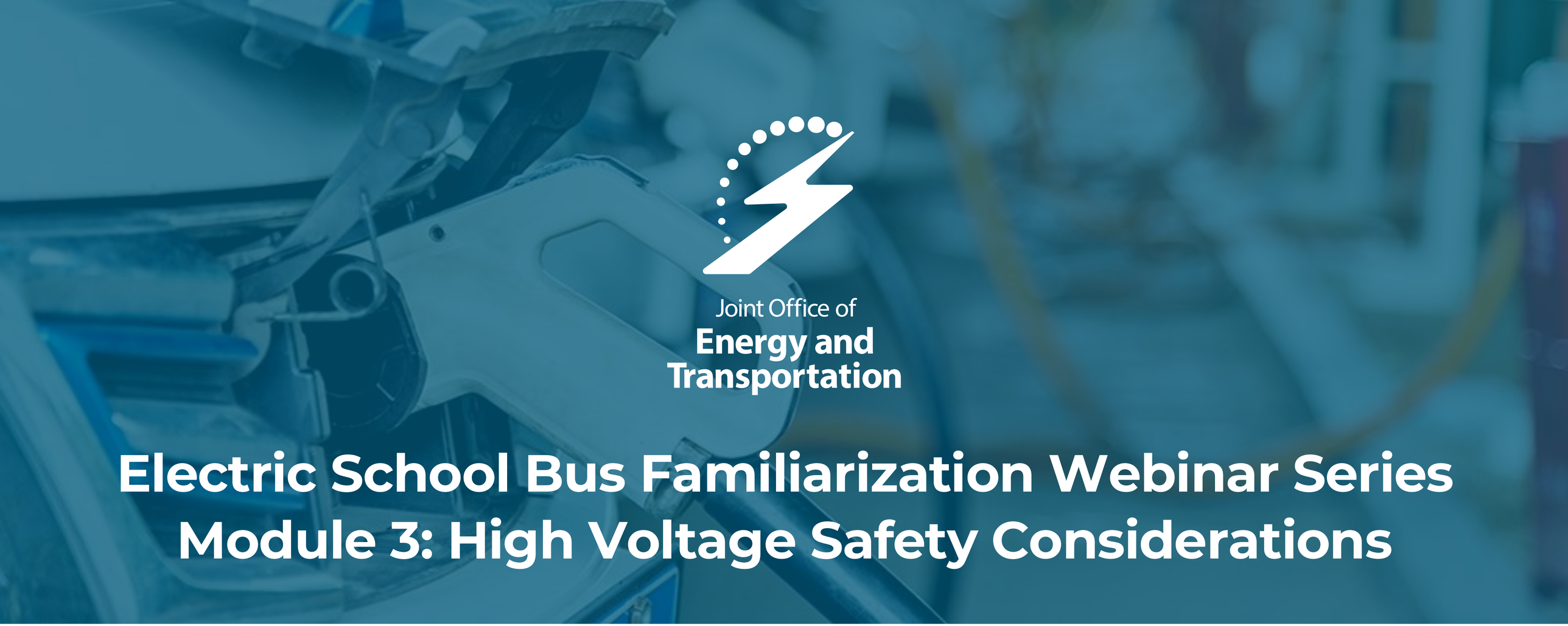


Joint Office of
Energy and
Transportation

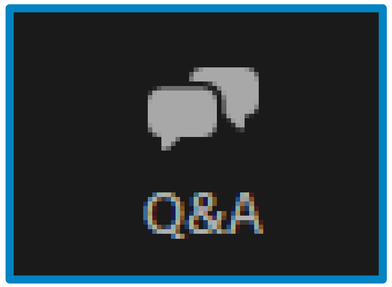
Electric School Bus Familiarization Webinar Series
Module 3: High Voltage Safety Considerations

10/1/2024

driveelectric.gov

Zoom Tips and Housekeeping

- Controls are located at the bottom of your screen. If they aren’t appearing, move your cursor to the bottom edge.
- Submit questions using the “Q&A” window



Disclaimer

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Mission and Vision

JOINT OFFICE OF
Energy and
Transportation

Mission

To accelerate an electrified transportation system that is affordable, convenient, equitable, reliable, and safe.

Vision

A future where everyone can ride and drive electric.

BIL Programs Supported by the Joint Office

The Joint Office will provide unifying guidance, technical assistance, and analysis to support the following programs:

National Electric Vehicle Infrastructure (NEVI) Formula Program (U.S. DOT)
$5 billion for states to build a national electric vehicle (EV) charging network along corridors

Charging & Fueling Infrastructure (CFI) Discretionary Grant Program (U.S. DOT)
$2.5 billion in community and corridor grants for EV charging, as well as hydrogen, natural gas, and propane fueling infrastructure

Low-No Emissions Grants Program for Transit (U.S. DOT)
$5.6 billion in support of low- and no-emission transit bus deployments

Clean School Bus Program (U.S. EPA)
$5 billion in support of electric school bus deployments

Clean School Bus Technical Assistance

The Joint Office of Energy and Transportation (Joint Office) is providing **FREE** technical assistance for the EPA's Clean School Bus program

Technical Assistance Offerings:

- **Fleets receiving funds or planning to apply are eligible**
- Proactive and reactive, hands-on assistance tailored to each fleet
- New and updated tools and resources.

Clean School Bus Technical Assistance

CleanSchoolBusTA@nrel.gov

driveelectric.gov/contact

Examples of How We Can Help

- Electric utility coordination
- Identifying available funding and incentives
- Analyzing charging infrastructure needs
- Conducting route analysis and planning
- Conducting training and workforce development
- Bus evaluation
- Analyzing energy needs and grid impact
- Identifying solar and battery storage opportunities

New Electric School Bus Familiarization Webinar Series

Brought to you by:

- Joint Office of Energy and Transportation
- National Renewable Energy Laboratory (NREL)
- International Transportation Learning Center (ITLC)
- School bus manufacturers

- Four-part module-based series for operators, technicians, and other school bus fleet members.
- Learn fundamentals of electric school bus (ESB) technology.
- Live Q&A during each session.
- Recordings with testing materials for internal training programs.

Agenda

Introduction from Ryan Frasier, National Renewable Energy Laboratory (NREL)

Presentations moderated by the International Transportation Learning Center (ITLC) with Q&A after each presentation

- *Overview of ESB HV & HV Risk and Safety*
  - Brad Beauchamp, Bluebird
- *Worker Protection*
  - Brandon Reid, Lion Electric
- *Required Skills and Knowledge*
  - Angel Yin, BYD-Ride

Today’s Moderator

John Schiavone
International Transportation Learning Center (ITLC)

2024 Sessions

Session 1

ESB Overview for Operators

Session 2

ESB Technical Overview

Session 3

High Voltage Safety Considerations

Session 4

ESB Charging Methods and Considerations

Fundamentals Of Electric School Buses

Welcome

- ITLC Mission – advance training on joint labor-management basis
- Organized similar webinar series for transit buses
- Purpose – provide introductory information

