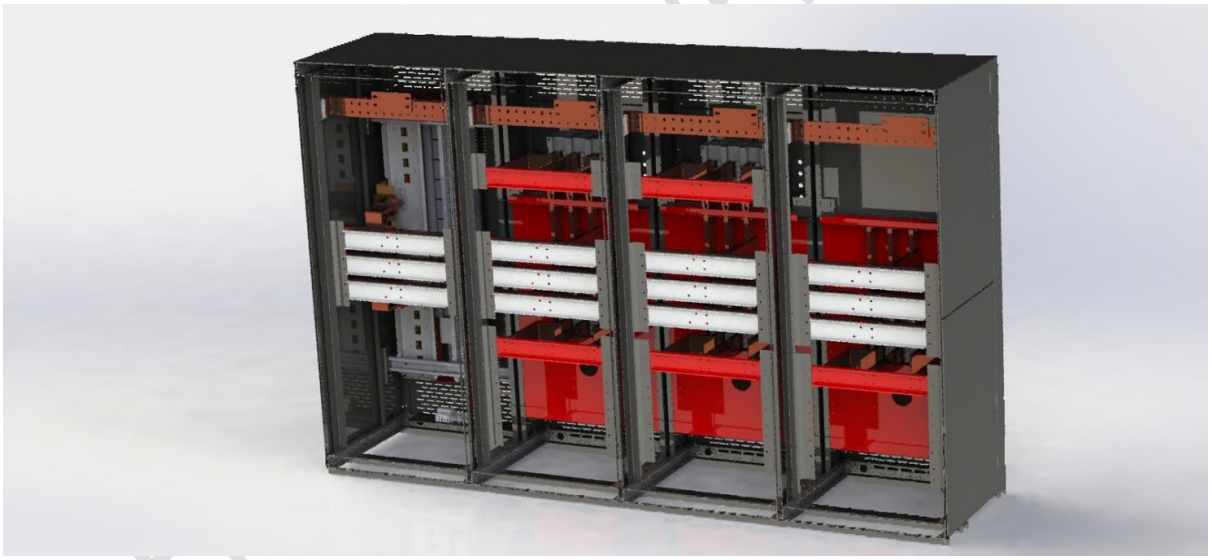
LOW VOLTAGE SWITCHBOARD INSTRUCTION MANUAL UL 891



Note: Manual to be included with each MPS Swtchboard.

These instructions do not cover every detail or variation in the equipment, nor do they account for every possible scenario related to installation, operation, or maintenance. If additional information is required or if specific issues arise that are not adequately addressed, please contact Millennium Power Systems sales representative. The content of this instruction manual does not form part of, or modify, any prior or existing agreements, commitments, or relationships. The sales contract encompasses MPS entire obligation. The warranty provided in the contract is MPS sole warranty. Any statements made herein do not create new warranties or alter the existing warranty.

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1.0 Safety Information

Switchboards contain hazardous voltages and can cause severe damage, injury, or death. It is crucial to follow all instructions, diagrams, and standards carefully when handling, installing, energizing, and operating the switchboard and its components. Only authorized personnel should operate or maintain the switchboard. Authorized personnel typically have NFPA-70 Arc Flash training and prior experience with Millennium Power Systems (MPS) equipment or switchboards.
Labels appear throughout the manual, and anyone working on or with the switchboard should be familiar with the various labels and warnings.

Hazardous voltages in electrical equipment can cause severe personal injury or death. Energizing a switchboard for the first time after initial installation or maintenance is especially dangerous. Ensure that inspection and maintenance are performed only on switchboards and equipment that have been de-energized, disconnected, and electrically isolated, so that accidental contact with live parts is prevented.
Certain types of electrical equipment can introduce harmonics into the electrical system, potentially leading to overheating. When determining the loading of the switchboard, consider the impact of these harmonics, as it may be necessary to de-rate the equipment to ensure safe operation.

MPS is not responsible for any damages that result from any errors or omissions that might occur in this document. Any damages and monetary losses that are the result of actions taken using this document and its information are not the liability of MPS. Do not use this manual to train non-qualified personnel. Being a custom product, this switchboard may possess components or aspects that are not included in the document. Therefore, do not base all details regarding status, operation, and performance of equipment solely on the manual. MPS has taken steps to guarantee that the document contains adequate instructions without errors or omissions. If further clarification is needed, MPS will elaborate on topics not fully detailed. **The manual's information is subject to change without notice.**

Follow all instructions and safety guidelines published by OSHA, industry professionals, and local, state, and federal agencies.

2.0 Introduction

The purpose of this manual is to help users develop safe and efficient procedures for the installation, maintenance, and operation of the equipment. For further guidance, refer to the NEMA Standards Publication PB2.1, "eneral Instructions for Proper Handling, Installation, Operation, and Maintenance of Deadfront Distribution Switchboards Rated 1000 Volts or Less" which can be accessed on the NEMA website (www.nema.org).
If you require additional information, please contact your MPS representative.
MPS warrants that, on the date of shipment, all goods manufactured by MPS are free from defects in workmanship and materials. If, within one year from the date of initial operation, but not more than eighteen months from the date of shipment by MPS, the purchaser discovers any non-conformities, and promptly notifies the company in writing, MPS will remedy the defect at its discretion by adjusting, repairing, or replacing the affected item and any associated parts.
Please refer to the "***Warranty Agreement***" for the complete warranty terms.

Disclaimer

The signal words "**DANGER**" "**WARNING**" and "CAUTION" used in this manual indicate the level of hazard that the user may encounter.
These terms are defined as follows:
DANGER – Indicates an imminent hazardous situation which, if not avoided, will result in death or serious injury.
WARNING – Indicates a potential hazardous situation which, if not avoided, could result in death or serious injury.
CAUTION – Indicates a potential hazardous situation which, if not avoided, may result in minor or moderate injury.

Dangerous Procedures

In addition to other procedures described in this manual as dangerous, user personnel must adhere to the following warnings:
Danger! High Voltage. Only qualified personnel should work on this equipment. Lock off all power before working inside. Always work on de-energized equipment, and ensure the equipment is de-energized before performing any tests, maintenance, or repairs.
WARNING! Always perform maintenance on the interrupting device only after the closing mechanism(s) have been fully discharged.
CAUTION! Allow interlock devices or safety mechanisms to perform their intended function without forcing or bypassing them.
CAUTION! Hydrocarbon spray propellants and compounds can degrade certain plastics. Consult your local MPS representative before using these products to clean or lubricate components during installation or maintenance.

