are packaged with the lead:

Vein pick

Stylets

Connector Tool

Literature

Accessories

Separately packaged lead accessories are available in addition to those packaged with the lead.

Vein Pick

The vein pick is a disposable plastic device designed to assist with insertion into a vein during a cutdown procedure.

Radiopaque Suture Sleeve

The radiopaque suture sleeve is an adjustable, tubular reinforcement that is visible under fluoroscopy. It is positioned over the outer lead insulation and is

designed to secure and protect the lead at the venous entry site after lead placement. Using a suture sleeve reduces the possibility of structural damage caused by suturing directly over the lead body. To move the suture sleeve, gently pinch and slide it over the lead until it is in the desired position. The window feature is designed to aid compression of the sleeve onto the lead during suturing.

NOTE: *A radiopaque suture sleeve is pre-loaded on the lead and is also available in a slit form as an accessory (Model 6403). The accessory slit suture sleeve is intended to be used as a replacement for the pre-loaded suture sleeve in the event of damage or loss.*

CAUTION: Use of multiple suture sleeves has not been evaluated and is not recommended.

Stylets

Stylets aid in positioning the lead. Ensure you use the length appropriate to the lead. Stylets of various degrees of stiffness are available depending on implant technique and patient anatomy.

Table 1. Stylet stiffness and knob color

Stylet Stiffness [a]	Knob Color
Soft	Green
Firm	White

a. The stylet stiffness is imprinted on the knob.

Table 2. Stylet length and cap color

Stylet Length (cm) (Imprinted on cap of the knob)	Cap Color
59	Yellow
64	Green
70	Black

Lead Cap

The lead cap may be used to isolate or cap the lead terminal that is not inserted in the pulse generator. Place a suture around the lead cap groove to secure the lead cap to the lead terminal. Use an appropriate cap for lead.

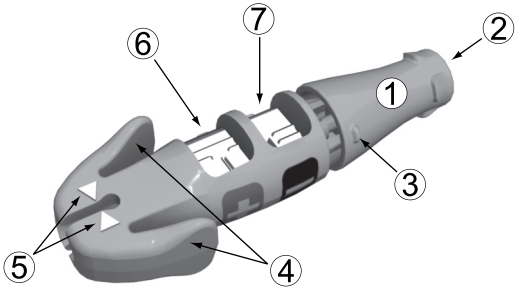
NOTE: *The lead cap (Model 7007) is available as an accessory.*

EZ-4 Connector Tool

The EZ-4 Connector Tool is packaged with the lead and when attached to the lead performs the following functions:

- Protects the lead terminal during the implant procedure.
- Provides a safe and secure connection between PSA patient cables and the lead terminal.

- Guides the stylet into the lead through the stylet funnel.



[1] Fixation knob (disengaged) [2] Stylet funnel [3] Rotation mark [4] Terminal boot levers [5] Indicator arrows [6] Anode (+) spring contact [7] Cathode (-) spring contact

Figure 1. Connector Tool

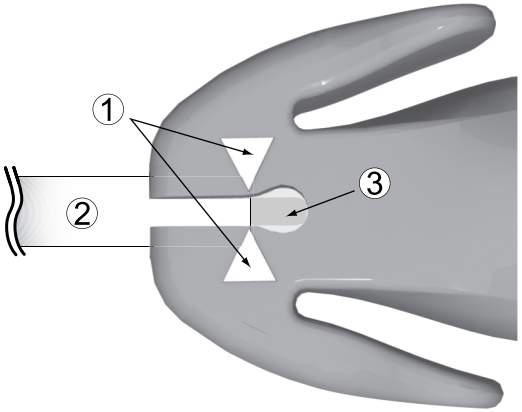
IMPLANTATION

NOTE: *Select the appropriate lead length for a given patient. It is important to select a lead that is long enough to avoid any sharp angles or kinks and to allow for a gentle curve of excess lead in the pocket. Typically, a minimum of 5 to 10 cm of excess lead is sufficient to achieve this configuration in the pocket. The suture sleeve should be secured to the lead as close to the vascular access site as clinically appropriate as described in "Securing the Lead" on page 23. Proper placement of the suture sleeve aids in maintaining this configuration in the pocket.*

Attaching the Connector Tool to the Lead

Follow the steps below to attach the Connector Tool to the lead.

1. Slide the Connector Tool onto the proximal end of the lead (Figure 2 Lead fully inserted into Connector Tool on page 14).
2. While squeezing the EZ-4 Connector Tool wings, push the lead into the tool until the white boot aligns with the arrows on the tool to ensure the lead is fully inserted.
3. Release the terminal boot levers to secure the Connector Tool to the proximal end of the lead.



[1] Indicator arrows [2] Terminal boot molding [3] Terminal molding

Figure 2. Lead fully inserted into Connector Tool

Inserting the Stylet

Follow the steps below to insert a stylet.

1. Remove any preinserted stylet before inserting a different one.
2. Select a stylet according to the function and to the preferred firmness. If desired, gently curve the stylet with any sterile, smooth-surfaced instrument (e.g., 10-cc or 12-cc syringe barrel) (Figure 3 Curve the stylet on page 14). A gentle curve is less likely to straighten than a sharp bend as the stylet is used.

CAUTION: Do not use a sharp object to curve the distal end of a stylet. Do not curve a stylet while it is in the lead. If a curved stylet is preferred, gently curve a straight stylet before inserting it into the lead to avoid damage to the stylet and lead.

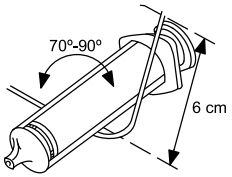


Figure 3. Curve the stylet

3. Carefully insert the stylet through the funnel of the Connector Tool and terminal pin.

NOTE: *To optimize insertion into the lead, do not allow body fluids to come in contact with the stylet.*

4. Ensure the stylet is fully inserted in the lead prior to inserting the lead into the vein.

CAUTION: Do not bend the lead with a stylet in place. Bending the lead could damage the conductor and insulation material.

Inserting the Lead

The lead may be inserted using one of the following methods: via the cephalic vein, or through the subclavian or internal jugular vein.

- **Via cutdown through the left or right cephalic vein** Only one incision over the deltopectoral groove is required to access the right or left cephalic vein in the deltopectoral groove.

  The vein pick packaged with this lead can be used to aid access during the cutdown procedure. Isolate the selected vein and introduce the point of the vein pick via this incision into the lumen of the vein. With the point of the vein pick facing in the direction of the desired lead passage, gently raise and tilt the pick. Pass the lead under the vein pick and into the vein.

  CAUTION: The vein pick is not intended either for puncturing the vein or for dissecting tissue during a cutdown procedure. Be sure that the vein pick does not puncture the insulation of the lead. This could prevent proper lead function.

Figure 4. Using the vein pick

- **Percutaneously or via cutdown through the subclavian vein** A subclavian introducer set is available for use during percutaneous lead insertion. Refer to the specifications for the recommended introducer size.

  CAUTION: When attempting to implant the lead via a subclavian puncture, do not introduce the lead under the medial one-third region of the clavicle. Damage or chronic dislodgment to the lead is possible if the lead is implanted in this manner. If implantation via the subclavian vein is desired, the lead must enter the subclavian vein near the lateral border of the first rib to avoid entrapment by the subclavius muscle or ligamentous structures associated with the narrow costoclavicular region. It has been established in the literature that lead fracture can be caused by lead entrapment in such soft tissue structures as the subclavius muscle, costocoracoid ligament, or the costoclavicular ligament.[5]

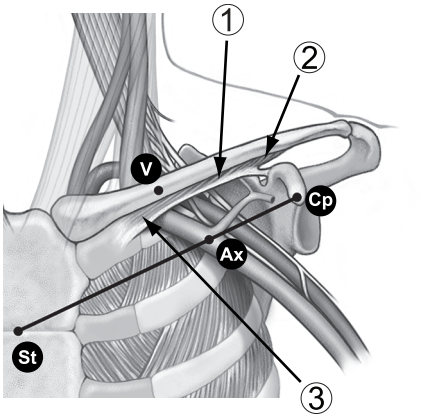
5. Magney JE, et al. Anatomical mechanisms explaining damage to pacemaker leads, defibrillator leads, and failure of central venous catheters adjacent to the sternoclavicular joint. PACE. 1993;16:445–457.

Leads placed by percutaneous subclavian venipuncture should enter the subclavian vein, where it passes over the first rib (rather than more medially), to avoid entrapment by the subclavius muscle or ligamentous structures associated with the narrow costoclavicular region.[6] It is recommended to introduce the lead into the subclavian vein near the lateral border of the first rib.

The syringe should be positioned directly above and parallel to the axillary vein to reduce the chance that the needle will contact the axillary or subclavian arteries or the brachial plexus. Use of fluoroscopy is helpful in locating the first rib and in guiding the needle.

The steps below explain how to identify the skin entry point and define the course of the needle toward the subclavian vein where it crosses the first rib.

1. Identify points St (sternal angle) and Cp (coracoid process) (Figure 5 Entry point for percutaneous subclavian venipuncture on page 16).



[1] Subclavius muscle [2] Costocoracoid ligament [3] Costoclavicular ligament

Figure 5. Entry point for percutaneous subclavian venipuncture

2. Visually draw a line between St and Cp, and divide the segment into thirds. The needle should pierce the skin at the junction of the middle and lateral thirds, directly above the axillary vein (point Ax).
3. Place an index finger on the clavicle at the junction of the medial and middle thirds (point V), beneath which point the subclavian vein should be located.
4. Press a thumb against the index finger and project 1–2 centimeters below the clavicle to shield the subclavius muscle from the needle (when hypertrophy of the pectoralis muscle is apparent, the thumb

6. Magney JE, et al. A new approach to percutaneous subclavian venipuncture to avoid lead fracture or central venous catheter occlusion. PACE. 1993;16:2133–2142.

should project about 2 centimeters below the clavicle because the subclavius muscle should be hypertrophied as well) (Figure 6 Location of thumb and needle entry on page 17).

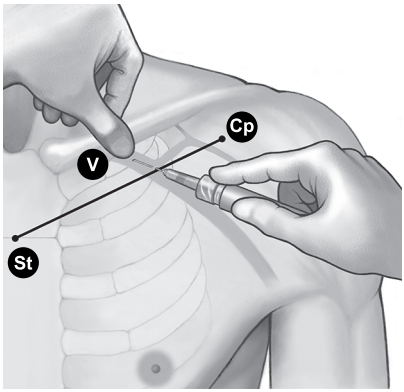


Figure 6. Location of thumb and needle entry

5. Feel with the thumb the pressure from the passage of the needle through the superficial fascia; direct the needle deep into the tissues toward the subclavian vein and the underlying first rib. Fluoroscopic guidance will reduce the chance that the needle would pass below the first rib and into the lung.

Positioning Lead in Right Ventricle

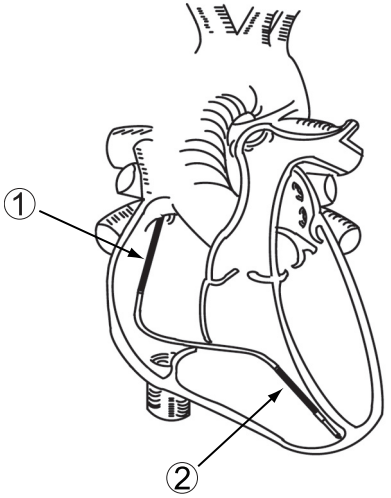
Correct functioning of the lead depends on appropriate placement of the electrodes. Follow the instructions below to position the lead.

1. Partially withdraw the stylet during lead positioning to minimize tip stiffness.

NOTE: *A curved stylet may enhance maneuverability.*

2. Under fluoroscopy and with a stylet in the lead, advance the lead as far as possible until the tip enters and becomes lodged in healthy myocardium in the apex of the right ventricle.

WARNING: Take care to obtain appropriate electrode position. Failure to do so may result in higher defibrillation thresholds or may render the lead unable to defibrillate a patient whose tachyarrhythmia(s) might otherwise be convertible by a pulse generator system.



[1] Proximal coil electrode [2] Distal coil electrode

Figure 7. Suggested electrode position within the heart

3. Verify under fluoroscopy that the distal coil electrode is situated in the right ventricle, below the tricuspid valve, and that the proximal coil electrode (in dual-coil models) is situated in the superior vena cava and high right atrium.

CAUTION: For patients with bipolar cardiac pacemakers, the lead pace/sense electrode (the tip electrode and distal coil electrode) should be placed as far as possible from the pacemaker electrodes to avoid cross-sensing between the defibrillator pulse generator and the pacemaker.

4. Ensure sufficient contact between the lead tip and the fixation site.

WARNING: In order to deliver defibrillation therapy, the single-coil models must be implanted with an additional defibrillation electrode. It is recommended to use the pectorally implanted defibrillator pulse generator that uses the metallic housing as a defibrillation electrode.

Checking for Lead Stability

Follow these steps to check lead stability:

1. After fixation, partially withdraw the stylet 20 to 25 cm.
2. Check the stability of the lead using fluoroscopy. Do not tug on the lead. If possible, have the patient cough or take several deep breaths.
3. When the electrode position is satisfactory, withdraw the stylet beyond the right atrium.

CAUTION: Should dislodgment occur, immediate medical care is required to resolve the electrode position and minimize endocardial trauma.

Evaluating Lead Performance

Verify electrical performance of the lead using a pacing system analyzer (PSA) before attaching the lead to the pulse generator.

1. Connect the lead to the PSA.
    - Attach the PSA cable alligator clips to the Connector Tool cathode (–) spring contact and anode spring contact (+). Use of the Connector Tool will protect the terminal pin from alligator clip damage and prevent bridging between terminal contacts. Fully engage the alligator clips on the cathode and anode spring contacts to avoid inaccurate baseline measurements (Figure 8 PSA clips attached to Connector Tool on page 19).

      WARNING: For DF4-LLHH or DF4-LLHO leads, only use the Connector Tool for electrical connections to pacing system analyzers or similar monitors. Do not attach alligator clips directly to the lead terminal or damage could occur.

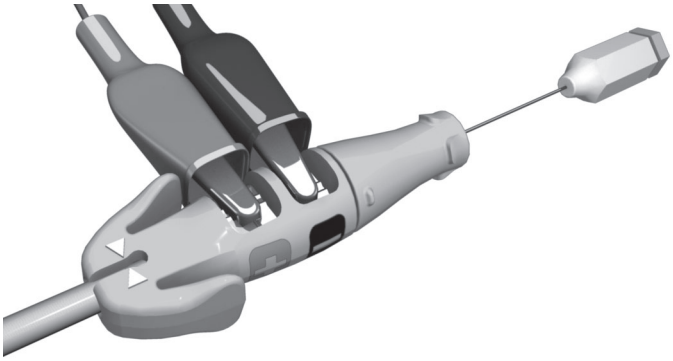


Figure 8. PSA clips attached to Connector Tool

2. Perform the measurements as indicated in the table.

Table 3. Recommended threshold and sensing measurements

Signal Type	Amplitude	Duration	Pacing Threshold[a]	Impedance
Pacing/ Sensing	≥ 5 mV	< 100 ms	≤ 1.5 V	300–1200 Ω
Defibrillation	≥ 1 mV	< 150 ms	NA	20–125 Ω

a. Pulse width setting 0.5 ms.

- Pulse generator measurements may not exactly correlate to the PSA measurements due to signal filtering. Baseline measurements should fall within the recommended values indicated in the table.
- Lower intrinsic potentials, longer durations, and higher pacing threshold may indicate lead placement in ischemic or scarred tissue. Because signal quality may deteriorate, reposition the lead if

necessary to obtain a signal with the largest possible amplitude, shortest duration, and lowest pacing threshold.

- Changes in the defibrillation electrode surface area, such as changing from a TRIAD configuration to a single coil configuration, can affect the impedance measurements. Baseline defibrillation impedance measurements should fall within the recommended values indicated in the table.

  CAUTION: R-wave amplitudes of less than the recommended value can cause inaccurate rate counting in the chronic state, possibly resulting in failure to sense a tachyarrhythmia or misdiagnosis of a normal rhythm as abnormal. Signal durations that exceed the programmed refractory period of the pulse generator can cause inaccurate rate sensing which may cause inappropriate behavior.

3. If measurements do not conform to the values in the table, perform the following steps:
   - Remove the PSA alligator clips from the Connector Tool.
   - Reinsert the stylet and reposition the lead using the procedures previously discussed and repeat the lead evaluation process.
   - If testing results are unsatisfactory, further lead system repositioning or replacement may be required.

Consider the following information:

- Low stimulation threshold readings indicate a desirable safety margin, since stimulation threshold may rise after implantation.
- Initial electrical measurements may deviate from recommendations because of acute cellular trauma. If this occurs, wait approximately 10 minutes and repeat testing. Values may be dependent on patient-specific factors such as tissue condition, electrolyte balance, and drug interactions.
- Amplitude and duration measurements are not inclusive of current of injury and are taken during the patient's normal baseline rhythm.

4. Test for diaphragmatic stimulation by pacing the lead at a high voltage output, using professional medical judgment to select the output voltage. Adjust the lead configurations and lead position as necessary. PSA testing at higher outputs may also be considered to better characterize stimulation margins. Testing should be conducted for all lead placements.
5. Once acceptable measurements are obtained, remove the pacing system analyzer connections, and remove the stylet.
6. Pinch the terminal boot levers and slide the Connector Tool off of the proximal end of the lead.
7. If additional repositioning and/or PSA measurements are necessary, reattach the Connector Tool, ensuring the lead is fully inserted, and repeat the evaluation process.

Connection to a Pulse Generator

Consult the applicable pulse generator physician's manual for more instructions for connecting lead terminals to the pulse generator.

1. Verify the stylet and any terminal pin accessories are removed prior to connecting the lead to the pulse generator.
2. Grasp the lead body in the labeled area distal to the terminal ring contacts and fully insert the lead terminal into the pulse generator port until the terminal pin is visible beyond the setscrew block. If the terminal pin is difficult to insert, verify the setscrew is completely retracted. Visualization of the terminal pin insertion indicator beyond the setscrew block may be used to confirm that the terminal pin is fully inserted into the pulse generator port.

NOTE: *If necessary, lubricate the entire lead terminal (area shown in Figure 9 DF4 Lead Terminal on page 21) sparingly with sterile water or sterile mineral oil to make insertion easier.*

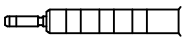


Figure 9. DF4 Lead Terminal

3. Apply gentle traction to the lead by grasping the labeled area of the lead body to ensure a secure connection.

CAUTION: Insert the lead terminal straight into the lead port. Do not bend the lead near the lead-header interface. Improper insertion can cause insulation or connector damage.

WARNING: When connecting the lead to the pulse generator, it is very important that proper connections are made. The terminal pin must be inserted beyond the setscrew block to enable a proper connection. Visualization of the terminal pin insertion indicator beyond the setscrew block may be used to confirm that the terminal pin is fully inserted into the pulse generator port. Evaluation of the electrical performance of the lead after connection to the pulse generator is the final confirmation of full insertion. An improper connection could result in loss of therapy or inappropriate therapy.

NOTE: *If the lead terminal will not be connected to a pulse generator at the time of lead implantation, you must cap the connector before closing the pocket incision. The lead cap is designed specifically for this purpose. Place a suture around the lead cap to keep it in place.*

4. Giving consideration to patient anatomy and pulse generator size and motion, gently coil any excess lead and place adjacent to the pulse generator. It is important to place the lead into the pocket in a manner that minimizes lead tension, twisting, sharp angles, and/or pressure.

Electrical Performance

1. Evaluate the lead signals using the pulse generator.
2. Place the pulse generator into the implant pocket as indicated in the pulse generator physician's manual. Also refer to the instructions in this manual ("Connection to a Pulse Generator" on page 21).
3. Evaluate the lead signals by viewing the real-time EGM. Consider the following:
    - The signal from the implanted lead should be continuous and without artifact, similar to a body-surface ECG.
    - A discontinuous signal may indicate a lead fracture or an otherwise damaged lead, or an insulation break that would necessitate lead replacement.
    - Inadequate signals may result either in a failure of the pulse generator system to detect an arrhythmia or in an unnecessary delivery of therapy.
4. Test for diaphragmatic stimulation by pacing the lead at a high voltage output, using professional medical judgment to select the output voltage. Adjust the lead configurations and lead position as necessary. Testing should be conducted for all lead placements.

Conversion Testing

After obtaining acceptable signals, use the pulse generator to demonstrate ability to reliably convert ventricular fibrillation (VF) and, when appropriate to the patient, ventricular tachycardias. This testing involves inducing arrhythmias and shocking the patient with high-voltage pulses delivered from the pulse generator, through the defibrillation electrodes of the lead, to the heart. Baseline measurements should fall within the recommended values listed in the Recommended threshold and sensing measurements table (Table 3 Recommended threshold and sensing measurements on page 19).

CAUTION: Following an unsuccessful high-energy shock, miscounting of cardiac rate, delayed detection, or nondetection due to low amplitude VF signals, it may be necessary to reposition the lead.

WARNING: Always have external defibrillation equipment available during implant and electrophysiologic testing. If not terminated in a timely fashion, an induced ventricular tachyarrhythmia can result in the patient's death.

Reliable conversion of VF should be demonstrated at an energy level less than the maximum energy setting of the pulse generator. Consider the following:

- It is recommended that multiple induction conversion tests of VF be performed to determine conversion reliability and the patient's defibrillation threshold (DFT).
- It is a matter of clinical judgment as to what constitutes a demonstration of reliable conversion. Since the result of any single test is subject to statistical variation, a one-time conversion of a rhythm disturbance at a particular energy level does not necessarily predict future conversion energy levels.
- Refer to the applicable pulse generator physician's manual for conversion testing guidelines.
- Weigh the probability of reliable conversion in the ambulatory state against the availability of the pulse generator energy settings and the patient's ability to tolerate multiple arrhythmia inductions.
- If a patient's arrhythmia(s) cannot be reliably converted with the lead, supplementary implantation of an alternate lead system will require additional conversion testing.

  WARNING: Do not use any component of the lead system to assist in delivery of external-source rescue shocks or extensive tissue damage could occur.
- The decision to implant any pulse generator lead system in any configuration should be based on demonstration of adequate safety margins at the programmed shock energy as determined by DFT and cardioversion energy requirement (CER) testing. Refer to the applicable pulse generator physician's manual for DFT and CER testing requirements.
- Clinical study indicates that a programmed safety margin of 9–10 J above the patient's DFT was used in the majority of patients. If a 9–10 J safety margin cannot be obtained, consider placing an alternative defibrillation lead system.

  NOTE: *If, after prolonged and repeated inductions of VF, a thoracotomy is to be performed, consider performing it at a later date.*

Securing the Lead

After the electrodes are satisfactorily positioned, use the suture sleeve to secure the lead to achieve permanent hemostasis and lead stabilization. Suture sleeve tie-down techniques can vary with the lead insertion technique used. Consider the following warning and precautions while securing the lead.

WARNING: Do not kink, twist, or braid the lead with other leads as doing so could cause lead insulation abrasion damage or conductor damage.

CAUTION: When ligating the vein, avoid stricture that is too tight. A tight stricture might damage the insulation or sever the vein. Avoid dislodging the distal tip during the anchoring procedure.

CAUTION: Do not suture directly over the lead body, as this may cause structural damage. Use the suture sleeve to secure the lead proximal to the venous entry site to prevent lead movement.

CAUTION: Avoid removing or cutting the suture sleeve from the lead. If removal of the suture sleeve is necessary, use caution as lead damage can occur.

CAUTION: Use of multiple suture sleeves has not been evaluated and is not recommended.

Percutaneous Implant Technique

1. Peel back the introducer sheath and slide the suture sleeve deep into the tissue (Figure 10 Example of suture sleeve, percutaneous implant technique on page 24).

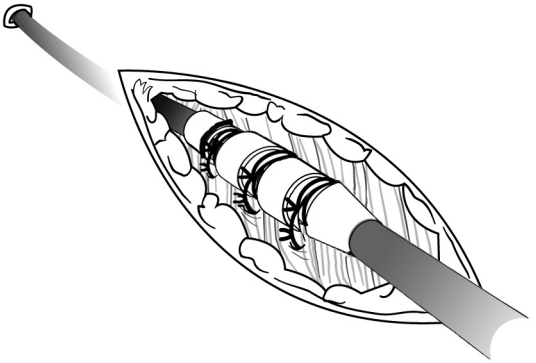


Figure 10. Example of suture sleeve, percutaneous implant technique

2. Using at least two grooves, ligate the suture sleeve and the lead to the fascia. For additional stability, the sleeve may be secured to the lead first before securing the sleeve to the fascia.
3. Check the suture sleeve after tie-down to demonstrate stability and lack of slippage by grasping the suture sleeve with fingers and trying to move the lead in either direction.

Venous Cutdown Technique

1. Slide the suture sleeve into the vein past the distal groove.
2. Ligate the vein around the suture sleeve to obtain hemostasis.
3. Using the same groove, secure the lead and vein to the adjacent fascia (Figure 11 Example of suture sleeve, venous cutdown technique on page 25).

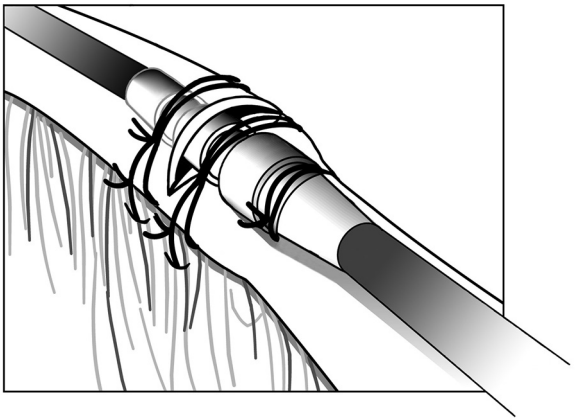


Figure 11. Example of suture sleeve, venous cutdown technique

4. Use at least two grooves to secure the sleeve to the lead. Secure the lead and suture sleeve to the adjacent fascia.
5. Check the suture sleeve after tie-down to demonstrate stability and lack of slippage by grasping the suture sleeve with fingers and trying to move the lead in either direction.

Tunneling the Lead

Follow these steps if tunneling the lead:

1. Allow slack on the lead for strain relief on the lateral side of the suture sleeve near the venous entry site when securing the leads to body tissue. This will prevent lead dislodgment caused by the weight of the pulse generator or upper extremity movement.

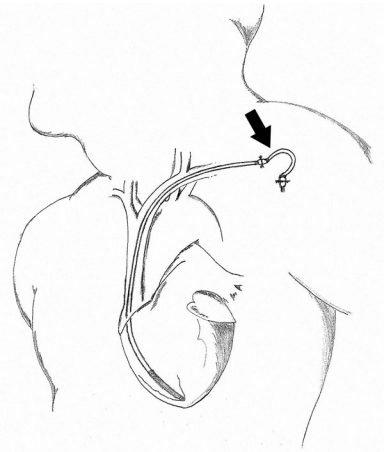


Figure 12. Strain relief loop

WARNING: Use caution handling the lead terminal when the Connector Tool is not present on the lead. Do not directly contact the lead terminal with any surgical instruments or electrical connections such as PSA (alligator) clips, ECG connections, forceps, hemostats, and clamps. This could damage the lead terminal, possibly compromising the sealing integrity and result in loss of therapy or inappropriate therapy.

2. Remove the stylet and Connector Tool.

NOTE: *A compatible tunneling tip is recommended for use with this lead if the pulse generator is implanted away from the vein insertion site. Refer to the instructions for use for the tunneling tip and/or tunneler kit if one is being used. When using a compatible tunneling tip, do not cap the lead.*

3. Cap the lead terminal if a tunneling tip and/or tunneler kit is not used. Grip the terminal pin with a hemostat, or equivalent.

WARNING: Do not contact any other portion of the lead terminal, other than the terminal pin, even when the lead cap is in place.

4. Gently tunnel the lead subcutaneously from the vein insertion site to the implant pocket.

CAUTION: Tunnel the lead from the chest area to the pulse generator implant site. Do not tunnel the lead from the pulse generator implant site to the chest area because this can damage the electrodes or lead body or both by permanently stretching the lead.

CAUTION: When tunneling the lead, take precautions not to place excessive tension on the lead. This can cause either structural weakness and/or conductor discontinuity.

CAUTION: After tunneling, re-evaluate the lead to verify that no significant change in signals or damage to the lead has occurred during the tunneling procedure. Reattach the Connector Tool and repeat the steps in Evaluating Lead Performance.

NOTE: *If the tunneling procedure must be delayed, cap the lead terminal and form a temporary pocket for the coiled lead. Capping the terminal protects it and prevents body fluids from entering the lumen of the lead.*

5. Reattach the lead terminals to the pulse generator and evaluate lead signals with the pulse generator as previously described.
    - If the measurements are unacceptable, check the electrical connections. A discontinuous or abnormal signal may indicate dislodgment, a loose connection, or lead damage.
    - If necessary, reposition the lead electrodes until acceptable values are obtained. To reposition the lead, carefully withdraw the tunneled portion back to the venous entry site. Release the permanent ligatures and reposition the lead using procedures previously discussed.

POSTIMPLANT

Postimplant Evaluation

Perform follow-up evaluation as recommended in the applicable pulse generator physician's manual.

CAUTION: For some patients, lead performance at implant may not predict performance in the chronic state. Therefore, it is strongly recommended that post-implant follow-up EP testing be performed should any change occur in lead performance. This testing should include at least one arrhythmia induction/conversion test of ventricular fibrillation.

WARNING: Ensure that an external defibrillator and medical personnel skilled in CPR are present during post-implant device testing should the patient require external rescue.

NOTE: *Chronic repositioning of the lead may be difficult because of body fluid or fibrotic tissue intrusion.*

Explantation

NOTE: *Return all explanted pulse generators and leads to Boston Scientific. Examination of explanted pulse generators and leads can provide information for continued improvement in system reliability and warranty considerations.*

WARNING: Do not reuse, reprocess, or resterilize. Reuse, reprocessing, or resterilization may compromise the structural integrity of the device and/or lead to device failure which, in turn, may result in patient injury, illness, or death. Reuse, reprocessing, or resterilization may also create a risk of contamination of the device and/or cause patient infection or cross-infection, including, but not limited to, the transmission of infectious disease(s) from one patient to another. Contamination of the device may lead to injury, illness, or death of the patient.

Contact Boston Scientific when any of the following occur:

- When a product is removed from service.
- In the event of patient death (regardless of cause), along with an autopsy report, if performed.
- For other observation or complications reasons.

NOTE: *Disposal of explanted pulse generators and/or leads is subject to applicable laws and regulations. For a Returned Product Kit, contact Boston Scientific using the information on the back cover.*

Consider the following items when explanting and returning the pulse generator and/or lead:

- Interrogate the pulse generator and print a comprehensive report.
- Deactivate the pulse generator before explantation.
- Disconnect the leads from the pulse generator.
- If leads are explanted, attempt to remove them intact, and return them regardless of condition. Do not remove leads with hemostats or any other clamping tool that may damage the leads. Resort to tools only if manual manipulation cannot free the lead.
- Wash, but do not submerge, the pulse generator and leads to remove body fluids and debris using a disinfectant solution. Do not allow fluids to enter the pulse generator's lead ports.
- Use a Boston Scientific Returned Product Kit to properly package the pulse generator and/or lead, and send it to Boston Scientific.

SPECIFICATIONS

Specifications (Nominal)

Table 4. Model Number and Lead Length

Model	Single Coil/Dual Coil	ePTFE-covered coil(s)	Length
0665	Dual Coil	No	59 cm
0636	Dual Coil	No	64 cm
0651	Dual Coil	No	70 cm
0682	Single Coil	Yes	59 cm
0683	Single Coil	Yes	64 cm
0654	Single Coil	Yes	70 cm
0685	Dual Coil	Yes	59 cm
0686	Dual Coil	Yes	64 cm
0655	Dual Coil	Yes	70 cm
0662	Single Coil	No	59 cm
0663	Single Coil	No	64 cm
0650	Single Coil	No	70 cm

Table 5. Specifications (Nominal)

Characteristic	Nominal
Terminal type	DF4-LLHH (dual-coil models) DF4-LLHO (single-coil models)
Compatibility	Pulse generators with a DF4-LLHH port or GDT-LLHH port, which accepts either a DF4-LLHH or DF4-LLHO terminal
Fixation	Tined
Electrode:	
Distal coil surface area	450 mm^2
Proximal coil surface area (dual-coil models)	660 mm^2
Tip surface area	3.5 mm^2
Tip to proximal coil electrode length (dual-coil models)	18 cm

Table 5. Specifications (Nominal) (continued)

Characteristic	Nominal
Tip to distal coil electrode length	12 mm
Diameter:	
Insertion	2.7 mm (8F)
Isodiametric lead body	2.4 mm (7.3F)
Material:	
External insulation	Silicone rubber
Terminal molding	Polyurethane (75D)
Terminal pin and ring contacts	MP35N™ [a] nickel-cobalt alloy
Pace/sense conductor	MP35N™ [a] nickel-cobalt alloy, PTFE covered
Shocking conductor	Drawn filled tube cable, ETFE coated
Tip electrode	IROX (iridium oxide) coated Pt-Ir
Distal fitting electrode	Titanium
Coil electrode covering (models with ePTFE-covered coils)	ePTFE
Coil backfill (models without ePTFE-covered coils)	Silicone
Steroid	0.97 mg dexamethasone acetate
Maximum Lead Conductor Resistance:	
From (low voltage) terminal pin to distal tip electrode	80 Ω
From (low voltage) proximal terminal ring contact to distal coil electrode	80 Ω
From (high voltage) middle terminal ring contact to distal coil electrode	2.5 Ω
From (high voltage) distal terminal ring contact to proximal coil electrode (dual coil models)	2.5 Ω

a. MP35N is a trademark of SPS Technologies, Inc.

Lead Introducer

Table 6. Lead introducer

Recommended lead introducer	
Introducer without guide wire[a]	8F (2.7 mm)

a. When retaining a guide wire, a 2.5F increase in introducer size is recommended.

Symbols on Packaging

The following symbols may be used on packaging and labeling (Table 7 Symbols on packaging on page 31):

Table 7. Symbols on packaging

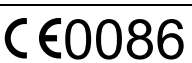
Symbol	Description
	Reference number
	Serial number
	Use by
	Lot number
	Date of manufacture
	Sterilized using ethylene oxide
	Do not resterilize
	Do not reuse
	Do not use if package is damaged
	Consult instructions for use on this website: www.bostonscientific-elabeling.com
	CE mark of conformity with the identification of the notified body authorizing use of the mark
	Opening instruction

Table 7. Symbols on packaging (continued)

Symbol	Description
EC REP	Authorized Representative in the European Community
	Manufacturer
AUS	Australian Sponsor Address

Boston Scientific

Boston Scientific Corporation
4100 Hamline Avenue North
St. Paul, MN 55112-5798 USA

EC REP

Guidant Europe NV/SA; Boston Scientific
Green Square, Lambroekstraat 5D
1831 Diegem, Belgium

AUS

Boston Scientific (Australia) Pty Ltd
PO Box 332
Botany NSW 1455 Australia
Free Phone 1 800 676 133
Free Fax 1 800 836 666

www.bostonscientific.com

1.800.CARDIAC (227.3422)

+1.651.582.4000

92017508-001 EN Canada 2016-04

CE 0086
Authorized 2012

Service Manual

Generator Set

QSK60 Engine with the PowerCommand® 3.3 Control

DQKAN (Spec A-B)

English
Original Instructions

8-2014

A046H644 (Issue 3)

Table of Contents

1 Important Safety Instructions

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

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 the 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 Power Generation with specific generator sets. In the event that this manual has been supplied in isolation please 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 Safety Precautions

1.2.1.1 General Safety Precautions

⚠ WARNING

Coolant under pressure.
Hot coolants under pressure can cause severe scalding.
Do not open a radiator or heat exchanger pressure cap while the engine is running. Let the engine cool down before removing the coolant pressure cap. Turn the cap slowly and do not open it fully until the pressure has been relieved.

⚠ WARNING

Moving parts.
Can cause severe personal injury or death.
Make sure all protective guards are properly in place before starting the generator set.

⚠ WARNING

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.

⚠ WARNING

Operation of equipment.
Is unsafe when mentally or physically fatigued.
Do not operate equipment in this condition, or after consuming any alcohol or drug.

⚠ WARNING

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

Flammable liquids.
Can cause fire or explosion.
Do not store fuel, cleaners, oil, etc. near the generator set.

⚠ WARNING

Generator sets in operation mode emit noise.
Exposure to noise can cause hearing damage
Wear appropriate ear protection at all times.

⚠ WARNING

Hot metal parts.
Can cause severe burns.
Avoid contact with the radiator, turbo charger, and exhaust system.

⚠ WARNING

Maintaining or installing a generator set.
Can cause severe personal injury.
Wear personal protective equipment such as safety glasses, protective gloves, hard hats, steel-toed boots, and protective clothing when working on equipment.

⚠ WARNING

Ethylene glycol.
Used as engine coolant, is toxic to humans and animals.
Clean up coolant spills and dispose of used antifreeze in accordance with local environmental regulations.

⚠ WARNING

Starting fluids, such as ether.
Can cause explosion and generator set engine damage.
Do not use.

⚠ WARNING

Accidental or remote starting.
Accidental starting of the generator set while working on it can cause severe personal injury or death.
To prevent accidental or remote starting while working on the generator set, disconnect the negative (–) battery cable at the battery using an insulated wrench.

⚠ CAUTION

Cleaning materials.
Loose cleaning materials can become entangled in moving parts or cause a fire hazard.
Make sure that all cleaning materials are removed from the generator set before operating the generator.

⚠ CAUTION

Combustible materials.
A build up of combustible materials under the generator set can present a fire hazard.
Make sure the generator set is mounted in a manner to prevent combustible materials from accumulating under the unit.

⚠ CAUTION

Accumulated grease and oil.
Can cause overheating and engine damage presenting a potential fire hazard.
Keep the generator set clean and makes sure oil leaks are repaired promptly.

⚠ CAUTION

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

⚠ CAUTION

Obstructions.

Articles left against the generator set or close by may restrict the air flow and cause over heating or a fire hazard.

Keep the generator set and the surrounding area clean and free from obstructions. Remove any debris from the set and keep the floor clean and dry.

NOTICE

Keep multi-class ABC fire extinguishers handy. 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 applicable region.)

NOTICE

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

Improper operation and maintenance.

Can lead to severe personal injury, or loss of life and property, by fire, electrocution, mechanical breakdown, or exhaust gas asphyxiation.

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

⚠ WARNING

Lifting and repositioning of the generator set.

Incorrect lifting can result in severe personal injury, death, and/or equipment damage.

Lifting must only be carried out using suitable lifting equipment, shackles, and spreader bars, in accordance with local guidelines and legislation, by suitably trained and experienced personnel. For more information, contact your authorized distributor.

1.3.1 Moving Parts Can Cause Severe Personal Injury Or Death

- Keep your hands, clothing, and jewelry away from moving parts.
- Before starting work on the generator set, disconnect the battery charger from its AC source, then disconnect the starting batteries using an insulated wrench, negative (–) cable first. This will prevent accidental starting.
- Make sure that fasteners on the generator set are secure. Tighten supports and clamps; keep guards in position over fans, drive belts, etc.

- Do not wear loose clothing or jewelry in the vicinity of moving parts or while working on electrical equipment. Loose clothing and jewelry can become caught in moving parts.
- If any adjustments must be made while the unit is running, use extreme caution around hot manifolds, moving parts, etc.

1.3.2 Moving the Generator Set

⚠ WARNING

Transportation and handling of generator sets.
Improper handling of the generator set may cause serious damage to the generator set and its components and can result in personal injury or death.
Transportation and handling of generator sets must only be undertaken by suitably trained and experienced personnel.

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

⚠ WARNING

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.
Do not lift the generator set by attaching to the engine or alternator lifting points.

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 your generator set for details of dimensions and mass.

- Ensure that the crane operating area is able to support the mass of the crane and the generator set.

⚠ WARNING

Access.
Using the generator set as a means of access when attaching lifting shackles, chains, or other lifting aids, may damage the generator set, causing severe personal injury or death.
Do not use the generator set as a means of access.

NOTICE

On an enclosed generator set, the canopy doors must be locked before re-positioning, and they must remain locked during transportation and siting.

- Ensure 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 ensure they are attached correctly.

- Hoist the generator set slowly using the indicated lifting points only.

⚠ DANGER

Raised Load.
Contact with a lifted generator set can result in severe personal injury or death.
Never stand underneath a lifted generator set.

- 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.

1.3.2.1 Positioning a Generator Set Using a Forklift Truck

⚠ WARNING

Transportation and handling of generator sets by forklift trucks.
Improper handling of the generator set may cause serious damage to the generator and its components and can result in severe personal injury or death.
Transportation and handling of generator sets by forklift trucks must only be undertaken by suitably trained and experienced personnel who are familiar with the transport of these items.

⚠ WARNING

Undersized forklift truck.
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.
Do not attempt to lift a generator set with an undersized forklift truck.

NOTICE

On an enclosed generator set, the canopy doors must be locked before re-positioning, and they must remain locked during transportation and siting.

- Fully insert the arms of the forklift into the forklift pockets, making sure the generator set completely rests on the forklift arms.
- Lift and handle the equipment slowly.
- Slowly set down the generator set in its final position.

If using a forklift truck to transport/position the generator set, the dimensions, mass, and route must be taken into account when selecting an appropriate lifting truck.

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

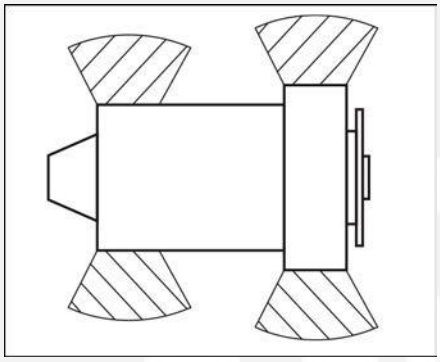
1.3.3 Alternator Operating Areas

⚠ WARNING

Catastrophic failure.

In the event of catastrophic failure, machine parts may be ejected from the alternator air inlet/outlet (shaded regions of diagram) that may cause personal injury or equipment damage.

Do not place controls near the air inlet/outlet and keep personnel from these regions during machine running.



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

⚠ WARNING

Energized circuits.

Any work with exposed energized circuits with potentials of 50 Volts AC or 75 Volts DC or higher poses a significant risk of electrical shock and electrical arc flash. These silent hazards can cause severe injuries or death.

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 the lockout/tagout section for more information.
- De-energize and lockout/tagout all circuits and devices before removing any protective shields or making any measurements on electrical equipment.
- Follow all applicable regional electrical and safety codes.

Guidelines to follow when working on energized electrical systems:

NOTICE

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

NOTICE

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

In summary:

- Do not tamper with or bypass interlocks unless you are authorized to do so.
- Understand and assess the risks - use proper PPE. Do not wear 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 AC Supply and Isolation

NOTICE

Local electrical codes and regulations (for example, *BS EN 12601:2010 Reciprocating internal combustion engine driven generating sets. Safety*) 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 Power Generation accepts no responsibility for providing the means of isolation.

1.4.2 AC Disconnect Sources

⚠ WARNING

Hazardous voltage.

The equipment may have more than one source of electrical energy. Disconnecting one source without disconnecting the others presents a shock hazard that can result in severe personal injury or death.

Before working on the equipment, disconnect and verify that all sources of electrical energy have been removed.

1.4.3 Medium Voltage Equipment (601 V to 15 kV)

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

1.5 Fuel And Fumes Are Flammable

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

- DO NOT fill fuel tanks while the engine is running, unless the tanks are outside the engine compartment. Fuel contact with hot engine or exhaust is a potential fire hazard.
- DO NOT permit any flame, cigarette, pilot light, spark, arcing equipment, or other ignition source near the generator set or fuel tank.
- Fuel lines must be adequately secured and free of leaks. Fuel connection at the engine should be made with an approved flexible line. Do not use copper piping on flexible lines as copper will become brittle if continuously vibrated or repeatedly bent.
- Be sure all fuel supplies have a positive shutoff valve.
- Be 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 or during 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.

If fluid containment is incorporated into the bedframe, it must be inspected at regular intervals. Any liquid present should be drained out and disposed of in line 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 Power Generation 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 daily system 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.
- Be sure the unit is well ventilated.

1.6.1 Exhaust Precautions

⚠ WARNING

Hot pipes.
Hot exhaust pipes and charge air pipes can cause severe personal injury or death from direct contact, or from fire hazard.
Wear appropriate PPE when working on hot equipment and avoid physical contact where possible.

⚠ WARNING

Hot exhaust gases.
Can cause burns resulting in severe personal injury.
Wear personal protective equipment when working on equipment.

⚠ WARNING

Inhalation of exhaust gases.
Breathing exhaust fumes can result in serious personal injury or death.
Be sure deadly exhaust gas is piped outside and away from windows, doors, or other inlets to buildings. Do not allow to accumulate in habitable areas.

⚠ WARNING

Contaminated insulation.
Is a fire risk which can result in severe personal injury and equipment damage.
Remove any contaminated insulation and dispose of 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 Earth Ground Connection

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

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

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

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2 Introduction

⚠ WARNING

Hazardous voltage.
Can cause severe personal injury or death and equipment damage.
Generator electrical output connections must be made by a trained and experienced electrician in accordance with the installation instructions and all applicable codes.

⚠ WARNING

Electrical generating equipment.
Can cause severe personal injury or death.
Generator sets must be installed, certified, and operated by trained and experienced person 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. This manual provides the controller calibration and adjustment procedures, control operation, alternator test and repair procedures and initial startup and testing of paralleled generator sets. It is for guidance and assistance with recommendations for correct and safe procedures. Cummins Power Generation (CPG) cannot accept any liability whatsoever for problems arising as a result of following recommendations 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 Power Generation 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.

Users are respectfully advised that it is their responsibility to employ competent persons to carry out any installation work in the interests of good practice and safety. 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 Power Generation literature. A generator set must be operated and maintained properly if you are to expect safe and reliable operation.

Should you require further assistance contact your authorized distributor.

2.2 Test Equipment

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

- True RMS meter for accurate measurement of small AC and DC voltages. Fluke models 87 or 8060A are good choices.
- Battery Hydrometer
- Power Factor Indicator
- Jumper Leads
- Tachometer or Frequency Meter

- Wheatstone Bridge or Digital Ohmmeter
- Variac
- Load Test Panel
- Megger or Insulation Resistance Meter
- InPower Service Tool (PC-based generator set service tool)
- InPower cable (0338-4590)
- Fluke 871V digital multimeter or better
- Insite Service Tool (PC-based engine service tool)
- RS232 to RS485 Converter (0324-0021)
- Manometer or 0-32 inches of water column gauge
- Express Card
- Inline 6 Datalink Adapter Kit (2892092)
- Refractometer
- Infra-red Non-contact Thermometer
- DCA Test Strips
- SAR-GEL® Water/Alcohol Indicating Paste or Equivalent

2.3 Schedule of Abbreviations

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

AmpSentry, INSITE, and InPower are trademarks of Cummins Inc. PowerCommand is a registered trademark of Cummins Inc.

ABBR.	DESCRIPTION	ABBR.	DESCRIPTION
AC	Alternating Current	LCT	Low Coolant Temperature
AMP	AMP, Inc., part of Tyco Electronics	LED	Light-emitting Diode
ANSI	American National Standards Institute	MFM	Multifunction Monitor
ASOV	Automatic Shut Off Valve	Mil Std	Military Standard
ASTM	American Society for Testing and Materials (ASTM International)	NC	Normally Closed
ATS	Automatic Transfer Switch	NC	Not Connected
AVR	Automatic Voltage Regulator	NFPA	National Fire Protection Agency
AWG	American Wire Gauge	NO	Normally Open
CAN	Controlled Area Network	NWF	Network Failure
CB	Circuit Breaker	OEM	Original Equipment Manufacturer
CE	Conformité Européenne	OOR	Out of Range
CFM	Cubic Feet per Minute	OORH / ORH	Out of Range High
CGT	Cummins Generator Technologies	OORL / ORL	Out of Range Low

ABBR.	DESCRIPTION	ABBR.	DESCRIPTION
CMM	Cubic Meters per Minute	PB	Push Button
CT	Current Transformer	PCC	PowerCommand® Control
DC	Direct Current	PGI	Power Generation Interface
DEF	Diesel Exhaust Fluid	PGN	Parameter Group Number
DPF	Diesel Particulate Filter	PI	Proportional/Integral
ECM	Engine Control Module	PID	Proportional/Integral/Derivative
ECS	Engine Control System	PLC	Programmable Logic Controller
EMI	Electromagnetic interference	PMG	Permanent Magnet Generator
EN	European Standard	PPE	Personal Protective Equipment
EPS	Engine Protection System	PT	Potential Transformer
E-Stop	Emergency Stop	PTC	Power Transfer Control
FAE	Full Authority Electronic	PWM	Pulse-width Modulation
FMI	Failure Mode Identifier	RFI	Radio Frequency Interference
FSO	Fuel Shutoff	RH	Relative Humidity
Genset	Generator Set	RMS	Root Mean Square
GCP	Generator Control Panel	RTU	Remote Terminal Unit
GND	Ground	SAE	Society of Automotive Engineers
HMI	Human-machine Interface	SCR	Selective Catalytic Reduction
IC	Integrated Circuit	SPN	Suspect Parameter Number
ISO	International Organization for Standardization	SW_B+	Switched B+
LBNG	Lean-burn Natural Gas	UL	Underwriters Laboratories
LCD	Liquid Crystal Display	UPS	Uninterruptible Power Supply

2.4 Related Literature

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

⚠ 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 documents below are in English:

- Operator Manual for DQKAN (A046H643)
- Installation Manual for DQKAN (A046H641)

- Generator Set Service Manual for DQKAN (A046H644)
- Controller Service Manual for PowerCommand 3.3 Controller (900-0670)
- Engine Operation & Maintenance Manual for QSK60 Engine (3666260)
- Alternator Installation and Service Manual for P80 Alternator (A040J851)
- Owner Manual for 15/12 Amp Battery Charger (901-0907)
- Owner Manual for PowerCommand Universal Annunciator (900-0301)
- Owner Manual for AUX101/AUX102 (A030K737)
- Recommended Spares List (RSL) for DQKAN (A048F499)
- *Specification* and *Data Sheet* - for engineering data specific to the generator set (NAS-5673-EN and NAD-5674-EN)
- Parts Manual for DQKAN (A048C644)
- Standard Repair Times - FD Family (A029F346)
- Service Tool Manual (A043D529)
- Failure Code Manual (F1115C)
- Application Manual T-030, *Liquid Cooled Generator Sets* - for application information (A040S369)
- Fuels for Cummins Engines Service Bulletin (33790010)
- Warranty Manual (A040W374)
- Global Commercial Warranty Statement (A028U870)

2.5 After Sales Services

Cummins Power Generation offers a full range of maintenance and warranty services.

