JOULEY
ELECTRIC BUS

Thomas BUILT BUSES

JOULEY-101

High Voltage Safety & Operators Guide

FOREWORD

Jouley Electric Bus and High Voltage Safety

The Jouley Electric School bus is a battery powered, electric vehicle powered by Proterra technology. It operates like other buses, with the exception of the motor/propulsion system. Two battery packs located under the floor provide power to the electric drive motor at the center of the bus.

During normal driving conditions, the batteries provide energy to the traction motor to turn the wheels on the drive axle. During a “Regenerative Braking” event, this flow of energy is reversed. In this sequence, the traction motor becomes a generator. The motion of the wheels on the drive axle turns the traction motor, which charges the batteries. Providing this additional charge to the batteries will extend the driving range of the electric vehicle.

NOTE: The regenerative braking feature is automatically controlled and is optionally disabled. In the event of slippery conditions, it will automatically deactivate and reactivate. During a regenerative braking event, the bus will undergo a deceleration similar to that of a traditional “retarder” where the vehicle slows down without the use of frictional brakes.

Electrical Shock Hazard
This electric vehicle utilizes a direct current (DC) energy storage and power distribution system that operates at up to 400 volts. **An electrocution hazard exists if humans come in contact with parts of this system.**

⚠ **– WARNING**
This bus contains areas of high voltage that should only be accessible by authorized personnel: under the hood, and under the bus. If necessary, get assistance from the maintenance manager for help.

⚠ **– IMPORTANT**
All access and servicing of this vehicle must be performed by properly trained and qualified personnel who are equipped with personal protective equipment (PPE) appropriate to the task at hand.

Table of Contents

Glossary of Terms

AC	Alternating Current; positive and negative swap 60 times a second (in the USA)
A/C	Air Conditioning – reference cabin air conditioning or the cooling loop used by the BMS
ABS	Antilock Braking System
BCM	Body Control Module
BMS	Battery Management System
CAN	Controller Area Network; Communication bus from one controller to another
DC	Direct Current; positive is always positive
DC-DC	Converter that transforms DC power from one voltage potential to another (i.e. 400VDC to 12VDC)
EPU	Export Power Unit
EV	Electric Vehicle
HV	High Voltage
SH	Specialist for High Voltage Systems in Automobiles
VCU	Vehicle Control Unit; The electronic control module that coordinates and commands all of the EV powertrain and auxiliary HV components
SOC	State of Charge; The energy remaining in the battery expressed as a percentage of the total capacity when full.
ZE	Zero Emissions

JOULEY
ELECTRIC BUS

Thomas BUILT BUSES

JOULEY -101

High Voltage Safety Training (HV1)

1. Scope of 101 HV Safety Training

Reading and understanding the information in this guide…

shall enable you to:

- Gain basic knowledge of High Voltage Systems in the Jouley Electric Bus
- Drive an instrumented series production vehicle containing a High Voltage System
- Drive a pre-series vehicle containing a High Voltage System

shall NOT enable you to:

- Power-down/ power-up any high voltage application
- Perform testing/validation a vehicle containing a high voltage system
- Operate a test bench containing a high voltage system
- Perform any ‘non-HV work’ on any vehicle containing a high voltage system
- Perform any work on automotive high voltage system

2. Technician Safety Training Roles

Throughout DTNA, High Voltage Safety training falls into three categories
- High Voltage 1 (HV1); HV2, and HV3.

Each category has specific task and roles the employee is allowed to perform. Reading and understanding this guide is the equivalent of HV1 Training.

The Jouley-101 (HV1) training is <u>required</u> for drivers, technicians, and any other personnel that will interact with a Jouley Electric Bus.

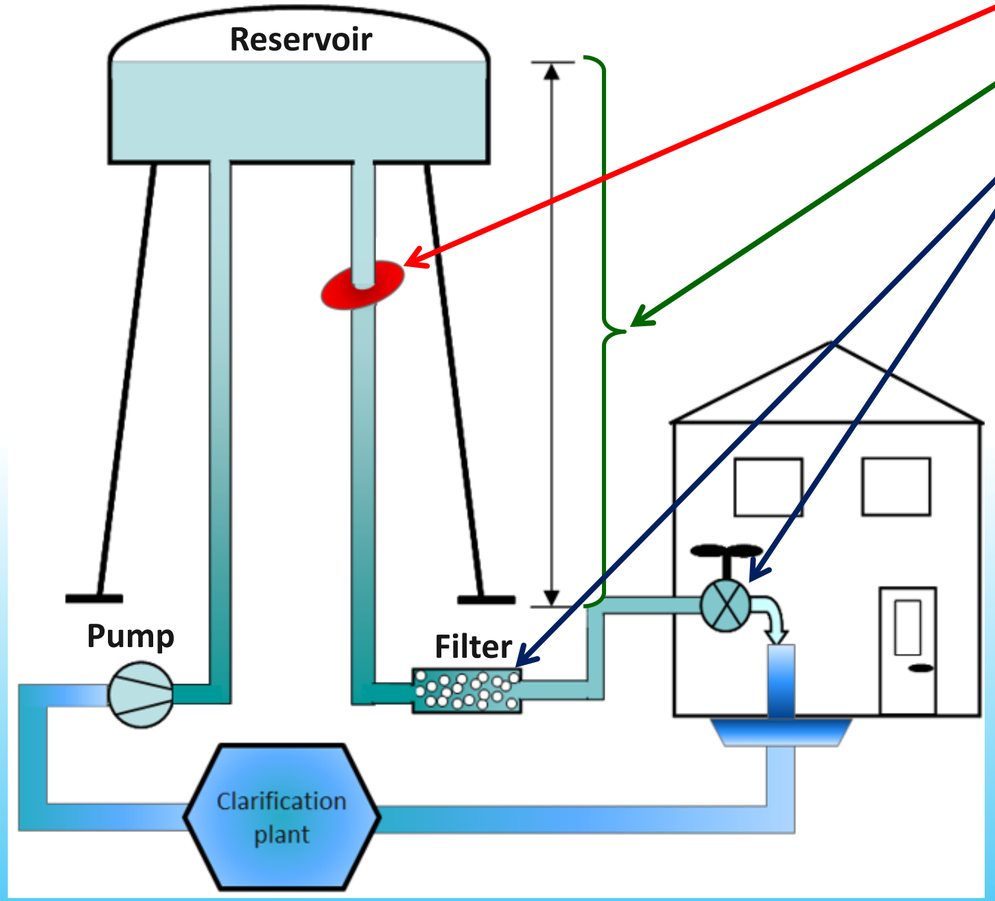
Employee Job Classification	Jouley 101 (HV1)	Jouley 201 (HV2)	Jouley 301 (HV3)
Driver production HV Vehicle	✓	✓	✓
Driver of pre-production HV Vehicle	✓	✓	✓
Fleet/ Customer Technician(working HV eVehicle but non-HV Components)		✓	✓
Fleet/ Customer Technician (working HV eVehicle and working on HV Components)			✓
Fleet/ Customer Maintenance Employees not working on eVehicles (Awareness)	✓	✓	✓
Dealer Technician (working HV eVehicle but non-HV Components)		✓	✓
Dealer Technician (working HV eVehicle and working on HV Components)			✓
Dealership Technicians not working on eVehicles (Awareness)	✓	✓	✓
Anyone moving in and around (inside physical safety barriers) a HV eVehicle while maintenance is being performed. Anyone that must go beneath a HV eVehicle for any reason, inspections or other purposes.		✓	✓
HV-System modifications / troubleshooting energized HV eVehicle			

3. Basics of Electricity

Current (A)
In this analogy, electric current can be compared to the flow rate of the water. More water flowing equates to more current. Current is measured in Amperes (amps).

Resistance (Ω)
Resistance is the circuit or component's opposition to the flow of electricity. It is represented in our water model by a filter, partially-closed valve, or other flow obstruction. Resistance is measured in Ohms, and represented by the Ω symbol.

Voltage (V)
Electromotive Force (EMF) is measured in Volts (V). In the water analogy, this is represented by water pressure. Higher pressure is equivalent to higher voltage. Higher voltage causes more current (A) to flow if the resistance is kept constant.



Current ≈ Amount of water / second

Voltage ≈ Water pressure

Resistor ≈ Water filter or Faucet

Current measured in Amps [A]

Voltage measured in Volts [V]

Resistance measured in Ohms [Ω]

4. Defining High Voltage

How much voltage is *High* Voltage?

According to the DIN VDE 0100 Part 410 standard, electrical hazard for humans starts at 50 V of alternating current (AC) or 120 V of direct current (DC). The updated / released OSHA standard 1910.303(g)(2)(i) applies, and specifies that the maximum voltage that can be left unguarded/unshielded as **50 V AC *or* DC**.

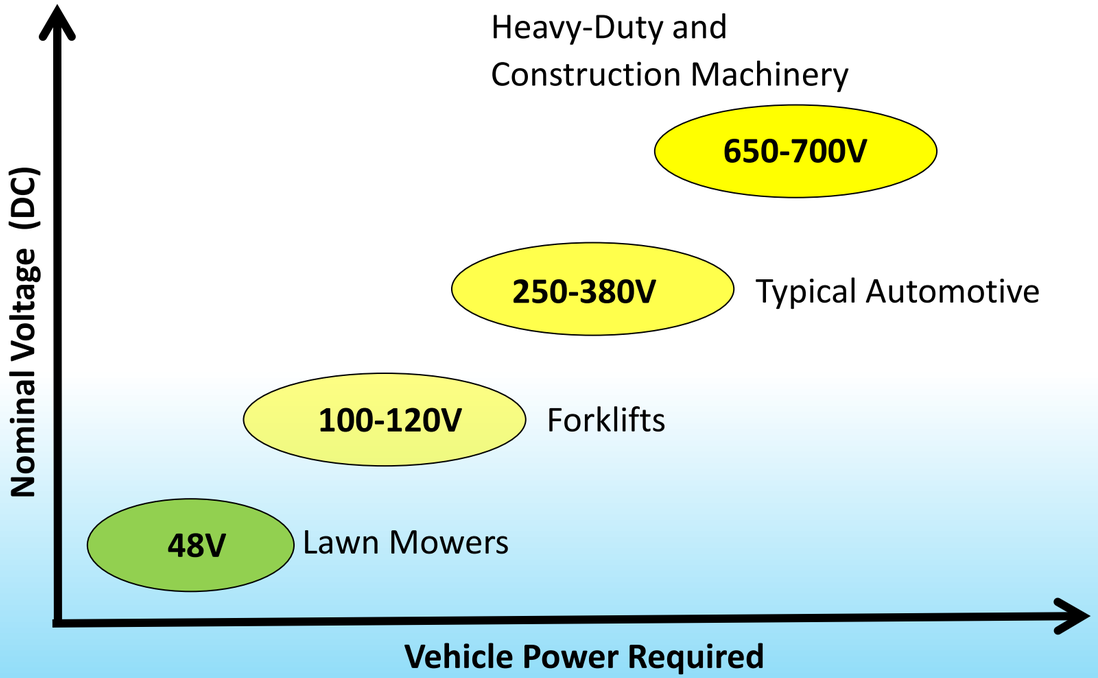
According to the OSHA, a hazard for humans starts at:
50 V alternating current (AC)
120 V direct current (DC)

OSHA 29 CFR 1910.303(g)(2)(i) /
NFPA 70E limit is **50V**, AC or DC.