WARNING: **Only Qualified Electrical Personnel familiar with the equipment, protection requirements, operation and the associated hazards inherent in the equipment should be permitted to work on Switchboards. Before any testing is started make sure the tester is familiar with the power distribution cutoffs for power being used in the equipment. All power, primary and secondary are to be de-energized prior to testing or maintenance.**

2.1 Field Service

Millennium Power Systems (MPS) provides the following support services for switchboards. For additional information or to schedule an appointment, call 844.MCS.1020.

Start-up Commissioning
Component and System Testing
Scheduled and Preventative Maintenance
Repair and Refurbishing
On-Site Operational Training

2.2 General Description

MPS switchboards are engineered and manufactured to operate efficiently under normal conditions. The instructions in this manual are designed to help users achieve long-lasting and economical service from their switchboards. For optimal operation and maintenance, distribute this information to operators and engineers responsible for the equipment.

These instructions apply to the standard construction details of MPS switchboards, including auxiliary equipment and necessary accessories. Any special equipment supplied based on purchase order requirements will have supplementary instruction manuals.

The switchboards described are of the dead front type, as defined by NFPA70 (NEC), UL891, and NEMA PB2. All parts, conductors, and insulation materials are designed to meet the voltage class of the equipment and are housed within grounded metal enclosures.

The provided equipment is designed to operate in systems with the circuit capacity specified by the purchaser. If the equipment is later used in a different system, or if the short-circuit capacity of the system increases, the momentary rating of the switchboards, the interrupting capacity of protective devices, and the bus capacity must be reevaluated. If service conditions change, the equipment must be reviewed to ensure its short-circuit capacity, amperage, and voltage class meet the new system's requirements.

Switchboards are free-standing units rated at 6000 amperes or less, operating at 600 volts AC or below. A typical switchboard contains a service entrance section with main devices and distribution sections with branch devices. These sections include disconnect devices, protective devices, auxiliary equipment, and current transformers for metering, control, or ground fault protection.

3.0 Pre-Installation: Receiving, Handling, Storage, Receiving

Before shipment, each switchboard undergoes inspection to ensure that its structural and electrical construction complies with the relevant specifications, codes, and standards. Depending on the switchboard's size and the number of sections, it is divided into shipping sections, with one or more vertical sections placed on wooden blocks. Each section is securely packaged, blocked, and braced for shipment. Regardless of the shipping method, all precautions are taken to minimize the risk of damage and ensure safe arrival. Delicate instruments or devices may be included in the assembly, so careful handling is required during unloading.

Upon the equipment's arrival at its destination, the packing list or marking tags should be checked against the received items to verify that the shipment is correct and complete. Claims for shortages or incorrect materials must be made in writing within **30 days** of receiving the shipment. Failure to provide such notice constitutes unqualified acceptance and waives all such claims.

For shipments consisting of multiple shipping groups, marking tags are attached to each package for identification. If marking tags are not present, the rating label on each section will contain the section marking. Refer to the general arrangement drawing to locate each unit within the lineup.

When the shipment arrives, follow these steps to ensure proper handling and documentation:

3.0.1 Upon arrival, check whether the equipment is properly protected from the elements. Record the trailer number on which the equipment arrived and note the blocking of the equipment. During unloading, ensure that the item count matches the delivery receipt.

3.0.2 Perform an immediate inspection for visible damage upon arrival. This inspection should be done before unloading when possible. If a complete inspection cannot be made while the equipment is still on the vehicle, closely inspect it during unloading, noting any visible damage. Take pictures if possible.

3.0.3 Any visible damage must be noted on the delivery receipt and acknowledged with the driver’s signature. Provide as much detail as possible about the damage, and include the note “Possible internal damage, subject to inspection” on the delivery receipt.

3.0.4 If the driver refuses to sign the delivery receipt with the damage noted, the consignee or their agent should not sign for the shipment.

3.0.5 Immediately notify the MPS Office of any damage.

3.0.6 Arrange for a carrier inspection of the damage right away. Important: Do not move the equipment from the location where it was placed during unloading. Ensure that this location is properly protected to prevent further damage. The equipment

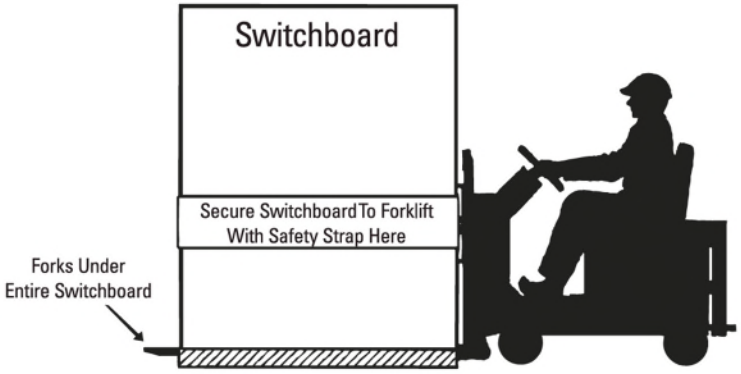
must be inspected by the carrier before it is handled after receipt. This helps prevent the carrier from claiming that the damage occurred or was exacerbated on-site after unloading. Concealed damage not reported at the time of delivery must be communicated to the carrier within five days; documented damage or missing claims must be reported within 30 days from the date of receipt.

3.0.7 After unloading, make sure the equipment is properly covered and protected from any further damage. Store the equipment in a clean, dry place with a uniform temperature to prevent condensation and additional damage.

3.1 Handling

WARNING: *Do not lay the equipment on its front, sides or back.*

A forklift is the preferred method for moving and handling switchboards. *Only qualified personnel should operate forklifts.* Ensure that the ground surface on which the forklift is operating is solid and flat. Check for any wet or slippery surfaces and always follow safety guidelines for forklift operation. Verify that the forklift's load and lifting ratings are adequate for the weight of the switchboard.
Always lift the switchboard from the front. Lifting from any other side may cause damage to the equipment.
When loading the forklift, ensure that the forks extend through the entire length of the pallet. Different forklifts may be required depending on the size of the switchboard. The forks must reach the far side of the shipping pallet.



Please refer to the NEMA Standards Publication PB 2.1 for alternate handling options.