2.5.1 Maintenance

⚠ WARNING

Electrical generating equipment
Incorrect 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/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.

2.5.2 Warranty

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

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

For further warranty details, contact your authorized distributor.

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

2.5.2.1 Warranty Limitations

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

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3 Specifications

3.1 Generator Set Specifications

TABLE 1. DQKAN SPECIFICATIONS

MODELS	DQKAN
Engine Cummins Diesel Series	 QSK60-G19
Generator kVA/kW Rating	2500kW (3125 kVa)
Engine Fuel Connection Inlet/Outlet Thread Size	 Refer to generator set outline drawing supplied (Appendix B on page 381)
Maximum Weight Generator Set with P80 Alternator	 Dry: 23027 kg (50766 lb); Wet: 23392 kg (51571 lb)
Fuel Max. Fuel Inlet Restriction Max. Fuel Inlet Temperature Max Fuel Flow	 30 kPa (9 in. Hg) 71 °C (160 °F) 1105 L/hr (292 gal/hr)
Exhaust Outlet Size Max. Allowable Back Pressure Exhaust Flow at Rated Load Exhaust Temperature	**1800 RPM** 254 mm. NB (10 in. NB) 2.2 in. Hg 473 m^3/min (18269 cfm) 551 °C (1022 °F)
Electrical System Starting Voltage Battery Group Number CCA (minimum)	 24 Volts DC 80 2200
Cooling System Capacity with 43 °C Radiator	 681 L (180 US gal)
Lubricating System Oil Capacity with Filters	 378 L (99 US gal)

3.2 Engine Fuel Consumption - QSK60 Engine

TABLE 2. FUEL CONSUMPTION (L/HR) AT 1800 RPM (60 HZ)

Model	DQKAN
Engine	**QSK60-G19 NR2**
Engine Performance Data at 60Hz[1]	656

1. Standby/Full Load

Refer to Data Sheets for other applications. In line with the CPG policy of continuous improvement, these figures are subject to change.

TABLE 3. FUEL CONSUMPTION (GAL/HR) AT 1800 RPM (60 HZ)

Model	DQKAN
Engine	**QSK60-G19 NR2**
Engine Performance Data at 60Hz[1]	173.1

1. Standby/Full Load
Refer to Data Sheets for other applications. In line with the CPG policy of continuous improvement, these figures are subject to change.

3.3 Derating Factors

Application	Derating Factor
Standby	Engine power available up to 300 m (1000 ft) at ambient temperature up to 40 °C (104 °F). Above these elevations, derate by an additional 5% per 300 m (1000 ft) and 12% per 10 °C (18 °F).

4 Periodic Maintenance

The periodic maintenance procedures should be performed at whichever interval occurs first. At each scheduled maintenance interval, perform all previous maintenance checks that are due for scheduled maintenance.

The tabular data that follows gives the recommended service intervals for a generator set on Standby service. If the generator set will be subjected to Prime usage or extreme operating conditions, the service intervals should be reduced accordingly.

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

- Use for continuous duty (prime power)
- Extremes in ambient temperature
- Exposure to elements
- Exposure to salt water
- Exposure to windblown dust or sand.

Consult with an authorized distributor if the generator set will be subjected to any extreme operating conditions and determine if extra protection or a reduction in service intervals is needed. Use the running time meter to keep an accurate log of all service performed for warranty support. Perform all service at the time period indicated, or after the number of operating hours indicated, whichever comes first.

4.1 Periodic Maintenance Schedule

TABLE 4. AIR INTAKE MAINTENANCE

MAINTENANCE ITEMS **Perform maintenance tasks as specified using Daily or Hourly periods – whichever occurs first**	**Daily 8 Hours**	**Weekly 50 Hours**	**6 Months 250 Hours**	**12 Months 250 Hours**	**1500 Hours 12 Months**	**2000 Hours**	**2 Years 6000 Hours**
Task	**Operator Task**		**Service Technician Task**				
Check air cleaner restriction indicator (where fitted): If the service indicator shows red, replace air cleaner elements and reset the air cleaner service indicator.	■						
Check air intake system for leaks: Visually inspect the air intake system for signs of wear or damage. Check audibly when the generator set is running. To replace, contact your authorized distributor.	■						
Clean air cleaner housing.				■			

TABLE 5. CONTROL MAINTENANCE

MAINTENANCE ITEMS Perform maintenance tasks as specified using Daily or Hourly periods – whichever occurs first	Daily 8 Hours	Weekly 50 Hours	6 Months 250 Hours	12 Months 500 Hours	1500 Hours 12 Months	2000 Hours	2 Years 6000 Hours
Task	**Operator Task**		**Service Technician Task**				
Check operation of Control Panel: Check display (the system will perform a control panel test on initial activation). To replace, contact your authorized distributor.	■						
Check operation of Emergency Stop Button: With the generator set running, press the Emergency Stop button. Check all systems, before resetting the fault.		■					

TABLE 6. COOLING MAINTENANCE

MAINTENANCE ITEMS Perform maintenance tasks as specified using Daily or Hourly periods – whichever occurs first	Daily 8 Hours	Weekly 50 Hours	6 Months 250 Hours	12 Months 250 Hours	1500 Hours 12 Months	2000 Hours	2 Years 6000 Hours
Task	**Operator Task**		**Service Technician Task**				
Check coolant level of radiator(s) (water jacket & LTA): If low, top up to coolant system specifications level, with Cummins recommended coolant mix.	■						
Check cooling fan blades: Visually inspect the fan blades through the guarding for signs of wear or damage. To replace, contact your authorized distributor.	■						
Check drive belt, condition and tension: Visually check belt for evidence of wear or slippage. To replace, contact your authorized distributor.	■						
Check coolant lines and radiator hoses for leaks, wear, and cracks: Visually check for leaks, worn or damages hoses. To replace, contact your authorized distributor.	■		■				
Check radiator air flow: Visually inspect the radiator through the guarding for blockage, build up of debris, signs of wear or damage. To clean or replace, contact your authorized distributor.	■						
Clean radiator matrix.			■[1]				
Check aftercooler core.						■	
Check water pump.						■	
Check belt driven fan hub.							■
Change coolant filter.			■				
Check coolant heater.					■		
Fan drive idler arm and fan belt tensioner check.					■		
Replace cooling system coolant.							■

■[1] – Cleaning schedule may be reduced depending on operating conditions/environment. Contact your authorized distributor.

TABLE 7. ENGINE MAINTENANCE

MAINTENANCE ITEMS Perform maintenance tasks as specified using Daily or Hourly periods – whichever occurs first	Daily 8 Hours	Weekly 50 Hours	6 Months 250 Hours	12 Months 250 Hours	1500 Hours 12 Months	2000 Hours	2 Years 6000 Hours
Task	**Operator Task**		**Service Technician Task**				
Check fuel lines and hoses: Visually check for leaks, worn or damages hoses. To replace, contact your authorized distributor.	■[1]						
Check engine oil level: If low, top up to engine specifications level, with recommended oil.	■						
Drain water from fuel system primary filter/water separator: Drain one cup, or more, of fuel to remove water and sediment. See procedure in this chapter.	■						
Crankcase breather tube/collector. Check for condensed oil. Drain and dispose of in accordance with local legislation.	■						
Check charge alternator: Check visually and audibly when the generator set is running. To replace, contact your authorized distributor.	■						
Check engine oil make-up system: If low, top up to to indicated level, with Cummins recommended oil.	■						
Check engine coolant heater: Check coolant heater has power and is running. To replace, contact your authorized distributor.	■						
Replace lubricating oil and filters.				■			
Check engine ground. Clean as necessary.				■			
Replace water separator element.			■	■			
Replace fuel system secondary filter.			■	■			
Check engine mounts.			■				
Check starting motor.					■		
Check turbocharger.					■		
Engine oil heater check.					■		
Engine steam clean.					■		
Air compressor discharge lines check.					■		
Check air compressor unloader and valve assembly.							■

■[1] – Check before starting and again with the generator set running.

TABLE 8. EXHAUST MAINTENANCE

MAINTENANCE ITEMS Perform maintenance tasks as specified using Daily or Hourly periods – whichever occurs first	Daily 8 Hours	Weekly 50 Hours	6 Months 250 Hours	12 Months 250 Hours	1500 Hours 12 Months	2000 Hours	2 Years 6000 Hours
Task	**Operator Task**		**Service Technician Task**				
Check all exhaust components, and hardware (fittings, clamps, fasteners, etc.): Visually inspect the exhaust system for signs of wear or damage. Check audibly when the generator set is running. To replace, contact your authorized distributor.	■						
Check exhaust condensation trap: Drain condensation into a suitable container. Dispose of fluids in accordance with local legislation.	■						

TABLE 9. GENERATOR SET MAINTENANCE

MAINTENANCE ITEMS Perform maintenance tasks as specified using Daily or Hourly periods – whichever occurs first	Daily 8 Hours	Weekly 50 Hours	6 Months 250 Hours	12 Months 250 Hours	1500 Hours 12 Months	2000 Hours	2 Years 6000 Hours
Task	**Operator Task**		**Service Technician Task**				
Check fuel level in tank: If low, add fuel (A full tank reduces condensation.)	■						
Check bedframe/enclosure fluid containment (where fitted): Drain as necessary. Clean all contaminated areas. Dispose of fluids in accordance with local legislation.	■						
Check generator set enclosure: Visually check enclosure, walk around inspection of generator set. Make sure no inlets/outlets are covered/restricted, service access doors are operational and safety systems are in place and operational. To replace damaged parts, contact your authorized distributor.	■						
Check batteries: Check connections are secure and battery area is free from tools and other items.		■			■		
Check battery electrolyte level.				■			
Check electrical connections (battery, starter motor and alternator connections).				■	■		

TABLE 10. PERIODIC MAINTENANCE SCHEDULE - 3000 HOURS TO SIX YEARS

Maintenance Items	3000 Hours	2 Years or 3000 Hours	4000 Hours	3 Years or 4500 Hours	3 Years or 6000 Hours	6 Years or 12000 Hours
Perform maintenance tasks as specified using Daily or Hourly periods – whichever occurs first	**Service Technician Task**		**Operator Task**	**Service Technician Task**		
Check fuel injectors. Replace as necessary.	■					
Check aftercooler core. Clean as necessary.		■				
Check alternator vibration levels. Clean as necessary.					■	
Check alternator bearing housings.						■
Check alternator winding condition.						■
Check alternator rotating diode assembly.						■
Replace cooling system coolant (commercial heavy duty).			■			
Replace cooling system coolant (ELC).						■
Replace alternator bearings.						■
Replace alternator NDE o-ring.						■
Add cooling system coolant extender (ELC).					■	
Clean and regrease alternator bearings.				■		

TABLE 11. ALTERNATOR SERVICE SCHEDULE

System	SERVICE ACTIVITY	Alternator running	TYPE				SERVICE LEVEL								
	X = required * = if necessary		Inspect	Test	Clean	Replace	Commission	Post Commission	250 hrs / 0.5 year	Level 1	1000 hrs / 1 year	Level 2	10,000 hrs / 2 years	Level 3	30,000 hrs / 5 years
Alternator	Alternator rating		X				X								
	Bedplate arrangement		X				X								
	Coupling arrangement		X				X					*		X	
	Environmental conditions and cleanliness		X				X	X		X		X		X	
	Ambient temperature (inside & outside)			X			X	X		X		X		X	
	Complete machine - damage, loose parts & earth bonds		X				X	X		X		X		X	
	Guards, screens, warning and safety labels		X				X	X		X		X		X	
	Maintenance access		X				X								
	Electrical nominal operating conditions & excitation	X		X			X	X		X		X		X	
	Vibration	X		X			X	X		X		X		X	
Windings	Condition of windings		X				X	X		X		X		X	
	Insulation resistance of all windings (PI test for MV/HV)			X			X	*		*		X		X	
	Insulation resistance of rotor, exciter and PMG			X				X		X					
	Temperature sensors	X		X			X	X		X		X		X	
	Customer settings for temperature sensors		X				X								
Bearings	Condition of bearings		X				X							X	
	Grease exhaust & trap				X			X		X		X		X	
	Grease in re-greasable bearing(s)	X				X		every 4000 to 4500 hours							
	Sealed bearing(s)		X					every 4000 to 4500 hours							
	Re-greasable & sealed bearing(s)					X						*		X	
	Temperature sensors	X		X			X	X		X		X		X	
	Customer settings for temperature sensors		X				X								

System	SERVICE ACTIVITY X = required * = if necessary	Alternator running	TYPE				SERVICE LEVEL								
			Inspect	Test	Clean	Replace	Commission	Post Commission	250 hrs / 0.5 year	Level 1	1000 hrs / 1 year	Level 2	10,000 hrs / 2 years	Level 3	30,000 hrs / 5 years
Terminal Box	All alternator/customer connections and cabling		X				X	X		X		X		X	
Controls & Auxiliaries	Initial AVR & PFC set up	X		X			X								
	AVR & PFC settings	X		X				X		X		X		X	
	Customer connection of auxiliaries			X			X			X		X		X	
	Function of auxiliaries			X			X	X		X		X		X	
	Synchronization settings		X				X								
	Synchronization	X		X			X	X		X		X		X	
	Anti condensation heater					X						*		X	
Rectifier	Diodes and varistors		X				X	X		X		X			
	Diodes and varistors					X								X	
Cooling	Air inlet temperature	X		X			X	X		X		X		X	
	Air flow (rate & direction)	X	X				X								
	Condition of fan		X				X	X		X		X		X	
	Condition of air filter (where fitted)			X			X	X		X		X		X	
	Air filters (where fitted)				X	X				*		*		*	

5 Troubleshooting

5.1 Troubleshooting - General

5.1.1 Control System

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

Refer to the control manual listed in the Related Literature section for control troubleshooting.

5.1.2 Safety Considerations

⚠ WARNING

Troubleshooting procedures.

Many troubleshooting procedures present hazards that can result in severe personal injury or death.

Only trained and experienced service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review the safety precautions in Chapter 1 on page 1

⚠ WARNING

High voltage.

Contacting high voltage components can cause electrocution, resulting in severe personal injury or death.

Keep the output box covers in place during troubleshooting.

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

⚠ WARNING

Battery gases.

Ignition of explosive battery gases can cause severe personal injury or death.

Arcing at battery terminals, a light switch or other equipment, flame, pilot lights, and sparks can ignite battery gases that can cause severe personal injury or death.

Do not smoke or switch a trouble light ON or OFF near a battery. Discharge static electricity from your body before touching batteries by first touching a grounded metal surface. Ventilate the battery area before working on or near a battery. Using an insulated wrench, disconnect the negative (-) cable first and reconnect it last.

⚠ WARNING

Accidental starting.

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

Prevent accidental starting by disconnecting the negative (−) cable from the battery terminal with an insulated wrench.

NOTICE

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

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

1. Make sure the generator set is in the Off mode.
2. Turn off or remove AC power from the battery charger.
3. Using an insulated wrench, remove the negative (−) battery cable from the generator set starting battery.

5.1.3 InPower Service Tool

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

InPower, when used improperly, can cause symptoms like warnings and shutdowns that appear to be a defective base board. When these problems occur, always verify that a self-test or fault simulation (override) have not been left enabled with InPower. If you do not have InPower, or the enabled fault simulation(s) cannot be found using InPower, disconnect battery power to disable the test or override condition.

Make sure that parameter adjustments and time delays, related to the fault condition, have been appropriately set for the application. It may be necessary to write the initial capture file to the device or update the calibration file.

Updating a calibration file requires the InPower Pro version. Confirm that the installed calibration part number matches the serial plate information.

NOTICE

Using the wrong calibration file can result in equipment damage. Do not swap base boards from another generator set model.

Some features are not available until the hardware for that feature is installed and InPower Pro is used to update (enable) that feature. Confirm that the feature is installed and enabled prior to troubleshooting the base board for symptoms related to a feature.

5.1.4 Network Applications and Customer Inputs

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

5.1.5 Test Equipment

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

- True RMS digital multi-meter for accurate measurement of resistance, AC voltage (0-1000 VAC), and DC voltage.

- Current probe(s).
- Battery hydrometer.
- Jumper leads.
- Tachometer.
- Megger or insulation resistance meter.
- InPower service tool (PC-based service tool)
- Newest InPower InCal files (calibration for control) from the InCal web site (**www.cumminspower.com** under “Services", “Software Updates", “InCal Quick Links").
- PC-based service tool connector (Cummins Power Generation Part number 0541-1199).
- Inline 4 / Inline 5 adapter or newer (Cummins Power Generation Part number 0491-8416).
- Inline 4 / Inline 5 drivers (available via kit or online at **http://inline.cummins.com/**).
- Basic electrical test lead set, with very small probe tips. Fluke test leads “TL80A" (part number 0541-1627) are recommended.
- 316289800 - Pressure/Temperature sensor breakout cable
- 382477400 - Pressure sensor breakout cable
- 382477600 - Pressure sensor breakout cable
- 316475200 - DanfossTM pressure sensor breakout cable TM pressure sensor breakout cable
- 382275800 - Male Deutsch/AMP/Metri-Pack test lead
- 382291700 - Female Deutsch/AMP/Metri-Pack test lead
- 382481200 - Deutsch socket pin test lead
- 382481100 - Deutsch pin test lead

5.1.6 Voltage/Continuity Testing

Voltage and continuity tests are required in the following tables. In some cases, it is necessary to remove a plug to complete the test.

The following corrective actions will mention when it is necessary to remove a plug for testing. In other cases, the plug must not be removed for testing. When plug removal is not mentioned, testing must be performed by inserting a narrow meter probe into the back of the plug.

5.1.7 CT Ratio Calculator

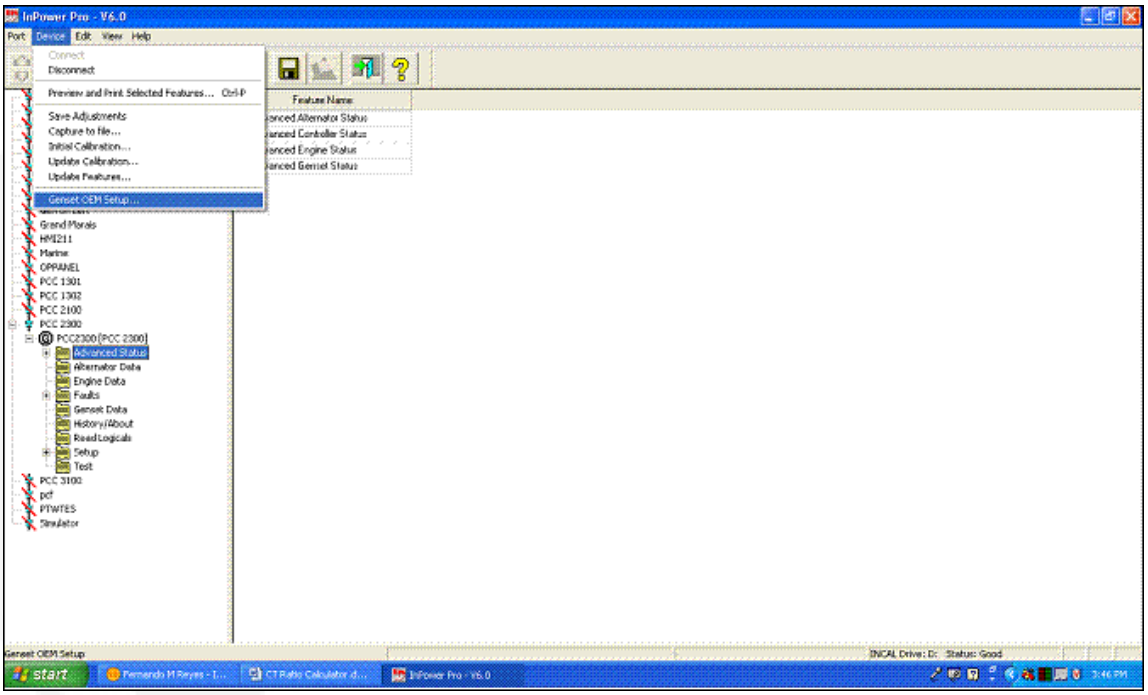
InPower has a built-in CT ratio calculator which allow you to determine the required CT size and CT ratio.

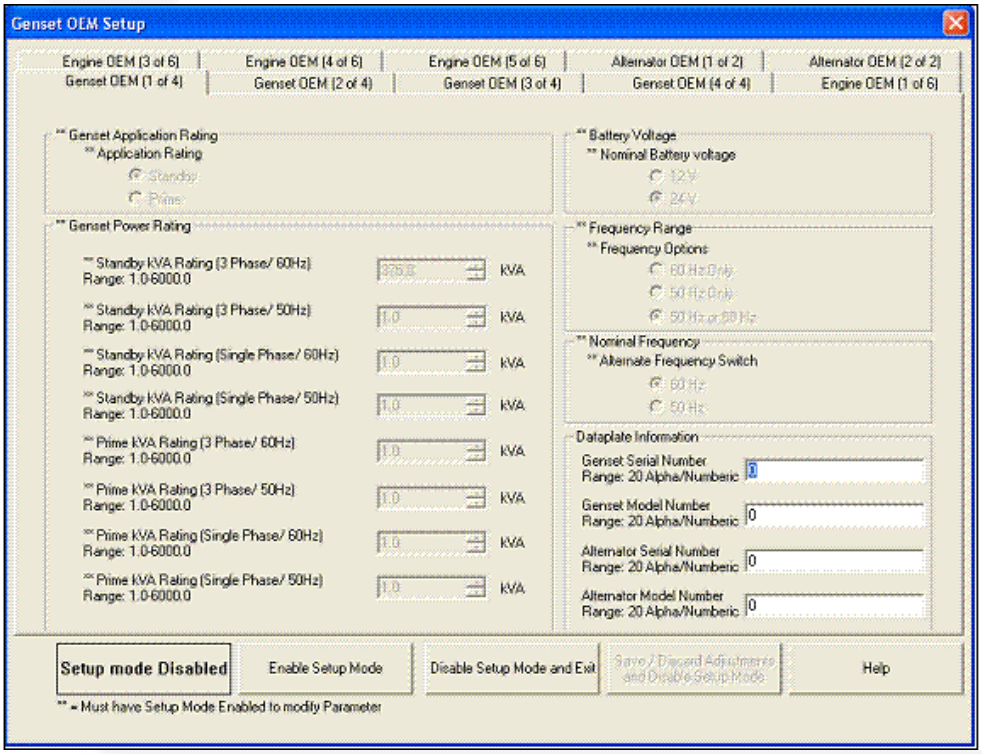
The following generator set information is required to calculate the CT ratio:

- Generator set power ratings
- Frequency range
- Nominal frequency
- Nominal voltage Limits
- Secondary CT ratio value

Follow these steps to use the CT ratio calculator in InPower.

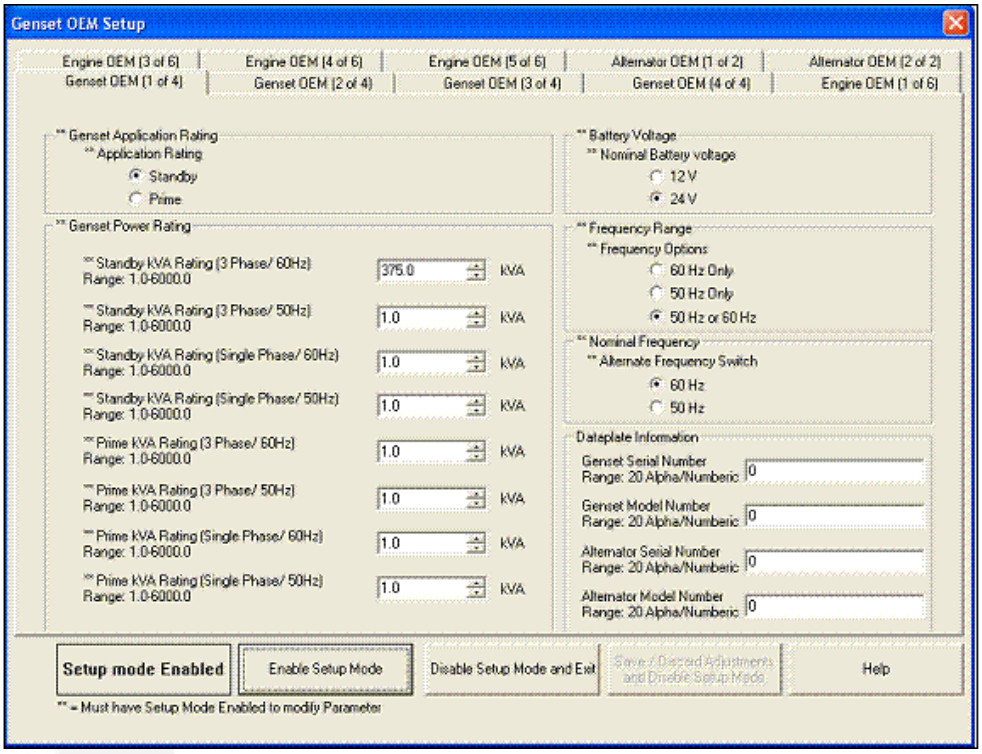
1. Connect to the PCC and highlight any of the folders under the PCC connection (such as Advanced Status). Right click on the folder, and click on Genset OEM Setup...



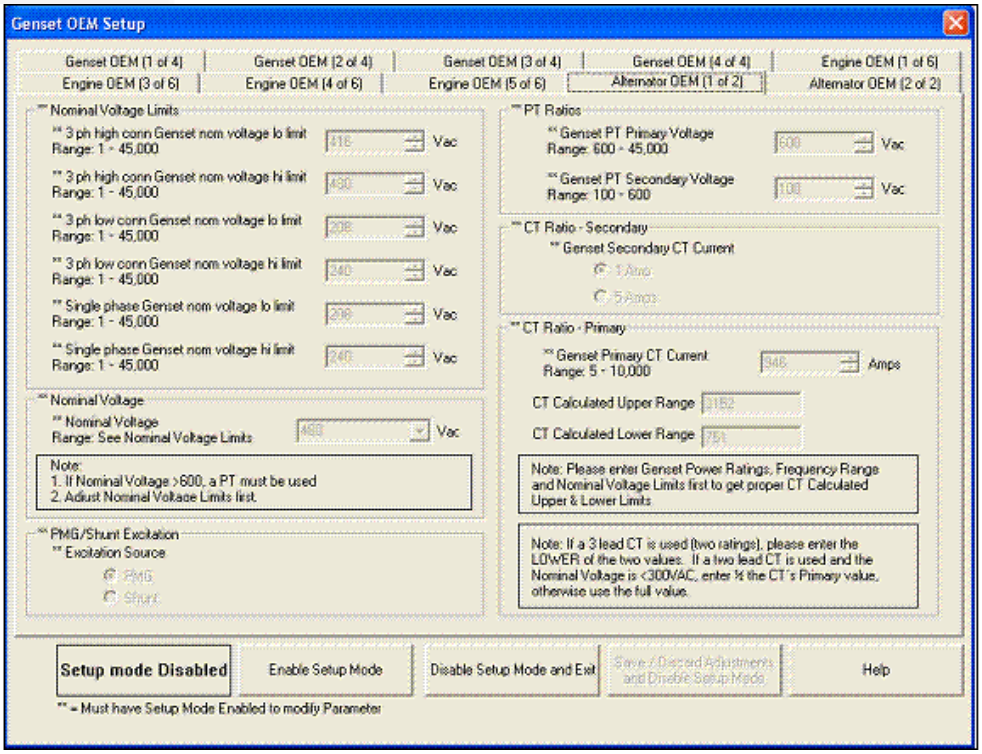


2. Click on Enable Setup Mode in order to enable the menu.
3. Enter the generator set information under Genset Power Ratings, Frequency Range, and Nominal Frequency.

4. Click on Save/Discard Adjustments and Disable Setup Mode in order to save the generator set settings. This step is required.



5. Open the Genset OEM Setup again.
6. Click on the Alternator OEM (1 of 2) tab to display the settings below.

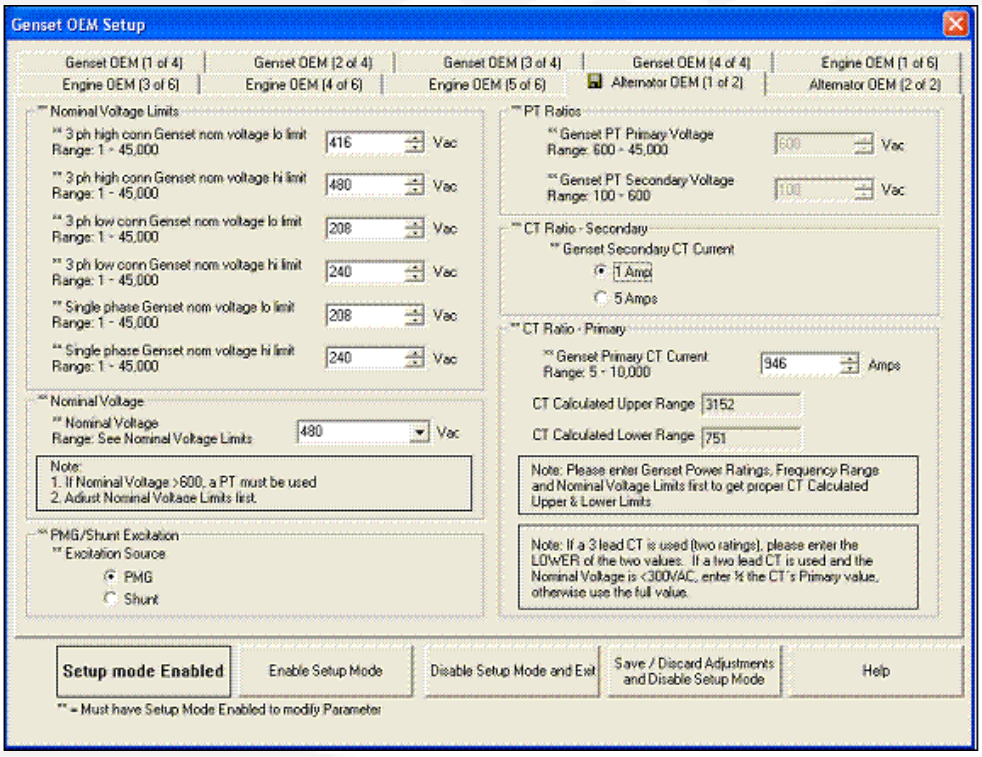


7. Click on Enable Setup Mode in order to enable the menu.

8. Enter the generator set information under Nominal Voltage Limits and CT Ratio –Secondary. After all the information is entered, InPower will calculate the required Genset Primary CT Ratio limits. The primary CT Ratio needs to be between the CT Calculated Upper Range and the CT Calculated Lower Range.

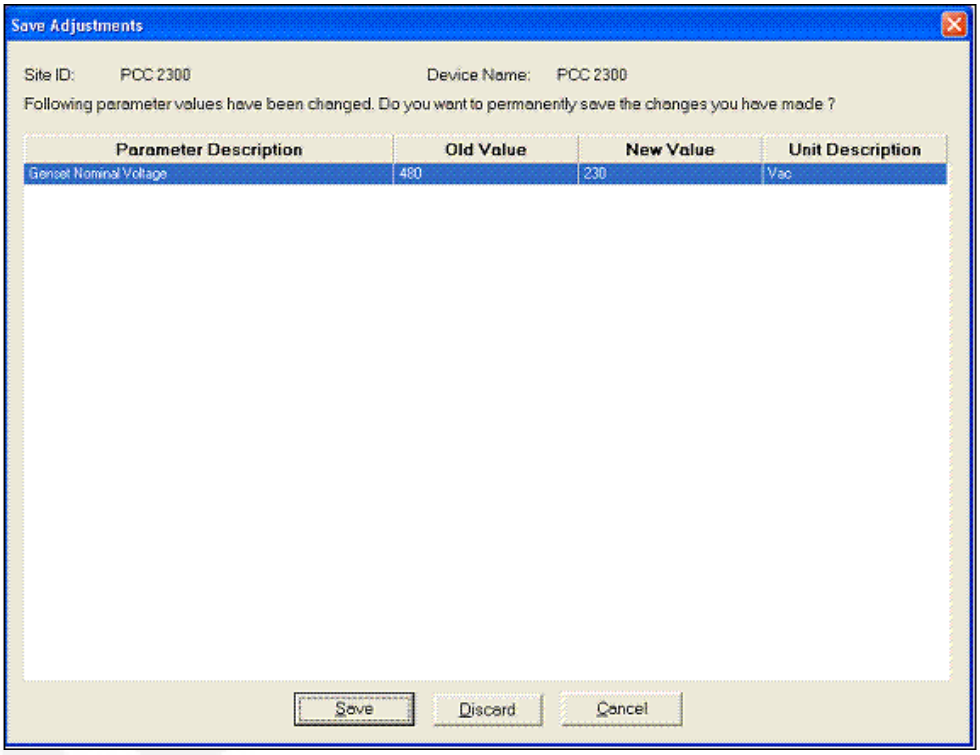
   The CTs and the CT ratio setting in the PCC require a primary CT ratio between the CT Calculated Upper Range and the CT Calculated Lower Range.

   The alternator CT ratio is required to have a secondary CT Ratio equal to the setting under the CT Ratio – Secondary.



9. To exit the setup mode and save changes, click on Save / Discard Adjustments and Disable Setup Mode.

   To exit the setup mode without saving changes, click on Disable Setup Mode and Exit. Then, click on Discard when the Save Adjustments Screen pops up.



5.1.8 Reading Fault Codes

When a fault occurs, the graphical display on the HMI will display the fault code/message.

After the fault is acknowledged and corrected, the recorded fault will be deleted from the control panel memory, but will remain in a data log to maintain a fault code history. The InPower service tool is required to view this data log.

5.1.9 Troubleshooting Procedures

The following list of troubleshooting procedures are a guide to help you evaluate problems with the generator set. You can save time if you read through the manual ahead of time and understand the system.

⚠ CAUTION

Always set the generator set to off mode before disconnecting or connecting harness connectors. Otherwise, disconnecting the harness connectors can result in voltage spikes high enough to damage the DC control circuits of the set.

⚠ CAUTION

Electrostatic discharge will damage circuit boards. Always wear a wrist strap when handling circuit boards or when disconnecting or connecting harness connectors. See the Circuit Board Removal/Replacement procedure in the controller Service Manual.

NOTICE

The troubleshooting procedures for ECM-related faults and engine-related faults are in the engine service manual.

NOTICE

Each fault code “warning" can be changed to a “shutdown" using InPower. Default settings are used in this manual. It is recommended that all changes to settings be recorded at each site to aid in the troubleshooting of the generator set.

If you are troubleshooting a fault that does not appear in the graphical display, look at the SA field in the Faults screens to identify the source of the fault. If this field is blank, the PCC is the source of this fault.

Try to think through the problem. Go over what was done during the last service call. The problem could be as simple as a loose wire, an opened fuse, or a tripped circuit breaker.

This section contains the following information:

- How to troubleshoot a local/remote failure to crank problem when the control panel does not indicate any fault condition.
- How to troubleshoot engine problems that are not within the detectable range of the PC control.
- How to troubleshoot a Check Engine lamp fault for generator sets that contain the low emissions option.
- Descriptions of each status, warning, and shutdown code; warning and shutdown limits where applicable; and basic corrective actions, such as checking fluid levels, control reset functions, battery connections, etc.
- Detailed troubleshooting procedures. In the following list of troubleshooting procedures, the fault codes are arranged in numeric order.

5.1.10 Fault Reset Signal

This signal may come from any of these sources:

- PCC Fault Reset connection (typically, the Reset button on the Operator Panel)
- Reset button on the Operator Panel
- Modbus networks
- PC-based service tool, such as InPower

This signal becomes active for one second when any of these sources changes from inactive to active. Then, the signal remains inactive until any of these sources changes from inactive to active again.

5.1.11 Delayed Shutdown

The PCC provides advance warning of an impending shutdown if all of these conditions are met:

- *Delayed Shutdown Enable* is set to Enable.
- The ECM is set to enable Battle Short mode (Core 2 ECMs only).
- A non-critical shutdown fault occurs, and there are no critical shutdown faults.

When these conditions are met, the PCC generates warning fault 1124 (Delayed Shutdown) and waits *Delayed Shutdown Time Delay* before it initiates the stop sequence.

5.2 Troubleshooting Fault Codes

5.2.1 Types of Events/Faults

The PCC generates these types of events/faults.

5.2.2 Event/Fault List Definition

Faults and events that appear in the table that do not have a troubleshooting procedure in this manual are engine driven faults/events. To troubleshoot these faults, consult the engine Service manual, engine Troubleshooting and Repair manual, and/or QuickServe OnLine.

5.2.3 Events

The PCC generates events to notify external devices when certain conditions are met. The PCC may send notifications any of these ways:

- Configurable outputs.
- PCCNet devices (For example, events might control a LED or a configurable output on a PCCNet device.)

It is up to the external devices to respond to an event when they are notified about one. Events do not appear in any screen in the Operator Panel.

5.2.4 Warning Faults

The PCC generates warning faults to warn the operator when unsafe conditions are occurring.

When the PCC generates a warning fault, the warning fault becomes active. However, active warning faults have no effect on generator set operation. The generator set can start, continue running, and stop as usual.

Active warning faults appear in the Warning Faults screen. In addition, the PCC provides these indications as long as there is an active warning fault:

- The Warning LED on the Operator Panel is on.
- Event 1540 (Common Warning) is active.
- Event 1483 (Common Alarm) is active.

Follow these steps to clear a warning fault.

1. Correct the condition(s) that caused the fault.
2. Activate the fault reset signal.

Faults that have been cleared appear in the Fault History screen.

5.2.5 Derate Events

Derate events are warning faults in which the PCC also requests a reduction in the kW output level of the generator set.

If a derate event is active, *Derate Request* (This Parameter is not available in the Operator Panel, refer to parameters table) is the percentage of the current kW output level the PCC would like to have removed. Each derate event has this percentage associated with it. If two or more derate events are active at the same time, the PCC considers only the maximum percentage requested by each derate event. The PCC does not add the percentages together. For example, if one derate event requests a 10% reduction and a second derate event requests a 20% reduction, *Derate Request (This Parameter is not available in the Operator Panel, refer to parameters table)* is 20%, not 30%.

The PCC is running in Load Govern paralleling state, the PCC requests that *Genset % Standby Total kW* be no more than 100% - *Derate Request (This Parameter is not available in the Operator Panel, refer to parameters table)*. This becomes a limitation for *Load Govern kW Target*.

If the PCC is not running in Load Govern paralleling state, the PCC generates warning fault 1464 (Load Dump Fault). If *Load Dump/Configurable Output #11 Output Function Pointer* is set to Default, the Load Dump connection is active. The PCC does not do anything else to reduce the kW output level. It is up to external devices to reduce the load.

If *LBNG Genset Enable* is set to Enable, the PCC recognizes derate requests from the engine control module (ECM) only if all of these conditions are met.

- *LBNG Derate Enable* is set to Enable.
- The AUX 101's Derate Authorization connection is active.

5.2.6 Shutdown Faults

The PCC generates shutdown faults to prevent damage to the generator set. The PCC shuts down the generator set immediately.

When the PCC generates a shutdown fault, the shutdown fault becomes active. The PCC initiates a Shutdown Without Cooldown sequence.

Active shutdown faults appear in the Shutdown Faults screen. In addition, the PCC provides these indications as long as there is an active shutdown fault:

- The Shutdown LED on the Operator Panel is on.
- Event 1541 (Common Shutdown) is active.
- Event 1483 (Common Alarm) is active.

You cannot start the generator set until you clear the shutdown fault. Follow these steps to clear a shutdown fault.

1. Correct the condition(s) that caused the fault.
2. Make sure the emergency stop buttons are inactive, and change the PCC to Off mode.

NOTICE
If Remote Fault Reset Enabled is set to Enable, you can also clear shutdown faults in Auto mode. In this case, change the PCC to Auto mode , and make sure the exercise signal and the remote start signal are inactive. The PCC generates event 2941 (Remote Shutdown Fault Reset Occurrence) when shutdown faults are reset in Auto mode.

3. Activate the fault reset signal.

Faults that have been cleared appear in the Fault History screen.

5.2.6.1 Shutdown with Cooldown Faults

Shutdown with cooldown faults are shutdown faults in which the PCC has time to cool down the generator set.

When the PCC generates a shutdown with cooldown fault, the shutdown with cooldown fault becomes active. If the PCC is running in Load Govern paralleling state, it initiates a Manual Stop sequence and starts running the load govern kW ramp unload process. If the PCC is not running in Load Govern paralleling state, it initiates a Controlled Shutdown sequence. When the stop sequence has finished, the PCC generates shutdown fault 1336 (Cooldown Complete).

If a shutdown with cooldown fault is active and the engine speed is greater than zero, warning fault 1132 (Controlled Shutdown) is active. You can assign this event/fault to a configurable output, so that the PCC notifies an external device that is going to shut down the generator set.

In other ways, shutdown with cooldown faults are the same as shutdown faults.

5.2.6.2 Critical Shutdown Faults vs. Non-critical Shutdown Faults

The PCC always shuts down the generator set when a critical shutdown fault is generated. Non-critical shutdown faults do not prevent the PCC from starting or running the generator set when Battle Short mode is active. The PCC also responds to critical shutdown faults and non-critical shutdown faults differently if Delayed Shutdown is set up .

NOTICE
This discussion applies to shutdown with cooldown faults as well as shutdown faults.

The table below identifies the critical shutdown faults.

TABLE 12. CRITICAL SHUTDOWN FAULTS

Event/Fault Code	Description
115	Eng Crank Sensor Error
234	Crankshaft Speed High
236	Both Engine Speed Signals Lost
359	Fail To Start
781	CAN Data Link Failure
1245	Engine Shutdown Fault
1247	Unannounced Engine Shutdown
1336	Cooldown Complete
1433	Local Emergency Stop
1434	Remote Emergency Stop
1438	Fail To Crank
1992	Crankshaft Sensor High
2335	AC Voltage Sensing Lost (Excitation Fault)
2914	Genset AC Meter Failed

All other shutdown faults are non-critical shutdown faults. The PCC still provides the usual indications that a shutdown fault has occurred, even if it overrides a non-critical shutdown fault.

5.2.7 Fault Codes

This table identifies the faults codes and events that the PCC can generate depending on it's configuration.

NOTICE
InPower can be used to raise the response/severity of an event or fault. For example, an event can be changed to a warning fault or a warning fault to a shutdown fault. The response/severity of an event or fault (except event/fault 1452 (Genset Breaker Fail to Close)) cannot be set lower than its default value, and the severity cannot be changed of any fault or event with an asterisk (**).

Codes marked with * are generator related fault codes. For all other codes for the possible cause, failure and diagnosis refer to the relevant engine service manual.

TABLE 13. FAULT CODES

Code	Event/Lamp	Displayed Message
111	Shutdown	Internal ECM Failure
115	Shutdown	Eng Crank Sensor Error
118	Warning	Fuel Pressure OOR High
119	Warning	Fuel Pressure Sensor OOR Low
121	Shutdown	Loss of Speed Sense
122	Warning	Manifold 1 Press High
123	Warning	Manifold 1 Press Low
124	Warning	Manifold 1 Press High
135	Warning	High Oil Rifle 1 Pressure
141	Warning	Low Oil Rifle 1 Pressure
143	Warning	Low Oil Rifle Pressure
144	Warning	High Coolant 1 Temp
145	Warning	Low Coolant 1 Temp
146	Derate	Pre-High Engine Coolant Temperature
151	Shutdown	High Coolant Temp
153	Warning	High Intake Manf 1 Temp
154	Warning	low Intake Manf 1 Temp
155	Shutdown	High Intake Manf 1 Temp
187	Warning	Sensor Supply 2 Low
195	Warning	High Coolant 1 Level
196	Warning	Low Coolant 1 Level
197*	Warning	Low Coolant Level

Code	Event/Lamp	Displayed Message
212	Warning	High Oil 1 Temperature
213	Warning	Low Oil 1 Temperature
214	Shutdown	High Oil 1 Temp
219	Warning	Eng Oil Level Remote Reservoir: Least Severe Level
221	Warning	Air Pressure Sensor High
222	Warning	Air Pressure Sensor Low
223	Warning	Oil Burn Valve Sol Low
224	Warning	Oil Burn Valve Sol High
227	Warning	Sensor Supply 2 Low
228	Shutdown	Low Coolant Pressure
231	Warning	High Coolant Pressure
232	Warning	Low Coolant Pressure
233	Warning	HT Coolant Pressure Moderate Low
234*	Shutdown	Crankshaft Speed High
235*	Shutdown	Low Coolant Level
236*	Shutdown	Both Engine Speed Signals Lost
238	Warning	Sensor Supply 3 Low
239	Warning	Main Supply High
245	Warning	Fan Control Low
254	Shutdown	FSO PWM High Contorl Error
255	Warning	FSO PWM Low Control Error
259	Warning	Engine Fuel Shutoff Valve Stuck Open
261	Warning	High Fuel Temperature
263	Warning	High Fuel 1 Temperature
265	Warning	Low Fuel 1 Temperature
266	Shutdown	High Fuel Temperature
271	Warning	Low Fuel Pump Press
272	Warning	High Fuel Pump Press
277		Fuel Control Valve Out of Adj
281	Warning	Cylinder Press Imbalance
284	Warning	Eng Speed/Position Sensor: Voltage Below Normal
285	Warning	CAN Mux PGN Rate Error
286	Warning	CAN Mux Calibration Error
287	Warning	CAN Mux Accel Data Error
295	Warning	Key On Air Pressure Error
311	Warning	ACT1 FF Shorted HS TO LS Error
312	Warning	ACT5 Shorted HS TO LS Error
313	Warning	ACT3 RF Shorted HS TO LS Error

Code	Event/Lamp	Displayed Message
314	Warning	ACT6 Shorted HS TO LS Error
315	Warning	ACT2 FT Shorted HS TO LS_Error
319	Warning	RTC PWR Intr: Data Erratic Intermittent or Wrong
321	Warning	ACT4 RT Shorted HS TO LS Error
322	Warning	Inj 1 Solenoid Low Curr
323	Warning	Inj 5 Solenoid Low Curr
324	Warning	Inj 3 Solenoid Low Curr
325	Warning	Inj 6 Solenoid Low Curr
331	Warning	Inj 2 Solenoid Low Curr
332	Warning	Inj 4 Solenoid Low Curr
341	Warning	Engine Control Module Data Lost
342	Shutdown	Calibration Code Fail
343	Warning	ECM Hardware Failure
351	Warning	Injector Supply Failure
352	Warning	Sensor Supply 1 Low
359*	Shutdown	Fail to Start
378	Warning	Elect Fuel Inj Cntrl Valve Ckt: Curr Below Normal
379	Warning	Elect Fuel Inj Cntrl Valve Ckt: Curr Above Normal
386	Warning	Sensor Supply 1 High
394	Warning	Eng Timing Actuator Driver: Curr Below Normal
395	Warning	Eng Timing Actuator Driver: Curr Above Normal
396	Warning	Fuel Cntl Valve Solenoid Driver 2 Sensor Ckt: OC
397	Warning	Fuel Cntl Valve Solenoid Driver 2 -
398	Warning	Eng Timing Actuator Driver 2 Circuit: OC
399	Warning	Eng Timing Actuator Driver 2: Grounded Ckt
415	Shutdown	Low Oil Rifle Press
418	Warning	High H2O in Fuel
419	Warning	Intake Manifold Pres Bank Imbalance: Data Erratic
421*	Derate	High Oil Temperature
422	Warning	Coolant Level Data Error
425	Warning	Oil Temperature Error
426*	Event	J1939 Datalink: Data Erratic/Intermittent/Wrong
427*	Warning	CAN Data Link Degraded
433	Warning	Intake Manifold Press Sensor Ckt: Data Erratic
435	Warning	Oil Pressure Switch Error
441*	Warning	Low Battery 1 Voltage
442*	Warning	High Battery 1 Voltage
449	Shutdown	Inj Metering 1 Press High

Code	Event/Lamp	Displayed Message
451	Warning	Inj Metering 1 Press High
452	Warning	Inj Metering 1 Press Low
482	Warning	Fuel Press Low: Valid But Below Normal: Mod Severe
488*	Derate	High Intake Manf 1 Temp
496	Warning	Eng Speed Sensor 2 Supply Volt: Root Cause Unknown
546	Warning	Fuel Delivery Press High
547	Warning	Fuel Delivery Press Low
553	Warning	APC Pressure High
554	Warning	APC Pressure Error
556	Shutdown	Crankcase Pressure High
559	Warning	Inj Metering 1 Press Low
611*	Warning	Engine Hot Shut Down
686	Warning	Turbo 1 Speed Incorrect
689	Warning	Crankshaft Speed Error
697	Warning	ECM Temperature High
698	Warning	ECM Temperature Low
731	Warning	Crankshaft Mech Misalign
757	Warning	All Persistent Data Lost Error
778	Warning	EPS Backup Lost Sync Error
781*	Shutdown	CAN Data Link Failure
782	Warning	SAE J1939 Data Link 2 Engine Network No Data Received – Condition Exists
783	Shutdown	Intake Manf 1 Rate Error
1117	Warning	Power Lost With Ignition On
1121*	Warning	Fail To Disconnect
1122*	Event	Rated To Idle Delay
1123*	Shutdown	Shutdown After Battle Short (Shutdown)
1124*	Warning	Delayed Shutdown
1131*	Warning	Battle Short Active
1132*	Warning	Controlled Shutdown
1139	Warning	UFD Injector 1 Error
1141	Warning	UFD Injector 2 Error
1142	Warning	UFD Injector 3 Error
1143	Warning	UFD Injector 4 Error
1144	Warning	UFD Injector 5 Error
1145	Warning	UFD Injector 6 Error
1219*	Warning	Utility Breaker Tripped
1223*	Warning	Utility Frequency

