Electric vehicle standardization: conflict, collaboration and cohesion

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Abstract

Standardization is a key element in the development and deployment of technology in society. It will have its particular application in the case of electrically propelled vehicles, which unite both automotive and electrical technologies, each with their own standardization and regulation cultures. The relevant standardization landscape is thus a complex one, particularly if new energy vectors such as hydrogen are taken into account. The growing interest for the deployment of hybrid electric drive technology has given rise to specific standardization issues, which are being tackled by specific technical teams. Current rating standards to evaluate the performance of ground vehicles must in fact be adapted to hybrid electric vehicles, with particular problems arising when considering plug-in hybrids. New standards are needed to evaluate the potential benefits of the hybrid systems against the future vehicle requirements with the specific bounds and regulations.Particular attention is given to a number of pending issues and to recommending specific work areas for standardization, highlighting the potential interaction of ongoing international standardization work activities.

Keywords: standardization, RCS, BEV, HEV

1 Introduction

Standardization, on a global level, is mainly dealt with by two institutions: the International Electrotechnical Commission (IEC), founded in 1904, deals with all things electrical, whileas the International Organization for Standardization (ISO), founded in 1948, deals with all other technologies. With standardization of the electric road vehicle becoming a key issue, the question arises which standardization body would have the main responsibility for electric vehicle standards. This problem is less straightforward then it looks: the electric vehicle, which introduces electric traction technology in a road vehicle environment, represents in fact a mixed technology [1]:

- on one hand, the electric vehicle is a road vehicle, the standardization competence for which is the province of ISO, where electrically propelled vehicles are dealt with by committee ISO TC22 SC21;
- on the other hand, the electric vehicle is an electrical device, the standardization competence for which falls under the wings of the IEC, where electrically propelled vehicles are dealt with by committee IEC TC69.

Furthermore, there is a fundamentally different approach taken towards the concept of standardization in the automotive and the electrotechnical world. There is a different ”standard culture”, the origin of which can be traced back to historical reasons.
There is a long tradition for standardization in the electrotechnical industry, as well a stronger tendency to standardize all and everything. Electric motors are covered by extensive IEC standards covering their construction and testing. Even subjects such as the colour code of wires are standardized (e.g. green and yellow for the protective or earth conductor). In the electrotechnical in-

dustry in fact, the role of specialist component manufacturers acting as suppliers to equipment manufacturers has always been more common.
Electricians do not only want to define the vehicle as a whole, but also to standardize its components, on a point of view of safety, environment, quality and interchangeability.
Furthermore, the customers of the electrotechnical industry are more likely to be powerful corporations (e.g. railway companies) who tend to enforce very strict specifications on the equipment they order or purchase, hence the need for more elaborate standards to ensure the compliance of the equipment. Industrial electrical equipment is also designed for an extended service life: continuous operation during several years, which corresponds to up to 100000 hours.

In the car manufacturing world on the other hand, standardization is limited to issues which are subject to government regulations (safety, environmental impact, performance measurement) and to the areas where interchangeability of components is a key issue. Since car manufacturers desire to develop their own technical solutions which embrace their proprietary technological know-how and which give their products an unique market advantage, there are few standards covering combustion engines for example. Car manufacturers accept that a vehicle, as a whole, is subjected to safety and environmental regulations, but do not feel the need for definition of individual components.
Furthermore, the automobile has become a mass-market product: extensive routine tests on every produced vehicle would be prohibitively expensive, and the customer is more likely to be a "consumer", less interested in providing the supplier with written specifications demanding compliance to specific international standards. The expected service life of an automobile (5000 to 10000 hours) is also much lower than of an industrial electrical machine.

This difference is further reflected in the constitution of the technical committees and their working groups which deal with electric vehicle standardization in respectively IEC and ISO. In the IEC committees many of the delegated experts are electricians or component manufacturers, whileas in ISO there is a much stronger input from vehicle manufacturers.

2 IEC-ISO activities on electric vehicles

2.1 Division of labour

Collaboration between ISO and IEC in the field of electric vehicles has been established since the foundation of the respective working groups, ISO TC22 SC21 and IEC TC 69, in the early 1970s. During the years however, there have been considerable discussions between the two groups as to the division of the work, in which there were a number of overlaps. By the end of the 1990s, a consensus was agreed [2] defining the specific compentences of the respective committees, as shown in Table 1.

Table 1: Basic division of work IEC/ISO

ISO	IEC
Work related to the electric vehicle as a whole	Work related to electric components and electric supply infrastructure

2.2 IEC-ISO Joint Steering Committee

To oversee the developments in the field, a Steering Group was set up in 1997 to deal with the issues related to the standardization of battery-electric road vehicles. Constituted of both IEC TC69 and ISO TC22 SC21 delegates, its task was to advise on the work programme of both committees. The Steering Group met several times up to 1999; with the reactivation of IEC TC69 in 2007 however it is foreseen to re-activate the Steering Group from 2008.

3 Current standardization activity on electric vehicles

3.1 IEC TC69

IEC TC69 had its work organized in several working groups.

3.1.1 WG2: Motors and controllers

This WG was founded in 1973, focusing on the "Definition and measuring methods concerning the performance of motors and motor control systems, including protection of personnel against electric shocks and protection of electrical components". WG2 initially produced a number of technical reports with the intention of having these harmonized with ISO documents in a later stage. This never materialized however, and these documents remain in the IEC catalogue up to this day without revision. These technical reports are:

- IEC 60783:1984 Wiring and connections for electric road vehicles
- IEC 60784:1984 Instrumentation for electric road vehicles
- IEC 60785:1984 Rotating machines for electric road vehicles
- IEC 60786:1984 Controllers for electric road vehicles

During the early 1990s, attempts were made to revitalize WG2 in order to revise and expand these four reports into full-blown standards. From 1995 onwards, work was performed on the revision of 60785 and 60786, incorporating them into a single document in order to reflect the technological evolution which closely integrated motors and controllers. A draft has been circulated with title "On-board power equipment for electric road vehicles", which had to emanate into IEC 61981. Work on this document has however been discontinued since 1999, following discussions in the IEC TC69/ISO TC22 SC21 steering group[**?**], mainly because the need for component standardization was not perceived by vehicle manufacturers. IEC61981 has thus been dormant as a PWI ever since, and so has WG2.

Although the idea of developing component standards for electrically propelled vehicles has not received a positive response from vehicle manufacturers, one can identify a number of issues which warrant the development of future activities for WG2. The activities of TC69 have also to be considered taking into account the fact that the term "electric vehicle" is now to be understood as "electrically propelled vehicle", which encompasses battery-electric, hybrid and fuel cell vehicles. All these electrically propelled vehicles make use of electric motors, drives and controllers, which are the province of WG2. Effective work in this field can only be done however in close liaison and relationship with relevant other committees such as ISO TC22 SC21 (Electric road vehicles), IEC TC77, IEC TC21, IEC SC23H,... It should be observed that there are still a number of issues that are presently not covered by other standards and for which a demand for standardization has been perceived, one example being the presence of hazardous voltages on capacitors accessed during maintenance; this subject has received renewed interest due to the emergence of electric double layer capacitors as peak power storage devices in electrically propelled vehicles.

Furthermore, the evolution in power electronics has led to a generalized use of a.c. drive technologies, which now have nearly fully supplanted the venerable d.c. drives. The a.c. inverter used in these vehicles charges the battery during regenerative braking; it could also be used however to charge from an a.c. power supply at high power levels, allowing fast charging without heavy and expensive off-board d.c. charging equipment. This configuration could even be used for supply network management purposes such as peak shaving. An electrically propelled vehicle used in this manner clearly has to be considered an "electric device", making it desirable to proceed to electrical standardization. To this effect, new work is under consideration the following theme: Electric traction equipment of electrically propelled road vehicles - connection to the electric supply network. This document would be applicable to electric power equipment on electrically propelled (battery-electric, hybrid and fuel cell) road vehicles which can be energized by both the main on-board energy source and the external electricity supply network. Examples include on-board inverters which are used for traction as well as for charging. The object of this standard is to lay down general rules for the design, installation and testing of electric power equipment on electrically propelled road vehicles and to indicate the technical requirements and testing conditions. Special attention should be given to EMC related issues for which the liaison with IEC TC77, which deals with EMC issues should be optimized.

New activities for WG2 could thus be launched within the framework of IEC TC69, on the condition however that a clear demand for such standards can be identified.

3.1.2 WG3: Batteries

The initial task of WG3 was "Energy storage systems, including safety of personnel against electric shocks and protection of electrical components". WG3, also founded in 1973, has performed work on the introduction of dynamic test cycles for electric vehicle batteries, leading to the amendment of the lead-acid battery standard IEC 60254-1 published in 1997 and incorporating dynamic test cycles for electric vehicle applications.
This WG became very active in the mid-1990s, having published the Technical Report IEC 61382-1 defining dynamic discharge performance test and dynamic endurance test for NiCd batteries, as well as a number of other projects which did not evolve into publications.
Close collaboration of TC69 WG3 with IEC TC21 "Batteries" eventually led to the regrouping of all battery standardization work to a joint working group encompassing TC21, SC21A and TC69, under the leadership of TC21. WG3 was then disbanded in 1997. TC21 has since published the IEC 61982 family of standard, which supersede IEC 61382-1 and the EV-related clauses of IEC 60254-1.

- IEC 61982-1:2006 Secondary batteries for the propulsion of electric road vehicles - Part 1: Test parameters
- IEC 61982-2:2002 Secondary batteries for the propulsion of electric road vehicles - Part 2: Dynamic discharge performance test and dynamic endurance test
- IEC 61982-3:2001 Secondary batteries for the propulsion of electric road vehicles - Part 3: Performance and life testing (traffic compatible, urban use vehicles)

TC21 has in its general work programme also the IEC 62485 family of standards about "Safety requirements for secondary batteries and battery installations", of which Part 3 refers to Traction batteries, including road vehicles. A CDV of this

document was circulated in November 2007 [3]. This document however, in its current form, was made without interaction with relevant ISO committees who deal with the same issues in ISO 6469-1. On this subject, the liaison should thus be activated through IEC TC69 in order to avoid conflicting standardization.
The use of electric double-layer capacitors (colloquially called super-capacitors) in electrically propelled vehicles has gained a considerable interest, due to their excellent power density and peak power storage capacity. Integrating this new component into an electrically propelled vehicle of course creates the need for new standardization work. To this effect, a new work item proposal was circulated in the fall of 2007 by the Japanese committee[4], with work on this issue to start early 2008. This work will be taken on by a specialized task force within IEC TC69.

3.1.3 WG4: Infrastructure

This WG was initially focused on power supply sources and chargers, including power supply sources external to the vehicle, chargers mounted or not on the vehicle, safety of personnel against electric shocks, protection of electrical components and a.c. or d.c. connectors. Its first major publication was the standard IEC 60718 Chargers for electric road vehicles, which saw different editions published in 1978, 1992 and 1997, to be eventually withdrawn in 2002.
WG4 entered a new elan in the mid-1990s to take up work on infrastructure standardization, which led to the IEC 61851 family of international standards, of which several parts were published in 2001:

- IEC61851-1:2001 Electric vehicle conductive charging system - Part 1: General requirements
- IEC61851-21:2001 Electric vehicle conductive charging system - