EBOOK

Enhancing Safety Measures for Personnel in Electric Vehicle Charging Operations

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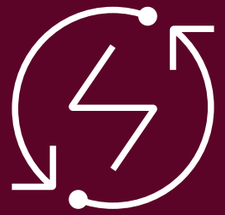
Introduction

Electric vehicles (EV) continue to expand their reach into the automotive market, highlighting the need for safety in EVs and all related infrastructure and equipment. Personnel protection systems, part of electric vehicle supply equipment (EVSE), are a crucial part of maintaining safe operation, and the certification of these systems is essential. These systems increase safety for the user and are required by UL 2594, the Standard for Safety for Electric Vehicle Supply Equipment (EVSE), and UL 2202, the Standard for DC Charging Equipment for Electric Vehicles (EVCE). Understanding certification requirements can help support innovation and encourage safety in the evolving EV market.



The importance of safety codes and standards for EVSE personnel protection systems

EVSE certification is essential to support safety, compatibility and consumer confidence. EVSE is a key part of the electrical infrastructure that supplies electricity to an EV and behaves like an intermediary between the utility grid power supply and the EV. These systems are often referred to as EV charging stations, designated Level 2 EVSE and fast DC charging, and provide an electrical access point for an EV to recharge safely and efficiently.

EVSE consists of the following main components:

1. EV couplers and EV cables – These allow for a convenient connection from the EVSE to the EV. They are evaluated to comply with UL 2251, the Standard for Plugs, Receptacles, and Couplers for Electric Vehicles, and UL 2263, the Standard for Offboard Cable, respectively.

2. Conductive EV supply equipment intended to supply AC power – More commonly known as charging stations, this equipment provides electrical power to the EV to charge the battery.

3. EV personnel protection system – These systems include components such as charge-circuit interrupting devices (CCIDs) or isolation monitor/interrupters (IM/Is) and are in place to detect and mitigate against shock hazards.

For human and system safety, the personal protection system is the most important component of EVSE. The role of EV personnel protection systems includes:

- Preventing electric shock – CCIDs monitor electrical current flow and detect imbalances indicative of potential electric shock during ground faults. These devices are required to interrupt the circuit as fast as 24.9 milliseconds (msec).
- Reducing fire risk – CCIDs can help mitigate the risk of electrical fires by promptly disconnecting power in the event of faulty wiring or device malfunctions.
- Increasing personal safety in wet environments – CCIDs are especially critical in wet conditions due to the heightened risk of electric shock.
- Supporting compliance and regulation: NFPA 70®, National Electric Code® (NEC), Article 625.22 mandates personnel protection systems in compliance with UL 2231, the Standard for Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits, equivalently referenced in UL 2594, Section 9.2, and UL 2202, Section 9.1.
- Contributing to public health and safety – Protection by CCID/IMI is vital in public and commercial settings to help prevent accidents and injuries.

Safety requirements and codes

North American EVSE is evaluated according to the following UL Standards for safety:

- UL 2594, the Standard for Safety for Electric Vehicle Supply Equipment (EVSE)
- UL 2202, the Standard for DC Charging Equipment for Electric Vehicles (EVCE)

These standards encompass the general safety requirements for EVSE, including electrical and mechanical construction and performance, to help enhance the safety EV operation and charging. They also require the certification of certain components within the EVSE. One important example of this is the requirement for testing of personnel protection systems, which are a part of EVSE and play a critical role in protecting users from electric shock.

Level 1 and Level 2 EVSE commonly use CCIDs to monitor for ground faults, similar in protective function to ground fault circuit interrupters (GFCIs), to help mitigate hazardous conditions that may pose a risk of shock to the user. DC fast charging stations commonly use IM/I, which monitor the isolation insulation resistance of the AC primary to the DC secondary output circuits. In the event of a fault condition, ground fault or loss of isolation, the EV personnel protection system is designed to interrupt the circuit to load in a safe and controlled manner.

Testing and certification to UL 2231 supports safer EV charging systems by evaluating the performance of EVSE components as a complete system to meet requirements for interrupting times and thresholds.

This standard groups safety requirements for personnel protection systems into two categories:

- Centrally grounded system – Utilizes CCIDs within centrally grounded EV charging systems, such as Level 1 and Level 2 EVSE. CCIDs are akin to GFCI protection, recognized by NEC, Article 210.8, for their contribution to electrical safety.
- Isolated system – Employs IM/Is for personnel protection in Level 3 or rapid, high-power DC charging equipment.