Code	Event/Lamp	Displayed Message
1224*	Warning	Genset Overvoltage
1225*	Warning	Genset Undervoltage
1226*	Warning	Genset Frequency
1243*	Derate	Engine Derated
1244*	Shutdown	Engine Normal Shutdown
1245*	Shutdown	Engine Shutdown Fault
1246*	Warning	Unknown Engine Fault
1247*	Shutdown	Unannounced Engine Shutdown
1248*	Warning	Engine Warning
1256	Warning	Ctrl Mod ID In State Error
1257	Shutdown	Ctrl Mod ID In State Fail
1312*	Event	Configurable Input # 2
1317*	Event	Configurable Input # 13
1318*	Event	Configurable Input # 14
1322*	Warning	kW Load Setpoint OOR High
1323*	Warning	kW Load Setpoint OOR Low
1324*	Warning	kVAR Load Setpoint OOR High
1325*	Warning	kVAR Load Setpoint OOR Low
1328*	Warning	Genset Breaker Tripped
1336*	Shutdown	Cooldown Complete
1357	Warning	Oil Remote Level Low
1363	Warning	Intake Manf 1 Press Low
1367	Warning	High Prefilter Oil Press
1368	Warning	Low Prefilter Oil Press
1376	Warning	Camshaft Speed Error
1411	Warning	High Out Freq Adjust Pot
1412	Warning	High Droop Adjust Pot
1416*	Warning	Fail To Shutdown
1417*	Warning	Power Down Failure
1418	Warning	High Gain Adjust Pot
1427	Warning	Overspeed Relay Error
1428	Warning	LOP Relay Error
1429	Warning	HET Relay Error
1431	Warning	Pre-LOP Relay Error
1432	Warning	Pre-HET Relay Error
1433*	Shutdown	Local Emergency Stop
1434*	Shutdown	Remote Emergency Stop
1435*	Warning	Low Coolant Temperature

Code	Event/Lamp	Displayed Message
1438*	Shutdown	Fail To Crank
1439*	Warning	Low Day Tank Fuel Switch
1441*	Warning	Low Fuel Level
1442*	Warning	Weak Battery
1443*	Shutdown	Dead Battery
1444*	Warning	Overload
1445*	Shutdown	Short Circuit
1446*	Shutdown	High AC Voltage
1447*	Shutdown	Low AC Voltage
1448*	Shutdown	Under Frequency
1449*	Warning	Over Frequency
1451*	Warning	Gen/Bus Voltages Out of Calibration
1452*	Warning	Genset Breaker Fail To Close
1453*	Warning	Genset Breaker Fail To Open
1454*	Warning	Genset Breaker Position Contact
1455*	Warning	Utility Breaker Position Contact
1456*	Warning	Bus Out Of Synchronizer Range
1457*	Warning	Fail To Synchronize
1458*	Warning	Sync Phase Rotation Mismatch Overfrequency
1459*	Shutdown	Reverse Power
1461*	Shutdown	Loss of Field (Reverse kVAR)
1463**	Event	Not In Auto
1464**	Warning	Load Dump Fault
1465**	Event	Ready To Load
1469*	Warning	Speed/Hz Mismatch
1471*	Warning	Over Current
1472*	Shutdown	Over Current
1475*	Warning	First Start Backup
1483*	Event	Common Alarm
1517	Shutdown	Failed Module Shutdown
1518	Warning	Failed Module Warning
1519	Warning	At Least One Module Has: Least Severe Fault
1540*	Event	Common Warning
1541*	Event	Common Shutdown
1548	Warning	Inj 7 Solenoid Low Curr
1549	Warning	Inj 8 Solenoid Low Curr
1551	Warning	Inj 7 Solenoid Low Curr
1552	Warning	Inj 7 Solenoid Low Curr

Code	Event/Lamp	Displayed Message
1553	Warning	Inj 7 Solenoid Low Curr
1554	Warning	Inj 7 Solenoid Low Curr
1555	Warning	Inj 7 Solenoid Low Curr
1556	Warning	Inj 7 Solenoid Low Curr
1557	Warning	Inj 7 Solenoid Low Curr
1573*	Event	Configurable Input #1
1597	Warning	ECM Device/Component
1622	Warning	Inj 9 Solenoid Low Curr
1689*	Warning	Real Time Clock Power
1695	Warning	Sensor Supply 5 High
1696	Warning	Sensor Supply 5 Low
1794*	Shutdown with Cooldown	Fire Detected
1843	Warning	Crankcase Press High
1844	Warning	Crankcase Press Low
1845	Warning	H2O In Fuel Sens High
1846	Warning	H2O In Fuel Sens Low
1847*	Shutdown w/Cooldown	Eng Coolant Temp - Shutdown w/Cool
1852*	Warning	Pre-High H2O In Fuel
1853*	Warning	Annunciator Input 1 Fault
1854*	Warning	Annunciator Input 2 Fault
1855*	Warning	Annunciator Input 3 Fault
1866	Warning	EGR DP Autozero Error
1891	Warning	Change Oil
1893	Warning	CAN EGR Valve Comm
1894	Warning	CAN VGT Comm Error
1895	Warning	EGA DL Mismatch Error
1896	Warning	EGR DL Valve Stuck
1899	Warning	Low EGR Dif Pressure
1911	Warning	Inj Metering 1 Press High
1912*	Warning	Utility Loss Of Phase
1913*	Warning	Genset Loss Of Phase
1914*	Warning	Utility Phase Rotation
1915*	Warning	Genset Phase Rotation
1916*	Event	Sync Check OK
1917*	Warning	Fuel Level High
1918*	Shutdown	Fuel Level Low
1933	Warning	High EGR Data Link Volt

Code	Event/Lamp	Displayed Message
1934	Warning	Low EGR Data Link Volt
1935	Warning	EGR DL Cmd Source Err
1942	Warning	THD AZ Error
1944*	Warning	HMI 113 Out Config Error
1961	Warning	High EGR DL EDU Temp
1974	Warning	Crankcase Press High
1978*	Warning	Speed Bias OOR Hi
1979*	Warning	Speed Bias OOR Lo
1992*	Shutdown	Crankcase Sensor High
1999*	Warning	Maximum Parallel Time
2185	Warning	Sensor Supply 4 High
2186	Warning	Sensor Supply 4 Low
2215	Warning	Fuel Pump Press Low
2249	Warning	APC 2 Pressure Low
2261	Warning	Fuel Pump Press High
2262	Warning	Fuel Pump Press Low
2265	Warning	High Fuel Lift Pump Volt
2266	Warning	Low Fuel Lift Pump Volt
2272	Warning	EGR DL POS Sensor Error
2273	Warning	EGR Delta P OOR High Error
2274	Warning	EGR Delta P OOR Low Error
2292	Warning	APC Flow high
2293	Warning	APC Flow Low
2311	Warning	EFI Control Valve Fail
2328*	Event	Utility Available
2331*	Warning	Utility Undervoltage
2332*	Event	Utility Connected
2333*	Event	Genset Connected
2335*	Shutdown	AC Voltage Sensing Lost (Excitation Fault)
2336*	Shutdown	Bad Checksum
2342*	Warning	Too Long In Idle
2349	Warning	EGR DL Motor Open Error
2351	Warning	EGR DL Motor Short Error
2357	Warning	EGR DL Motor Lock Error
2358*	Warning	Utility Overvoltage
2359	Warning	EGR Delta P IR High Error
2375	Warning	EGR Orifice TMPTR OOR High Error
2376	Warning	EGR Orifice TMPTR OOR Low Error

Code	Event/Lamp	Displayed Message
2377	Warning	High Fan Control Voltage
2396*	Warning	Utility Breaker Fail To Close
2397*	Warning	Utility Breaker Fail To Open
2448	Warning	Coolant Level Moderately Low
2539*	Warning	High Voltage Bias
2541*	Warning	Low Voltage Bias
2544	Shutdownw/Cooldown	Over Temperature (ECM Internal temperature Data valid but above normal opertional range Most severe level)
2545*	Warning	Keysw Reset Required
2555	Warning	Low GHC 1 Voltage
2556	Warning	High GHC 1 Voltage
2619*	Warning	Aux101 0 Input 1 Fault
2621*	Warning	Aux101 0 Input 2 Fault
2622*	Warning	Aux101 0 Input 3 Fault
2623*	Warning	Aux101 0 Input 4 Fault
2624*	Warning	Aux101 0 Input 5 Fault
2625*	Warning	Aux101 0 Input 6 Fault
2626*	Warning	Aux101 0 Input 7 Fault
2627*	Warning	Aux101 0 Input 8 Fault
2628	Warning	Aux102 0 Expansion Input 9 Fault
2629	Warning	Aux102 0 Expansion Input 10 Fault
2631	Warning	Aux102 0 Expansion Input 11 Fault
2632	Warning	Aux102 0 Expansion Input 12 Fault
2653*	Warning	Exhaust St 2 Temp High
2657*	Warning	Exhaust St 1 Temp High
2661	Shutdown	At Least One Unacknowledged Most Severe Fault 0 Condition Exists
2662	Warning	At Least One acknowledged: Most Severe Fault
2677*	Shutdown	Fail to Stop (Shutdown)
2678*	Warning	Charging Alternator Fail
2727	Warning	Critical CEN Not Accessible Error
2738	Warning	Ether INJ Low CTRL Error
2739	Warning	Ether INJ High CTRL Error
2774	Warning	EGR DP Clogged Tubes Error
2779*	Event	Utility Unloaded Event
2814*	Shutdown	Genset CT Ratio Low
2815*	Warning	Genset CT Ratio High
2816*	Shutdown	Genset PT Ratio Low
2817*	Warning	Genset PT Ratio High

Code	Event/Lamp	Displayed Message
2818*	Warning	Bus PT Ratio Low
2819*	Warning	Bus PT Ratio High
2821*	Warning	Utility PT Ratio Low
2822*	Warning	Utility PT Ratio High
2882*	Warning	Aux101 1 Input 1 Fault
2883*	Warning	Aux101 1 Input 2 Fault
2884*	Warning	Aux101 1 Input 3 Fault
2885*	Warning	Aux101 1 Input 4 Fault
2886*	Warning	Aux101 1 Input 5 Fault
2887*	Warning	Aux101 1 Input 6 Fault
2888*	Warning	Aux101 1 Input 7 Fault
2889*	Warning	Aux101 1 Input 8 Fault
2891*	Warning	Aux102 1 Expansion Input 9 Fault
2892*	Warning	Aux102 1 Expansion Input 10 Fault
2893*	Warning	Aux102 1 Expansion Input 11 Fault
2894*	Warning	Aux102 1 Expansion Input 12 Fault
2895*	Warning	PCCNet Device Failed
2896*	Shutdown	Critical PCCnet Dev Fail
2914*	Shutdown	Genset AC Meter Failed
2915*	Warning	Gen Bus AC Meter Failed
2916*	Warning	Utility AC Meter Failed
2917*	Warning	Gen Bus Voltage OOR Hi
2918*	Warning	Utility Voltage OOR Hi
2919*	Warning	Utility Current OOR Hi
2921*	Warning	Gen Bus Current OOR Hi
2922*	Warning	High Genset Neutral Curr
2923*	Warning	Gen Bus kW OOR Hi
2924*	Warning	Gen Bus kVAR OOR Hi
2925*	Warning	Gen Bus kVA OOR Hi
2926*	Warning	Utility kW OOR Hi
2927*	Warning	Utility kVAR OOR Hi
2928*	Warning	Utility kVA OOR Hi
2931*	Shutdown	Aux101 Device ID Fault
2934*	Warning	High Ambient Temp
2935*	Warning	Low Ambient Temp
2936*	Warning	Fuel Level High
2937*	Warning	Fuel Level Low
2938*	Warning	Earth/Ground Fault

Code	Event/Lamp	Displayed Message
2939*	Warning	Modbus Failure
2941*	Event	Remote Shutdown Fault Reset Occurrence
2942*	Warning	Shutdown Override Fail
2943*	Warning	Manual Sw Config Fail
2944*	Warning	Auto Switch Config Fail
2945*	Warning	Rupture Basin Switch
2946*	Warning	Exhaust St 2 Temp Low
2947*	Warning	Exhaust St 1 Temp Low
2948*	Warning	Exhaust St 2 Temp High
2949*	Warning	Exhaust St 1 Temp High
2951*	Warning	Alternator 1 Temp High
2952*	Warning	Alternator 1 Temp Low
2953*	Warning	Alternator 1 Temp High
2954*	Warning	Alternator 2 Temp High
2955*	Warning	Alternator 2 Temp Low
2956*	Warning	Alternator 2 Temp High
2957*	Warning	Alternator 3 Temp High
2958*	Warning	Alternator 3 Temp Low
2959*	Warning	Alternator 3 Temp High
2962	Warning	EGR RPM Derate Error
2965*	Event	Genset Available
2967*		Governor Fault
2968*		AVR Fault Failure and Diagnosis
2969*		LON Failure failure and Diagnosis
2971*	Warning	Test/Exercise Fault
2972*	Shutdown	Field Overload
2973	Warning	Charge Press IR Error
2977*	Warning	Low Coolant Level 2 Sw
2978*	Warning	Low Intake Manf 1 Temp
2979*	Warning	High Alternator Temp Sw
2981*	Warning	High Drive Bearing Temp
2982*	Warning	Low Drive Bearing Temp
2983*	Warning	High Drive Bearing Temp
2984*	Warning	High Free Bearing Temp
2985*	Warning	Low Free Bearing Temp
2986*	Warning	High Free Bearing Temp
2992*	Warning	High Intake Manf 1 Temp
2993*	Warning	Battery Charger Sw Fail

Code	Event/Lamp	Displayed Message
3131*	Shutdown	Secondary Engine Overspeed
3226*	Event	Genset is paralleled to utility in base load operation
3397*	Shutdown	Low Gearbox Oil Pressure – Condition Exists
3398*	Shutdown	High Gearbox Oil Pressure – Condition Exists
3399*	Shutdown	Differential Fault – Condition Exists
3411*	Warning	DC Power Supply Fault – Condition Exists
3412*	Warning	GIB Isolator Open Fault – Condition Exists
3413*	Warning	Radiator Fan Trip Fault – Condition Exists
3414*	Warning	Ventilator Fan Trip Fault – Condition Exists
3415*	Warning	Louvres Closed Fault – Condition Exists
3416*	Warning	Start System Fault – Condition Exists
3417*	Warning	Alternator Heater Trip Fault – Condition Exists
3457*	Warning	Loss of Bus Voltage Sensing
3479*	Warning	Start-Inhibit Warning Fault Event
3481*	Warning	Start-Inhibit Warning Fault Event
3482*	Shutdown	Start-Inhibit Shutdown Fault
3483*	Shutdown	High Alternator Temperature 1 Shutdown Fault
3484*	Shutdown	High Alternator Temperature 2 Shutdown Fault
3485*	Shutdown	High Alternator Temperature 3 Shutdown Fault
3486*	Shutdown	High Drive End Bearing Temperature Shutdown Fault
3487*	Shutdown	High Non-Drive End Bearing Temp Shutdown Fault
3513*	Warning	Negative Sequence Overcurrent
3599*	Warning	Ground Current OOR Warning
3611*	Warning	Custom Overcurrent Fault
3629*	Warning	Device Calibration Update Recommended
3631*	Shutdown	Device Calibration Update Required
3641*	Shutdown	Start Enable1 Shutdown Fault
3642*	Shutdown	Start Enable2 Shutdown Fault
3643*	Warning	Start Enable3 Shutdown Fault
4358*	Warning	SetUp Mode Run Fault
4761*	Warning	Genset Voltage Sensing MCB Protection
4766*	Warning	Customer Gas Valve Close
4767*	Warning	Customer Gas Valve Close
4872*	Warning	System Network Failure
4873*	Warning	Genset Failed to Come Online
4874*	Warning	Load Demand SW Version Incompatibility
4875*	Warning	Genset Ineligible for Load Demand
4876*	Warning	Genset Lost on System Network

Code	Event/Lamp	Displayed Message
4877*	Warning	System Settings not Synchronized
4878*	Warning	Check System Network Installation
4879*	Warning	Load Demand Setup Error
4881*	Warning	System Genset ID Conflict
4882*	Warning	Genset Bus Overload
5135*	Warning	Overload Shutdown Fault
5145*	Warning	Load Demand Genset Bus Failure
9945	Warning	Injector 6 Circuit 2 Error
9946	Warning	Injector 5 Circuit 2 Error
9947	Warning	Injector 4 Circuit 2 Error
9948	Warning	Injector 3 Circuit 2 Error
9949	Warning	Injector 2 Circuit 2 Error
9951	Warning	Injector 1 Circuit 2 Error
9954*	Warning	Differential Fault
9955*	Warning	DC Power Supply Fault
9956*	Warning	GIB Isolator Fault
9957*	Warning	Radiator Dan Trip Fault
9958*	Warning	Vent Fan Trip Fault
9959*	Warning	Louvres Closed Fault
9960*	Warning	Start System Fault
9961*	Warning	Alt Heater Trip Fault
9971*	Warning	ECM Derate Fault
9973*	Warning	Watchdog Reset Fault

5.3 Alternator Performance Troubleshooting

5.3.1 No Voltage (No Load)

Possible Causes:

1. Faulty permanent magnet generator, stator or rotor
2. Insulation failure to earth (ground) on permanent magnet stator
3. Voltmeter faulty
4. Loose, broken, or corroded connections
5. Automatic voltage regulator high excitation protection circuit activated, collapsing output voltage
6. Main rectifier diodes short circuit
7. Open circuit in exciter stator windings
8. Faulty automatic voltage regulator

9. Winding fault, open circuit, or short circuit

5.3.1.1 No Voltage (No Load) - Diagnosis and Repair

1. Faulty permanent magnet generator, stator or rotor
    - Disconnect the permanent magnet generator leads from automatic voltage regulator terminals P2, P3, and P4.
        - Check voltage across leads with a multimeter, with the set running at correct speed.
        - For 50 Hz, voltage should be approximately 160 to 180 VAC.
        - For 60 Hz, voltage should be approximately 190 to 210 VAC.
2. Insulation failure to earth (ground) on permanent magnet stator
    - Disconnect leads P2, P3, P4 and, use insulation test meter to measure the resistance value of the insulation to earth (ground).
3. Voltmeter faulty
    - Check and verify voltage at generator output terminals with a multimeter.
4. Loose, broken, or corroded connections
    - Check all connections, repair and replace where necessary.
5. Automatic voltage regulator high excitation protection circuit activated, collapsing output voltage
    - Automatic voltage regulator protection circuit is factory set to trip at +70 VDC across automatic voltage regulator output, X+ (F1) and XX- (F2), after pre-set time delay.
        - Shut down the alternator, start and run alternator up again. If the voltage builds up normally but collapses again, the protection circuit has operated.
        - Run alternator again and check the excitation voltage across automatic voltage regulator output. If greater than 70 VDC, the protection circuit is operating correctly.
6. Main rectifier diodes short circuit
    - Check diodes.
        - Test diodes on the main rotating rectifier assembly with a multimeter.
7. Open circuit in exciter stator windings
    - Remove external leads from generator. Check the resistance value of the exciter stator across these two leads (approximately 18 to 30 ohms) with a multimeter. Refer to the procedure(s) in the troubleshooting and repair manual for the specific alternator for correct values.
8. Faulty automatic voltage regulator
    - Replace automatic voltage regulator and re-test.
9. Winding fault, open circuit, or short circuit
    - Remove external leads from the alternator.
        - Use appropriate metering equipment (Wheatstone bridge or Kelvin bridge). Measure the low resistance winding of the main rotor and stator.

5.3.2 Low Voltage (No Load)

Possible Causes:

1. Engine speed low, under frequency roll-off
2. Voltage sensing is faulty
3. Automatic voltage regulator voltage adjustment trim is configured incorrectly
4. Faulty automatic voltage regulator

5.3.2.1 Low Voltage (No Load) - Diagnosis and Repair

1. Engine speed low, under frequency roll-off
    - Under frequency roll-off protection is activated, indicating low engine speed.
        - Adjust or correct engine speed to an acceptable nominal.
2. Voltage sensing is faulty
    - Check and verify voltage at generator output terminals with a multimeter.
3. Automatic voltage regulator voltage adjustment trim is configured incorrectly
    - With the InPower service tool adjust nominal voltage parameter to the appropriate value for the application level.
4. Faulty automatic voltage regulator
    - Replace automatic voltage regulator and re-test.

5.3.3 High Voltage (No Load)

Possible Causes:

1. Automatic voltage regulator voltage adjustment trim is configured incorrectly
2. Low sensing supply from main stator
3. Faulty automatic voltage regulator

5.3.3.1 High Voltage (No Load) - Diagnosis and Repair

1. Automatic voltage regulator voltage adjustment trim is configured incorrectly
    - With the InPower service tool adjust nominal voltage parameter to the appropriate value for the application level.
2. Low sensing supply from main stator
    - Check sensing supply at all of leads of the alternator.
        - Open circuit or low sensing signal will cause the automatic voltage regulator to produce high excitation, this will produce a high output voltage.
3. Faulty automatic voltage regulator
    - Replace automatic voltage regulator and re-test.

5.3.4 Unstable Voltage (No Load)

Possible Causes:

1. Engine speed hunting (unstable)
2. Automatic voltage regulator parameters configured incorrectly
3. Loose or corroded connections
4. Intermittent earth (ground) on machine

5.3.4.1 Unstable Voltage (No Load) - Diagnosis and Repair

1. Engine speed hunting (unstable)
    - Check with a frequency meter or tachometer for speed variations due to hunting, or cyclic irregularities in the engine.
        - This may improve as load is applied.
2. Automatic voltage regulator parameters configured incorrectly
    - Adjust automatic voltage regulator gain and/or damping trims to the appropriate value(s).
        - Check again when loaded.
3. Loose or corroded connections
    - Check push on terminals on automatic voltage regulator.
        - Check auxiliary terminals for loose connections.
        - Repair or replace as necessary.
4. Intermittent earth (ground) on machine
    - Use insulation test meter to test all the windings including the exciter stator.
        - Low insulation resistance can affect the automatic voltage regulator.

5.3.5 Unbalanced Voltage (No Load)

Posible Causes:

1. Fault in the main stator winding

5.3.5.1 Unbalanced Voltage (No Load) - Diagnosis and Repair

1. Fault in the main stator winding
    - Disconnect all external leads to the alternator and re-test.
        - Separately excite alternator by connecting DC battery supply to the exciter stator leads X+ (F1) and XX- (F2).
        - A winding short will get hot, and engine will sound slightly loaded.
        - Shut down the set and check by hand for hot spots.

5.3.6 Unbalanced Voltage (With Load)

Possible Causes:

1. Single-phased load current unevenly distributed over the three phases

5.3.6.1 Unbalanced Voltage (No Load) - Diagnosis and Repair

1. Fault in the main stator winding
    - Disconnect all external leads to the alternator and re-test.
        - Separately excite alternator by connecting DC battery supply to the exciter stator leads X+ (F1) and XX- (F2).
        - A winding short will get hot, and engine will sound slightly loaded.
        - Shut down the set and check by hand for hot spots.

5.3.7 Unstable Voltage (With Load)

Possible Causes:

1. Engine governing hunting (unstable)
2. Leading power factor load created by power factor correction capacitors
3. Non-linear loads causing interaction between dynamic closed loop control systems
4. Fluctuations in load current (motor starting or reciprocating loads)
5. Automatic voltage regulator parameters configured incorrectly

5.3.7.1 Unstable Voltage (With Load) - Diagnosis and Repair

1. Engine governing hunting (unstable)
    - Check with frequency meter or tachometer for engine governor hunting, or cyclic irregularities in the engine.
2. Leading power factor load created by power factor correction capacitors
    - Isolate the power factor correction capacitors until sufficient motor load has been applied to counteract the leading power factor.
3. Non-linear loads causing interaction between dynamic closed loop control systems
    - The interaction of the alternator and the engine closed loop systems controls the load.
        - Instability is caused by oversensitive control settings.
        - Adjust automatic voltage regulator to high gain (stability) and load drive system to low gain.
        - Increase engine speed droop to stabilize engine.
        - Contact factory for further advice regarding non-linear loads.
4. Fluctuations in load current (motor starting or reciprocating loads)
    - Check the load current on a stable supply, i.e. mains or separately excite the machine.
        - A variable DC supply is required for on load separate excitation tests.

5. Automatic voltage regulator parameters configured incorrectly
    - With the InPower service tool adjust AVR control parameters, until voltage is stable.

5.3.8 Poor Voltage Regulation (With Load)

Possible Causes:

1. Large speed droop on engine
2. Unbalanced load
3. Automatic voltage regulator parameters configured incorrectly
4. Voltage drop between alternator and load, caused by losses in supply cable (power losses)
5. Fault on main rectifier or excitation winding
6. Under frequency roll-off protection activated

5.3.8.1 Poor Voltage Regulation (With Load) - Diagnosis and Repair

1. Large speed droop on engine
    - Check that the speed droop from no load to full load is no greater than 4%.
2. Unbalanced load
    - Check voltage and load current on all phases.
        - If unbalanced, redistribute the load more evenly across the phases.
3. Automatic voltage regulator parameters configured incorrectly
    - With the InPower service tool, adjust automatic voltage regulator control parameters until voltage is stable.
4. Voltage drop between alternator and load, caused by losses in supply cable (power losses)
    - Check the voltage at both ends of the cable run at full load.
        - Large differences in voltages indicate a large volts drop along the cable.
        - A larger diameter cable is required in severe cases.
5. Fault on main rectifier or excitation winding
    - Check the no load excitation voltage across automatic voltage regulator X+ (F1) and XX- (F2).
        - Voltage should be no higher than 12 VDC.
6. Under frequency roll-off protection activated
    - Under frequency roll-off protection is activated, indicating low engine speed.
        - Adjust or correct engine speed to an acceptable nominal.

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

Possible Causes:

1. Engine performance
2. Load current surges significantly exceed the full load of the generator

3. Under frequency roll-off protection on automatic voltage regulator operational
4. Voltage drop between alternator and load, caused by power losses in supply cable. This will be worse during current surges (motor starting and etc)
5. Automatic voltage regulator stability controls incorrectly set
6. Fault on windings or rotating rectifier
7. Fault in automatic voltage regulator

5.3.9.1 Poor Response to Load Surges or Motor Starting (With Load) - Diagnosis and Repair

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

5.3.10 Voltage Collapses (With Load)

Possible Causes:

1. Protection circuit in automatic voltage regulator activated, due to high excitation condition across automatic voltage regulator output, X+ (F1) and XX- (F2)

2. Protection circuit in automatic voltage regulator operated, due to fault in alternator windings or diodes
3. Malfunction of protection circuit in automatic voltage regulator
4. Severe overload or short circuit on across phases

5.3.10.1 Voltage Collapses (With Load) - Diagnosis and Repair

1. Protection circuit in automatic voltage regulator activated, due to high excitation condition across automatic voltage regulator output, X+ (F1) and XX- (F2)
    - Automatic voltage regulator protection circuit is factory set to trip at +70 VDC across automatic voltage regulator output X+ (F1) and XX- (F2), after pre-set time delay.
        - Shut down and restart the alternator. If the voltage builds up normally but collapses again, the protection circuit has operated.
        - With alternator running, check the excitation voltage across sautomatic voltage regulator output X+ (F1) and XX- (F2). If greater than 70 VDC, the protection circuit is operating correctly.
        - Check load current for overload.
2. Protection circuit in automatic voltage regulator operated, due to fault in alternator windings or diodes
    - Shut down and restart the alternator. If voltage returns as normal, but collapses again when loaded, protection circuit is activated due to high excitation.
        - Remove external leads from the alternator.
        - Use appropriate metering equipment (Wheatstone bridge or Kelvin bridge). Measure the low resistance winding of the main rotor and stator.
        - Check diodes.
        - Test diodes on the main rotating rectifier assembly with a multimeter.
3. Malfunction of protection circuit in automatic voltage regulator
    - Replace automatic voltage regulator and re-test when loaded.
4. Severe overload or short circuit on across phases
    - Check load current with clip-on ammeter.

5.3.11 High Voltage (With Load)

Possible Causes:

1. Unbalanced load
2. Leading power factor
3. Faulty automatic voltage regulator

5.3.11.1 High Voltage (With Load) - Diagnosis and Repair

1. Unbalanced load
    - Check voltage on all three phases. If unbalanced, re-distribute loading over the three phases.

2. Leading power factor
    - Check for capacitive (leading) PF load (i.e. kVA correction fluorescent lights).
        - Apply motor (lagging) PF load, or switch off capacitors.
        - A leading power factor load will give abnormally low DC excitation volts across X+ (F1) and XX-(F2).
3. Faulty automatic voltage regulator
    - Replace automatic voltage regulator and re-test.

5.3.12 Low Voltage (With Load)

Possible Causes:

1. Engine speed droop greater than 4%
2. Under frequency roll-off protection circuit operational
3. Faulty permanent magnet generator stator or rotor
4. Automatic voltage regulator faulty
5. Fault on winding or rotating diodes
6. Voltage drop between alternator and load, due to power losses in the cable

5.3.12.1 Low Voltage (With Load) - Diagnosis and Repair

1. Engine speed droop greater than 4%
    - Check engine speed at no load and full load.
        - Engine speed droop should be within + 4% and –1% of nominal speed.
        - Reset as necessary.
2. Under frequency roll-off protection circuit operational
    - Under frequency roll-off protection is activated, indicating low engine speed.
        - Adjust or correct engine speed to an acceptable nominal.
3. Faulty permanent magnet generator stator or rotor
    - Disconnect the permanent magnet generator leads from automatic voltage regulator terminals P2, P3, and P4.
        - Check voltage across leads with a multimeter, with the set running at correct speed.
        - For 50 Hz, voltage should be approximately 160 to 180 VAC.
        - For 60 Hz, voltage should be approximately 190 to 210 VAC.
4. Automatic voltage regulator faulty
    - Replace automatic voltage regulator and re-test.
5. Fault on winding or rotating diodes
    - Any fault in this area will appear as high excitation voltage across X+ (F1) and XX-(F2).
        - Remove external leads from the alternator.

- Use appropriate metering equipment (Wheatstone bridge or Kelvin bridge). Measure the low resistance winding of the main rotor and stator.
- Check diodes.
- Test diodes on the main rotating rectifier assembly with a multimeter.

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

5.3.13 Alternator Troubleshooting - P80

5.3.13.1 Without AVR

NOTICE
Do tests in order, unless stated otherwise. Do method steps in order. Achieve result before doing the next step, unless action (in bold) states otherwise.

TABLE 14. FAULTFINDING: WITHOUT AVR

TEST	METHOD		RESULT and ACTION
1 External Excitation	1	Disconnect the exciter stator positive X+ (F1) lead from the AVR.	-
	2	Disconnect the exciter stator negative XX- (F2) lead from the AVR.	-
	3	Test the resistance across the exciter stator winding between positive and negative leads, with a multimeter.	Resistance of exciter stator winding greater than minimum values (see **Section 6.3.1.12.7.4.1 on page 306**)
	4	Connect an external 24 V variable d.c. source to the exciter stator leads, positive to positive, negative to negative. Test the voltage.	Measured excitation is 12 V d.c. (15 V d.c. for P80) ±10% error.
	5	Run the alternator with no load connected. Test the speed.	Measured speed is within 4% of rated speed.
	6	Test the phase-to-phase and phase-to-neutral voltage at output terminals. Adjust variable d.c. source.	Measured output equal to rated voltage (with same error as excitation), balanced across phases within 1%. Main & exciter stators, main & exciter rotors, and rectifier diodes are functioning correctly. **Go to test 7 AVR Sensing and Power Supply** If unbalanced by more than 1%, **Go to test 2 Main Stator** If balanced within 1%, but output voltage is more than 10% below rated voltage, and test 3 **not** yet done, **Go to test 3 Rectifier** If balanced within 1%, but output voltage is more than 10% below rated voltage, and test 3 already done, **Go to test 4 Exciter Rotor**
2 Main Stator	A fault in the main stator will produce short circuit currents between turns in the windings. Test for symptoms to confirm diagnosis.		
	1	Disconnect main stator leads to exclude external components from the test.	-
	2	Test phase to neutral resistances of main stator windings with a micro ohmmeter.	Resistances of main stator windings dissimilar, and/or less than minimum values (see **Section 6.3.1.12.7.4.1 on page 306**)
	3	Run up the alternator within 4% of nominal speed, no load or excitation. Connect battery to exciter stator (see test 1).	When battery connected to excite alternator, short circuit fault creates heat and burning smell. Engine sound changes with extra slight loading.
	4	-	**Repair or replace faulty main stator winding**
	5	Re-connect main stator leads	**Go to test 1 External Excitation**

TEST	METHOD		RESULT and ACTION
3 Rectifier	1	Test the rectifier varistors (see Section 6.3.1.12.5 on page 300)	Both varistors functioning correctly.
	2	Test the rectifier diodes (see Section 6.3.1.12.5 on page 300)	All diodes functioning correctly. **Go to test 1 External Excitation**
4 Exciter Rotor	1	Inspect windings and insulation	Windings are not burnt or damaged.
	2	Disconnect the 6 exciter rotor leads from the a.c. connection studs on the rectifier.	-
	3	Taking 3 leads that were connected to the same rectifier plate, Test the phase-to-phase resistance, with a milliohm meter or micro ohmmeter.	Resistance of each phase pair greater than minimum values (see Section 6.3.1.12.7.4.1 on page 306)
	4	Re-connect the exciter rotor leads.	**Go to test 5 Main Rotor**
5 Main Rotor	1	Disconnect a main rotor lead from the connection stud on one of the rectifier plates.	**-**
	2	Test the resistance across the main rotor winding between positive and negative leads, with a multimeter or milliohm meter.	Resistance of main rotor greater than minimum value (see Section 6.3.1.12.7.4.1 on page 306)
	3	Re-connect the main rotor lead.	**Go to test 6 Exciter Stator Insulation**
6 Exciter Stator Insulation	Poor insulation of the exciter stator winding can affect AVR performance.		
	1	Test the electrical insulation of the exciter stator winding (see Section 6.3.1.12.7 on page 304)	Resistance of exciter stator winding to earth is greater than minimum value. **Go to test 7 AVR Sensing and Power Supply**
7 AVR Sensing And Power Supply	Output voltage is sensed at the AVR for closed loop control of the excitation voltage. The alternator wiring diagram shows how sensing leads 6, 7 & 8 (E1, E2, E3) at the output terminals are connected to the AVR, via transformers (as required). AVR power is also taken from the sensing leads or from a permanent magnet generator (PMG).		
	1	Disconnect the sensing and power supply(ies) from the AVR	-
	2	Follow the method of Test 1 to run the alternator with excitation from a battery.	Alternator runs within 4% of rated speed, 10% of rated output voltage, balanced within 1% across phases.
	3	Test the sensing voltage feedback at the AVR terminals. Check circuit between output terminals and AVR.	Measured voltage within range (see AVR instructions), balanced across phases. No wiring or transformer faults.
	4	Disconnect battery, re-connect AVR and run alternator.	**See Faultfinding: self-excited AVR or Faultfinding: separately-excited AVR.**

5.3.13.2 Separately-Excited AVR - OFF load

TABLE 15. FAULTFINDING: SEPARATELY-EXCITED AVR - OFF LOAD

SYMPTOM	CAUSE	ACTION
NO VOLTAGE (NO LOAD)	Faulty permanent magnet generator (PMG), stator or rotor .	Disconnect the PMG leads from AVR terminals P2, P3, P4. Run the alternator at rated speed. Test the phase-to-phase voltage at P2, P3 & P4 leads of the PMG with an r.m.s. measuring instrument. Measured voltage 170 to 195 V a.c. (at 50 Hz), 204 to 234 V a.c. (at 60 Hz), balanced within 5% across phases. (Refer to factory for latest voltage ranges in design data specification DD-15590) Test the phase-to-phase resistance of the PMG stator windings with a multimeter. Resistance to be within 10% of expected value (see **Section 6.3.1.12.7.4.1 on page 306**), balanced across phases. Replace or re-test according to PMG Fault Diagnosis table below.
	Insulation failure to earth (ground) on PMG stator.	Test the insulation resistance of PMG stator windings. (see **Section 6.3.1.12.7 on page 304**)
	Panel voltmeter faulty.	Test voltage at alternator terminals with a multimeter.
	Connections loose, broken or corroded.	Inspect AVR push-on terminals. Repair or renew where necessary.
	AVR high excitation protection circuit activated, collapsing output voltage. AVR protection circuit is factory set to trip (refer to AVR data sheet for voltage set point) across AVR output X+ (F1), & XX- (F2), after pre-set time delay.	Check AVR LED. If lit, protection circuit is activated. Shut down engine, and re-start. If the voltage builds up normally but collapses again, the protection circuit has operated, & AVR LED will be lit. Run again & check the excitation voltage across AVR X+ (F1) and XX- (F2). If greater than voltage set point, the protection circuit is operating correctly. Follow Faultfinding without AVR see (**Section 5.3.13.1**) to find cause of high excitation volts.
	Short circuit of varistor on rotating rectifier	Test varistors. (see **Section 6.3.1.12.5 on page 300**)
	Short circuit of diode(s) on rotating rectifier.	Test diodes. (see **Section 6.3.1.12.5 on page 300**)
	Open circuit in exciter stator windings	Faultfinding without AVR (see **Section 5.3.13.1 on page 61**
	AVR fault	Replace AVR and re-test.
	Winding fault. Open circuit or short circuit on any winding in the machine	Faultfinding without AVR (see **Section 5.3.13.1 on page 61**)

SYMPTOM	CAUSE	ACTION
LOW VOLTAGE (NO LOAD)	Engine speed low	Test speed with tachometer. Adjust governor control to nominal speed.
	Under frequency protection (UFRO) circuit activated	Inspect UFRO LED at AVR. If lit, UFRO is activated, indicating low speed. Adjust engine speed to within –1% to +4% of nominal.
	AVR volts control or external hand trimmer incorrectly set	1. Test engine speed is correct with tachometer, and UFRO is OFF. 2. Adjust voltage by AVR volts control, or remote trimmer.
	Panel voltmeter faulty or 'sticking'	Test voltage at alternator terminals with a multimeter.
	AVR fault.	Replace AVR and re-test.
HIGH VOLTAGE (NO LOAD)	AVR volts control or external trimmer incorrectly set.	1. Test engine speed is correct with tachometer, and UFRO is OFF. 2. Adjust voltage by AVR volts control, or remote trimmer.
	Voltage sensing input to AVR is open circuit or too low.	Test the AVR sensing supply feedback in Faultfinding without AVR (see Section 5.3.13.1 on page 61)
	Faulty AVR.	Replace AVR and retest.
UNSTABLE VOLTAGE (NO LOAD)	Engine speed hunting (unstable).	Test engine speed stability with a frequency meter or tachometer. Sometimes this problem will clear when load is applied.
	AVR stability control incorrectly adjusted.	Inspect AVR stability links or selection, adjust stability potentiometer. Check again on load.
	Connections loose or corroded.	Inspect all auxiliary board terminals. Inspect AVR push-on terminals. Repair or renew where necessary.
	Intermittent earth (ground) (low resistance of windings insulation).	Test the insulation resistance of all windings in Faultfinding without AVR (see Section 5.3.13.1 on page 61)
UNBALANCED VOLTAGE (NO LOAD)	Fault in main stator winding.	Test the main stator windings in Faultfinding without AVR (see Section 5.3.13.1)

TABLE 16. PMG FAULT DIAGNOSIS

PMG stator voltage		PMG stator phase-to-phase resistance	
		In range & balanced	Out of range or unbalanced
In range	Balanced	No fault	Re-test resistance
	Unbalanced	Check connector	Replace PMG stator
Out of range	Balanced	Replace PMG rotor	Replace PMG stator
	Unbalanced	Check connector	Replace PMG stator

5.3.13.3 Separately-Excited AVR - ON load

TABLE 17. FAULTFINDING: SEPARATELY-EXCITED AVR - ON LOAD

SYMPTOM	CAUSE	ACTION
LOW VOLTAGE (ON LOAD)	Engine speed low.	Test speed with tachometer. Adjust governor control to nominal speed.
	Under frequency protection (UFRO) circuit activated .	Inspect UFRO LED at AVR. If lit, UFRO is activated, indicating low speed. Adjust engine speed, to within -1% to +4% of nominal.
	Faulty permanent magnet generator (PMG) stator or rotor.	Disconnect the PMG leads from AVR terminals P2, P3, P4. Check voltage across leads with a Multimeter, with the set running at correct speed. For 50Hz, Voltage across P2, P3 and P4 should be approx. 160VAC – 180VAC. For 60Hz, Voltage is approx. 190VAC – 210VAC.
	AVR fault.	Replace AVR and re-test.
	Fault on winding or rotating diodes.	Any fault in this area will appear as high excitation voltage across X+ (F1) and XX- (F2). See Faultfinding without AVR (see Section 5.3.13.1 on page 61)
	Voltage drop between alternator and load, due to I^2R losses in the cable. This will be worse during current surges (e.g. motor starting).	Test the voltage at both ends of the cable at full load. In severe cases, a larger diameter cable is required.
HIGH VOLTAGE (ON LOAD)	Unbalanced load.	Test voltages on all phases. If unbalanced, re-distribute loading between phases.
	Leading Power Factor Load.	Test excitation volts across X+, (F1) and XX- (F2). A leading power factor will give an abnormally LOW d.c. excitation. Remove power factor correction capacitors from system at low load.
	Parallel droop transformer reversed.	Check for droop reversal. See Faultfinding Parallel Operation (Section 5.3.13.4 on page 70)

SYMPTOM	CAUSE	ACTION
UNSTABLE VOLTAGE (ON LOAD)	Engine governing unstable (hunting)	Test engine speed stability with a frequency meter or tachometer for governor hunting, or cyclic irregularities in the engine.
	Leading power factor load created by power factor correction capacitors.	Isolate the power factor correction capacitors until sufficient motor load has been applied.
	Non linear loads, causing interaction between dynamic closed loop control systems.	Interaction of closed loop systems controlling the load, the alternator and the engine. Instability is caused by oversensitive control settings. Try different settings of AVR stability, including changing the link to a smaller of larger kW range. Involve designers of the non-linear load to modify their control loop settings. Increase engine speed 'droop' to stabilize engine. Contact factory for further advice regarding non-linear loads.
	Fluctuations in load current, (motor starting, or reciprocating loads).	Test the load current on a stable supply, i.e. mains, or see Faultfinding without AVR using a variable d.c. supply (Section 5.3.13.1 on page 61)
	AVR stability control incorrectly adjusted.	Adjust AVR stability control, until voltage is stable.
UNBALANCED VOLTAGE (ON LOAD)	Single-phase loads (phase - neutral) unevenly distributed over the three phases.	Test current in each phase with clamp ammeter. The full load rated current must NOT be exceeded on any individual phase. Re-distribute load if necessary.
POOR VOLTAGE REGULATION (ON LOAD)	Large speed droop on engine. AVR UFRO protection activated.	Test the speed droop from no load to full load is no greater than 4%. Inspect AVR LED. If lit, increase engine speed.
	Unbalanced load.	Check voltage and load current on all phases. If unbalanced, redistribute the load more evenly across the phases.
	Parallel droop circuit incorrectly adjusted, or requires shorting switch for single running.	The droop circuit will give additional voltage droop of -3% at full load 0.8 power factor. For single running machines this can be improved by fitting a shorting switch across the droop CT input, (S1 – S2), on the AVR.
	Voltage drop between alternator and load, caused by losses in supply cable, (I^2R losses).	Test the voltage at both ends of the cable run at full load. In severe cases, a larger diameter cable is required.
	AVR stability control incorrectly adjusted.	Adjust AVR control, until voltage is stable.
	Fault on rectifier or excitation winding.	Test the no load excitation volts across AVR X+ (F1) and XX- (F2). If higher than 12V dc, see Faultfinding without AVR (Section 5.3.13.1)
	Under frequency protection (UFRO) activated.	Inspect UFRO LED at AVR. If lit, UFRO is activated, indicating low speed. Test speed with tachometer and adjust to correct nominal speed, (or frequency).

SYMPTOM	CAUSE	ACTION
POOR VOLTAGE RESPONSE TO LOAD SURGES OR MOTOR STARTING	Engine governor sticking or slow to respond.	Check performance of engine during application of load. Check if AVR LED is lit during motor starting. Check if AVR 'DIP' or 'DWELL' circuits are activated. Adjust as necessary. (See AVR instruction sheet).
	AVR 'UFRO' protection activated.	Test the speed droop from no load to full load is no greater than 4%. Inspect AVR LED. If lit, increase engine speed.
	Parallel droop circuit incorrectly set.	Too much droop will increase voltage dips when motor starting. Fit shorting switch for single running alternators. See Faultfinding Parallel Operation (**Section 5.3.13.4 on page 70**)
	Load surges cause current to exceed 2.5 times the full load current.	Test current with a clamp ammeter. Voltage dip may be excessive if the current exceeds 2.5 times full load. Refer to factory for motor starting calculations.
	Voltage drop between alternator and load, caused by I^2R losses in supply cable. This will be worse during current surges (e.g. motor starting).	Test the voltage at both ends of the cable at full load. In severe cases, a larger diameter cable is required.
	Motor contactors dropping out during starting, (large current surges, voltage dips greater than 30%).	All causes and actions in this section may apply to this problem. Refer to factory for typical voltage dips.
	AVR stability control incorrectly adjusted.	Set AVR stability control for optimum performance. Adjust anticlockwise until voltage is unstable, then slightly clockwise until stable.
	Fault on windings or rotating rectifier.	Any fault in this area will appear as high excitation voltage across X+ (F1) and XX- (F2). If higher than 12V d.c., see Faultfinding without AVR (**Section 5.3.13.1 on page 61**)
	Engine relief circuit activated during motor starting.	Check if AVR 'DIP' or 'DWELL' engine relief circuits are activated. Adjust as necessary. See AVR instructions for details.
	AVR fault.	Replace and re-test on load.

SYMPTOM	CAUSE	ACTION
VOLTAGE COLLAPSES (ON LOAD)	Protection circuit in AVR activated, due to high excitation condition across AVR output, (X+ (F1) and XX- (F2).	Excitation volts higher than 70V d.c. Test voltage across X+ (F1) and XX- (F2) on load. Ensure engine speed is correct at full load. Check output voltage, ensure it does not exceed the rated voltage. Check load current for overload.
	Protection circuit in AVR operated, due to fault in alternator windings or diodes.	Check AVR LED. if lit, protection circuit is activated. Shut down engine, and re-start. If voltage returns as normal, but collapses again on load, protection circuit is activated, due to high excitation. Follow Faultfinding without AVR to find cause of high excitation volts.
	AVR fault.	Replace AVR and re-test on load.
	Severe overload or short circuit across phases.	Check load current with clamp ammeter.

5.3.13.4 Parallel Operation

TABLE 18. FAULTFINDING: PARALLEL OPERATION

SYMPTOM	CAUSE	ACTION
CIRCUIT BREAKER WILL NOT CLOSE WHEN ATTEMPTING PARALLEL OPERATION	Circuit breaker fitted with 'Check Synchronizing' protection, which prevents out of phase synchronizing.	Ensure that the synchroscope is indicating that machines are IN PHASE, or close to the eleven o'clock position, (when rotating in a clockwise direction). Ensure that the speed difference between the incoming set and the bus bar is small enough to prevent rapid rotation of the synchroscope, (or rapid fluctuations of the lights), before closing circuit breaker.
	Phase rotation of alternators differs.	DO NOT ATTEMPT TO PARALLEL until the phase rotation of all alternators are identical. Check the phase rotation of each alternator. Exchange the connections of two of the phases to reverse the phase rotation of an alternator.
	Voltage difference too high between the incoming alternator and the bus bar.	The voltage on the incoming set can be up to 4% higher than the bus bar voltage. THIS IS NORMAL. Do not adjust original no-load Voltage settings. If difference is greater than 4%, check for excessive droop on the loaded alternator(s).
UNSTABLE IN-PHASE CONDITION, BEFORE SYNCHRONIZING	Governor drift on one or more of the engines.	Let engines warm up and stabilize before paralleling. If speed is still drifting check governors and engine condition.
	Load variation on the bus bar causing speed/ frequency changes on the loaded alternator when synchronizing.	Disconnect any rapidly varying load. Check that there is no likelihood of a motor or automatic load starting when attempting to synchronize. DO NOT attempt to parallel if the load current is unstable.
UNSTABLE FREQUENCY IN PARALLEL WHEN ON LOAD	Engine speed droop too 'tight' or cyclic irregularities (instability) between the engines. (Check kW meters for rapid shifting of kW power between sets).	Increase the engine governor speed droop to 4% (no load to full load). Check for "sticky" governors on a new engine. Check engines for cyclic problems, (firing, out of balance, etc),

SYMPTOM	CAUSE	ACTION
STABLE VOLTAGE BEFORE AND AFTER BUT UNSTABLE WHILE SYNCHRONIZING	Usually results from 'pick- up' through the synchronizing panel and/or earth leakage protection circuits that can form a temporary 'closed loop' link between the alternators during synchronisation.	The fluctuation will decay when the alternators approach synchronizm, (almost identical speeds), and will disappear completely when the circuit breaker is closed. The synchronizing equipment, earth leakage protection, and/or wiring circuits in the switchboard can produce temporary pickup problems.
CURRENT UNCONTROLLED, RISES FAST WHEN CIRCUIT BREAKER CLOSED	Parallel droop equipment reversed on one of the alternators.	Check the droop CTs for reversal. Reverse lead S1-S2 on the droop CT. Test excitation volts - the alternator with reversed droop will have highest excitation volts.
STABLE CIRCULATING CURRENT ON ALL ALTERNATORS, NOT REDUCED BY VOLTAGE ADJUSTMENT	Parallel droop reversed on ALL alternators.	Check droops for reversal. Reverse leads S1–S2 to correct. This repeated wiring error will result in a stable circulating current which cannot be adjusted out by normal means.
STABLE CIRCULATING CURRENT ON BOTH ALTERNATORS AT NO LOAD	Voltage difference (excitation level) between the alternators.	Check Voltages at no load, (identical frequencies), and ensure all alternators have identical voltages. Do not adjust when load sharing.
	Parallel droop equipment reversed on BOTH alternators. (Unlike ONE droop reversal, which is a highly UNSTABLE condition).	Check ALL droop CTs for reversal.
	Incorrect setting of parallel droop equipment.	Check settings of droop trimmers. Check droop CTs are in correct phase. Check CT output to AVR S1-S2 is correct.
UNBALANCED POWER ON KILOWATT METERS	Engines not sharing the power (kW) equally.	Adjust the governor droop of the engines to equalize the kilowatt sharing.
UNBALANCED CURRENT ON AMMETERS AFTER EQUILIZING KILOWATTS	Voltage difference (excitation levels) between the machines.	Test the machines individually for exact voltage at no load.
	Parallel droop equipment incorrectly adjusted.	Adjust as stated in previous text.
UNBALANCED POWER AS LOAD INCREASED OR DECREASED	Engine governors are incompatible, or new governors 'sticking', causing unequal kW sharing over load range variations.	The engine governors must be adjusted to give similar no load to full load characteristics. Check for 'sticky' governors on new or repainted engines. Electronic governors should be set with a minimum 2% speed droop to ensure satisfactory kilowatt load sharing. If tighter speed regulation is required, an Isochronous Load Sharing system should be installed.

