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# Electrical Safety at Electric Vehicle Charging Stations

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**ABSTRACT**

Electric vehicles (EVs) are alternative transport systems, which protect our environment and reduce pollution. By using conventional vehicles, they affect the environment by causing air pollution. To avoid this effect EVs are promising solutions. In order to operate under normal conditions, plug-in vehicles (PEVs) must adhere to minimum safety standards for crashes and other unfavorable situations. The consumer may be vulnerable to a variety of risks brought on by human involvement with these vehicles, including chemical, accident, electrical, and fire threats. To reduce potential contact during a collision, the battery connections should be placed as far apart as feasible. Voltage levels and the amount of available electric energy linked with a particular battery technology both raise the electrical hazard. PEV chargers transform ac power to dc and send the electricity from the source to the utility grid or renewable energy sources, such as solar cells, to the PEV battery. While charging (i.e., connection to the network or to off-board chargers). The proper insulation of live items inside the EV, such as insulated wires and enclosures, performs the function of protecting against direct contact. The importance of safety concerns, notably electric shock protection for EV users, cannot be overstated. The EV's higher working voltages, various frequencies, and potential inability to defend against direct and indirect connections may jeopardize the safety of users. High voltage is commonly described as any voltage that is greater than 30 Vac and 60 Vdc. The conductive structure of the PEV, which is not electrified during normal vehicle operation, is connected to the negative terminal of the battery, increasing the risk of electric shock. Due to the enormous conductive surface of the EV in this instance, there is a greater likelihood that someone already in contact with a part at the positive terminal potential will also be in contact with the chassis.

Keywords: Electric vehicle charging stations, plug-in vehicles, charging stations.

## 1. Introduction

Transportation is the main cause (or) drop of our environment. By using fossil fuel vehicles that get polluted and cause greenhouse gas emissions to solve this problem, the government takes the main role of introducing electric vehicles(EVs). Maintaining electric vehicles should be more efficient and effective and it will be low cost to purchase these vehicles. As well as charging stations are also built within a certain area in proper condition. Mainly hybrid electric vehicles are run using batteries, So then the batteries must be in a more efficient condition to avoid battery combustion and vehicle blasting (or) burning. plugs and connectors are to avoid loose connections to get rid of failure conditions; these precautions are to be taken into electrical safety consideration. The government introduced some guidelines as per the instructions and safety policies the charging stations will be designed with proper safety assessments.

1. Fire safety.
2. Transformer deaths as a result of improper PEV charging.
3. Integration of photovoltaic systems (smart charging).
4. Earth Protection System (EPS).
5. A communication-assisted defense plan can minimize the flaws. (To guarantee that EVCS is evaluated for safe charging)

An emergency voice communication system is referred to as EVCS. It serves as the primary means of communication for power systems. Through efficient EV control, these will respond to utility signals while in transient operational modes and operate as distributed energy resources (DER). The charging was processed with the low time taken and efficient charging to the battery to get rid of damage. Future EV uptake will depend significantly on the EVCS' ability to maintain grid stability and flexibility. EVCS became the primary responsibility for communication networks, upholding greater benefits and assuming sizeable problems. They researched cyber security and the cyber reliability of distribution systems for consistent charging station performance. To avoid dangerous situations and manage the risk associated with plugs and connectors, EVCS depends on the risk management control mechanism employed during the design phase.

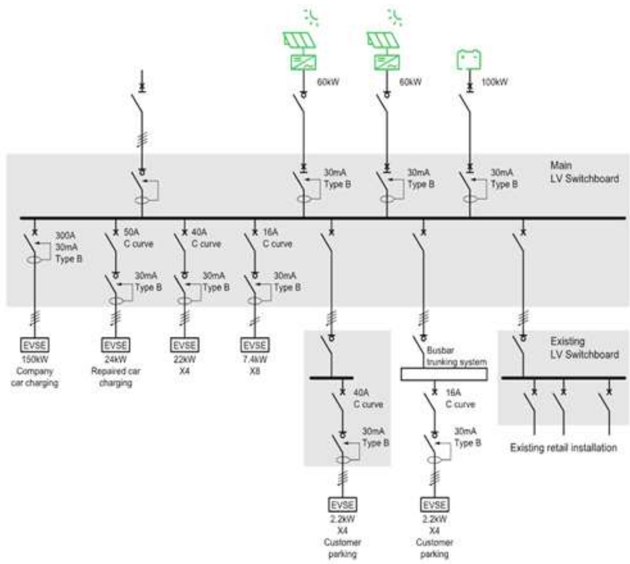
## 2. Design of an electric vehicle charging stations

There are three basic techniques that are frequently used to charge an EV:

(I) conductive charging, in which the battery is connected directly to an EVSE via a cable; (ii) inductive when the electricity is used for charging, also known as wireless charging is transferred from one magnetic coil to another through an air gap in the charging unit to a second magnetic coil installed in the vehicle; (iii) Battery exchange, in which an electric vehicle's battery is replaced with new ones in a battery swapping station (BSS) Conductive The benefits of charging include low cost, excellent efficiency, and basic design. Standards and Requirements for EV Charging The power level of charging are described by the charging level. conductive charging techniques are used in the outlet. SAE J1772 has two AC and two DC versions as of 2017 [25]. following charging levels:

1) AC Level 1, commonly referred to as home charging, supports a maximum current level of 16 A and a voltage level of 120 V.
2) AC Level 2 provides a maximum of 208-240 V support. 80 A is the current. The 19.2 kW maximum power available here may be used for charging at home, business, and public places facilities.
3) DC level 1, having an output voltage range of 50 to 1000. 80 A as its maximum current.
4) DC level 2, with the identical Despite a maximum current, DC level 1 output voltage It has a 400 A maximum.

Although both AC levels demand the EV has a single-phase AC charger built into the vehicle, DC levels charge the EV battery using power from the EVSE. immediately with Off-board charging with DC power, where Both the utility's single-phase and three-phase AC power supplies can be converted to DC power. As opposed to SAE J1772, SAE J3068 is a suggested practice for using three-phase AC power for conductive charging




Figur1: EV Charging infrastructure for a vehicle dealership that considers the various charging requirements

Design of an EV charging infrastructure example. Following is a diagram that shows an illustration of an EV charging infrastructure that adheres to the presumptions mentioned. A new Main Low Voltage is linked to all EV loads. Switchboard (MLVS) (MLS). A protection circuit for each EV is used. a 30mA type B residual current device with a circuit breaker (RCD), in accordance with IEC 60364-7-722, (verify whether an EV charging station already has RCD built in. EVSE needs to be shielded against transient overvoltages. as a result of lightning strikes. Depending on the building's lightning protection, the EVSE's location, and other factors, surge protection devices may be necessary (indoor or outdoor), and how far the EVSE is from the SPD at the LV switchboard, and EVSE ought to have automated disconnection protection from residual current and overcurrent can be bundled into a single unit (like the 150 kW EVSE). circuit). The EVSE should be examined to see if it has built-in AC and DC sides, and between the protection tools chosen appropriately. It is advised that the multiple 7.4kW single phase EVSE be connected evenly throughout the three phases to prevent unbalance Given that numerous EVSEs are situated in the same building an LV in the vicinity (customer parking) might be worthwhile. sub panel close by for these EV loads to enhance the length and number of cables. Due to the numerous EVSEs, A busbar is situated nearby (staff parking). Using a trunking system can offer a flexible, affordable successful, and reliable solution like the present dealership the new main LV switchboard, where the installation is linked. Selectivity is required for overcurrent and residual current protection. must be weighed. The power is increased by the new EV loads. significant demand Adding another photovoltaic system and Storage can assist in offsetting some of the increased power demand.

Homes, people who are open to changing their way of life, and people with other characteristics that are similar. More than 6500 FCVs had been sold to

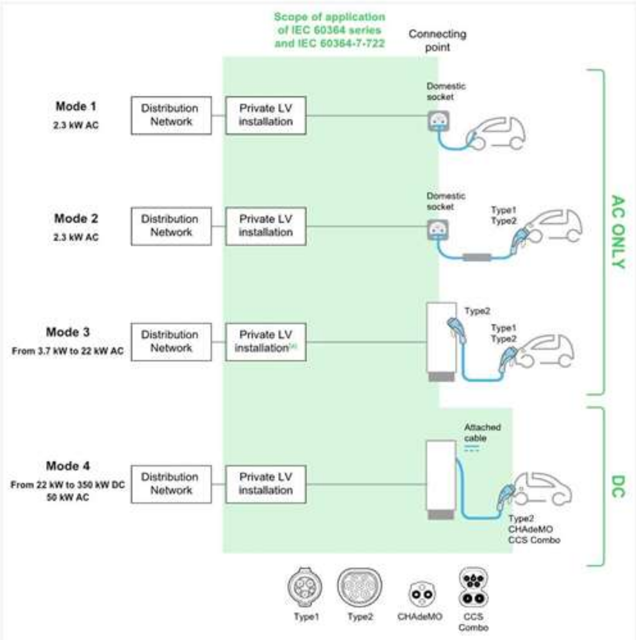

Scope of application of IEC 60364 series and IEC 60364-7-722
Connecting point
Mode 1
2.3 kW AC
Distribution Network
Private LV installation
Domestic socket
Mode 2
2.3 kW AC
Distribution Network
Private LV installation
Domestic socket
Type1 Type2
Mode 3
From 3.7 kW to 22 kW AC
Distribution Network
Private LV installation
Type2
Type1 Type2
AC ONLY
Mode 4
From 22 kW to 350 kW DC
50 kW AC
Distribution Network
Private LV installation
Attached cable
Type2 CHAdeMO CCS Combo
DC
Type1
Type2
CHAdeMO
CCS Combo

Figure 1. Charging modes

## Hazardous for electric vehicle users at charging stations

### *1. Electric shocks*

The high voltages required to charge electric vehicles make users susceptible when plugging in, unplugging, and handling cords, whether at home or a public station (an AC charger needs 110-240V). Electric shock danger can be increased by damage to cables and charging equipment, including wiring and plug damage from deterioration, cable chaffing, dragging, and environmental factors. Additionally vulnerable to copper theft and vandalism are public charging stations, where exposed wiring could result in injury or even death. lowering the danger Electric shock risk at charging stations can be considerably decreased with simple upkeep of cable insulation, plugs, and wiring. Before turning on the charger or inserting it into your car, check all of the equipment's parts frequently. Although electric shocks do occur, learning what to do in an emergency if one occurs is advised to lessen the severity of injuries. Wearing rubber-soled shoes and other basic electrical safety precautions can help lower your risk of harm. You can decrease your chance of injury by taking additional basic electrical safety precautions like wearing shoes with rubber soles.

### *2. Lithium-ion battery-related high-voltage fires.*

All electric vehicles on the road are powered by lithium-ion batteries, which are a relatively recent development. They are vulnerable to damage from overheating or when exposed to high temperatures through a thermal runaway reaction since they are made to be as light as possible while having a high energy storage capacity. Any car can catch fire from a short circuit, but lithium-ion batteries' flammable electrolyte liquid can set off a high-voltage fireball that burns at extremely high temperatures and spews out a lot of poisonous fumes. Additionally, these fires can take days and tens of thousands of gallons of water to put out due to the strength of the fire and the limited expertise rescue personnel have with EVs– continually endangering people, property, and the environment. lowering the danger Your lithium-ion battery's resistance to damage will sharply lower the likelihood of a fire. Avoid overcharging, fast charging with DC, and keeping batteries in hot vehicles as they can all cause the battery to become unstable and increase the risk of explosion. While the battery charges, a shutdown separator keeps the two unstable sections apart. They can be used to give an extra layer of protection to the built-in shutdown mechanisms in lithium-ion batteries, albeit they do not completely eliminate the risk of fire. The risk of an explosion or fire can be decreased by routinely checking your cooling system, whether it uses fluid or air, and making sure it is well-maintained. This will assist to keep temperatures down when driving and charging.

### *3. Trip over power cables.*

Electric car wires are larger and more noticeable than standard electric cables, but they still pose a significant trip danger. Due to their scarcity and susceptibility to poor planning, low lighting, especially at night, and a high volume of people running around, public charging stations are frequently busy. Home charging presents additional difficulties, such as improper placement of the charging station, which necessitates that cables be run across sidewalks or dangle precariously in the air, endangering both the EV and the charging equipment and posing a serious risk of serious injury from trips and falls. lowering the danger Avoid using cables that are longer than necessary to prevent coiling and twisting that could snag a foot or leg and cause a fall. Parking as near to the charging station as you can help the cable go less distance and prevent it from crossing sidewalks and streets. If you must run your cable across a walk or carriageway, get a cable protector that will prevent damage and raise the risk of fire or electric shock while also allowing people to speak over the line while it is lying flat. Take the time to thoroughly analyze the ideal location of the charging station from a trip hazard perspective before installation if you decide on a personal home charger.

### *4. Cyberattacks*

In order to coordinate operation systems, make driving easier, and improve the experience, EVs frequently rely on data, software, sensors, and artificial intelligence. Due to this connectivity, additional devices are exposed to cybersecurity risks such as hacking, data compromise, system disruptions, bad actors, and hostile assaults. You become more susceptible to these attacks if you charge your EV at a public station and plug it into the grid. By cutting the brakes, disabling the lights, and controlling the steering controls, hackers can endanger human life. If your ID badge is copied and used to conduct transactions or breach your account in mobile apps related to EV, your personal privacy may also be in danger. lowering the danger You may shield your EV against cybersecurity risks by incorporating defense methods. To effectively conceal the IP address connected to your EV and offer security for your internet operations, such as updating your onboarding software, use a VPN for your car. In addition to preventing malware and fraud, using a Software-as-a-Service (SaaS) for your car's Wi-Fi and surfing capabilities can also limit search results. Although connecting your phone or other mobile devices to your EV may be convenient, you should think about each one's security before doing so because they could be used by hackers to compromise your systems. Additionally, effective tech hygiene practices include the use of strong passwords, two-step authentication, and digital signatures where your devices support them.

### *5. collisions between automobiles and pedestrians.*

EVs are well renowned for being significantly quieter than gas-powered vehicles. Without the sound of the engine, they may be hard to hear and may collide with pedestrians and cyclists who are more susceptible to injury or death on the road. EV users are more likely to collide at crowded public charging stations as both a pedestrian and a driver, especially if they have vision or hearing impairment. utilize great loss, harm, and damage. lowering the danger 2019 saw the EU's introduction of the Regulation on the Sound Level of Motor Vehicles, which aims to reduce the frequency of EV incidents with pedestrians. An Acoustic Vehicle Alert System (AVAS), which imitates the sound of a regular gasoline engine and makes EVs easier to hear, has become a legal requirement for all new electric vehicles. Purchasing a noise-emitting AVAS will assist make your car more noticeable and less prone to cause accidents if your EV is older than 2019. At public charging stations, taking simple safety precautions lowers your risk of hitting pedestrians or other vehicles. Following road signs, traffic flow instructions, and speed limits will help limit your liability in the event of an accident.

## Conclusion:

We come to the conclusion that the government implemented standards and guidelines for the arc flash boundary, grid interoperability, periodic inspection, fire safety, and maintenance related to the EVCS facilities discussed by National Fire Protection Association (NFPA) and Canadian Standards Association in order to guarantee a safe operating environment for the EVCSs (CSA). We have also broken down the planned EVCS cyber-physical system's several layers of safety considerations. The hierarchy of hazard control approaches can be used by EVCS operators to assess electrical safety using the risk assessment model that is proposed for big EVCSs. Using numerical case studies, it was shown that the risk assessment model for EVCSs can analyze big EVCSs' safety requirements and assist in informing planning and operating decisions.

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