Topics for Today

Presentation 1

Overview of ESB HV & HV Risk and Safety

Brad Beauchamp, EV Product Segment Leader

Presentation 2

Worker Protection

Brandon Reid, Director of Customer Success, USA

Presentation 3

Required Skills and Knowledge

Angel Yin, Policy Analyst

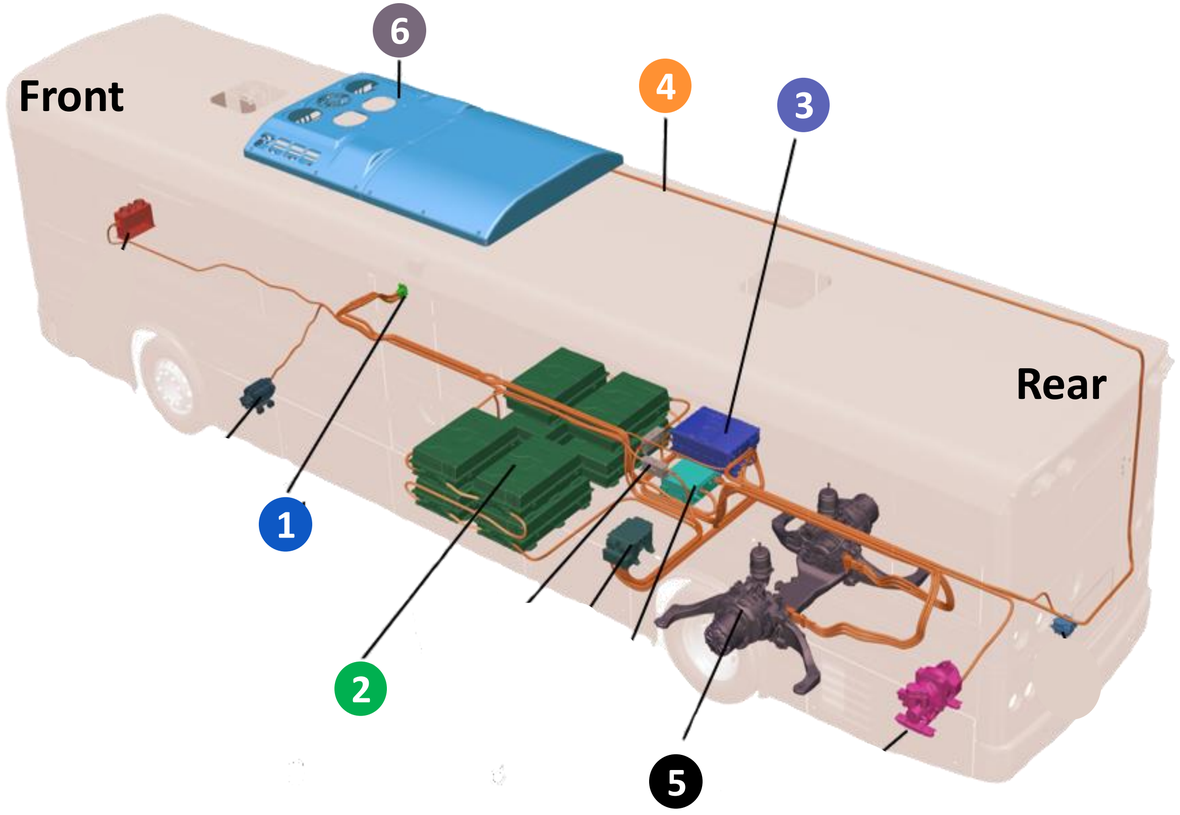
Key Terms

AC (Alternating Current) Powers drive wheels	**CAN (Controller Area Network)** Vehicle data communication	**Charging Port** Accepts external charging plug
DC (Direct Current) Battery voltage	**DC-DC Converter** Converts DC HV to lower DC voltages as needed	**ESS (Energy Storage System)** 400-900V DC battery pack
HVIL (High Voltage Interlock Loop) HV safety disconnect	**HVJB (High Voltage Junction Box)** Protected HV connections	**Inverter** Converts DC HV to AC
Regenerative Braking Uses braking energy to charge batteries	**Traction Motor** Uses AC to power vehicle (replaces ICE)	**V2G (Vehicle-to-Grid)** Uses bus to supply grid, other AC sources

ESB Component Identification & Principal of Operation

High-Voltage (HV) Electrical System Components Bus Layout

1. Charging Port
2. Energy Storage System (DC batteries)
3. Inverter (DC to AC)
4. High-Voltage Cables
5. AC Traction (Drive) Motor and Axle Assembly
6. AC Powered Accessories (includes HVAC)



BLUE BIRD®

Presentation 1

Overview of ESB HV & HV Risk and Safety

Brad Beauchamp

INTERNATIONAL TRANSPORTATION LEARNING CENTER

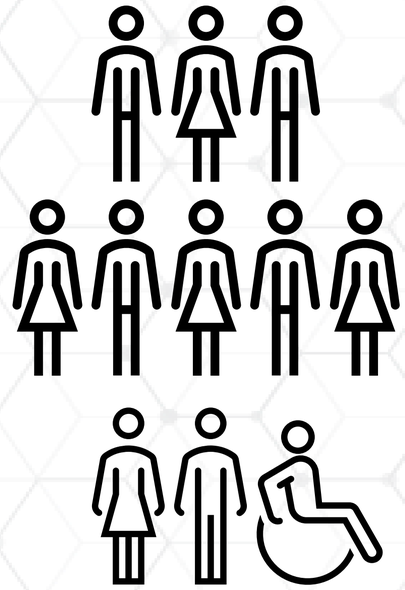
Learning Outcomes

- Identify standards, risks and who should remain safe
- Identify the role of OSHA and NFPA70E
- Discuss effects of contact with high voltage
- Examine ESB PPE basics
- Define Lock Out – Tag Out
- Compare current ESB training

Training Requirements

Affected employees that will receive ESB training as determined by job needs:

- Maintenance Technicians
- Drivers
- Bus Aides
- Supervisors
- Shop Forman
- Transportation Directors
- Dispatchers
- Trainers
- Yard Assistants
- Fueling/Charging Staff



Can I Be Cited For Not Complying With NFPA 70E?

Answer: Yes

The employer must assess the workplace for electrical hazards and the need for PPE under 29 CFR 1910.335(a)(1)(i).

The employer is expected to use the best means available to comply with this requirement and that is done through consensus standards.

In the event of injury or death due to an electrical accident, if OSHA determines that compliance with 70E electrical safety standard would have prevented or lessened the injury, OSHA may cite the employer under the general duty clause.

Introduction to NFPA 70E

NFPA 70E
Standard for Electrical Safety in the Workplace

Why is it distributed?

90.2 Purpose

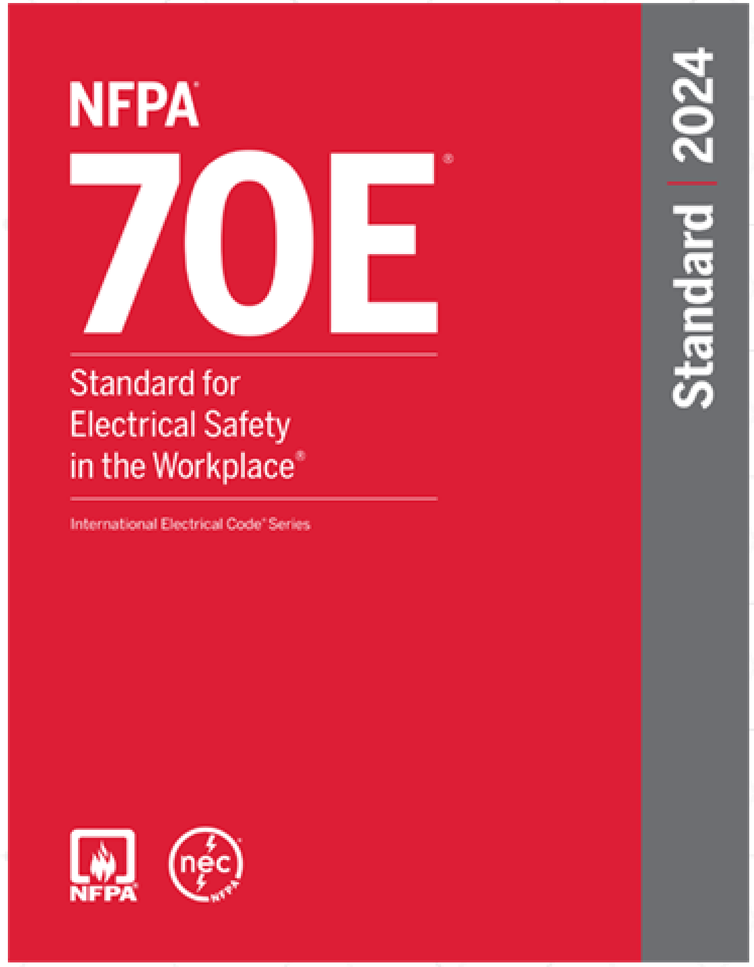
Why it is relevant to electric school buses?