SYMPTOM	CAUSE	ACTION
INCREASING UNBALANCED CURRENT AS LOAD INCREASED	Difference in parallel droop level settings. Difference in no load to full load voltage regulation of AVRs. These settings are the major contributing factors to the load/voltage characteristics of the machine, and therefore must be set to give equal characteristics to the machines with which it is paralleled.	Run each alternator individually, and apply load at approximately 25%, 50% & 100% of full load. Test voltage at each load and compare values with the other alternators. Adjust control systems to remove regulation differences. Repeat method with as much inductive load as possible i.e. motors, transformers etc. Adjust the parallel droop trimmers, to achieve equal inductive load sharing.
POOR VOLTAGE REGULATION WHEN MACHINE RUNNING ALONE	Excess amount of parallel droop in circuit.	For normal voltage regulation as a single running machine, a shorting switch should be fitted across the parallel droop transformer. (S1-S2). This should be clearly marked ‘Single’ and ‘Parallel’ operation on the panel.
UNBALANCED POWER, ENGINES 'ROCK' ON MOUNTS	Electronic engine governor speed ‘droop’ characteristics are set too tight.	At least 2% engine droop is essential for kW (Active current) sharing. If 1% or less speed regulation is required, an electronic governing and Isochronous Load Sharing system should be installed.

5.3.13.5 AVR Fault Finding

This section has general advice to diagnose faults on AVRs. Further troubleshooting guidance is given in the Specification, Installation and Adjustments instructions or the Instruction Manual specific to the AVR model. The AVR has a protection circuit which operates under fault conditions after about 8 seconds (exact delay depends on AVR type). The circuit removes the alternator excitation, causing output voltage to collapse, and latches until the alternator is stopped and restarted. The system designer must make sure that this feature is compatible with the overall system protection.

Symptom	Action
VOLTAGE DOES NOT INCREASE WHEN STARTING	Check link K1:K2 on AVR or auxiliary terminals. Replace if necessary and restart.
VOLTAGE INCREASES WHEN STARTING TO WRONG VALUE	Check AVR volts control potentiometer setting. Correct if necessary. Check ‘Hand Trimmer’ if fitted. Adjust if necessary. Check alternator speed. Correct if necessary and restart. Check AVR ‘UFRO’ indicator. If illuminated, see UFRO Setting Procedure.
VOLTAGE INCREASES VERY SLOWLY WHEN STARTING	Check alternator accelerates as expected. Correct if necessary and restart. Check setting of adjustable ramp. Correct if necessary and restart.
VOLTAGE INCREASES TO HIGH VALUE WHEN STARTING	Check AVR wiring with wiring diagram.
VOLTAGE INCREASES TO HIGH VALUE THEN FALLS TO LOW VALUE WHEN STARTING	Check AVR wiring with wiring diagram.

Symptom	Action
VOLTAGE NORMAL THEN FALLS TO LOW VALUE WHEN RUNNING	Check alternator loading Check rectifier system (see Service and Maintenance chapter)
VOLTAGE UNSTABLE EITHER WHEN RUNNING NO-LOAD OR ON-LOAD	Check that the alternator speed is stable. Correct if necessary and restart. Check AVR wiring with wiring diagram. Adjust the AVR stability control slowly clockwise until steady.
VOLTAGE FALLS TO LOW VALUE WHEN LOAD APPLIED	Check alternator speed is not dropping as load is applied. Correct if necessary and restart. Check AVR 'UFRO' indicator. If it illuminates as load is applied, see UFRO Setting Procedure.

If all the tests and checks listed above fail to locate the alternator fault then it must be assumed that the AVR is faulty. There are no serviceable items in the AVR.

The AVR should be replaced only by a genuine STAMFORD part.

5.3.13.5.1 UFRO Setting Procedure

1. Stop the alternator.
2. Check that the AVR UFRO selection link is set for the required operation frequency.
3. Start the alternator set and run it with no load at rated speed.
4. If the voltage is now correct and the UFRO indicator is not illuminated, return to the fault finding procedure.
5. If the UFRO LED indicator is illuminated, continue as follows.
6. Adjust the UFRO control fully clockwise.
7. Set the alternator speed to the desired UFRO threshold (typically 95% of rated speed).
8. Adjust the UFRO control slowly counter-clockwise until the UFRO indicator illuminates.
9. Return the control slightly clockwise until the indicator turns off.
10. The UFRO setting is now correct - return to the fault finding procedure.

5.4 Annunciator Fault Codes

5.4.1 Fault Code 1853 - Annunciator Input 1 Fault

Customer fault 1 (input 1, LED 1) on the Universal Annunciator is active.

Possible Causes:

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

A. Condition For Which "Annunciator Input #1" Is Configured For Is Active

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

B. Incorrectly Configured or Wiring Issue

1. Customer input 1 on the Universal Annunciator can be configured to conform to different applications. Below are two configurations that have an impact on how input 1 becomes active.

Configurable Parameter	Option 1 (Default)	Option 2
Negative or Positive Input 1 Activation	Negative Input (ground input)	Positive Input (B+ input)
Inverting Active Hardware Signals	Don't Invert	Invert

   Negative or positive Input 1 activation: Allows the user to activate with a negative (ground) or positive (B+) input; the default setting is a negative (ground) input.

   Inverting active hardware signals: Input 1 has the capability to be inverted. If annunciator input 1 is set to inverted, then an active hardware signal will be considered inactive and an inactive signal will be considered active, default is set to non-inverted.

   When set to default, event/fault code 1853 (customer input 1) becomes active when there is a ground input at TB1-1 on the back of the Universal Annunciator.

   Ensure that the Universal Annunciator is correctly configured; for setup and configuration instructions, refer to the Universal Annunciator operator's manual (P/N 0900-0301).

2. Check the wiring at TB1-1 and ensure that customer input 1 is not wired incorrectly. Depending on the configuration of the annunciator in step 1A, ensure that there is not a short or open circuit at the TB1-1 connection.
3. Check the sender, relay, or device that is activating Input 1 on the Universal Annunciator, replace if faulty.

C. Faulty Annunciator

1. If the wiring and configuration is satisfactory, replace the Universal Annunciator.

5.4.2 Fault Code 1854 - Annunciator Input 2 Fault

Customer fault 2 (input 2, LED 2) on the Universal Annunciator is active.

Possible Causes:

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

3. Faulty annunciator.

A. Condition For Which "Annunciator Input #2" Is Configured For Is Active

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

B. Incorrectly Configured or Wiring Issue

1. Customer input 2 on the Universal Annunciator can be configured to conform to different applications. Below are two configurations that have an impact on how input 2 becomes active.

Configurable Parameter	Option 1 (Default)	Option 2
Negative or Positive Input 2 Activation	Negative Input (ground input)	Positive Input (B+ input)
Inverting Active Hardware Signals	Don't Invert	Invert

   Negative or positive Input 2 activation: Allows the user to activate with a negative (ground) or positive (B+) input; the default setting is a negative (ground) input.

   Inverting active hardware signals: Input 2 has the capability to be inverted. If annunciator input 2 is set to inverted, then an active hardware signal will be considered inactive and an inactive signal will be considered active, default is set to non-inverted.

   When set to default, event/fault code 1854 (customer input 2) becomes active when there is a ground input at TB1-2 on the back of the Universal Annunciator.

   Ensure that the Universal Annunciator is correctly configured; for setup and configuration instructions, refer to the Universal Annunciator operator's manual (P/N 0900-0301).

2. Check the wiring at TB1-2 and ensure that customer input 2 is not wired incorrectly. Depending on the configuration of the annunciator in step 1A, ensure that there is not a short or open circuit at the TB1-2 connection.
3. Check the sender, relay, or device that is activating Input 2 on the Universal Annunciator, replace if faulty.

C. Faulty Annunciator

1. If the wiring and configuration is satisfactory, replace the Universal Annunciator.

5.5 Auxilliary Codes-101

5.5.1 Fault Code 2619 - AUX 101 Input #1 Fault

Analog input #1 fault is active.

Possible Causes:

1. Condition for which "Analog Input #1" is configured is active
2. "Analog Input #1 Active State Selection" parameter is configured incorrectly
3. Incorrectly wired; or open circuit or short circuit in the wiring

A. Condition For Which "Analog Input #1" Is Configured Is Active

1. Check the condition for which "Analog Input #1" has been configured for. After the issue is resolved, press the Reset button on the Operator Panel in order to clear the fault, if the fault does not clear go to next step.

B. Analog Input #1 Active State Selection Parameter Is Configured Incorrectly

1. With InPower or through the Operator Panel check the switch input setting (active closed or active open) for Analog Input #1. Ensure that the switch input setting is correctly set. If “Analog Input #1 Sensor Type" parameter is set to active low, an active high will invert the logic, causing this fault code to go active.

C. Incorrectly Wired; Or Open Circuit Or Short Circuit In The Wiring

1. Check the wiring at J11-1 (reference input 1) and J11-2 (switch input) for an open circuit, short circuit, or a miswired condition.

5.5.2 Fault Code 2621 - AUX 101 Input #2 Fault

Analog input #2 fault is active.

Possible Causes:

1. Condition for which "Analog Input #2" is configured is active
2. "Analog Input #2 Active State Selection" parameter is configured incorrectly
3. Incorrectly wired; or open circuit or short circuit in the wiring

A. Condition For Which "Analog Input #2" Is Configured Is Active

1. Check the condition for which "Analog Input #2" has been configured for. After the issue is resolved, press the Reset button on the Operator Panel in order to clear the fault, if the fault does not clear go to next step.

B. Analog Input #2 Active State Selection" Parameter Is Configured Incorrectly

1. With InPower or through the Operator Panel check the switch input setting (active closed or active open) for Analog Input #2. Ensure that the switch input setting is correctly set. If “Analog Input #2 Sensor Type" parameter is set to active low, an active high will invert the logic, causing this fault code to go active.

C. Incorrectly Wired; Or Open Circuit Or Short Circuit In The Wiring

1. Check the wiring at J11-3 (reference input 1) and J11-4 (switch input) for an open circuit, short circuit, or a miswired condition.

5.5.3 Fault Code 2622 - AUX 101 Input #3 Fault

Analog input #3 fault is active.

Possible Causes:

1. Condition for which "Analog Input #3" is configured is active
2. "Analog Input #3 Active State Selection" parameter is configured incorrectly
3. Incorrectly wired; or open circuit or short circuit in the wiring

A. Condition For Which "Analog Input #3" is Configured is Active

1. Condition for which "Analog Input #3" is configured is active
    a. Check the condition for which "Analog Input #3" has been configured for. After the issue is resolved, press the Reset button on the Operator Panel in order to clear the fault, if the fault does not clear go to next step.

B. Analog Input #3 Active State Selection" Parameter Is Configured Incorrectly

1. With InPower or through the Operator Panel check the switch input setting (active closed or active open) for Analog Input #3. Ensure that the switch input setting is correctly set. If “Analog Input #3 Sensor Type" parameter is set to active low, an active high will invert the logic, causing this fault code to go active.

C. Incorrectly Wired; Or Open Circuit Or Short Circuit In The Wiring

1. Check the wiring at J11-5 (reference input 1) and J11-6 (switch input) for an open circuit, short circuit, or a miswired condition.

5.5.4 Code 2623 - AUX 101 Input #4 Fault

Analog input #4 fault is active.

Possible Causes:

1. Condition for which "Analog Input #4" is configured is active
2. "Analog Input #4 Active State Selection" parameter is configured incorrectly
3. Incorrectly wired; or open circuit or short circuit in the wiring

A. Condition For Which "Analog Input #4" Is Configured Is Active

1. Check the condition for which "Analog Input #4" has been configured for. After the issue is resolved, press the Reset button on the Operator Panel in order to clear the fault, if the fault does not clear go to next step.

B. Analog Input #4 Active State Selection" Parameter Is Configured Incorrectly

1. With InPower or through the Operator Panel check the switch input setting (active closed or active open) for Analog Input #4. Ensure that the switch input setting is correctly set. If “Analog Input #4 Sensor Type" parameter is set to active low, an active high will invert the logic, causing this fault code to go active.

C. Incorrectly Wired; Or Open Circuit Or Short Circuit In The Wiring

1. Check the wiring at J11-7 (reference input 1) and J11-8 (switch input) for an open circuit, short circuit, or a miswired condition.

5.5.5 Fault Code 2624 - AUX 101 Input #5 Fault

Analog input #5 fault is active.

Possible Causes:

1. Condition for which "Analog Input #5" is configured is active
2. "Analog Input #5 Active State Selection" parameter is configured incorrectly
3. Incorrectly wired; or open circuit or short circuit in the wiring

A. Condition For Which "Analog Input #5" Is Configured Is Active

1. Check the condition for which "Analog Input #5" has been configured for. After the issue is resolved, press the Reset button on the Operator Panel in order to clear the fault, if the fault does not clear go to next step.

B. Analog Input #5 Active State Selection" Parameter Is Configured Incorrectly

1. With InPower or through the Operator Panel check the switch input setting (active closed or active open) for Analog Input #5. Ensure that the switch input setting is correctly set. If “Analog Input #5 Sensor Type" parameter is set to active low, an active high will invert the logic, causing this fault code to go active.

C. Incorrectly Wired; Or Open Circuit Or Short Circuit In The Wiring

1. Check the wiring at J11-9 (reference input 1) and J11-10 (switch input) for an open circuit, short circuit, or a miswired condition.

5.5.6 Fault Code 2625 - AUX 101 Input #6 Fault

Analog input #6 fault is active.

Possible Causes:

1. Condition for which "Analog Input #6" is configured is active
2. "Analog Input #6 Active State Selection" parameter is configured incorrectly
3. Incorrectly wired; or open circuit or short circuit in the wiring

A. Condition For Which "Analog Input #6" Is Configured Is Active

1. Check the condition for which "Analog Input #6" has been configured for. After the issue is resolved, press the Reset button on the Operator Panel in order to clear the fault, if the fault does not clear go to next step.

B. Analog Input #6 Active State Selection" Parameter Is Configured Incorrectly

1. With InPower or through the Operator Panel check the switch input setting (active closed or active open) for Analog Input #6. Ensure that the switch input setting is correctly set. If “Analog Input #6 Sensor Type" parameter is set to active low, an active high will invert the logic, causing this fault code to go active.

C. Incorrectly Wired; Or Open Circuit Or Short Circuit In The Wiring

1. Check the wiring at J11-11 (reference input 1) and J11-12 (switch input) for an open circuit, short circuit, or a miswired condition.

5.5.7 Fault Code 2626 - AUX 101 Input #7 Fault

Analog input #7 fault is active.

Possible Causes:

1. Condition for which "Analog Input #7" is configured is active
2. "Analog Input #7 Active State Selection" parameter is configured incorrectly
3. Incorrectly wired; or open circuit or short circuit in the wiring

A. Condition For Which "Analog Input #7" Is Configured Is Active

1. Check the condition for which "Analog Input #7" has been configured for. After the issue is resolved, press the Reset button on the Operator Panel in order to clear the fault, if the fault does not clear go to next step.

B. "Analog Input #7 Active State Selection" Parameter Is Configured Incorrectly

1. With InPower or through the Operator Panel check the switch input setting (active closed or active open) for Analog Input #7. Ensure that the switch input setting is correctly set. If “Analog Input #7 Sensor Type" parameter is set to active low, an active high will invert the logic, causing this fault code to go active.

C. Incorrectly Wired; Or Open Circuit Or Short Circuit In The Wiring

1. Check the wiring at J11-13 (reference input 1) and J11-14 (switch input) for an open circuit, short circuit, or a miswired condition.

5.5.8 Fault Code 2627 - AUX 101 Input #8 Fault

Analog input #8 fault is active.

Possible Causes:

1. Condition for which "Analog Input #8" is configured is active
2. "Analog Input #8 Active State Selection" parameter is configured incorrectly
3. Incorrectly wired; or open circuit or short circuit in the wiring

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A. Condition For Which "Analog Input #8" Is Configured Is Active

1. Check the condition for which "Analog Input #8" has been configured for. After the issue is resolved, press the Reset button on the Operator Panel in order to clear the fault, if the fault does not clear go to next step.

B. "Analog Input #8 Active State Selection" Parameter Is Configured Incorrectly

1. With InPower or through the Operator Panel check the switch input setting (active closed or active open) for Analog Input #8. Ensure that the switch input setting is correctly set. If “Analog Input #8 Sensor Type" parameter is set to active low, an active high will invert the logic, causing this fault code to go active.

C. Incorrectly Wired; Or Open Circuit Or Short Circuit InThe Wiring

1. Check the wiring at J11-15 (reference input 1) and J11-16 (switch input) for an open circuit, short circuit, or a miswired condition.

5.5.9 Fault Code 2729 - IO Module Lost (Warning)

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

Possible Causes:

1. Incorrect Wiring
2. I/O settings misconfigured

A. Incorrect Wiring

1. Connection between AUX 101 and PCC 1302 is incorrect. Ensure proper wiring.
    a. PCC 1302 TB1-1 – PCC Net A (+) to AUX 101 J1-3
    b. PCC 1302 TB1-2 – PCC Net B (-) to AUX 101 J1-4
    c. PCC 1302 TB1-3 – B+ Return to AUX 101 J14-2
    d. PCC 1302 TB1-5 – Customer Fused B+ to AUX 101 J14-1
    e. PCC 1302 TB15-5 – System Wake-up to AUX 101 J1-5

B. I/O Settings Misconfigured

1. If no AUX 101 is connected to PCC 1302, connect to InPower. Under Adjustments > System I/O Adjustment > Output Relays ensure System IO Board Enable is disabled.

2. If no AUX 101 is connected to PCC 1302, connect to InPower. Under Adjustments > System I/O Adjustment > ensure no inputs or outputs are configured as enabled.

5.5.10 Fault Code 2731 - IO Module Lost (Shutdown)

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

Possible Causes:

1. Incorrect Wiring
2. I/O settings misconfigured

A. Incorrect Wiring

1. Connection between AUX 101 and PCC 1302 is incorrect. Ensure proper wiring.
    a. PCC 1302 TB1-1 – PCC Net A (+) to AUX 101 J1-3
    b. PCC 1302 TB1-2 – PCC Net B (-) to AUX 101 J1-4
    c. PCC 1302 TB1-3 – B+ Return to AUX 101 J14-2
    d. PCC 1302 TB1-5 – Customer Fused B+ to AUX 101 J14-1
    e. PCC 1302 TB15-5 – System Wake-up to AUX 101 J1-5

B. I/O Settings Misconfigured

1. If no AUX 101 is connected to PCC 1302, connect to InPower. Under Adjustments > System I/O Adjustment > Output Relays ensure System IO Board Enable is disabled.
2. If no AUX 101 is connected to PCC 1302, connect to InPower. Under Adjustments > System I/O Adjustment > ensure no inputs or outputs are configured as enabled.

5.5.11 Fault Code 2882 - AUX 101 (1) Input #1 Fault

AUX 101 1 Analog/Switch input #1 fault is active.

Possible Causes:

1. Condition for which Analog/Switch Input #1 is configured for is active
2. Aux 101 1 Analog Input #1 active state selection parameter is configured incorrectly
3. Faulty switch unit
4. Faulty switch connector(s)
5. Wiring harness incorrectly wired, open circuit, or short circuit to the AUX 101 board

A. Condition For Which Analog/Switch Input #1 Is Configured For Is Active

1. Verify the condition for which Analog/Switch Input #1 has been configured. After the issue is resolved press the Reset button on the operator panel in order to clear the fault.
    a. If the fault does not clear go to the Aux 101 1 Analog Input #1 active state selection parameter is configured incorrectly step below.

B. Aux 101 1 Analog Input #1 Active State Selection Parameter Is Configured Incorrectly

1. With the InPower service tool or through the operator panel verify the switch input setting (active closed or active open) for Analog/Switch Input #1. Go to: **Setup > Aux 101 Setup.**
    a. Verify that the switch input setting is set correctly.
    b. If Aux 101 1 Analog/Switch Input #1 Sensor Type parameter is set to active close, an active open will invert the logic, causing this fault code to go active.

C. Faulty Switch Unit

1. Visually inspect the switch for proper operation, intended range of movement, and functionality. If any defects or a physical damage are detected the switch unit should be replaced.
2. Measure the resistance of the switch, if the switch is reading incorrectly (shorted or open circuit), replace the switch (< 10 ohms for closed; > 100K ohms for open).

D. Faulty Switch Connector(s)

1. Check the switch unit's connection at the plug for an adequate connection, short circuit, open circuit, or a wiring mismatch at the switch connector end.
2. Inspect the switch and the harness connector pins for:
    a. Bent or broken pins, pushed back, or expanded pins.
    b. Evidence of moisture or corrosion in or on the connector.
    c. Missing or damaged connector seals.
    d. Dirt or debris in or on the connector pins.

E. Wiring Harness Incorrectly Wired, Open Circuit, Or Short Circuit To The AUX 101 Board

1. Check the wiring at J11-3 (reference input) and J11-4 (switch input) for an open circuit, short circuit, or a miss wired condition at the AUX 101 input side.
2. Verify the wiring harness running from the switch plug to the AUX 101 board for shorted low condition at the J11-4 (switch input) side for an active closed parameter fault setting activation.
    a. With the switch disconnected measure the resistance from the J11-4 input pin to the engine block ground; value should be more than 100k ohms.
3. Disconnect the wiring harness.
    a. Test the resistance of the wiring between the switch's output leads (input and return) and input leads at the base board; value should be less than 10 ohms.
    b. Test the resistance from the switch's output leads (input and return) to all other pins in the harness connector; value should be greater than 100k ohms.

5.5.12 Fault Code 2883 - AUX 101 (1) Input #2 Fault

AUX 101 1 Analog/Switch input #2 fault is active.

Possible Causes:

1. Condition for which Analog/Switch Input #2 is configured for is active
2. Aux 101 1 Analog Input #2 active state selection parameter is configured incorrectly
3. Faulty switch unit
4. Faulty switch connector(s)
5. Wiring harness incorrectly wired, open circuit, or short circuit to the AUX 101 board

A. Condition For Which "Analog Input #2" Is Configured Is Active

1. Check the condition for which "Analog Input #2" has been configured for. After the issue is resolved, press the Reset button on the Operator Panel in order to clear the fault, if the fault does not clear go to next step.

B. Aux 101 1 Analog Input #2 Active State Selection Parameter Is Configured Incorrectly

1. With the InPower service tool or through the operator panel verify the switch input setting (active closed or active open) for Analog/Switch Input #2. Go to: **Setup > Aux 101 Setup.**
    a. Verify that the switch input setting is set correctly.
    b. If Aux 101 1 Analog/Switch Input #2 Sensor Type parameter is set to active close, an active open will invert the logic, causing this fault code to go active.

C. Faulty Switch Unit

1. Visually inspect the switch for proper operation, intended range of movement, and functionality. If any defects or a physical damage are detected the switch unit should be replaced.
2. Measure the resistance of the switch, if the switch is reading incorrectly (shorted or open circuit), replace the switch (< 10 ohms for closed; > 100K ohms for open).

D. Faulty Switch Connector(s)

1. Check the switch unit’s connection at the plug for an adequate connection, short circuit, open circuit, or a wiring mismatch at the switch connector end.
2. Inspect the switch and the harness connector pins for:
    a. Bent or broken pins, pushed back, or expanded pins.
    b. Evidence of moisture or corrosion in or on the connector.
    c. Missing or damaged connector seals.
    d. Dirt or debris in or on the connector pins.

E. Wiring Harness Incorrectly Wired, Open Circuit, Or Short Circuit To The AUX 101 Board

1. Check the wiring at J11-1 (reference input) and J11-2 (switch input) for an open circuit, short circuit, or a miss wired condition at the AUX 101 input side.

2. Verify the wiring harness running from the switch plug to the AUX 101 board for shorted low condition at the J11- 2 (switch input) side for an active closed parameter fault setting activation.
    a. With the switch disconnected measure the resistance from the J11- 2 input pin to the engine block ground; value should be more than 100k ohms.

5.5.13 Fault Code 2884 - AUX 101 (1) Input #3 Fault

AUX 101 1 Analog/Switch input #3 fault is active.

Possible Causes:

1. Condition for which Analog/Switch Input #3 is configured for is active
2. Aux 101 1 Analog Input #3 active state selection parameter is configured incorrectly
3. Faulty switch unit
4. Faulty switch connector(s)
5. Wiring harness incorrectly wired, open circuit, or short circuit to the AUX 101 board

A. Condition for which Analog/Switch Input #3 is configured for is active

1. Verify the condition for which Analog/Switch Input #3 has been configured. After the issue is resolved press the Reset button on the operator panel in order to clear the fault.
    a. f the fault does not clear go to the Aux 101 1 Analog Input #3 active state selection parameter is configured incorrectly step below.

B. Aux 101 1 Analog Input #3 Active State Selection Parameter Is Configured Incorrectly

1. With the InPower service tool or through the operator panel verify the switch input setting (active closed or active open) for Analog/Switch Input #3. Go to: **Setup > Aux 101 Setup.**
    a. Verify that the switch input setting is set correctly.
    b. If Aux 101 1 Analog/Switch Input #3 Sensor Type parameter is set to active close, an active open will invert the logic, causing this fault code to go active.

C. Faulty Switch Unit

1. Visually inspect the switch for proper operation, intended range of movement, and functionality. If any defects or a physical damage are detected the switch unit should be replaced.
2. Measure the resistance of the switch, if the switch is reading incorrectly (shorted or open circuit), replace the switch (< 10 ohms for closed; > 100K ohms for open).

D. Faulty Switch Connector(s)

1. Check the switch unit’s connection at the plug for an adequate connection, short circuit, open circuit, or a wiring mismatch at the switch connector end.

2. Inspect the switch and the harness connector pins for:
    a. Bent or broken pins, pushed back, or expanded pins.
    b. Evidence of moisture or corrosion in or on the connector.
    c. Missing or damaged connector seals.
    d. Dirt or debris in or on the connector pins.

E. Wiring Harness Incorrectly Wired, Open Circuit, Or Short Circuit To The AUX 101 Board

1. Check the wiring at J11-5 (reference input) and J11-6 (switch input) for an open circuit, short circuit, or a miss wired condition at the AUX 101 input side.
2. Verify the wiring harness running from the switch plug to the AUX 101 board for shorted low condition at the J11-6 (switch input) side for an active closed parameter fault setting activation.
    a. With the switch disconnected measure the resistance from the J11-6 input pin to the engine block ground; value should be more than 100k ohms.
3. Disconnect the wiring harness.
    a. Test the resistance of the wiring between the switch's output leads (input and return) and input leads at the base board; value should be less than 10 ohms.
    b. Test the resistance from the switch's output leads (input and return) to all other pins in the harness connector; value should be greater than 100k ohms.

5.5.14 Fault Code 2885 - AUX 101 (1) Input #4 Fault

AUX 101 1 Analog/Switch input #4 fault is active.

Possible Causes:

1. Condition for which Analog/Switch Input #4 is configured for is active
2. Aux 101 1 Analog Input #4 active state selection parameter is configured incorrectly
3. Faulty switch unit
4. Faulty switch connector(s)
5. Wiring harness incorrectly wired, open circuit, or short circuit to the AUX 101 board

A. Condition For Which Analog/Switch Input #4 Is Configured For Is Active

1. Condition for which Analog/Switch Input #4 is configured for is active
    a. Verify the condition for which Analog/Switch Input #4 has been configured. After the issue is resolved press the Reset button on the operator panel in order to clear the fault.
        a. If the fault does not clear go to the Aux 101 1 Analog Input #4 active state selection parameter is configured incorrectly step below.

B. Aux 101 1 Analog Input #4 active state selection parameter is configured incorrectlY

1. With the InPower service tool or through the operator panel verify the switch input setting (active closed or active open) for Analog/Switch Input #4. Go to: **Setup > Aux 101 Setup.**
    a. Verify that the switch input setting is set correctly.
    b. If Aux 101 1 Analog/Switch Input #4 Sensor Type parameter is set to active close, an active open will invert the logic, causing this fault code to go active.

C. Faulty Switch Unit

1. Visually inspect the switch for proper operation, intended range of movement, and functionality. If any defects or a physical damage are detected the switch unit should be replaced.
2. Measure the resistance of the switch, if the switch is reading incorrectly (shorted or open circuit), replace the switch (< 10 ohms for closed; > 100K ohms for open).

D. Faulty Switch Connector(s)

1. Check the switch unit's connection at the plug for an adequate connection, short circuit, open circuit, or a wiring mismatch at the switch connector end.
2. Inspect the switch and the harness connector pins for:
    a. Bent or broken pins, pushed back, or expanded pins.
    b. Evidence of moisture or corrosion in or on the connector.
    c. Missing or damaged connector seals.
    d. Dirt or debris in or on the connector pins.

E. Wiring Harness Incorrectly Wired, Open Circuit, Or Short Circuit To The AUX 101 Board

1. Check the wiring at J11-7 (reference input) and J11-8 (switch input) for an open circuit, short circuit, or a miss wired condition at the AUX 101 input side.
2. Verify the wiring harness running from the switch plug to the AUX 101 board for shorted low condition at the J11-8 (switch input) side for an active closed parameter fault setting activation.
    a. With the switch disconnected measure the resistance from the J11-8 input pin to the engine block ground; value should be more than 100k ohms.
3. Disconnect the wiring harness.
    a. Test the resistance of the wiring between the switch's output leads (input and return) and input leads at the base board; value should be less than 10 ohms.
    b. Test the resistance from the switch's output leads (input and return) to all other pins in the harness connector; value should be greater than 100k ohms.

5.5.15 Fault Code 2886 - AUX 101 (1) Input #5 Fault

AUX 101 1 Analog/Switch input #5 fault is active.

Possible Causes:

1. Condition for which Analog/Switch Input #5 is configured for is active
2. Aux 101 1 Analog Input #5 active state selection parameter is configured incorrectly
3. Faulty switch unit
4. Faulty switch connector(s)
5. Wiring harness incorrectly wired, open circuit, or short circuit to the AUX 101 board

A. Condition For Which Analog/Switch Input #5 Is Configured For Is Active

1. Verify the condition for which Analog/Switch Input #5 has been configured. After the issue is resolved press the Reset button on the operator panel in order to clear the fault.
    a. If the fault does not clear go to the Aux 101 1 Analog Input #5 active state selection parameter is configured incorrectly step below.

B. Aux 101 1 Analog Input #5 Active State Selection Parameter Is Configured Incorrectly

1. With the InPower service tool or through the operator panel verify the switch input setting (active closed or active open) for Analog/Switch Input #5. Go to: **Setup > Aux 101 Setup.**
    a. Verify that the switch input setting is set correctly.
    b. If Aux 101 1 Analog/Switch Input #5 Sensor Type parameter is set to active close, an active open will invert the logic, causing this fault code to go active.

C. Faulty Switch Unit

1. Visually inspect the switch for proper operation, intended range of movement, and functionality. If any defects or a physical damage are detected the switch unit should be replaced.
2. Measure the resistance of the switch, if the switch is reading incorrectly (shorted or open circuit), replace the switch (< 10 ohms for closed; > 100K ohms for open).

D. Faulty Switch Connector(s)

1. Check the switch unit's connection at the plug for an adequate connection, short circuit, open circuit, or a wiring mismatch at the switch connector end.
2. Inspect the switch and the harness connector pins for:
    a. Bent or broken pins, pushed back, or expanded pins.
    b. Evidence of moisture or corrosion in or on the connector.
    c. Missing or damaged connector seals.
    d. Dirt or debris in or on the connector pins.

E. Wiring Harness Incorrectly Wired, Open Circuit, Or Short Circuit To The AUX 101 Board

1. Check the wiring at J11-9 (reference input) and J11-10 (switch input) for an open circuit, short circuit, or a miss wired condition at the AUX 101 input side.
2. Verify the wiring harness running from the switch plug to the AUX 101 board for shorted low condition at the J11-10 (switch input) side for an active closed parameter fault setting activation.
    a. With the switch disconnected measure the resistance from the J11-10 input pin to the engine block ground; value should be more than 100k ohms.
3. Disconnect the wiring harness.
    a. Test the resistance of the wiring between the switch's output leads (input and return) and input leads at the base board; value should be less than 10 ohms.
    b. Test the resistance from the switch's output leads (input and return) to all other pins in the harness connector; value should be greater than 100k ohms.

5.5.16 Fault Code 2887 - AUX 101 (1) Input #6 Fault

AUX 101 1 Analog/Switch input #6 fault is active.

Possible Causes:

1. Condition for which Analog/Switch Input #6 is configured for is active
2. Aux 101 1 Analog Input #6 active state selection parameter is configured incorrectly
3. Faulty switch unit
4. Faulty switch connector(s)
5. Wiring harness incorrectly wired, open circuit, or short circuit to the AUX 101 board

A. Condition For Which Analog/Switch Input #6 Is Configured For Is Active

1. Verify the condition for which Analog/Switch Input #6 has been configured. After the issue is resolved press the Reset button on the operator panel in order to clear the fault.
    a. If the fault does not clear go to the Aux 101 1 Analog Input #6 active state selection parameter is configured incorrectly step below.

B. Aux 101 1 Analog Input #6 Active State Selection Parameter Is Configured Incorrectly

1. With the InPower service tool or through the operator panel verify the switch input setting (active closed or active open) for Analog/Switch Input #6. Go to: **Setup > Aux 101 Setup.**
    a. Verify that the switch input setting is set correctly.
    b. If Aux 101 1 Analog/Switch Input #6 Sensor Type parameter is set to active close, an active open will invert the logic, causing this fault code to go active.

C. Faulty Switch Unit

1. Visually inspect the switch for proper operation, intended range of movement, and functionality. If any defects or a physical damage are detected the switch unit should be replaced.
2. Measure the resistance of the switch, if the switch is reading incorrectly (shorted or open circuit), replace the switch (< 10 ohms for closed; > 100K ohms for open).

D. Faulty Switch Connector(s)

1. Check the switch unit's connection at the plug for an adequate connection, short circuit, open circuit, or a wiring mismatch at the switch connector end.
2. Inspect the switch and the harness connector pins for:
    a. Bent or broken pins, pushed back, or expanded pins.
    b. Evidence of moisture or corrosion in or on the connector.
    c. Missing or damaged connector seals.
    d. Dirt or debris in or on the connector pins.

E. Wiring Harness Incorrectly Wired, Open Circuit, Or Short Circuit To The AUX 101 Board

1. Wiring harness incorrectly wired, open circuit, or short circuit to the AUX 101 board
    a. Check the wiring at J11-11 (reference input) and J11-12 (switch input) for an open circuit, short circuit, or a miss wired condition at the AUX 101 input side.
    b. Verify the wiring harness running from the switch plug to the AUX 101 board for shorted low condition at the J11-12 (switch input) side for an active closed parameter fault setting activation.
        a. With the switch disconnected measure the resistance from the J11-12 input pin to the engine block ground; value should be more than 100k ohms.
    c. Disconnect the wiring harness.
        a. Test the resistance of the wiring between the switch's output leads (input and return) and input leads at the base board; value should be less than 10 ohms.
        b. Test the resistance from the switch's output leads (input and return) to all other pins in the harness connector; value should be greater than 100k ohms.

5.5.17 Fault Code 2888 - AUX 101 (1) Input #7 Fault

AUX 101 1 Analog/Switch input #7 fault is active.

Possible Causes:

1. Condition for which Analog/Switch Input #7 is configured for is active
2. Aux 101 1 Analog Input #7 active state selection parameter is configured incorrectly
3. Faulty switch unit
4. Faulty switch connector(s)

5. Wiring harness incorrectly wired, open circuit, or short circuit to the AUX 101 board

A. Condition For Which Analog/Switch Input #7 Is Configured For Is ActivE

1. Verify the condition for which Analog/Switch Input #7 has been configured. After the issue is resolved press the Reset button on the operator panel in order to clear the fault.
    a. If the fault does not clear go to the Aux 101 1 Analog Input #7 active state selection parameter is configured incorrectly step below.

B. Aux 101 1 Analog Input #7 Active State Selection Parameter Is Configured Incorrectly

1. With the InPower service tool or through the operator panel verify the switch input setting (active closed or active open) for Analog/Switch Input #7. Go to: **Setup > Aux 101 Setup.**
    a. Verify that the switch input setting is set correctly.
    b. If Aux 101 1 Analog/Switch Input #7 Sensor Type parameter is set to active close, an active open will invert the logic, causing this fault code to go active.

C. Faulty Switch Unit

1. Visually inspect the switch for proper operation, intended range of movement, and functionality. If any defects or a physical damage are detected the switch unit should be replaced.
2. Measure the resistance of the switch, if the switch is reading incorrectly (shorted or open circuit), replace the switch (< 10 ohms for closed; > 100K ohms for open).

D. Faulty Switch Connector(s)

1. Check the switch unit’s connection at the plug for an adequate connection, short circuit, open circuit, or a wiring mismatch at the switch connector end.
2. Inspect the switch and the harness connector pins for:
    a. Bent or broken pins, pushed back, or expanded pins.
    b. Evidence of moisture or corrosion in or on the connector.
    c. Missing or damaged connector seals.
    d. Dirt or debris in or on the connector pins.

E. Wiring Harness Incorrectly Wired, Open Circuit, Or Short Circuit To The AUX 101 Board

1. Check the wiring at J11-13 (reference input) and J11-14 (switch input) for an open circuit, short circuit, or a miss wired condition at the AUX 101 input side.

2. Verify the wiring harness running from the switch plug to the AUX 101 board for shorted low condition at the J11-14 (switch input) side for an active closed parameter fault setting activation.
    a. With the switch disconnected measure the resistance from the J11-14 input pin to the engine block ground; value should be more than 100k ohms.
3. Disconnect the wiring harness.
    a. Test the resistance of the wiring between the switch's output leads (input and return) and input leads at the base board; value should be less than 10 ohms.
    b. Test the resistance from the switch's output leads (input and return) to all other pins in the harness connector; value should be greater than 100k ohms.

5.6 Auxilliary Codes-102

5.6.1 Fault Code 2628 – AUX 102 Input #9 Fault

Discrete input #9 fault is active.

Possible Causes:

1. Condition for which "Discrete Input #9" is configured is active
2. "Discrete Input #9 Active State Selection" parameter is configured incorrectly
3. Incorrectly wired; or open circuit or short circuit in the wiring

A. Condition For Which "Discrete Input #9" Is Configured Is Active

1. Check the condition for which "Discrete Input #9" has been configured for. After the issue is resolved, press the Reset button on the Operator Panel in order to clear the fault, if the fault does not clear go to next step.

B. Discrete Input #9 Active State Selection" Parameter Is Configured Incorrectly

1. With InPower or through the Operator Panel check the switch input setting (active closed or active open) for Discrete Input #9. Ensure that the switch input setting is correctly set. If "Discrete Input #9 Sensor Type" parameter is set to active low, an active high will invert the logic, causing this fault code to go active.

C. Incorrectly Wired; Or Open Circuit Or Short Circuit In The Wiring

1. Check the wiring at J4-1 (switch input 1) and J4-2 (reference input) for an open circuit, short circuit, or a miswired condition.

5.6.2 Fault Code 2629 – AUX 102 Input #10 Fault

Discrete input #10 fault is active.

Possible Causes:

1. Condition for which "Discrete Input #10" is configured is active
2. "Discrete Input #10 Active State Selection" parameter is configured incorrectly

3. Incorrectly wired; or open circuit or short circuit in the wiring

A. Condition For Which "Discrete Input #10" Is Configured Is Active

1. Check the condition for which "Discrete Input #10" has been configured for. After the issue is resolved, press the Reset button on the Operator Panel in order to clear the fault, if the fault does not clear go to next step.

B. Discrete Input #10 Active State Selection" parameter is configured incorrectly

1. With InPower or through the Operator Panel check the switch input setting (active closed or active open) for Discrete Input #10. Ensure that the switch input setting is correctly set. If “Discrete Input #10 Sensor Type" parameter is set to active low, an active high will invert the logic, causing this fault code to go active.

C. Incorrectly Wired; Or Open Circuit Or Short Circuit In The Wiring

1. Check the wiring at J4-3 (switch input 1) and J4-4 (reference input) for an open circuit, short circuit, or a miswired condition.

5.6.3 Fault Code 2632 – AUX 102 Input #12 Fault

Discrete input #12 fault is active.

Possible Causes:

1. Condition for which "Discrete Input #12" is configured is active
2. "Discrete Input #12 Active State Selection" parameter is configured incorrectly
3. Incorrectly wired; or open circuit or short circuit in the wiring

A. Condition For Which "Discrete Input #12" Is Configured Is Active

1. Check the condition for which "Discrete Input #12" has been configured for. After the issue is resolved, press the Reset button on the Operator Panel in order to clear the fault, if the fault does not clear go to next step.

B. Discrete Input #12 Active State Selection" Parameter Is Configured Incorrectly

1. Check the wiring at J4-7 (switch input 1) and J4-8 (reference input) for an open circuit, short circuit, or a miswired condition.

C. Faulty Switch Unit

1. Visually inspect the switch for proper operation, intended range of movement, and functionality. If any defects or a physical damage are detected the switch unit should be replaced.
2. Measure the resistance of the switch, if the switch is reading incorrectly (shorted or open circuit), replace the switch (< 10 ohms for closed; > 100K ohms for open).

D. Faulty Switch Connector(s)

1. Check the switch unit's connection at the plug for an adequate connection, short circuit, open circuit, or a wiring mismatch at the switch connector end.
2. Inspect the switch and the harness connector pins for:
   a. Bent or broken pins, pushed back, or expanded pins.
   b. Evidence of moisture or corrosion in or on the connector.
   c. Missing or damaged connector seals.
   d. Dirt or debris in or on the connector pins.

E. Incorrectly Wired; Or Open Circuit Or Short Circuit In The Wiring

1. Check the wiring at J4-7 (switch input 1) and J4-8 (reference input) for an open circuit, short circuit, or a miswired condition

5.6.4 Fault Code 2891 - AUX 102 (1) Input #1 Fault

NOTICE
AUX 102 Input #1 may be referred to as Input #9 in some cases.

AUX 102 1 Discrete input #1 fault is active.

Possible Causes:

1. Condition for which Discrete Input #1 is configured for is active
2. Aux 102 1 Discrete Input #1 active state selection parameter is configured incorrectly
3. Faulty switch unit
4. Faulty switch connector(s)
5. Wiring harness incorrectly wired, open circuit, or short circuit to the AUX 102 board

A. Condition For Which Discrete Input #1 Is Configured For Is Active

1. Verify the condition for which Discrete Input #1 has been configured. After the issue is resolved press the Reset button on the operator panel in order to clear the fault.
   a. If the fault does not clear go to the Aux 102 1 Discrete Input #1 active state selection parameter is configured incorrectly step below.

B. Aux 102 1 Discrete Input #1 Active State Selection Parameter Is Configured Incorrectly

1. With the InPower service tool or through the operator panel verify the switch input setting (active closed or active open) for Discrete Input #1. Go to: **Setup > Aux 101 Setup.**
   a. Verify that the switch input setting is set correctly.

b. If Aux 102 1 Discrete Input #1 Sensor Type parameter is set to active close, an active open will invert the logic, causing this fault code to go active.

C. Faulty Switch Unit

1. Visually inspect the switch for proper operation, intended range of movement, and functionality. If any defects or a physical damage are detected the switch unit should be replaced.
2. Measure the resistance of the switch, if the switch is reading incorrectly (shorted or open circuit), replace the switch (< 10 ohms for closed; > 100K ohms for open).

D. Faulty Switch Connector(s)

1. Check the switch unit's connection at the plug for an adequate connection, short circuit, open circuit, or a wiring mismatch at the switch connector end.
2. Inspect the switch and the harness connector pins for:
   a. Bent or broken pins, pushed back, or expanded pins.
   b. Evidence of moisture or corrosion in or on the connector.
   c. Missing or damaged connector seals.
   d. Dirt or debris in or on the connector pins.

E. Wiring Harness Incorrectly Wired, Open Circuit, Or Short Circuit To The AUX 101 Board

1. Check the wiring at J4-2 (reference input) and J4-1 (switch input) for an open circuit, short circuit, or a miss wired condition at the AUX 102 input side.
2. Verify the wiring harness running from the switch plug to the AUX 102 board for shorted low condition at the J4-1 (switch input) side for an active closed parameter fault setting activation.
   a. With the switch disconnected measure the resistance from the J4-1 input pin to the engine block ground; value should be more than 100k ohms.
3. Disconnect the wiring harness.
   a. Test the resistance of the wiring between the switch's output leads (input and return) and input leads at the base board; value should be less than 10 ohms.
   b. Test the resistance from the switch's output leads (input and return) to all other pins in the harness connector; value should be greater than 100k ohms.

5.6.5 Fault Code 2892 - AUX 102 (1) Input #2 Fault

AUX 102 1 Discrete input #2 fault is active.

Possible Causes:

1. Condition for which Discrete Input #2 is configured for is active
2. Aux 102 1 Discrete Input #2 active state selection parameter is configured incorrectly
3. Faulty switch unit
4. Faulty switch connector(s)

5. Wiring harness incorrectly wired, open circuit, or short circuit to the AUX 102 board

NOTICE
AUX 102 Input #2 may be referred to as Input #10 in some cases.

A. Condition For Which Discrete Input #2 Is Configured For Is Active

1. Verify the condition for which Discrete Input #2 has been configured. After the issue is resolved press the Reset button on the operator panel in order to clear the fault.
    a. If the fault does not clear go to the Aux 102 1 Discrete Input #2 active state selection parameter is configured incorrectly step below.

B. Aux 102 1 Discrete Input #2 Active State Selection Parameter Is Configured Incorrectly

1. With the InPower service tool or through the operator panel verify the switch input setting (active closed or active open) for Discrete Input #2. Go to: **Setup > Aux 101 Setup.**
    a. Verify that the switch input setting is set correctly.
    b. If Aux 102 1 Discrete Input #2 Sensor Type parameter is set to active close, an active open will invert the logic, causing this fault code to go active.

C. Faulty Switch Unit

1. Visually inspect the switch for proper operation, intended range of movement, and functionality. If any defects or a physical damage are detected the switch unit should be replaced.
2. Measure the resistance of the switch, if the switch is reading incorrectly (shorted or open circuit), replace the switch (< 10 ohms for closed; > 100K ohms for open).

D. Faulty Switch Connector(s)

1. Check the switch unit's connection at the plug for an adequate connection, short circuit, open circuit, or a wiring mismatch at the switch connector end.
2. Inspect the switch and the harness connector pins for:
    a. Bent or broken pins, pushed back, or expanded pins.
    b. Evidence of moisture or corrosion in or on the connector.
    c. Missing or damaged connector seals.
    d. Dirt or debris in or on the connector pins.

E. Wiring Harness Incorrectly Wired, Open Circuit, Or Short Circuit To The AUX 101 Board

1. Check the wiring at J4-4 (reference input) and J4-3 (switch input) for an open circuit, short circuit, or a miss wired condition at the AUX 102 input side.

2. Verify the wiring harness running from the switch plug to the AUX 102 board for shorted low condition at the J4-3 (switch input) side for an active closed parameter fault setting activation.
   a. With the switch disconnected measure the resistance from the J4-3 input pin to the engine block ground; value should be more than 100k ohms.
3. Disconnect the wiring harness.
   a. Test the resistance of the wiring between the switch's output leads (input and return) and input leads at the base board; value should be less than 10 ohms.
   b. Test the resistance from the switch's output leads (input and return) to all other pins in the harness connector; value should be greater than 100k ohms.

5.6.6 Fault Code 2893 - AUX 102 (1) Input #3 Fault

AUX 102 1 Discrete input #3 fault is active.

Possible Causes:

1. Condition for which Discrete Input #3 is configured for is active
2. Aux 102 1 Discrete Input #3 active state selection parameter is configured incorrectly
3. Faulty switch unit
4. Faulty switch connector(s)
5. Wiring harness incorrectly wired, open circuit, or short circuit to the AUX 102 board

NOTICE
AUX 102 Input #3 may be referred to as Input #11 in some cases.

A. Condition For Which Discrete Input #3 Is Configured For Is Active

1. Verify the condition for which Discrete Input #3 has been configured. After the issue is resolved press the Reset button on the operator panel in order to clear the fault.
   a. If the fault does not clear go to the Aux 102 1 Discrete Input #3 active state selection parameter is configured incorrectly step below.

B. Aux 102 1 Discrete Input #3 Active State Selection Parameter Is Configured Incorrectly

1. With the InPower service tool or through the operator panel verify the switch input setting (active closed or active open) for Discrete Input #3. Go to: **Setup > Aux 101 Setup.**
   a. Verify that the switch input setting is set correctly.
   b. If Aux 102 1 Discrete Input #3 Sensor Type parameter is set to active close, an active open will invert the logic, causing this fault code to go active.

C. Faulty Switch Unit

1. Visually inspect the switch for proper operation, intended range of movement, and functionality. If any defects or a physical damage are detected the switch unit should be replaced.
2. Measure the resistance of the switch, if the switch is reading incorrectly (shorted or open circuit), replace the switch (< 10 ohms for closed; > 100K ohms for open).

D. Faulty Switch Connector(s)

1. Check the switch unit's connection at the plug for an adequate connection, short circuit, open circuit, or a wiring mismatch at the switch connector end.
2. Inspect the switch and the harness connector pins for:
   a. Bent or broken pins, pushed back, or expanded pins.
   b. Evidence of moisture or corrosion in or on the connector.
   c. Missing or damaged connector seals.
   d. Dirt or debris in or on the connector pins.

E. Wiring Harness Incorrectly Wired, Open Circuit, Or Short Circuit To The AUX 101 Board

1. Check the wiring at J4-6 (reference input) and J4-5 (switch input) for an open circuit, short circuit, or a miss wired condition at the AUX 102 input side.
2. Verify the wiring harness running from the switch plug to the AUX 102 board for shorted low condition at the J4-5 (switch input) side for an active closed parameter fault setting activation.
   a. With the switch disconnected measure the resistance from the J4-5 input pin to the engine block ground; value should be more than 100k ohms.
3. Disconnect the wiring harness.
   a. Test the resistance of the wiring between the switch's output leads (input and return) and input leads at the base board; value should be less than 10 ohms.
   b. Test the resistance from the switch's output leads (input and return) to all other pins in the harness connector; value should be greater than 100k ohms.

5.6.7 Fault Code 2894 - AUX 102 (1) Input #4 Fault

AUX 102 1 Discrete input #4 fault is active.

