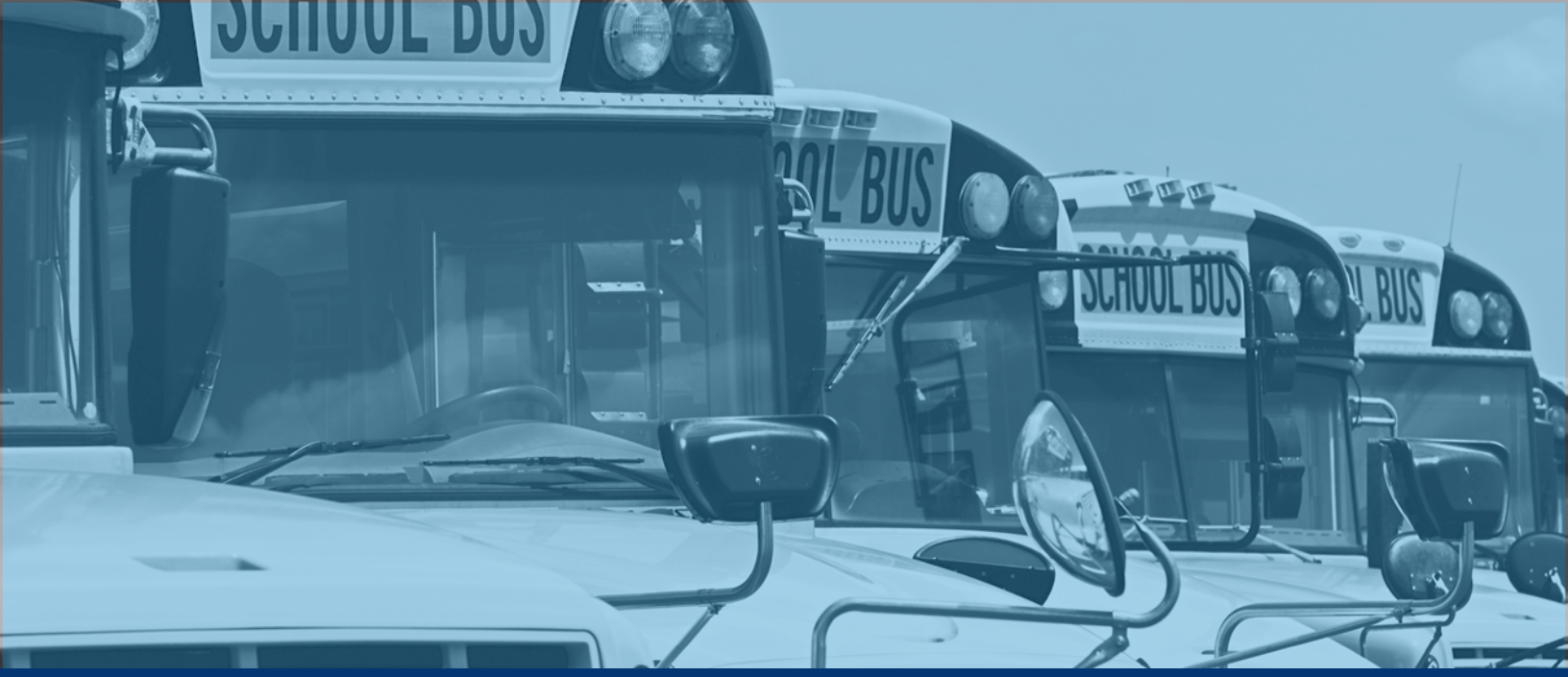

Electric School Bus Guidebook

Guide 9: Safety

NEW YORK STATE | NYSERDA

Understanding the potential risks and mitigation strategies can help ensure safe operations of ESB and chargers.

Electric school buses (ESBs) and chargers include many features that ensure the safety of drivers, maintenance technicians, and other ESB users. This guide explores the safety features of ESBs and chargers, and summarizes best safety practices for drivers, technicians, and first responders.

This chapter of the Electric School Bus Guidebook answers these questions:

- What technology and safety standards exist to ensure ESBs and chargers are safe?
- What are the available fire prevention technologies?
- When should school districts contact first responders?
- Where can I find more information about ESB and charger safety?

Key Activities

Initial actions you can take after reading this chapter include:

- Collect emergency response guides from your ESB and charger dealers and ask about trainings they offer or recommend.
- Purchase any necessary personal protective equipment (PPE) for your maintenance and technician staff.
- Read the user manuals provided by the manufacturers to understand best operating and maintenance practices for your newly purchased equipment.

ESB Safety

In general, electric school buses are very safe; the risk of an ESB catching fire is significantly lower than that of a combustion-powered vehicle.[1] The safety features of ESBs start with their manufacturer design and testing, but in order to keep all users safe, it is important for fleet owners, technicians, drivers, and first-responders to know about the different features of the bus's drivetrain.

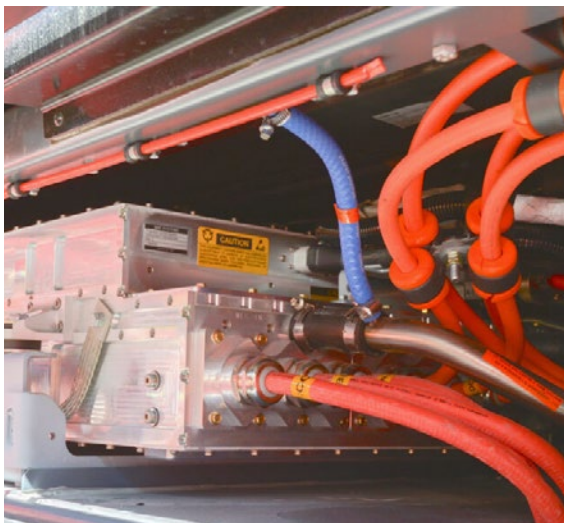

Figure 1: Orange High-Voltage Cabling

ESBs contain high-voltage cabling, which are made clearly visible to technicians by their bright orange color, and equipment including battery packs and electric drivetrains (Figure 1). Servicing this equipment requires special training and personal protective equipment (PPE), such as insulated rubber gloves and proper footwear. This work is typically performed by certified technicians at the local dealership, especially while buses are under manufacturer warranty. While many of the non-warranty maintenance and repair procedures are similar to those of conventional buses, technicians should also receive general training before performing maintenance on ESBs. Training is recommended for any staff that may come in contact with the ESB drivetrains, battery packs, and high voltage wiring, even if they are not directly servicing these components. Additional information on training can be found in Guide 10: Workforce Development.

Charger Safety

Chargers are required to meet strict technical national and international codes and standards.[2,3] It is important to confirm with your dealer that the charger you purchase and install meets all required safety standards and codes to ensure safe and reliable usage. These standards and codes regulate the type of components charger equipment use, ensure the functionality of internal and external electrical conductors and equipment, and verify electrical load and equipment load ratings of chargers and ESBs.

Charger components typically include an enclosure certified by the National Electrical Manufacturers Association (NEMA)[4], electronics, a power connection, flexible electric cables, connectors that plug into the ESB, and in some cases, network connectivity hardware.[5] While most charger components are protected by the enclosure, the ports, charging cables, and connectors are outside the housing. The exposed components are used for charging operations and are safe to use under normal operating conditions, including hot and cold temperatures and wet conditions. Users should always visually inspect these exterior components for any damage before connecting to an ESB.

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[1] https://sfregionalcouncil.org/wp-content/uploads/2023/08/Blue-Bird-Emergency-Response-Guide.pdf
[2] https://share.ansi.org/evsp/ANSI_EVSP_Roadmap_June_2023.pdf
[3] https://www.nrel.gov/docs/fy21osti/78085.pdf
[4] https://www.nema.org/docs/default-source/nema-documents-libraries/electric-vehicle-supply-equipment-systems-trifold.pdf
[5] https://www.besen-group.com/what-are-the-main-components-of-ev-chargers/#:~:text=The%20power%20supply%2C%20charging%20cable,role%20in%20the%20charging%20process

ESB and Charger Fire Safety

Electric vehicles are far less likely to be involved in fires than those powered by diesel or gasoline. The federal National Transportation Safety Board collects data on vehicle fires and an analysis of that data found that, in 2022, 1,530 gasoline-powered vehicles per 100,000 were involved in vehicle fires while only 25 electric vehicles per 100,000 were involved in fires (Figure 2).[6] As of early September 2023, there are over 1,200 ESBs deployed in the United States.[7] Out of these, only one bus fire has been reported, and this was attributable to a computer component failure and the fire did not spread to the battery.[8]

While fires involving ESBs occur far less frequently when compared to diesel/gasoline buses, they can reach higher temperatures and require more water and time for fire service personnel to extinguish. You can install, or upgrade an existing, fire prevention system to limit damage and reduce fire spread in the rare event of a battery fire. National Fire Protection Association (NFPA) has developed useful resources that can be shared with drivers and other maintenance staff to help prepare for ESB emergencies.

Fast Facts: NEMA enclosures

- NEMA enclosures are rigid casings around chargers designed to prevent electric shock and protect electronics from environmental hazards such as water intrusion.
- Your charger installer should note in their contract that they must install NEMA enclosures in compliance with NFPA 70, National Electric Code, which ensures people and surrounding equipment are properly protected against electrical hazards.

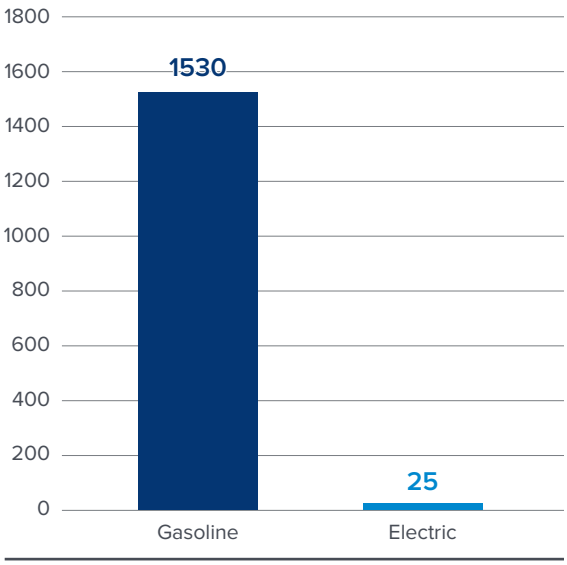

Figure 2: Vehicle Fires

Fire Prevention: ESB Equipment

The best way for fleet owners to minimize fire risk is to continue purchasing high-quality and rigorously-tested products, which electric school bus equipment manufacturers all offer. The following fire and general safety considerations are part of the development and ongoing improvement of ESBs:

- **Extensive battery testing.** ESB batteries must follow globally recognized safety standards that include SAE J2929 and ISO 26262. Additionally, lithium-ion batteries must have UL and UN safety certifications.[9] All standards must be met for a vehicle to be certified for sale.
- **Increasingly stable battery chemistry.** The chemistry in lithium-ion batteries, which are used in almost all ESBs, is more stable than that of batteries commonly used in EVs. This chemistry enables the battery to operate through long durations of high temperatures, which decreases the chances of fire.
- **Substantial battery protection.** ESB batteries are housed in a protective casing, which is typically constructed from steel or aluminum and protects the battery cells from mechanical damage, creates an airtight and waterproof seal, cushions battery cells against vibrations, and helps protect other ESB components from battery fires.[10]
- **Battery management system.** ESB batteries are equipped with Battery Management Systems (BMS), which regulates voltage, temperature, and humidity levels to minimize cell damage and fire risk.[11] In the event of an ESB collision or short circuit, emergency disconnect switches automatically disengage the battery from the high-voltage systems to protect against electrical arcing and reduce fire risk.
- **Collision safety measure.** ESB batteries are centered under the chassis in the middle of the bus, which creates a lower and more stable center of gravity. This design feature helps prevent damage to the battery from collisions, rollovers, and tipping during sharp turns.[12] Emergency electrical disconnects automatically activate when a collision or short circuit is detected.

[6] https://www.kbb.com/car-news/study-electric-vehicles-involved-in-fewest-car-fires/
[7] https://www.wri.org/insights/where-electric-school-buses-us
[8] https://sierrawave.net/small-fire-erupts-in-electric-school-bus-swift-action-by-bishop-volunteer-fire-department-prevents-disaster/
[9] https://www.shopulstandards.com/ProductDetail.aspx?productId=UL1642
[10] https://blog.evbox.com/what-are-ev-batteries-made-of#:~:text=Finally%2C%20the%20individual%20cells%20are,protects%20it%20against%20mechanical%20damage
[11] https://afdc.energy.gov/files/u/publication/electric-school-bus-us-market-study-buyers-guide.pdf?da24b3ed9c
[12] https://electricschoolbusinitiative.org/all-about-electric-school-bus-battery-safety

Fire Prevention: Charger Equipment

Fleet operators must practice prevention via regular maintenance and safe charging. Before connecting a charger to an ESB, the connector and connector port should be inspected to ensure there are no obstructions. Users should also confirm there is no damage to the connector or connector port. If there is an obstruction or damage, contact the dealer or a licensed technician for repairs.[13] Similarly, users should inspect cabling for any damage such as nicked or frayed cords or exposed wiring. When charging is complete, users should unplug the connector from the charging port and place it in the appropriate receptacle located on or near the charger as directed in the charger user manual. Chargers are weather resistant and can be used in the rain and in hot or cold weather without any additional safety considerations.[14] Make sure to follow all manufacturer-provided charger operation and safety documentation to understand the function of your installed charger before using. Refer to Guide 8: Charger Operations and Maintenance, for more information.

Fire Prevention: Collision Response

If a collision occurs, a thorough visual inspection of the battery by authorized personnel (e.g. trained technicians, supervisors, etc.) should be conducted before redeployment to ensure no damage has occurred. Damaged batteries are more likely to result in a fire. If an ESB battery appears to have been damaged, the ESB should be kept at least 50 feet from other structures or vehicles to prevent the spread of fire, should it occur.[15] Additionally, contact your dealer, who will perform any necessary battery maintenance or replacement required for the safe operation of your ESBs.

Fire Response

A critical part of minimizing fire risk and maintaining high levels of safety on and around electric school buses is engaging early and often with local fire and first response teams. ESB alert systems for potential battery fires, based on overheating, off-gassing or other warning signs, generally provide notification before a fire breaks out or spreads. Knowing what to do immediately after an alert is critical. The following steps can help fleet owners and employees be prepared in the event of an incident:

- Meet your fire department early in the process so they are familiar with both the buses and the chargers before responding to any event. Fire personnel should also be familiarized with where the shut off switches are.
- Manual “shut off” switches for the chargers should be clearly labeled and located near an entrance or the fire service information point to assist the fire department in the event of a fire.
- Provide fire extinguishers and fire blankets rated for your ESB battery type to control small fires before they grow.
- Identify and ensure employees are aware of where to bring a bus that is showing signs of a potential battery issue.

Additional Resources

The National Fire Prevention Association (NFPA) – The webpage for NFPA alternative fuel vehicles safety and training resources.

Alternative Fuels Data Center – The U.S. Department of Energy’s webpage on maintenance and safety for electric vehicles.

ESB manufacturers have worked independently and with the NFPA to prepare emergency and first responder guides for their vehicles. ESB emergency and first responder guides from electric school bus manufacturers include:

- Thomas Built Electric Buses 2020 Emergency Response Guide
- IC Bus Electric Buses First Responder Guides
- Lion Electric Buses 2020 Emergency Response Guide
- Blue Bird Electric Buses 2019 Emergency Response Guide

FEMA Electric Vehicle Charging Safety Tips – FEMA webpage for EV fire prevention and charger operating and installation safety tips.

[13] https://evitp.org/newyork
[14] https://www.nhtsa.gov/vehicle-safety/electric-and-hybrid-vehicles
[15] https://www.automotive-fleet.com/10209851/putting-ev-battery-risks-and-safety-into-perspective