UL 2231 is divided into two parts and personnel protection systems must fully comply according to both parts:

- UL 2231-1 addresses general requirements for personnel protection systems in EV supply circuits, establishing safety criteria for design and installation to provide adequate electric shock protection.
- UL 2231-2 specifies requirements for protection devices in charging systems, detailing performance characteristics and test methods for devices that safeguard against electric shock during EV charging.

Testing and compliance to UL 2231 assesses system reliability, including hardware, interrupting means and microprocessor software control, for ground fault protection, along with the following critical conditions:

Ground fault detection and interruption:
This process is in line with the interrupting time versus magnitude of ground fault current, often referred to as the Class A equation. CCIDs are evaluated to requirements equivalent to those for GFCIs assessed to UL 943, the Standard for Safety of Ground Fault Circuit Interrupters. CCIDs must demonstrate compliance with the time-current trip curve under all conditions, including fault, supply voltage and reliability thermal shock (-35°C-66•C) to demonstrate effective personnel ground fault protection.

Isolation monitor detection and interruption (IM/I):
This function activates when the isolation between primary and secondary circuits surpasses a predefined time versus impedance threshold (100 ohm/V), as an additional safety measure.

Auto-supervisory test circuit:
This feature confirms the integrity of the protective function automatically before each charging session, contributing to the overall safety and reliability of the EVSE.

Auto-reclosure feature:
Unique to EV protection systems, this function permits a reattempt to initiate a charging session if the EVSE previously interrupted the circuit due to a detected fault. UL 2231 requires the assessment of safeguards through functional safety for associated risks in accordance with:

- UL 991, the Standard for Tests for Safety-Related Controls Employing Solid-State Devices
- UL 1998, the Standard for Software in Programmable Components

EV supply equipment standards

1. EV charging adapter

UL 2252
The standard for adapters for use with electric vehicle couplers

2. Vehicle connector

UL 2251
The standard for plugs, receptacles and couplers for electric vehicles

UL 2278
The standard for megawatt charging configured electric vehicle couplers

3. Offboard cable

UL 2263
The standard for electric vehicle cable

IEC 62893-1

IEC 62893-2

IEC 62893-4-1

IEC 62893-4-2

DIN EN 50620

4. Cordset

UL 2594
The standard for electric vehicle supply equipment

ISA/IEC 62443

IEC 62752

IEC 61851-1

5. Personal protection equipment

UL 2231-1 and UL 2231-2
The standard for Personal protection systems for electric vehicle (EV) supply circuits

IEC 61008-1

IEC 61009-1

IEC 62955

IEC 62423

6. Wireless charging

UL 2750
Outline of investigation for wireless power transfer equipment for electrical vehicles