Possible Causes:

1. Condition for which Discrete Input #4 is configured for is active
2. Aux 102 1 Discrete Input #4 active state selection parameter is configured incorrectly
3. Faulty switch unit
4. Faulty switch connector(s)
5. Wiring harness incorrectly wired, open circuit, or short circuit to the AUX 102 board

NOTICE
AUX 102 Input #4 may be referred to as Input #12 in some cases.

A. Condition For Which Discrete Input #4 Is Configured For Is Active

1. Verify the condition for which Discrete Input #4 has been configured. After the issue is resolved press the Reset button on the operator panel in order to clear the fault.
    a. If the fault does not clear go to the Aux 102 1 Discrete Input #4 active state selection parameter is configured incorrectly step below.

B. Aux102_ 1 Discrete Input #4 Active State Selection Parameter Is Configured Incorrectly

1. With the InPower service tool or through the operator panel verify the switch input setting (active closed or active open) for Discrete Input #4. Go to: **Setup > Aux 101 Setup.**
    a. Verify that the switch input setting is set correctly.
    b. If Aux 102 1 Discrete Input #4 Sensor Type parameter is set to active close, an active open will invert the logic, causing this fault code to go active.

C. Faulty Switch Unit

1. Visually inspect the switch for proper operation, intended range of movement, and functionality. If any defects or a physical damage are detected the switch unit should be replaced.
2. Measure the resistance of the switch, if the switch is reading incorrectly (shorted or open circuit), replace the switch (< 10 ohms for closed; > 100K ohms for open).

D. Faulty Switch Connector(s)

1. Check the switch unit's connection at the plug for an adequate connection, short circuit, open circuit, or a wiring mismatch at the switch connector end.
2. Inspect the switch and the harness connector pins for:
    a. Bent or broken pins, pushed back, or expanded pins.
    b. Evidence of moisture or corrosion in or on the connector.
    c. Missing or damaged connector seals.
    d. Dirt or debris in or on the connector pins.

E. WiringHarnessIncorrectlyWiredOpenCircuitOr Short CircuitToThe AUX 101Board

1. Check the wiring at J4-8 (reference input) and J4-7 (switch input) for an open circuit, short circuit, or a miss wired condition at the AUX 102 input side.

2. Verify the wiring harness running from the switch plug to the AUX 102 board for shorted low condition at the J4-7 (switch input) side for an active closed parameter fault setting activation.
   a. With the switch disconnected measure the resistance from the J4-7 input pin to the engine block ground; value should be more than 100k ohms.
3. Disconnect the wiring harness.
   a. Test the resistance of the wiring between the switch's output leads (input and return) and input leads at the base board; value should be less than 10 ohms.
   b. Test the resistance from the switch's output leads (input and return) to all other pins in the harness connector; value should be greater than 100k ohms.

5.7 Battle Short Procedures

5.7.1 Battle Short Mode Procedures

All of the following procedures are required to activate Battle Short mode.

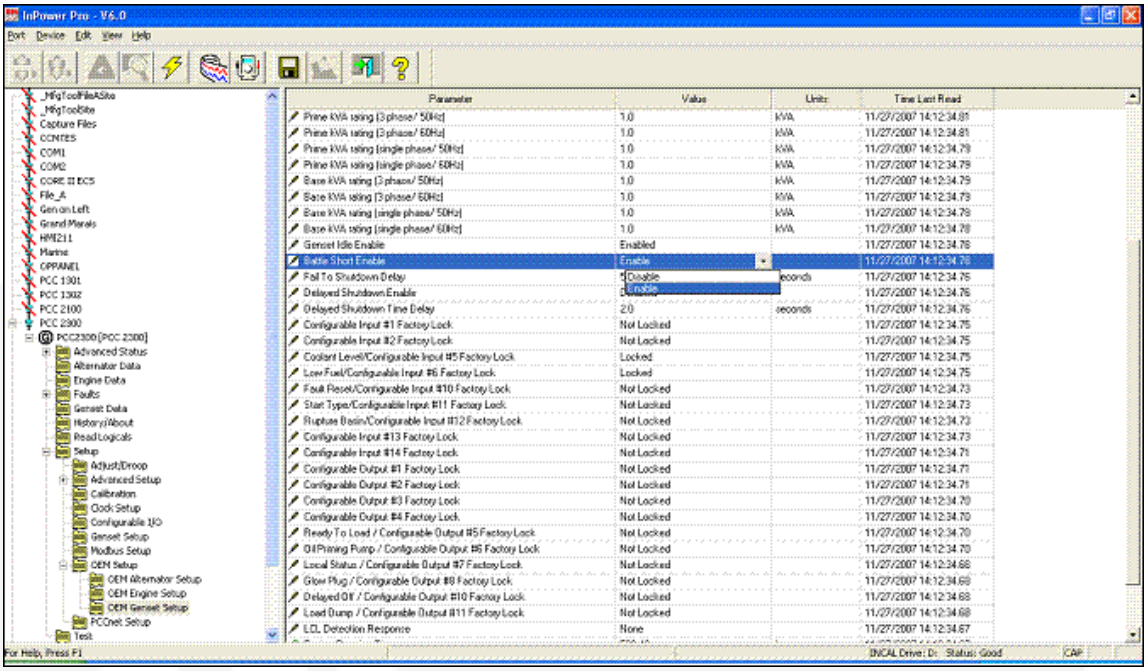
These procedures require the equipment identified in the table below.

TABLE 19. REQUIRED EQUIPMENT FOR BATTLE SHORT MODE PROCEDURES

Part Description	Part Number
InPower Pro service tool	0998-0077-02 (existing user) 0988-0077-04 (new user)
INLINE 4 product kit	4918190
INLINE 5 product kit	4918416
PC-based service tool harness	0541-1199

5.7.2 Enable Battle Short Mode in the PCC

1. Put the PCC in Off mode.
2. Use the PC-based service tool harness to connect the computer to TB15 on the PCC base board.
3. Open InPower (make sure that the security dongle is attached to the computer), and select the control in the left side of the window (Example: PCC 2300 shown).
4. Click on the Setup >OEM Setup > OEM Genset Setup folders.
5. Set the Battle Short Enable parameter to Enable, as shown below.

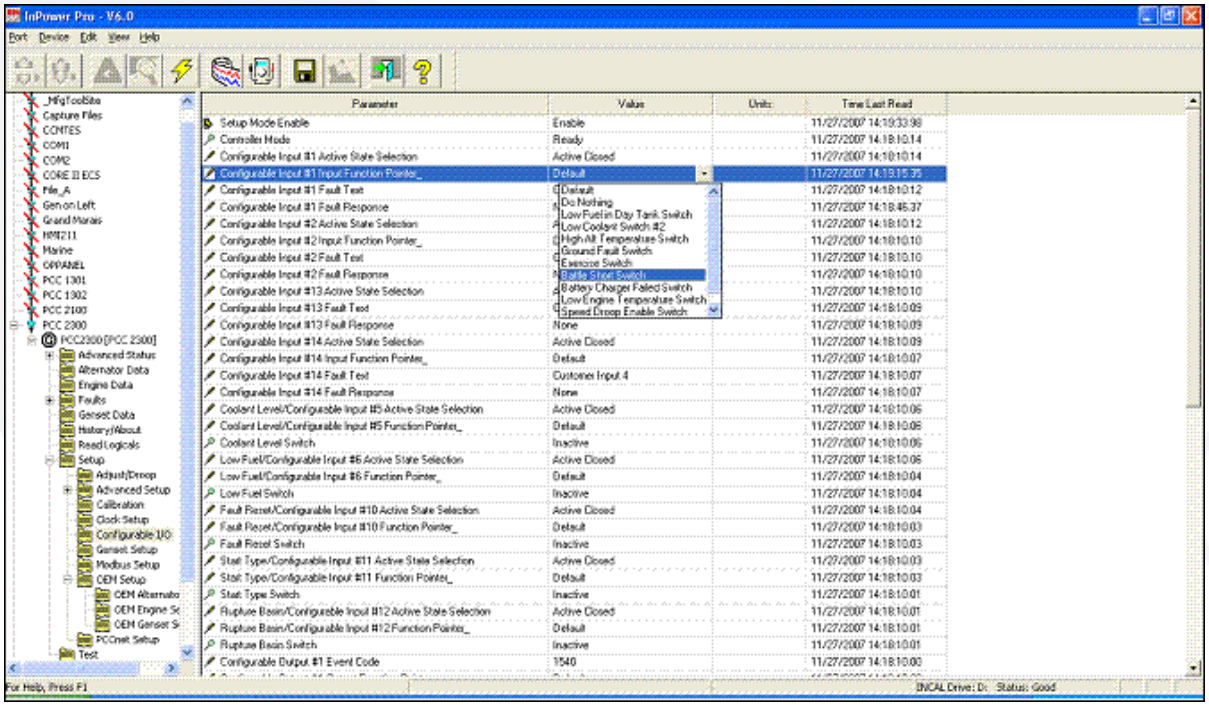


6. Click on Save in order to save the changes.

5.7.3 Activate Battle Short Mode

Each configurable input can be Active Open or Active Closed. Check the value of the configurable input that was configured to Battle Short Switch, and activate the configurable input accordingly.

For example, Configurable Input #1 Active State Selection is set to Active Closed below. In order to activate Battle Short mode, Configurable Input #1 (TB-12 and TB13) has to be closed (connected together).



If Configurable Input #1 Active State Selection were set to Active Open, Configurable Input #1 (TB-12 and TB13) has to be an open contact (disconnected) to activate Battle Short mode.

5.7.4 Battle Short Mode

Battle Short mode is used to satisfy local code requirements. While Battle Short mode is active, the PCC ignores non-critical shutdown faults and non-critical shutdown with cooldown faults. It does not initiate a stop sequence and continues to run the genset until Battle Short Mode is inactive. Otherwise, genset operation remains the same.

⚠ WARNING

Use of Battle Short mode can cause a fire or electrical hazard, resulting in severe personal injury, death, and/or property and equipment damage. This mode must only be used during supervised, temporary operation of the genset.

Battle Short mode must be set up at the factory or by an authorized service representative. Contact your local distributor for assistance.

Battle Short mode is active only when all of these conditions are met:

- *Battle Short Enable* is set to Enable.
- The ECM is set to enable Battle Short mode (Core 2 ECMs only).
- The Battle Short Switch or *Battle Short Switch (Modbus)* is active. (*Battle Short Switch (Modbus*) is not available in the Operator Panel.)

The PCC generates warning fault 2942 (Shutdown Override Fail) if the Battle Short Switch is active but any of the other conditions are not met.

Battle Short mode is not a distinct mode of operation . The PCC is still in Off mode, Manual mode, or Auto mode while Battle Short mode is active. The PCC still follows the appropriate sequence of operation to start the genset and to stop the genset.

The PCC generates warning fault 1131 (Battle Short Active) as long as Battle Short mode is active.

While Battle Short mode is active, the PCC ignores most shutdown faults and only initiates a Shutdown Without Cooldown sequence if a critical shutdown fault occurs.

When the PCC overrides a shutdown fault, it generates warning fault 1416 (Fail To Shutdown) after *Fail To Shutdown Delay* as long as Battle Short mode remains active. It also turns on the Shutdown LED.

⚠ WARNING

The faults that are overridden in Battle Short mode can affect genset performance and might cause permanent engine, alternator, or connected equipment damage. All shutdown faults, including those overridden in Battle Short mode, must be acted upon immediately to ensure the safety and well-being of the operator and the genset.

NOTICE

Any damage caused to the genset as a direct result of running in Battle Short mode is not covered by the warranty.

5.8 Battery Troubleshooting

5.8.1 No DC Output (No Fault Message)

Charger cannot sense any DC output.

Possible Cause:

1. Tripped DC circuit breaker.
2. Blown AC fuse(s) (on 277, 380, 416 and 600 VAC battery chargers).
3. Tripped AC circuit breaker(s) (on 120, 208 and 240 VAC battery chargers).

A. Tripped DC Circuit Breaker

1. Correct the possible overload and reset the circuit breaker.

B. Blown AC Fuse(s) (on 277, 380, 416 and 600 VAC Battery Chargers)

1. Correct the possible overload and replace the fuse(s).

C. Tripped AC circuit breaker(s) (on 120, 208 and 240 VAC battery chargers)

1. Correct the possible overload and reset the circuit breaker.

5.8.2 Low DC Output (No Fault Message)

Charger senses low DC output.

Possible Cause:

1. Battery Failure.
2. Charger failure.

A. Battery Failure

1. Replace the battery and cycle through the Setup menus to clear the fault.

B. Charger Failure

1. Replace the battery charger.

5.8.3 High DC Output (No Fault Message)

Charger senses high DC Output.

Possible Cause:

1. Charger failure.

A. Charger Failure

1. Replace the battery charger.

5.8.4 Fault Code 441 - Low Battery Voltage

Logic:

Battery voltage is low

Possible Causes:

1. No battery connected.
2. Output breaker is in the “Off” (down) position.
3. A 12 V battery is connected but the charger is set for 24 V charging.
4. Battery can no longer maintain charge.
5. The wire between the charger and the battery is loose or broken

A. No Battery Connected

1. Connect the battery.

B. Output Breaker Is In The “Off” (Down) Position.

1. Verify the output breaker is in “On” (up) position.

C. A 12V Battery Is Connected But The Charger Is Set For 24V Charging

1. Attach a 24V battery or set the charger for 12V charging

D. Battery Can No Longer Maintain Charge

1. Replace the battery.

E. The Wire Between The Charger And The Battery Is Loose Or Broken

1. Check the wire.

5.8.5 Fault Code 442 - High Battery Voltage

Battery voltage is high.

Possible Causes:

1. A 24 V battery is connected but the charger is set for 12 V charging.
2. Large load dump may have caused momentary voltage rise.

A. A 12V Battery Is Connected But The Charger Is Set For 24V Charging

1. Attach a 24V battery or set the charger for 12V charging

B. Large Load Dump May Have Caused Momentary Voltage Rise

Cycle through the Setup menus to clear the fault and restart charging.

C. Cycle Through The Setup Menus To Try And Clear The Fault

- If the fault returns, the charger control may have failed.

D. Clearing the Fault Code

NOTICE
Fault code can only be cleared by: • **Disconnect the charger harness plug,** • **Cycle completely through the setup menus,** **Or** • **Recycling the power.**

5.8.6 Fault Code 1442 - Weak Battery

This fault occurs when the engine is starting (cranking) and the voltage of the battery drops below the “Weak Battery Voltage threshold" for the time set in the “Weak Battery Voltage Set Time".

Possible Causes:

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

A. Weak Or Discharged Battery

1. Measure the voltage of the battery with a voltmeter. Battery voltage should be 12 VDC or greater in a 12 V system or 24 VDC or greater in a 24 VDC system. If the battery voltage is low, check the electrolyte level in the battery. Replenish the electrolyte level if low and recharge the battery; the specific gravity for a fully charged lead acid battery is approximately 1.260 at 80 °F (27 °C).
2. If the battery cannot hold adequate voltage, replace the battery.

B. Battery Connections Are Loose Or Dirty

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

C. “Weak battery" voltage threshold parameter is set too high

1. Ensure that the Weak Battery Voltage parameter is set to an appropriate voltage value that takes into account voltage drop during cranking (refer to the parameter list to see the default value). To access the battery voltage setup menu from the operator panel, go to **Setup > OEM Setup > OEM Engine Setup > Weak Battery** and change the weak battery voltage parameter of the control accordingly.

D. Insufficient Battery Charging Voltage

1. Ensure that the battery charger is charging the battery at an acceptable rate. Adjust the charge rate if the rate is below the recommendation of the manufacturer.
2. If the battery located far from the battery charger, ensure that a proper wire size is used to compensate for voltage drop.

E. Faulty Engine DC Alternator

1. Check the engine DC alternator. If normal charging voltage is not 12 to 14 VDC in a 12 V system or 24 to 26 VDC in a 24 V system then replace the DC alternator.

F. Faulty harness

1. Measure the battery voltage at the battery terminals, then measure the battery voltage at the base board input. Measure the voltage at B+ (J20–9, J20–10, J20-20, J20–21) and B- (negative) input (J20–2, J20–4, J20–7, J20–12).
    - If the voltage at the battery terminals and the control is not the same then check the harness and replace if necessary.

5.8.7 Fault Code 1443 - Dead Battery

During cranking, the battery voltage drops below the operating voltage of the control, which resets the control. After the control has reset three consecutive times, event/fault code 1443 will become active.

Possible Causes:

1. Weak or discharged battery.
2. Battery connections are loose or dirty.
3. Insufficient battery charging voltage.
4. Faulty engine DC alternator.
5. Faulty harness.

A. Weak Or Discharged Battery

1. Measure the voltage of the battery with a voltmeter. Battery voltage should be 12 VDC or greater in a 12 V system or 24 VDC or greater in a 24 VDC system. If the battery voltage is low, check the electrolyte level in the battery. Replenish the electrolyte level if low and recharge the battery; the specific gravity for a fully charged lead acid battery is approximately 1.260 at 80 °F (27 °C).
2. If the battery cannot hold adequate voltage, replace the battery.

B. Battery Connections Are Loose Or Dirty

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

C. Insufficient Battery Charging Voltage

1. Ensure that the battery charger is charging the battery at an acceptable rate. Adjust the charge rate if the rate is below the recommendation of the manufacturer.
2. If the battery located far from the battery charger, ensure that a proper wire size is used to compensate for voltage drop.

D. Faulty Engine DC Alternator

1. Check the engine DC alternator. If normal charging voltage is not 12 to 14 VDC in a 12 V system or 24 to 26 VDC in a 24 V system then replace the DC alternator.

E. Faulty harness

1. Measure the battery voltage at the battery terminals, then measure the battery voltage at the base board input. Measure the voltage at B+ (J20–9, J20–10, J20-20, J20–21) and B- (negative) input (J20–2, J20–4, J20–7, J20–12).
    - If the voltage at the battery terminals and the control is not the same then check the harness and replace if necessary.

5.8.8 Fault Code 2331 - Low AC Voltage

AC input voltage is more than 10% below nominal rated voltage.

Possible Causes:

1. AC input voltage is more than 10% below nominal rated voltage.

A. AC Input Voltage Is More Than 10% Below Nominal Rated Voltage

1. Check level of input voltage.
    - Charger will not operate with voltage 10% or more below nominal.

5.8.9 Fault Code 2358 - High AC Voltage

Logic:

AC input voltage is more than 10% above nominal rated voltage.

Possible Causes:

1. AC input voltage is more than 10% above nominal rated voltage.

A. AC Input Voltage Is More Than 10% Above Nominal Rated Voltage

1. Check level of input voltage.
    - Charger will not operate with voltage 10% or more above nominal.

5.8.10 Fault Code 2993 - Battery Charger Failed

1. Charger failure.

A. Charger Failure

1. Replace the battery charger.

5.9 Engine Performance Troubleshooting

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

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

Possible causes:

1. No power is supplied to the control. (Control Alive indicator on the base board is not flashing).
2. The base board is not properly calibrated or the calibration is corrupt (the Control Alive indicator on the base board is flashing every 0.5 seconds).
3. The Emergency Stop switch or wiring is defective.
4. The Manual input is not getting from the Manual Select Switch (S12) to the base board.
5. The Manual Run/Stop button, harness, or the base board is defective.

5.9.1.1 Engine Does Not Crank in Manual Mode - Diagnosis and Repair

1. No power is supplied to the control. (The Control Alive indicator on the base board is not flashing).
   - Poor battery cable connections. Clean the battery cable terminals and tighten all connections using an insulated wrench.
   - Remove F4 and check continuity. If open, replace the fuse with one of the same type and amp rating (5 Amps).
     - If F4 is OK, remove connector P7 and check for B+ at P7-1 through P7-4 and GND at P7-5 through P7-8.
     - If B+ or ground missing, isolate to the harness and the TB BAT terminal mounted on the engine block.
     - If B+ and ground check OK, the base board may be defective. Cycle power to the base board by reconnecting P7.
2. The base board is not properly calibrated or the calibration is corrupt. (The Control Alive indicator flashes every ½ second.)
   - Confirm that the installed calibration part number matches the serial plate information. Re-enter a calibration file if necessary. (When properly installed, the Control Alive indicator flashes once every second.)

3. The Emergency Stop switch or wiring is defective.
    - With the Emergency Stop push button not activated, remove connector P1 and check for continuity between P1-1 (ESTOP-NC1) and P1-2 (ESTOP-NC2). (If the circuit is open, the control will detect a local E-Stop condition but will not display the E-Stop condition.) If the circuit is open, isolate to the Emergency Stop switch and wiring.
    - If there is continuity, go to the next step.
4. The Manual input is not getting from the Manual select switch (S12) to the base board indicating that S12, the base board, or the harness is defective.
    - With S12 in the Manual position, remove connector P1 from the base board and check for continuity from P1-6 (MAN) to P1-9 (GND). If there is no continuity, isolate the switch and wiring.
    - If there is continuity, go to the next step.
5. The Manual Run/Stop button, harness, or the base board is defective.
    - Remove connector P3 from the base board and check for continuity from P3-9 (MAN RUN/STOP) to P3-10 (GND). If there is no continuity when pressing the Manual Run/Stop button, replace the front membrane panel.

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

Logic:

PCC has not received or recognized a remote start signal.

Possible Cause:

1. The remote start switch or customer wiring is faulty.
2. The Auto mode input is not getting from the Auto select switch (S12) to the base board indicating that S12 or the harness is defective.

5.9.2.1 Engine Does Not Crank in Remote Mode - Diagnosis and Repair

1. The remote start switch or customer wiring is faulty.
    - Reset the control. Attempt to start and check for ground at TB1-1.
        - If ground is not present, isolate to the remote switch or customer wiring. Repair as necessary.
        - If ground is present, go to next step.
2. The Auto mode input is not getting from the Auto select switch (S12) to the base board, indicating that the S12 switch or the harness is defective.
    - With S12 in the Auto position, remove connector P1 from the base board and check for continuity from P1-5 (Auto) to P1-9 (GND).
        - If no continuity exists, isolate to the switch or the wiring harness.

5.9.3 Engine Lacks Power or Is Unstable (No Fault Message)

Logic: The PCC has not received or recognized a generator set fault.

Possible causes:

1. Current ambient conditions cause a derate, limiting power to less than the rated power.
2. The engine air filter element is dirty.
3. Check for exhaust restrictions.
4. Engine hunting at 90% to 100 % of full load.
5. Engine hunting when load is removed
6. The engine is worn.

5.9.3.1 Engine Lacks Power or Is Unstable - Diagnosis and Repair

1. Determine proper derates for ambient conditions. Refer to the Specification Sheet for site derating factors.
2. Replace the air filter element.
3. See the Installation Manual.
4. Check for low coolant and fill if necessary.

   Check for air in the cooling system and, if necessary, bleed the cooling system.
5. See instructions for Fault Code 1318.
6. Service the engine according to the engine service manual.

5.9.4 Engine is Difficult to Start or Does Not Start (Exhaust Smoke)

Possible Causes:

1. Battery voltage
2. Starting procedure/aid
3. Fuel system issue(s)
4. Air intake or exhaust issue(s)
5. Sensor issue(s)
6. Other issue(s)

5.9.4.1 Engine is Difficult to Start or Does Not Start (Exhaust Smoke) - Diagnosis and Repair

1. Battery voltage
   - Battery voltage is low, interrupted, or open.
     - Check the batteries connections, unswitched battery supply circuit, and fuses.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
2. Starting procedure/aid
   - Starting procedure is not correct.
     - Verify the correct starting procedure.

- Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

- Starting aid is necessary for cold weather or starting aid is malfunctioning.
  - Check for the correct operation of the starting aid.
  - Refer to the manufacturer's instructions.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

3. Fuel system issue(s)
   - Inspect fuel lines, fuel connections and fuel filters for leaks.
     - Repair if leaks found.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Open the fuel tank cap and verify the fuel level is not below the pickup tube in the tank.
     - Add fuel to the fuel tank if the fuel level is found to be low.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Manual fuel shutoff valve is closed.
     - Check the OEM fuel shutoff valves.
     - Verify that the fuel tanks are open.
   - Fuel shutoff valve solenoid or circuit is malfunctioning.
     - Check the fuel shutoff valve solenoid and circuit.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Check for air in the fuel system.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Check for the fuel inlet restriction.
     - Check the fuel inlet lines for restriction.
     - Check for plugged fuel filters, a restricted lift pump bypass check valve, pinched fuel lines, or a restricted stand pipe in the fuel tank.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Check for fuel drain line restriction.
     - Check the fuel drain lines for restriction.
     - Clear or replace the fuel lines, check valves, or tank vents as necessary.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

- Fuel system restriction is above specification.
  - Check all fuel system lines for restrictions or debris.
  - Clear or replace the fuel lines, fuel tubes, fuel manifold, check valves, tank vents, actuator screens, and cylinder head drillings as necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Gear pump is malfunctioning.
  - Check the gear pump output pressure.
  - Replace the gear pump if necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

4. Air intake or exhaust issue(s)
   - Air intake system restriction is above specification.
     - Check the air intake system for restriction.
     - Clean or replace the air filter and inlet piping as necessary.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Exhaust system restriction is above specification.
     - Check the exhaust system for restrictions.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
5. Sensor issue(s)
   - Fuel system pressure sensors (fueling/timing) are malfunctioning.
     - Check the fuel system pressure sensors (fueling/timing).
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Intake manifold pressure sensor is malfunctioning.
     - Check the intake manifold pressure sensor.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Ambient air pressure sensor is malfunctioning.
     - Check the ambient air pressure sensor.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Crankshaft and/or camshaft speed/position sensor(s) reading incorrectly.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

6. Other issue(s)
    - Engine parasitics are excessive.
        - Check engine-driven units for correct operation.
        - Check the cooling fan for correct operation and cycle time.
        - Refer to the OEM specifications.
    - Overhead adjustments are not correct.
        - Adjust the overhead settings.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
    - Base engine problem.
        - Check the engine for high crankcase pressure, low compression, damaged pistons, camshaft, and other parts.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
    - Injector O-rings are damaged or missing.
        - Remove and check the injectors.
        - Replace the injector O-rings.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

5.9.5 Engine is Difficult to Start or Does Not Start (No Exhaust Smoke)

Possible Causes:

1. Emergency stop/remote emergency stop
2. Battery voltage
3. Run/stop circuit issue
4. Fuel system issue(s)
5. Air intake or exhaust issue(s)
6. Sensor issue(s)
7. Other issue(s)

5.9.5.1 Engine is Difficult to Start or Does Not Start (No Exhaust Smoke) - Diagnosis and Repair

1. Emergency stop/remote emergency stop
    - Emergency Stop/Remote Emergency Stop circuit energized.
        - Verify that either the Emergency Stop or the Remote Emergency Stop circuit is not energized.

2. Battery voltage
    - Battery voltage is low, interrupted, or open.
        - Check the battery connections, un-switched battery supply circuit, and fuses.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
3. Run/Stop circuit issue
    - Run/Stop circuit is malfunctioning.
        - Check the generator Run/Stop circuit.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
4. Fuel system issue(s)
    - Inspect fuel lines, fuel connections, and fuel filters for leaks.
        - Repair if leaks found.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
    - Open the fuel tank cap and verify the fuel level is not below the pickup tube in the tank.
        - Add fuel to the fuel tank if the fuel level is found to be low.
    - Manual fuel shutoff valve is closed.
        - Check the OEM fuel shutoff valves.
        - Verify that the fuel tanks are open.
    - Fuel shutoff valve solenoid or circuit is malfunctioning.
        - Check the fuel shutoff valve solenoid and circuit.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
    - In-line check valve(s) are installed backwards or have incorrect part number.
        - Inspect the check valve(s) for correct installation and part number.
    - Check for air in the fuel system.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
    - Check for fuel inlet restriction.
        - Check the fuel inlet lines for restriction.
        - Look for plugged fuel filters, a restricted lift pump bypass check valve, pinched fuel lines, or a restricted stand pipe in the fuel tank.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
    - Check for fuel drain line restriction.
        - Check the fuel drain lines for restriction.

- Clear or replace the fuel lines, check valves, or tank vents as necessary.
- Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

- Fuel system restriction is above specification.
  - Check all fuel system lines for restrictions or debris.
  - Clear or replace the fuel lines, fuel tubes, fuel manifold, check valves, tank vents, actuator screens, and cylinder head drillings as necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Gear pump is malfunctioning.
  - Check the gear pump output pressure.
  - Replace the gear pump if necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

5. Air intake or exhaust issues
   - Air intake system restriction is above specification.
     - Check the air intake system for restriction.
     - Clean or replace the air filter and inlet piping as necessary.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Exhaust system restriction is above specification.
     - Check the exhaust system for restrictions.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
6. Sensor issue(s)
   - Crankshaft and/or camshaft speed/position sensor(s) reading incorrectly.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Intake manifold pressure sensor is malfunctioning.
     - Check the intake manifold pressure sensor.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Ambient air pressure sensor is malfunctioning.
     - Check the ambient air pressure sensor.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

7. Other issue(s)
    - Overhead adjustments are not correct.
        - Adjust the overhead settings.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
    - Internal engine damage.
        - Analyze the oil and inspect the filters, pistons, camshaft, and other parts to locate an area of probable damage.

5.9.6 Engine Experiences Low Power, Poor Acceleration, or Poor Response

1. Excessive load
2. Fuel system issue(s)
3. Air intake or exhaust issue(s)
4. Sensor issue(s)
5. Other issue(s)

5.9.6.1 Engine Experiences Low Power, Poor Acceleration, or Poor Response - Diagnosis and Repair

1. Excessive load(s)
    - Ensure that the load on the generator set does not exceed the generator set KW rating.
        - Revisit the generator set sizing process to ensure that the generator set is correctly sized for the application, especially if new loads have been introduced into the system.
        - Refer to the T−030 manual for proper generator set sizing and application.
2. Fuel system issue(s)
    - Inspect fuel lines, fuel connections, and fuel filters for leaks.
        - Repair if leaks found.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
    - Open the fuel tank cap and verify the fuel level is not below the pickup tube in the tank.
        - Add fuel to the fuel tank if the fuel level is found to be low.
    - Fuel grade is not correct for the application; fuel quality is poor or presence of water in the fuel.
        - Operate the engine from a tank of high-quality fuel.
        - Refer to Fuel for Cummins Engines, Bulletin 3379001.

- Check for air in the fuel system.
  - Refer to procedure in the troubleshooting and repai manual for the specific engine.
- Check for fuel inlet restriction.
  - Check the fuel inlet lines for restriction.
  - Look for plugged fuel filters, a restricted lift pump bypass check valve, pinched fuel lines, or a restricted stand pipe in the fuel tank.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Check for fuel drain line restriction.
  - Check the fuel drain lines for restriction.
  - Clear or replace the fuel lines, check valves, or tank vents as necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Fuel system restriction is above specification.
  - Check all fuel system lines for restrictions or debris.
  - Clear or replace the fuel lines, fuel tubes, fuel manifold, check valves, tank vents, actuator screens, and cylinder head drillings as necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Gear pump is malfunctioning.
  - Check the gear pump output pressure.
  - Replace the gear pump if necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Fuel pump overflow valve is malfunctioning.
  - Check the overflow valve.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine..
- Fuel lift pump is malfunctioning.
  - Check the fuel lift pump for correct operation.
  - Check the pump output pressure.
  - Replace the fuel lift pump if necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Fuel injection pump is malfunctgioning.
  - Remove and test the fuel injection pump.
  - Replace the pump if necessary.

        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
    - Check for injector malfunction.
        - Perform the cylinder performance test.
        - Replace injectors as necessary.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

3. Air intake or exhaust issue(s)
    - Air intake system restriction is above specification.
        - Check the air intake system for restriction.
        - Clean or replace the air filter and inlet piping as necessary.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
    - Air intake or exhaust leaks.
        - Inspect the air intake and exhaust systems for air leaks.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
    - Turbocharger is malfunctioning.
        - Monitor the turbocharger boost pressure with an INSITE electronic service tool.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
    - Exhaust system restriction is above specification.
        - Check the exhaust system for restrictions.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
4. Sensor issue(s)
    - Coolant temperature sensor is malfunctioning.
        - Use InPower or INSITE service tool(s) to check the coolant temperature sensor.
        - Refer to the procedure in the troubleshooting and repair manual for the specific engine.
    - Intake manifold pressure sensor is malfunctioning.
        - Check the intake manifold pressure sensor.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
    - Ambient air pressure sensor is malfunctioning.
        - Check the ambient air pressure sensor.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

5. Other issue(s)
    - Engine is operating above recommended altitude.
        - Engine power decreases above recommended altitude.
        - Refer to the Engine Data Sheet for the specific engine for specifications.
    - Engine parasitics are excessive.
        - Check engine-driven units for correct operation.
        - Check the cooling fan for correct operation and cycle time.
        - Refer to the OEM specifications.
    - Overhead adjustments are not correct.
        - Adjust the overhead settings.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
    - Base engine problem.
        - Check the engine for high crankcase pressure, low compression, damaged pistons, camshaft, and other parts.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

5.9.7 Engine Runs Rough or Misfires

1. Air intake or exhaust issue(s)
2. Fuel system issue(s)
3. Sensor issue(s)
4. Other issue(s)

5.9.7.1 Engine Runs Rough or Misfires - Diagnosis and Repair

1. Air intake or exhaust issue(s)
    - Air intake system restriction is above specification.
        - Check the air intake system for restriction.
        - Clean or replace the air filter and inlet piping as necessary.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
    - Exhaust system restriction is above specification.
        - Check the exhaust system for restrictions.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
2. Fuel system issue(s)
    - Inspect fuel lines, fuel connections, and fuel filters for leaks.
        - Repair if leaks found.

    - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Fuel grade is not correct for the application; fuel quality is poor or presence of water in the fuel.
    - Operate the engine from a tank of high-quality fuel.
    - Refer to Fuel for Cummins Engines, Bulletin 3379001.
- Check for air in the fuel system.
    - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Check for fuel inlet restriction.
    - Check the fuel inlet lines for restriction.
    - Look for plugged fuel filters, a restricted lift pump bypass check valve, pinched fuel lines, or a restricted stand pipe in the fuel tank.
    - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Check for fuel drain line restriction.
    - Check the fuel drain lines for restriction.
    - Clear or replace the fuel lines, check valves, or tank vents as necessary.
    - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Fuel system restriction is above specification.
    - Check all fuel system lines for restrictions or debris.
    - Clear or replace the fuel lines, fuel tubes, fuel manifold, check valves, tank vents, actuator screens, and cylinder head drillings as necessary.
    - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Gear pump is malfunctioning.
    - Check the gear pump output pressure.
    - Replace the gear pump if necessary.
    - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Fuel pump overflow valve is malfunctioning.
    - Check the overflow valve.
    - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Check for injector malfunction.
    - Perform the cylinder performance test.
    - Replace injectors as necessary.

- Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

- Fuel lift pump is malfunctioning.
  - Check the fuel lift pump for correct operation.
  - Check the pump output pressure.
  - Replace the fuel lift pump if necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Fuel injection pump is malfunctioning.
  - Remove and test the fuel injection pump.
  - Replace the pump if necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

3. Sensor issue(s)
   - Crankshaft and/or camshaft speed/position sensor(s) reading incorrectly.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Fuel system pressure sensors (fueling/timing) are malfunctioning.
     - Check the fuel system pressure sensors (fueling/timing).
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Coolant temperature sensor is malfunctioning.
     - Use InPower service tool to check the coolant temperature sensor.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Intake manifold pressure sensor is malfunctioning.
     - Check the intake manifold pressure sensor.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Ambient air temperature sensor is malfunctioning.
     - Check the ambient air temperature sensor.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
4. Other issue(s)
   - Engine parasitics are excessive.
     - Check engine-driven units for correct operation.
     - Check the cooling fan for correct operation and cycle time.
     - Refer to the OEM specifications.

- Engine mounts are worn, damaged, loose, or not correct.
  - Verify the condition of the mounts.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Overhead adjustments are not correct.
  - Adjust the overhead settings.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Base engine problem.
  - Check the engine for high crankcase pressure, low compression, damaged pistons, camshaft, and other parts.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

5.9.8 Engine Shuts Off Unexpectedly or Dies During Deceleration

1. Emergency Stop/Remote Emergency Stop
2. Fuel system issue(s)
3. Electronic control module related issue(s)
4. Other issue(s)

5.9.8.1 Engine Shuts Off Unexpectedly or Dies During Deceleration - Diagnosis and Repair

1. Emergency Stop/Remote Emergency Stop
   - Emergency Stop/Remote Emergency Stop circuit energized.
     - Verify that either the Emergency Stop or the Remote Emergency Stop circuit is not energized.
2. Fuel system issue(s)
   - Open the fuel tank cap and verify the fuel level is not below the pickup tube in the tank.
     - Add fuel to the fuel tank if the fuel level is found to be low.
   - Manual fuel shutoff valve is closed.
     - Check the OEM fuel shutoff valves.
     - Verify that the fuel tank isolation valves are open.
   - Fuel shutoff valve solenoid or circuit is malfunctioning.
     - Check the fuel shutoff valve solenoid and circuit.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

- Check for air in the fuel system.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Check for fuel inlet restriction.
  - Check the fuel inlet lines for restriction.
  - Check for plugged fuel filters, a restricted lift pump bypass check valve, pinched fuel lines, or a restricted stand pipe in the fuel tank.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Check for fuel drain line restriction.
  - Check the fuel drain lines for restriction.
  - Clear or replace the fuel lines, check valves, or tank vents as necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Fuel system restriction is above specification.
  - Check all fuel system lines for restrictions or debris.
  - Clear or replace the fuel lines, fuel tubes, fuel manifold, check valves, tank vents, actuator screens, and cylinder head drillings as necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Gear pump is malfunctioning.
  - Check the gear pump output pressure.
  - Replace the gear pump if necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Fuel lift pump is malfunctioning.
  - Check the fuel lift pump for correct operation.
  - Check the pump output pressure.
  - Replace the fuel lift pump if necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

3. Electronic control module related issue(s)
   - Battery voltage supply to the electronic control module has been lost.
     - Check the battery connections.
     - Check the un-switched battery supply circuit.
     - Refer to the operation and maintenance manual, for the specific engine.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

- Electronic control module is not grounded correctly.
  - Check the electronic control module for correct placement of star washers.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Electronic control module is malfunctioning.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

4. Other issue(s)
   - Base engine problem.
     - Check the engine for high crankcase pressure, low compression, damaged pistons, camshaft, and other parts.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

5.9.9 Engine Speed Surges at High or Low Idle

1. Fuel system issue(s)
2. Sensor issue(s)
3. Other issue(s)

5.9.9.1 Engine Speed Surges at High or Low Idle - Diagnosis and Repair

1. Fuel system issue(s)
   - Open the fuel tank cap and verify the fuel level is not below the pickup tube in the tank.
     - Add fuel to the fuel tank if the fuel level is found to be low.
   - Check for air in the fuel system.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Check for fuel inlet restriction.
     - Check the fuel inlet lines for restriction.
     - Look for plugged fuel filters, a restricted lift pump bypass check valve, pinched fuel lines, or a restricted stand pipe in the fuel tank.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Check for fuel drain line restriction.
     - Check the fuel drain lines for restriction.
     - Clear or replace the fuel lines, check valves, or tank vents as necessary.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Fuel lift pump is malfunctioning.
     - Check the fuel lift pump for correct operation.

- Check the pump output pressure.
- Replace the fuel lift pump if necessary.
- Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

- Fuel system restriction is above specification.
  - Check all fuel system lines for restrictions or debris.
  - Clear or replace the fuel lines, fuel tubes, fuel manifold, check valves, tank vents, actuator screens, and cylinder head drillings as necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Gear pump is malfunctioning.
  - Check the gear pump output pressure.
  - Replace the gear pump if necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Check for injector malfunction.
  - Perform the cylinder performance test.
  - Replace injectors as necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Fuel pump overflow valve is malfunctioning.
  - Check the overflow valve.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Fuel injection pump is malfunctioning.
  - Remove and test the fuel injection pump.
  - Replace the pump if necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

2. Sensor issue(s)
   - Crankshaft or camshaft speed or position sensor(s) reading incorrectly.
     - Refer to the troubleshooting procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Fuel system pressure sensors (fueling/timing) are malfunctioning.
     - Check the fuel system pressure sensors (fueling/timing).
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

3. Other issue(s)
    - Engine parasitics are excessive.
        - Check engine-driven units for correct operation.
        - Check the cooling fan for correct operation and cycle time.
        - Refer to the OEM specifications.
    - Base engine problem.
        - Check the engine for high crankcase pressure, low compression, damaged pistons, camshaft, and other parts.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
    - Alternator is malfunctioning.
        - Temporarily disconnect the alternator and test-run the engine.
        - Replace the alternator if necessary.
        - Refer to the OEM service manuals.

5.9.10 Engine Speed Surges Under Load or in Operating Range

Possible Causes:

1. Parameter(s) configured incorrectly
2. Alternator paralleling control
3. Fuel system issue(s)
4. Sensor issue(s)
5. Other issue(s)

5.9.10.1 Engine Speed Surges Under Load or in Operating Range - Diagnosis and Repair

1. Parameter(s) configured incorrectly
    - With the InPower service tool verify that all of the configurable parameters that can affect the engine operation are set correctly.
        - Adjust parameter(s) accordingly only when found to be configured incorrectly.
2. Alternator paralleling control
    - Alternator paralleling controls are sending inconsistent or incorrect commands to the engine electronic control system.
        - Verify that the alternator paralleling controls are functioning correctly.
        - Refer to the paralleling controls user manual for specifications.
3. Fuel system issue(s)
    - Fuel grade is not correct for the application; fuel quality is poor or presence of water in the fuel.
        - Operate the engine from a tank of high-quality fuel.

- Refer to Fuel for Cummins Engines, Bulletin 3379001.

- Check for air in the fuel system.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Check for fuel inlet restriction.
  - Check the fuel inlet lines for restriction.
  - Look for plugged fuel filters, a restricted lift pump bypass check valve, pinched fuel lines, or a restricted stand pipe in the fuel tank.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Check for fuel drain line restriction.
  - Check the fuel drain lines for restriction.
  - Clear or replace the fuel lines, check valves, or tank vents as necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Fuel system restriction is above specification.
  - Check all fuel system lines for restrictions or debris.
  - Clear or replace the fuel lines, fuel tubes, fuel manifold, check valves, tank vents, actuator screens, and cylinder head drillings as necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Gear pump is malfunctioning.
  - Check the gear pump output pressure.
  - Replace the gear pump if necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Check for injector malfunction.
  - Perform the cylinder performance test.
  - Replace injectors as necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

4. Sensor issue(s)
   - Crankshaft and/or camshaft speed/position sensor(s) reading incorrectly.
     - Refer to the troubleshooting procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Fuel system pressure sensors (fueling/timing) are malfunctioning.
     - Check the fuel system pressure sensors (fueling/timing).
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

5. Other issue(s)
    - Moisture in the wiring harness connectors.
        - Dry the connectors with Cummins electronic cleaner, Part Number 3824510.
    - Base engine problem.
        - Check the engine for high crankcase pressure, low compression, damaged pistons, camshaft, and other parts.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
    - Alternator is malfunctioning.
        - Temporarily disconnect the alternator and test-run the engine.
        - Replace the alternator if necessary.
        - Refer to the OEM service manuals.

5.9.11 Engine Starts But Will Not Keep Running

Possible Causes:

1. Parameter(s) configured incorrectly
2. Battery voltage
3. Run/Stop circuit issue(s)
4. Fuel system issue(s)
5. Other issue(s)

5.9.11.1 Engine Starts But Will Not Keep Running - Diagnosis and Repair

1. Parameter(s) configured incorrectly
    - With the InPower or INSITE service tool(s) verify that engine idle speed is not set too low.
        - Verify the correct idle speed setting.
        - Increase the idle speed if necessary.
2. Battery voltage
    - Battery voltage is low, interrupted, or open.
        - Check the battery connections, un-switched battery supply circuit, and fuses.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
3. Run/Stop circuit issue(s)
    - Run/Stop circuit is malfunctioning.
        - Check the alternator Run/Stop circuit.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

4. Fuel system issue(s)
    - Open the fuel tank cap and verify the fuel level is not below the pickup tube in the tank.
        - Add fuel to the fuel tank if the fuel level is found to be low.
    - Fuel grade is not correct for the application; fuel quality is poor or presence of water in the fuel.
        - Operate the engine from a tank of high-quality fuel.
        - Refer to Fuel for Cummins Engines, Bulletin 3379001.
    - Fuel system restriction is above specification.
        - Check all fuel system lines for restrictions or debris.
        - Clear or replace the fuel lines, fuel tubes, fuel manifold, check valves, tank vents, actuator screens, and cylinder head drillings as necessary.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
5. Other issue(s)
    - Engine parasitics are excessive.
        - Check engine-driven units for correct operation.
        - Check the cooling fan for correct operation and cycle time.
        - Refer to the OEM specifications.
    - Base engine problem.
        - Check the engine for high crankcase pressure, low compression, damaged pistons, camshaft, and other parts.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine..

5.9.12 Poor Engine Transient Response

Possible Causes:

1. Excessive load(s)
2. Fuel system issue(s)
3. Air intake or exhaust issue(s)
4. Sensor issue(s)
5. Other issue(s)

5.9.12.1 Poor Engine Transient Response - Diagnosis and Repair

1. Excessive load(s)
    - Ensure that the load on the generator set does not exceed the generator set KW rating.
        - Re-visit the generator set sizing process to ensure that the generator set is correctly sized for the application, especially if new loads have been introduced into the system.

- Refer to the T−030 manual for proper generator set sizing and application.

2. Fuel system issue(s)
   - Inspect fuel lines, fuel connections, and fuel filters for leaks.
     - Repair if leaks found.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Fuel grade is not correct for the application; fuel quality is poor or presence of water in the fuel.
     - Operate the engine from a tank of high-quality fuel.
     - Refer to Fuel for Cummins Engines, Bulletin 3379001.
   - Low or no fuel pressure at the fuel filters (primary pressure).
     - Use an electronic service tool to measure the fuel pressure at the fuel filter.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Check for air in the fuel system.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Check for fuel inlet restriction.
     - Check the fuel inlet lines for restriction.
     - Look for plugged fuel filters, a restricted lift pump bypass check valve, pinched fuel lines, or a restricted stand pipe in the fuel tank.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Fuel system restriction is above specification.
     - Check all fuel system lines for restrictions or debris.
     - Clear or replace the fuel lines, fuel tubes, fuel manifold, check valves, tank vents, actuator screens, and cylinder head drillings as necessary.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Check for fuel drain line restriction.
     - Check the fuel drain lines for restriction.
     - Clear or replace the fuel lines, check valves, or tank vents as necessary.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Gear pump is malfunctioning.
     - Check the gear pump output pressure.
     - Replace the gear pump if necessary.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

- Check for injector malfunction.
  - Perform the cylinder performance test.
  - Replace injectors as necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

3. Air intake or exhaust issues
   - Air intake or exhaust leaks.
     - Inspect the air intake and exhaust systems for air leaks.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Air intake system restriction is above specification.
     - Check the air intake system for restriction.
     - Clean or replace the air filter and inlet piping as necessary.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Exhaust system restriction is above specification.
     - Check the exhaust system for restrictions.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Turbocharger is malfunctioning.
     - Monitor the turbocharger boost pressure.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
4. Sensor issue(s)
   - Intake manifold air temperature is below specification.
     - Refer to the coolant temperature below normal symptom tree in the troubleshooting and repair manual for the specific engine.
   - Fuel system pressure sensors (fueling/timing) are malfunctioning.
     - Check the fuel system pressure sensors (fueling/timing).
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Coolant temperature sensor is malfunctioning.
     - Use InPower service tool(s) to check the coolant temperature sensor.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Intake manifold pressure sensor is malfunctioning.
     - Check the intake manifold pressure sensor.

- Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

- Ambient air temperature sensor is malfunctioning.
  - Check the ambient air temperature sensor.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

5. Other issue(s)
   - Engine is operating above recommended altitude.
     - Engine power decreases above recommended altitude.
     - Refer to the specific engine Engine Data Sheet for specifications.
   - Engine parasitics are excessive.
     - Check engine-driven units for correct operation.
     - Check the cooling fan for correct operation and cycle time.
     - Refer to the OEM specifications.
   - Overhead adjustments are not correct.
     - Adjust the overhead settings.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Base engine problem.
     - Check the engine for high crankcase pressure, low compression, damaged pistons, camshaft, and other parts.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

5.9.13 Engine Will Not Reach Rated Speed (RPM)

Possible Causes:

1. Excessive load(s)
2. Air intake or exhaust issue(s)
3. Fuel system issue(s)
4. Sensor issue(s)
5. Other issue(s)

5.9.13.1 Engine Will Not Reach Rated Speed (RPM) - Diagnosis and Repair

1. Excessive load(s)
   - Ensure that the load on the generator set does not exceed the generator set KW rating.
     - Re-visit the generator set sizing process to ensure that the generator set is correctly sized for the application, especially if new loads have been introduced into the system.

- Refer to the T−030 manual for proper generator set sizing and application.