5. Electric Vehicle – Why High Voltage?

One equation for electrical power is **P = V x A**. From this equation, you can see that as power demands rise, voltage, current, or both, must rise proportionally. Raising current is the more problematic of the two, because it necessitates larger, heavier electrical components and conductors. Also, raising current increases **I2*R** losses, which lower overall system efficiency and elevate cooling requirements. To create 600 HP from a 12V electrical system would require over 37,000 amperes!

Of course, raising voltage to astronomical levels in order to keep current low is also impractical. This is primarily due to the increasing shock hazards involved, and also the physical limitations of insulation, controls, and battery construction materials.

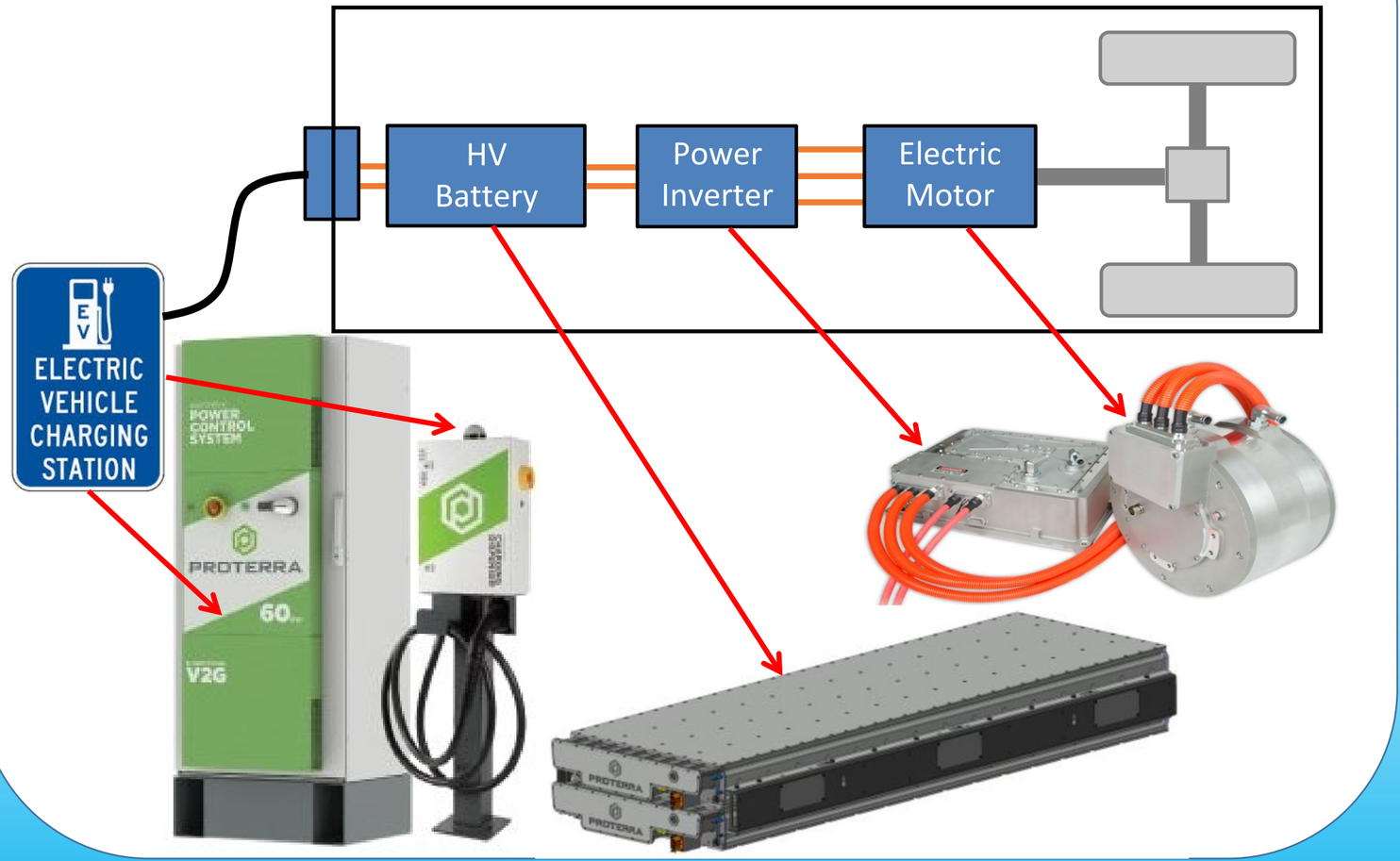


6. Jouley Power Specifications

Vehicle:	**Jouley School Bus – C2 Electric Bus**
Power E-motor cont. :	120KW/161HP (Proterra)
Voltage level / energy content	400V, 220 - 226 kWh
Range:	138 miles (estimated range)

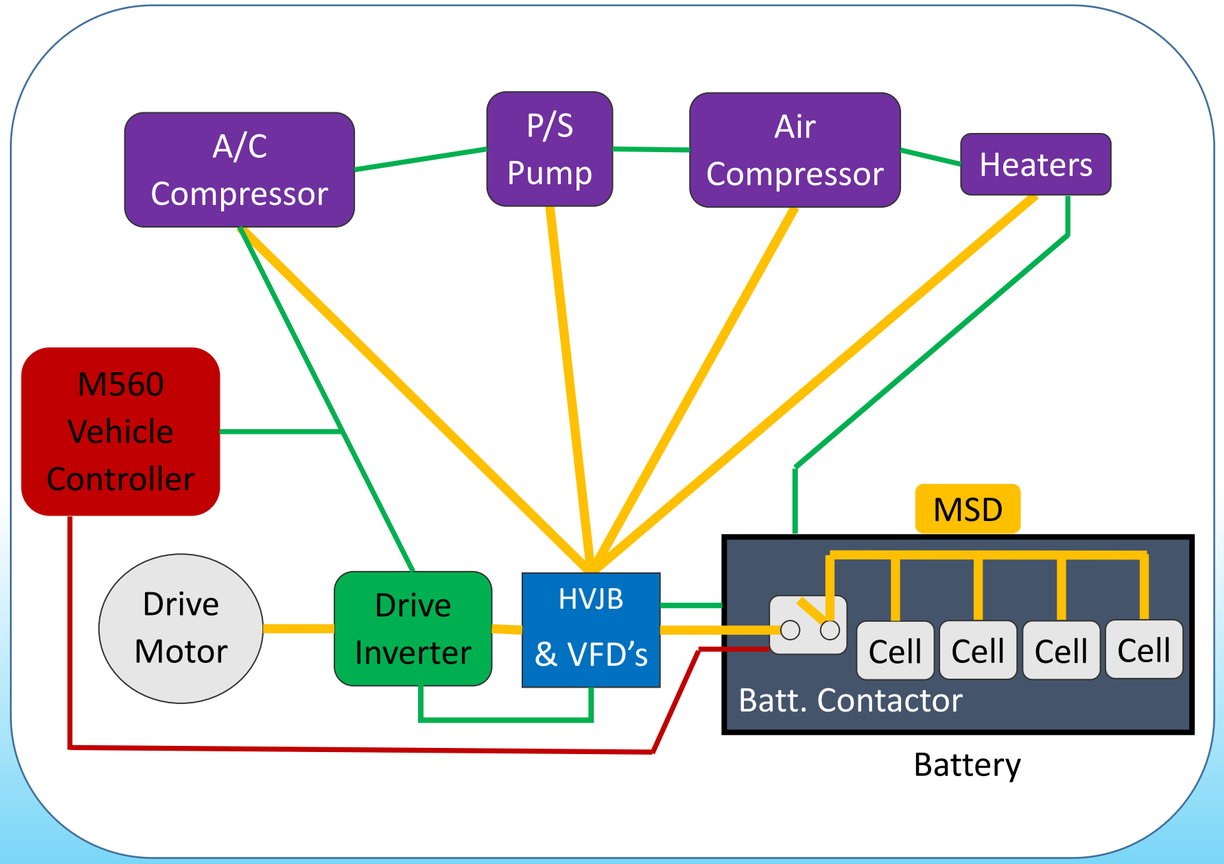
7. Electric Drive Vehicle Basic Layout

EV charging stations supply DC power straight to the battery. The HV battery supplies the current that is used to propel the vehicle and maintain the low voltage (12v) features and components. The drive power inverter converts the DC current that is supplied by the battery into AC current that is used by the motor, and controls the motor's speed. When braking, it acts as a rectifier to convert the motor's AC output into DC current in order to charge the battery. The drive motor is a 3-phase AC synchronous motor.



High Voltage Interlock Loop (HVIL)

There are multiple vehicle interlocks that can cause the battery contactor to open, such as a disconnected high-voltage connector, or other problem with high voltage component. The M560 Vehicle Controller provides a signal to *de-energize* the high voltage system when a connector or cover is removed, and *prevents re-energizing* the high voltage system if the connector or cover is not properly fastened. It is a continuous series loop that if continuity is broken, it is sensed by the vehicle controller, which in turn signals the battery contactors to open.

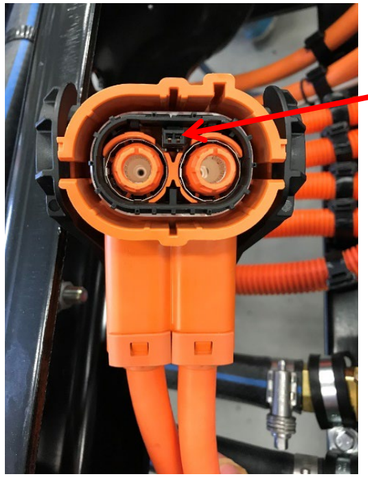


JOULEY ELECTRIC BUS

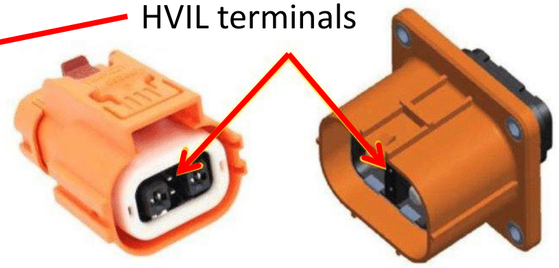
Thomas BUILT BUSES

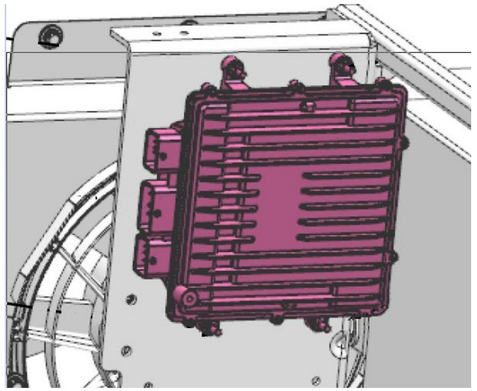
Shown are the High Voltage Interlock Loop (HVIL) contacts on high voltage power connector.

HVIL terminals are recessed to be the last to make contact when connecting and the first to break contact when disconnecting.