90.3 Workplaces Covered

How is it organized?

90.4 Standard Arrangement

90.5 Mandatory Rules, Permissive Rules, and Explanatory Material

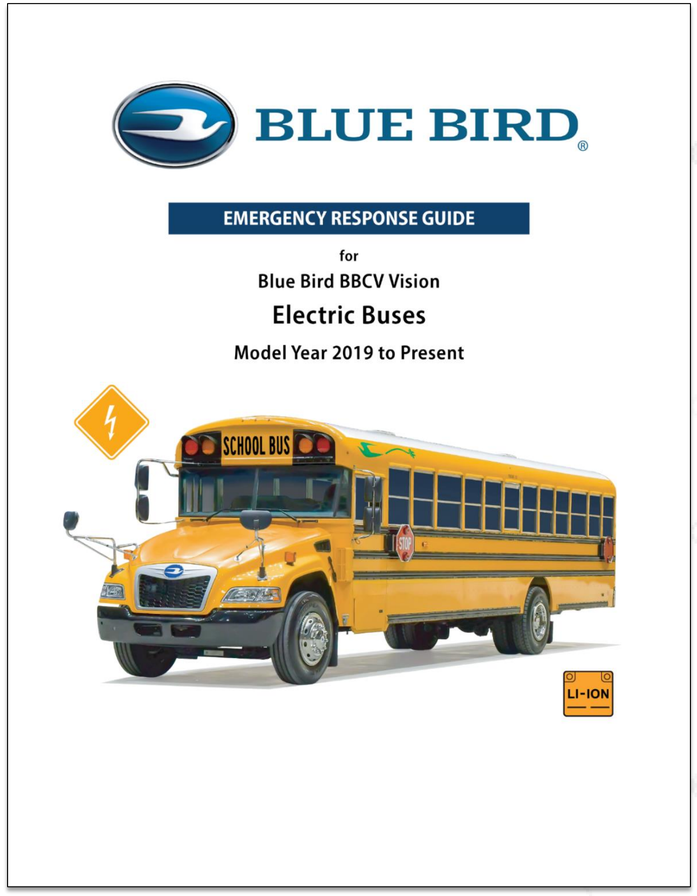


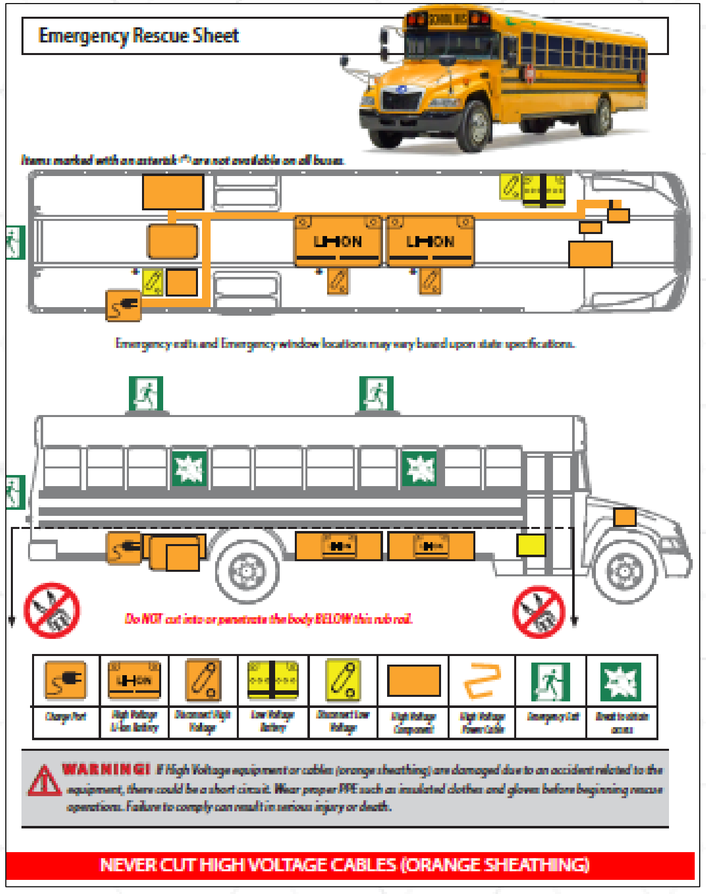
Other Documentation

Other Non-NFPA Documents

Emergency Response Guide for Electric Buses

- Emergency response procedures for the Electric Bus: Model Years 2019 to present.
- Includes procedures like:
  - Covering confirmation that a bus is an EV
  - Accessing bus occupants
  - Submerged buses
  - Towing a bus.





Other Documentation

Existing Electrical Safety Guidelines

Definition of High Voltage

- 30 – 1000 vAC
- 50 – 1500 vDC

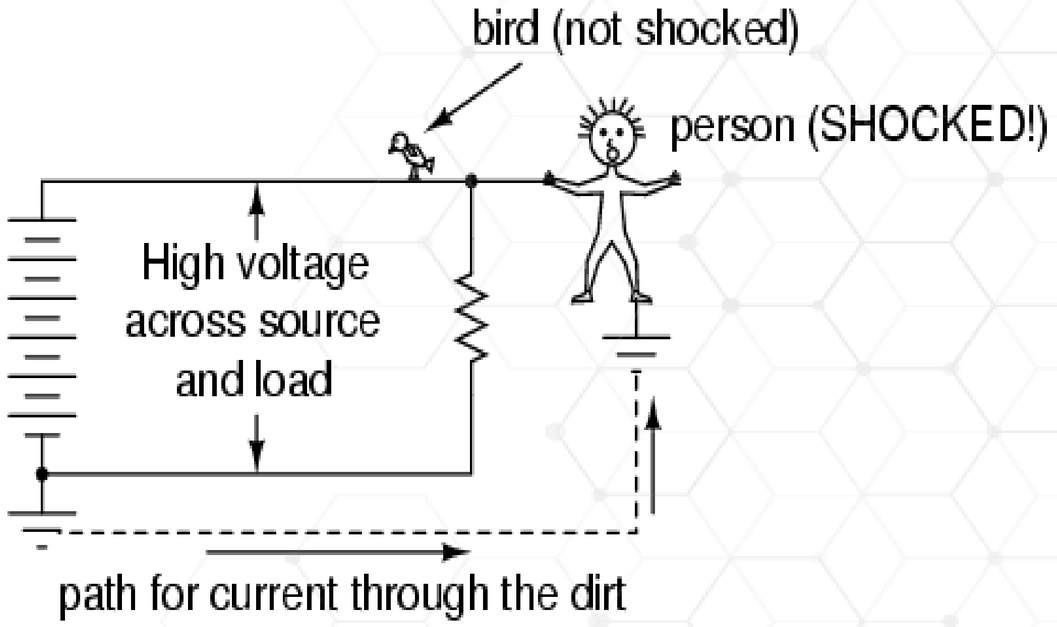
Anatomy of Electricity Flowing Through the Body

SEVERITY of Shock Depends On:

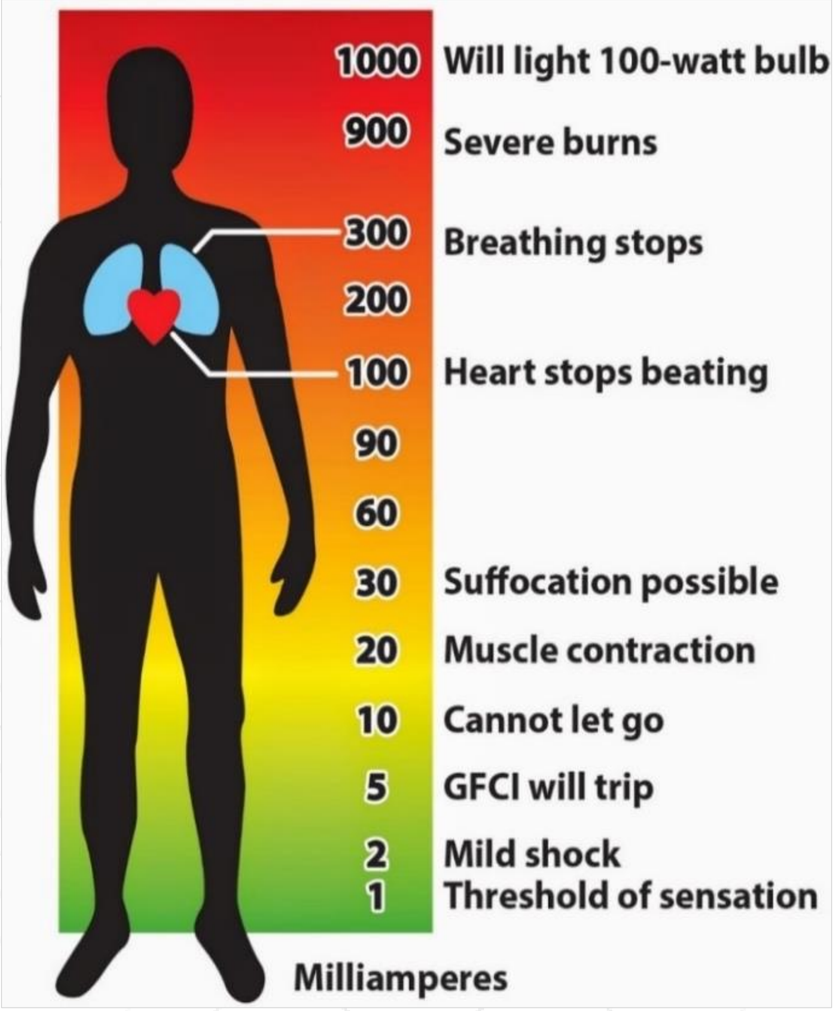
1. **PATH** of current through the body
2. **AMOUNT** of current flowing through the body (Amps)
3. **DURATION** of the shocking current through the body

LOW VOLTAGE DOES NOT MEAN LOW HAZARD!!!!

Current level	Probable effect on the human body
1mA	**Slight tingling sensation.** Still dangerous under certain conditions.
5 mA	**Slight shock felt; not painful but disturbing.** Average individual can let go. However, strong involuntary reactions to shocks in this range may lead to injuries.
6-16 mA	**Painful shock, begin to lose muscular control.** Possible fall danger. Referred to as the freezing current or "let-go" range.
17-99 mA	**Extreme pain, respiratory arrest, severe muscular contractions.** Individual cannot let go. Death is possible.
100-2000 mA	**Ventricular fibrillation (uneven, uncoordinated pumping of the heart.)** Muscular contraction and nerve damage begins to occur. Death is likely.
Over 2000 mA	**Cardiac Arrest, internal organ damage, and severe burns.** Death is probable.



Effects of High Voltage on Human Body



- ⚠ Current as little as 0.1 Amp traveling across the heart can kill.
- ⚠ Most sensitive organs are heart and brain.
- ⚠ ALWAYS assume circuit is energized.

Effects of High Voltage on the Human Body

ARC FLASH

Light and heat emitted by the explosion is known as **arc flash**. When an arc fault occurs, result is a massive electrical explosion.

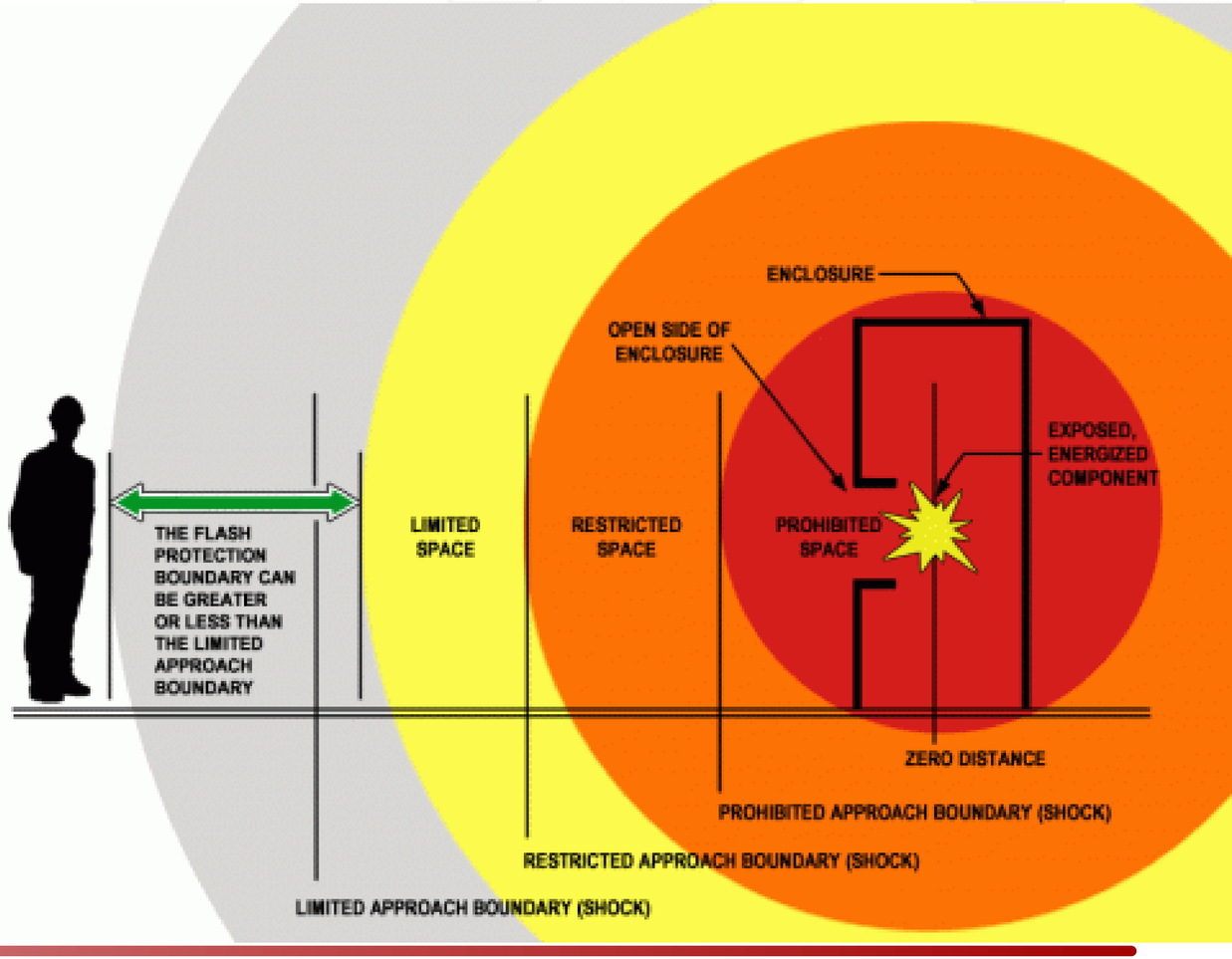
ARC BLAST

Pressure wave created by the arc flash is known as the **arc blast**.