Use a safety strap to secure the switchboard to the forklift. Given the top-heavy nature of the equipment, there is a risk that the switchboard may shift or fall. Ensure the strap is positioned strategically to prevent any movement, while taking care not to damage any components.

Once the switchboard is securely fastened to the forklift, slowly lift the equipment to the minimum height required from the floor for safe relocation.

Lifting Methods

In addition to forklifts, cranes are the preferred method for transporting switchboards when lifting eyes are provided. Upon delivery, an overhead crane should be used to unload the switchboard from the truck.
Lifting brackets/eyes are pre-installed on the top of the switchboard to facilitate safe and efficient handling. To secure the crane to the switchboard, use appropriately rated cables, spreader bars, and hooks to attach to the lifting brackets. Ensure that all lifting components are rated to support the switchboard's weight. Direct attachment of cables to the lifting brackets is not permitted; always adhere to the recommended lifting configuration as illustrated below.

Securely attach the lifting straps to the shackles and spreader bars (not provided with the switchboard). Before operating the crane, thoroughly inspect and confirm the entire lifting assembly. Once verified, use the crane to pull the assembly taut, ensuring no slack remains. Do not lift the switchboard directly from the floor at this stage.

With the rigging now taut, perform another check of the lifting assembly to confirm everything is properly aligned. Make any necessary adjustments before proceeding.

Carefully lift the equipment to the minimum height required for relocation. Suspend the switchboard approximately two (2) inches above its intended final position and conduct a visual inspection of the lifting equipment. After confirming that everything is secure, gently lower the switchboard into place and proceed to remove the lifting equipment.

3.2 Storage

Indoor Switchboards (NEMA 1)

If the switchboard is not to be installed immediately, it should be unpacked, inspected, and stored in a clean, dry location with adequate air circulation and a uniform temperature to prevent condensation. If the switchboard is to be stored for an extended period before installation, reapply the packing material for protection. If the packing material has been removed, cover the switchboard to protect it from dust, debris, and moisture. Indoor switchboards are neither weatherproof nor drip-proof, so they must be stored indoors. If the switchboard must be kept outdoors or in a humid, unheated area, provide adequate covering to protect against weather and dirt. Additionally, place an approx. 250-watt heater operating at 120V within each vertical section. Note that space heaters are not standard equipment on indoor switchboards. Before energizing the heat source, remove any loose packaging or flammable materials from inside the switchboard. If the switchboard is stored for an extended period, lubricate any moving parts such as hinges and shutters.

Storage – Outdoor Switchboards (NEMA 3R)

Outdoor switchboards should be stored following the same guidelines as indoor switchboards. When it is necessary to store outdoor switchboards in an area exposed to the weather or in humid conditions, they must be kept clean and dry as described above. Energize the self-contained space heaters (if provided) and ensure that louvers and vents are uncovered to allow air circulation. Cover shipping splits to protect the switchboard from the elements. Refer to the wiring diagram provided with the equipment for space heater circuit connections. Additionally, lubricate hinges, shutters, and other moving parts.

4.0 Installation

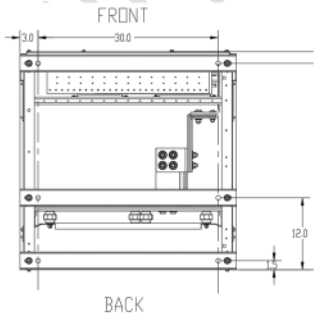
4.1 Location

Identify the designated location for the switchboard on the construction drawings. The placement must be on a smooth, solid, and level surface. Ensure that the surface slope is less than ±0.125 inches per every three (3) feet and verify alignment prior to placement. Adequate working clearances must be maintained in accordance with Section 110-26 of the National Electrical Code® (NEC®). The guidelines and clearances based on NEC 110-26 are as follows:

- If the switchboard is front-access-only, all field connections, such as mains, branches, and bus, must be reachable and maintainable from the front.
- For switchboards with rear ventilation, provide a minimum clearance of 6 inches (152 mm) between the rear of the switchboard and the wall to ensure proper ventilation. The construction drawings will indicate whether a switchboard is front-access or rear-access.
- A rear-access switchboard requires at least 42 inches (1067 mm) of open space behind it to allow for installation, connections, and maintenance.
- If a front-access-only switchboard is located outdoors or regularly exposed to water, use an enclosure or protective equipment to shield the switchboard from moisture or water. An outdoor switchboard requires a minimum clearance of 3 inches (76 mm) between the rear of the switchboard and the wall to allow for proper drainage.
- Choose a location for installation that is well ventilated. The temperature of the area should not exceed 40°C (104°F).

An uneven location or one that does not maintain the correct clearances can result in misalignment or improper operation of the switchboard and its components. Always ensure the location is sturdy and stable before final installation.

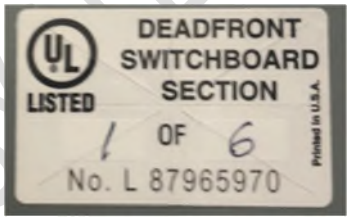
Keep the switchboard and its components upright during installation. Handle the switchboard carefully to avoid damaging the base, frame, or other parts, as improper handling can harm sensitive components. Pay extra attention when handling circuit boards and other fragile parts. Before moving the switchboard, identify all possible obstacles along the path to its designated location. Follow a pre-determined plan to ensure safe handling and transport. Be mindful of conduit stubs entering through the bottom and top of the switchboard to ensure proper clearance from the chassis, structure, cross-bus, ground, neutral, and other components.



4.2 Conditional: Installation of NEMA 1 Switchboard Sections

If the switchboard consists of multiple sections, it may be shipped separately. Sections may be either fully separated or partially joined before transportation. Once all sections have arrived and been accounted for, refer to the switchboard lineup layout drawings and exterior labels to determine the correct order of placement.

The switchboard lineup layout drawings specify the section numbers and the correct arrangement of the sections. Additionally, each section has an exterior label that indicates its position in the sequence. The label reads “Section: ___ of ___,” with the appropriate numbers filled in during manufacturing by MPS. For example, the first section of a three-section switchboard will be labeled “Section: 1 of 3,” and the second section, located next to it, will be labeled “Section 2 of 3.”



When installing the switchboard, place the sections from left to right, with the first section on the far left and the final section on the far right. The switchboard lineup layout drawings provide detailed diagrams to ensure the correct order of the switchboard sections.

Switchboards with multiple sections are designed to be either front- and rear-access or front- access-only. The construction drawings specify the access side under "General Specifications" and provide visual details. To ensure proper access, the orientation outlined in the construction drawings must be followed during installation.

Splice plates, cables, and/or interconnect plugs may be installed between switchboard sections to transfer power. It is crucial to accurately note the placement of these splice plates and cables to ensure the proper transfer of power during installation.

If the switchboard contains splice plates and associated hardware, remove these components and carefully note their exact placement for future reference. If necessary, additional hardware for connecting and installing multiple sections will be provided by MPS. The standard hardware includes 3/8 × 1 inch hex head bolts, with Belleville washers and 3/8" hex nuts. Inspect the hardware to confirm that the correct pieces are included before installation.

Section to Section Fastener

The hardware is securely stored inside one of the switchboard sections during transportation. Before energizing the switchboard, perform a visual inspection to ensure that all splice plates and hardware have been accounted for and installed.

Store the splice plates and hardware in a clean and safe environment prior to installation, ensuring that the components remain undamaged. When moving sections, take care to prevent damage to any factory-installed cables and wires used for power and control power transfer between sections.

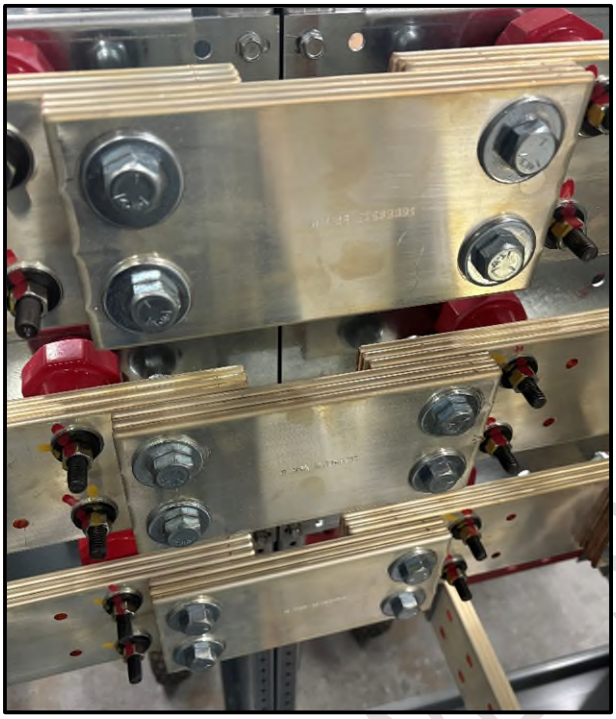
If an interconnection harness is included, refer to the orange tag and switchboard lineup layout drawings to correctly route it to the appropriate section. Ensure that the cable is properly attached, remains clear of sharp edges, and is not damaged during field assembly or installation.

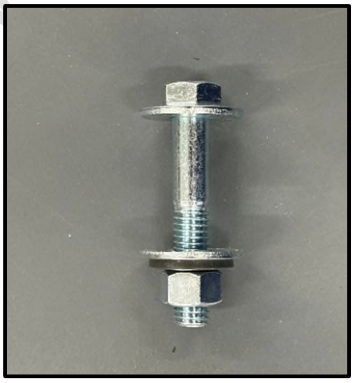
After moving the switchboard sections to the designated location, align the sections and ensure they are level. When setting up multi-section equipment, begin by positioning the largest and/or heaviest sections first. Once alignment is confirmed, proceed to connect the switchboard sections securely.

Pre-existing holes for connecting hardware are installed during the manufacturing process. Using the provided hardware and pre-existing holes, join the sections together. Ensure the sections remain aligned and level while tightening the hardware. Torque each piece to the specifications in Table B.

After connecting the switchboard sections, perform a visual inspection for foreign objects or any signs of damage. Confirm that proper clearance of live parts is maintained by the structure.

If applicable, retrieve the splice plates and hardware from storage. Reinstall the section-to-section splice plates and torque each piece according to the specification in Table B.





Bus Splices with Hardware

4.3 Conditional: Installation of NEMA 3R Switchboard

For NEMA 3R installation, the following additional steps must be followed:

The NEMA 3R switchboard is designed for outdoor use. If the NEMA 3R switchboard consists of only one section, it includes a roof sheet with an overhang and side end roof caps. During production, MPS installs the roof sheet and attaches the side caps to the left and right sides of the switchboard.

Hardware is included and installed before shipment. Ensure each hardware piece is torqued according to the specifications in Table B. Use the switchboard lineup layout drawings to verify the correct placement of sections. Note that side caps are not shown in these drawings.

For NEMA 3R switchboards with multiple sections, the installation includes a roof sheet, side end roof caps on the left and right, and intermediate caps. MPS installs the roof sheet and side roof caps during production. Intermediate caps are loosely torqued to one of the adjoining sections.

Do not remove the side caps or roof sheet during installation. If intermediate caps need to be removed, store them in a clean environment away from the switchboard sections during positioning, and ensure they are not damaged prior to reconnecting.

To connect the intermediate cap to multiple sections, follow these steps:

1. **Position the First Section:** Place the first switchboard section in the desired location with the intermediate cap loosely torqued in place using the appropriate hardware.
2. **Move the Next Section:** Position the next switchboard section alongside the first. If needed, loosen or remove the intermediate cap to facilitate proper placement.
3. **Align and Secure:** Once both sections are correctly positioned and connected according to the multi-section assembly, ensure the intermediate cap is loosely torqued to the first section. Align the intermediate cap with the pre-drilled holes on the second section and install the appropriate hardware. Torque all hardware on the intermediate cap according to the specifications in Table B.
4. **Verify Placement:** Use the switchboard lineup layout drawings to confirm the correct placement of sections and roof sheet.
5. **Repeat for Additional Sections:** If the switchboard consists of more than two sections, repeat the procedure by loosely torquing the intermediate cap to the second section and installing the next section. Continue this process until all sections are installed and all intermediate caps are correctly placed and torqued.

After the switchboard is fully installed and all roof caps are attached, visually inspect the roof assembly to ensure a firm, reliable, and watertight connection. Verify the connection before energizing the switchboard. The flat roof design used by MPS for standard NEMA 3R switchboards does not require sealant if the roof sheets and applicable roof caps are correctly installed.

4.4 Electrical connections

Ensure the switchboard is de-energized to prevent severe injury or death.
Power to the switchboard must be disabled at the source before any work is performed.