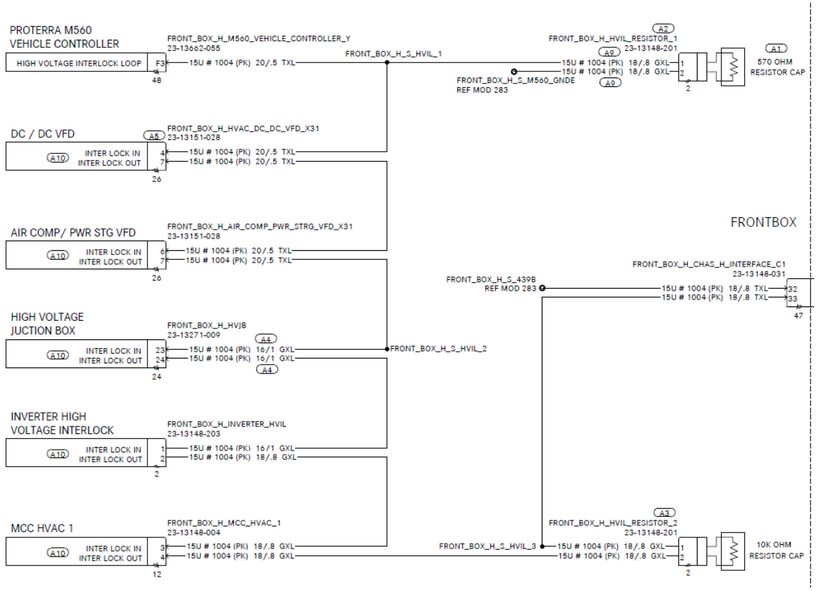


HVIL terminals





M560 Vehicle Controller



HVIL Wiring Diagram

High Voltage Safety Software features

Primary Function

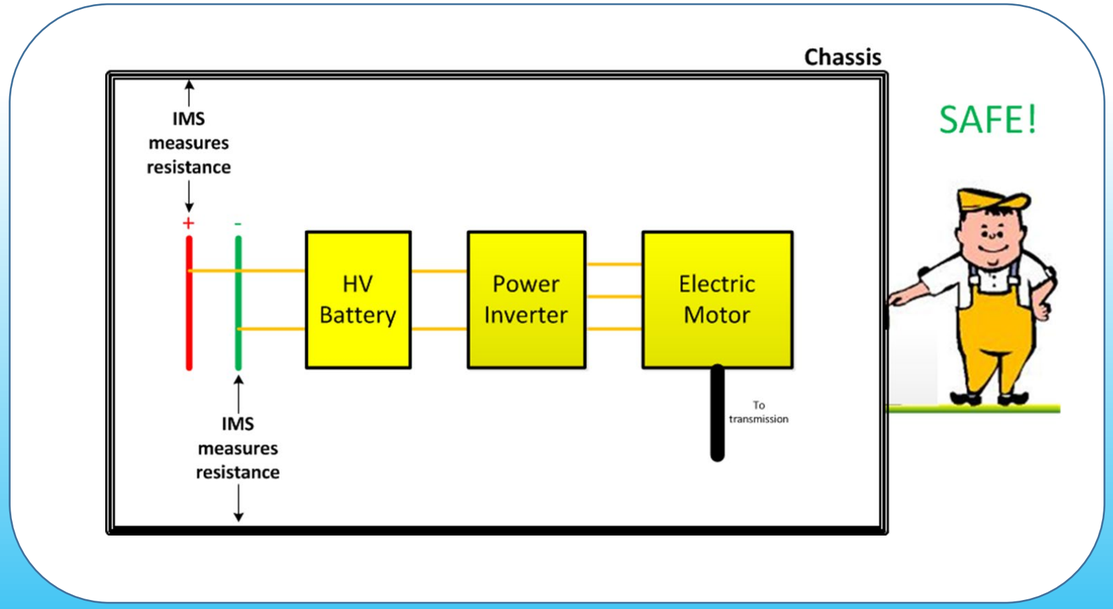
- Prevent energizing the HV system until all the necessary signals are valid

Application

- Provide a signal to de-energize the HV circuit when a necessary CAN signal from a critical component is invalid
- The system shall inhibit re-energizing the HV circuit until a necessary CAN signal from a critical component is valid

Isolation Monitoring System (IMS)

The isolation monitoring system constantly measures the resistance between the high voltage conductors and ground. It warns the vehicle operator if the resistance falls below a set threshold.



Safety by Mechanical & Functional Design

Mechanical design
High voltage conductors and live components can only be accessed by disassembly tools.

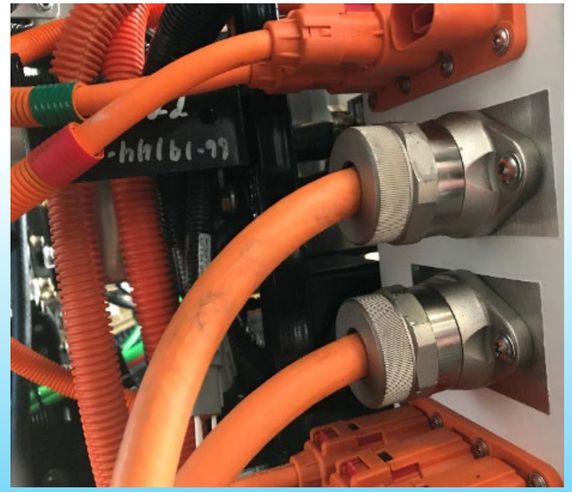
Discharge of DC Capacitor

Active Discharge

- Discharge of the DC link through permanent discharge resistor
- Requirement: Voltage <60V in <120 seconds

High Voltage Component Labels
All high voltage components are identified with the following labels:

High Voltage Cables in Orange
HV cables outside HV-component housings are orange.

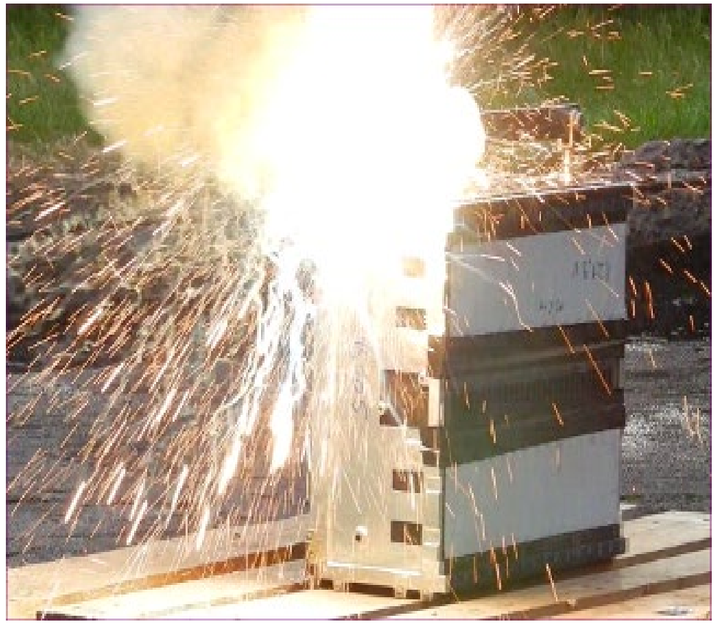


9. Hazards of Electric Current

Electrical Arc Flash

Arc flash is likely the primary hazard present with high voltage vehicles. It is often caused by the interruption of a large electrical current in an inductive circuit (as shown in the example below). This interruption forces electrons through the air, heating it and surrounding materials to extremely high temperatures. It can throw sparks and molten material up to 6 feet away. The flash is extremely bright, and can permanently damage your vision.

o Per NFPA 70E Table 130.5(G), the **Thomas Built eC2 HV System is *not* considered an Arc Flash hazard**



- Electric arc radius ca. 10 in
- Flying sparks up to 6 ft.
- Electric arc temperature > 1,000 °C

Electrical Arcs in HV Battery during Short Circuit Test

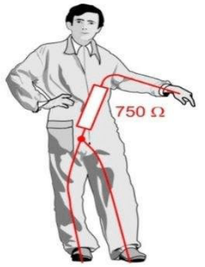
JOULEY
ELECTRIC BUS

Thomas BUILT BUSES

Electrical Shock

Electric current passing through the human body can cause shock, burns and in extreme cases, death. The body's electrical resistance can be affected by many factors. Skin moisture, body size, and body composition can cause these values to vary. Also, the more voltage that is applied, the lower the body's resistance value.

Current Path	Resistance
Hand – to - hand	1000Ω
One hand – two feet	750Ω
Two hands – two feet	500Ω

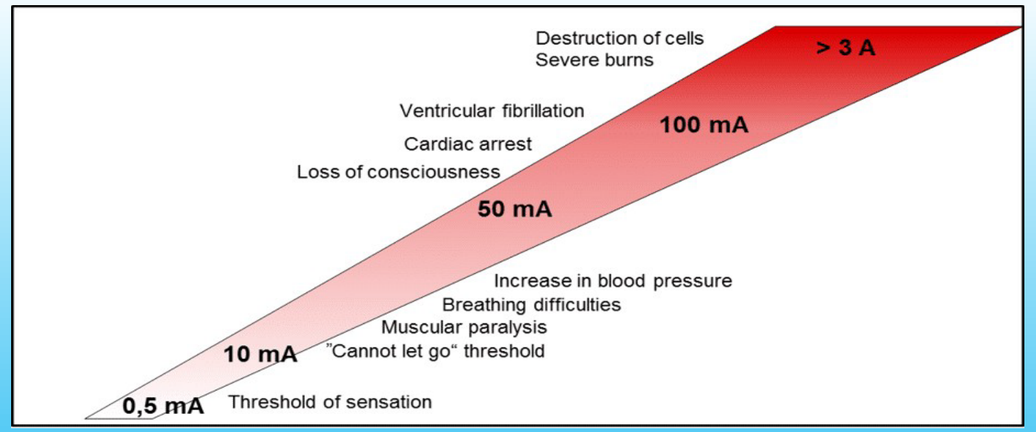


Typical electrical resistance for different paths through the body

Using the nominal voltage value for a commercial vehicle battery, and the best-case resistance, Ohm's Law shows a 600 mA current.

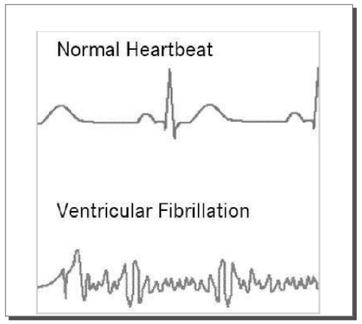
$$I = \frac{V}{R} = \frac{600V}{1000\Omega} = 600\ mA$$

The 600 mA that we calculated above would be in the most dangerous part of this chart



Effects of current on the body. Length of exposure increases severity.

Effects of Electric Shock



Alternating current can cause uncoordinated twitching of the heart, resulting in no blood flow.

Current flow can cause severe burns, and bursting of blood vessels

Current flow (particularly DC) can cause a breakdown of the cell chemistry. This effect is toxic, and can manifest days after the shock.

Secondary hazards
These hazards can be caused due to electric shock, electric arcs, etc. For example, falling down from a ladder due to electric shock.