2. Air intake or exhaust issue(s)
   - Air intake system restriction is above specification.
     - Check the air intake system for restriction.
     - Clean or replace the air filter and inlet piping as necessary.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Exhaust system restriction is above specification.
     - Check the exhaust system for restrictions.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
3. Fuel system issue(s)
   - Fuel grade is not correct for the application; fuel quality is poor or presence of water in the fuel.
     - Operate the engine from a tank of high-quality fuel.
     - Refer to Fuel for Cummins Engines, Bulletin 3379001.
   - Check for air in the fuel system.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Fuel system restriction is above specification.
     - Check all fuel system lines for restrictions or debris.
     - Clear or replace the fuel lines, fuel tubes, fuel manifold, check valves, tank vents, actuator screens, and cylinder head drillings as necessary.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Gear pump is malfunctioning.
     - Check the gear pump output pressure.
     - Replace the gear pump if necessary.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
4. Sensor issue(s)
   - Crankshaft and/or camshaft speed/position sensor(s) reading incorrectly.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Fuel system pressure sensors (fueling/timing) are malfunctioning.
     - Check the fuel system pressure sensors (fueling/timing).
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

- Intake manifold pressure sensor is malfunctioning.
  - Check the intake manifold pressure sensor.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Ambient air temperature sensor is malfunctioning.
  - Check the ambient air temperature sensor.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

5. Other issue(s)
   - Engine parasitics are excessive.
     - Check engine-driven units for correct operation.
     - Check the cooling fan for correct operation and cycle time.
     - Refer to the OEM specifications.
   - Engine is operating above recommended altitude.
     - Engine power decreases above recommended altitude.
     - Refer to the specific engine Engine Data Sheet for specifications.
   - Overhead adjustments are not correct.
     - Adjust the overhead settings.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Injector O-rings are damaged or missing.
     - Remove and check the injectors.
     - Replace the injector O-rings.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Base engine problem.
     - Check the engine for high crankcase pressure, low compression, damaged pistons, camshaft, and other parts.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

5.9.14 Engine Will Not Shut Off

Possible Causes:

1. Run/Stop circuit issue
2. Fumes in the intake air
3. Fuel system issue(s)
4. Turbocharger seal leak
5. Other issue(s)

5.9.14.1 Engine Will Not Shut Off - Diagnosis and Repair

1. Run/Stop circuit issue
   - Run/Stop circuit is malfunctioning.
     - Check the alternator Run/Stop circuit.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
2. Fumes in the intake air
   - Engine is running on fumes drawn into the air intake.
     - Check the air intake ducts.
     - Locate and isolate the source of the fumes.
     - Repair as necessary.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
3. Fuel system issue(s)
   - Fuel shutoff valve solenoid or circuit is malfunctioning.
     - Check the fuel shutoff valve solenoid and circuit.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Check for injector malfunction.
     - Perform the cylinder performance test.
     - Replace injectors as necessary.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
4. Turbocharger seal leak
   - Turbocharger oil seal is leaking.
     - Check the turbocharger for oil seals and for leaks.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
5. Other issue(s)
   - Base engine problem.
     - Check the engine for high crankcase pressure, low compression, damaged pistons, camshaft, and other parts.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

5.9.15 Fuel Consumption is Excessive

Possible Causes:

1. Excessive load(s)

2. Maintenance, repair, or environment effect(s)
3. Air intake or exhaust issue(s)
4. Fuel system issue(s)
5. Sensor issue(s)
6. Other issue(s)

5.9.15.1 Fuel Consumption is Excessive - Diagnosis and Repair

1. Excessive load(s)
    - Ensure that the load on the generator set does not exceed the generator set KW rating.
        - Re-visit the generator set sizing process to ensure that the generator set is correctly sized for the application, especially if new loads have been introduced into the system.
        - Refer to the T−030 manual for proper generator set sizing and application.
2. Maintenance, repair, or environment effect(s)
    - Fuel consumption has increased after an engine repair.
        - Evaluate the engine repair to determine its effect on fuel consumption.
        - Check part numbers to make sure the correct parts were used.
    - Lubricating oil level is above specification.
        - Check the oil level.
        - Verify the dipstick calibration and oil pan capacity.
        - Fill the system to the specified level.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
    - Environmental factors are affecting fuel consumption.
        - Consider altitude and ambient air temperature when evaluating fuel consumption.
        - Refer to the specific engine Engine Data Sheets for altitude derate information.
3. Air intake or exhaust issue(s)
    - Air intake or exhaust leaks.
        - Inspect the air intake and exhaust systems for air leaks.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
    - Air intake system restriction is above specification.
        - Check the air intake system for restriction.
        - Clean or replace the air filter and inlet piping as necessary.
        - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

- Exhaust system restriction is above specification.
  - Check the exhaust system for restrictions.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
- Turbocharger is not correct.
  - Check the turbocharger part number and compare it to the control parts list.
  - Replace the turbocharger if necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

4. Fuel system issue(s)
   - Inspect fuel lines, fuel connections and fuel filters for leaks.
     - Repair if leaks found.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Fuel grade is not correct for the application; fuel quality is poor or presence of water in the fuel.
     - Operate the engine from a tank of high-quality fuel.
     - Refer to Fuel for Cummins Engines, Bulletin 3379001.
   - Gear pump is malfunctioning.
     - Check the gear pump output pressure.
     - Replace the gear pump if necessary.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Check for injector malfunction.
     - Perform the cylinder performance test.
     - Replace injectors as necessary.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Fuel pump overflow valve is malfunctioning.
     - Check the overflow valve.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Fuel lift pump is malfunctioning.
     - Check the fuel lift pump for correct operation.
     - Check the pump output pressure.
     - Replace the fuel lift pump if necessary.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

- Fuel injection pump is malfunctioning.
  - Remove and test the fuel injection pump.
  - Replace the pump if necessary.
  - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

5. Sensor issue(s)
   - Crankshaft and/or camshaft speed/position sensor(s) reading incorrectly.
     - Refer to the troubleshooting procedure in the troubleshooting and repair manual for specific engine.
   - Fuel system pressure sensors (fueling/timing) are malfunctioning.
     - Check the fuel system pressure sensors (fueling/timing).
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
6. Other issue(s)
   - Engine parasitics are excessive.
     - Check engine-driven units for correct operation.
     - Check the cooling fan for correct operation and cycle time.
     - Refer to the OEM specifications.
   - Overhead adjustments are not correct.
     - Adjust the overhead settings.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.
   - Base engine problem.
     - Check the engine for high crankcase pressure, low compression, damaged pistons, camshaft, and other parts.
     - Refer to the procedure(s) in the troubleshooting and repair manual for the specific engine.

5.9.16 Fuel in the Coolant

Possible Causes:

1. Coolant is contaminated
2. Cracked cylinder head

5.9.16.1 Fuel in the Coolant - Diagnosis and Repair

1. Coolant is contaminated
   - Bulk coolant supply is contaminated.
     - Check the bulk coolant supply.
     - Drain the coolant and replace with non-contaminated coolant.
     - Replace the coolant filters.

B.3 Entrance Box and Terminal Box Outline Drawings

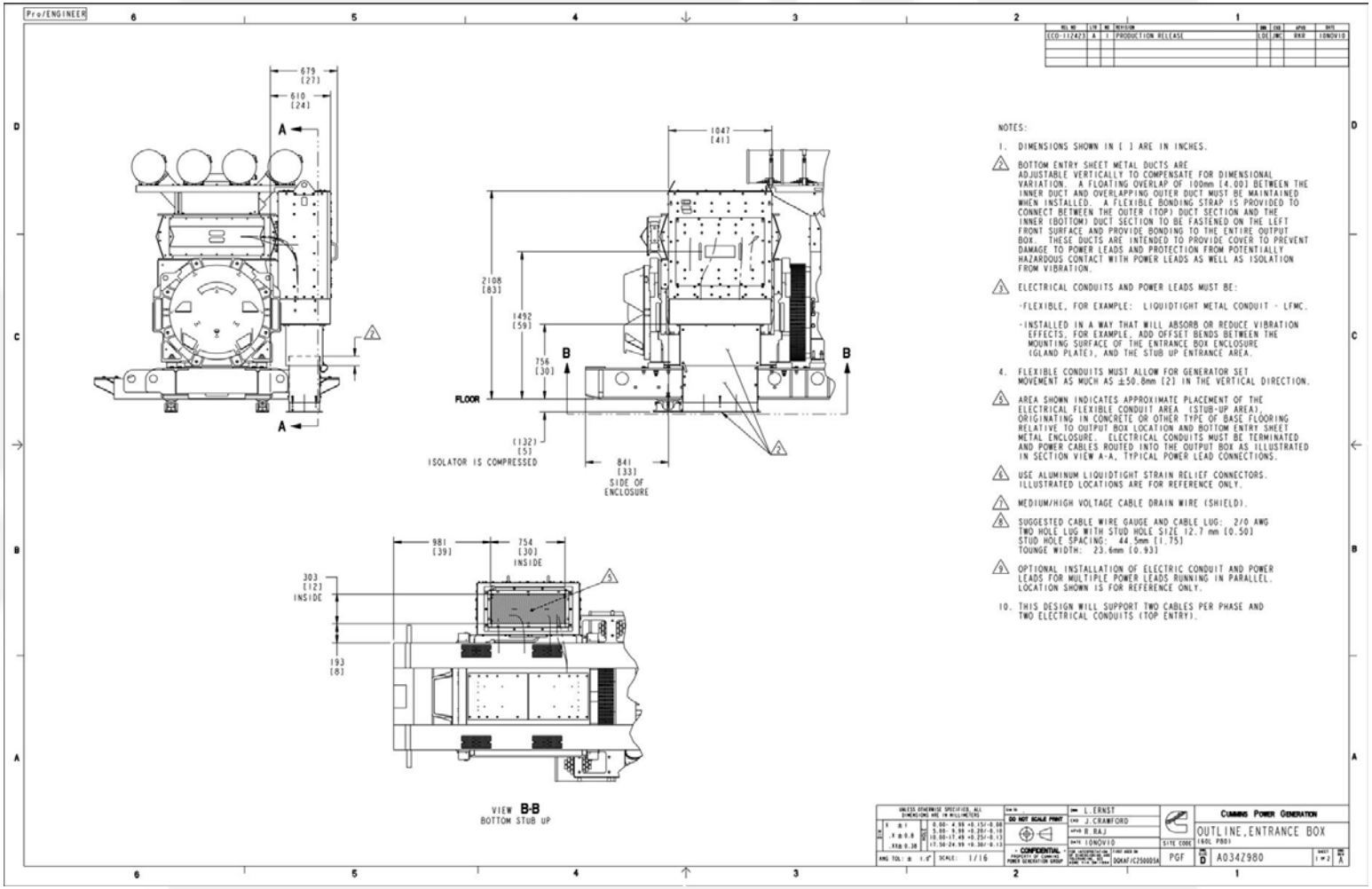


FIGURE 58. P80 ALTERNATOR ENTRANCE BOX OUTLINE DRAWING (SHEET 1 OF 2)

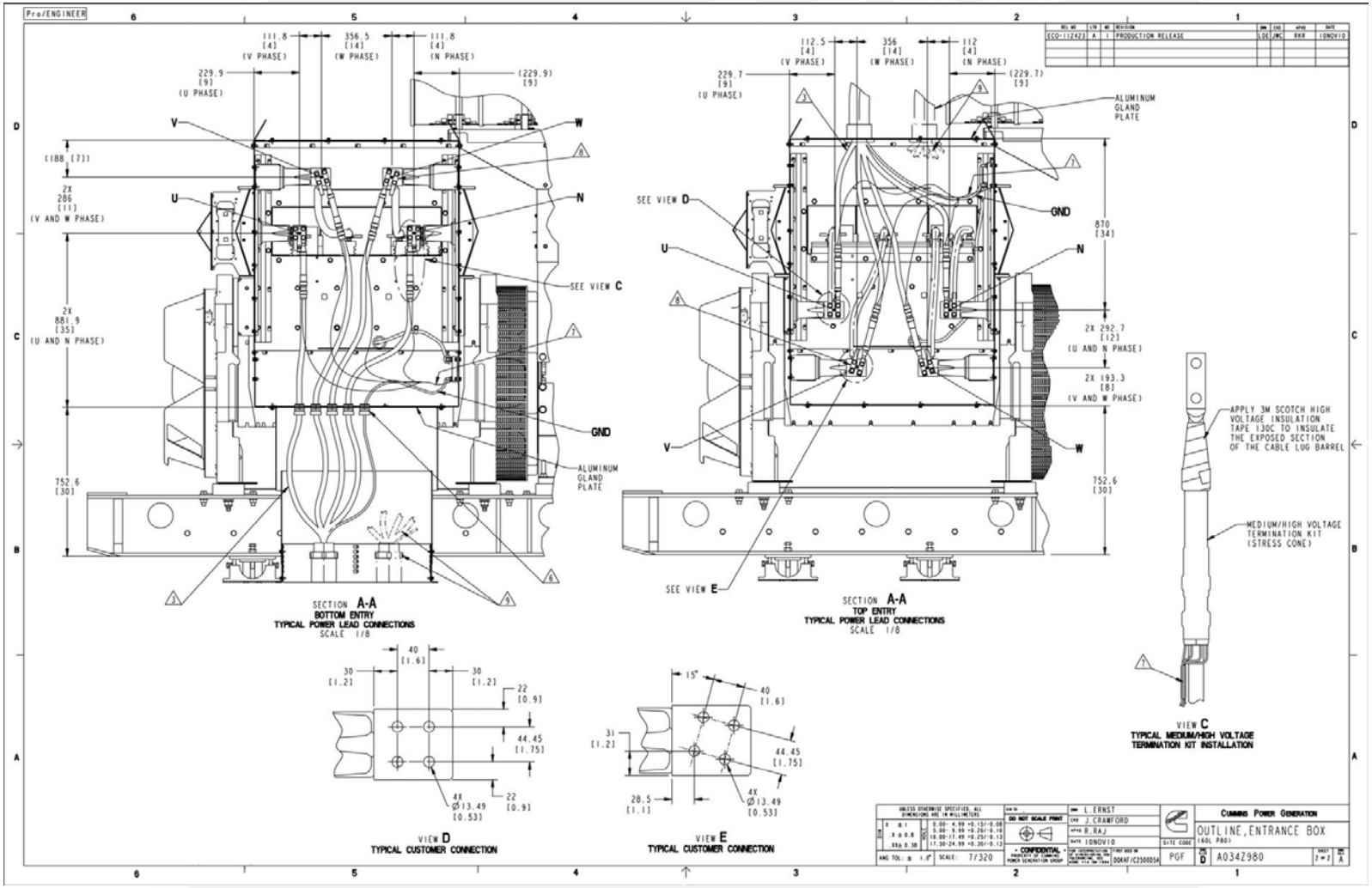


FIGURE 59. P80 ALTERNATOR ENTRANCE BOX OUTLINE DRAWING (SHEET 2 OF 2)

B.4 Terminal Box Outline High Voltage (Bottom and Top Entry) for DQKAN

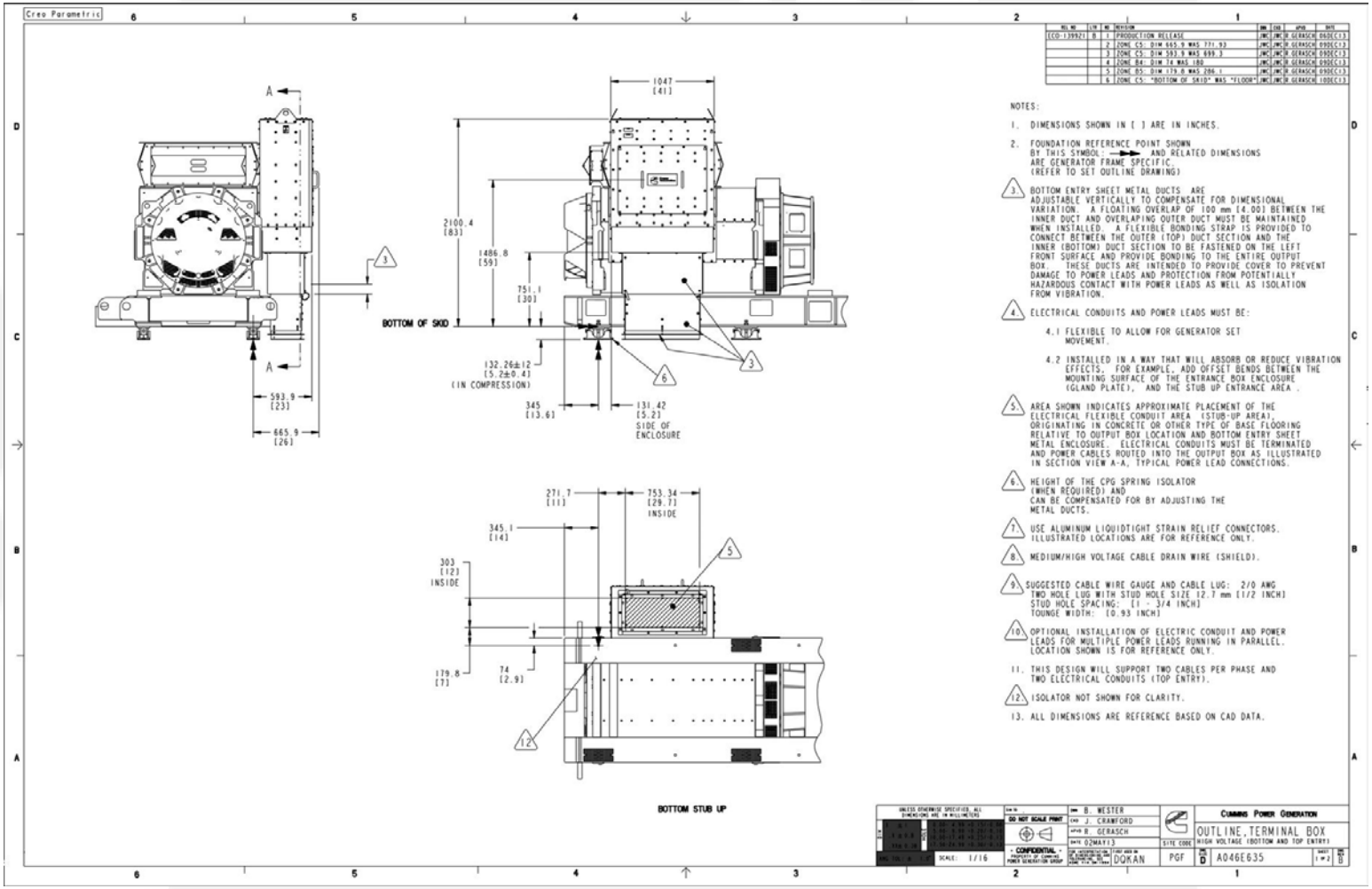


FIGURE 60. TERMINAL BOX OUTLINE, HIGH VOLTAGE, BOTTOM STUB UP (SHEET 1 OF 2)

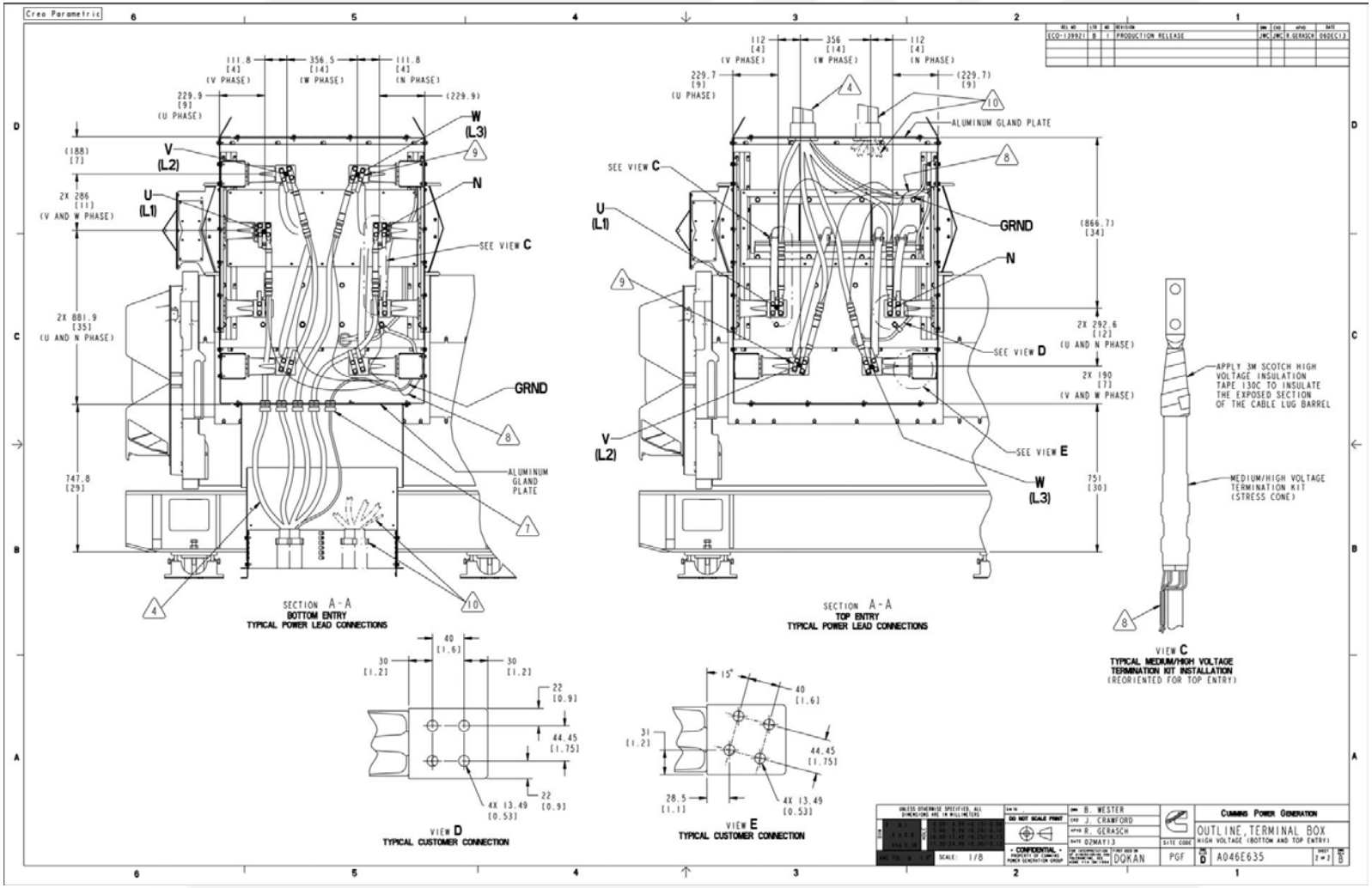


FIGURE 61. TERMINAL BOX OUTLINE, HIGH VOLTAGE, TYPICAL POWER LEAD CONNECTIONS AND TYPICAL CUSTOMER CONNECTIONS (SHEET 2 OF 2)

B.5 Terminal Box Outline with P80 Low Voltage, Top Entry for DQKAN

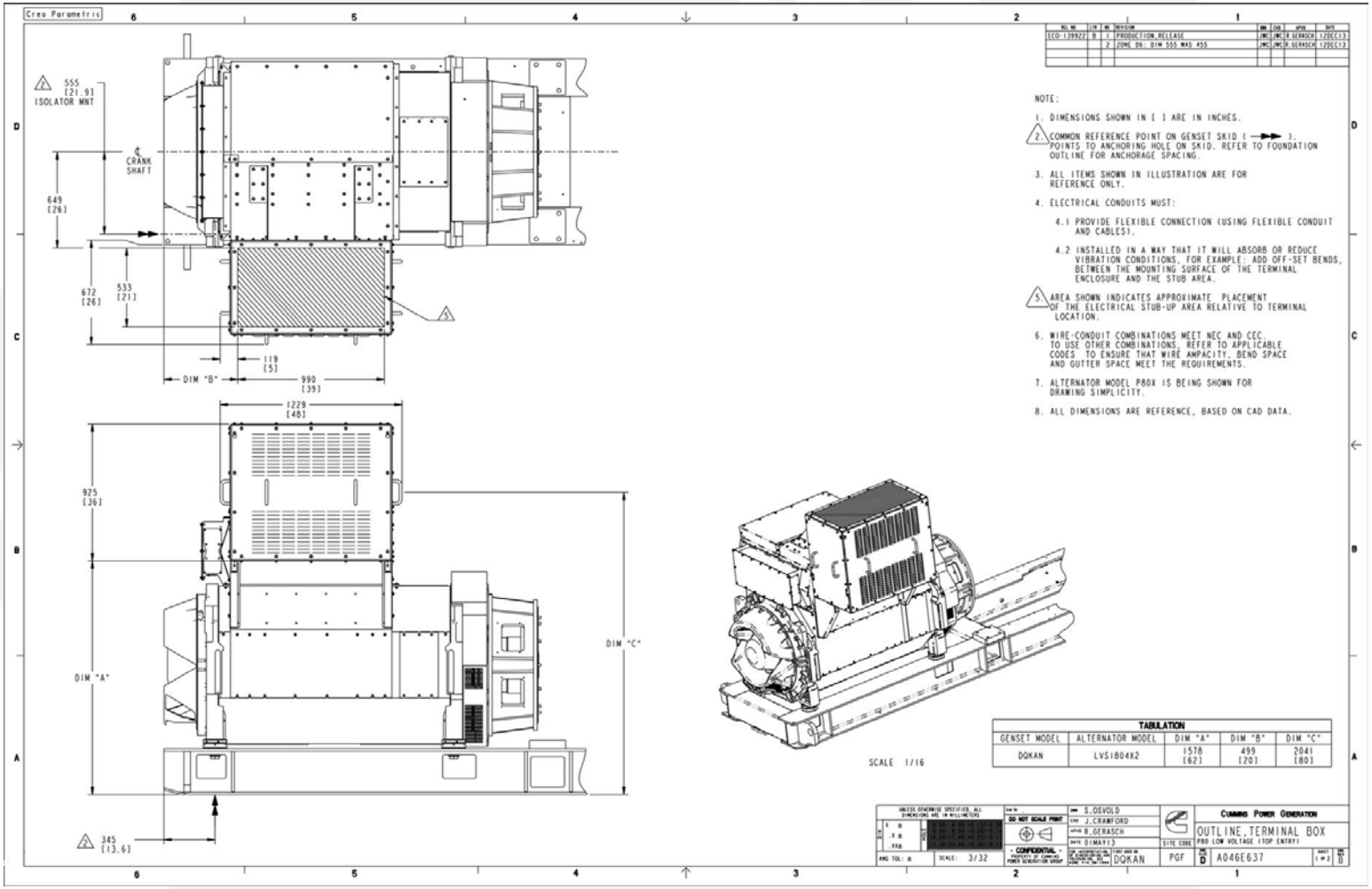


FIGURE 62. TERMINAL BOX OUTLINE, INSTALLATION DIMENSIONS (SHEET 1 OF 2)

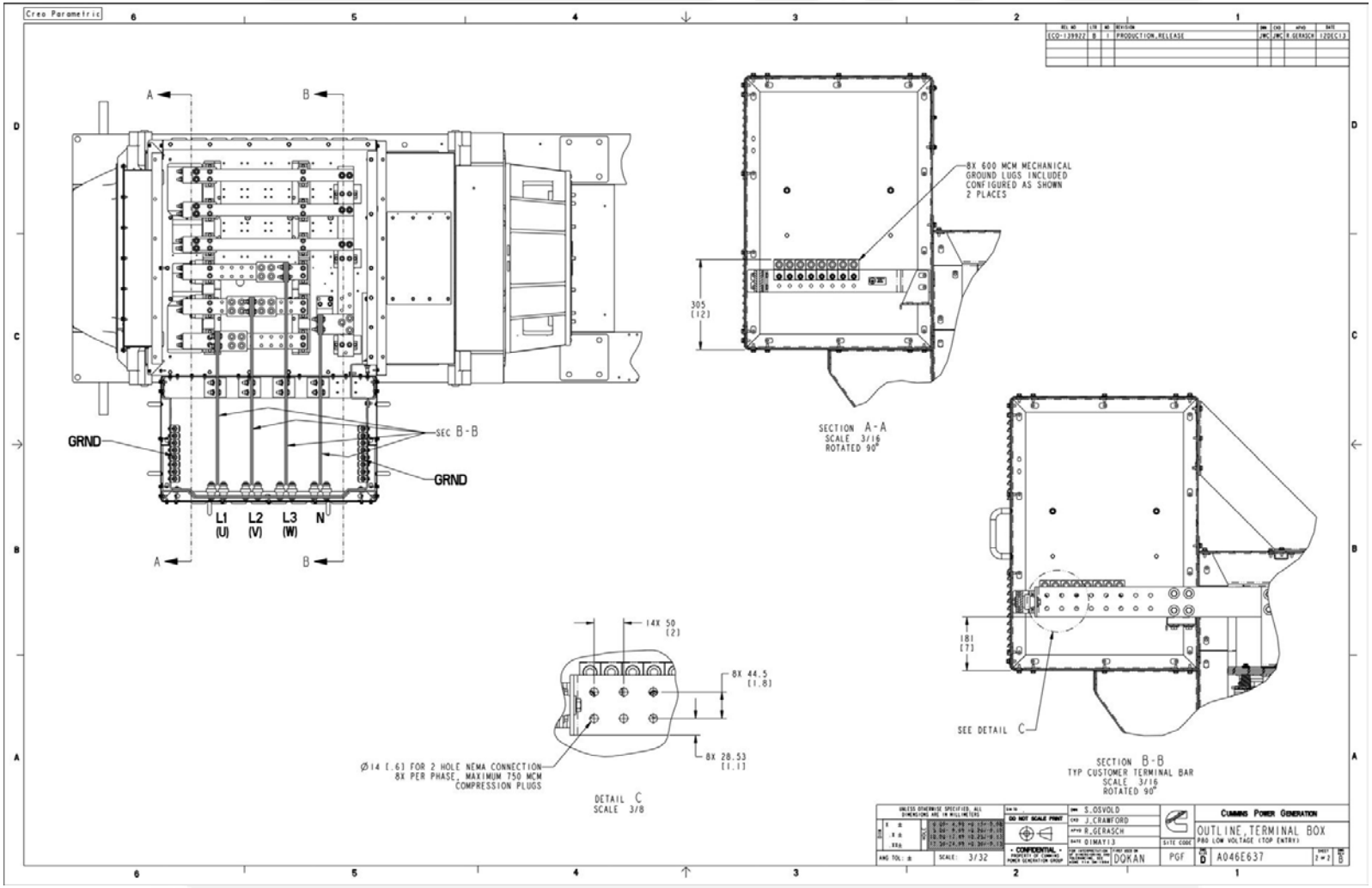


FIGURE 63. TERMINAL BOX OUTLINE, INSTALLATION CONNECTIONS (SHEET 2 OF 2)

B.6 Terminal Box Outline with P80 Low Voltage, Bottom Entry for DQKAN

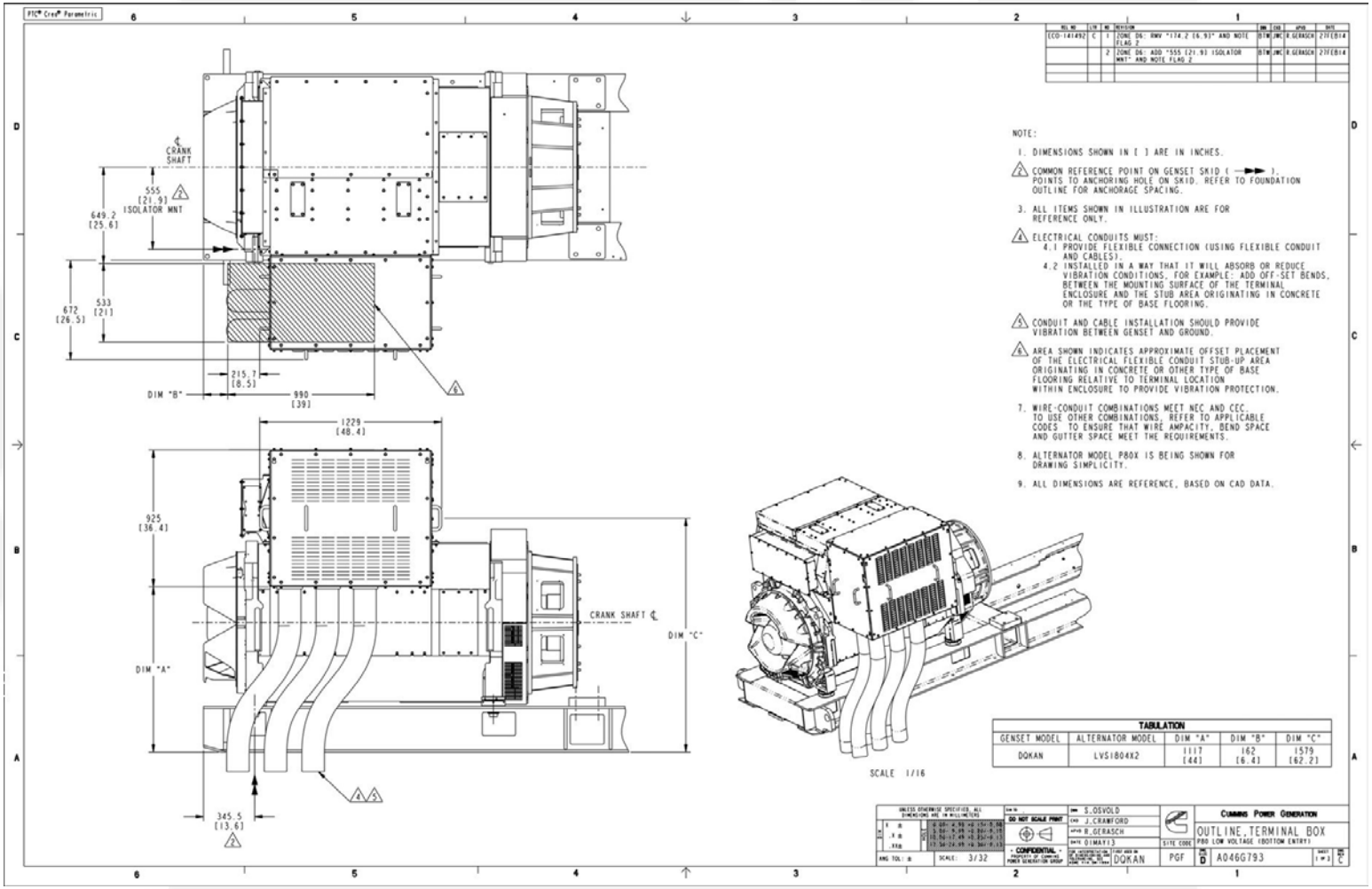


FIGURE 64. TERMINAL BOX OUTLINE, INSTALLATION DIMENSIONS (SHEET 1 OF 3)

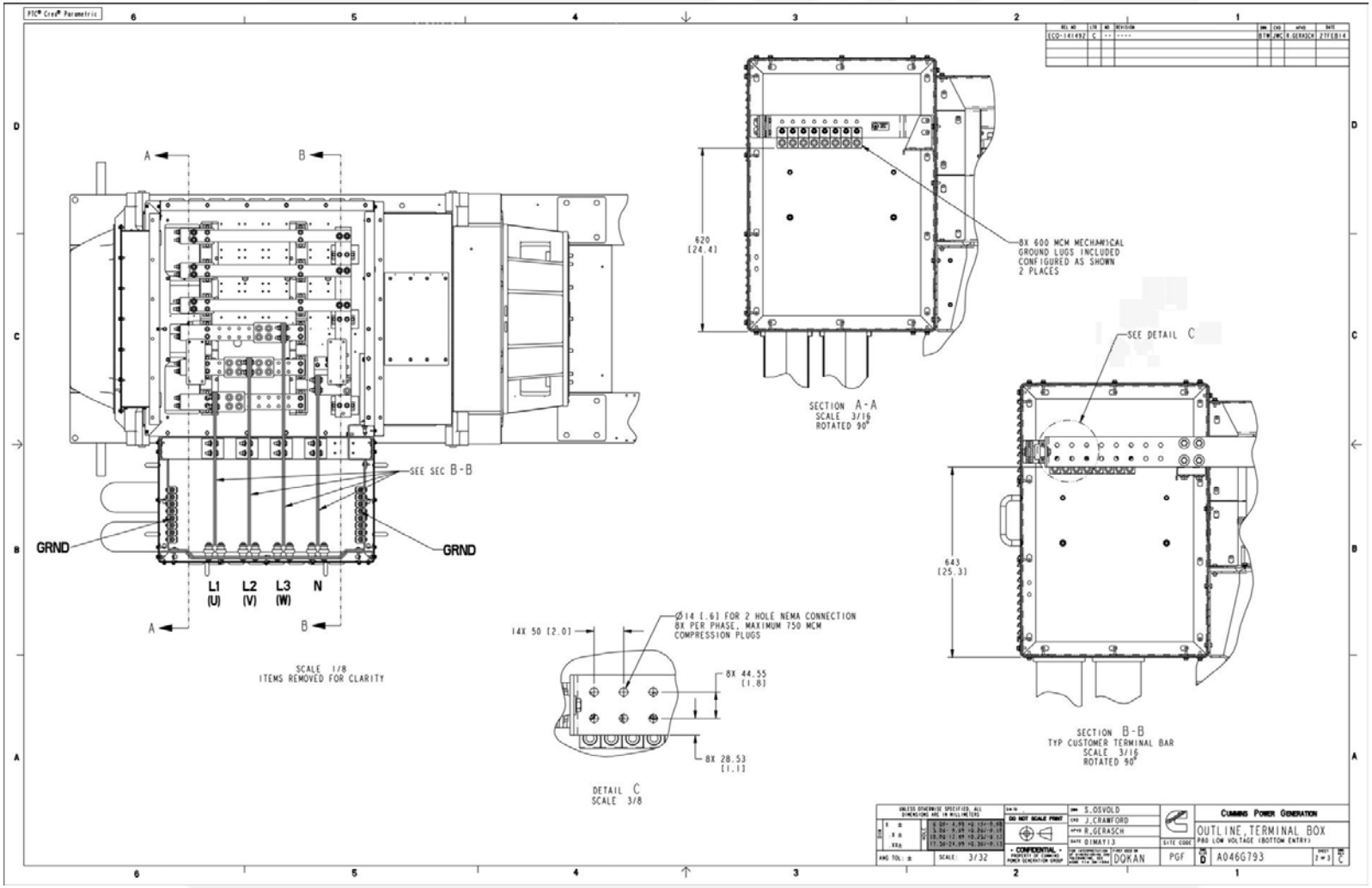


FIGURE 65. TERMINAL BOX OUTLINE, INSTALLATION CONNECTIONS (SHEET 2 OF 3)

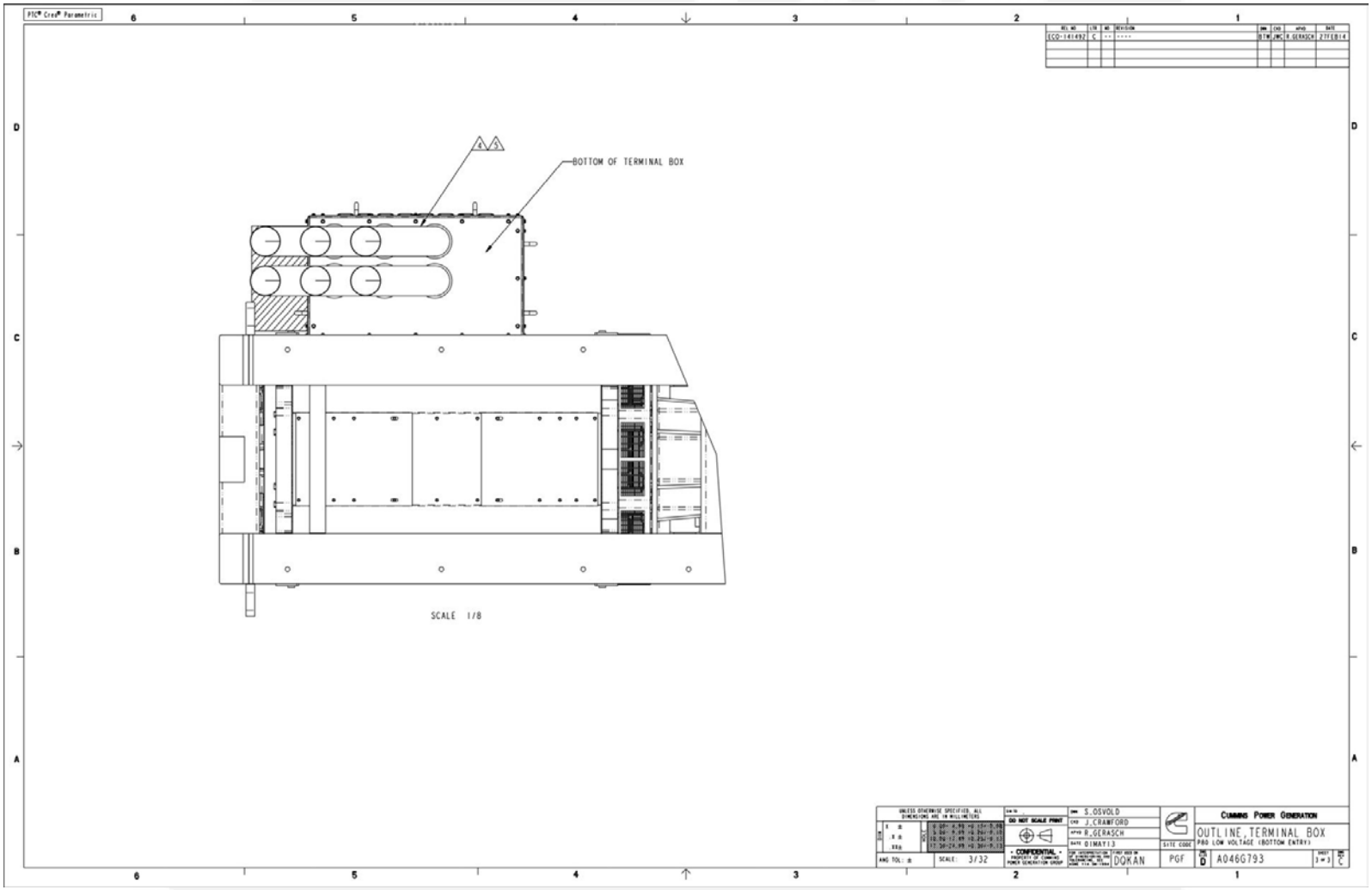


FIGURE 66. TERMINAL BOX OUTLINE, ELECTRICAL CONDUIT INSTALLATION (SHEET 3 OF 3)

B.7 Coolant Heater Outline Drawing

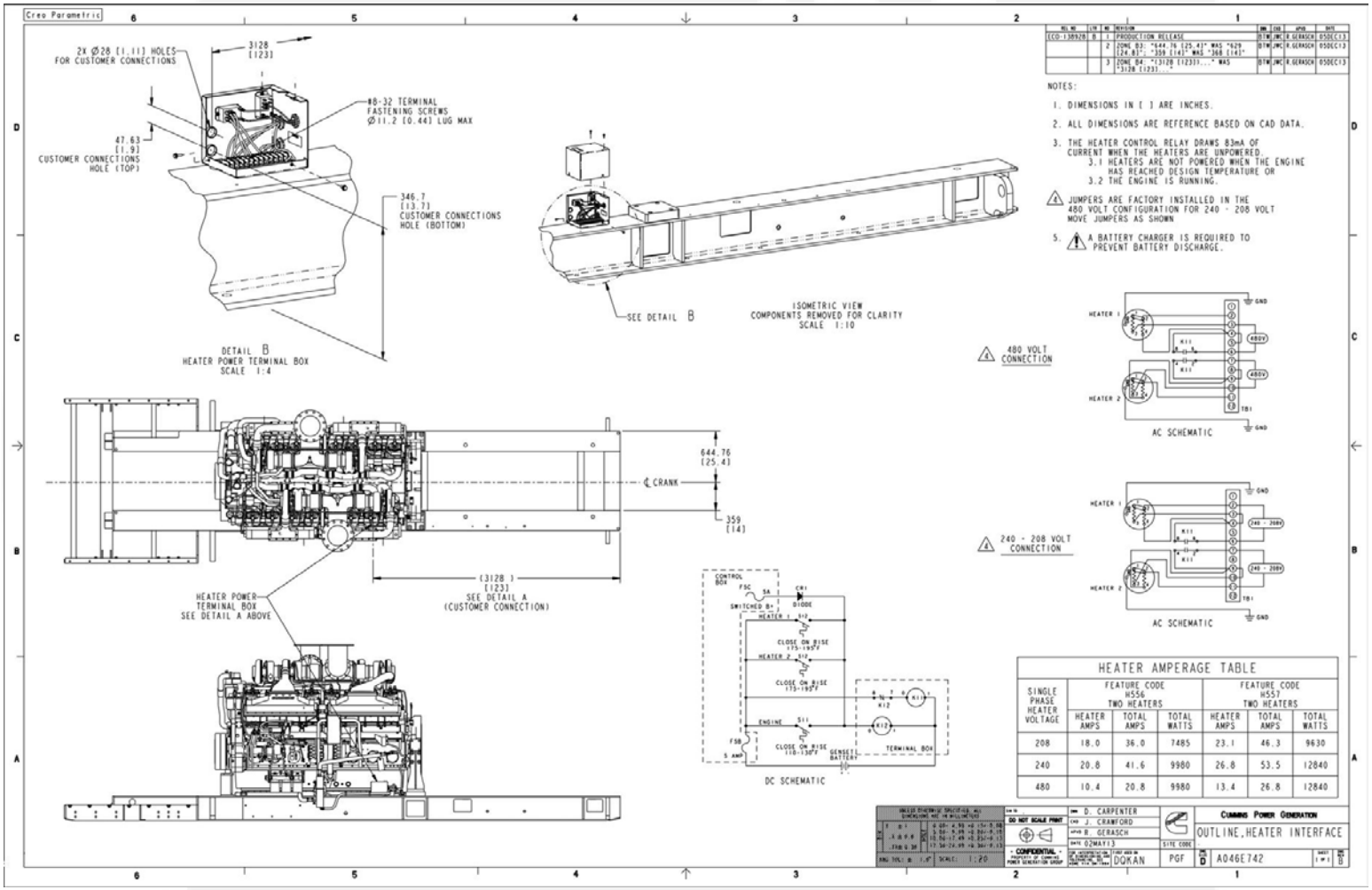


FIGURE 67. COOLANT HEATER INTERFACE OUTLINE DRAWING

B.8 Foundation Drawing for High Ambient and Enhanced High Ambient Cooled System DQKAN Spec A

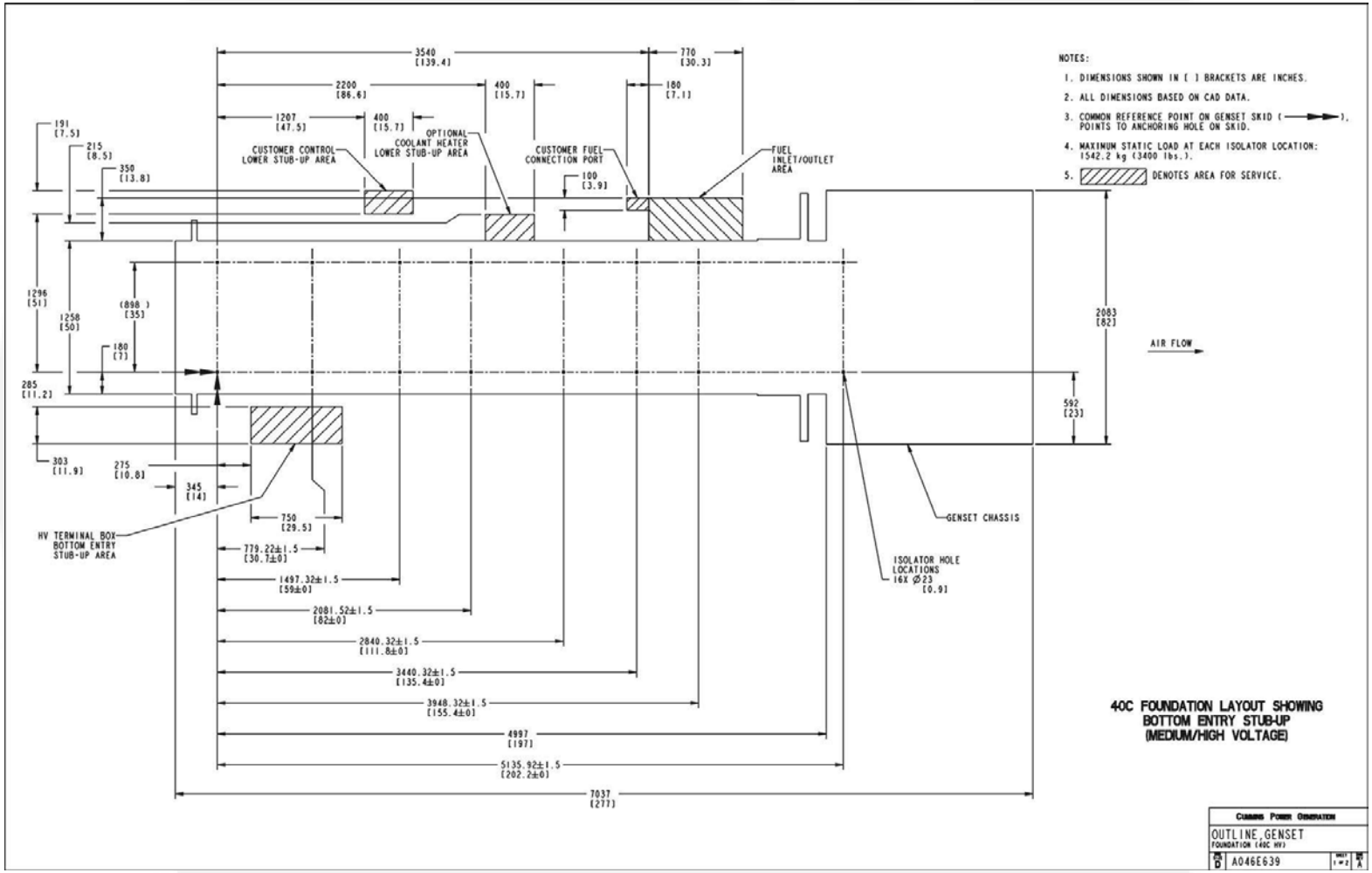


FIGURE 68. FOUNDATION LAYOUT FOR HIGH/ENHANCED HIGH AMBIENT COOLED SYSTEM SHOWING ENTRANCE BOX STUB-UP FOR P80 ALTERNATOR, DQKAN SPEC A (MEDIUM/HIGH VOLTAGE)