Typically, the switchboard is equipped with bus splice plates, pre-installed cables, and busway connections to link the internal electrical components. All interior connections are installed by MPS prior to shipment. The switchboard lineup layout drawings provide detailed information on the configuration of the busway and connections within the switchboard.

Interior connections can be accessed by removing the dead front covers and side panels. Retain all mounting hardware to facilitate reassembly, and store components in a clean and safe environment to prevent damage.

The line side connections deliver power from the utility and other energy sources to the switchboard. Cable connectors for these line side connections are located at the front or rear of the switchboard. Refer to the switchboard lineup layout drawings for the specific location of cable terminations.

Hazardous Voltage Warning:

The switchboard contains hazardous voltage.
Always de-energize the switchboard before working on it to prevent severe injury or death.
Follow the proper Lock-out/Tag-out (LOTO) procedures when disconnecting the switchboard from power.

Cables may be connected at multiple locations depending on the switchboard design. They can enter the switchboard through the top, bottom, sides, front, or rear. Refer to the switchboard lineup layout drawings to identify the proper termination points for each cable.

Cable entry restrictions must adhere to the wire-bending space requirements specified by the National Electrical Code (NEC). The switchboard lineup layout drawings provide details on cable entry points. All line side connection hardware is installed by MPS before shipment, unless otherwise specified on the switchboard lineup layout drawings. To access line side connections,

structure covers can be opened and removed. Consult the switchboard lineup layout drawings for the specific locations of these covers. Keep all cover hardware in place to facilitate reassembly and store all components in a clean and safe environment to prevent damage.

All switchboard connections are rated for use at a minimum temperature of 75 °C. If wires are used in environments where temperatures exceed 75 °C, use the ampacity of wires rated for 75 °C to assist in sizing. Refer to NEC standards (Sections 310 and 312) for guidance on: Bending allowance, proper wiring size, ampacity, and wire insulation temperature.

Once the switchboard is secured in its final location, open the panel to install the load side connections. Consult the switchboard lineup layout drawings for the specific location of the panel.

Color-coded cables are used for load connections to supply power to the facility. MPS uses industry-accepted phase colors—brown, orange, and yellow—to differentiate the switchboard cables.

Function	Color Code (120/208/240v)	Color Code (277/480 V)
Three Phase Line (L1)		
Three Phase Line (L2)		
Three Phase Line (L3)		
Neutral (N)		
Protective Earth (PE) or Ground (PG)	Bare Wire	
Single Phase Line (L1)		
Single Phase Neutral (N)		

Cables used in MPS switchboards adhere to UL 891 switchboard procedures, National Electrical Manufacturers Association (NEMA) standards, Federal Specification standards, and NEC regulations.

For special applications, MPS pre-cuts load side connection cables prior to shipment and includes them with the switchboard equipment. Switchboard lineup layout drawings are provided to ensure the accuracy of predetermined cable lengths and to indicate the correct connections.

NOTE: The NEC prohibits the installation of cables and other conductors running horizontally through vertical switchboard sections unless they are housed in a protected wireway. For more details, refer to the NEC guidelines.

When cables are provided by MPS, visually inspect them to ensure they are undamaged. Report any damage to MPS to receive replacement parts. Confirm that the phase colors of the cables match the construction drawings and the documented color-coding system.

Cables are connected using either mechanical set screw lugs or compression lugs.

Compression lugs, as shown below, are designed to prevent disconnection due to vibration or time. They are often pre-installed on the cable ends to prevent insulation and wires from making improper contact with metal parts.

Mechanical set screw lugs (Aluminum extruded lugs), also shown below, are another option in switchboards. The required torque for mechanical set screw lugs is indicated on the screw. If needed, refer to vendor specifications to confirm the correct torque. If no lugs or hardware are provided with the switchboard, procure the appropriate equipment and install it according to the construction drawings.

Mechanical Lug (Aluminum Lug)

One-hole Compression Lug

Two-hole Compression Lug

Cable Lugs

Compression lugs, as illustrated above, are optional for most switchboards. Follow the manufacturer's guidelines (and tooling) for crimping requirements. If no lugs or hardware are provided with the switchboard, acquire the appropriate equipment and install it according to the “As Built” drawings.

Example of good wiring practice

Refer to Bus Torque Table B below for necessary torque of each compression lug hardware. Each switchboard also has exterior labeling displaying necessary torque.

Bolt Size (in)	Wrench Size	Coarse Threads/ Inch	Silicon Bronze Stainless/Galvanized Steel *(lb-in.)*	*(lb-ft.)*
1/4	7/16	20	80	7
5/16	1/2	18	180	15
3/8	9/16	16	240	20
M10	17mm	1.5mm	40 Newton Meters	
1/2	3/4	13	480	40
5/8	15/16	11	660	55
3/4	1-1/8	10	960	87

INSULATORS: 3/8" – 20 lbf-ft

Table B

Note: The above Table B is applicable to torque requirements for hardware used to secure lugs to busbar.

APPLY TORQUE MARK AFTER FINAL TORQUE IS PERFORMED

4.5 Cable Lashing

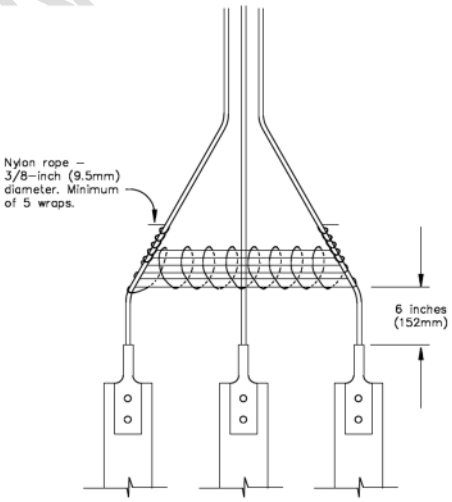
Cable lashing is required for line cable connections rated at 65kAIC and greater to prevent damage caused by cable movement during a fault. For switchboards with short-circuit current ratings of 65kAIC and greater, lashing is not required in the following cases:

- **Single fusible main switch** rated 4000 Amps or less, where line side cables are shorter than 48 inches.
- **Single main molded case circuit breaker** rated 4000 Amps or less, where line side cables are shorter than 48 inches.
- **Single main fused circuit breaker** rated 4000 Amps or less, where line side cables are shorter than 48 inches.
- **Main lugs only** rated 4000 Amps or less, where line side cables are shorter than 48 inches.