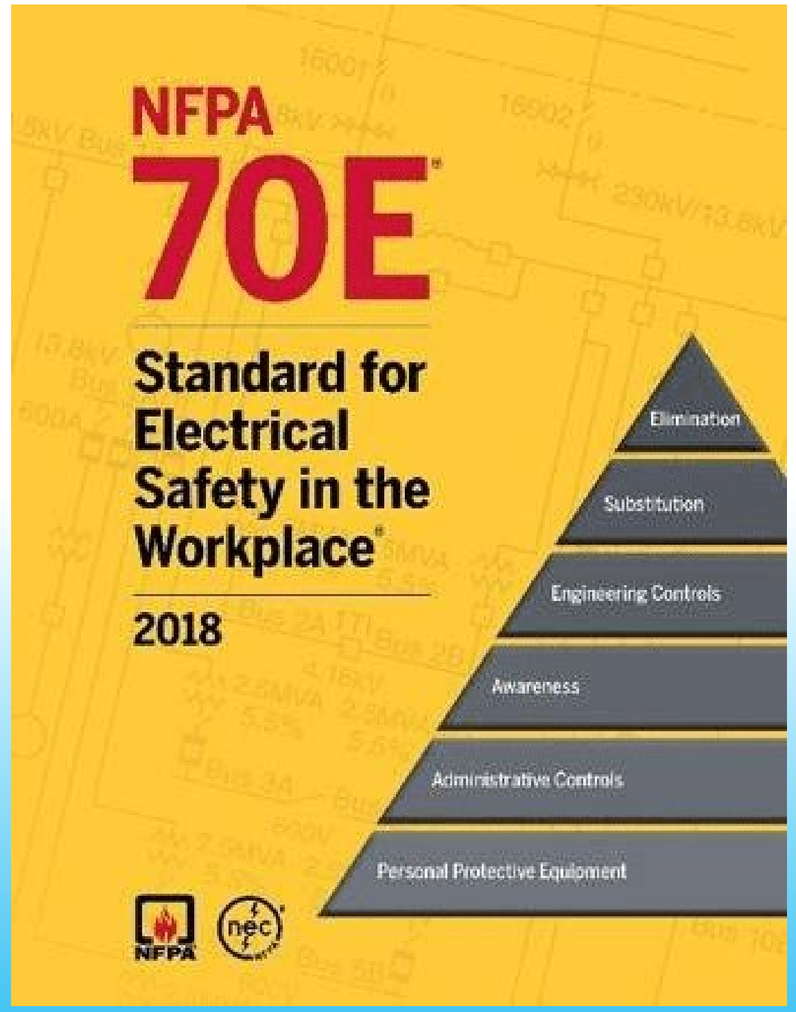
10. Safety Regulations

NFPA 70E

The NFPA 70E lists requirements for safe work practices that protect personnel by reducing exposure to electrical hazards. Originally developed at OSHA's request, NFPA 70E helps companies and employees avoid workplace injuries and fatalities due to shock, electrocution, arc flash, and arc blast, and assists in complying with OSHA 1910 Subpart S and OSHA 1926 Subpart K.

Some NFPA 70E Topics

- Guidelines for electrical safety in the workplace
- Electric safety related work practices
- Hazard identification and assessment
- Selection of appropriate of Personal Protective Equipment (PPE)
- Requirements for special equipment



The important basic rule that serve the goal of avoiding accidents at work:
Never perform work on live parts.

Before performing any work on the above mentioned live parts, the voltage-free condition has to be tested by approved means and has to be safeguarded while at work.
NFPA 70E also complies with IEC EN60903, an International Standard for Safety

11. Work on Electrical Installations and Equipment

Strategies Used to Ensure Electrical Safety

- Remove the Danger

The Specialist for High Voltage Systems (SH) will remove power from a high voltage vehicle before it is worked-on. There are five steps to this procedure.

- **Disconnect the source of high voltage to the vehicle**. This generally consists of ensuring that the battery contactors are open.
- **Secure the electrical system against reconnection to high voltage**. Follow your shop's lock- out/tag-out procedure to prevent the vehicle from being inadvertently reenergized.
- **Verify that the high-voltage system is de-energized**. Before performing any work involving the high voltage system, the system *must* be verified voltage free by use of a dual-pole voltage tester.
- **Grounding and short-circuiting**. This step must be carried-out only if the system's nominal rated voltage exceeds 1000 VAC or 1500 VDC. It can thus be skipped if the first three steps are carried-out successfully.
- **Provide protection from adjacent live parts**. This step will likely not be necessary, as when the vehicle is de-energized, there will be no adjacent live parts. However, you must still protect workers from other hazards that might be present, such as rotating equipment, hot surfaces, etc.

- Safety by Design

As discussed earlier in the course, the vehicle is designed and constructed to provide the maximum safety to the operator and service technician through use of safety interlocks, component guards, and electrical insulation.

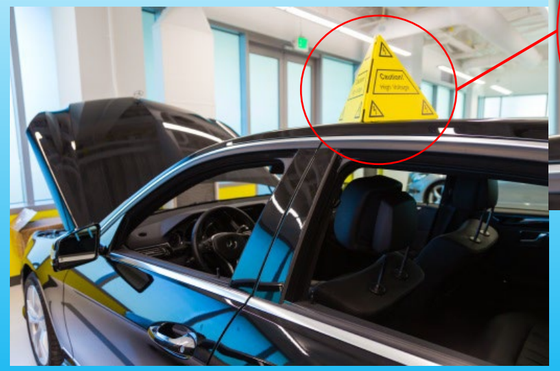
JOULEY ELECTRIC BUS

Thomas BUILT BUSES

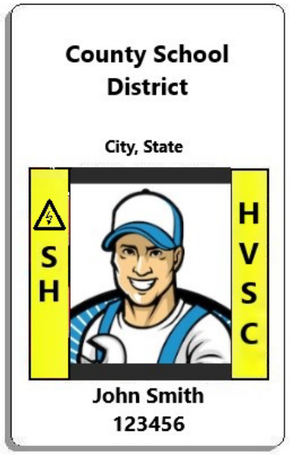
- Safety by Organization

When working on a high voltage vehicle, access to these high voltage systems is restricted to personnel that are properly trained, and are actually performing maintenance or repair.

Electrical Safety Area

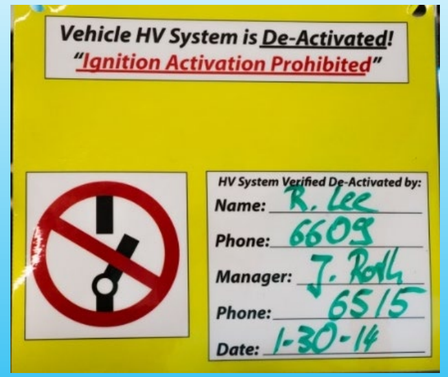


Marking of
HV vehicle in workshop



Marking employee's HV
Training on badge

Temporary Barrier
Around Work Area



Marking of a
De-energized vehicle

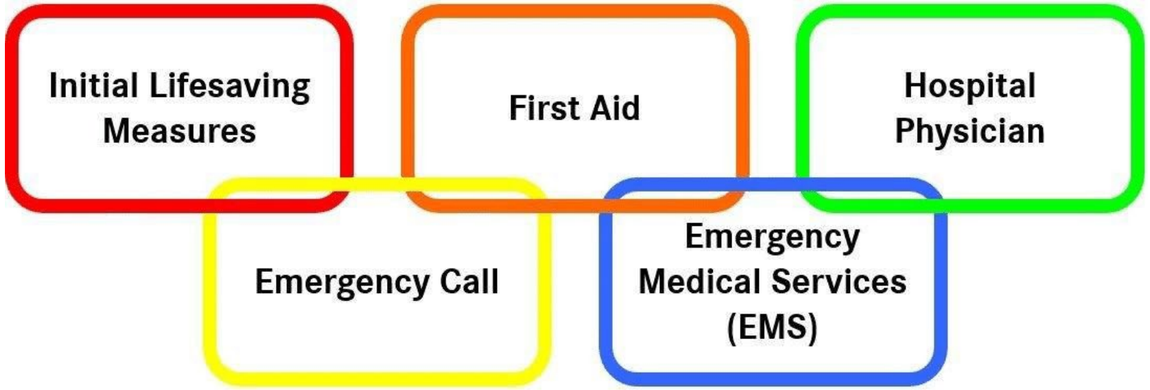
- Personal Protective Equipment (PPE)

In addition to the PPE that is normally worn in a shop environment, PPE that protects the wearer against high voltage contact or arc flash must also be worn when appropriate.

- Behavior-Related Measure

High voltage work must be conducted by trained personnel according to approved, risk-assessed work instructions. The shop must have a culture of safe work habits. Shop personnel must know first aid.

13. First Aid



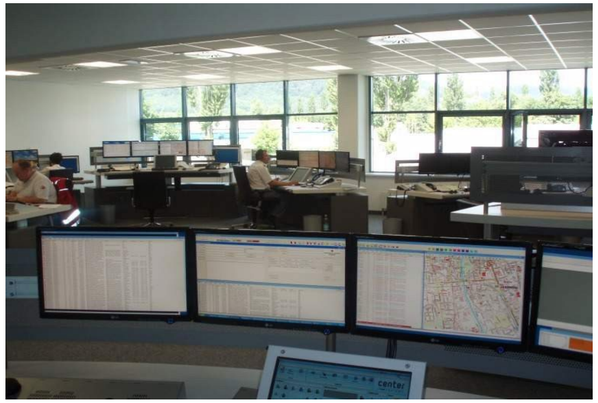
there is a mishap at the workplace, having a strategic plan to quickly move from one end of the chain to the other can greatly enhance your ability to contribute to a positive outcome for the victim. **These steps are only a suggestion. Please follow your companies / location safety processes.**

Initial Lifesaving Measures

This step involves getting the victim out of danger and preventing further injuries. If a person is in contact with a live electrical conductor, shutting off the power is the easiest, quickest, and safest way of preventing further injury. If this is not possible, a rescue hook could be used, if available, to separate the victim from the conductor, but you could also don electrical safety gloves and accomplish the same thing with more control. The most important thing to remember is **do not become a casualty yourself.** Relocate the victim to a safe space for evaluation (away from fire, traffic, etc.)

13. First Aid

Emergency Call



Know the address of your building, or where to find it. A great place to post the address is above the exit doors, especially in shop areas. Give the emergency operator all of the information they ask for, and wait for them to hang-up at the completion of the call. The next call you should make is to corporate security (if applicable). They will help first responders quickly find the area where you are located.

First Aid

Determine if the victim has a pulse and respiration. If not, have an assistant retrieve an AED while you perform CPR. Remember that the AED may still require you to continue CPR after it has stopped any heart fibrillation. Use cool water on burns to stop the heat damage of tissue. Cover any burns with a clean, dry gauze dressing. The purpose of this dressing is only to prevent the burn from getting dirty.

13. First Aid

Emergency Medical Services (EMS)

Open any necessary doors to allow EMS access. Don't get in their way, but render any assistance that they ask for.

Hospital Physician

This step is performed at a hospital or other medical care facility.

Summary

The key to effectively providing aid to a person that has been involved in a workplace mishap is preparation. Know the locations of first aid and firefighting equipment in your building, and get first aid training when available. Calm, determined action will provide the most help to a colleague in need.

