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Standard Development Process for the Establishment of North American Harmonized Requirements for Electric Vehicle Supply Equipment (EVSE)

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ABSTRACT

This paper presents an overview of the efforts of Canadian Standards Association regarding the development of North American Harmonized Requirements for the electric vehicle supply equipment (EVSE). We discuss three areas of focus: identifying and addressing the immediate needs of industry stakeholders in the North American market; addressing expected changes in technologies and advancements in existing technologies; and finally, understanding the international standards landscape and the role of North American harmonized standards and related needs for harmonization at the international level. The issue and success of harmonization of EV standards is important in helping support and maintain compatibility between jurisdictions. This is especially true in the highly integrated North American market, and also in terms of helping to position North American producers as leaders and innovators globally.

1. Introduction

Electric Vehicles (EV's) have arrived. Although currently the EV in its entirety still represents only a small proportion of the total number of passenger vehicles in most jurisdictions, it is widely expected that the EV will experience rapid growth over the coming decades. In a 2009 study, for example, JP Morgan estimated that by 2020 more than 6 million plug-in hybrids and battery powered EVs will be sold in North America per year, with over 11 million EVs projected to be sold worldwide. According to JP Morgan, this will mean that the EV will equal 19 percent of the North American market and 13 percent of the global passenger market at that point in time. Meanwhile, Canada's technology roadmap for the EV concluded that by 2018, there will be at least 500,000 highway-capable plug in electric-drive vehicles on Canadian roads, as well as what may be a larger number of hybrid-electric vehicles.

The impact of the EV in regards to public health and safety, environmental sustainability, as well as how quick this technology is adopted will be greatly influenced by the standards to which the EV and related infrastructure are designed and the adherence to these standards by manufacturers, technicians, and other related professionals. Standards are also important in that these provide a mechanism to share knowledge and make this knowledge a public good. This in effect increases the economic efficiency of development as producers and developers can share in best practices and lessons learned. It is also important that, given the diverse and wide spectrum of technologies involved with the EV and seeing the varying level of development of each, standardization will have to play varying roles across the development spectrum.

Within the last number of years, large as well as specialized automakers have launched EV products into the North American marketplace, and several more are slated to be introduced in the coming year ahead. When considering the North American market generally, in Canada, new vehicle introductions have typically lagged the U.S. market by 6 to 12 months. And the same has proven to be true for the EV. Furthermore, while the auto OEM launch plans are firmly in place, the development of the appropriate EV standards has had to play catch-up. This has been particularly true for Canada where, as recent as 2009, published EV-specific requirements were only to be found in a few CSA electrical standards and scattered in Sections in the Canadian Electrical Code (CEC).

Many countries also have a suite of their own EV-related standards, many relying or consistent with international standards. Japan, being the world's predominant producer of hybrids and many battery technologies, has established the Japanese Electric Vehicle Association which in turn publishes a series of standards specific to the EV. Europe has also developed a range of EV-related standards, as published by the European Committee for Electrotechnical Standardization. In the U.S, EV-related standards have been developed by UL since 1998 and are now undergoing updates, while China appears to largely rely on adaptations of SAE standards for the EV.

The majority of standards are developed using a consensus-based approach, where stakeholders and experts from industry, government, academia, and the informed public come to agreement on acceptable performance levels and procedures. Their development is not directly under the control of government in most countries, but rather facilitated by accredited Standards Development Organizations (SDOs). SDOs help develop standards where there is a need identified by regulators, academics, industry, or voiced by the concerned public. Some of the most relevant SDOs to this article include the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC), both operating at the international level. There are also a range of national-based SDOs focused on developing relevant standards and ensuring compatibility with international standards, such as the Institute of Electrical and Electronics Engineer (IEEE) and Underwriters Laboratories (UL) (both based in the United States), the Standardization Administration of the People's Republic of China (China), Japanese Standardization Association (Japan), the European Committee for Electrotechnical Standardization (Europe), DIN Electromobility Office (Germany), Standards

Australia Institute (Australia) or Canadian Standards Association (Canada). There are also the SDOs working in more specialized contexts, of which perhaps the most relevant is SAE International (Society of Automotive Engineers) who are primarily focused on standards related to the automotive industry.

This paper will first look at the early challenges faced by Canadian industry and government as related to the increasing penetration of the EV, and in particular, the challenges that were being created by the use of varying standards and practices within the North American marketplace. We then consider the resultant actions that have been and will be taken in order to establish harmonized standards for North America in terms of the EV and Electric Vehicle Supply Equipment (EVSE) and the associated certification programs made available by these actions.

2. The challenges of varying standards in an integrated market and economy

Three main reasons underlie the need for harmonized North American standards as related to the EV. These include helping to facilitate trade and commerce within the North America market, to help ensure consistency in terms of the safety of end use consumers in these jurisdictions, and, third, recognition of the environmental issues that characterize these jurisdictions – notably minimizing greenhouse gas emissions, air pollution, and the consumption of petroleum fuels.

As noted, prior to the North American harmonization initiatives undertaken by CSA as documented in this paper, the standards landscape for the EV in the North American marketplace consisted largely of U.S.-based standards, and only a scattering of Canadian standards. Of the few standards of similarity, there was little harmonization – and this was seen by many as increasingly creating barriers to trade and commerce within North America. This was seen as a challenge since the North American automotive industry is highly integrated in terms of both production and the automotive parts sector. The need for harmonization was further emphasized seeing that the EV is expected to experience rapid growth in demand, production, and technological advancement in future years.

Recognizing a need for standards, CSA initiated an effort in late 2009 to implement change. Through a stakeholder engagement process, CSA started to lay the ground work of an action plan that would attempt to fill the standards' gaps that existed in the Canadian EV marketplace. This involved creating an "Electric Vehicle Resource Task Group" (evRTG), formed in the fall of 2009 and made up of a diverse and comprehensive list of stakeholders representing the main automobile and automotive parts producers, utilities, and governmental organizations (provincial and federal). Through this process, the Canadian EV industry, utilities, and relevant regulatory authorities relayed their perspectives and understanding of the current and future needs for EV standards as related to harmonization.

2.1 Laying out the priorities for the EV

The evRTG communicated that, first, EV standards for the charging infrastructure were needed in order to help ensure a timely and smooth introduction of the EV into Canada. This especially included the need for establishing Canadian electrical safety requirements of EVSE in order to allow for the safe use and installation of the EV charging infrastructure. Then relevant standards within the North American market should be harmonized, with this then leading to consideration of international standards and the role of North American standards harmonization in this regards

So it was recognized that not only were EV standards needed for Canada, but that these requirements should be harmonized for North America to allow for a more seamless certification and approval of the EVSE.

As a result, harmonization became a priority within the action plan, as did revising Part I of the Canadian Electrical Code (CEC) to include EV installation requirements addressing electrical safety. A plan with three focal points was then initiated that would take place over multiple years, with this first phase and focal point focusing on immediate needs specific to the North American market, the second focusing ongoing needs, including how to address new technologies and technological advancement, and finally the third focal point to ensure that all harmonized standards reflect international standards, particularly those by the IEC and ISO.

However, although firm ground work had been laid between late 2009 and 2010, and even though stakeholder engagement remained high and revisions to the Part I of the CEC were well underway, harmonization had not yet begun. This could have created further challenges since EVs were soon to be launched in the U.S., and Canada would not be too far off. Specifically, without harmonized requirements between these two countries industry felt that certification and approvals of the required EVSE would be hindered, with the potential to create barriers to trade and commerce within the integrated North American vehicle market.

2.2 Development of Technical Information Letters

It was at this point – approximately December of 2010 – that CSA undertook the development of Technical Information Letters (TIL's) to fill the gap of Canadian EV requirements to address electrical safety of the EVSE. These interim requirements would align in subject matter and technical content with those key EVSE standards in the U.S., and were intended to provide the basis for the harmonization effort between Canada and the U.S. But just as important, the TIL's would provide industry with certification requirements for their products coming into Canada and remove any regulatory uncertainty that was starting to creep into the marketplace. Here, it is important to emphasize that these TIL's were written in response to a request of Canadian regulatory authorities in order to address their concerns of pressing needs within the Canadian marketplace. TIL's also allow for the use of a CSA mark that signals conformance to a certain standard or requirements.

The following five TIL's were published in June 2011:

1. A-34 - Interim Certification Requirements of Electric Vehicle connectors/couplers and receptacles/plugs for use in a conductive charging system.

2. A-35 - Interim Certification Requirements for Electric Vehicle cord sets and power supply cords.

3. D-33 - Interim Certification Requirements for Charging Circuit Interrupting Devices/Line Isolation Monitors rated up to 600V for use in Electrical Vehicle Supply Equipment.

4. I-44 - Interim Certification Requirements for supply equipment for electric vehicles with inputs and outputs rated 600 V or less

5. J-39 - Interim Certification Requirements for Electric Vehicle Cables, rated 600 V maximum and intended for use in accordance with CSA C22.1, Canadian Electrical Code (CEC), Part I and CAN/CSA-C22.2 No. 0.

The TIL's helped establish Canadian requirements for the EVSE, including those for fast charging (i.e. Level III charging), meaning that EV products entering into and produced within the Canadian market could be certified. As a result, CSA can now certify EVSE for Canada and the U.S..

The TIL's also proved to be just the stimulus industry needed to re-invigorate harmonization talks. And it was in July of 2011 that North American harmonization of EVSE standards finally took off.

3. Addressing immediate needs of the Canadian EV industry

3.1 Inclusion of relevant EV standards and requirements within the Canadian Electrical Code

Canadian industry identified a number of immediate needs for the development of EV related standards. Many of these have been successfully addressed, particularly with the inclusion of relevant standards and requirements within the newly published 2012 Canadian Electrical Code (CEC). Specifically, Part I of the CEC now contains significant changes reflecting requirements for EVs in Canada, including:

- The provision of clarification that EV charging equipment may be either plug-in or permanently connected;
- Allowance for use of an EV as an electric power production source;
- Clarification of the impact of EVs on load calculations.

The CEC also contains specific standards for charging equipment, including the apparatus and conductors (including the electric vehicle connectors, attachment plugs, and all other fittings and devices) specifically used to supply current from the premises wiring to the EV. In addition to EV charging, the 2012 CE Code also recognizes that specially-designed EV charging equipment

may actually be used to deliver energy from the EV to the premises (reverse flow), provided that such equipment is specifically approved and marked accordingly for that purpose.

In terms of EV charging equipment, these can be further described as either stationary or portable:

- Stationary charging equipment is located on the premises, with charging current delivered to the electric vehicle by a cord connected to the vehicle.
- Portable charging equipment is located within the vehicle itself, with power supplied to the vehicle by means of cord set from a standard receptacle installed at the premises.

An *Electric Vehicle Inlet* is a conductive or inductive device permanently affixed to the electric vehicle; an electrical vehicle connector is then inserted into the EV inlet for charging and information exchange. Since this inlet is considered to be part of the vehicle and not part of the charging equipment, it is not covered by the Rules of Section 86 of the 2012 CE Code.

There are also significant revisions in Section 86 with respect to installation of permanently and cord-connected electric vehicle charging equipment. Broadly these include defining requirements for installation of receptacle for EV charging in each dwelling. They also include defining the requirement for circuits supplying charging equipment. Some specifics of the update to Section 86 include:

- A separate branch circuit is required for EV charging equipment. This circuit cannot supply any other loads except ventilation equipment related to EV charging.
- Separate disconnecting means must be provided for EV charging equipment rated at 60 A or more, or more than 150 volts-to-ground; there are also additional requirements for visibility, accessibility and locking.
- Receptacles installed on the premise for EV charging must be identified and labeled accordingly.
- Each receptacle provided for EV charging equipment must conform to CSA configuration 5-20R, and be supplied from a branch circuit rated at not less than 20 A.
- If the EV charging equipment requires a supply rated more than 125 V or more than 20 A, then the receptacle must have a CSA configuration complying with Diagram 1 or 2 of the CE Code.
- Where a 5-20R receptacle is provided, it must be protected with a Class A-type ground fault circuit interrupter if it is installed outdoors and within 2.5 m of finished grade.
- A standardized mounting height for outdoor EV charging equipment, recognizing that vehicles may be charged in more than one location.

While most major changes have occurred in Section 86 of the Code, other Sections feature new rules for EV installations. For example, Section 8 recognizes that EV charging equipment imposes significant loads on feeders and services; accordingly, Section 8 now requires that EV charging equipment and related loads be added with a demand factor of 100% for residential occupancies. Consistent with previous editions of the Code, Section 86 of the new Code classifies EV charging loads as “continuous” for purposes of Rule 8-104.

In certain jurisdictions, local building codes or zoning bylaws may mandate that a certain number of parking spaces be reserved for EV charging purposes. Section 26 of the 2012 CE Code now sets out requirements for the location of EV charging equipment receptacles, where such parking spaces are mandated by other codes or bylaws.

It is also important to note that there are certification requirements related to these code changes. For example, as related to connectors, this includes the need to certify the connector which mates between the supply source (AC or DC) and the vehicle. There is also a need to certify the cords used between the supply equipment and the vehicle supply connector. Personal protection equipment also needs to be certified (i.e. the device which monitors the flow of current and disconnects in case of a loss of current from the supply circuit (indicated by a fault in the system), as well as electric vehicle supply equipment (i.e. either a cord set or level I or II supply equipment)).

There are already discussions about possible revisions for 2015 CEC as the industry evolves and due to the National Electrical Code (U.S.) work that is also going on in parallel. More (or less) sections of the CEC may be affected as time moves forward.

3.2 Publication of 4 harmonized standards in 2012

Further to the release of the CEC, four harmonized standards are expected to be published in 2012. These specifically work to harmonize the requirements found within four UL standards for components of the EVSE with the TIL's created by CSA for the Canadian market. In terms of the UL standards, these include:

- UL 2231-1 – Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: General Requirements
- UL 2231-2 – Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: Particular Requirements for Protective Devices for Use in Charging Systems
- UL 2251 – Safety of Plugs, Receptacles and Couplers for Electric Vehicles
- UL Subject 2594 – Outline of Investigation for Electric Vehicle Supply Equipment

These have been specifically harmonized with the following TILs:

- A-34 - Interim Certification Requirements of Electric Vehicle connectors/couplers and receptacles/plugs for use in a conductive charging system.

- A-35 - Interim Certification Requirements for Electric Vehicle cord sets and power supply cords.

- D-33 - Interim Certification Requirements for Charging Circuit Interrupting Devices/Line Isolation Monitors rated up to 600V for use in Electrical Vehicle Supply Equipment.

- I-44 - Interim Certification Requirements for supply equipment for electric vehicles with inputs and outputs rated 600 V or less

3.3 Development of training tools to upgrade the skill sets of workers

Further to the development of the EV specific requirements within the CEC and the four soon-to-be published harmonized standards, CSA is in the early stages of undertaking efforts for the development of EV-related training tools.

4. Addressing ongoing change and technology developments - an update of CEC Part II product standards

The second area of focus in the EV standards roadmap, and particularly our efforts to create harmonized standards within the North American marketplace, was to consider standards specific to EV related products. This was in recognition of the need to address ongoing technological changes and developments.

There are a number of emerging technology areas as related to the EV that are of particular interest in terms of where there may be needs for not only new standards, but also bilateral and eventually international harmonization of standards.

Advancements are now being made around “fast charging”, namely where the battery can be charged to near full capacity in relatively short periods of time. Over the last year there have been a number announcements concerning the implementation of fast charging stations, including along the “West Coast Electric Highway” – a 444-kilometre stretch of highway transversing a number of U.S. states and British Columbia, Canada. Fast charging stations are also referred to as level 3 charging. These use 3-phase 400-600 VAC electrical service, and can recharge batteries rather than hours in the case of level 2 charging systems.

There are also rapid developments as related to inductive/wireless charging and the parallel need to help ensure battery safety. Inductive charging uses an electromagnetic field to transfer energy between two objects – the term wireless is often used since there often is a small gap between the sender and receiver of energy. While the technology is still not in commercial production for the EV, companies such as Qualcomm are advancing with pre-commercial trials and the aim to move towards production if successful. There are a number of relevant SAE/UL/IEC standards as related to inductive/wireless charging that already exist. For these areas, CSA will develop requirements in new, emerging areas where “gaps” exist. This includes battery safety as the industry develops and as needs are identified.

In general, the CSA work plan would be, (1) to develop CSA requirements where gaps exist (2) develop harmonized N.A. requirements (3) then harmonize internationally. Also, there are extensive standards development activities at IEC (published and soon-to-be published standards) but in many cases the gaps are currently too significant to adopt for North America. This underlies the need and current activity by U.S. Standard Develop Organizations (e.g. UL) to be active at IEC TC 69 and IEC 23H. Canada, and particularly CSA, recognize the need to contribute and also be ready to adopt when the time comes.

One emerging area which CSA is pursuing with specific consideration of expected future technology advancements is the area of batteries. CSA may pursue harmonization efforts with IEC standards, with UL standards, or to develop a non-consensus based standard first. In terms of potential standards for harmonization this includes - UL SUBJECT 2580 – Outline of Investigation for Batteries for Use in Electric Vehicles (These requirements cover electrical energy storage assemblies such as battery packs and combination battery pack-electrochemical capacitor assemblies and the subassembly/modules that make up these assemblies for use in electric-powered vehicles as defined in this standard), UL Subject 2271 – Outline of Investigation for Batteries for Use in Light Electric Vehicle (LEV) Applications (These requirements cover nickel, lithium ion and lithium ion polymer batteries and battery packs for use in light electric vehicles (LEVs), as well as SAE J2929, EV and PHEV propulsion Battery System).

5. International harmonization efforts

CSA also received feedback from industry stakeholders and government representatives that it was key to have proactive participation on international standards development activities in anticipation of future global harmonization efforts of the charging infrastructure.

A range of international standards as well as country-specific standards have existed for many years as related to the EV. There are also efforts to prioritize standardization efforts and needs in regards to ongoing developments with the EV and related infrastructure.

Some of the most prominent EV-related standards that are already in place have been developed by international standards setting bodies, namely ISO and IEC. These international standards include the newly revised ISO 6469, a two-part standard intended to help manufacturers design fail-safe electrically propelled vehicles, and 9 different standards documents have already been published under IEC TC69 – Electric Road Vehicles and Electric Industrial Trucks. These include the following new standards which are new or currently under development. This includes IEC 61851-23 /-24 and IEC 62196-3 - all which cover D.C. charging (i.e. FAST charging). CSA is currently an observer to the first of these, but there is a need to play a bigger role in order to help achieve the needs of North America. In terms of IEC 62196-3, this is being developed at IEC TC 23H. Canada has participating status and CSA has just started to track activities and, as soon as yesterday, we will be playing a more contributory role. (including on the -1 and -2 parts)

Part 1 of the revised ISO 6469 specifies safety requirements for the on-board rechargeable energy storage systems (RESS) of electrically propelled road vehicles, including battery-electric vehicles (BEVs), fuel-cell vehicles (FCVs) and hybrid electric vehicles (HEVs). Part 2 specifies requirements for operational safety means and protection against failures related to hazards specific to electrically propelled road vehicles.

The scope of the IEC Technical Committee, meanwhile, is to prepare international standards for road vehicles (totally or partly electrically propelled from self-contained power sources), and for electric industrial trucks. The 9 publications produced thus far have been specific to such EV components as wiring and connectors, controllers, and charging stations. 32 different countries are members of this standardization committee, including the most prominent vehicle producers, the U.S., Japan, and Germany, as well as emerging producers such as India and China.

6. Conclusions

This paper has presented an overview of the efforts of Canadian Standards Association regarding the development of North American Harmonized Requirements for the electric vehicle supply equipment (EVSE). We have discussed three areas of focus: identifying and addressing the immediate needs of industry stakeholders in the North American market; addressing expected changes in technologies and advancements in existing technologies; and finally, understanding the international standards landscape and the role of North American harmonized standards and related needs for harmonization at the international level. The issue and success of harmonization of EV standards is important in helping support and maintain compatibility between jurisdictions. This is especially true in the highly integrated North American market, and also in terms of helping to position North American producers as leaders and innovators globally.