However, cable lashing is required for all switchboards utilizing power circuit breakers with 65kAIC or greater ratings.

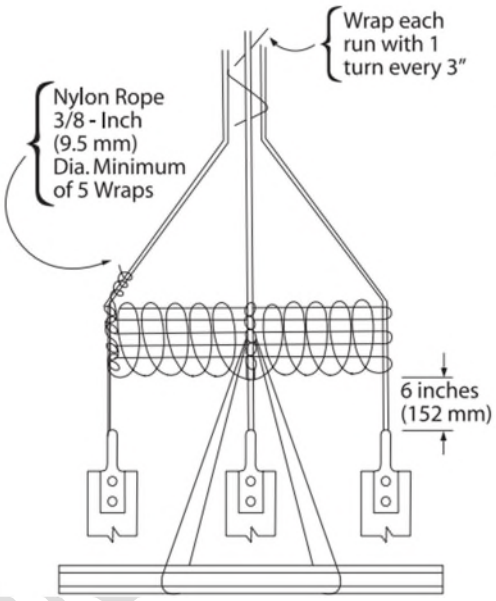
For switchboards rated 65kAIC maximum, use a 3/8-inch nylon rope or an equivalent rope with a minimum tensile strength of 2000 pounds to secure the line cables together. Begin wrapping the rope around the cables at the switchboard entrance, ensuring one wrap every 3 inches (76 mm) until the cables are laced together. Provide additional support by securing the cables 6 inches (152 mm) from where they lace into the terminals and repeat the lashing every 12 inches (305 mm) beyond the starting point.

For further details, consult the accompanying diagram.



For switchboards rated with a 100kAIC maximum, use a 3/8-inch nylon rope or equivalent rope with a minimum tensile strength of 2000 pounds to lash the line cables together. Begin wrapping the rope at the switchboard entrance, ensuring one wrap every 3 inches (76 mm) until the cables are laced together. Provide additional support by securing the cables 6 inches (152 mm) from the point where the cables lace into the terminals and repeat the lashing every 9 inches (229 mm) beyond the starting point.

For further instructions and visual guidance, refer to the accompanying diagram.



4.6 Final Connections and Close-Up

Ensure that each compression and/or mechanical lug is tightened according to the specified guidelines. Verify that both the line side and load side connections are properly torqued to the required specifications. Cross-check the construction drawings to confirm that the placement and connections of all cables are correct. Once all connections have been verified, close and securely fasten all panels to complete the installation process.

5.0 Pre-energizing Procedures and Inspection

Before the switchboard is energized, a thorough inspection is paramount to ensure it can safely and efficiently perform its function. Follow these steps to complete the inspection process:

5.1 Pre-energizing Procedures and inspection.

1. **Confirm Power Status**: Verify with absolute certainty that the switchboard is not energized to prevent any potential hazards.
2. **Clear Away Residue**: Remove all packing materials from the vicinity of the switchboard, discarding them in an appropriate manner to keep the area free of obstructions.
3. **Conduct a Visual Sweep**: Survey the entire switchboard for any foreign materials, such as tools, dirt, or debris. If any such items are present, remove them meticulously. In the event of loose hardware or components, contact MPS Power Systems at 844.MCS.1020.
4. **Clean with Care:** Use a vacuum cleaner to remove dust and dirt, ensuring no particles linger. A lint-free cloth can be used for finer cleaning. Avoid using compressed air, as it risks blowing debris into sensitive electrical components, and refrain from using solvents or chemicals that may compromise the switchboard's integrity.
5. **Check Ventilation**: Inspect all ventilation openings to confirm that they are free from obstructions. Any debris should be promptly cleared to prevent airflow restrictions that could affect performance.
6. **Inspect for Damage**: Carefully examine the insulation, busbars, and conductors for any signs of damage. If any damage is detected, do not proceed with energizing the switchboard—contact MPS immediately.
7. **Verify Connections**: Ensure that all busbars and wires are securely connected, with torque values precisely aligned with the instructions provided on the switchboard itself.
8. **Check Factory Connections**: While factory connections are made to withstand the rigors of transportation, the vibrations inherent in transit can sometimes cause shifts. Randomly check 10% of factory connections to confirm their tightness. Should you find any loose connection, extend your inspection to all factory-installed connections, including busbar hardware, switch terminals, circuit breakers, contractors, and metering points.
9. **Bolted Pressure Switches (BPS)**: If the switchboard is equipped with Bolted Pressure Switches, confirm that they are correctly fused. Fuses are often purchased separately, so make sure they are properly installed.

Note: See Table A for Pre-energization Checklist and Technician's notes.

Bolted Pressure Switch (BPS)

This thorough pre-energizing procedure ensures that the switchboard is fully prepared for operation and protected against potential hazards. By attending to every detail—from clearing debris to verifying torque specifications—you minimize the risk of malfunction and lay the foundation for reliable, efficient performance.

5.2 OVERCURRENT DEVICES

When the switchboard is shipped, overcurrent devices are positioned in the open (OFF) or "tripped" state. After installation, manually close and open these devices to confirm proper functionality. Once verification is completed, ensure that all overcurrent devices are returned to the open (OFF) or "tripped" position before proceeding.

Breaker with Overcurrent Device

Visually inspect overcurrent devices for damage.

DANGER: If damage is found, contact MPS. Do not energize the switchboard!

5.3 Circuit Breakers

Some circuit breakers are equipped with adjustable trip units, typically set to minimum ratings when shipped. MPS uses two types of trip units: thermal-magnetic and electronic.

Thermal-Magnetic Trip Units: These may include adjustable magnetic settings. Refer to engineering guidelines to set the magnetic level according to recommended values. Be cautious when setting magnetic levels too low, particularly with high inrush loads, as this can cause nuisance tripping during startup. For more details, consult the instruction documents provided with the circuit breakers. If documentation is missing, contact MPS at 844.MCS.1020.

Electronic Trip Units: These units offer multiple settings based on the specific requirements of the switchboard. They may feature long-time (L), short-time (S), instantaneous (I), and ground fault (G) settings, which can be combined into LS, LSI, LSG, and LSIG configurations. Detailed instructions on these settings can be found in the coordination study and in the circuit breaker or trip unit instruction documents.

DANGER: Follow proper site **Lock-out/Tag-out (LOTO)** procedure when disconnecting switchboard from power. Failure to do so may result in severe injury or death due to exposure to hazardous electrical energy. Always ensure that the switchboard is fully de-energized before performing any work.