JOULEY
ELECTRIC BUS

Thomas BUILT BUSES

JOULEY™

-101

Operators Guide

Introduction

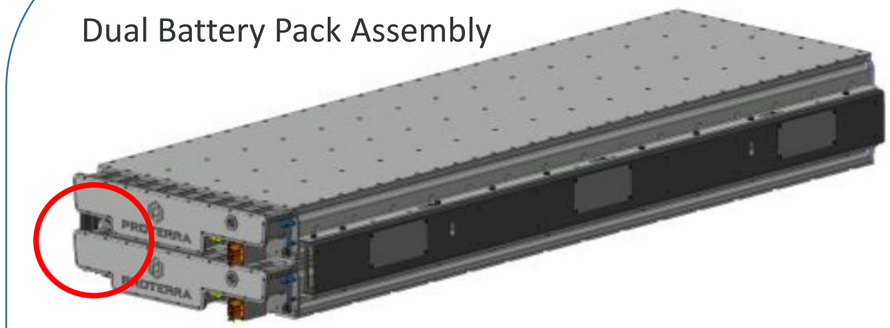
This Operator's Manual is intended to help you quickly get acquainted with your Thomas Built Buses Jouley Electric Bus. It provides basic information and instructions on technology and convenience features as well as display features.

1. Jouley Electric Bus Component Overview

High Voltage Battery Packs

This bus is a battery powered, electric vehicle. The high voltage system powers all high-power systems on the vehicle. Primary energy is stored in the high voltage battery packs located below the floor. When the vehicle is started, contactors close within the battery packs and energize the high voltage buss. This powers the high voltage components and the low voltage 12 volt system through a DC to DC converter. The battery packs are cooled by an internal heat exchanger and are connected to an external heat exchanger and HVAC chill plates by a dedicated cooling loop. The batteries have vents to relieve any high atmospheric pressure. Manual Service Disconnects (MSD) are located on the driver's side rearward end of each pack to isolate power within the battery.
Various controllers on the vehicle work together to manage safety and power flow of the high voltage system. The high voltage system is continuously monitored for safety during operation.

Dual Battery Pack Assembly



OR

Manual Service Disconnects (MSD)

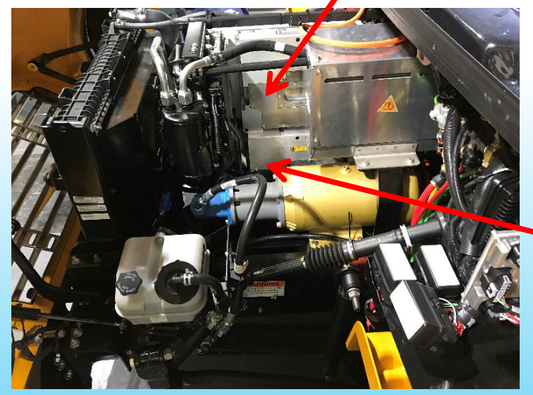
JOULEY™
ELECTRIC BUS

Thomas BUILT BUSES®

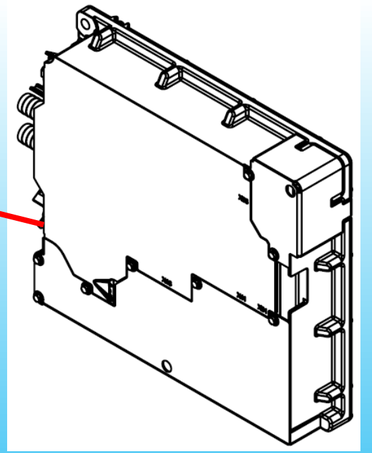
Accessory Variable Frequency Drives
VFD – Dual Output

The Variable Frequency Drive (Dual Output) is mounted under the front hood on the drivers side / back of the High Voltage Junction Box. This liquid-cooled VFD supplies high-voltage three phase AC power to the air compressor and power steering motor. It is CAN controlled by enable and speed commands from the Main Body Controller.

VFD – Dual Output



VFD – 14 Volt

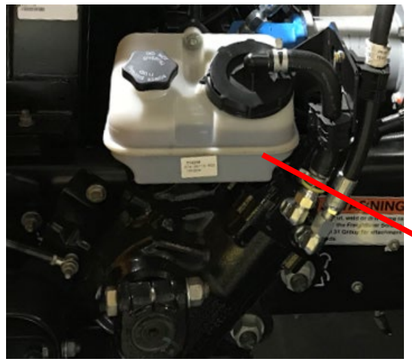


VFD – 14 Volt (DC - DC Converter)

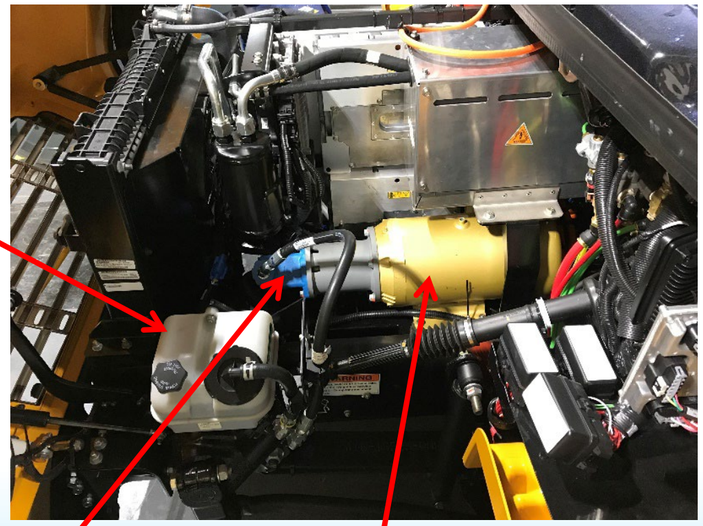
The VFD – 14 Volt is a DC to DC Converter mounted under the front hood on the drivers side below the VFD Dual Output. This liquid-cooled converter steps down the high-voltage supplied by the battery packs and provides a 14-volt DC output to the two low-voltage (12 volt) batteries and body accessories. A version of this unit will also supply AC voltage to the cabin A/C compressor motor if passenger A/C is ordered.

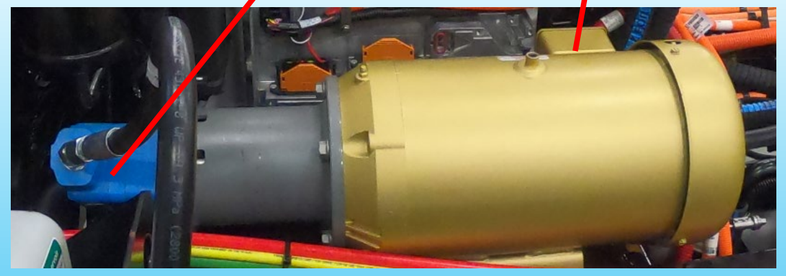
Power Steering Pump, Motor, and Reservoir

The Power Steering Pump is located under the front hood on the drivers side mounted inboard of the steering gear. The pump is operated by an electric motor, which is controlled by the Motor Controller (Variable Frequency Drive). The pump and motor are non-serviceable. The Power Steering Reservoir is mounted above Steering Gear and is common to all Thomas Built Buses C2 units.



Power Steering Reservoir and Steering Gear





Power Steering Pump

Power Steering Motor

JOULEY
ELECTRIC BUS

Thomas BUILT BUSES

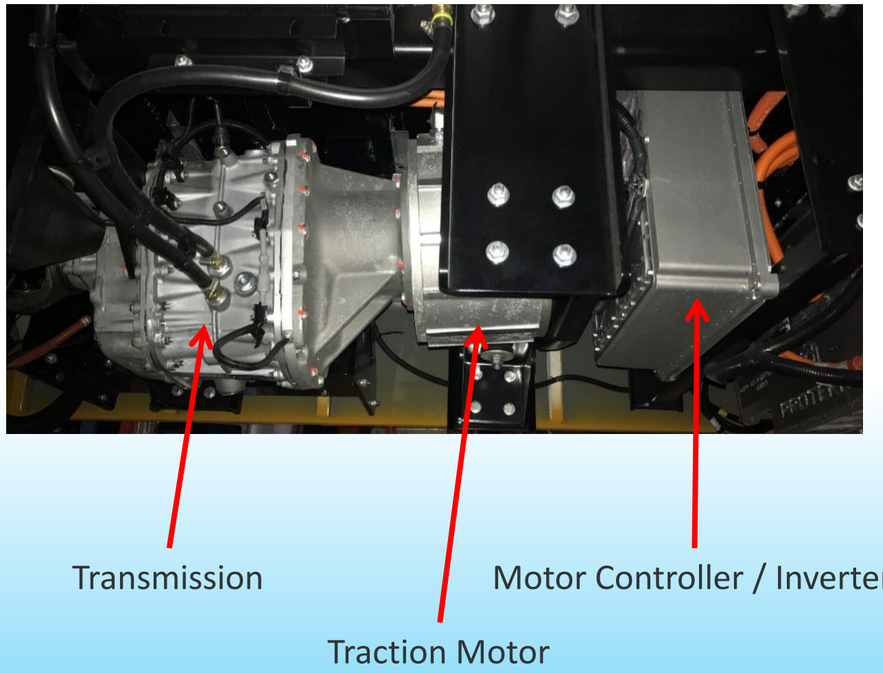
Traction Motor, Motor Controller/Inverter, and Transmission

The drive train consists of the motor controller, traction motor, transmission, driveshaft, and rear axle assembly.

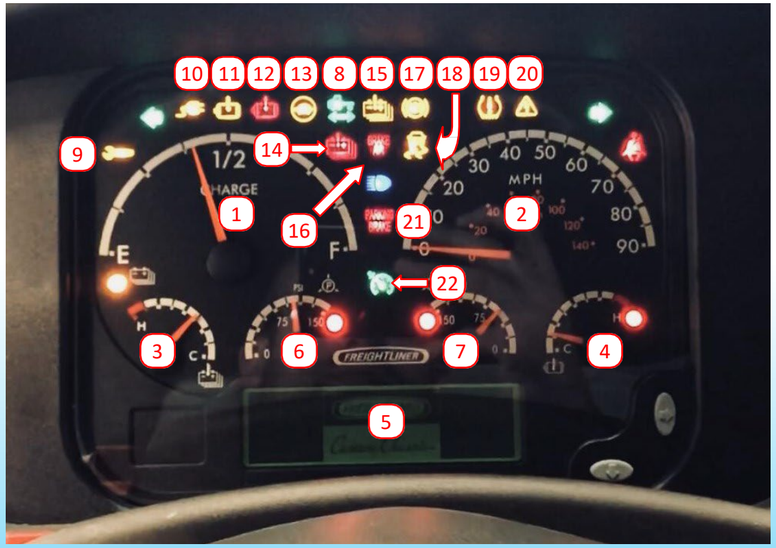
The Traction Motor, or Drive motor, is a 3 phase AC, permanent-magnet, liquid cooled motor. The Traction Motor is connected to a liquid cooled Motor Controller / Inverter (inverter) with three-phase, HV power cables and a data cable. The Inverter converts HV DC from the main battery into variable frequency, variable current, three-phase power to turn the traction motor at the desired speed and power level.

Power flow through the inverter is bidirectional. When accelerating, power flows from the main battery pack to the inverter and then to the traction motor. When decelerating, the traction motor generates electricity which flows to the inverter, gets converted to DC, and recharges the main battery. Regenerative braking significantly improves vehicle energy efficiency.

The drivetrain includes a two-speed, automated-manual transmission. An air actuated shifter controls gear selection. When no air is applied the transmission defaults to neutral. Reverse is achieved simply by turning the main traction motor in reverse. An oil cooler ensures fluid temperature remains within limits for a long life.



