NECA 413

Standard for Installing and Maintaining Electric Vehicle Supply Equipment (EVSE)

ANSI Canvass Draft
October 2016

(This foreword is not a part of the standard)

Foreword

National Electrical Installation Standards® (*NEIS®*) are designed to improve communication among specifiers, purchasers, and suppliers of electrical construction services. They define a minimum baseline of quality and workmanship for installing electrical products and systems. *NEIS®* are intended to be referenced in contract documents for electrical construction projects. The following language is recommended:

> Electric vehicle supply equipment shall be installed and maintained in accordance with NECA 413-201x, *Standard for Installing and Maintaining Electric Vehicle Supply Equipment (EVSE)* (ANSI).

Use of *NEIS®* is voluntary, and the National Electrical Contractors Association (NECA) assumes no obligation or liability to users of this publication. Existence of a standard shall not preclude any member or non-member of NECA from specifying or using alternate construction methods permitted by applicable regulations.

This publication is intended to comply with the National Electrical Code (NEC). Because they are quality standards, *NEIS* may in some instances go beyond the minimum safety requirements of the NEC. It is the responsibility of users of this publication to comply with state and local electrical codes and Federal and state OSHA safety regulations as well as follow manufacturer installation instructions when installing electrical products and systems.

Suggestions for revisions and improvements to this standard are welcome. They should be addressed to:

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1. Scope

This standard describes the procedures for installing and maintaining AC Level 1, AC Level 2 and fast charging DC (initially known in the industry as AC Level 3 and currently known in the industry as DC Level 2) Electric Vehicle Supply Equipment (EVSE).

Figure 1.1.1 Electric vehicle supply equipment Courtesy of NECA Copyright Rob Colgan

1.1 Products and Applications Included

This Standard applies to Electric Vehicle Supply Equipment (EVSE) that complies with applicable local, state and federal regulations, codes, and standards for AC Level 1, AC Level 2 and fast charging DC (DC Level 2) EVSE intended for transferring energy between premises wiring systems and electric vehicles (EVs) by conductive, inductive, or wireless power transfer (contactless inductive charging) means.

Figure 1.1.2 Photo showing typical AC Level 1 electric vehicle supply equipment (EVSE) Courtesy of Legrand/Pass and Seymour

Figure 1.1.3 Photo showing typical AC Level 2 electric vehicle supply equipment (EVSE)
Courtesy of Legrand/Pass and Seymour

1.2 Products and Applications Excluded

This Standard does not apply to other than Code compliant AC Level 1, AC Level 2 and fast charging DC (DC Level 2) EVSE, as well as off-road, self-propelled electric vehicles, such as industrial trucks, hoists, lifts, transports, golf carts, airline ground support equipment, tractors, boats, and the like.

1.3 Regulatory and Other Requirements

All information in this publication is intended to conform to the NEC (ANSI/NFPA 70). Installers shall follow the NEC, applicable state and local codes, manufacturer instructions, and contract documents when installing and maintaining Electric Vehicle Supply Equipment (EVSE).

Only qualified persons as defined in the NEC familiar with the construction and installation of Electric Vehicle Supply Equipment (EVSE) shall perform the technical work described in this publication. Administrative functions and other non-technical tasks can be performed under the supervision of a qualified person. All work shall be performed in accordance with NFPA 70E, *Standard for Electrical Safety in the Workplace.*

General requirements for installing electrical products and systems are described in NECA 1, *Standard Practices for Good Workmanship in Electrical Construction (ANSI).* Other *NEIS* provide additional guidance for installing particular types of electrical products and systems. A complete list of *NEIS* is provided in Annex C.

1.4 Mandatory Requirements, Permissive Requirements, Quality and Performance Instructions, Explanatory Material, and Informative Annexes

Mandatory requirements in manufacturer instructions, or of Codes or other mandatory Standards that may or not be adopted into law, are those that identify actions that are specifically required or prohibited and are characterized by the use of the terms "must" or "must not," "shall" or "shall not," or "may not," or "are not permitted," or "are required," or by the use of positive phrasing of mandatory requirements. Examples of mandatory requirements may equally take the form of, "equipment must be protected," "equipment shall be protected," or "protect equipment," with the latter interpreted (understood) as "(it is necessary to) protect equipment."

Permissive requirements of manufacturer instructions, or of Codes or other mandatory Standards that may or not be adopted into law, are those that identify actions that are allowed but not required, or are normally used to describe options or alternative means and methods, and are characterized in this Standard by the use of the terms "may," or "are permitted," or "are not required."

Quality and performance instructions identify actions that are recommended or not recommended to improve the overall quality or performance of the installation and are characterized by the use of the terms "should" or "should not."

Explanatory material, such as references to other Codes, Standards, or documents, references to related sections of this Standard, information related to another Code, Standard, or document, and supplemental application and design information and data, is included throughout this Standard to expand the understanding of mandatory requirements, permissive requirements, and quality and performance instructions. Such explanatory material is included for information purposes only, and is identified by the use of the term "NOTE," or by the use of italicized text.

Non-mandatory information and other reference standards or documents relative to the application and use of materials, equipment, and systems covered by this Standard are provided in informative annexes. Informative annexes are not part of the enforceable requirements of this Standard, but are included for information purposes only.

2. Definitions

AC Level 1 Charging. Electric vehicle (EV) charging that employs cord-and-plug connected portable electric vehicle supply equipment (EVSE). AC Level 1 EVSE is rated single-phase, nominal 120VAC, with either a 15A or 20A configuration, and is suitable for connection to NEMA 5-15R or 5-20R receptacles.

AC Level 2 Charging. AC Level 2 EVSE is rated single-phase, nominal 208VAC or 240VAC, 80A maximum, with branch circuit overcurrent protection as required. AC Level 2 charging for indoor use could be cord and plug connected or permanently wired EVSE operated at a fixed or portable location used specifically for EV charging.

AC Level 3 Charging. At the time of publication of this Standard, the voltage, ampacity, and power ratings of AC Level 3 charging are not finalized.

Authority Having Jurisdiction (AHJ). An organization, office or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

Battery. An electrochemical device that transforms stored chemical energy into electric energy during discharge. Batteries for EVs are electrically connected in a series and/or parallel arrangement to provide the voltage, power, capacity, and packaging requirements of the EV. Also see Battery Pack and Battery System.

Battery Electric Vehicle (BEV). An automotive-type vehicle that is powered solely by the battery energy storage system available on-board the vehicle. Since there is no other significant energy source, BEV batteries are typically an order of magnitude larger than the batteries in hybrid or plug-in hybrid electric vehicles (PHEV). Also see Plug-in Hybrid Electric Vehicle (PHEV).

Battery Pack. A group of batteries connected in a serial and/or parallel arrangement, selected and configured as a unit to meet the voltage, power, capacity, and packaging requirements of the EV.

Battery System. The EV battery pack and battery support equipment, such as thermal management and battery monitoring and controls.

Cable Management System. An apparatus designed to control and organize the output cable to the electric vehicle or to the primary pad.

Capacity. The total number of ampere-hours (Ah) that can be withdrawn from a fully charged cell or battery for a specific set of operating conditions, including discharge rate, temperature, age, stand time, and discharge termination criteria.

Charge Circuit Interrupting Device (CCID). A protective device that continuously monitors the current differential between all current-carrying conductors in a grounded system and opens the circuit if the differential current exceeds a preset threshold.

Charger. An electrical device that converts alternating-current (AC) energy to a regulated direct-current (DC) energy for replenishing the energy of an energy storage device, such as a battery, and for operating other vehicle electrical systems.

Charger Power Converter. The device used to convert energy from the power grid to a high-frequency output for wireless power transfer.

Continuous Load. A load where the maximum current is expected to continue for 3 hours or more.

DC Level 1 Charging. EV charging that employs permanently wired EVSE that is operated at a fixed location and is used specifically for EV charging. DC Level 1 EVSE is rated 200VDC to 450VDC with 80A maximum.

DC Level 2 Charging (Fast Charging DC). EV charging that employs permanently wired EVSE that is operated at a fixed location and is used specifically for EV charging. DC Level 2 EVSE is rated 200VDC to 450VDC with 200A maximum. DC Level 2 is currently known as Fast Charging DC.

DC Level 3 Charging. DC Level 3 EVSE is rated 200VDC to 600VDC with 400A maximum. At the time of the publication of this Standard, the voltage, ampacity, and power ratings of DC Level 3 charging are not finalized.

Electric Vehicle (EV). An automotive-type vehicle for on-road use, such as passenger automobiles, buses, trucks, vans, neighborhood electric vehicles (EVs), electric motorcycles, and the like, primarily powered by an electric motor that draws current from a rechargeable storage battery, fuel cell, photovoltaic array, or other source of electric current. Plug-in hybrid electric vehicles (PHEV) are considered EVs. For the purpose of this Standard, off-road, self-propelled EVs, such as industrial trucks, hoists, lifts, transports, golf carts, airline ground support equipment, tractors, boats, and the like, are not included.

Electric Vehicle (EV) Connector. A device that, when electrically coupled (conductive or inductive) to an EV inlet, establishes an electrical connection to the EV for the purpose of power transfer and information exchange. This device is part of the EV coupler.

Figure 2.1 EV connector J1772™ Courtesy of General Motors

Electric Vehicle (EV) Cord. The off-board cable containing the conductors to connect the EV plug with the EV power controller to transfer energy between the EVSE and the EV, and to provide for communications during energy transfer.

Electric Vehicle (EV) Coupler. A mating EV inlet and EV connector set.

Electric Vehicle (EV) Inlet. The device on the EV into which the EV connector is electrically coupled (conductive or inductive) for power transfer and information exchange. This device is part of the EV coupler. For the purposes of this Standard, the EV inlet is considered to be part of the EV and not part of the EVSE.

Electric Vehicle (EV) Storage Battery. A battery, comprised of one or more rechargeable electrochemical cells, that has no provision for the release of excessive gas pressure during normal charging and operation, or for the addition of water or electrolyte for external measurements of electrolyte-specific gravity.

Electric Vehicle Supply Equipment (EVSE). The conductors, including the ungrounded, grounded, and equipment grounding conductors and the EV connectors, attachment plugs, and all other fittings, devices, power outlets, or apparatus installed specifically for the purpose of transferring energy between the premises wiring and the EV.

Figure 2.1.1 Typical EVSE (Level 2 shown) Courtesy of Eaton Corporation

Fast Charging DC (DC Level 2). EV charging that employs permanently-wired EVSE that is operated at a fixed location and is used specifically for EV charging. As of the date of publication of this Standard, fast charging DC (DC Level 2) EVSE is rated 200VDC to 450VDC, 200A maximum. Fast charging DC was initially known in the industry as AC Level 3 charging. Fast charging DC is currently known as DC Level 2 charging.

Fastened in Place. Mounting means of an EVSE in which the fastening means are specifically designed to permit periodic removal for relocation, interchangeability, maintenance, or repair without the use of a tool.

Fixed in Place. Mounting means of an EVSE attached to a wall or surface with fasteners that require a tool to be removed.

Hybrid. See Plug-in Hybrid Electric Vehicle (PHEV).

Inductive Charging System. A charging system that transfers alternating current (AC) energy across a take-apart transformer and rectifies that energy into direct current (DC) energy for the purpose of transferring energy between the premises wiring system and EV.

National Fire Protection Association (NFPA). Professional organization that promotes the science and improves the methods of fire protection and prevention, electrical safety, and other safety related goals. NFPA also develops consensus codes and standards.

Non-Continuous Load. A load where the maximum current is expected to continue for less than 3 hours.

Off-Board Charger. A charger with control and monitoring capabilities built into the EVSE, not on the EV.

On-Board Charger. A charger with control and monitoring capabilities built into the EV, not in the EVSE.

Output Cable to the Electric Vehicle (EV). An assembly consisting of a length of flexible EV cable and an EV Connector (supplying power to the EV).

Output Cable to the Primary Pad. A multi-conductor, shielded cable assembly consisting of conductors to carry the high frequency energy and any status signals between the charger power converter and the primary pad.

Personnel Protection System. A system of personnel protection devices and constructional features that when used together provide protection against electric shock of personnel.

Plug-in Hybrid Electric Vehicle (PHEV). A type of EV intended for on-road use with the ability to store and use off-vehicle electrical energy in the rechargeable energy storage system, and having a second source of motive power.

Portable (as applied to EVSE). A device intended for indoor or outdoor use that can be carried from charging location to charging location and is designed to be transported in the vehicle when not in use.

Power Supply Cord. An assembly consisting of an attachment plug and length of flexible cord that connects equipment to a receptacle.

Primary Pad. A device external to the EV that provides power via the contactless coupling and may include the charger power converter.

Range. The maximum distance that an EV can travel on a single battery charge over a specified driving cycle to the battery manufacturer's recommended maximum discharge level.

Smart Charger. An EV battery charger that has the ability to communicate with the EV battery management system (BMS) in order to control and monitor the EV battery charging process. Smart chargers also have the ability to send and receive signals from electric utility grid operators to provide the ability to control the charging rate of EVs in response to electric utility grid operating characteristics, such as voltage, frequency, and power demand. Also see Vehicle-to-Grid (V2G).

Vehicle-to-Grid (V2G). A system in which electric utility grid operators have the ability via smart chargers to temporarily reverse the EV charging process to return stored energy from EV batteries to the grid. V2G energy storage can be used to release energy over a period of time ranging from seconds to a few hours. Also see Smart Charger.

Wireless Power Transfer (WPT). The transfer of electrical energy from a power source to an electrical load via electric and magnetic fields or waves by a contactless inductive means between a primary and a secondary device.

Wireless Power Transfer Equipment (WPTE). Equipment consisting of a charger power converter and a primary pad. The two devices are either separate units or contained within one enclosure.

3. Overview

Electric vehicles (EVs) are automotive-type vehicles designed for on-road use, such as passenger automobiles, buses, trucks, vans, neighborhood EVs, electric motorcycles, and the like, primarily powered by an electric motor that draws current from a rechargeable storage battery, fuel cell, photovoltaic array, or other source of electric current.

Historically, EVs have been specialty vehicles, such as forklifts and golf carts. Modern EVs include passenger cars, buses, and delivery trucks. The range of an EV, or the distance that the EV can travel before recharging, varies with the vehicle and is dependent upon the battery system and the hybrid nature of the vehicle if it is a PHEV.

Battery systems and battery technology have improved in recent years. Modern EV batteries do not emit hydrogen gas and can be safely charged in a non-ventilated, indoor environment.

EV batteries are located on-board the vehicle. Energy is transferred between the on-board battery and the premises wiring system through the EV inlet, which is considered part of the vehicle. The connector is the device that, by insertion into an EV inlet, establishes an electrical connection to the EV for the purpose of transferring energy and exchanging information. The inlet and connector together are referred to as the coupler. The means of coupling to the electric vehicle are conductive, inductive, or wireless power transfer.

EVSE consists of the cords, connector, attachment plugs, and all other fittings, devices, power outlets, or apparatus installed specifically for the purpose of transferring energy between the premises wiring and the EV. Attachment plugs, electric vehicle connectors, and electric vehicle inlets must be listed or labeled for the purpose.

There are currently three levels of EVSE predominantly in use, AC Levels 1 and 2 and fast charging DC (DC Level 2), based on the operating voltage and the peak power drawn during energy transfer, with AC Level 1 operating on single-phase 120V, AC Level 2 operating on single-phase 208V or 240V, and fast charging DC (DC Level 2) operating on either a single-phase or three-phase supply voltage configuration.

AC Level 1 charging typically takes between 16 and 20 hours to complete, AC Level 2 charging typically takes between 4 and 6 hours to complete, and fast charging DC (DC Level 2) typically takes less than one hour to complete.

For AC Level 1 and 2, the conversion of AC power to DC power required for battery charging occurs in the EV's on-board charger. For fast charging DC (DC Level 2), the conversion from AC to DC power occurs off-board the EV, so that DC power is delivered directly to the vehicle.

EV battery charging times vary greatly and depend upon the age and capacity of the EV battery pack, the state of charge of the battery at the time of charging, and the available capacity of the EVSE at the time of charging.

Installing AC Level 1 or 2 or fast charging DC (DC Level 2) is a decision based on the type of EV selected and is typically determined at a very early stage of the EVSE installation process. *NOTE: As of the date of publication of this Standard, industry standards-writing bodies are considering refining the ratings of AC Level 3 and DC Level 3 charging.*

EVs connected to the electric utility grid via smart chargers provide a source of stored energy available to electric utility grid operators who can temporarily reverse the EV charging process in response to a critical need to partially discharge EVs connected to the electric utility grid (a process known as vehicle-to-grid or V2G). V2G energy storage can be used to release energy over a period of time ranging from seconds to a few hours.

Smart Charger V2G can also incorporate utility control of the EV charger, allowing the utility to control the EV rate of charge in addition to discharging energy from the batteries. *NOTE: Some automotive industry battery experts believe this demand response approach will have the same effect by providing virtual energy storage with lower V2G infrastructure costs,*

4. Safety

4.1 General

Only qualified persons familiar with the construction and operation of EVSE should perform the technical work described in this Standard. See the definitions of the term *Qualified Person* as provided in Article 100 of the NEC and NFPA 70E.

Before installing, cleaning, inspecting, testing, or performing maintenance on EVSE, electrically isolate EVSE in accordance with established procedures. De-energize, lock-out, tag-out and re-energized equipment in accordance with OSHA 1910.333(b) and NFPA 70E to establish an electrically safe work condition.

Consider all ungrounded and grounded metal parts of equipment and devices to be energized at the highest voltage to which they are exposed unless they are tested and are positively known by testing to be de-energized. Failure to follow these procedures may result in property damage, personal injury or death.

Turn off or disconnect the power supplying EVSE before beginning work. Contact the local electric utility company when required to disconnect power to EVSE. Keep in mind that the line side of the main disconnecting means remains energized unless power is disconnected upstream from the main disconnecting means.

Do not work on energized equipment. Using established safety procedures, guard energized conductors and equipment in close proximity to the work.

Use appropriate Personal Protective Equipment (PPE) and established safety procedures when working on or near energized electrical equipment, anticipating that equipment will fail when operated.

Use care when opening and closing compartment doors while EVSE is energized. Connections and conductors may be exposed and within reach of compartment openings. Maintain as much distance as practical from equipment and devices that may arc during operation or handling.

The EV itself may present a source of energy when connected to the EVSE. Disconnect the EV when working on or near EVSE components.

Perform preliminary inspections and tests prior to beginning work to determine existing conditions. Check existing conditions against available record documents. Visually verify all connections to equipment. Keep in mind that transposed conductors may be connected to different terminals than expected.

Resolve discrepancies between installed conditions and electrical drawings. Have drawings corrected, if required, to match actual field conditions. Provide warning labels on equipment and conductors, where necessary to indicate unexpected and potentially hazardous conditions.

De-energize EVSE by opening source switching devices. Verify by testing that desired conductors and equipment are de-energized. Secure circuit breakers and switches in the "open" position with locks and tags.

Test EVSE to confirm that it is de-energized. Test conductors and equipment at sources and at EVSE to confirm that equipment is de-energized.

Remove locks and tags only after work is complete and tested, and all personnel are clear of the area.

Before applying power to the system, check all components for damage, and check to ensure that there are no loose or disconnected wires, cables, or mechanical connections.

The EVSE connector includes a switch that operates the latch securing it to the EV. Depressing this switch signals the EV to stop charging, opening the circuit and making the disconnection non-powered and safe, while also releasing the latch securing the connector to the EV.

In the event of an equipment malfunction, only qualified personnel may disassemble EVSE. Contact the manufacturer for recommendations. Keep in mind that unauthorized servicing or incorrect reassembly can result in a significant risk of property damage, personal injury or death, and may void the product warranty.

4.2 Installations Requiring Ventilation

The possibility of invoking the ventilation requirements or hazardous environment requirements of the NEC Article 625 exists when installing EVSE indoors. When the EVSE connector makes contact with the EV inlet, the pilot signal from the vehicle will identify whether or not the EV battery system requires ventilation. Suitable EVSE contains controls to turn on the ventilation system when required and also to stop charging should that ventilation system fail.

The NEC identifies three classes of hazardous locations in Articles 500 through 516. Class I locations are those in which flammable gases, flammable liquid-produced vapors or combustible liquid-produced vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures. Class II locations are those that are hazardous because of the presence of combustible dusts. Class III locations are those that are hazardous because of the presence of easily ignitable fibers or where materials producing combustible flyings are handled, manufactured, or used.

Ventilation is required when flooded batteries are charged in enclosed spaces. Few contemporary batteries are flooded lead-acid or nickel-iron batteries that require ventilation during charging. In the few circumstances where non-sealed batteries are used, electrolysis (the separation of water into hydrogen and oxygen) can occur when a flooded lead-acid or a nickel-iron battery is fully charged and additional current is passed through the battery (overcharging).

Hydrogen gas is potentially explosive over a wide range of concentrations. Since hydrogen is lighter than air and rises, ventilation must be provided above the EV if it is charged in an enclosed space. The lower flammability limit (LFL) of hydrogen in air is a 4% mixture by volume. Locations are classified as hazardous wherever 25% of the hydrogen LFL (a 1% hydrogen/air mixture) is exceeded.

The current industry battery standard is sealed lead-acid, nickel-metal hydride (NiMH), or Lithium batteries. In sealed lead acid batteries, hydrogen and oxygen recombine into water, eliminating the ventilation requirement. Consequently, the need for ventilation in indoor charging facilities is increasingly rare.

When a ventilation system is required in accordance with NEC Article 625 for EVSE installed indoors, receptacles and power outlets must be marked “Ventilation Required.” When ventilation is not required or provided, the EVSE, receptacles, and power outlets must be clearly marked “Ventilation Not Required.”

Required ventilation equipment includes both supply and mechanical exhaust which intakes from, and exhausts directly to, the outdoors. Locate the passive intake vent low on one side of the enclosed space, and the exhaust fan in the ceiling on the other side of the enclosed space. The ventilation system must be interlocked with the EVSE to turn on when the charging cycle starts, and should continue to operate a minimum of five minutes after the charging cycle is complete.

Ventilation systems should be designed and sized in accordance with manufacturer recommendations and applicable codes. Mechanical ventilation requirements shall be determined in accordance with NEC Article 625. Positive pressure ventilation systems are permitted only in vehicle charging buildings or areas that have been specifically designed and approved for that application.

Feeder and branch circuit conductors and overcurrent protective devices for EVSE and for ventilation systems must be sized for continuous duty and must have a rating of not less than 125% of the maximum current in accordance with NEC requirements for supplying a continuous load. Where non-continuous loads are supplied from the same feeder, the overcurrent device must have a rating of not less than the sum of the non-continuous loads plus 125 percent of the continuous loads in accordance with the NEC.

For EVSE receptacles rated at 125 volts, single phase, 15 and 20 amperes, the receptacle must be switched and marked in accordance with NEC Article 625, and the mechanical ventilation system must be electrically interlocked through the switch supply power to the receptacle. EVSE supplied from less than 50V DC must be switched and marked in accordance with NEC Article

625, and the mechanical ventilation system must shall be electrically interlocked through the switch supply power to the EVSE.

4.3 Safety Interlocks

NOTE: Because of the duration of the EV charging cycle, safety interlocks are necessary to protect people and equipment during unattended operation. The SAE J1772^{TM}-compliant conductive charge coupler contains contacts that enable communication, interlocking and control between the EVSE and the EV.

There are four main safety devices incorporated into modern EVSE for safe and reliable operation, namely the connection interlock, charge circuit interrupt device (i.e., ground-fault protection or service ground monitor), automatic de-energization device, and ventilation interlock. While each device serves a specific function, they work together as a system to provide a safe and seamless charging event.

4.3.1 Connection Interlock

The connection interlock is required by NEC Article 625 to ensure adequate plug and socket (connector and inlet) contact pressure before energizing, and to prevent energization when the connector is not connected to the inlet. The connection interlock is a device that provides for a dead (de-energized) interface between the EVSE and the EV.

When the EV connector is not connected to the vehicle, the connection interlock prevents power from being applied to the cable or EV connector. When the EV connector is connected to the vehicle, a signal indicates that the EV connector is positively connected to the EV inlet, and the EVSE performs a systems check. Subsequent to confirming system integrity, the EVSE commands/controls energy to flow through the cable and connector to the EV.

A connection interlock is not required for portable cord-and-plug-connected EVSE intended for connection to receptacle outlets rated at 125 volts, single phase, 15 and 20 amperes. Similarly, an interlock is not required for DC supplies less than 50V DC.

4.3.2 Charge Circuit Interrupter Device

A Personal Protection System to provide protection against electric shock of personnel is required for all charging levels in accordance with NEC Article 625. The personnel protection systems for EVSE use ground or isolation monitoring, a circuit interrupting device, and basic, double, or reinforced insulation. Product safety standards developed by UL specify what combinations of these devices EV and EVSE manufacturers can use to meet personnel protection requirements, allowing for a systems approach to providing protection versus a device-only approach.

Where cord-and-plug connected EVSE is used, the interrupting device of a listed personnel protection system must be provided as an integral part of the attachment plug or must be located in the power supply cord not more than 300 mm (12 inches) from the attachment plug.

4.3.3 Automatic De-Energization Device

An automatic de-energization device is required in accordance with NEC Article 625. The automatic de-energization device is a mechanism that will de-energize the EVSE if a strain occurs to the cable or EV connector that could result in a cable rupture, separation of the cable from the connector, or live parts being exposed. An example would be where a parked EV connected to EVSE accidentally rolls back, resulting in strain to the cable and the potential disconnection of the connector from the inlet during the charging cycle. The automatic de-energization device will abort the charging cycle before the cable or EV connector becomes disconnected during the charging cycle.

Automatic means to de-energize the cable conductors and EV connector is not required for portable cord-and-plug-connected EVSE intended for connection to receptacle outlets rated at 125 volts, single phase, 15 and 20 amperes. Similarly, an interlock is not required for DC supplies less than 50V DC.

4.3.4 Ventilation Interlocks

Ventilation interlocks are required in accordance with NEC Article 625 to avoid creating a situation where hydrogen gas can collect in an enclosed space, such as a garage, during the EV charging cycle. *NOTE: With conventional starter batteries used in gasoline vehicles and some conversion EVs, hydrogen gas can be generated during charging. Modern batteries used in EVs generally do not generate hydrogen gas. In short, EV batteries that do not require ventilation have become the rule, and EV batteries that require ventilation have become the exception.*

The ventilation interlock performs three functions in order to meet the requirements of Article 625 and pertinent sections of state and locally adopted building codes. First, the EVSE queries the EV to determine if the EV requires ventilation during charging. Second, the EVSE determines whether ventilation is available. Finally, if ventilation is required, and if ventilation is available, the EVSE operates the ventilation during and after the charging process cycle in accordance with applicable codes.

5. Pre-Installation Considerations

5.1 General

Install EVSE, equipment, components, accessories, and ancillary equipment in accordance with contract documents, the NEC, and manufacturer's installation instructions, drawings, and wiring diagrams to include overall dimensions, front view, and sectional view, typical installation and module arrangement, raceway entry, and ventilation and exhaust systems.

Locate EVSE, equipment and components to minimize the possibility of damage from flooding, including flooding resulting from fire fighting, sewer backup, and similar occurrences. Avoid installing EVSE, equipment, and components in locations where corrosive gases are generated, or in locations exposed to dust or dirt.

Locate equipment to allow ready accessibility and adequate working space for inspection, repair, maintenance, cleaning, or replacement. Guard live parts in accordance with NEC Article 110.

Verify that a separate emergency lighting system is provided if no other emergency lighting is present.

5.2 Battery Operating and Charging Temperature Considerations

Battery capacity, charging voltage, and life expectancy are temperature dependent, and EVs can be exposed to both high and low temperature extremes. Battery capacity, or how many amp-hours a battery can store, is reduced as temperature decreases, and is increased as temperature increases. Battery charging voltage is also temperature dependent, with higher charging voltage needed at lower temperatures.

Similarly, battery life expectancy is reduced as temperature increases, but EV batteries tend to average out low and high temperature operation to meet the average life expectancy. Continuous operation at elevated temperatures decreases efficiency and life expectancy.

The EV controls the charging system temperature that is required for the EV charge cycle. EVSE merely delivers AC or DC energy as requested from the EV. Consideration should be given to providing shade for EVSE installed outdoors and for EV charging locations, such as in direct sunlight, or to providing ventilation for indoor locations, to mitigate charging in elevated temperatures.

5.3 Smart Chargers

Smart EVSE can be programmed to charge vehicles during periods of lower demand and during periods of lower energy costs. Smart EVSE also incorporates software algorithms that allow charging vehicles to be grouped as a single power resource that can be controlled and managed by the energy provider who can use EVs as a source of distributed generation (vehicle-to-grid, or V2G).

Smart charging requests are transmitted over a variety of secure, two-way communication methods, and enable EVs to be controlled for:

- Load shifting. Charging can be performed during other than peak load periods by establishing time-based charging windows during which energy is delivered to participating EVs.
- Load shaping. By integrating a variety of real-time signals, utilities are able to dynamically control the EV charging cycle to achieve specific objectives or mitigate location specific and system-wide grid stress.
- Ancillary services**.** In real-time, vehicle charging load can be adaptively increased or reduced by the electric utility to provide system regulation and spinning reserves.
- Vehicle-to-Grid (V2G). The two-way flow of power between the grid and EVs can be managed, returning energy to the grid when needed.

EVSE that is part of an interactive system that serves as an optional standby system, an electric power production source, or a bidirectional power feed must be listed, evaluated for use with specific electric vehicles, and marked as suitable for that purpose. When used as an optional standby system, the requirements of NEC Article 702 apply to EVSE. When used as an electric power production source, the requirements of NEC Article 705 apply to EVSE.

NOTE: For further information on interactive EVSE, see ANSI/UL 1741, Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources, and ANSI/UL 9741, Bidirectional Electric Vehicle (EV) Charging System Equipment. For further information on interactive EV systems, see SAE J3072, Standard for Interconnection Requirements for Onboard, Utility-Interactive Inverter Systems.

5.4 Charging Power

Charging times will vary, based on battery size and electrical capacity at the charging station. BEV's have a large battery requiring higher power charging to maintain a reasonable charge time. PHEV's have a smaller battery and an auxiliary gas or diesel engine. The smaller battery in the PHEV requires lower power charging to maintain a reasonable charge time, and can be efficiently charged using a standard 120-volt circuit (AC Level 1 charging). BEV's require at least a 208V or 240V circuit (AC Level 2 charging) for faster charging.

Commercial fleet charge stations will likely include multiple charge locations, and may include more than one charge level. The additional electric load from EVSE will need to be included in load calculations when sizing service entrance equipment for a facility.

Each outlet installed for the purpose of charging EVs is required to be supplied by a dedicated branch circuit with no other outlets.

5.4.1 AC Level 1 Charging

AC Level 1 charging typically takes between 16 and 20 hours to complete because of the relatively limited amount of power that can be delivered over a single-phase 120V circuit. AC Level 1 systems were developed with the intention of connecting to common 125V NEMA 5-15R or 5-20R receptacles, although the SAE J1772™ connector and a Personal Protection System must be used. AC Level 1 systems are recommended in situations where AC Level 2 systems are not available. When using AC Level 1 charging, a dedicated branch circuit with no other outlets is required in accordance with the NEC.

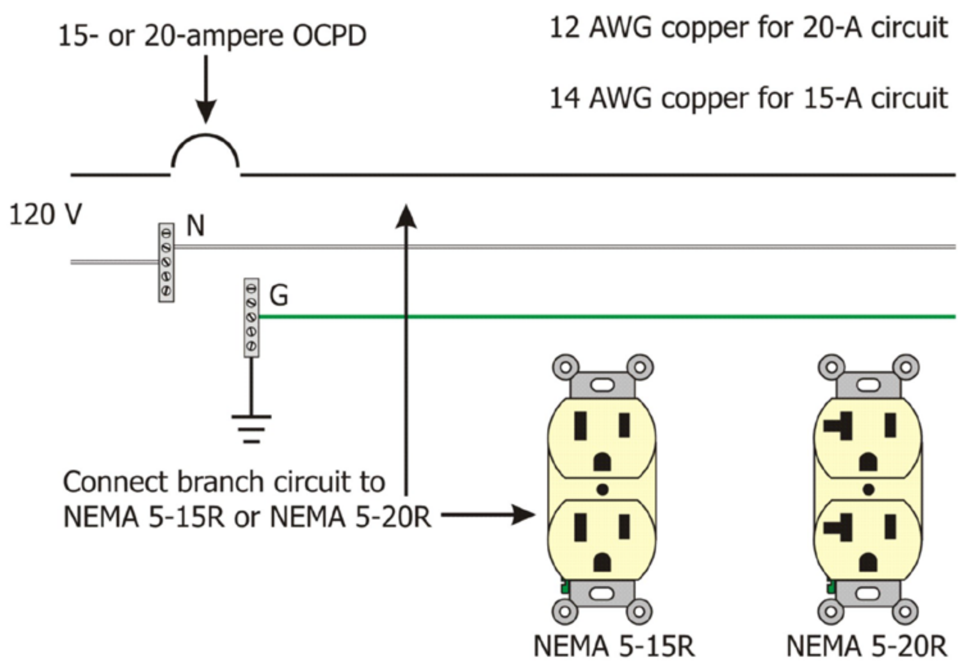

Figure 5.4.1 AC Level 1 individual branch circuit requirements

5.4.2 AC Level 2 Charging

AC Level 2 charging uses single-phase 208V or 240V circuits and typically takes between 4 and 6 hours to complete. AC Level 2 is typically described as the preferred EV charging method for both private and publicly available facilities. The SAE J1772™ connector is suitable for load current as high as 80 amps AC. Overcurrent protection for EVSE is sized to 125% of the EVSE nameplate continuous output rating in accordance with the NEC.

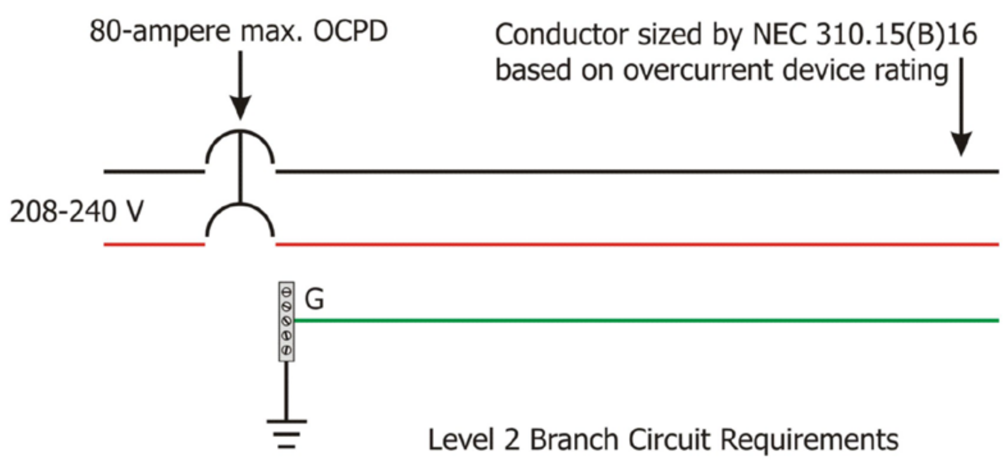

Figure 5.4.2 AC Level 2 individual circuit requirements

The SAE J1772™ connector is used for both AC Level 1 and 2 charging. When connected, the vehicle charger will communicate with the EVSE to identify the circuit rating and adjust the charge to the battery accordingly.

5.4.3 Fast Charging DC (DC Level 2)

Fast charging DC (DC Level 2) uses three-phase 208V, 480V or 600V circuits and typically takes less than one hour to complete. For chargers rated up to 30kW, three-phase 208 VAC or 480VAC is suitable, and three-phase 480VAC is suitable for chargers rated greater than 30kW. This energy transfer method utilizes dedicated EVSE capable of replenishing more than half of the capacity of an EV battery in as little as ten minutes.

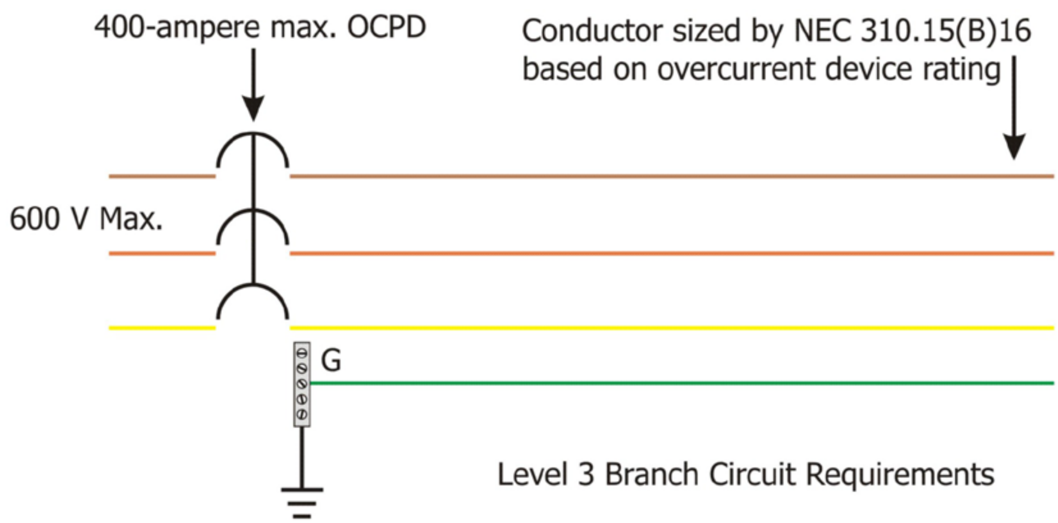

Figure 5.4.3 Fast charging DC (DC Level 2) individual circuit requirements

For fast charging DC (DC Level 2), the conversion from AC to DC power occurs off-board the EV, so that DC power is delivered directly to the vehicle. The vehicle's on-board battery management system controls the off-board charger to deliver DC directly to the battery. Fast charging DC (DC Level 2) is typically used for fleet vehicle and other commercial EV applications.

5.5 Conductive, Inductive, and Wireless Power Transfer (WPT) EV Charger Technologies

Three available technologies can be used to connect EVs to EVSE, conductive charging using the SAE J1772™ standard, inductive charging using the SAE J1773 standard, and wireless power transfer (contactless inductive charging) using the SAE TIR J2954 standard. Any are available for all levels of charging. No manufacturers currently use inductive coupler charging for commercially available EVs. Wireless power transfer is an emerging EV charging technology.

Conductive and inductive charge connectors are different and are not interchangeable. An EV that uses conductive charging cannot be connected to an inductive charge connector. Each technology has its strengths and weaknesses.

While there are differences between inductive and conductive EV charging from a safety standpoint, inductive coupler charging is a less efficient and more complex charging means than conductive charging. Consequently, inductive coupler charging is typically a more expensive method of charging EVs.

Recently, hands-free inductive charging has become available where a model-specific charge adapter is mounted on the EV and the EVSE is equipped with a floor-mounted magnetic charging block located close to where the EV is parked and where the EV-mounted charge adapter is located. When the EV is parked, power is delivered to the EV through magnetic induction between the floor-mounted charging block and the EV-mounted charge adapter. Unlike using the J1773 inductive charge coupling, no intervention is required to initiate EV charging beyond parking the EV with the charge adapter in close proximity to the floor-mounted magnetic charging block.

5.5.1 Conductive Charging

Conductive charging uses physically connecting contacts, similar to methods used by common electric appliances. It is the method used by most on-board chargers, or systems that place the charging circuitry and control on the vehicle. The connector for these systems is usually a pin and sleeve type connector.

5.5.2 Inductive Technologies

Inductive charging systems transfer energy to the EV by magnetically coupling a primary winding on the supply side to a secondary winding on the vehicle side of the connector. Current flows through the primary inductor coil, or paddle, and the resulting magnetic flux induces an alternating current through the magnetic field and across the secondary coil, completing the circuit. The AC current is converted to DC for storage in the vehicle battery.

Inductive chargers keep most of the charging circuitry and controls in an off-board charging stand, and communicate with the battery and vehicle electronics via infrared or radio frequencies.

While SAE J1773, the Inductive Charge Coupler, remains an active standard, no EV manufacturers are currently using inductive battery charging in commercially available EVs.

5.5.3 Wireless Power Transfer (WPT)

Wireless power transfer (WPT) or contactless inductive charging of EVs is an emerging technology where an EV parked over the primary pad base plate of wireless power transfer equipment (WPTE). The WPTE establishes communication and transfers power wirelessly across the air gap to a WPT-compatible EV with no further interactions.

5.6 Communication and Data Requirements

Communication between the EV and the EVSE is necessary for data transfer, safety and control. When installing new EVSE, it may be useful to include Internet or some other communication capability. Additional communication options include wireless, cellular, infrared, and radio frequency.

Communications abilities allow data collection, such as frequency of charging and duration of use. Customers may be able to track the charging progress of their EVs through wireless communication via smart phone applications. Consult the EVSE supply vendor for data collection and communications options and minimum requirements.

5.6.1 Communication Between the EV and EVSE

Communication between the EV and the EVSE may include:

- Vehicle code identification (e.g. for assignment of the vehicle to the account of the owner at the power supplier.
- Vehicle charging system identification (what kind of charging is required).
- Vehicle connection interlock to ensure adequate electrical connection between the EV and the EVSE.
- Accomplishment of personal protection.
- Acceptance of interlocks to initiate and to terminate the charging process.
- Signal for interlocking of charging system.
- Signal for activation of the ventilation system, if required.
- Activation of the EV immobilizer system.
- Service ground continuity monitoring.

5.6.2 Communication Between the EV and the Power Supplier

Communication between the EV and the Power Supplier may include:

- Controlled supply of power/variable rate of charging.
- Provision of different customer billing rates.
- Billing of delivered power.
- Controlled use of vehicle battery as a power reservoir (vehicle-to-grid, V2G).

5.7 EVSE Equipment and Siting Requirements

EVSE facilities must comply with all local, state, and national codes and regulations (see Annex A). EVSE installations typically require a permit. Check with the local planning department and review local building codes for construction details for EVSE before starting work. Keep in mind that the local electric utility company will not energize a new electrical service without an approved building/electrical inspection.

EVSE must be certified (listed) and marked by a nationally recognized testing laboratory (NRTL), in accordance with NEC Article 625.

The EVSE cord may provide a maximum of 7.5 m (25 feet) of flexibility from the EVSE location to the EV inlet, unless equipped with a cable management system, in accordance with NEC Article 625.

For charging facilities located with public access, an extended EV cord may present a tripping hazard. Locate EVSE in areas with minimal pedestrian traffic. Consider the installation of an overhead support or trolley system to allow the cord to hang above the vehicle in the general location of the EV inlet.

If EV batteries require ventilation during indoor charging, EVSE is required to energize a properly sized ventilation system in accordance with NEC Article 625. Once the charge connector is attached to the EV inlet, the EVSE will communicate with the EV to determine whether ventilation is required. If ventilation is required but no ventilation system exists, the EVSE will not charge the vehicle.

5.7.1 Electrical Load Calculations

Perform calculations to determine the minimum ampacity of branch circuits, feeders and services that supply EVSE, and associated ventilation systems, where required, in accordance with NEC Article 220. Refer to the load calculation examples found in NEC Annex D for dwelling units and other than dwelling units.

For existing facilities, conduct a site visit, inventory electrical equipment, and interview the facility occupants to determine the cyclical daily and seasonal loading of the facility. When available, review a minimum of 12 months of electric utility bills to determine the maximum demand for incorporation into load calculations.

AC Level 1 and AC Level 2 EVSE are considered continuous loads with the maximum current expected to continue for 3 hours or more. Load calculations and sizing of branch circuit, feeder, and service entrance conductors and overcurrent protective devices for EVSE and associated ventilation systems, where required, must be sized for 125% of the maximum current in accordance with the NEC. Where an automatic load management system is used, the maximum EVSE load current is limited by the automatic load management system.

Where non-continuous loads are supplied from the same feeder, the overcurrent device must have a rating of not less than the sum of the non-continuous loads plus 125 percent of the continuous loads in accordance with the NEC.

For commercial installations, consideration for future expansion and additional EVSE should be included in load calculations. Involve electrical utility planners early in the planning process for EVSE fleet applications.

5.7.2 Site Selection and Preparation

The EVSE location should be easy to find and conveniently accessed. In a very large parking lot, such as at a shopping mall, it may be more beneficial to place EVSE at several locations rather than to place all EVSE in one location.

Determine locations for EVSE that allow for proper layout of the charging equipment and adequate access space for EVs. Regardless of the type of EVs in use, allow sufficient space for vehicles as well as the personnel operating them. If the site selected for installation of EVSE is susceptible to water runoff from adjacent areas or roof drainage, or is not level, a concrete equipment pad may be required.

Install concrete pads for EVSE and EVs in accordance with contract documents, drawings and specifications, and manufacturer recommendations, and in accordance with all applicable codes and standards.

Provide curbs, wheelstops and setbacks to properly position the EV with respect to the EVSE, to protect the EVSE from the EV, and to reduce the likelihood that an outstretched charging cord could present a tripping hazard. Consider ease of access to the charger, mobility of users, and foot traffic in the area when installing curbs, wheel stops, and setbacks.

Ensure that EV charging spaces are not located near potential hazards. EVSE should not be installed near explosive material, flammable vapors, liquids, or gases, combustible dust or fibers, or materials that ignite spontaneously on contact with air. NEC Articles 500 to 516 describe equipment and procedures for installation of electrical systems in hazardous locations. If EVSE is installed in an enclosed area, ensure that ventilation requirements are met. See Sections 4.2 and 4.3.4.

Additional site selection considerations include:

- Determine the distance from EVSE to the vehicle charge inlet to avoid a tripping hazard.
- Locate the EVSE in close proximity to available AC power supply to minimize voltage drop.
- Determine whether the existing electrical service is adequate for the additional and future projected loads, or that an upgrade or a new service is required.
- Determine the local electric utility metering requirements, such as requiring a separate utility revenue meter for EV charging.
- Provide adequate space and accessibility to meet ADA requirements (if applicable).
- Consider vandalism, lighting, signage, and safety requirements.
- Identify potential nearby hazards or hazardous materials.
- Review the site for running water, standing water, and flooding. Permits for construction of facilities, including EV charging stations, must include a review to determine whether the site is located in a flood prone area.
- Check the EV manufacturer's recommended operating and charging temperature range for the batteries and site the EVSE accordingly, such as providing shade for outdoor locations or ventilation for indoor locations.

The EVSE location should balance safety, by minimizing the tripping hazard from the charge cord, with convenience and location relative to the AC power supply to minimize cost.

The following regulatory and code issues affect the placement of EVSE:

- EVSE must be located for direct electrical coupling of the EV connector (conductive, inductive, or WPT) to the EV.
- Unless specifically listed and marked for the location, the coupling means of EVSE must be stored or located at a height not less than 450 mm (18 inches) above the floor for indoor locations in accordance with NEC Article 625.

- Unless specifically listed and marked for the location, the coupling means of EVSE must be stored or located at a height not less than 600 mm (24 inches) above grade level for outdoor locations in accordance with NEC Article 625.
- When EVSE is installed in a hazardous (classified) location, the EVSE installation must comply with NEC Articles 500 through 516 (NEC Article 625). It is recommended that EVSE be installed in non-hazardous locations that do not contain any explosive materials, flammable vapors, liquids, or gases, combustible dust or fibers, or materials that ignite spontaneously on contact with air.

EVSE located outdoors should be properly designed for exterior use. Consideration must be given to precipitation and temperature extremes. In geographic areas that experience high precipitation, pooling of water may be a concern. Freezing temperatures can also create an issue for cords freezing to the parking surface, and cord support should be considered.

NOTE: The NEC and locally adopted electrical codes typically require special signs for EVSE. Signs may also be needed to designate parking spaces for EV-use only. These signs should be positioned high enough to be seen over parked vehicles.

Trouble reporting can be very important in public EV charging locations. Each public charging location should be equipped with a method for notifying the individual or organization responsible for maintaining and repairing the EVSE of trouble with the equipment, which may be a normal business telephone number or a service that monitors many public-charging locations, and will require communications, which may be wireless. At a minimum, a sign may be posted at the EVSE location with directions for making public comments.

5.7.3 Commercial Fleet Lots

Commercial fleets make up the highest population of EVs at the present time. Electrical service requirements will be much higher than residential or multi-family installations and can have a significant impact on electrical usage and on the utility. Consideration for future expansion and additional EVSE should be included in load calculations. Electrical utility planners should be involved early in the fleet planning process.

The EV fleet manager will be interested in charging vehicles off-peak, or during times other than peak electrical load demand periods. Flood prone area restrictions must be considered as well as issues of standing water. Large parking lots frequently have low spots that accumulate water. Although EVSE contains proper protection devices, such as a Personal Protection System to provide protection against electric shock, operating the EVSE in standing water is not recommended.

Fleet managers must also be aware of other equipment to be stored in the vicinity of the EVSE. It is important that a hazardous environment, such as a vehicle fueling station, does not already exist in the area planned for EVSE installation.

Locate EVSE such that other activities within the fleet facility are accommodated. It is advisable to locate EVSE in a low-traffic area of the facility. EVs may be required to remain parked for several hours to complete the charging cycle and could block the movement of other fleet vehicles.

Cords and cables associated with charging equipment should not cross sidewalks or pedestrian traffic patterns.

Some EV batteries have operating and charging temperature limits. In extreme heat or extreme cold climate conditions, it may be necessary to site EVSE in a shaded area or an enclosed space.

To avoid vehicles from inadvertently driving into the EVSE, provide curbs, wheel stops, and setbacks. Consider user access and mobility issues when installing equipment.

5.8 Electric Utility Interconnection Requirements

Contact the local electrical utility company to determine interconnection requirements. Specific requirements may include electric utility policies along with regulatory and statutory requirements. Discussions should include:

- Power capacity of the facility.
- Metering requirements, such as a second utility revenue meter.
- Rate structure, such as time-of-use (TOU), demand response (DR), real time pricing (RTP), vehicle-to-grid (V3G), or off-peak EV charging.
- Interconnection requirements for vehicle-to-grid (V2G) distributed generation.
- Smart grid applications and EV charging control.

Where the existing electrical service has insufficient capacity, consider a load control strategy to manage the charging load within the capacity of the electrical service, such as off-peak charging, rather than upgrading the service to accommodate increased building load from EV charging. *NOTE: Many AC Level 2 EVSE suppliers provide controls in the EVSE to enable charging at programmable times to take advantage of off-peak power pricing. If not, a time clock or timer device may be installed in the circuit to control charging times.*

6. Installation

6.1 General

The installation requirements for EVSE vary from manufacturer to manufacturer. Install EVSE in accordance with manufacturer recommendations and in accordance with applicable local, state, and federal codes and regulations.

Mount EVSE such that wall mounted outlets are not more than 1.2 m (48 inches) above the ground. Provide a minimum of 600 mm (24 inches) clearance around all sides of outdoor pedestal-mounted EVSE. Provide bollards, curbs, or wheel stops to protect EVSE from vehicles.

If trenching or boring, consider providing one or more spare raceways for future growth, expansion, or upgrade.

Provide a clean, level surface for mounting EVSE that is free of obstructions, such as level, sealed concrete pads or floors, or on appropriate support stands. Check concrete pads for proper size and flatness in accordance with manufacturer instructions. The pad should be sized to accommodate the equipment and any external mounting brackets, and should extend beyond the edge of the equipment an adequate amount to prevent the pad from cracking or breaking when anchor bolts are installed. The pad should have a maximum pitch of one-half degree and should have a flatness of within 6 mm (one-quarter inch).

Anchor EVSE to surfaces in accordance with manufacturer recommendations. For EVSE mounted to concrete surfaces, provide J-Bolts cast in concrete or drill holes for concrete anchors. Mark the mounting bolt pattern on the mounting surface using the manufacturer's template. Drill pilot holes in the mounting surface. Follow the manufacturer's recommendations for depth and diameter of pilot holes. Keep in mind that different materials, such as steel, concrete, and wood, will require different fasteners and different types of pilot holes.

Anchor EVSE to surfaces in accordance with manufacturer recommendations. Use manufacturer approved anchors, fasteners, and mounting hardware, and torque in accordance with manufacturer instructions. Use not less than the manufacturer recommended minimum number of fasteners to secure EVSE to the mounting surface.

6.1.1 Free Standing EVSE

Figure 6.1.1.1 Free-standing EVSE Courtesy of PEP Stations

If a raised concrete pad is required, size the pad in accordance with manufacturer instructions. Typically, the concrete pad is sized such that the EVSE is placed with the front edge is flush with the front edge of the concrete pad, with a minimum of 150 mm (6 inches) of the pad extending out from beneath the other three sides.

Attach mounting straps or angle brackets to secure the EVSE in place using the provided hardware. Use manufacturer approved hardware, anchors, and fasteners when replacements are required.

When required, install a grounding electrode and connect to the branch circuit, feeder, or service equipment grounding conductor in accordance with NEC Article 250. *NOTE: Where used, auxiliary electrode installations must connect to the supply circuit equipment grounding conductor in addition to the frame of the equipment in accordance with NEC Article 250*.

6.1.2 RFID or Antenna and Parking Bumper or Wheelstop Installation

Where EVSE has provisions for radio frequency identification (RFID) tag sensing antennae installed in parking bumpers or wheelstops, route and install raceways and locate PVC boxes and enclosures in accordance with manufacturer instructions.

Measure each parking bumper or wheelstop and its openings to ensure the proper fit of conduits, boxes, and enclosures. Make sure that the conduits, boxes, and enclosures are oriented in accordance with manufacturer instructions.

Install plastic trim covers and their securing lanyards, if required, before placing the parking bumper or wheelstop over the raceway/enclosure assembly.

Using the lifting rings provided, squarely place each parking bumper or wheelstop over the raceway and enclosure. Insert the lifting rings through the bumper or wheelstop mounting holes and thread them into the embedded nut.

Use a properly sized forklift, lifting rings and proper lifting procedures when installing bumpers or wheelstops. Do not use a hand truck or similar device for lifting bumpers or wheelstops.

After final positioning of the bumpers or wheelstops parallel to the enclosure, anchor bumpers and wheelstops in place by using the anchor bolts provided. Use the correct hardware and follow manufacturer installation and torque instructions.

Pull the EV sensing antenna cables through raceways and into boxes and enclosures. Locate any cable slack inside the EVSE gutter space or junction box. Label antenna cables where more than one cable is pulled through a raceway. Connect antenna cables to the appropriate charge port in the EVSE. Label antenna cables in accordance with the manufacturer’s numbering convention.

Connect all antenna components to each of the antenna cables and place each antenna inside the appropriate PVC enclosures, oriented in accordance with manufacturer instructions. Secure antennae with the screws and hardware provided.

Install box and enclosure lids and install trim covers on bumper and wheelstop openings.

Mount the tag assembly onto the vehicle structural member in accordance with manufacturer recommendations. Affix the radio frequency identification (RFID) tag to the underside of each EV that will be charged at RFID-enabled EVSE. Install the RFID tag on a structural member of the EV situated approximately above the RF antenna located in the parking bumper or wheelstop. Select a structural member no more than 325 mm (13 inches) above the top of the parking bumper or wheelstop. Insulate the RFID tag from EV metal surfaces by mounting it on a 3/4” thick piece of plastic (nylon, EPDM, or polypropylene) with a suitable adhesive.

The RFID tag stores EV, battery configuration, and charge cycle history in a semiconductor chip. Because it contains unique information for that specific vehicle, each RFID tag must remain with the EV to which it is attached. A vehicle without an RFID tag will not be recognized by the EVSE and will not be charged.

6.1.3 WPT Primary Pad and Charger Power Converter Installation

Install the primary pad base plate and charger power converter of WPT in accordance with manufacturer instructions. Provide and protect embedded raceways in accordance with manufacturer instructions and design documents.

The charger power converter, when not integral to the primary pad, must be provided with a minimum Type 3R enclosure rating, and must be mounted at a height of not less than 450 mm (18 inches) above the floor level for indoor locations or 600 mm (24 inches) above grade level for outdoor locations.

The charger power converter is permitted to be mounted on one of the following forms:

- Pedestal
- Wall or pole
- Building or structure
- Raised concrete pad

The primary pad (and charger power converter, where integral to the primary pad) is permitted to be installed on the surface, embedded in the surface of the floor with its top flush with the surface, or embedded in the surface of the floor with its top below the surface.

If the WPT primary pad is located in an area requiring snow removal, it must not be located on or above the surface, except where installed on private property where snow removal is done manually, the primary pad is permitted to be located on or above the surface.

Provide a suitable enclosure rating, minimum Type 3, for the primary pad. If the primary pad is located in an area subject to severe climatic conditions, such as flooding, the primary pad enclosure must be suitably rated for those conditions or be provided with a suitably rated enclosure.

Protect the output cable to the primary pad. Secure the output cable in place over its entire length for the purpose of restricting its movement and to prevent strain at the connection points. Provide supplemental protection where output cables could be driven over.

6.2 Electrical Installation Requirements

EVSE equipment and components must be listed for the intended application. EVSE, equipment and components, must be readily accessible.

Working spaces about EVSE must conform with NEC Article 110. Measure working space from the edges of EVSE enclosures. *NOTE: Additional space may be needed to accommodate EVSE equipment installation, such as hoisting equipment and component removal or installation.*

Provide illumination for working spaces associated with EVSE equipment and components. Lighting outlets must not be controlled by automatic means only. Additional lighting outlets are not required when the work space is illuminated by an adjacent light source. The location of luminaires must not expose personnel to energized system components when performing maintenance on the luminaires in the system space, or create a hazard to the system or system components upon failure of the luminaire.

Provide a disconnecting means that is readily accessible from EVSE for circuits rated more than 60A or more than 150 volts to ground in accordance with NEC requirements. Disconnecting means must be lockable in the OPEN position.

Locate receptacles for cord-and-plug connected EVSE in a location within 1.8 m (6 feet) of EVSE that is fastened in place. Locate receptacles to avoid physical damage to the flexible cord.

6.2.1 Conductors, Raceways, Connections, and Terminations

Use the manufacturer recommended raceway entry locations or knockouts for EVSE. When provided by the manufacturer, select and remove the appropriate sized knockouts considering raceway diameter.

Install raceways and tighten connectors and fittings. Install cables and conductors, and connect and terminate in accordance with manufacturer instructions. Provide cable and conductor sizes and types in accordance with manufacturer instructions.

Branch circuit, feeder, and service conductors and overcurrent protective devices for EVSE and for ventilation systems, where required, must be sized not less than 125% of the maximum rated load current or the nameplate value, whichever is greater, or comply with the maximum ampacity and overcurrent protection indicated on the equipment, in accordance with NEC requirements for supplying continuous loads.

Install conductors, raceways, cables, links, connections, and terminations in accordance with manufacturer instructions, contract documents, and installation drawings. Refer to construction documents, drawings and specifications, and/or manufacturer shop drawings for raceway entry locations into cabinets or racks, conductor sizing, and specific grounding requirements.

Check phase, neutral, and grounding conductors for proper sizing and configuration. Check phase rotation and phase matching of battery charge controller, rectifier, and inverter input and output feeder conductors, if applicable. Derate the ampacity of conductors as required for the number of current-carrying conductors within a raceway in accordance with the NEC. Derating of conductors should take into consideration the ambient design temperature as well. Install an equal number of positive and negative conductors in each raceway of DC power circuits. Consider providing one or more spare power conductors for single-phase 208 VAC and 240 VAC circuits for future use.

Check that interconnecting cables, terminals, connections, screws, spades, and lugs are tightened in accordance with manufacturer recommendations. Provide lugs and terminals, as needed, in accordance with manufacturer recommendations.

6.2.2 Grounding Conductor Terminations

Conductor terminations shall be tightened in accordance with 2017 NEC 110.14(D). When installing conductors in electrical equipment terminations in which the tightening torque is marked on the product or provided in the installation instructions, a calibrated torque tool must be used, unless an alternate method for tightening is provided by the equipment manufacturer installation instructions. See 2016 NFPA 70B 8.11.1 recommendations for the initial installation of conductor terminations.

After a conductor has been terminated, verifying the torque value with a calibrated torque tool at the specified torque value is not reliable. Reference 2016 NFPA 70B 8.11.2 to 8.11.4 recommendations to check conductor termination tightness after the initial install.

For verifying proper tightness after initial installation, use a low-resistance ohmmeter to measure the connection and termination resistance and compare to similar connections and terminations, perform an infrared scan, or use a calibrated torque tool set at 90% of the specified torque value for a conductor termination. If the screw or tool does not move when using a calibrated torque tool, the termination is considered properly torqued. If it moves, the conductor should be removed and reinstalled properly. If there are signs of degradation of the conductor/termination, such as thermal damage, the detrimental situation must be corrected.

6.2.3 Grounding

Ground EVSE in accordance with contract documents, manufacturer recommendations, standard grounding practices, and the NEC. *NOTE: An improper or inadequate grounding configuration may cause problems at start-up. Failure to properly ground EVSE may deteriorate electrical insulation and may cause electric shock due to leakage currents.*

Connect the EVSE to either the branch circuit or feeder equipment grounding conductor in accordance with NEC Article 250.

Provide a separate, insulated equipment grounding conductor in all feeder and branch raceways. Ground non-current-carrying EVSE equipment to the feeder equipment grounding conductor with a separate bonding jumper, where required.

6.3 Setting Equipment in Place

Set equipment, cabinets, and components in place using manufacturer recommended procedures. Handle equipment and components in accordance with manufacturer instructions.

Use manufacturer-recommended hardware and fasteners to anchor equipment to the mounting surface. Use manufacturer recommended bolts, fasteners, and anchors to meet seismic requirements, if applicable. Use a manufacturer-provided template or make a template to locate fasteners on the mounting surface. Fasten the template to the mounting surface, and mark the locations of anchor holes on the mounting surface or drill small pilot holes for the anchors. Remove the template, and drill holes properly sized in accordance with manufacturer recommendations to the appropriate depth for the anchors, and insert the anchors.

Remove equipment from wooden pallets by raising the equipment with a forklift or pallet jack and removing the hardware used to secure the pallet to the equipment. Raise the equipment until the bottom clears the pallet, and pull the pallet from underneath the equipment. Discard or recycle wooden pallets in a responsible manner.

Align equipment to the anchor locations, and carefully lower the equipment until the base touches the mounting surface. Loosely bolt the equipment to the mounting surface using manufacturer approved materials and methods. Level equipment in accordance with manufacturer instructions. Once level, torque anchoring hardware in accordance with manufacturer instructions.

After setting equipment in place, make final connections in accordance with manufacturer instructions and wiring diagrams.

6.4 EVSE Start-up and Commissioning

Start up and commission EVSE in accordance with manufacturer recommendations. See Section 4.1 for safety recommendations. *NOTE: Some manufacturers require that the initial start-up of EVSE be performed only under the supervision of a factory-certified service technician to ensure proper system operation. Failure to abide by this requirement may void warranties for the equipment.*

Follow manufacturer instructions for properly parking EVs at EVSE, connecting the charge connector, and interpreting the user interface display and indicator lights during the charging process. Remove the EV charge connector by the housing. Do not remove the charge connector from the EV inlet by pulling the cord.

When possible, test the EVSE by charging a compatible EV with suitable ratings, couplers, connectors, and equipment, or by using an EV simulator test tool.

7. Maintenance

7.1 General

Clean EVSE in accordance with manufacturer recommendations using recommended materials and methods. Follow the safety recommendations found in Section 4.1.

Generally, use a soft damp cloth with a mild detergent to wipe down the exterior of the EVSE with the main power service off. For EVSE with stainless steel surfaces, use standard stainless steel polish only in accordance with manufacturer instructions.

Check all usable parts for wear, and conduct periodic inspections to ensure that all parts remain in proper working order. Check that communications systems are functioning properly, and that lamps are illuminated and working properly. Replace burned-out lamps, if so equipped, in accordance with manufacturer's instructions. Check for damage and vandalism. Repair damage and vandalism in accordance with manufacturer instructions.

Inspect the charge connector, plugs, receptacles, cords, cables, and strain relief clamps for evidence of damage before each use. Shake charge connectors, listening for sounds such as rattles that can indicate loose components. Check connectors and inlets for tightness. Replace

SAE connectors that are misapplied, improperly installed, damaged, worn, that show signs of overheating or discoloration, or that show any sign of alterations of a blade or connection slot.

Inspect cables and conductors for signs of wear, abrasion, and damaged or worn insulation. Verify that EV coupler and connector cables are securely fastened to boxes. Verify that appropriate coverplates and access panels are installed and secure, and that panels and covers are in contact with the finished surface on all edges.

Shut off, do not use, and replace damaged, discolored, disfigured, modified, hot, sparking, popping, or otherwise suspect EVSE couplers or plugs, or if ozone is detected in their immediate vicinity.

(*This annex is not part of the Standard)*

Annex A: Product Regulations, Codes and Standards

A.1 General

EVSE safety requirements have been incorporated into various standards, including industry and equipment standards such as the Society of Automotive Engineers (SAE) and Nationally Recognized Testing Laboratories (NRTL), accessibility standards such as Americans with Disabilities Act (ADA), and safety and installation standards such as NFPA and the NEC®, and other local and state building codes.

Additionally, EVSE can be used to attain credit towards certification under the Leadership in Energy and Environmental Design (LEED) program in accordance with the U.S. Green Building Council requirements.

A.2 Society of Automotive Engineers (SAE) Standards

The Society of Automotive Engineers (SAE) provides standards and recommendations for equipment, materials and components related to vehicles. The following current SAE standards form a basis of EVSE design and quality:

- SAE J1772™ SAE Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler
- SAE J1773 SAE Electric Vehicle Inductively Coupled Charging
- SAE J2293 Energy Transfer System for Electric Vehicles
- SAE J2836 Use Cases for Communication Between EVs and the Utility Grid
- SAE J2847 Communication Between EVs and the Utility Grid
- SAE TIR J2954 Wireless Power Transfer for Light-Duty Plug-In/Electric Vehicles and Alignment Methodology
- SAE J3072, Interconnection Requirements for Onboard, Utility-Interactive Inverter Systems

SAE J1772™ defines a common EV conductive charging system architecture. The Standard describes the functional and dimensional specifications for the EV coupler (inlet and connector), along with the communication protocol and performance requirements. The SAE J1772™ conductive charge coupler is circular and 43 mm (1-5/8-inches) in diameter, and contains five contacts or pins:

- Two pins for power (AC line 1 and AC line 2/neutral)
- One pin for ground
- One pin for signals related to the amount of current allowed for the particular vehicle model being charged
- One pin for preventing the car from being moved while charging is under way.

The SAE J1772™ connector will support communication over power lines to identify the vehicle and control charging. When connected, the vehicle charger will communicate with the EVSE to identify the circuit rating (voltage and amperage) and will adjust to the battery accordingly. Thus, an EV that is capable of receiving 20 Amperes will receive that current, even when connected to a 40-Ampere-rated circuit.

The SAE J1772™ connector is designed to withstand up to 10,000 connection and disconnection cycles, along with exposure to all kinds of elements, dust, salt, and water, and is able to withstand a vehicle driving over it. With one connection/disconnection cycle daily, the average life expectancy of the SAE J1772™ connector is estimated to exceed 27 years.

The SAE J1772™ coupler is capable of conducting single-phase power up to 240VAC and up to 80 amperes to an EV.

Additional SAE documents related to EV and EVSE are under development.

A.3 Nationally-Recognized Testing Laboratory (NRTL) Listing

The Nationally Recognized Testing Laboratories (NRTL) program is a certification program operated by the Occupational Safety and Health Administration to certify organizations that provide testing and certification of equipment that complies with relevant product safety standards for products used in the workplace.

The following Underwriter's Laboratories (UL) standards form a basis for certifying EVSE:

- UL 2202 Standard for Electric Vehicle (EV) Charging System Equipment
- UL 2231 Standard for Safety of Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits
- UL 2251 Standard for Safety of Plugs, Receptacles, and Couplers for Electric Vehicles
- UL 2594 Standard for Electric Vehicle Supply Equipment

UL 2594 covers EVSE rated a maximum of 250 VAC with a frequency of 60 Hz, and intended to provide power to an EV with an onboard charging unit. The products covered by UL 2594 include EV Power Outlets, EV cord sets and AC Level 1 and 2 EVSE.

Equipment that successfully completes the testing is “certified," “approved,” or “listed” as meeting the requirements in the applicable product standard. The local AHJ can verify that components are approved, or listed and labeled. According to NEC, approved is defined as being acceptable to the AHJ.

All electrical materials and equipment associated with EVSE are required to be listed.

A.4 Americans with Disabilities Act (ADA) Requirements

Generally, Americans with Disabilities Act (ADA) parking requirements apply to EVs and EVSE.

The federal ADA, state revised statutes, and state structural Codes may identify requirements for location, design, and number of parking spaces for persons with disabilities. Such regulations contain requirements for the quantity, location, design and installation of:

- Number of required accessible parking stalls, including van-accessible stalls
- Connector and receptacle heights
- Special curb cutouts
- Parking and EVSE access

- Signage and pavement striping and markings

To enable persons with disabilities to have access to EVSE, EV connectors should be stored or located within an accessible reach, and access must be provided around the vehicle in order to connect the connector to the EV inlet. Whether indoors or outdoors, this means that the EV connector should be stored or located at a height of not more than 1.2 m (4 feet) and not less than 600 mm (24 inches) above the parking surface.

EV parking should be provided in premium locations similar to accessible locations. Because stalls containing EVSE may be dedicated for EV use only, the accessible parking stalls should be in addition to those required by local building codes for accessible parking.

For new construction, an accessible path from the EVSE to other services provided at the site is required. For new and existing parking facilities, it is important that EVSE locations permit adequate space (a minimum of 900 mm (36 inches)) for a wheelchair to pass parking bumpers and wheelstops.

A.5 State and Local Codes and Ordinances

Local jurisdictions can either adopt National or State codes, or can enact more stringent building regulations. Check with local building code officials to determine the exact Codes in force prior to installing EVSE.

A.5.1 National Electrical Code® (NEC®)

NFPA 70, National Electrical Code, (NEC), provides requirements that provide the practical safeguarding of persons and property arising from the use of electricity. In addition to the general requirements in Chapters 1 through 4 of the NEC, Article 625 governs the specific design, construction, and installation requirements for EVSE.

The NEC is provided as purely advisory to regulatory bodies in the interest of life and property protection. Adoption of the NEC into law is carried out by local jurisdictions and adoption of new NEC versions may follow several years from the most recent version of NFPA 70 (NEC).

A.6 Leadership in Energy and Environmental Design (LEED)

Leadership in Energy and Environmental Design (LEED) was developed by the U.S. Green Building Council to provide standards for environmentally sustainable construction and facility operations. LEED requires a study of CO^2 emissions and encourages the use of alternative fuel vehicles through monetary incentives or preferred parking.

LEED provides credits for installing EVSE and suggests certain percentages of parking be devoted to alternative fuel vehicles. These locations will apply to employees, as well as public visitors using the facility. Companies interested in being LEED-certified are excellent sites for publicly available EVSE. Available LEED credits for installing EVSE include:

- LEED for New Construction Sustainable Sites Credit 4.3 provides three (3) available points towards LEED accreditation if 5% of parking is made available for low-emission & fuel efficient vehicles, such as EVs.

- LEED for Existing Buildings Sustainable Site Credit 4.0 provide three (3) to fifteen (15) available points for the reduction in conventional commuting trips from 10-75%.

(*This annex is not part of the Standard)*

Annex B: EVSE Pre-Installation and Inspection Guidelines

B.1 General

The following is a set of guidelines for conducting preliminary surveys and inspections prior to installing EVSE. While not all inclusive, these guidelines identify the areas of concern for installing typical EVSE in residential and commercial applications.

B.2 Code Enforcement and Permitting

- Contact the local Code enforcement office to identify the Authority Having Jurisdiction (AHJ).
- Verify the applicable Codes and Standards enforced by the AHJ.
- Determine whether there are any local amendments to Codes and Standards enforced by the AHJ.
- Review Americans with Disabilities Act (ADA) requirements for EVSE.
- Determine whether a plan review is required. Ensure that the plan review, when required, includes a review of whether the EVSE site is within a flood plain.
- Obtain electrical wiring permit(s).
- Coordinate and facilitate the inspection and approval process with the AHJ.
- Keep in mind that the local electric utility will not energize a new electric meter without an approved building/electrical inspection.

B.3 Site Survey

- Determine whether the EVSE installation site is subject to roof drainage, water run-off, or standing water that may pool and/or freeze. Locate EVSE away from low areas of parking lots that are prone to accumulate standing water.
- Identify any potential nearby hazards or hazardous materials, such as explosive materials, flammable vapors, liquids, or gases, combustible dust or fibers, or materials that ignite spontaneously upon contact with air. Locate EVSE away from hazards and hazardous materials.
- Identify any potential obstructions or debris that could accumulate around EVSE, such as leaves, limbs, and trash.
- Determine the suitability of site and area lighting for EVSE operation, maintenance, safety, and security.
- Consider signage, visibility, and access for drivers to easily locate and operate EVSE.
- Evaluate the location and access of EVSE for safety and security, considering vandalism and theft.
- Consider physical protection of EVSE from EV's, such as wheelstops, bollards, sidewalk, curbs, or setbacks.
- Determine whether the EVSE site location is level or will require a level concrete pad.
- Consider providing shade for outdoor locations exposed to sunlight.
- Consider distributing multiple EVSE for greater public access and convenience in lieu of grouping EVSE in one location.
- Ensure that EVSE complies with ADA requirements for adequate space and accessibility.

- Verify adequate access space and clearance dimensions for EV and operating personnel.
- Check the distance from the EVSE to the EV to avoid tripping hazards. Locate and orient EVSE such that charging cords do not cross sidewalks, walkways, or other areas of pedestrian traffic.

B.4 Determine EV Charging Level

- Determine the type of EV and EVSE being installed (one or more of AC Level 1, 2, or 3, or DC Level 1, 2, or 3).
- Contact the EV and EVSE manufacturers to determine the supply voltage configuration, ampacity and power requirements of EVSE.
- Recalling that EVSE is considered to be a continuous load, determine the ampacity of conductors and overcurrent protective devices (not less than 125% of full load current).

B.5 EVSE Evaluation

- Review and follow the manufacturer's installation instructions.
- Ensure that EVSE is listed and marked by a Nationally Recognized Testing Laboratory (NRTL).
- Check that EVSE cord length does not exceed 7.5 m (25 feet) or that a cable management system is permitted.
- Where ventilation is required for charging EV's indoors, verify that a suitable mechanical ventilation system is installed and can be controlled and interlocked with the EVSE.
- Verify the manufacturer's recommended operating and charging temperature range. Consider providing shade for outdoor installations, and ventilation for indoor installations.
- Determine communication and control requirements, such as internet connections, radio frequency identification (RFID), wireless, and infrared.

B.6 Load Calculations

- Use EVSE nameplate data to calculate the full load current of equipment.
- Recalling that EVSE is considered to be a continuous load, size ampacity of conductors and overcurrent protective devices at not less than 125% of the calculated load current.
- Consider additional capacity for future expansion and additional EVSE.
- Evaluate the existing electric service to determine its adequacy for installing new EVSE.

B.7 Existing Utility Service Evaluation

- Submit all required applications and fees to the electric utility provider.
- Contact the local electric utility provider to determine whether there are any utility interconnection, control, or communication requirements that apply to EVSE, such as different utility rate or tariff, separate utility revenue meter, EVSE programming, utility load shed control, and smart charger.
- Review a minimum of the prior 12 months of electric utility bills to determine energy usage and demand data to evaluate whether EVSE loads can be added to the existing service.
- Where the capacity of the existing utility service is inadequate, evaluate whether a load control strategy can be employed, such as time clocks, utility load shed control, EVSE

programming, or smart chargers, in lieu of installing a new utility service or upgrading the existing utility service.

- Evaluate the existing utility service and existing panelboards to determine whether there is sufficient capacity and space to install the required overcurrent protective devices and connect EVSE. When adding circuits to existing panelboards, do not exceed the maximum number of circuits in accordance with manufacturer instructions. Install half-sized (tandem or twin) circuit breakers or install a sub-panel as needed.
- Locate EVSE in close proximity to the AC power source to minimize voltage drop.

B.8 Commercial Fleet EVSE

- Contact the local electric utility capacity planners to assist with the evaluation of the capacity of the existing utility service.
- Consider future expansion and additional EVSE in load calculations.
- Locate EVSE away from petroleum fueling stations.
- Locate EVSE in low-traffic areas to accommodate other activities in the lot.

(*This annex is not part of the Standard)*

Annex C: Reference Standards

SAE J1772™ SAE Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler

SAE J1773 SAE Electric Vehicle Inductively Coupled Charging

SAE J2293 Energy Transfer System for Electric Vehicles

SAE J2836 Use Cases for Communication Between EVs and the Utility Grid

SAE J2847 Communication Between EVs and the Utility Grid

SAE TIR J2954 Wireless Power Transfer for Light-Duty Plug-In/Electric Vehicles and Alignment Methodology

SAE J3072, Interconnection Requirements for Onboard, Utility-Interactive Inverter Systems

UL 1741, Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources

UL 2202 Standard for Electric Vehicle (EV) Charging System Equipment

UL 2231 Standard for Safety of Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits

UL 2251 Standard for Safety of Plugs, Receptacles, and Couplers for Electric Vehicles

UL 2594 Standard for Electric Vehicle Supply Equipment

UL 9741, Bidirectional Electric Vehicle (EV) Charging System Equipment