WHITE PAPER

ELECTRIC VEHICLE CHARGING SYSTEMS

By North Eastern Ohio Fire Prevention Association (NEOFPA)

March 2023

The North Eastern Ohio Fire Prevention Association (NEOFPA) is a Fire Prevention group which was formed to organize the major fire prevention departments throughout the Northeast Ohio, so that fire prevention related matters such as code changes, fire safety issues, and other related topics could be uniformly supported and disseminated with a cohesive voice.

Members represent hundreds of fire departments and private fire protection companies throughout the Northeast Ohio region, and the organization has experienced continued growth since its inception. The organization is recognized by the State of Ohio Fire Marshal's Office, the Ohio Fire Officials Association and participates nationally through various organizations including the NFPA (IFMA) and the ICC. Education, Enforcement, and Engineering are the premise for all fire prevention activities. The purpose is to be effective in the execution of any changes necessary to protect the public throughout a statewide network of fire officials.

NEOFPA recognizes the need for establishing critical information on Electric Vehicle Charging Systems. Within the last few years, the manufacturing rate of electric vehicles have drastically increased (approximately 40%) and will continue to do so for the foreseeable future. Upon researching articles published by National Renewable Energy Laboratory (NREL), Forbes Advisor, Fortune Business and The National Fire Protection Association (NFPA), NEOFPA with the backing of the Ohio Fire Officials Association (OFOA), is establishing a white paper to discuss and recommend local ordinances regarding the installation of electric vehicle charging systems (EVCS) for the safety of businesses and consumers.

In 2020, approximately 300,000 EV's were sold which equals about 2% of new US automobiles sold. It is forecasted that by 2030, 35 million EV's will be on the road in the US. This presents a possible issue with charging station locations and the time it takes to recharge a vehicle. Couple this with technological challenges, government regulations, and electrical grid updates and we could have a bottleneck when it comes to rapid charging of vehicles. Building public charging stations requires plan submission and approval through local governments. A framework of best practices and consistent regulations will streamline the process for everyone. The use of current fuel stations for EV charging presents additional concerns and disadvantages due to required time to recharge a vehicle. The best locations for these charging stations are at business/parking lots where people spend more time.

With regard to standards, the NEC (National Electric Code) Article 625 titled Electric Vehicle Power Transfer System covers the electrical conductors and equipment connecting an EV to premises wiring for the purpose of charging, power export, or bidirectional current flow. Providing GFCI protection, using UL listed and tested components, and ensuring the charging equipment is installed by qualified electricians are also part of the requirements in this code. Maintenance is also a key component for these systems to ensure hazards to the public are abated.

To date, the state and national fire codes along with some NFPA codes do not address fire safety in regard to the charging of EV's. There are future code changes to address this issue in the standards being developed over the next few years; however, the code is always behind technology. This may require AHJ's to adopt language to address these issues locally to provide safe charging stations for the public today. Many of the recommendations in this document have

been extracted from standards and documents under review at the current time; however, due to the code adoption process many of these codes/standards may not take effect till 2024 or 2025.

The NEOFPA recognizes that not all jurisdictions can inspect or mandate the requirements as described in this paper; however, emphasis should be placed on the importance of safety for these installations and that technology and growth in this area will happen regardless of the implementation of these recommendations. The recommendations listed in this paper have been researched and many of them are in the process of code adoption at the national level within the next 2-3 years. Due to the current code cycles for both national and state codes, it is recommended that cities and townships review these recommendations and enact them locally, so these charging stations are installed with the safety of the public and responders in mind. The NEOFPA further supports research and development into the extinguishment technologies that may become available to first responders.

In summary, NEOFPA issues this white paper in order to make clear the hazards associated with EVCS and to help local jurisdictions develop ordinances or standards to minimize the likelihood of a fire or event in their jurisdiction. Included in this paper is information on frequently asked questions, as well as a reprinted article on fires involving electric vehicles. This is done to answer common questions and relay the issues surrounding the potential fires in these vehicles. It is also our position that this industry will continue to evolve and change and that as additional information becomes available this paper will need to be updated.

TOP FAQS FOR PUBLIC EV CHARGING

For a long time, the key factor holding back the electric vehicle revolution was the fact that there was not nearly enough funding for public electric vehicle supply equipment (EVSE). That is changing — now billions of dollars are being allocated with a goal of installing half a million public EV chargers by 2030. As the number of public chargers and the EV adoption rate continue to rise, it's normal to wonder how the public charging process works. To help you navigate through this process, we have listed some answers to the most frequently asked questions for public EV charging.

1. Why is at home EV charging preferred over public EV charging?
Over 80% of EV charging happens at home. This is partly due to the fact that there has been a lack of public EV chargers in the past. As more EVSE are added to communities and places of work, this will likely change. However, many EV owners will still likely prefer the convenience, control and cost savings of charging at home.

2. What are my public EV charging options?
Public EV charging stations will either be Level 2 or Level 3 DC Fast Chargers (DCFC). Level 2 EV chargers supply alternating current (AC) to the vehicle's on-board charger which converts the AC power to direct current (DC) to charge the battery. On the contrary, DC Fast Chargers bypass the vehicle's on-board charger and supply DC power directly to the EV battery.

3. Does DC fast charging damage the EV battery?
Excessive DC fast charging can negatively impact EV battery performance and durability. Compared to standard charging, eight years of fast charging would take approximately 10% off of the EV battery life. While DCFC is convenient and at times absolutely necessary, this method of charging should be utilized only when essential.

4. Can I use any public EV charger?
If charging with Level 2, you can use any public EV charger as they all use or have an adaptor for a standard SAE J1772 connector. Level 3 DC Fast Chargers typically have one of two connectors - these connectors are incompatible. However, a lot of EVs have a charging port for each. Tesla used to have a third connection type for Level 3 charging, but Tesla superchargers are now compatible with other vehicle models. To be safe, make sure you know your EV connector (all EVs except Nissan and Mitsubishi should use CCS).

5. How can I find a public EV charger?
Finding a public EV charger is easier than ever. Almost all public EV charging companies have a network, accessible through an app, to display charging station locations. With the advancement of interoperability, charging networks also exchange information with one another to display chargers from multiple companies. This Open Charge Point Protocol (OCPP) simplifies the user experience by eliminating the need to download multiple apps. Public EV chargers are also visible on some navigation software such as Google Maps.

6. How long does public EV charging take?
Public EV charging time is dependent on the type of charger, among other factors. Level 2 EV chargers, more commonly found in local communities and places of work, can add around 15 to 30 miles of range per hour. DC Fast Chargers, more common along highways, can charge your EV in as little as 30 minutes. No matter how you choose to charge your EV away from home, expect the process to take longer than filling a gas tank.

7. How much does public EV charging cost?
This is dependent on what type of charger you use, when you charge and what pricing model is in effect. Public EV pricing models include monthly subscriptions, pay as you go or some combination of both. While there are variables, you can assume that using a DC Fast Charger will cost around $15-30 for a full charge. Already less expensive than filling up with gas, EV charging will only get cheaper as you decrease your charging level to Level 2 or Level 1.

The below article was reproduced and included with this paper to provide insight into the question about EV fires in vehicles and extinguishment. There are many similar articles available on this issue.

Electric vehicle fires are rare, but hard to fight — here's why

PUBLISHED SAT, JAN 29 2022 8:00 AM EST

Andrew Evers@ANDEVERS6

Lora Kolodny@LORAKOLODNY

Electric vehicles provide a path to better air quality, reduced fuel costs and comprise a growing new category for automakers. But with the transition to electric transportation comes a new challenge: Vehicles with lithium-ion batteries can be especially dangerous when they catch fire.

The good news is battery electric vehicle fires don't happen often.

Project Director of EV FireSafe in Melbourne, Australia, Emma Sutcliffe, says researchers need more data to determine fire rates conclusively, but preliminary studies indicate fires in fully electric cars are rare.

Research by another firm, AutoinsuranceEZ, says battery electric vehicles have just a .03% chance of igniting, compared to internal combustion engine vehicle's 1.5% chance. Hybrid electrics, which have both a high voltage battery and an internal combustion engine, have a 3.4% likelihood of vehicle fires according to their study.

However, when fires do occur, electric vehicles with lithium-ion batteries burn hotter, faster and require far more water to reach final extinguishment, Sutcliffe says. And the batteries can re-ignite hours or even days after the fire is initially controlled, leaving salvage yards, repair shops and others at risk.

Chas McGarvey, the Chief Fire Officer of Pennsylvania's Lower Merion Fire Department, told CNBC that one Tesla Model S Plaid fire his department handled in 2021 burned so hot that it melted the roadway beneath it.

Sutcliffe told CNBC, "A lot of the time firefighters and fire agencies are just expected to kind of figure it out." With so many new models hitting the road, McGarvey the fire chief in Pennsylvania said, "We're still trying to catch up with all this stuff. But it changes almost every day!"

The Director of Maryland's Energy Institute, Eric Wachsman, says that the qualities that make lithium-ion battery cells powerful enough to move a passenger vehicle can also make them vulnerable to igniting-- especially if battery cells within them are damaged or defective.

Lithium-ion battery cells have electrodes placed close together, which increases the chances of a short, he says, and they are filled with a flammable liquid electrolyte.

"This flammable liquid could get into what's called a thermal runaway situation where it just starts sort of boiling, and that results in a fire," he said.

Electric vehicles include battery management systems to maintain the right operating temperature for high voltage batteries inside, and those systems control how fast batteries charge and discharge. Improvements to them as well as the battery cells themselves promise to make EVs safer.

Tesla recently announced it's switching from lithium-ion battery cells to lithium iron phosphate (LFP) batteries. Other major automakers including Ford, and VW are also substituting LFPs for nickel or cobalt formulations used in some of their electric vehicles.

"These are generally believed to be a lot safer," said Paul Christensen, a professor of electrochemistry at Newcastle University whose research focuses on lithium-ion battery fires and safety.

In the end, he believes, fully electric vehicles have a chance to be safer than the gasoline- or diesel-burning models they replace.

"We've had a long time to fully understand the risks and hazards associated with petrol and diesel cars. We're going to have to learn faster how to deal with the challenges with electric vehicles. But we will".

Electric Vehicle Charging Stations (EVCS) (*Sample Ordinance*)

For purpose of this section, an EVCS shall mean a public parking space that is served by battery charging station equipment for the purpose of transferring electrical energy (by conductive or inductive means) to a battery or other energy storage device within an electric vehicle.

General Requirements

1) These requirements pertain to all EVCS that are either a Level 2 or Level 3 charger. If a charging station has more than (1) one port, each port shall count as a charging station.
2) The designated parking space(s) for an EVCS shall be above the minimum number of parking spaces required for the site in accordance with COW Chapter 1161.
3) The recommended parking space dimensions for an EVCS are a minimum of ten (10) feet wide by twenty (20) feet long when new spaces are installed for such use. An additional five feet in width shall be required for ADA accessible locations.
4) The charging station and equipment shall be protected by wheel stops and bollards in accordance with Ohio Fire Code Section 312.
5) Each parking space designated for EVCS shall be clearly identified as reserved for EV Charging Only.
6) Charging station equipment shall not exceed eight (8) feet in height.
7) Charging stations shall not include overhead canopies.
8) The EVCS shall comply with the current National Electric Code (NEC) and shall be inspected once a year and proof of inspection shall be made available to the AHJ.
9) An EVCS shall be installed in a location as follows:
    a. Ten (10) feet from property lines
    b. Twenty (20) feet or more from buildings having combustible exterior wall surfaces
    c. Ten (10) feet or more from buildings having a one-hour fire resistive exterior surface.
10) EVCS shall be designed and constructed in accordance with state and local building codes and this ordinance.
11) EVCS shall be constructed, operated, and maintained based on manufactures instructions.
12) Any attendants shall be trained in the operation of the EVCS system and able to supervise and respond to emergencies.
13) EVCS shall be provided with one or more clearly identified shutoff devices or electrical disconnects with an approved sign stating “Emergency Electrical Vehicle Charging System Shutoff”.
14) EVCS shall have emergency instructions conspicuously posted in the area and shall include the following:
    a. Use of Emergency shutoff button/disconnection device
    b. Report incident by calling 911
    c. Report location to emergency services
15) Emergency shutoff devices or electrical disconnects shall be installed in an approved location accessible to patrons but not less than 20 feet or more than 30 feet from the EVCS.

16) Resetting from an emergency shutoff condition shall require manual intervention.
17) Lighting shall be selected and installed in accordance with applicable building codes and local ordinances and shall be sufficient for safe operation and security.
18) At least one portable fire extinguisher for each group of EVCS shall be provided and shall not exceed a travel distance of 75 feet.

Motor Fuel Dispensing Facilities

1) Additional EVCS installation requirements:
    a. Twenty (20) feet or more in all directions from dispensing devices for flammable or combustible liquids.
    b. Ten (10) feet in all directions from above ground/underground tanks, tank fill connections, remote/submersible pump transfer equipment, vapor recovery equipment and vents.
    c. Twenty-five (25) feet in all directions from the location of tank vehicles while filling and transferring flammable or combustible liquids.
2) EVCS shall be designed so that the pooling of flammable or combustible liquids cannot occur in the charging area.
3) At attended locations and motor fuel dispensing facilities, an additional emergency shutoff or electrical disconnect shall be located at the attendant's location.