2. Instrument Panel



1. Battery SOC (State of Charge)
2. Vehicle Speed
3. HV Battery Temperature
4. Motor Temperature
5. Message Center
6. Primary Air Pressure
7. Secondary Air Pressure
8. *Vehicle HV Enabled* Indicator
9. Service Required
10. Charger Plugged In
11. Minor Fault
12. Critical Fault
13. Limp Mode / De-rate
14. HV Battery Critical
15. HV Battery Warning
16. Low Brake Air Warning
17. ABS
18. ESC Event
19. Tire Pressure Monitoring System (TPMS)
20. HVIL
21. Park Brake Applied (On)
22. Cruise Control Active (if equipped)

3. Important Driving Guidelines

The following operational limits **must** be adhered to unless in a controlled situation, such as during a test with a Proterra Customer Service Representative present:

• Although allowing the bus to coast and progressively slow down during a stop regenerates electricity into the batteries, using the brake pedal during stops should NEVER be discouraged.

• **DO NOT** accelerate and decelerate often in an attempt to “regenerate” more power into the batteries. Smooth operation during acceleration and deceleration provides the highest driving efficiency.

• When at 100% SOC, regenerative braking will be limited to prevent overcharge of the batteries.

• Full throttle at 50% SOC has a slight torque decrease from full throttle at 100% SOC.

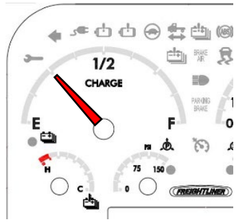
• Driving in Reverse – Limited to 8 mph and decreased torque.
(requires more throttle travel / input to move in reverse)

• Turn Temp Dial from “Red” to “Blue” zone when heaters are not in use. The “Red” zone activates HV coolant heaters regardless of heater blower activation. This practice will help gain the full mileage potential of the HV batteries.

• If “Low Voltage” appears in the Instrument Panel Message Center, all auxiliary components should be shut down immediately, including all heaters, AC, and body fans. The bus should be moved to a safe location off of the road to park until the message clears, or proper troubleshooting is completed.

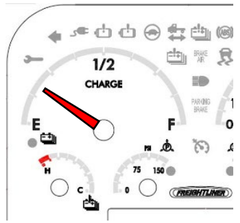
4. State of Charge (SOC) Schedule

SOC -25%



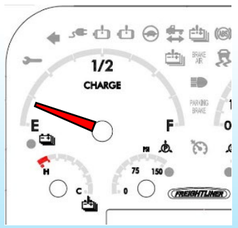
- Cruise Control Disables

SOC -18%



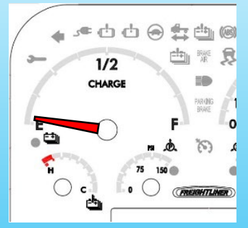
- Dash HVAC @20%

SOC -8%



- Traction Motor De-Rate (32% available)
- Dash HVAC @20%
- Passenger HVAC @ 20%

SOC -4%



- Significant Traction Motor De-Rate (16% available)
- Fuel Gauge Indicator
- Dash HVAC @20%
- Passenger HVAC Disabled

SOC -1%

- Fuel Guge Indicator
- Dash HVAC Disabled
- Passenger HVAC Disabled
- HV System / Traction Motor Disabled

- A HV Battery Warning fault or a HV Battery Critical fault can result in a significant Traction Motor De-Rate

HV Battery Warning

HV Battery Critical

Traction Motor De-Rate

5. Be an energy saving “STAR” Driver

Your Goal: The Most Miles with the Least Energy

Be an energy saving “STAR” driver.

Start slow and gradually increase speed.

Slowly and smoothly apply power up to road speed and drive at the speed limit.

Light on the Pedal

Transition smoothly between acceleration and deceleration.

Sudden acceleration uses more electricity than necessary. Do not **Speed up and slow down in an attempt to “regenerate” more energy into the batteries.**

Anticipate and Regenerate

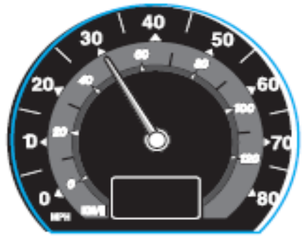
Anticipate the need to slow down early.

Thinking ahead about traffic signals, and upcoming stops will allow the bus more distance to slow down using the motor and add energy back into the battery. This is called regenerative braking. Lift off the accelerator as soon as you notice the distance closing between you and a slower moving vehicle. **Do not hesitate to use the service brakes as needed for safety.**

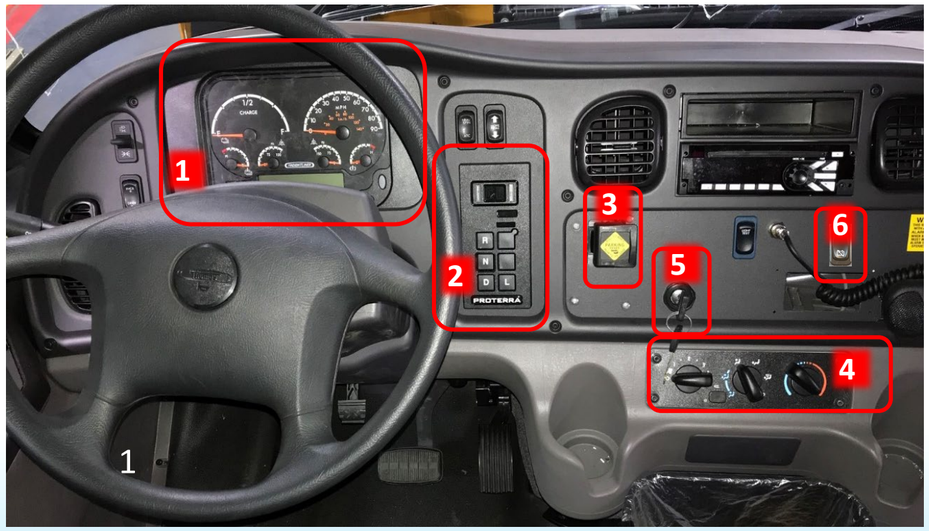
Smooth and Steady

Regulate constant speed

Maintaining a constant speed uses less energy. Lift off the accelera-tor at the beginning of a downhill section of roadway to reduce the need for service brake application. At the bottom of a downhill section of roadway, slowly press the accelerator to avoid a drop in speed when reaching level ground or beginning an uphill climb.



6. Instruments and Controls

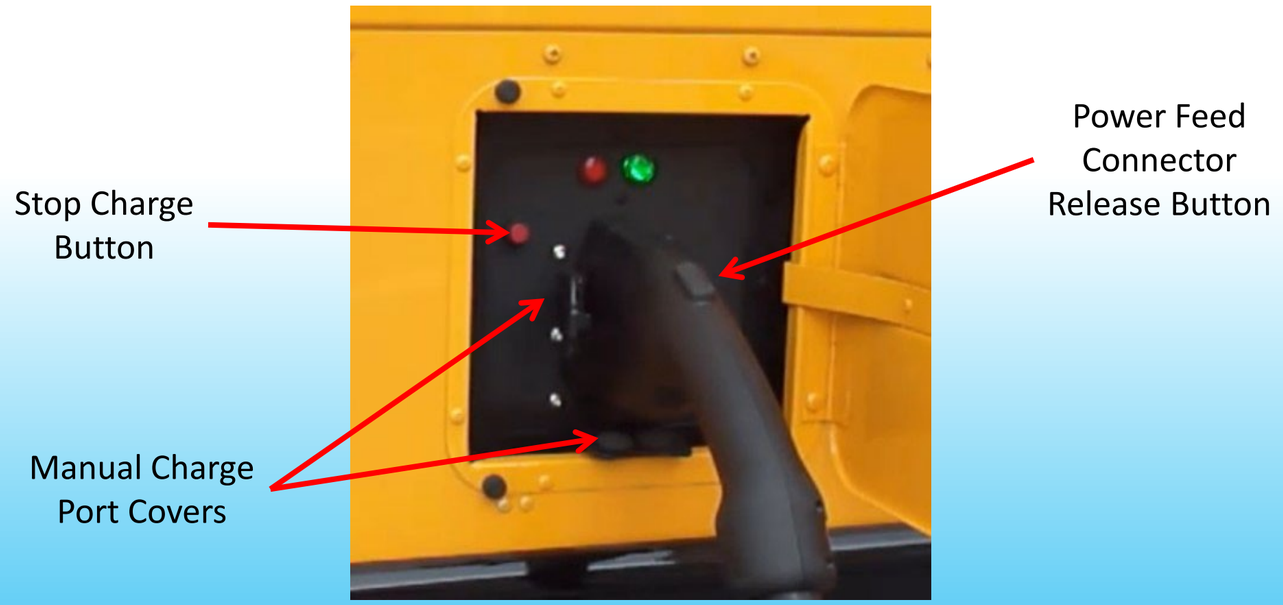


1. Instrument Cluster
2. Push Button Shift Pad
3. Park Brake Control Switch
4. Air Conditioner Controls
5. Key switch
6. Low Voltage Battery “Connect” Switch*

* A Gigavac switch is located in the low voltage battery box behind the low voltage disconnect switch. It will disconnect power if low voltage drops to 11.9 volts for 30 seconds. Press and release momentary dash switch to reconnect low voltage power.

7. Operation

1. Perform the initial walk-around ensure that all exterior panels are closed. Review charger to confirm “State of Charge”. Press the STOP CHARGE button located on the Manual Charge Plate, charging will be interrupted and the **GREEN** indicator light will begin a fast flash rate. After ending the charge, the connector lock should release. Press the button on the Power Feed Connector and pull out to disconnect it from the Manual Charge Port. Place the Power Feed Connector back into the charger retaining port. Close the two Manual Charge Port covers and the access door.



2. Perform the power off / down portion of the pre-trip inspection. The front hood can be opened to inspect fluid levels, steering components, and brake system. Close the hood and all open panels / access door once complete.

3. Turn the Ignition Switch to the ON position.

Note: You will hear the sound of relays, electric pumps, and fans starting and operating. Both visual and audible alarms will start, then shut-off within a few seconds.

4. Check to ensure that the parking brake is engaged. Pull out the yellow parking switch to engage, if needed.

5. Turn the Ignition Switch to the Start / Crank position and release. The Power ON process may take up to 1 minute. The Vehicle HV Enabled indicator will illuminate.

6. After the startup function checks are completed, ensure that there are no faults shown on the driver's display.

7. Perform the "Pre-trip" inspection at this time.

8. Once "Pre-trip" is complete, return to the drivers set and depress the foot-brake.

9. Press the yellow "Parking Brake" switch to release.

10. Press the forward or reverse drive selector, as necessary.

11. Remove your foot from the foot-brake, and press the accelerator pedal to start driving.

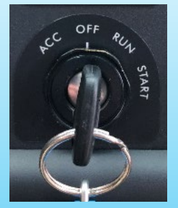
10. Press the forward or reverse drive selector, as necessary.