CAUTION: De-energize the circuit breaker and verify that it is not in service before conducting any tests.

CAUTION: De-energize the switchboard before performing a circuit breaker test that may result in tripping the circuit breaker.

These precautions help prevent potential hazards and ensures safe testing conditions.

5.4 Overcurrent Devices with Ground Fault Protection

In accordance with the National Electrical Code (NEC), certain switchboards are required to have Ground Fault Protection (GFP) for installation. GFP can be integrated into overcurrent devices or provided as a separate system connected through a shunt tripping mechanism. Refer to the switchboard lineup layout drawings for details on GFP device placement.

Installation and Testing:

Initial Inspection: Upon receipt of the switchboard, visually inspect GFP systems, neutral sensors, and ground connections to ensure they are intact and secure. Follow manufacturer guidelines for additional details.

Presetting: MPS presets GFP at minimum set points prior to transportation.

Neutral Disconnect: For GFP testing, disconnect the switchboard neutral disconnect link(s) to isolate the system's neutral from the supply and ground. Ensure that the neutral connection from the supply to the service equipment complies with NEC guidelines.

Testing: Test all GFP systems upon installation. Follow NEC Article 230.95 guidelines for testing procedures. Testing should only be performed by qualified personnel. Record the status and results of GFP system testing in Table C.

Interconnected Systems: For systems with interconnected GFP, visually locate sensors around the bus of the protected circuit using the switchboard lineup layout drawings. Ensure no grounding points bypass the ground fault sensors. Introduce full-scale current to simulate a ground fault condition and test the system or use an equivalent method. Record the status and results in Table C.

Additional Notes:

GFP systems and testing procedures may vary by product. Identify the type of GFP device and system provided and refer to the manufacturer's guidelines for specific instructions.

Contact MPS at 844.MCS.1020 for further information.

Ensure that the building's electrical installation personnel retain records for reference.

GFP testing should be conducted by a qualified testing organization or personnel.

5.5 Current Transformers

For switchboards requiring metering and monitoring equipment, current transformers (CTs) are often included as an integral component. These CTs are factory-installed and tested.

Pre-Energizing Check:

Inspection: Before energizing the switchboard, visually inspect the load side of the CTs to ensure all connections are secure.

Shorting Procedure: If the load side of the CTs is not connected, short them together or to ground using a shorting terminal block. This prevents potential damage during testing.

Removal of Shorting Means: When operating CTs with metering equipment, remove the shorting means.

Reference: Consult electrical diagrams for detailed instructions regarding CT connections and configurations.

CAUTION**:** *If a short circuit or disconnect failure occurs during switchboard testing, electronic components may be at risk of failure or damage.*

5.6 CONTROL POWER FUSING & SPDs

Devices Installed with Control Power Fusing

For devices requiring control power fusing—such as metering equipment, electronic breaker trip units, electronic control devices, motor operators, and communication equipment—ensure they are disconnected from the switchboard during the testing phase to prevent potential damage.

DANGER: Follow proper Lock-out/Tag-out (LOTO) procedures when disconnecting the switchboard from power.

WARNING: Disconnect any sources of hazardous voltage before removing or installing fuses.

Turn Off Control Power: Ensure all control power devices in the switchboard are turned off before energizing and testing. This prevents damage to devices that use control power fusing. You can use the control power switch or remove fuses to turn off control power.

Isolate Equipment: Isolate customer metering, breaker accessories, and other equipment that relies on power supplies before energizing and testing the switchboard.

Manufacturer's Warranty: Failure to disconnect control power during testing may lead to electronic component failure and void the manufacturer's warranty.

Surge Protective Devices (SPDs) (Transient Voltage Suppressors (TVSS))

Surge Protective Devices have been noted as Transient Voltage Suppressors (TVSS) or Surge Protective Devices (SPDs).

Surge Protective Devices (SPDs) must be disconnected prior to switchboard testing. This includes all phase and neutral connections to SPDs. Isolate these connections in a clean and safe environment until reconnection.

CAUTION: Failure to disconnect line and neutral connections during testing will result in SPD system failure and void the device warranty.

CAUTION: Failure to disconnect control power from SPDs will lead to interior electronic equipment failure.

Reconnect SPDs: After completing insulation testing, reconnect all previously disconnected phase and neutral wiring to the SPDs.

6.0 Pre-Energizing Insulation Testing

WARNING: Keep the switchboard disconnected from the power source throughout the entire testing process. Power source interference can damage the equipment.

Preparation:

1. **Remove Devices:** Ensure all control power fusing devices, surge protective devices (SPDs), and connections to products are removed to prevent damage.
2. **Isolate Components:** The neutral must be isolated from ground, and switches and/or circuit breakers must be open before testing.

6.1 Electrical Insulation Resistance Tests: Conduct a megger or direct current (DC) test on the switchboard before energizing, performing the following tests:

1. Phase-to-phase
2. Phase-to-ground
3. Phase-to-neutral
4. Neutral-to-ground

WARNING: Ensure that circuits are isolated from the switchboard system before operating the resistance tests. Failure to do so may damage metering circuits, SPDs, or other control circuits. Reconnect circuits after completing the megger tests.

Documentation: Record test results for future reference using the form provided by MPS (see TABLE C). Resistance readings should be 1 MΩ or higher. If readings are unsatisfactory, contact MPS for further assistance.

Post-Testing Procedures

1. **De-energize:** Ensure the switchboard remains de-energized after testing.
2. **Reconnect Devices:** Reconnect all control power fusing devices, SPDs, and other connections that were removed prior to testing.

Securing the Switchboard:

1. **Reinstall Covers and Trims:** Correctly reinstall all covers, doors, and trims using designated hardware. Ensure that conductors or wires are not pinched between parts

and that all panels are aligned and secured. Address any holes or gaps in the deadfront construction.

2. **Clean the Area:** Remove any dust or debris from the switchboard and surrounding area using a vacuum or lint-free cloth.

WARNING: Do not use compressed air, solvents, or chemicals for cleaning. Using these items can damage the equipment. Only use a vacuum or lint-free cloth to clean debris or dust.

7.0 Energizing Switchboard

DANGER: Follow proper site Lock-out/Tag-out (LOTO) procedures when disconnecting the switchboard from power.

DANGER: Switchboard contains hazardous voltage.