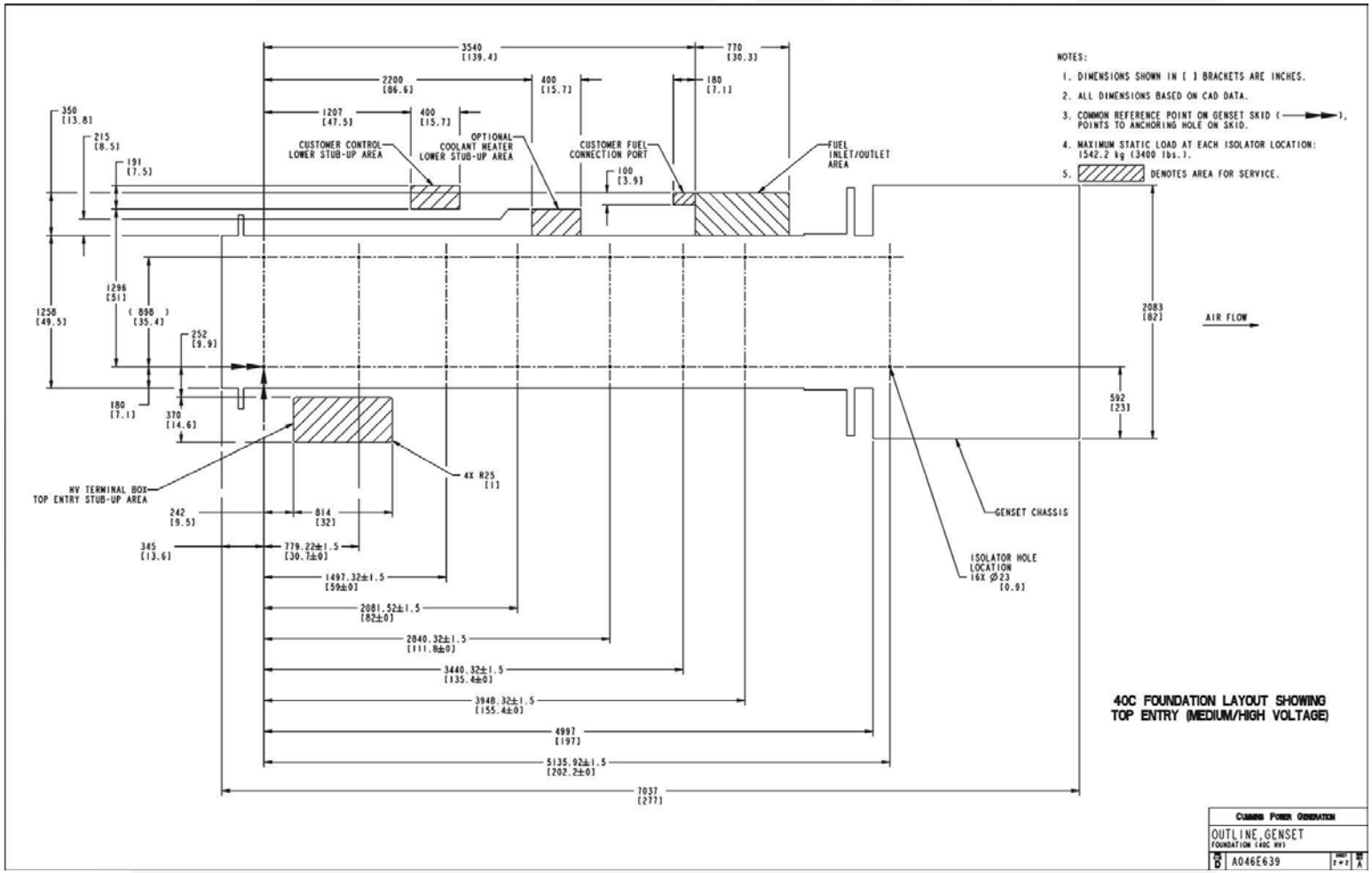


FIGURE 69. FOUNDATION LAYOUT FOR HIGH/ENHANCED HIGH AMBIENT COOLED SYSTEM SHOWING ENTRANCE BOX STUB-UP FOR P80 ALTERNATOR, DQKAN SPEC A (LOW VOLTAGE)

B.9 Foundation Drawing for High Ambient and Enhanced High Ambient Cooled System DQKAN Spec B

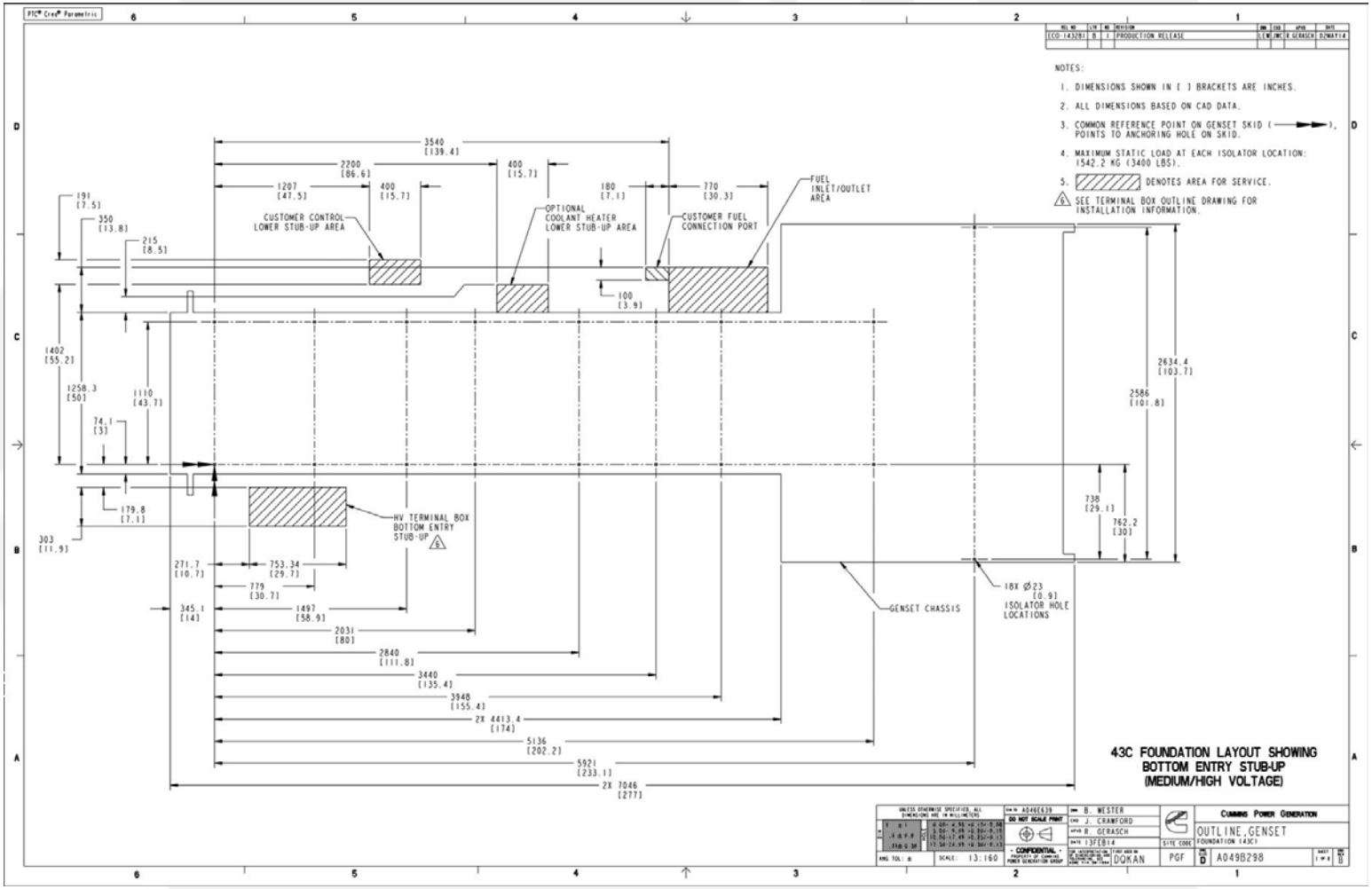


FIGURE 70. FOUNDATION LAYOUT FOR HIGH/ENHANCED HIGH AMBIENT COOLED SYSTEM SHOWING ENTRANCE BOX STUB-UP FOR P80 ALTERNATOR, DQKAN SPEC B SHEET 1 OF 4 (MEDIUM/HIGH VOLTAGE)

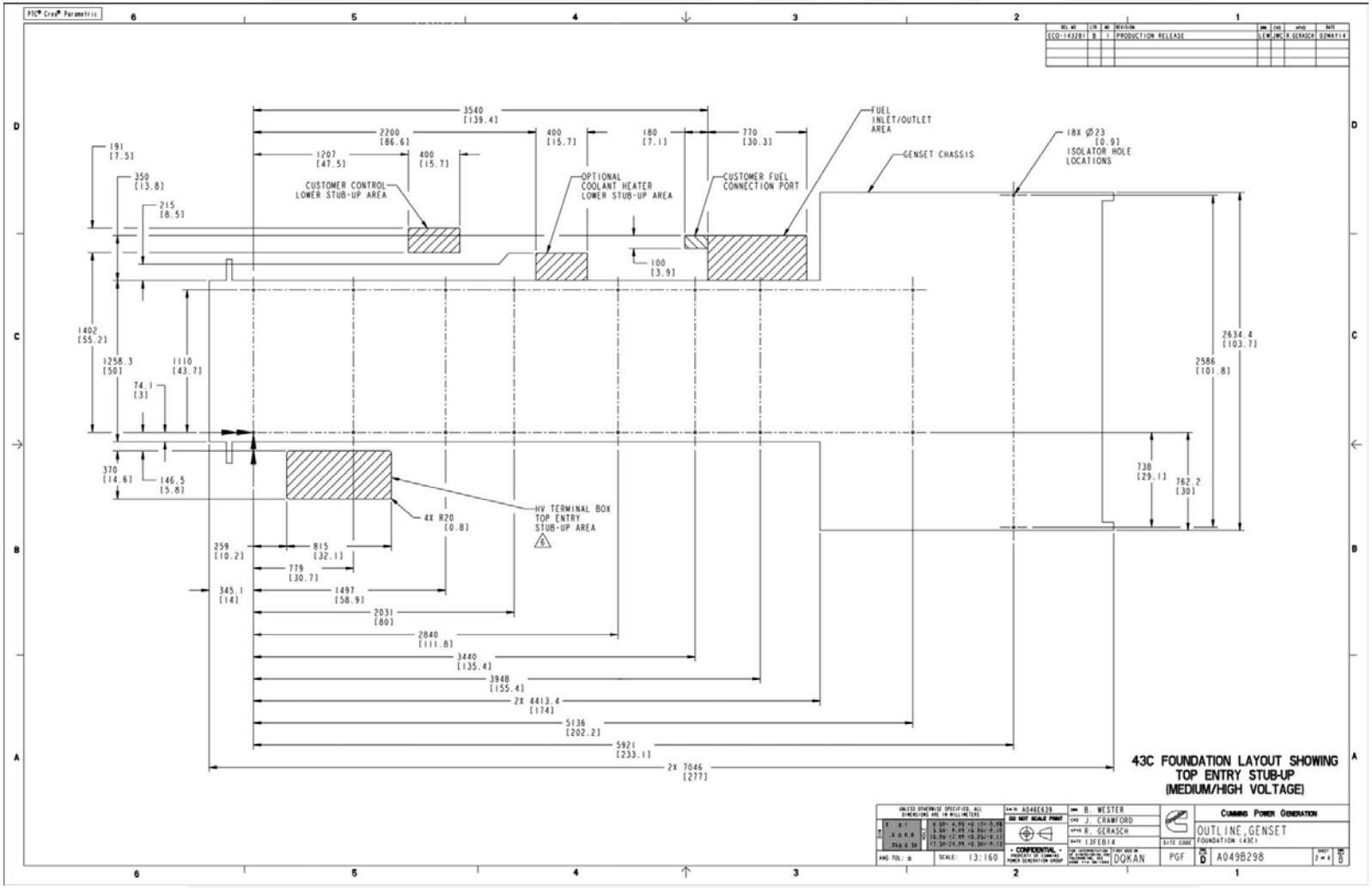


FIGURE 71. FOUNDATION LAYOUT FOR HIGH/ENHANCED HIGH AMBIENT COOLED SYSTEM SHOWING ENTRANCE BOX STUB-UP FOR P80 ALTERNATOR, DQKAN SPEC B SHEET 2 OF 4 (LOW VOLTAGE)

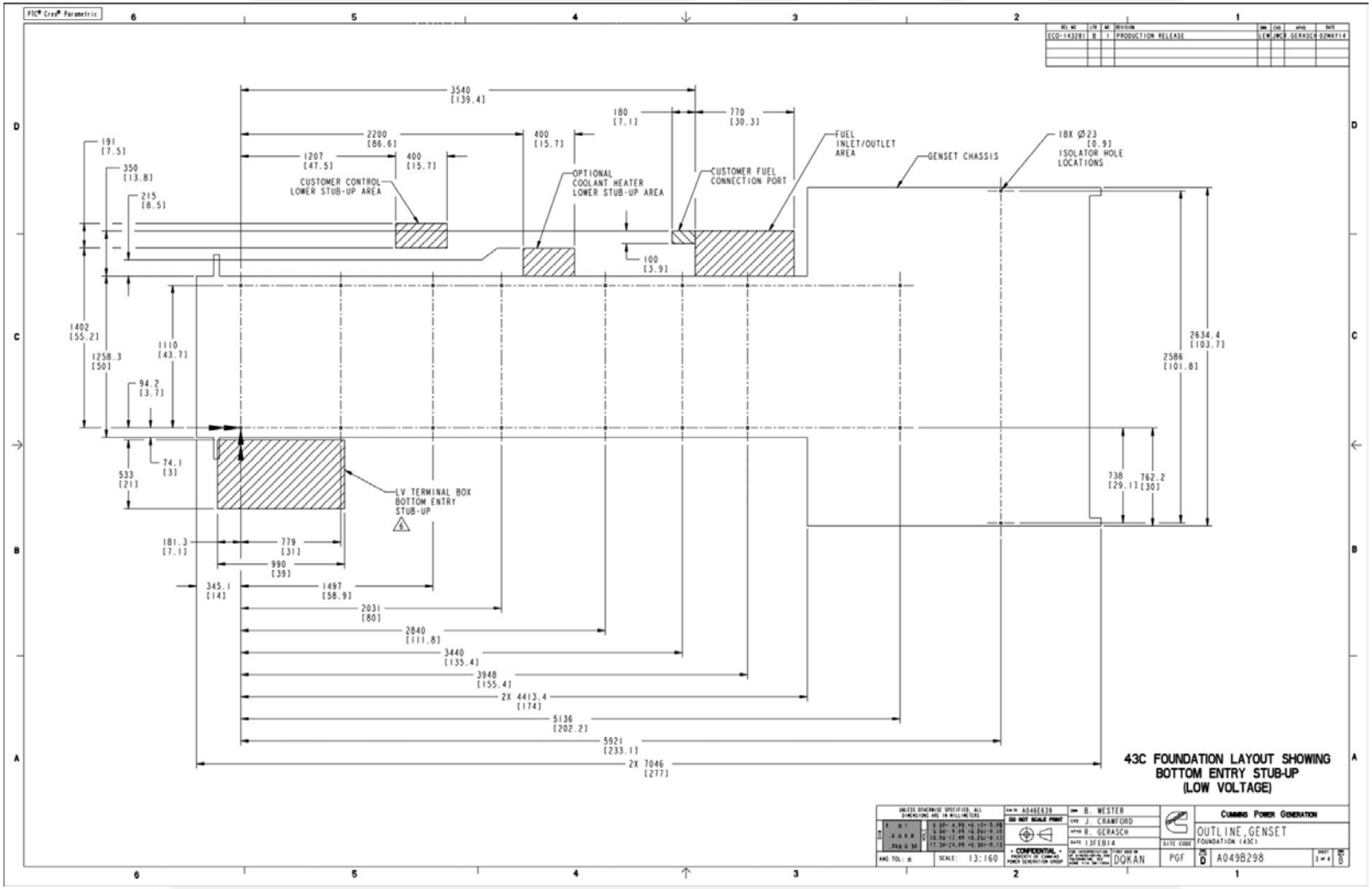


FIGURE 72. FOUNDATION LAYOUT FOR HIGH/ENHANCED HIGH AMBIENT COOLED SYSTEM SHOWING ENTRANCE BOX STUB-UP FOR P80 ALTERNATOR, DQKAN SPEC B SHEET 3 OF 4 (MEDIUM/HIGH VOLTAGE)

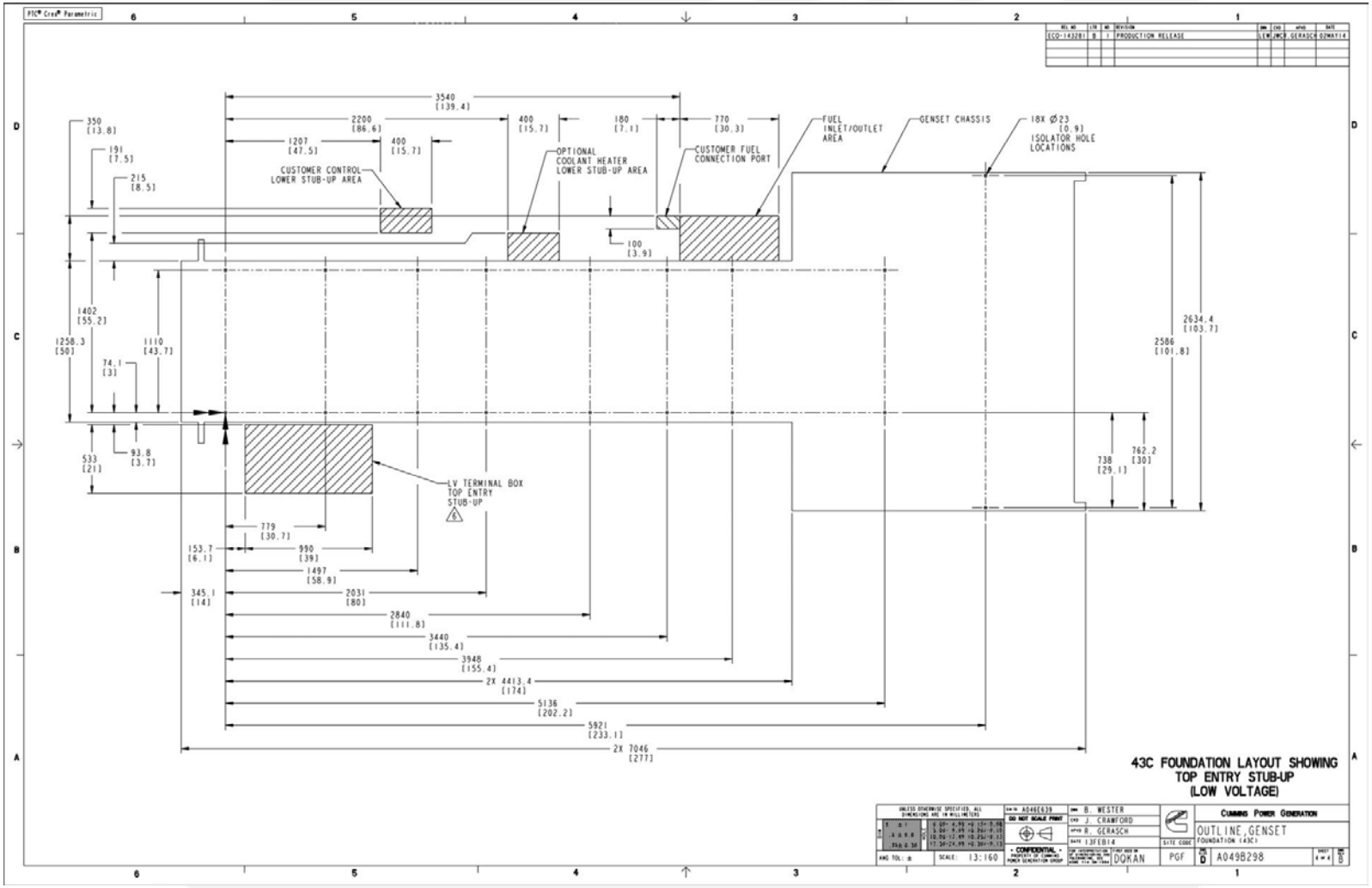


FIGURE 73. FOUNDATION LAYOUT FOR HIGH/ENHANCED HIGH AMBIENT COOLED SYSTEM SHOWING ENTRANCE BOX STUB-UP FOR P80 ALTERNATOR, DQKAN SPEC B SHEET 4 OF 4 (MEDIUM/HIGH VOLTAGE)

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Appendix C. 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.