Pressure waves generated by an arc flash explosion can carry a force up to thousands of pounds per square inch

Powerful enough to knock down or throw nearby workers and cause damage to eardrums, lungs, brain and other organs.

Other effects include high temperature.



Direct and Indirect Types of Electrical Injuries

Direct:

- **Electrocution or death** due to electrical shock
- **Electrical** shock
- **Burns**
- **Hearing loss** from arc blast

Indirect:

- Falls
- Fire

Employee Responsibilities

It is Your Responsibility to Know the Work Hazards

- ✓ Know the Hazards of Electricity
- ✓ Know the Equipment
- ✓ Use Safe Work Practices
- ✓ Inspect Your PPE Before Each Use
- ✓ Don’t Work on Energized Circuits Without Permission

OSHA Act of 1970-SEC.5 Duties

https://www.osha.gov/

(a) Each employer shall:

(1) Furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees;

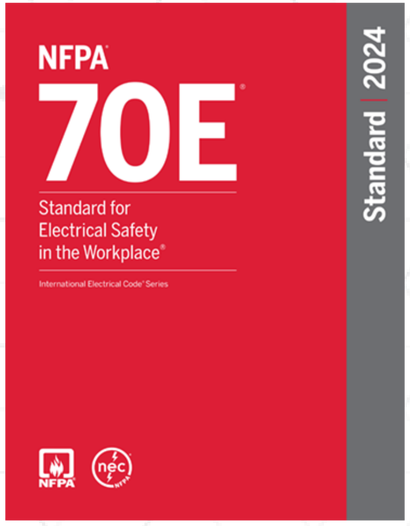
(2) Comply with occupational safety and health standards promulgated under this Act.

(b) Have each employee comply with occupational safety and health standards and all rules, regulations, and orders issued pursuant to this Act which are applicable to his own actions and conduct.

Employers Responsibilities

Employers Must Protect Workers From Hazards Posed by Flames and Electric Arc

- ✓ Identify employees who will be working around these hazards.
- ✓ Estimate the incident heat energy of any electric-arc flash-hazard to which a worker would be exposed.
- ✓ With certain exceptions, ensure workers exposed to such hazards wear protective clothing and other protective equipment with an arc rating equal to or greater than the estimated heat energy.



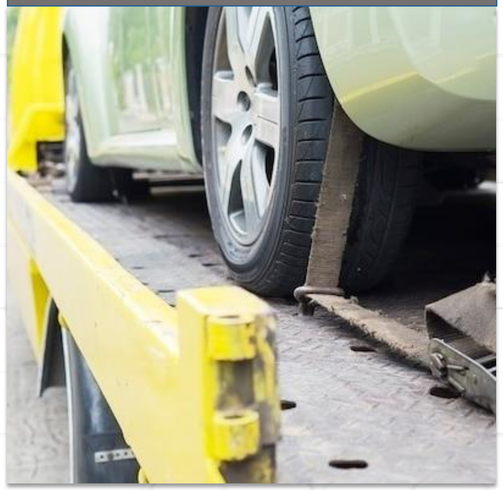
The Key Areas

Safety Management

Job Safety Assessment (JSA)

PPE

Hazard Response



Safety Management

It covers the NFPA 70E requirements describing an organization’s electrical safety programs, procedures, equipment, and training

Job Safety Assessment (JSA)

Job Safety Assessment—NFPA 70E requirements describe what occurs during an electrical safety risk assessment of a work area prior to starting any job task.

- **JSAs are performed as part of an organization's safety programs and procedures.**
- **When performing a JSA, make sure the NFPA 70E requirements are being followed and it is safe to perform a job task(s).**

Personal Protective Equipment (PPE)

Personal Protective Equipment (PPE)

Covers NFPA 70E requirements related to the selection of clothing and PPE.

Hazard Response

Hazard Response

NFPA requirements explaining how to assess an unknown situation and the surrounding environment for possible electrical hazards/risks before taking any action.

Hazard Response

Hazard Response – NFPA requirements explaining how to assess an unknown situation and the surrounding environment for possible electrical hazards/risks before taking any action.

- Difference between the Hazard Response category and the Job Safety Assessment is that the hazard response is to an unknown situation, while the JSA is primarily completed onsite at an organization and is already being maintained with an electrical safety program.
- Electrical risks/hazards that come with electric vehicles are not solely located in a workplace but can occur anywhere the electric vehicle can go.

Hazardous Energy Sources for Lock-out Tag-out

- Notify others, in particular all affected employees and any contractors that may be working in the area
- Place warning signs and barriers

Verify Isolation

- Verify isolation of energy has occurred with testing equipment
- Visual inspection to verify correct devices have been locked and tagged out in correct position
- Use deliberate attempt to restart equipment

Where We Are With ESB (Level One)

LEVEL ONE - Electrically Aware Person (Current Training Level)

An individual who may or may not have received appropriate training to work on HV systems or components of the EV vehicle.

High Voltage Disabling procedure prior to even routine servicing of an ESB.

Displaying the partition between HV and maintenance

- Orange Cabling
- Location of HV Components
- How to isolate the HV energy in the system

High Voltage Disabling procedure steps:

- Disable high voltage.
- Test for the presence of high voltage
- Know when personal protection equipment (PPE) is required.

General High Voltage Dangers (Level Two)

LEVEL TWO - High-Voltage Vehicle Technician

- Received HV electrical training
- Demonstrated skills and knowledge related to the construction, operation, and repair of electrically powered HV vehicles
- Maintains an electrically safe working area

Danger - Always perform the High Voltage Disabling

- Personal Protection Equipment (PPE)
- Proper Procedures
- HV systems or components of the EV vehicle
- How to disable high voltage
- How to test for the presence of high voltage.
- Identify condition under which high voltage is always present and personal protection equipment (PPE)

Components and Applying NFPA 70E Requirements to an ESB

Systems For Level 2

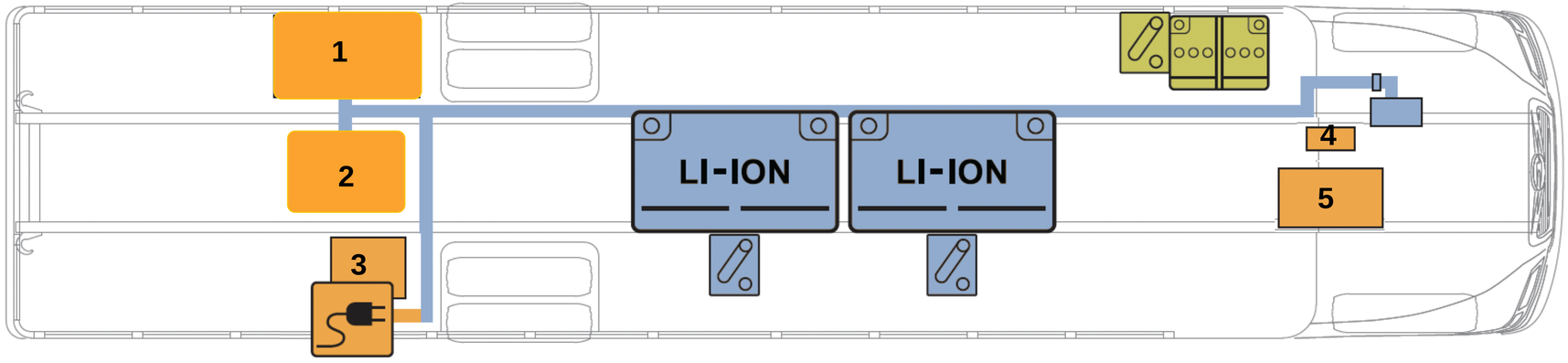
1 HV Module

2 Electric motor

3 High voltage air compressor

4 Power steering pump

5 Thermal management unit



1. **What's happening to the component?**
2. **What NFPA 70E requirement(s) apply?**
3. **Why does the requirement(s) apply?**
4. **What needs to be done to meet the requirement?**

Emerging Training for ESB HV Battery (Level Three)

DANGER - **Before working internally on the high voltage battery, BE SURE TO WEAR PERSONAL PROTECTION EQUIPMENT (PPE) in accordance with National Fire Protection Association (NFPA) 70E, PPE Category 2, Minimum Arc Rating 12 cal/cm^2**

- ✓ Safety helmet, face shield and sock hood/balaclava
- ✓ Safety rated long sleeve shirt and pants, or safety rated coveralls
- ✓ Hearing protection
- ✓ Certified and up-to-date Class "0" Insulation gloves rated at 1000V with leather protectors.
  - ➢ Visually and functionally inspect the gloves before use.
  - ➢ Wear the Insulation gloves whether the system is energized or not.