WARNING: Only personnel trained and qualified to operate electrical components of the switchboard should energize and/or service the equipment.

Precautions: When dealing with electrical distribution and switchboards, exposure to hazardous voltages poses severe risks, including injury or death. To ensure safety and protect property, adhere to the following precautions:

1. *Power Down:* Turn OFF all overcurrent devices, internal loads, and mains in downstream equipment before engaging the switchboard. Follow site LOTO procedures to ensure safety.
2. *Sequence and Phase Check:* Verify and follow the correct sequence for energizing circuits and loads. Check the phase sequencing on motors and other loads to prevent damage or destruction from incorrect phase connections.
3. *Energizing Procedure:*
    - **Start with the Main(s):** Turn ON the main(s) first.
    - **Sequentially Energize Devices:** Gradually turn ON each overcurrent device in the switchboard, following the correct sequence.

By adhering to these steps, you minimize the risk of faults and ensure a safer energizing process for the switchboard.

8.0 Maintenance

Regular maintenance is crucial to keep the switchboard operating effectively. Maintenance tasks should only be performed by qualified personnel due to the complex nature of switchboard systems. Proper handling, operation, and inspection are essential.

Millennium Power Systems offers various levels of annual maintenance services, including comprehensive switchboard maintenance. Customers should plan and discuss maintenance needs and pricing with MPS customer service before the project's completion. Additional tests and services can be arranged at pre-determined prices upon customer request. For maintenance inquiries, contact MPS at 844.MCS.1020.

Maintenance Tasks:

1. **De-energize Switchboard:**
    - **DANGER:** Switchboard contains hazardous voltage. Always de-energize the switchboard to prevent severe injury or death.
2. **Follow Lock-out/Tag-out (LOTO) Procedures:**
    - **DANGER:** Follow proper site Lock-out/Tag-out (LOTO) procedures when disconnecting the switchboard from power.
3. **Qualified Personnel Only:**
    - **WARNING:** Only personnel trained and qualified to operate electrical components of the switchboard should perform maintenance or service equipment.
4. **Isolate Circuits for Testing:**
    - **WARNING:** Ensure that circuits are isolated from the switchboard system before performing resistance tests. Failure to do so may cause damage to metering circuits, surge protective devices (SPD), or other control circuits. Reconnect circuits after completing tests.
5. **Testing Precautions:**
    - **WARNING:** Do not use alternating current (AC) dielectric or megger testing on the switchboard as it may damage the equipment.

For those not purchasing maintenance services from MPS, refer to the manufacturer's maintenance guidelines for instructions on keeping the switchboard operational.

8.1 Maintenance Procedures

1. **Inspect Voltage and Control Power Transformers:**
    - Visually check all voltage and control power transformers for any signs of damage or irregularities.
2. **Clean Equipment:**
    - Use a vacuum and a lint-free cloth to clean the interior equipment.

WARNING: Avoid using compressed air, solvents, or chemicals as cleaning tools for switchboards. These can damage equipment.

3. **Inspect Insulators and Bus Bars:**
    - Visually check all insulators, barriers, and bus bars for any signs of wear or damage.
4. **Verify Trip Unit Settings:**
    - Confirm that the trip unit settings are correctly adjusted as per specifications.
5. **Check Internal Connections:**
    - Verify the tightness of accessible internal bus and cable connections.
6. **Inspect Relays:**
    - Visually check all relays to ensure proper torque, connections, and secure mounting.
7. **Check Safety Interlocks:**
    - Ensure all safety interlocks are functioning correctly.
8. **Inspect Control Wiring:**
    - Visually check all control wiring for any signs of damage or loose connections.
9. **Verify Environmental Conditions:**
    - Ensure the environment is at an appropriate temperature and dry. This does not apply to NEMA 3R switchboards, which are designed for outdoor use.

10. **Record Maintenance Status:**
    - Document the status and details of completed maintenance in an organized manner. These records are valuable for future maintenance or repairs.
11. **Test System Controls:**
    - Conduct tests on system controls to verify proper operation.

By following these procedures, you ensure that the switchboard remains in optimal working condition and prevent potential issues from arising.

8.2 Adverse Circumstances

Unexpected situations may occur to damage the switchboard. Contact Millennium Power Systems for assistance and guidance in the following situations:

In the event of a short-circuit, ground fault, or overload, complete a full inspection to locate the origin of fault. Complete an additional inspection of all insulating materials throughout the switchboard. Replace any damaged insulation, conductors, and overcurrent devices. Contact MPS for replacement parts and assistance.

In the event of physical damage to the switchboard, thoroughly inspect the exterior and interior of the switchboard. Replace any components that are damaged and ensure the switchboard does not possess any exposure to live parts. Contact MPS for replacement parts and assistance.

DANGER: Wet switchboard poses greater threat of exposure to hazardous voltage, which may cause severe injury or death. De-energize all switchboard components prior to servicing.
DANGER: If standing water is present, do not enter the area or service switchboard. De-energize switchboard using upstream source disconnecting means.

In the event of water accumulation around switchboard that is deeper than two (2) inches, contact MPS. The switchboard is likely significantly damaged. De-energize switchboard's source and do not attempt to clean or move accumulated water.

WARNING: If switchboard components, including circuit breakers, fusible switches, and metering, are subjected to water or moisture; the equipment may become unsafe and must be replaced.

In the event of water accumulation around switchboard that is less than two (2) inches, de-energize switchboard and apply heat to area until the water evaporates. Inspect the switchboard for damage and ensure components are correctly placed. Once the switchboard is fully dry, re-energize the source. Contact MPS for any guidance renewing or replacing parts. Details on parts are on switchboard lineup layout drawings.

9.0 DOCUMENTS (RETENTION AND STORAGE)

Documents are to be retained in a secure location for later reference.

Documents may include (but are not limited to) the following:

a. Manufacturer instruction manuals
b. Wiring diagrams
c. Test records
    1. Initial test records (e.g. Ductor tests)
    2. Circuit breaker testing
    3. Initial sign off reports
d. Regular inspection records
e. Repair or replacement records
f. Serial numbers of equipment (as necessary)

10.0 Appendices

10.1 Initial inspection/acceptance forms

10.2. Pre-energization checklist – Table A

10.3 Bus Joint torque specification tables – Table B

10.4 Ground fault test record – Table C

10.5 Insulation testing Record form – Table D

10.6 Technician Notes – Table E