C.1 QSK60 Engine Wiring Diagram with PowerCommand 3.3 Control

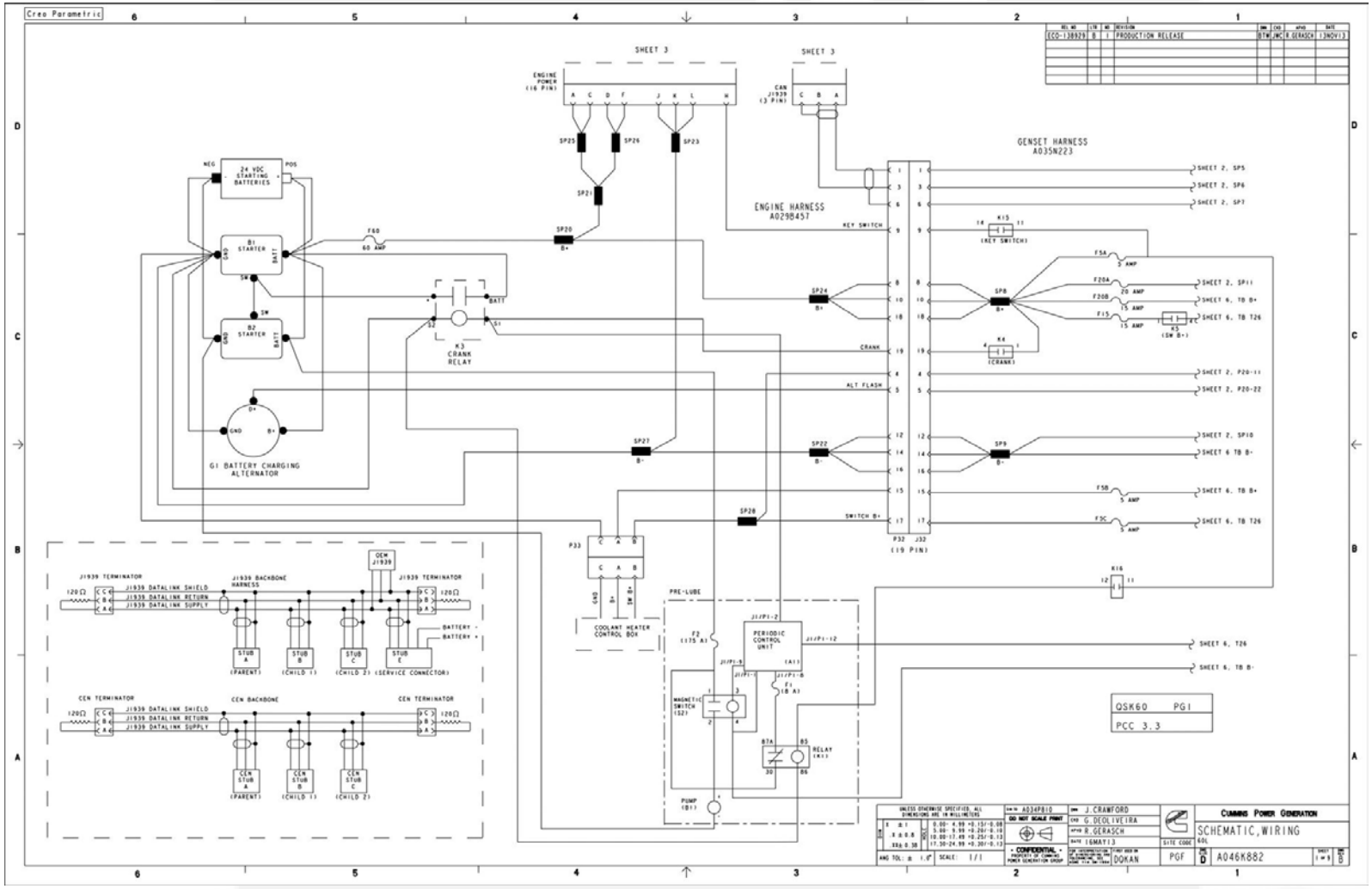

FIGURE 74. ENGINE TO GENERATOR SET HARNESS CONNECTIONS

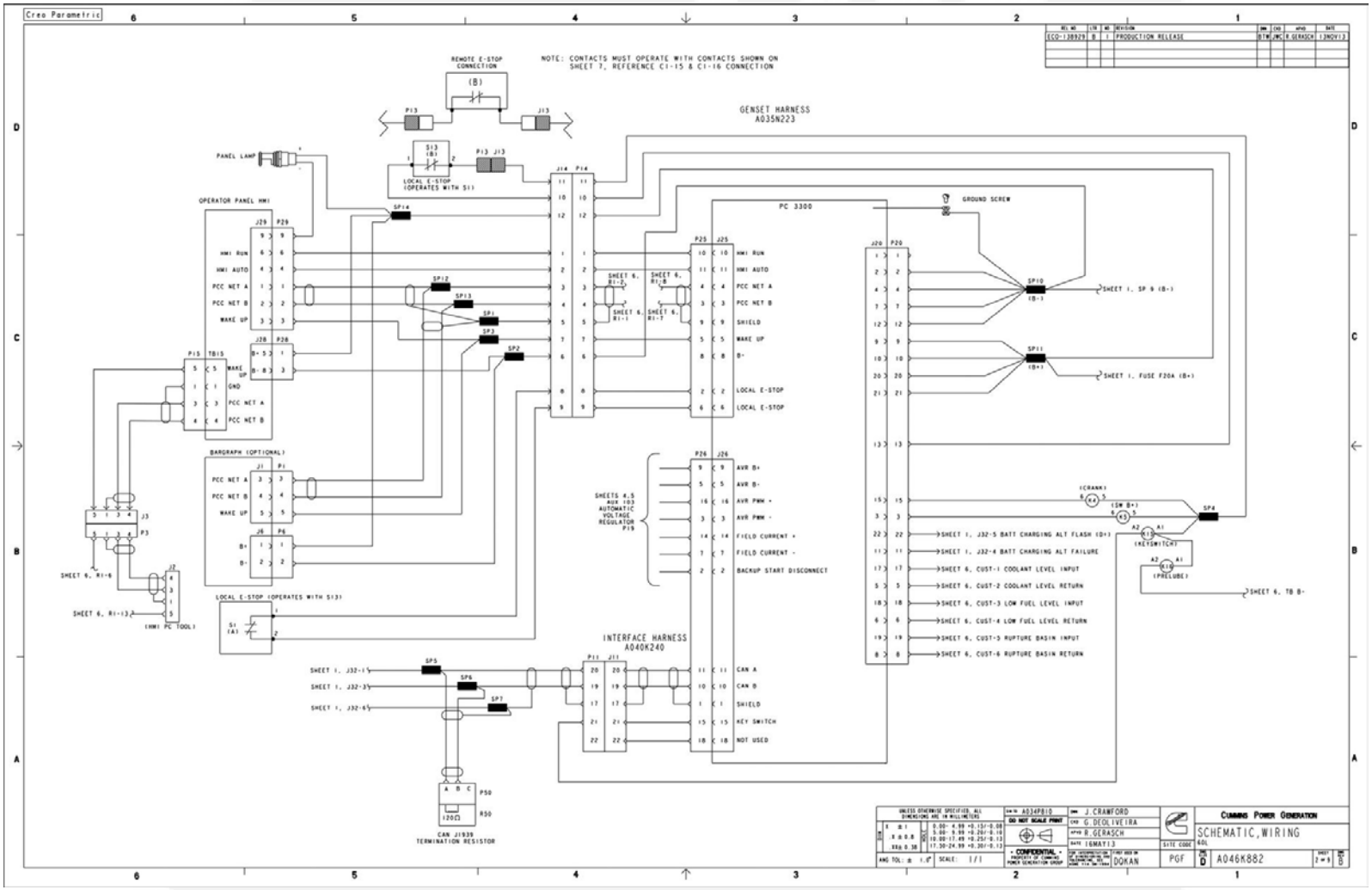

FIGURE 75. OPERATOR PANEL TO CONTROL BOARD CONNECTIONS

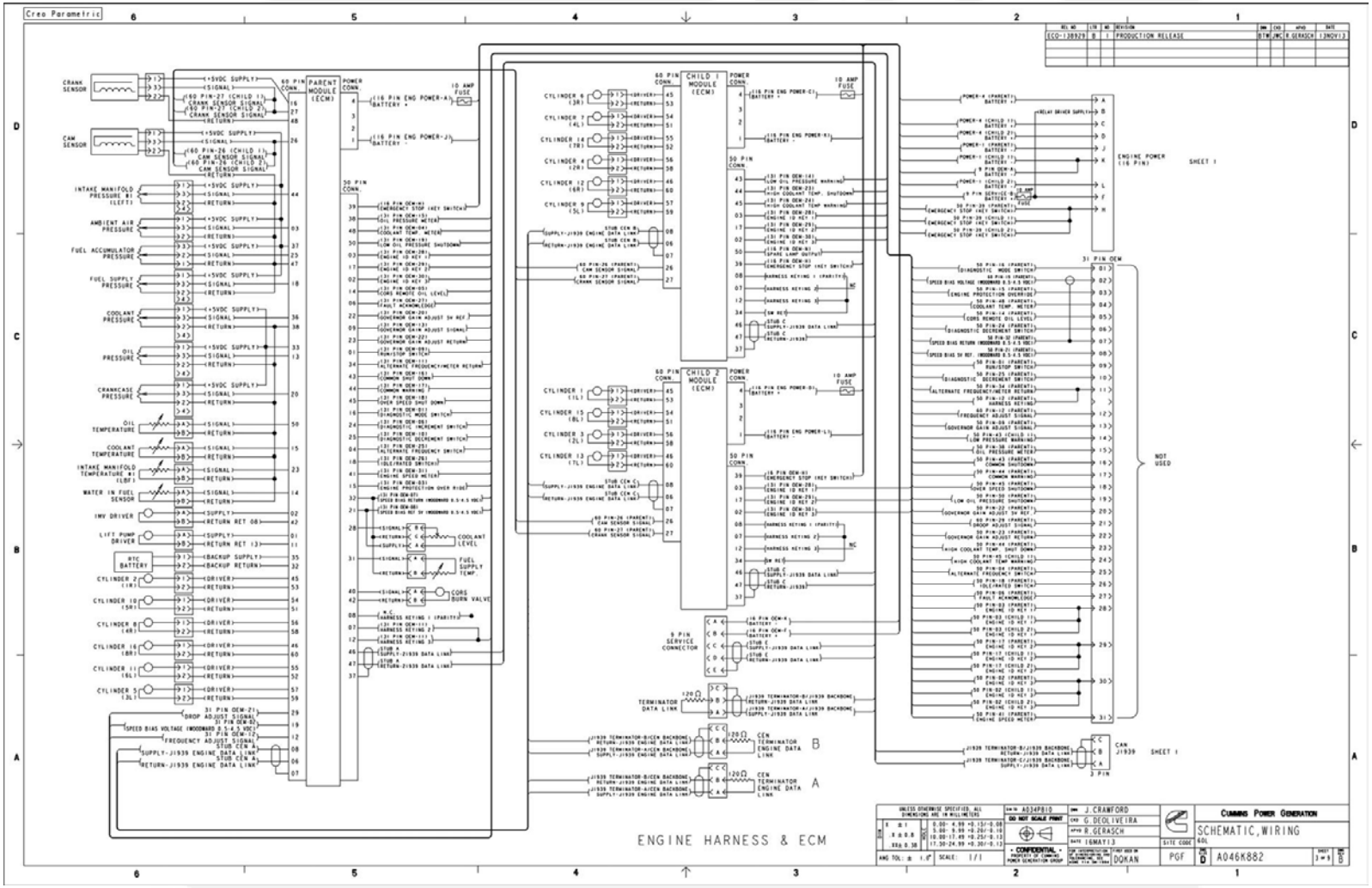

FIGURE 76. ENGINE HARNESS AND ECM CONNECTIONS

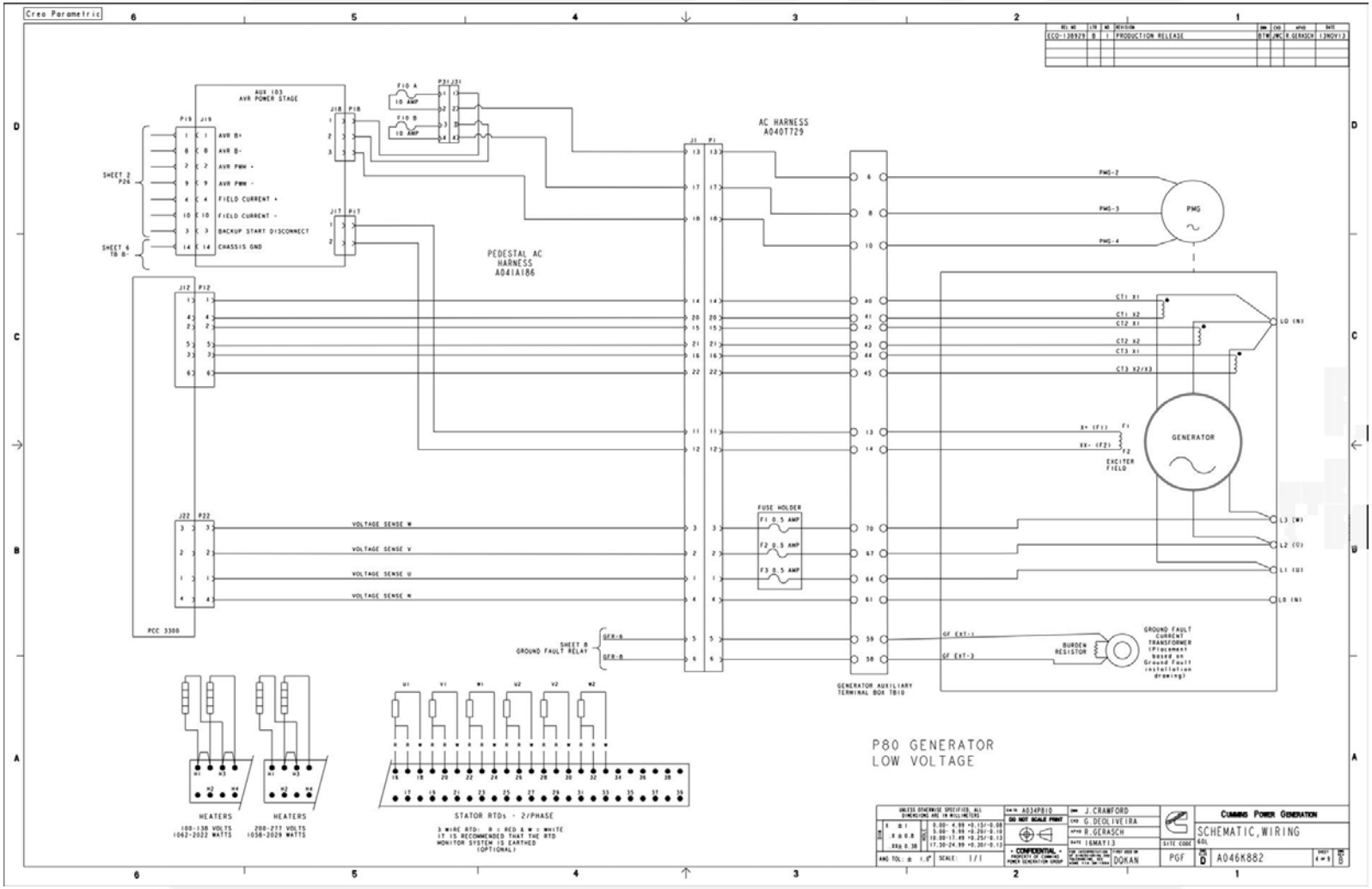

FIGURE 77. LOW VOLTAGE P80 ALTERNATOR CONNECTIONS

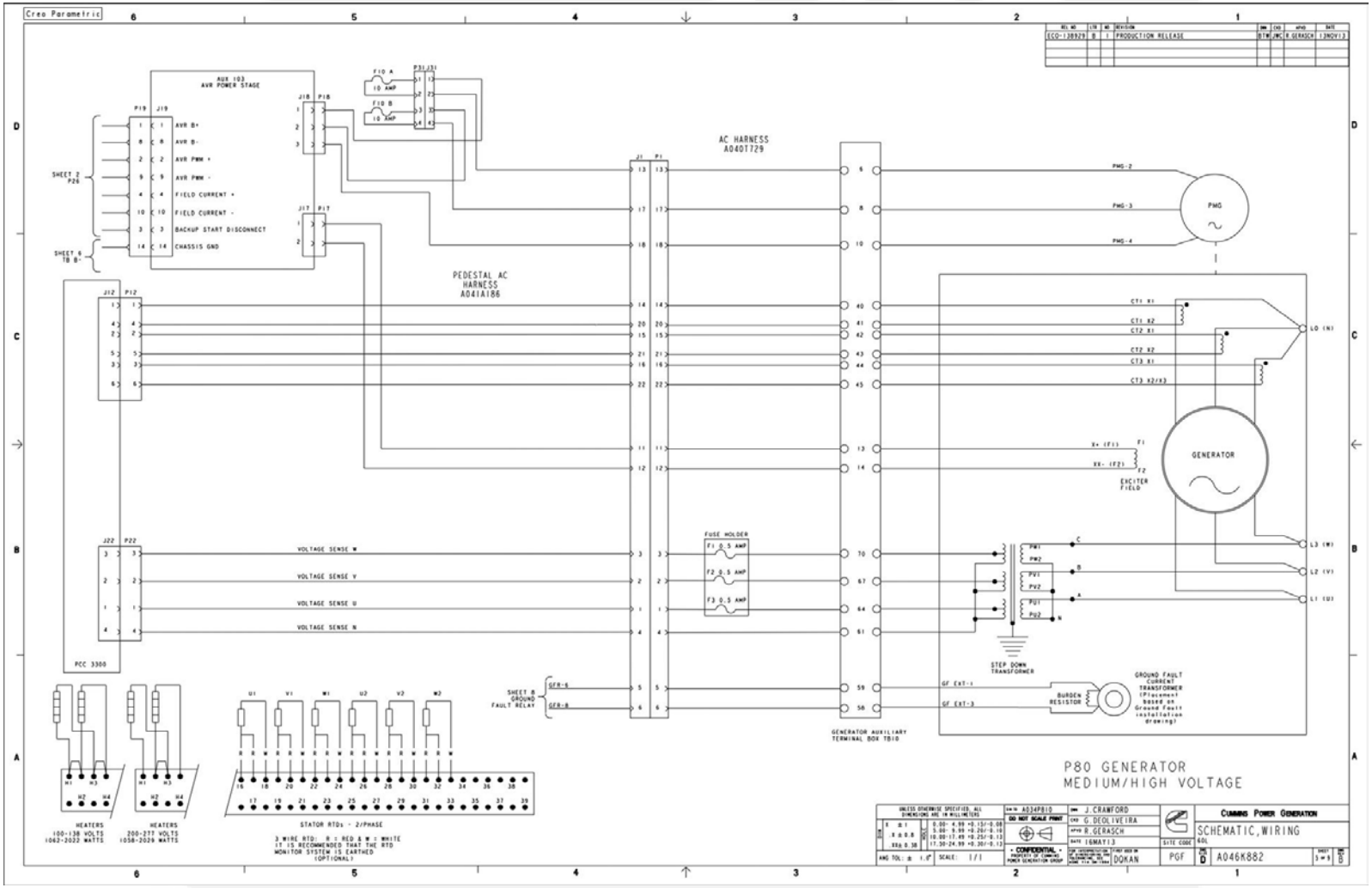

FIGURE 78. MEDIUM/HIGH VOLTAGE P80 ALTERNATOR CONNECTIONS

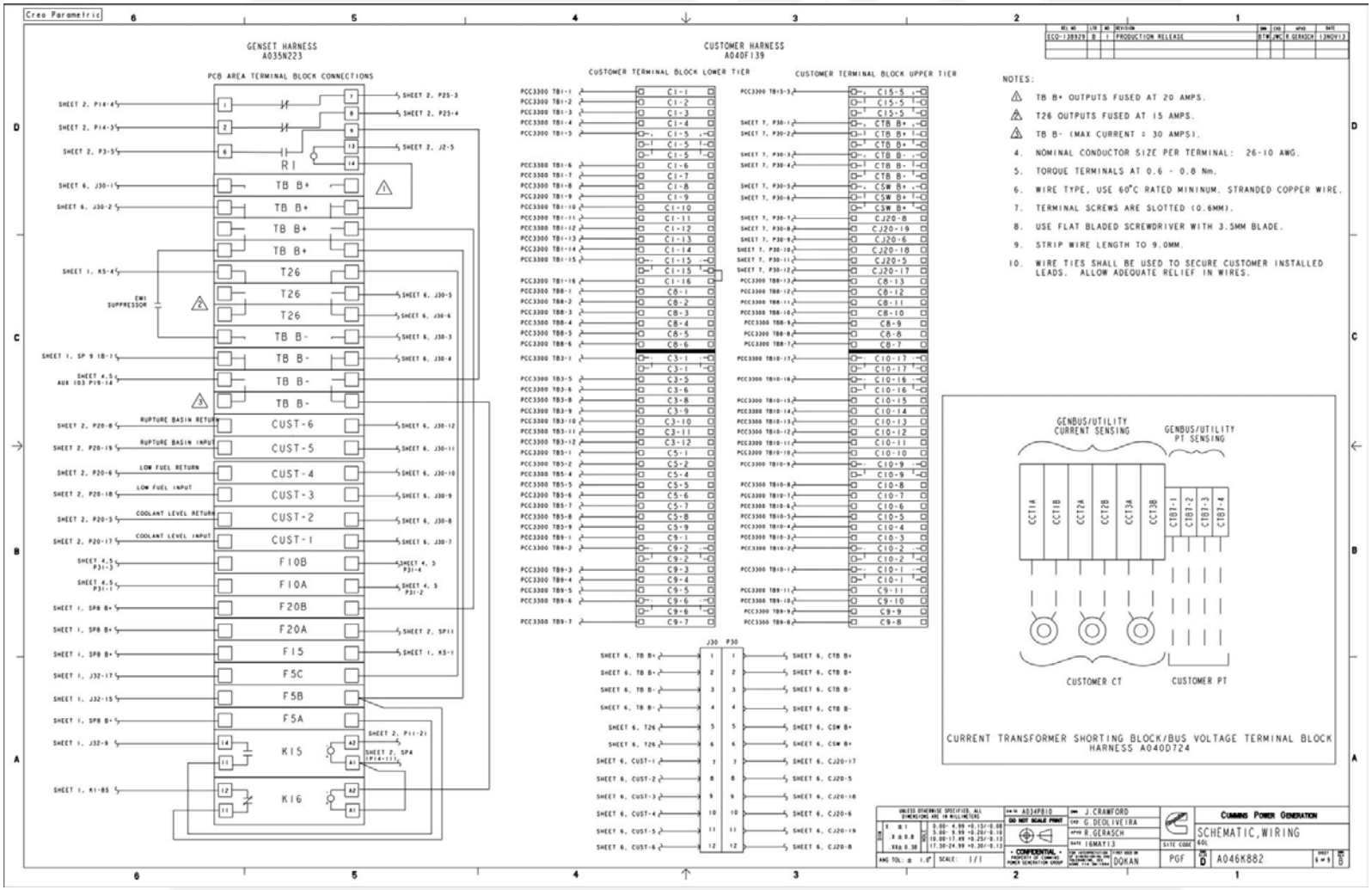

FIGURE 79. CUSTOMER CONNECTIONS

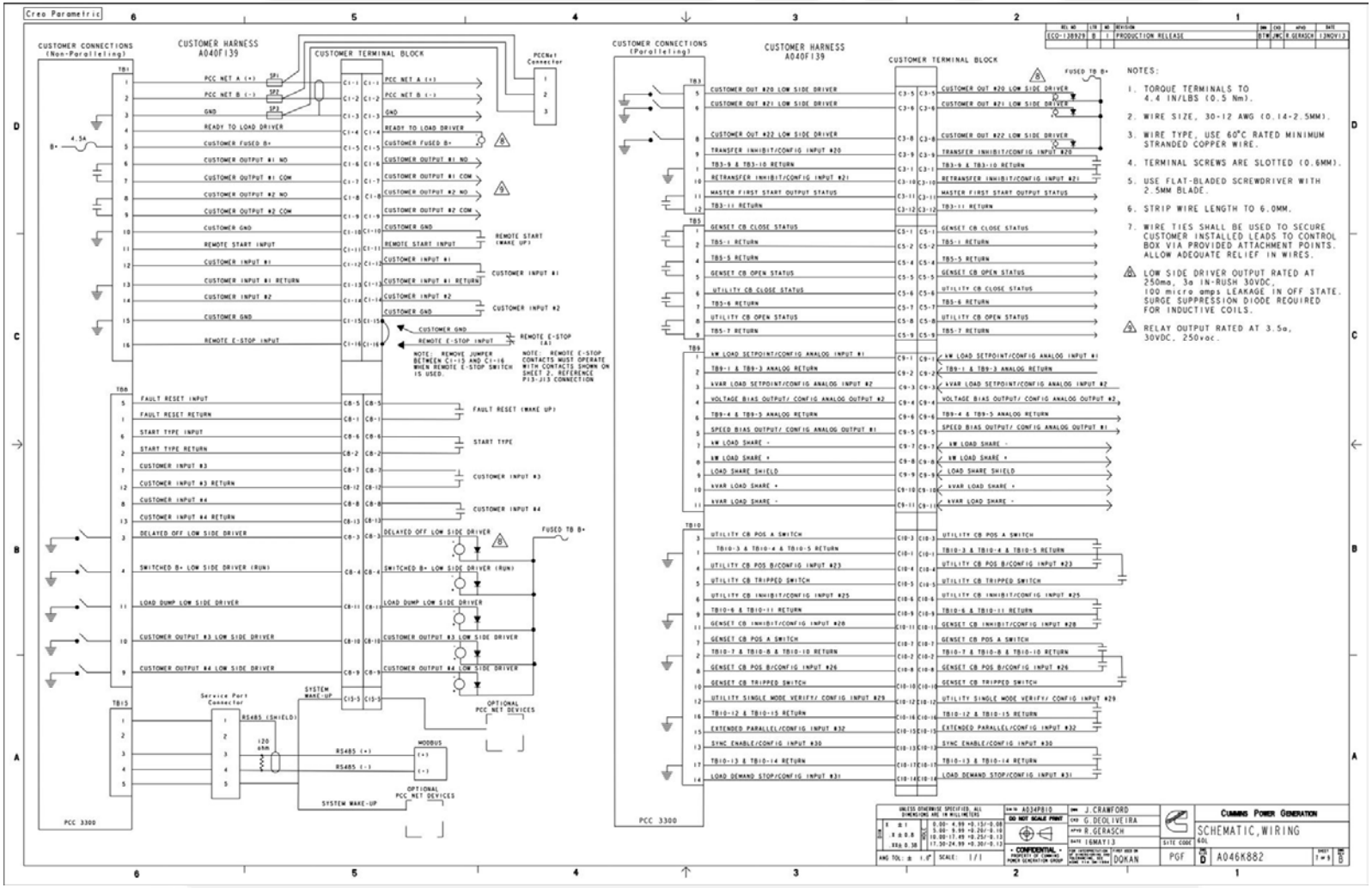

FIGURE 80. CUSTOMER CONNECTIONS

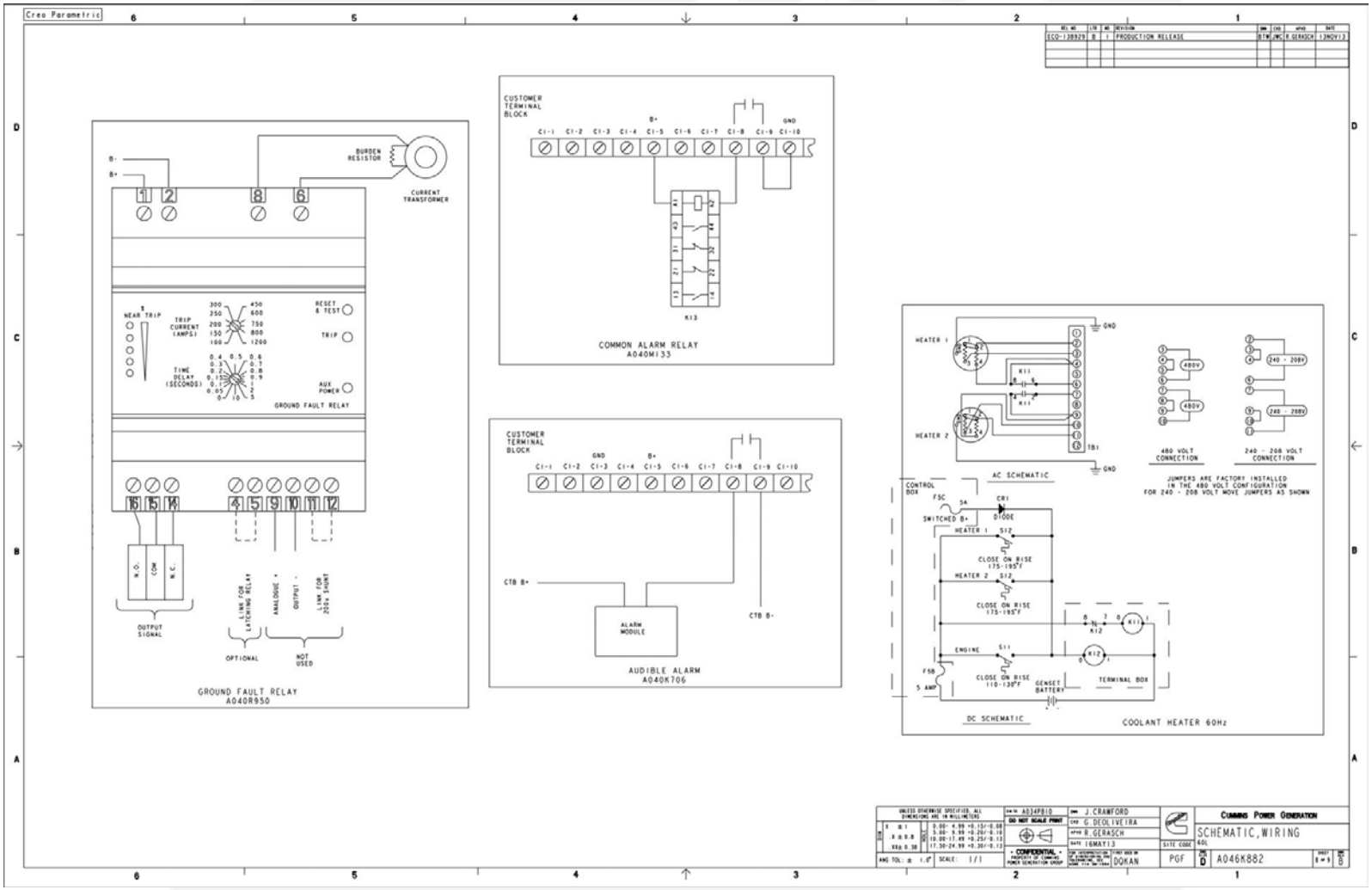

FIGURE 81. CUSTOMER CONNECTIONS

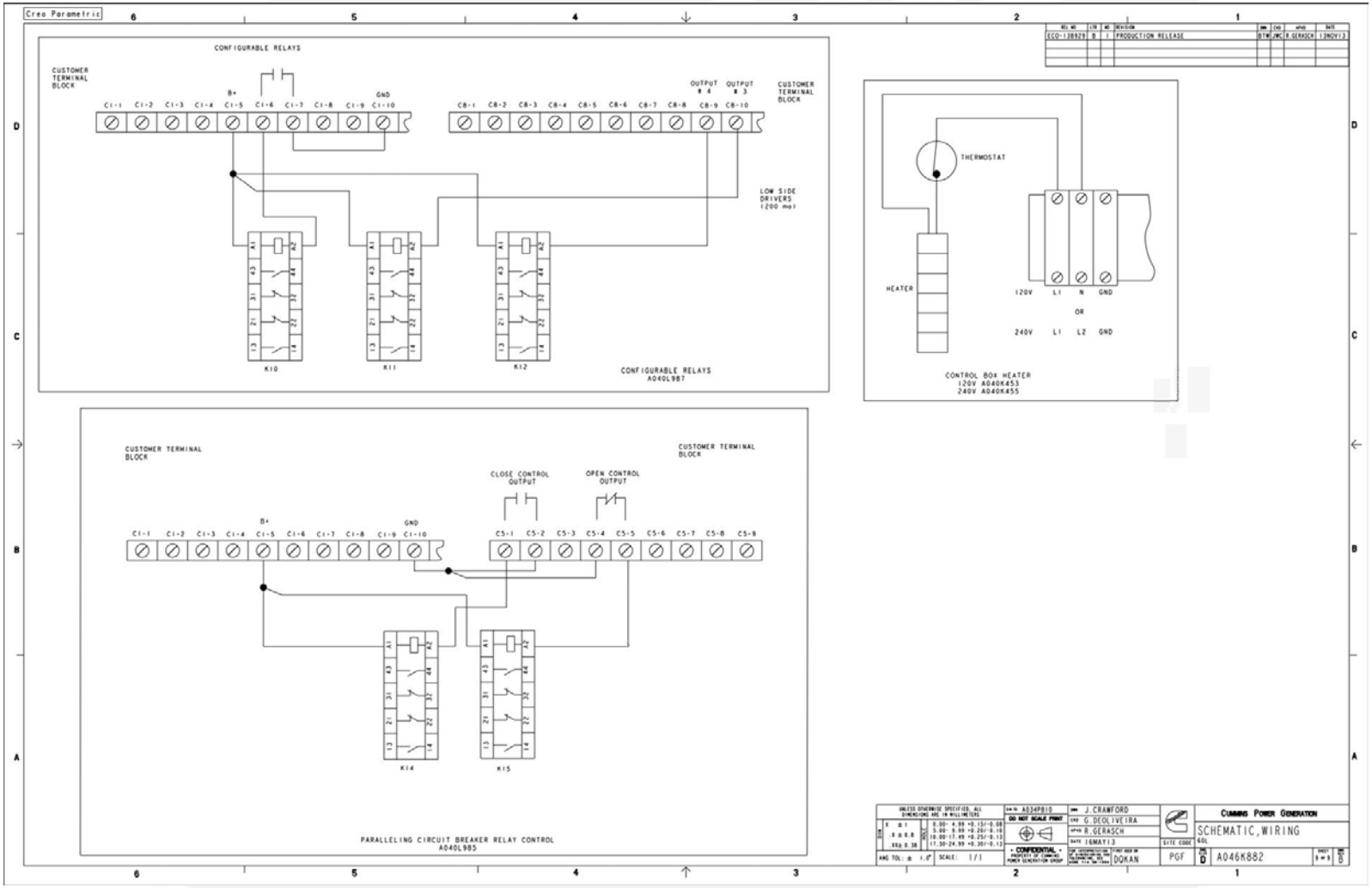

FIGURE 82. CUSTOMER CONNECTIONS

C.2 Control Wiring Diagrams

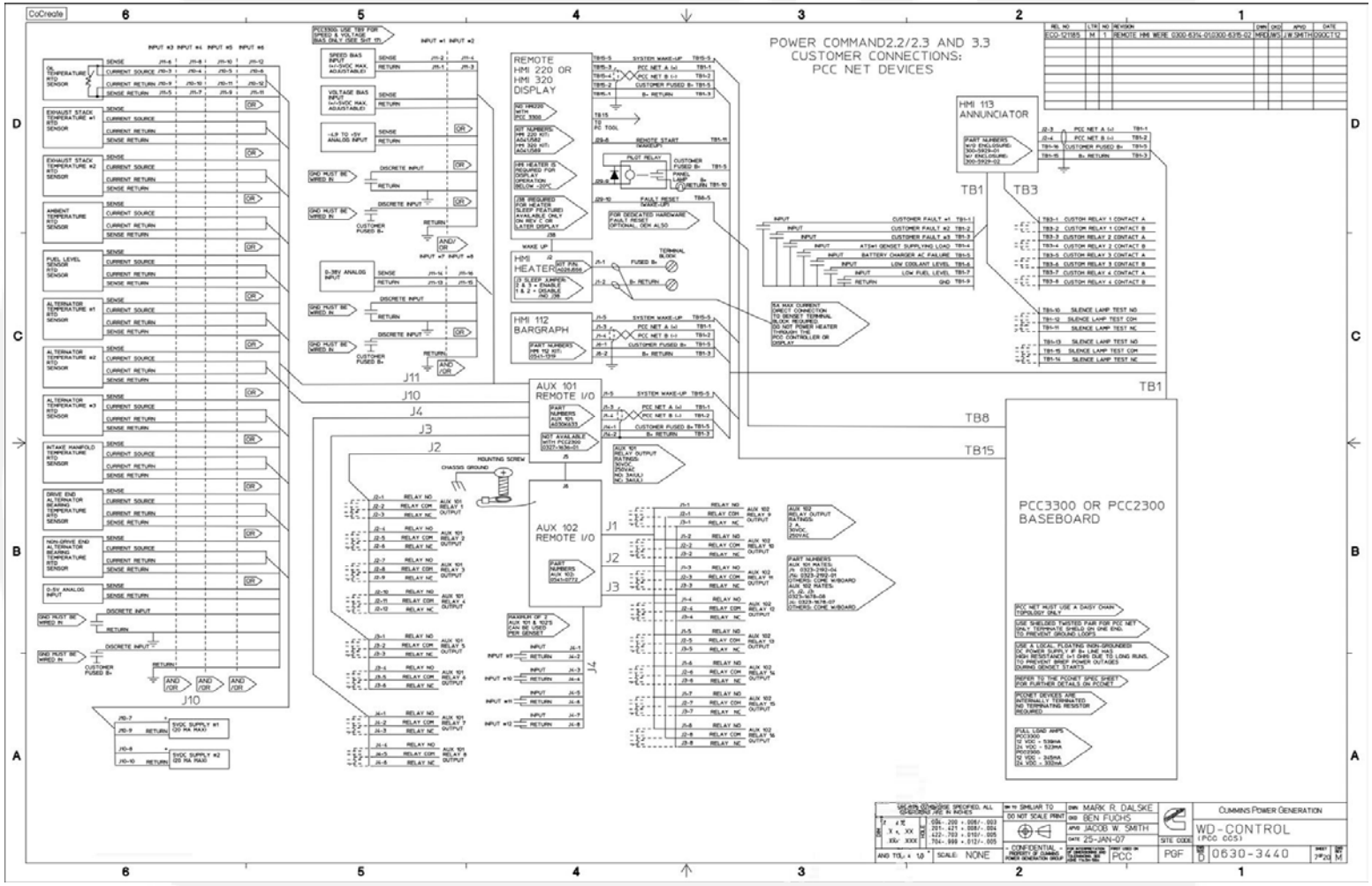

FIGURE 83. CONTROL CUSTOMER CONNECTIONS - PCC NET DEVICES

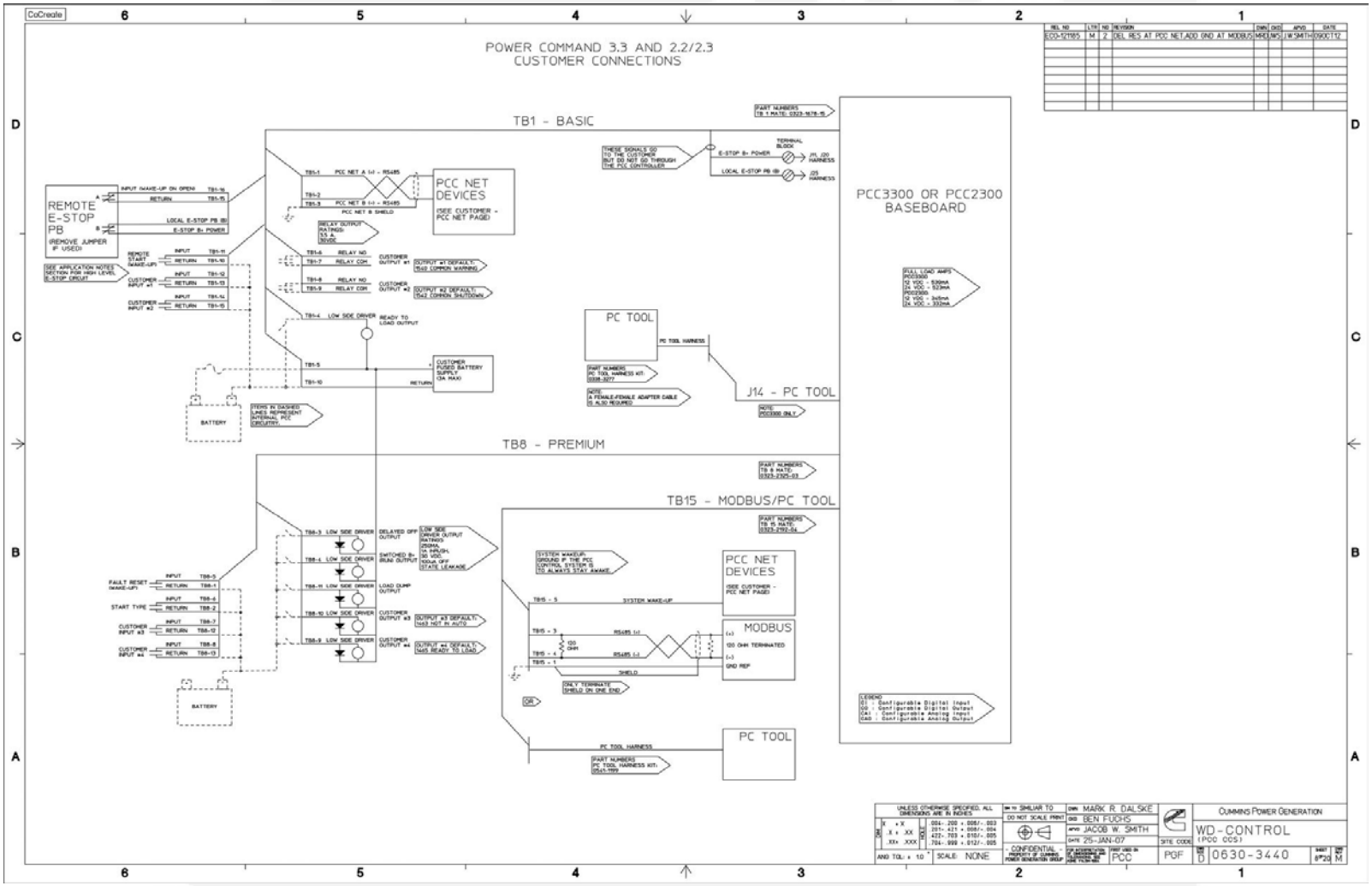

FIGURE 84. CUSTOMER CONNECTIONS

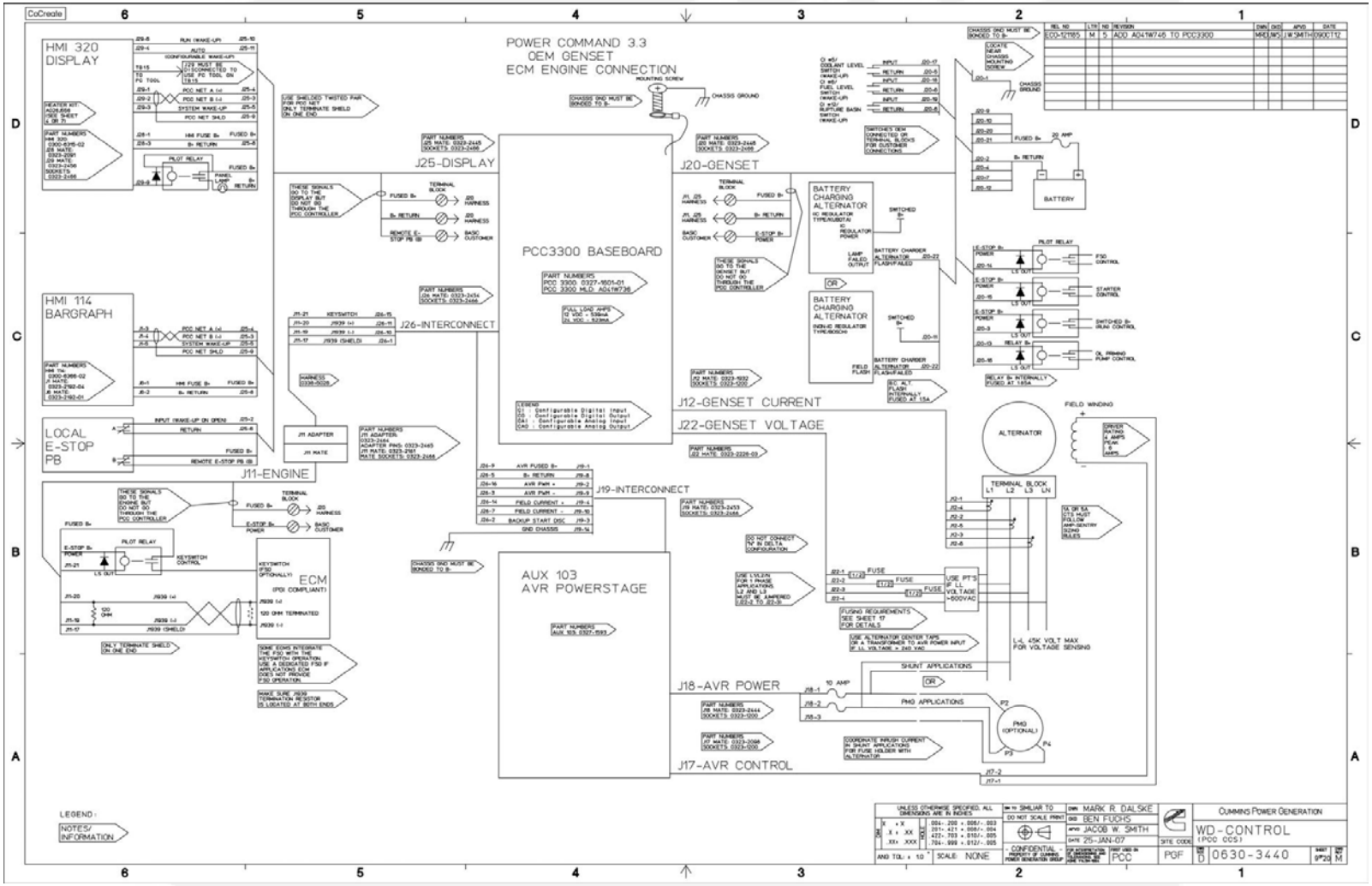

FIGURE 85. POWERCOMMAND 3.3 CONNECTIONS - ECM-BASED ENGINES

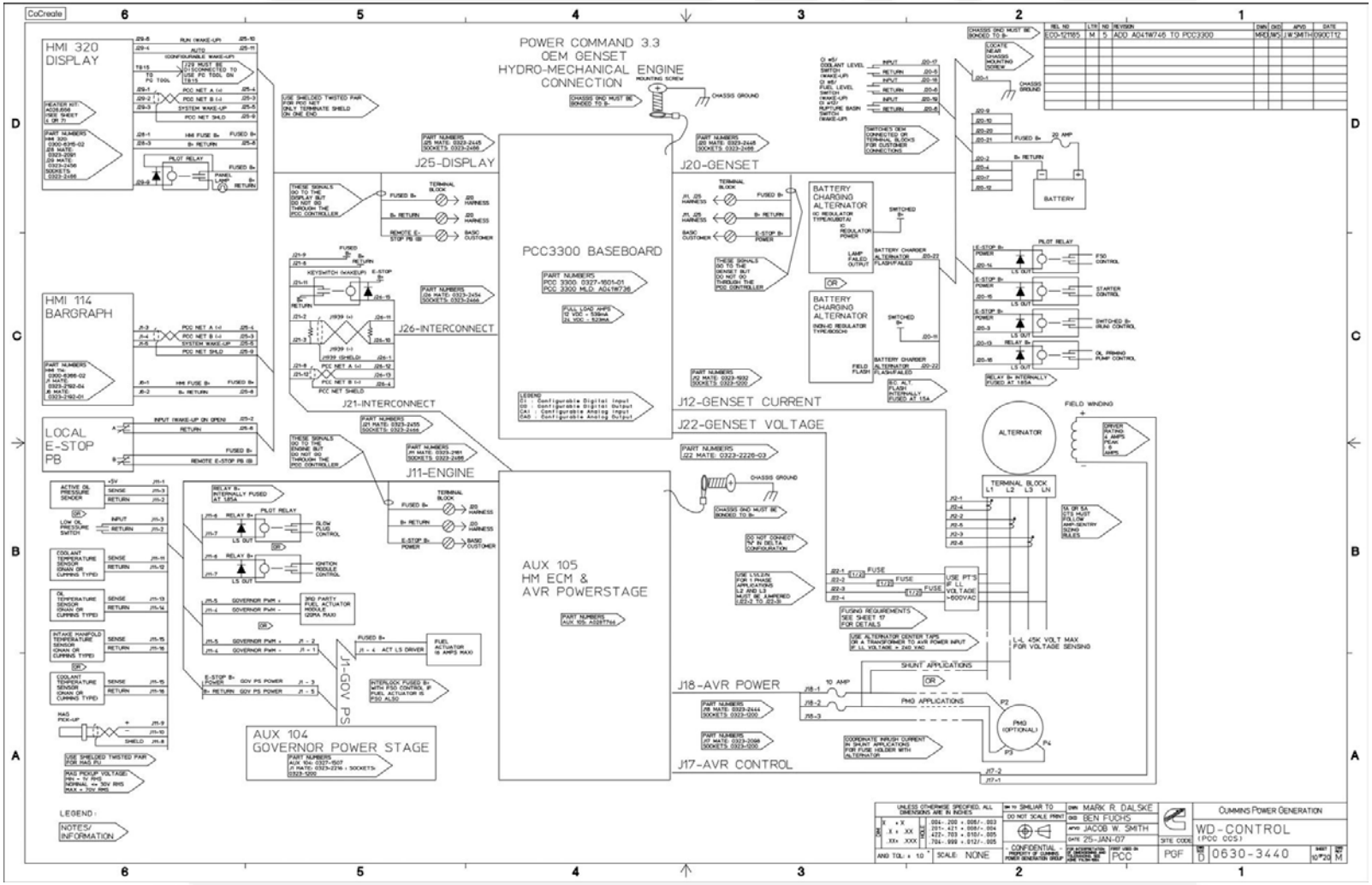

FIGURE 86. POWERCOMMAND 3.3 CONNECTIONS - HYDROMECHANICAL ENGINES

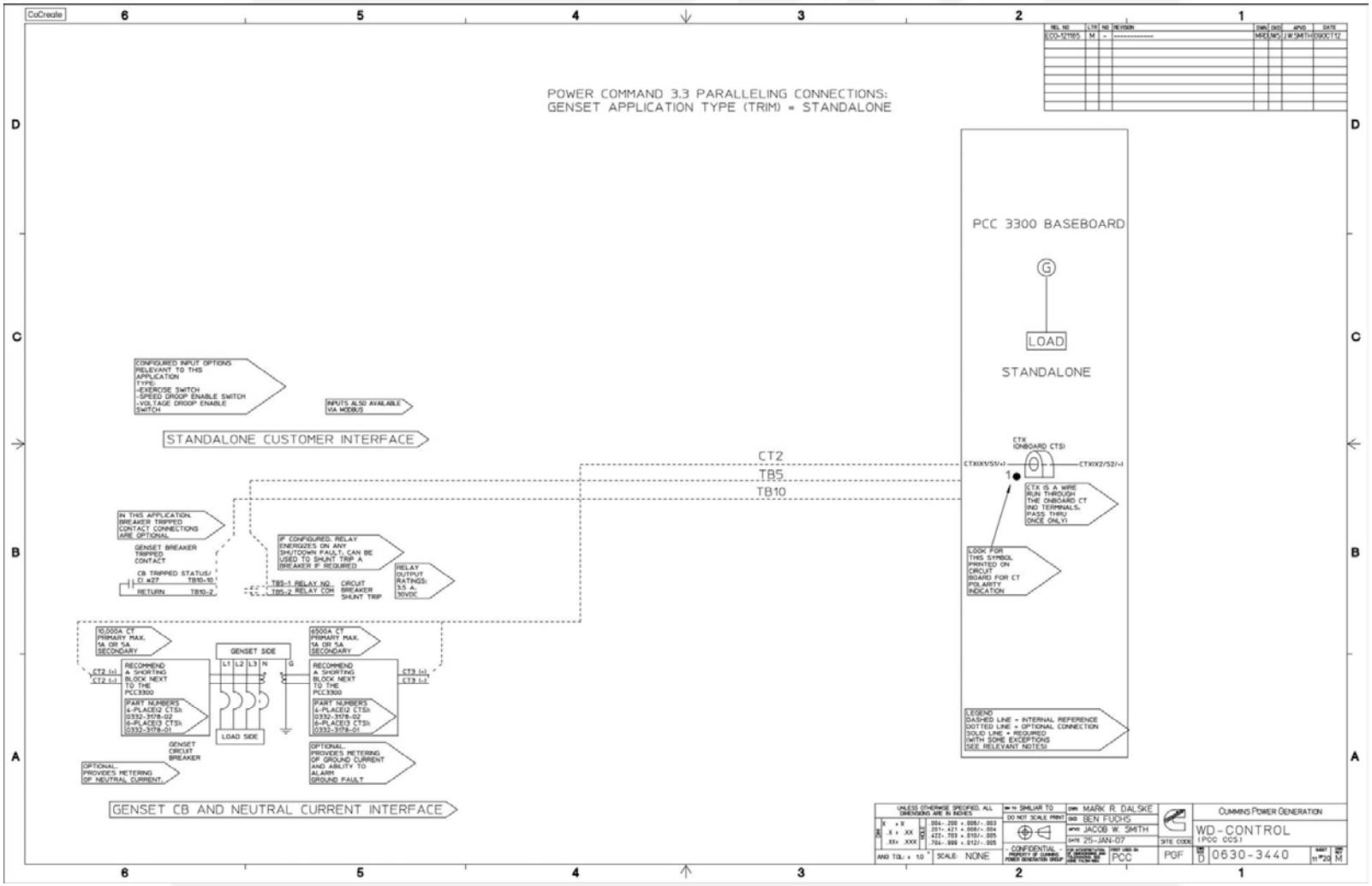

FIGURE 87. POWERCOMMAND 3.3 PARALLELING CONNECTIONS - STANDALONE GENERATOR SET

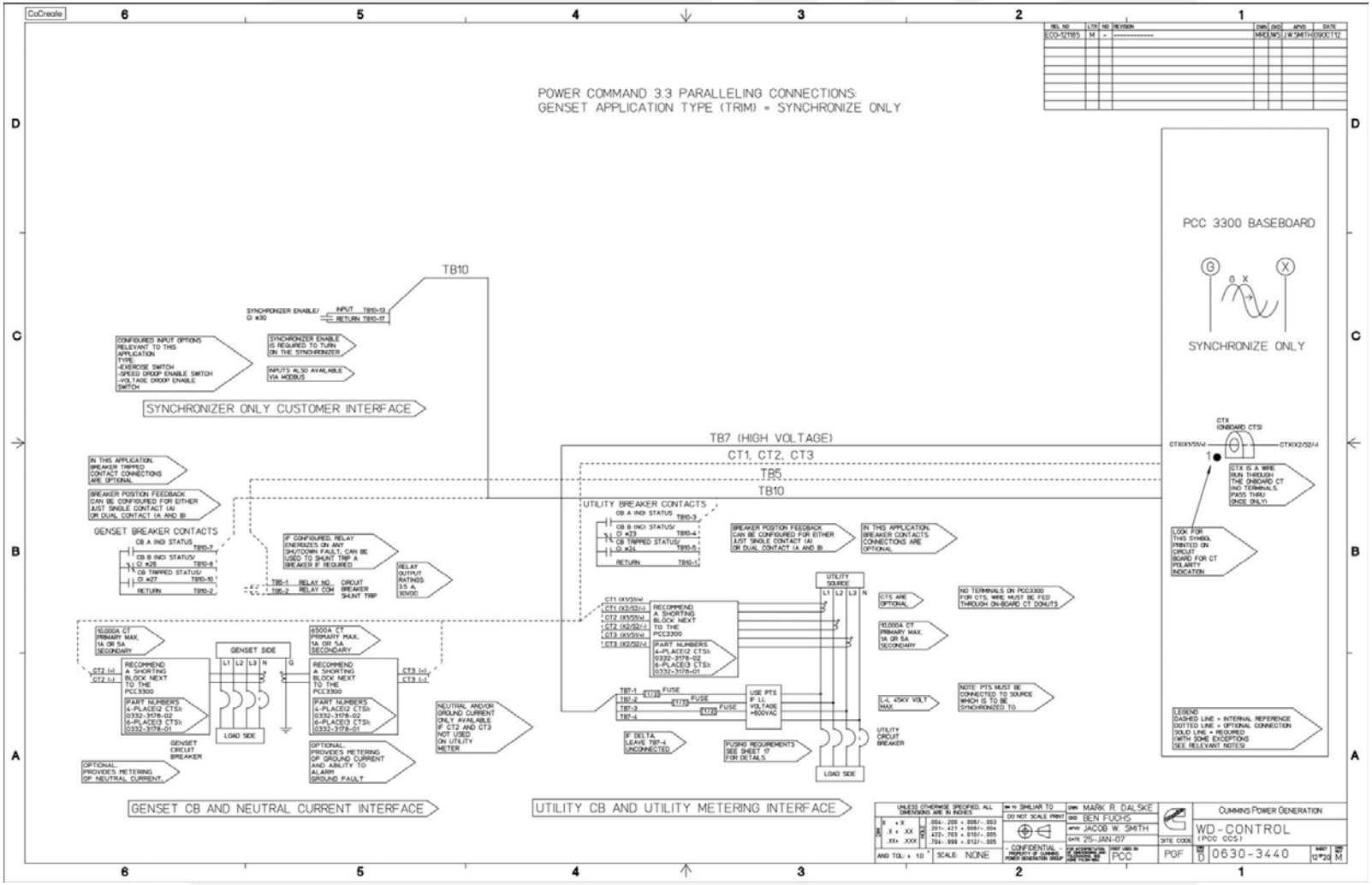

FIGURE 88. POWERCOMMAND 3.3 PARALLELING CONNECTIONS - SYNCHONIZE ONLY

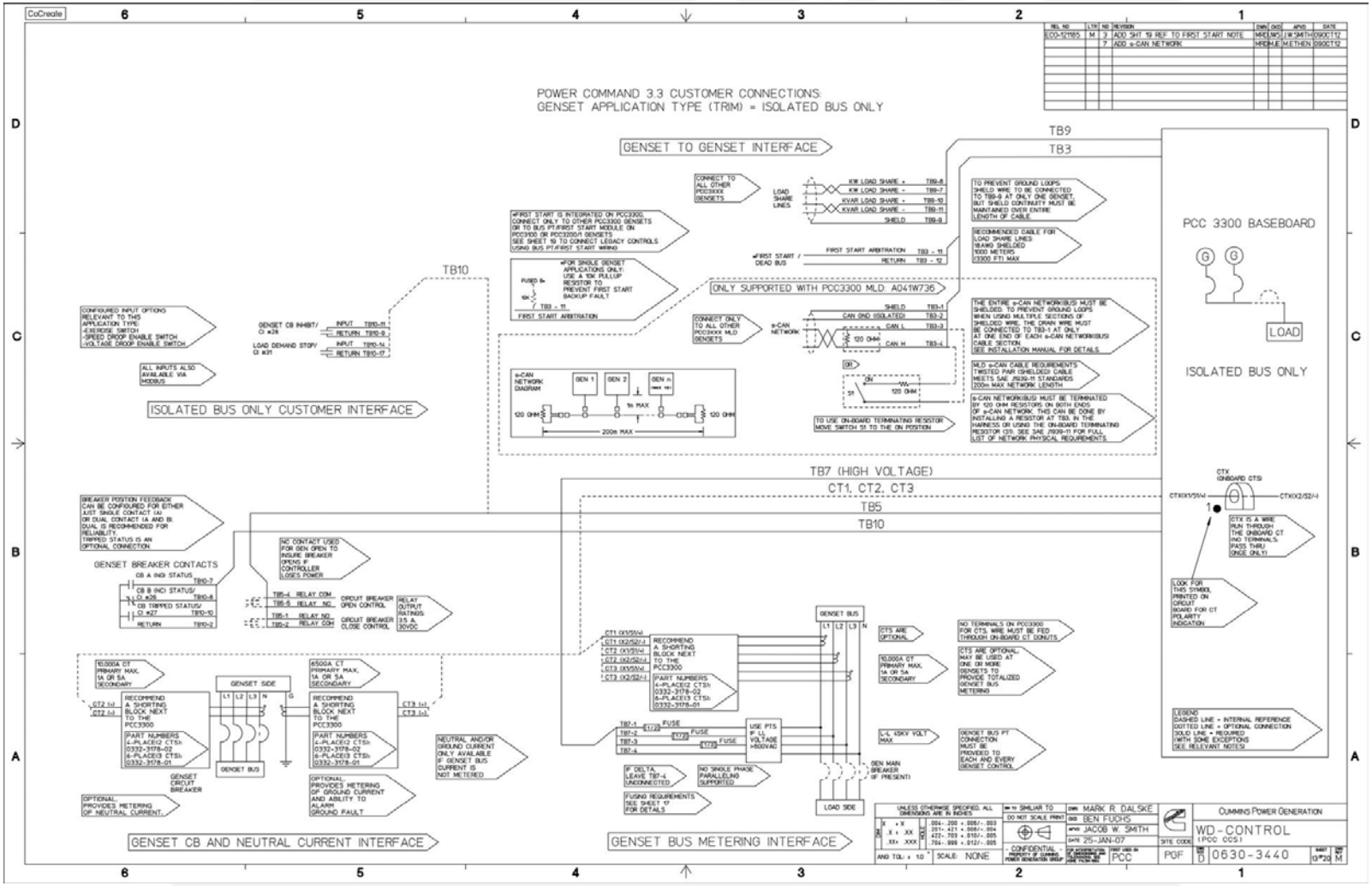

FIGURE 89. POWERCOMMAND 3.3 PARALLELING CONNECTIONS - ISOLATED BUS ONLY

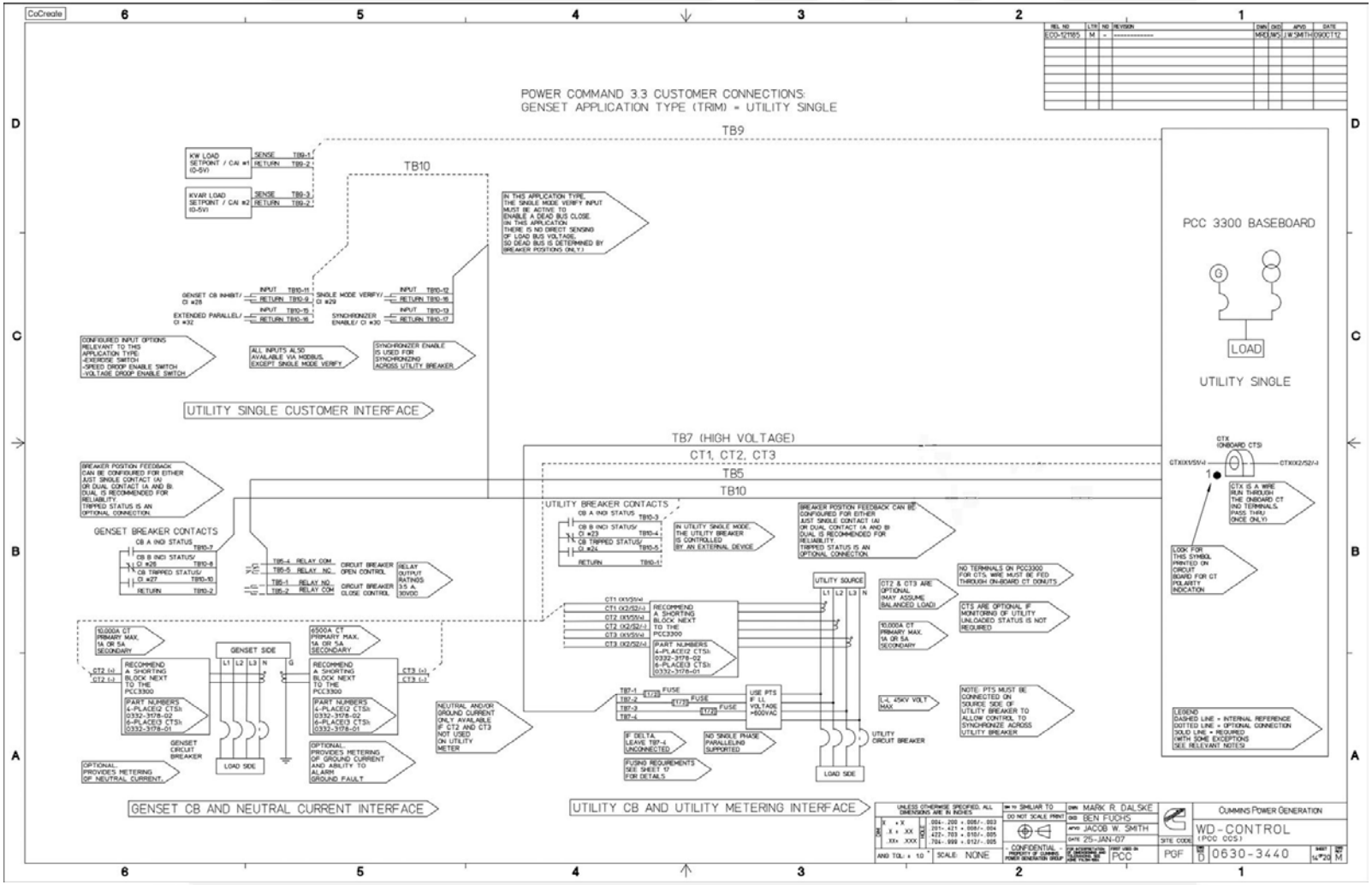

FIGURE 90. POWERCOMMAND 3.3 PARALLELING CONNECTION - UTILITY SINGLE

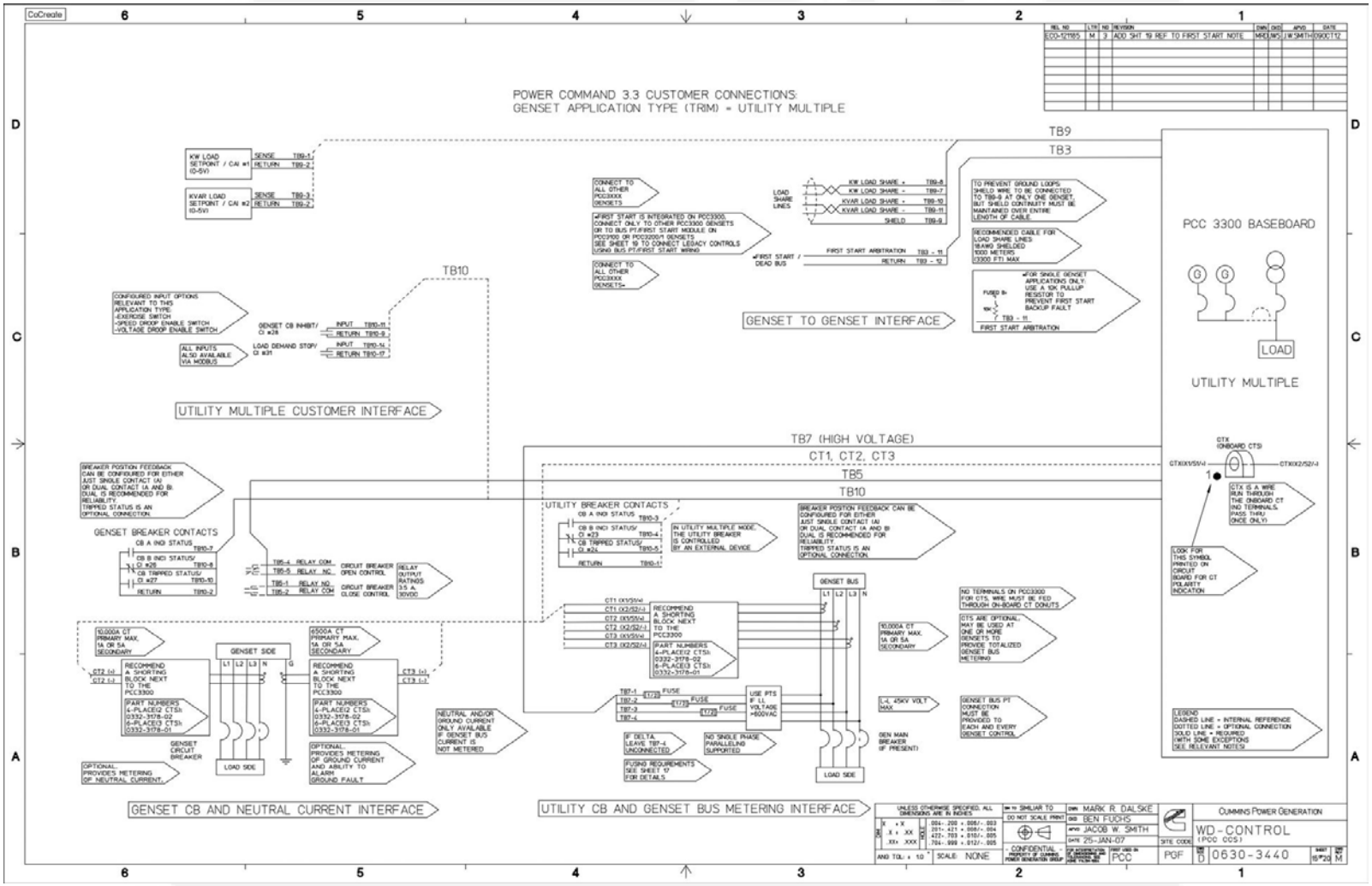

FIGURE 91. POWERCOMMAND 3.3 PARALLELING CONNECTIONS - UTILITY MULTIPLE

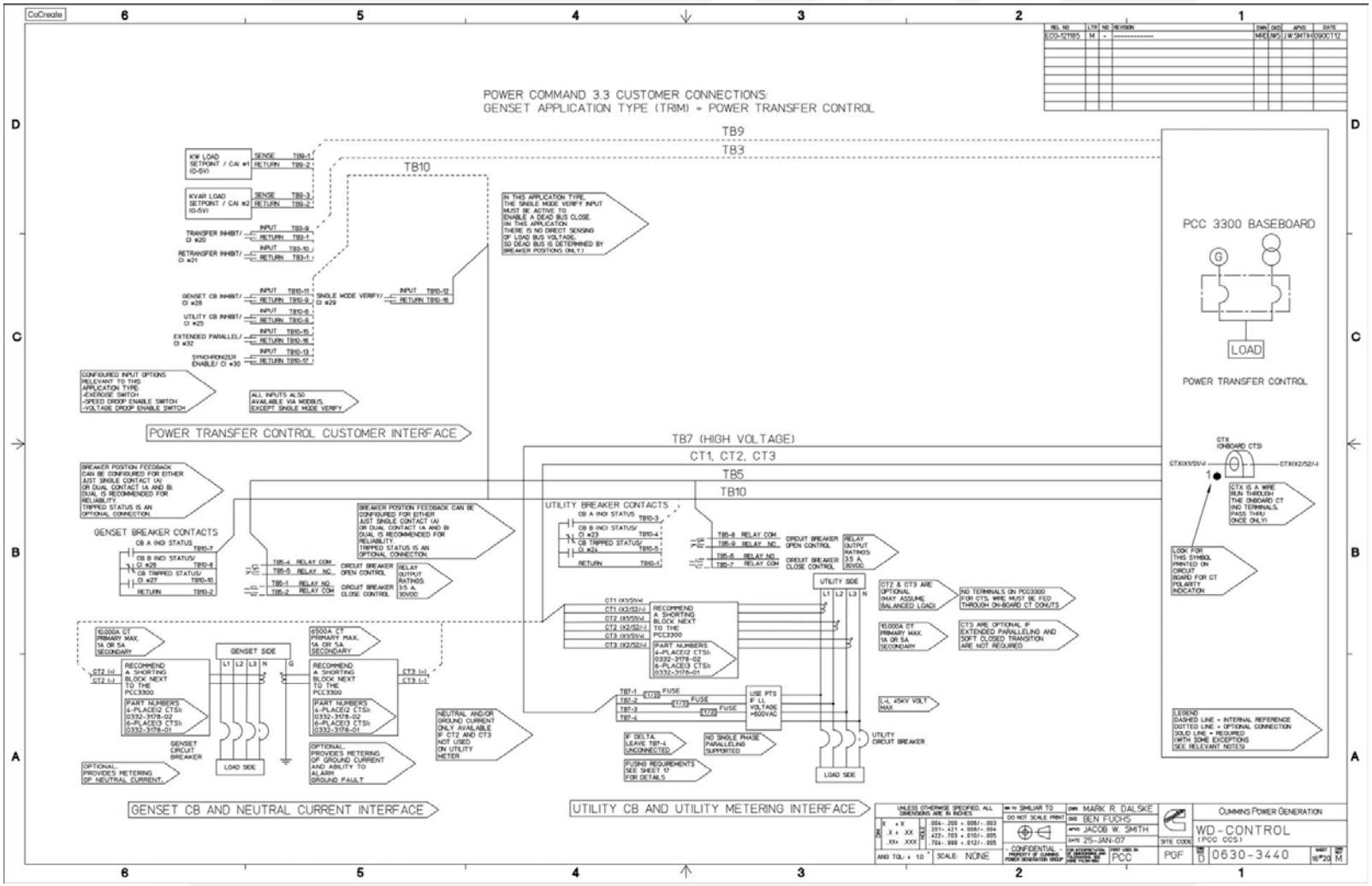

FIGURE 92. POWERCOMMAND 3.3 PARALLELING CONNECTIONS - POWER TRANSFER CONTROL

FIGURE 93. POWERCOMMAND 3.3 PARALLELING CONNECTIONS - CONFIGURABLE PARALLELING I/O

C.3 Prelube Wiring Diagrams

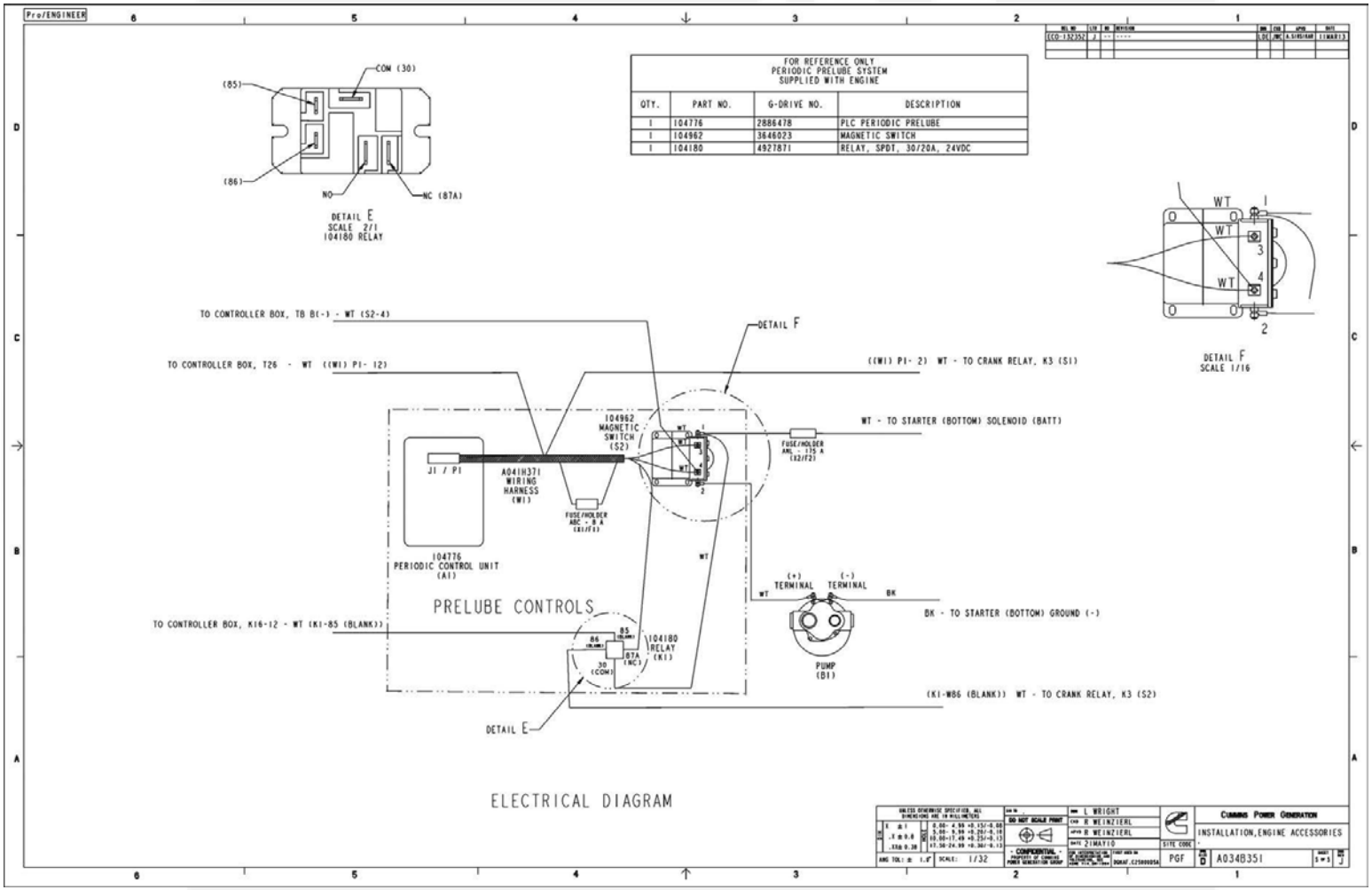

FIGURE 94. PRELUBE ELECTRICAL DIAGRAM

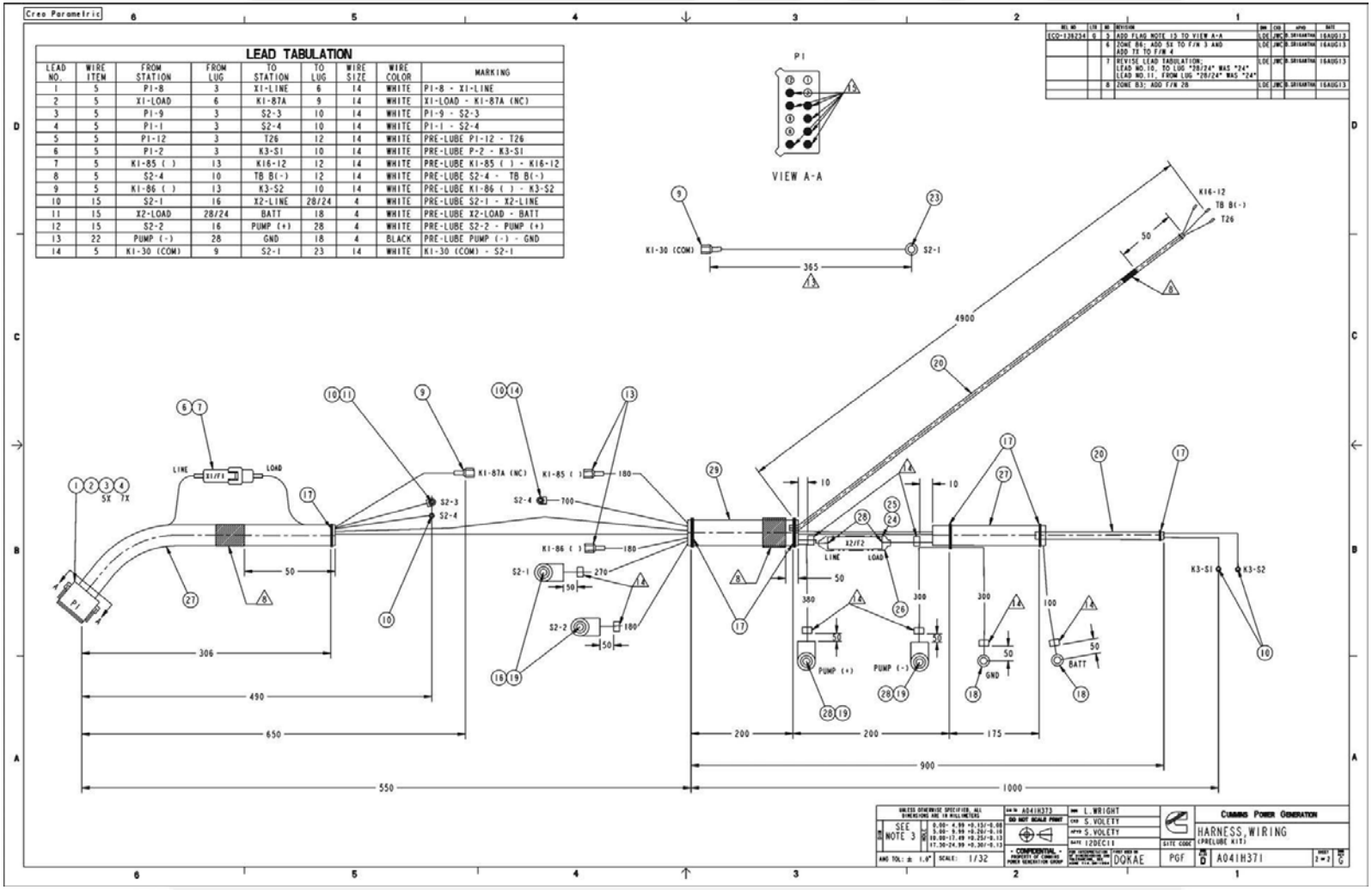

FIGURE 95. PRELUBE WIRING HARNESS (SHEET 1)

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