Failure to follow the procedures may result in serious injury or death.

Questions and Answers

LION ELECTRIC

Presentation 2
Worker Protection

Brandon Reid

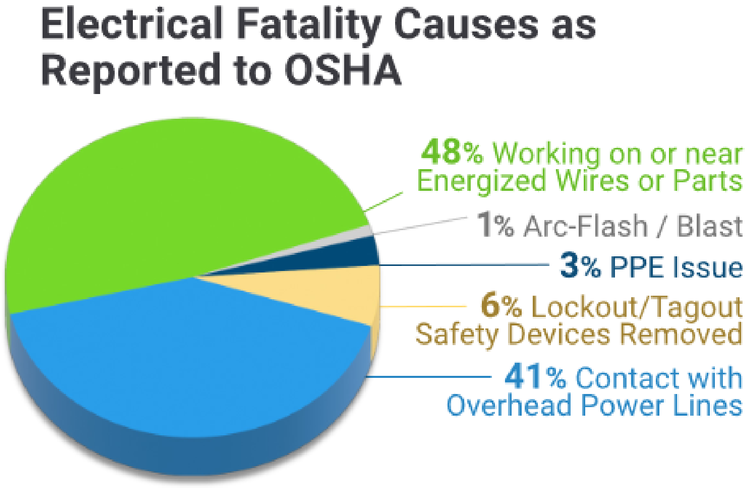
Learning Outcomes

- Discuss how to safely begin work on and near high-voltage (HV) equipment
- Identify the proper equipment for working on electric vehicles
- Discuss High Voltage Worker Considerations

Working Safely On or Near High-Voltage (HV) Equipment

Safety Statistics

- **According to OSHA, in 2020:**
  - 126 electrical-related fatalities
  - 2,346 total electrical non-fatal safety incidents
  - 5.3% of all electrical incidents were fatal
  - "Constructing, Repairing, Cleaning" accounted for the leading worker activity for electrical fatalities at **64%.** "Using or Operating Tools, Machinery" accounted for **22%.**
- **No stand-alone data for the automotive industry, but overall fatality rates have remained consistent since 2003**
- **Between 2011 and 2022, 70% of fatalities occurred in non-electrically related occupations**



Sources:
https://www.ase.com/dist/docs/ASExEVElectricalSafetyStandardsVersion1Industry.pdf
https://www.esfi.org/wp-content/uploads/2024/01/ESFI-Workplace-Fatalities-Infographic.pdf
https://www.esfi.org/news/esfi-releases-updated-workplace-electrical-fatalities-and-injuries-data/

Working Safely On or Near High-Voltage (HV) Equipment

What You Need To Know: Vehicle Information

- Make, model, and type of electrical propulsion (hybrid, battery electric)
- Any vehicle-specific safety information and recommended safety practices found in the owners or safety manual
- Basic operation:
  - Moving the vehicle a short distance
  - Putting in park and setting the brake
  - Turning the vehicle on and off
  - Activating hazard lights

Working Safely On or Near High-Voltage (HV) Equipment

What You Need To Know: Labeling

Warning symbols are found on HV batteries, HV components, and specialized parts to indicate the presence of high voltage.

Anyone interacting with an electric school bus shall be familiar with and follow manufacturer's guidelines for *identifying and following* the labeling on the vehicle and its systems.

These labeled components ***shall not*** be opened except for by specially trained personnel and according to manufacturers instructions.

High-voltage cables are **ORANGE** so they are easily identified.

CAUTION - HV Part

Working Safely On or Near High-Voltage (HV) Equipment

What You Need To Know: a Safety Plan

Have a plan **to ensure YOUR safety** that includes:

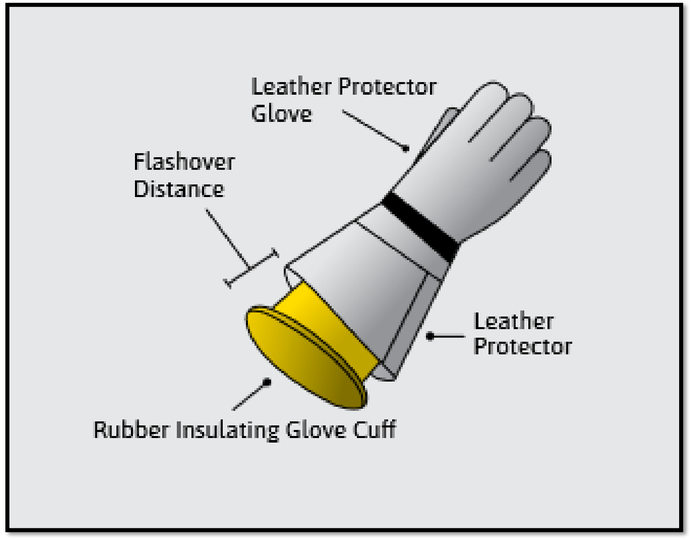
1. *A safe*, *clean, dry*, adequately lit work-space.
2. Familiarity with your organization and building's safety guidelines.
3. Removal of any conductive or metallic items from your person and/or pockets.
4. Making sure you are not working alone.
5. Inspection and proper use of all required personal protective equipment (PPE) and tools.
6. A secured and clearly marked work environment.
7. **De-energize the circuits and verify the absence of voltage.**
   - *Until an "absence of voltage" test is performed, always assume that the circuit is live, even if the system has been properly de-energized and is free of faults*
   - Lock-Out, Tag-Out (LOTO) the vehicle once de-energized

Equipment to Work on Electric Vehicles

Personal Protective Equipment (PPE): Gloves

Rubber Insulated Gloves:

- Protect the users' hands from electrocution when working on or near live, high voltage systems
- Voltage present in modern HV battery packs range from 300 – 900VDC
- Use **only** properly rated gloves
  - Class 00 = 1500VDC max *
  - Class 0 = 750VDC max



Leather Protector Gloves:

- Should always be worn over a rubber insulating glove to provide protection from cuts, abrasions, and punctures

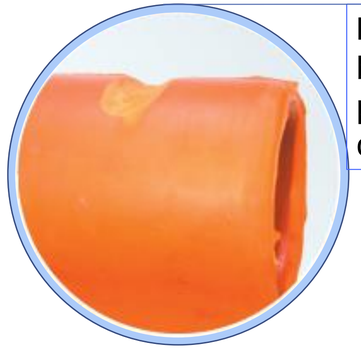
Equipment to Work on Electric Vehicles

Personal Protective Equipment (PPE): Glove Inspection

Prior to performing any de-energization or LOTO on the vehicle, visually inspect your gloves for ***CUTS, HOLES, TEARS,*** and any other obvious defects…

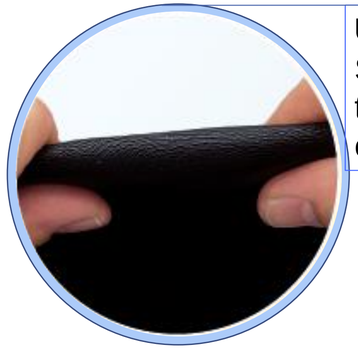
Cracking & Cutting: damage caused by prolonged folding or compressing.