11. Remove your foot from the foot-brake, and press the accelerator pedal to start driving.

12. Once trip is complete, stop the bus in a safe location.

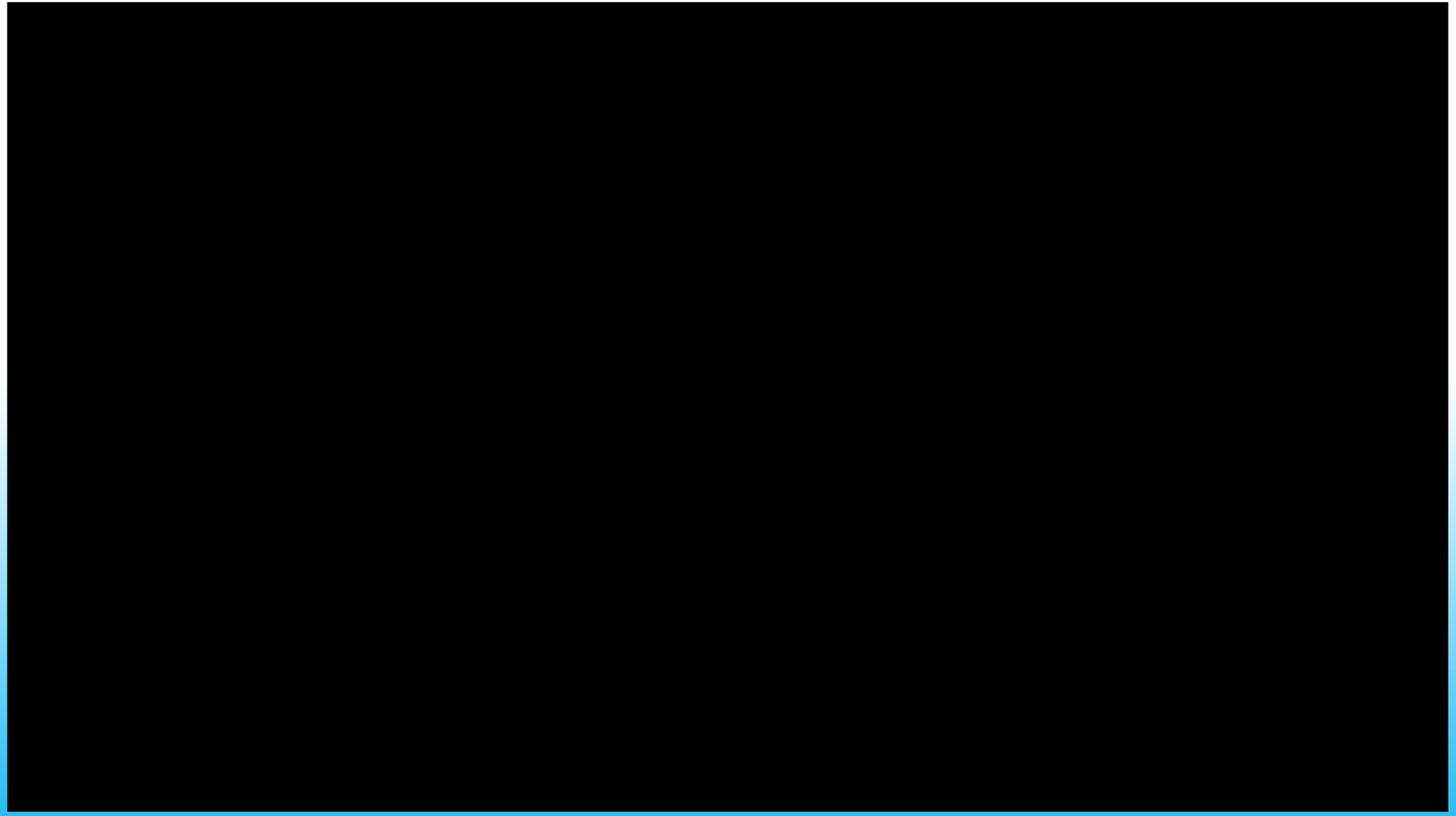
13. Place the bus in neutral by pressing the "N" button on the push button shifter.

14. Set the parking brake by pulling up on the yellow control switch.



15. Turn the Ignition Switch to the OFF position to shut down the bus.

8. Charging - Video



8. Charging

Note: At 0% SOC (230 VDC), the bus may fail the charger “Test Charge”. Update pending.

For Key Off charging, a complete ignition cycle is needed if the low voltage battery disconnect switch was “OFF” or cycled.

1. Carefully move the bus into position for charging.

2. Prepare the bus for charging by performing the following:
    a. Place the bus in neutral by pressing the "N" button on the push button shifter.
    b. Apply the Parking Brake by pulling up on the Parking Brake switch.
    c. Ignition key switch can be “ON” or “OFF” depending if driver is waiting with bus.
    d. Keep the 12 volt battery disconnect switch inside the battery box “ON”.

3. When ready to charge, remove the power feed connector from its retaining port.

4. Open the Charge panel access door. Open the charge port cover, top cover first (two manual charge port covers per port).

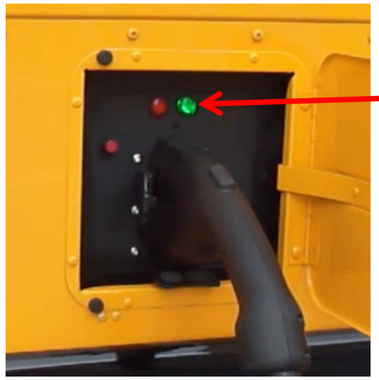
Power Feed Connector

Charge Port with Manual Covers open

5. Inspect the condition of the Power Feed Connector to ensure that there is no damage. Plug the connector into Manual Charge Port on the bus. Insert the connector firmly into the port, until you hear it "click" when fully seated.
DO NOT force the plug into the charge port or damage may occur.
Note: When connected, the bus may beep three (3) times to indicate status.

6. Once connected, the charging process will begin after a short (5 to 10 second) delay. The connector will lock into the port with an audible “click” and the **GREEN** light above the Manual Charge Port will begin a slow flash during the charging process.

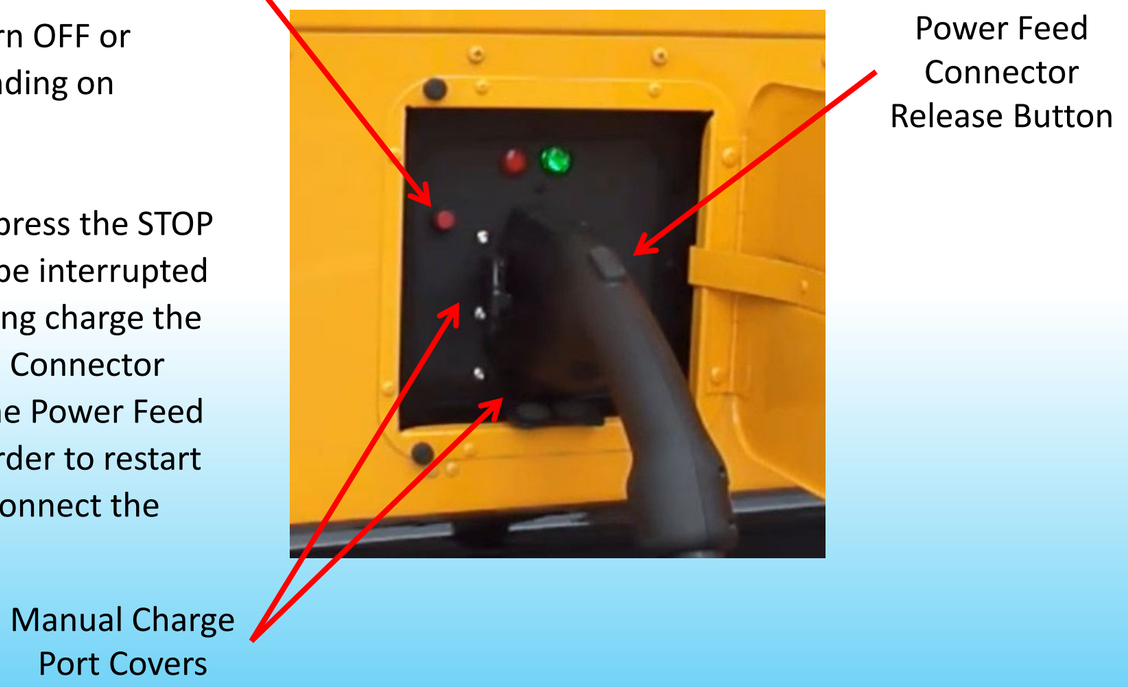
NOTICE! A steady (solid) **GREEN** light indicates that the charge process is complete.



⚠ **– IMPORTANT**
If charging does not begin automatically, check to see if the **RED** light above the manual charge port is on and then check the charger display for errors. If the charging process does not start automatically, disconnect the Power Feed Connector and return it to the charger retaining port, **wait two minutes**, and then reconnect the Power Feed Connector. If the problem persists, contact Maintenance.

7. When charging has completed, the charger will automatically turn OFF or enter “Trickle Charge” mode to maintain the battery charge, depending on requirements.

NOTICE: To stop charging at any time during the charging process, press the STOP CHARGE button located on the Manual Charge Plate, charging will be interrupted and the **GREEN** indicator light will begin a fast flash rate. After ending charge the connector lock should release, press the button on the Power Feed Connector and pull out to disconnect it from the Manual Charge Port. Place the Power Feed Connector back into the retaining port if charging is complete. In order to restart the charging process you must completely disconnect and then reconnect the Power Feed Connector.

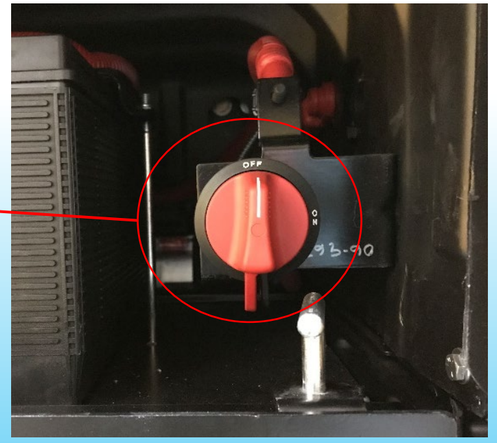


9. Low Voltage (12 volt) Battery Jump

If the Low Voltage Battery Disconnect switch is “On” and the Ignition Key switch is turned “On” and the dash does not respond or only states “Low Voltage” in the message center, you will need to perform a Low Voltage Jump Start.

1. Turn the ignition key switch to the “Off” position.

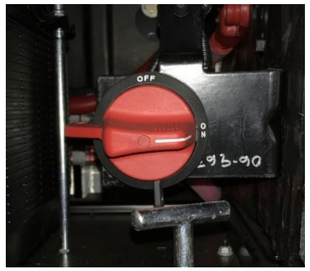
2. Open the Low Voltage (12 volt) battery access door. Turn the Low Voltage Disconnect Switch to the “Off” position.



3. Pull up on the spring latch handles and slide the battery tray out to access the battery terminals.

4. Using a 6 amp minimum Jump Box or battery charger, carefully connect the cable clamps to the proper terminals, positive to positive and negative to negative. Do not allow the clamps to touch each other or the other terminal.

5. Wait five (5) minutes to allow the bus batteries to build an initial charge.



6. Leave the charging cables connected and turn the Low Voltage Disconnect Switch to the “On” position.

7. Turn the Ignition Switch to the “On” position.

Note: You will hear the sound of relays, electric pumps, and fans starting and operating. Both visual and audible alarms will start, then shut-off within a few seconds.

8. Check to ensure that the parking brake is engaged. Pull out the yellow parking switch to engage, if needed.

9. Turn the Ignition Switch to the Start / Crank position and release. The Power ON process may take up to 1 minute. The Vehicle HV Enabled indicator will illuminate.

10. Allow the “Low Voltage” status to clear then disconnect the charging cables. Return the battery tray to it’s stowed position and close the access door.

10. Towing

⚠ **– WARNING**
Do not tow an unbraked vehicle if the combined weight of both vehicles is more than the sum of the gross axle weight ratings (GAWR) of the towing vehicle. Otherwise brake capacity will be inadequate, which could result in personal injury or death.

⚠ **– IMPORTANT**
When it is necessary to tow the vehicle, make sure the instructions below are closely followed to prevent damage to the vehicle.
When towing or pushing the vehicle, regardless of the distance or speed traveled, either disconnect the driveshaft at the rear axle and support it as necessary, or remove the axle shafts.

NOTE: Towing rules and regulations vary from federal, state, local, and transit authority. These laws must be followed when towing the bus.

Front Towing Hookup

NOTE: The vehicle should **never** be towed from the rear. The gross axle weight rating (GAWR) of the front axle may not be sufficient to support the increased load when towing from the rear. This could damage the front axle.

1. Disconnect the Low Voltage (12v) battery ground cables.

2. Remove both drive axle shafts.

⚠ **– CAUTION**
Failure to remove the axle shafts when towing the vehicle with the rear wheels on the ground could result in damage to the transmission and other parts.

3. Cover the ends of the hubs with metal plates or plywood cut to fit the axle opening, and drilled to fit the axle shaft studs. This prevents lubricant from leaking out and will keep contaminants from getting into and damaging the wheel bearings and axle lubricant.

4. Remove the bumper.

5. Attach the towing device. Due to the many variables that exist in towing, positioning the lifting and towing device is the sole responsibility of the towing-vehicle operator.

6. Lift the vehicle and secure the safety chains. If extra towing clearance is needed, remove the front wheels.

NOTE: Failure to protect the frame rails from the chains could cause damage, leading to eventual frame failure.

7. Connect the clearance lights, taillights, and signal lights. Connect any special towing lights required by local regulations.

⚠ **– WARNING**
Failure to chock the tires or connect the tow truck's air brake system before releasing the spring parking brakes could allow the disabled vehicle to suddenly roll. This could cause property damage or personal injury.

⚠ **– CAUTION**
Before attempting to tow a vehicle with an air suspension (and during the towing operation), ensure that the air suspension is properly charged. Charge the suspension through the Schrader valve on the air dryer. Attempting to tow a vehicle with an improperly charged air suspension may result in damage to the chassis and body.

8. Chock the tires on the disabled vehicle and connect the towing vehicle's air brake system to the vehicle being towed. Then, release the spring parking brake and remove the chocks.

11. CDL Brake Test - Intellipark

General Information

The following is the process to perform an air brake tests for vehicles equipped with Bendix Intellipark Park Brake System. For identification purposes, the park brake switch is equipped with upper and lower red LED lights, both lights will be illuminated when the parking brake is set and both lights off when the parking brake is released. For electric powered buses to not operate the high voltage system you simply turn the key to ignition on and not to the start position, to engage HV, turn the key to start position and release.

Work Instructions Subject: Air Brake Test

Air Brake Test Procedure

Step 1 Static Air Leakage test (start with the air system fully charged)

In order to perform this test you need chock the tires to prevent any unintended movement of the vehicle With the ignition key in the on position, engine off or if electric bus HV disengaged Release the parking brake and remove foot from the brake pedal Press the throttle pedal and hold it there Watch the air gauges and time the air pressure drop, after the initial stabilizing of the air pressure the loss rate should be no more than 2 psi in 1 minute. Set the parking brake for the remainder of the tests.

Step 2 Service Brake Air Leakage Test

With the ignition key in the on position, engine off or if electric bus HV system disengaged Firmly apply service brake pedal and hold steady After initial drop, pressure drop should be no more than 3psi in 1 minute.

Step 3 Low Air Warning System Check

With the ignition key in the on position, engine off or if electric bus HV system disengaged Depress the brake pedal repeatedly to fan off air pressure from the system Listen for the audible buzzer and watch for the visual low air warning light in the dash and the both LED lights on the parking brake switch will blink.

Step 4 Spring Bake Valve Test

With the ignition key in the on position, engine off or if electric bus HV system disengaged Continue to depress the brake pedal repeatedly to fan off air pressure from the system Observe the Park Brake Switch lights for parking brake set will be indicated by the top LED light will change from flash to solid.

Step 5 Air Pressure Recovery Check
Start the engine or turn ignition to start on electric powered vehicles Raise to operating RPMs or high idle for engine powered vehicles Observe that the pressure builds and measure the time from 85 lbs. to 100 lbs. within 45 seconds.

Step 6 Governor Cut Out Check
With the drivetrain still running or HV engaged Observe the governor Cut Out pressure is between 120 lbs. and 130 lbs.

Step 7 Governor Cut In Check
With the drivetrain still running or HV engaged Depress the brake pedal serval times to reduce the air pressure to around 90 – 100 lbs. Observe the compressor Cut In pressure.

Step 8 Spring Brake Test (In a safe location away from other vehicles)
With the HV system engaged and the parking brake engaged removed the wheel chocks Depress the brake pedal and hold Release the parking brake switch (both red LED lights will go out on the switch) Shift the transmission into drive and move forward to around 3 – 5 mph While in motion engage the parking brake switch (both red LED lights will be on) Vehicle should stop.

Step 9 Service Brake Test
In a safe location away from other vehicles With the drivetrain still running or HV engaged Wait for normal air pressure in the vehicle and while depressing the brake pedal release the parking brake Shift into drive and move forward to around 5 mph Firmly apply the service brake (depress the brake pedal) Note any pulling to one side, unusual feel, or delayed stopping action.

12. Intellipark Operation

This Thomas Built Buses school bus is built with Intellipark, an interlock park brake system. Functions include:

- Ergonomic advantage over traditional pneumatic valve.
- Visual indicator of parked state.
- Interlocked with key, service brakes and, when applicable, lift door.
- Audible alarm when vehicle is left un-parked.
- Active rollaway assist when driver doesn't intervene within 30 seconds to park vehicle.

1. To release (ignition "On" with 90 psi brake system pressure)
   - Depress service brake / press and release park brake switch.
     (Both LEDs will turn "Off" to indicate park brake is released)

2. To Set (at a full stop)
   - Pull and release park brake switch.
     (Both LEDs will turn "On" to indicate park brake is set)

* To release follow Anti-Roll-Away event (both LEDs blinking)
   - Pull and release park brake switch.
     (Both LEDs will turn "On" to indicate park brake is set)
   - Depress service brake / press and release park brake switch.
     (Both LEDs will turn "Off" to indicate park brake is released)

⚠ WARNING

The parking brake is controlled by the yellow park brake electric switch. If the Low Voltage (12 volt) system is disabled, the yellow park brake electric switch is disabled. To set the park brake without power, the Service Brake pedal must be pumped to reduce air pressure until the parking brake engages.

Note:

- Pulling the park brake switch for 3 seconds below 12 mph will set the park brake stopping the bus and will shift the transmission to neutral.
- Pulling the park brake switch for 3 seconds above 12 mph will "Spring Brake Modulate" the service brakes slowing the bus and will shift the transmission to neutral. Releasing the switch ends "Spring Brake Modulation", transmission remains in neutral.

13. Intellipark LED Table

LED Operation			
Lower	Upper	Status	
On	On	All LEDs illuminate for 3 sec when ignition is applied	Self-Check
On	On	3 sec after ignition is applied – both power vehicle and towed vehicle are parked	Park Brake Set
Off	Off	3 sec after ignition is applied – both power vehicle and towed vehicle are unparked	Park Brake Released
Blinking	On	A fault is present on the power vehicle park brake system. Both the towed vehicle and the power vehicle are parked.	Fault or Low Air – Below 60 psi
Blinking	Off	A fault is present on the power vehicle park brake system. Both the towed vehicle and the power vehicle are unparked.	Fault or Low Air – Below 90 psi
Blinking	Blinking	-Anti-Roll-Away event. -A fault with the power vehicle PVM pressure sensor has been detected. See notes 1 and 2.	-Must pull switch to set/park before releasing. Should extinguish once released. -Pressure sensor fault or slow park brake release as system changes.

Notes

[1]Both LEDs blink to indicate an Anti-Roll-Away event or that the state of the Intellipark vehicle system cannot be determined by the DECU.

[2]If not functioning / operating as described, immediately chock the wheels and have the system serviced as soon as possible.

JOULEY
ELECTRIC BUS

Thomas BUILT BUSES

CONNECTING AND CHARGING

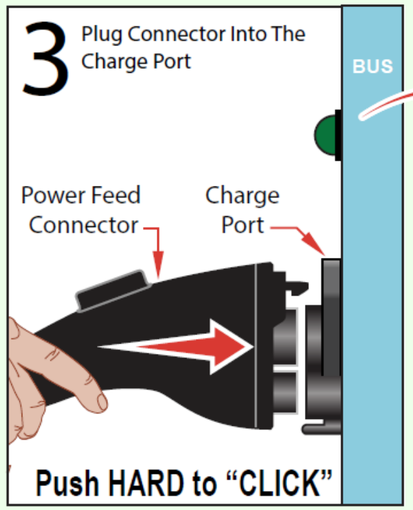
1 Park The Bus Near The Charger

Set Brake!

2 Make Sure Vehicle Master Disconnect Is "ON"

Must be "ON" to CHARGE

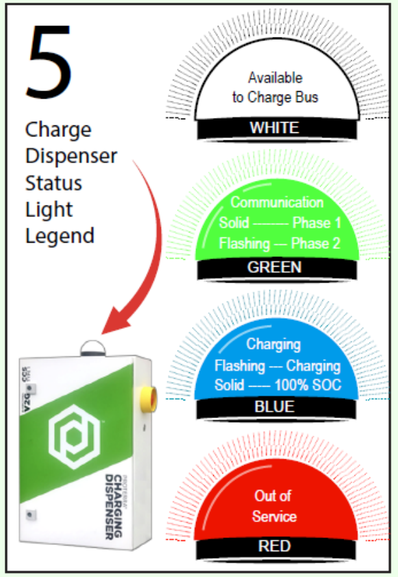
3 Plug Connector Into The Charge Port



Push HARD to "CLICK"

4 Green Light Above The Charging Port On The Bus Must Begin To Flash.

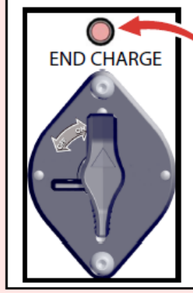
5 Charge Dispenser Status Light Legend



ENDING CHARGE AND DISCONNECTING

1 When Charge Is Complete Or To End A Charge Session Press The End Charge Button On The Bus Or On The Charge Dispenser and Wait 15 seconds.

Press Either "End Charge" Button And Wait 15 Seconds Before Disconnecting



Press One

ESTOP For Emergency ONLY! Not For Ending Charging Session!

Wait 15 Seconds

2 Confirm That The Green Light Above The Charge Port Is Flashing Rapidly

Then...

Press The Release Button And Disconnect The Power Feed Connector

Thank You for Your Time

PROTERRA POWERED

Thomas BUILT BUSES
Because every mile matters.SM

FREIGHTLINER Custom Chassis