ISA/IEC 62443

7. AC charging station

UL 2594
The standard for electric vehicle supply equipment

IEC 61851-1

IEC 61851-1-21-2

IEC 61439-7

IEC 62752

ISA/IEC 62443

IEC 61508

8. DC charging station

UL 2202
The standard for electric vehicle (EV) charging system equipment

IEC 61851-1

IEC 61851-23

IEC 61851-21-2

IEC 61851-24

IEC 61439-7

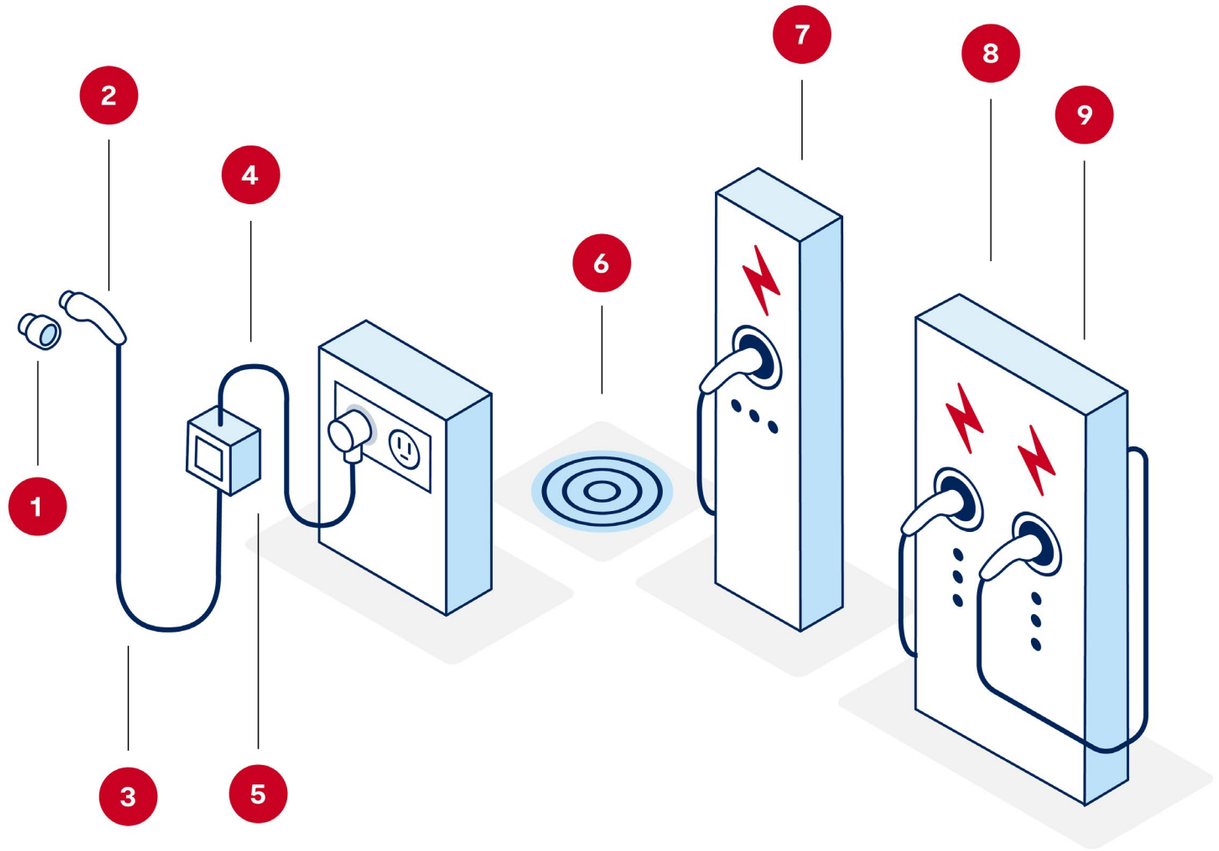
ISA/IEC 62443

IEC 61508

9. Bidirectional charging station

UL 9741
Outline of investigation for Electric vehicle power export equipment (EVPE)

ISA/IEC 62443



Benefits of certification for EVSE and personnel protection systems

Manufacturers of EVSE are obligated to demonstrate compliance with both UL 2231 and UL 2594/UL 2202 when designing and producing their charging equipment. The benefits of certification include:

Safety: Certification confirms that the EVSE has undergone testing and complies with specific safety standards to mitigate electrical hazards such as shock, short circuit and fire. Certified equipment is engineered to manage continuous high-power levels and withstand harsh outdoor environments necessary for the safe charging of EVs.

Compliance with regulations: EVSE must adhere to regional regulations and electrical codes. Certification signifies that the equipment conforms to these legal mandates, which may encompass material quality, electrical connection design and unit robustness. In North America, NFPA 70, Article 625, on electric vehicle power transfer systems addresses electrical conductors and equipment connecting an EV to premises wiring for charging purposes.

Reliability: Certified EVSE demonstrate reliability through extensive testing that assesses performance under various conditions. This is vital for EV owners who rely on their chargers to function correctly with each use.

Consumer confidence: Certification indicates to consumers that an EVSE meets independent standards, enhancing their confidence in the product. This trust can help advance the adoption of electric vehicles by alleviating concerns about charging infrastructure.

Innovation and continuous improvement: The certification process helps promote innovation and advancements in charging technology as manufacturers aim to fulfill and surpass established standards.

Adherence to recognized standards helps support the safety and reliability of EVSE for consumer use. Certification to applicable standards through UL Solutions helps demonstrate that the equipment adheres to applicable safety and performance standards and meets requirements for protection against electrical hazards and installation in accordance with the NEC.

To learn more about these requirements and to better understand the significance of certification marks, please visit our Electric Vehicle (EV) Charging Infrastructure Services page.

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