Snags: Damage shown here is due to wood and metal splinters and other sharp objects.

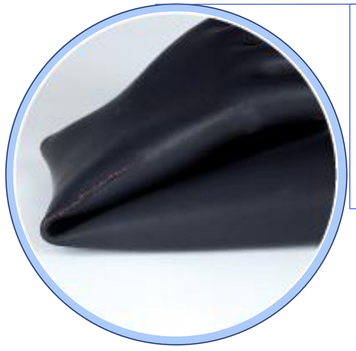


Physical Damage: Rope burns, deep cuts and puncture hazards are cause for rejection.

Chemical Attack: This photo shows swelling caused by oils and petroleum compounds.



UV Checking: Storing in areas exposed to prolonged sunlight causes UV checking.



Avoid Folding: The strain on rubber at a folded point is equal to stretching the rubber to twice its length.

Equipment to Work on Electric Vehicles

Personal Protective Equipment (PPE): Glove Inspection

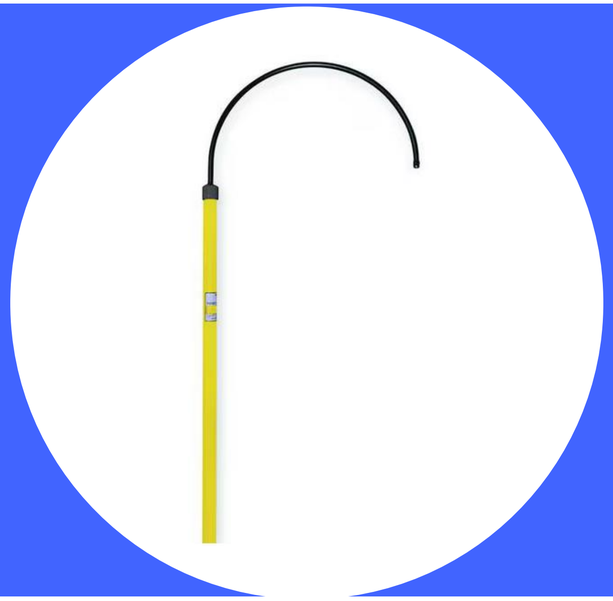
Other Glove Inspections and Tests

- *Air tests*
  - Blow and fold
  - Glove inflator

- *Inspect the Test Date*
  - Make sure your gloves have been replaced or tested every six (6) months

Equipment to Work on Electric Vehicles

Personal Protective Equipment (PPE): Other Items



Fiberglass Rescue Hook

Safety Glasses

Natural Fiber Clothing

EH Rated Safety boots

Equipment to Work on Electric Vehicles

Insulated Hand Tools

Usually available in kits

Use of insulated hand tools is **required** when any employee is in contact with parts or components of high voltage systems - *EVEN those which have been deenergized.*

Use only insulated hand tools that are compliant with **OSHA and NFPA** codes.

A **test date** is stamped on these tools as well, follow manufacturers schedule for re-testing or replacing.

Ask the school bus manufacturer or vendor if there are any specific tools required to perform work on or de-energization.

Equipment to Work on Electric Vehicles

Vehicle HV Safety Perimeter

What is it?

An obvious, highly visible barrier or marking that surrounds the entire vehicle to notify others that high voltage work is being performed.

When to put up:

Installed *prior to LOTO*, and certainly before any HV vehicle work is performed.

Why?

To prevent untrained, unfamiliar, or unprotected individuals from being exposed to potential lethal voltage.

What to use:

Cones, Caution tape, Specialty HV barriers, etc..

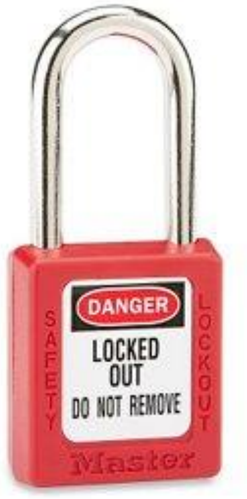
When to remove:

Once all HV components have been secured, verified safe, and all LOTO equipment has been removed.

DO NOT REMOVE A SAFETY PERIMETER UNLESS YOU ARE THE INDIVIDUAL THAT INSTALLED IT

Equipment to Work on Electric Vehicles

Tools Needed for Lock Out, Tag Out (LOTO)



Lock

Safety Hasp

Tags

CAT III Digital Multimeter
(rated for 0 to 1000 volts)

Working Safely On or Near High-Voltage (HV) Equipment

De-energizing the Vehicle

Always follow OEM instructions when de-energizing an electric school bus.

Generic steps include:

1. With **proper PPE equipped** and a **clear safety plan**, ensure the vehicle is properly shut down.
   - If a keyless fob is equipped, secure outside of any possible key detection range.
2. Locate all high voltage and (if applicable) low voltage disconnects. These can include:
   - Switches
   - Cable and connector
   - Service or other disconnects on a HV battery

3. Isolate HV energy by turning **off** or **removing** all means of disconnect
4. Wait several minutes for energy to dissipate before continuing to the next step:

   An LDL test

Working Safely On or Near High-Voltage (HV) Equipment

Live – Dead – Live Test (LDL test)

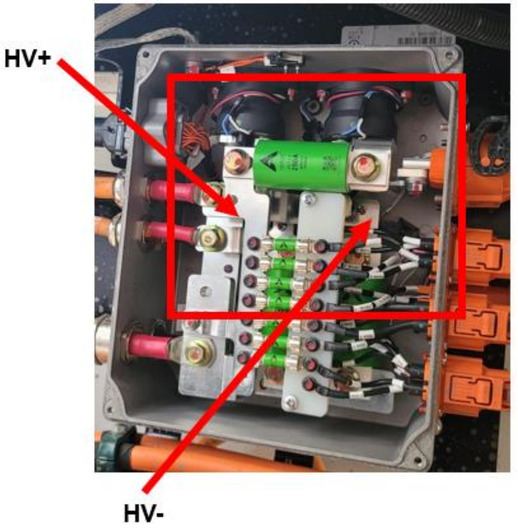
Required procedure that verifies **absence of voltage** in circuits using a portable test instrument (multimeter) and verifies the equipment taking measurements is functioning accurately.

How to perform an LDL test:

1. Using a multimeter (CAT-III) check a circuit that you know is LIVE and is a known voltage

   Tips: 12v battery, power tool battery

2. Then, at the vehicle, measure voltage of the circuit/system you believe to be “DEAD” and verify the absence of voltage (0.00V)
3. Go back to the LIVE circuit (12V battery) to ensure your meter is still operating properly



TEST before you TOUCH!

Working Safely On or Near High-Voltage (HV) Equipment

Generic Lock out, Tag out Procedures

What is Lock-Out, Tag-Out (LOTO)?

Lockout – physically isolates sources of energy making the bus safe to work on

Tagout – prominent warning that states the vehicle is de-energized, not to re-energize it, and communicates who tagged the vehicle out

- Lockouts will be applied to *switches*, *cables*, and *various other locations* where controls can be operated to energize a circuit.
- Vehicle-specific procedures and instructions **will** apply, check with your OEM.
- <u>The employer is responsible for providing training specific to the vehicle and needs of the qualified person working on the vehicle.</u>

Worker Considerations

- **Always assume voltage is present** in a system until you have personally verified the system is safe
- Pay special attention to the certification/test dates, condition, and proper use of PPE
- Ensure you aren't working **alone** when around high voltage…
- **and** that another person is nearby, prepared and ready to react if a safety incident occurs
- Follow a **consistent** safety plan
- *Do not get complacent*

Questions and Answers

Presentation 3

Required Skills and Knowledge

Angel Yin

Learning Outcomes

- Compare similarities & differences between an ICE school bus and an ESB
- List tasks that a trained ESB technician needs to perform
- Discuss needed background skills for ESB technicians and sources for acquiring these skills
- Identify recommended ESB technician qualifications

Electric School Bus (ESB) vs. ICE School Bus

Differences in Maintaining Internal Combustion and Electric Systems

Internal Combustion Only 	Internal Combustion & Electric Similarities	Electric Only 
Engine system (engine, radiator, oil filter, coolant hoses, etc.)	Body and interior maintenance (doors, windows, seats, etc.)	High-voltage systems (battery, inverter, components, etc.)
Exhaust system (exhaust pipes, exhaust brake, etc.)	Low Voltage Systems (Climate control, accessories, and telematics)	High-voltage safety (protective equipment, procedures)
Fuel system (tank, pump, injector, etc.)	Brakes and suspension	Charger system (outlets, wiring, voltage, etc)
	Gauges and warnings (instrument cluster, fault codes)	Chassis and driveline system modifications (body mounts, e-axles, drive shaft)

Background Skills for ESB Technicians

Needed Background Skills

Internal Combustion & Electric Similarities Be experienced in performing maintenance on internal combustion engine on vehicles in the areas of:	**EV Basics-prerequisite** Never performs maintenance on an EV but has a solid understanding of electrical theories and is skills at interpreting electrical schematics	**EV Advanced** Be experienced in performing maintenance on other types of electric vehicles in the areas of:
Body and interior maintenance (Doors, windows, seats, etc.)	Basic Electrical Schematic & Standards (Electrical principals & circuits) - Multiplexing	HV Accessories (HVAC, Defroster, Sensors, Telematics, etc.)
Low Voltage Systems (Climate control, accessories, and telematics)	High Voltage System Basics & Safety (Battery, inverter, components, protective equipment, procedures, etc.)	Diagnostic Tool (Diagnosis information & equipment)
Brakes, Suspension and Steering	Charger System (Outlets, wiring, voltage, etc.)	
Gauges and Warnings (Instrument cluster, fault codes)	Chassis and Driveline System Modifications (Body mounts, e-axles, drive shaft)	
Proper Towing Method	Preventive Maintenance (Systems that require regular maintenance, maintenance schedule etc.)	

ESB Component Identification

High-Voltage (HV)

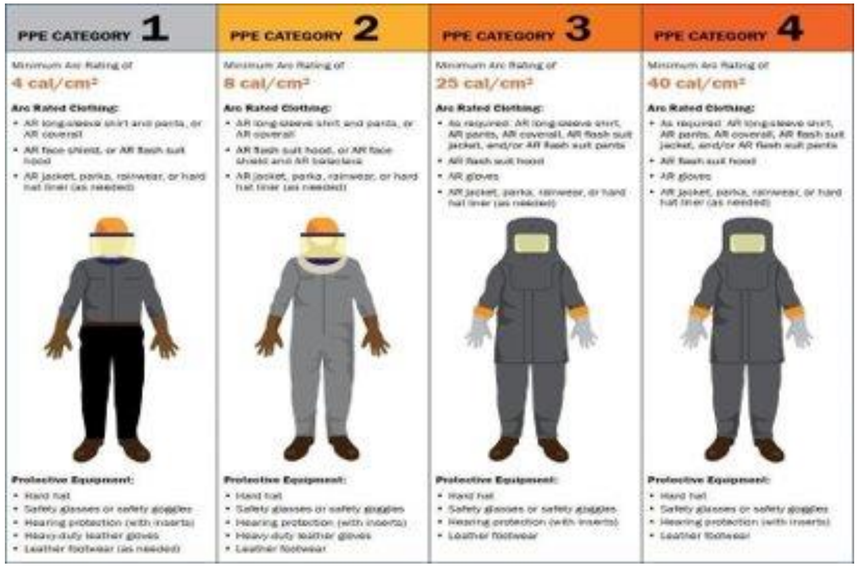
Safety First!

For automotive applications, any voltage **greater than 30 volts AC (or 60 volts DC)** is considered high or hazardous voltage due to the potential to produce serious injury or death due to electric shock.

Most ESBs in the market **use HV systems (500V-900V) to operate major vehicle components including motors, controllers, AC**, etc.

As with all technology, proper care and tools must be taken when operating and servicing this type of vehicle.

Electric Propulsion Systems require an AR rated **Category 2 level PPE** with an **8 cal/cm² minimum protection**.



Background Skills for ESB Technicians

Where to acquiring background knowledge and skills

Sources	Examples
Community Colleges	Electric Vehicle Technology Certificate Program (national, online) – Open Education Consortium, National STEM Consortium, US Department of Labor
Trade Schools	Advanced Transportation & Manufacturing Pathway (ATM) (local, in-person) - Los Angeles Trade Tech (LATTC)
Employers	Check with your employer
Government	EV Champion Training (national, online) - National Institute of Building Sciences, National Renewable Energy Lab (NREL)
Private Organizations	Transportation Technologies Service Professionals, Future Tech Auto (national, online) - Transportation Technologies Service Professionals, Future Tech Auto
Other (Union/non-profit)	ETA International (national, online) - Electric Vehicle Technician Certification
OEM or Dealer	Check with your OEM & Dealer

Great Resources

WRI Electric School Bus Initiative **Electric School Bus Technician Training Database** contains both online and in-person programs across 19 states.

Technician Certifications

Recommended Qualifications

National Fire Protection Association 70E, Standard For Electrical Safety In The Workplace

SAE International
Vehicle Dynamics Certificate Program

The National Institute for Automotive Service Excellence

Training Program Example: BYD|RIDE

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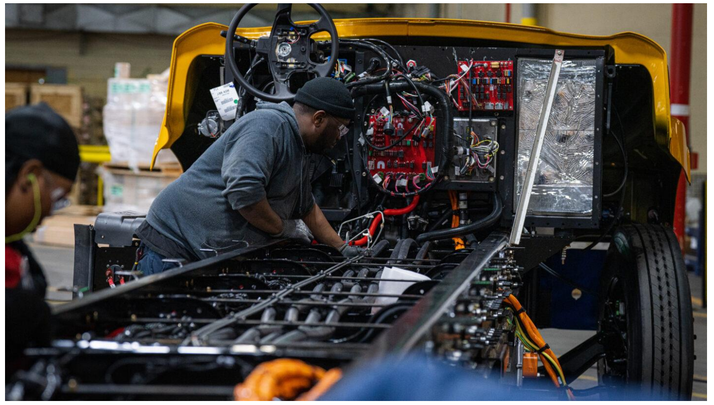
Operator

This module is designed for personnel who will drive the bus:

- Vehicle Overview
- Pre-drive Walkaround Inspection
- Safe Driving Techniques
- Emergency Handling Best Practices

Technician



This module is designed for technicians performing electrical work on the bus:

- Vehicle Overview
- HV Safety & Lockout Tagout
- LV System
- HVAC & HV Defroster
- BESS
- Preventive Maintenance

First Responder

This module is designed for first responders for accident or emergency responding:

- Introduction to Ride
- Disabling Ride Vehicles
- High-voltage Components
- Vehicle Safety Equipment

Questions and Answers

OEM Training Program

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Register for ESB Familiarization Webinars

Webinar topics:

- Module 1: Operator Overview (April 10)
- Module 2: Electric School Bus Technology Overview (August 7)
- Module 3: High Voltage Safety Considerations (October 1)
- *Module 4: Charging Considerations

Register at:
driveelectric.gov/webinars

Registration for Module 4 coming soon!

Thank you!

Today's Presentation:
Module: High Voltage Safety Considerations

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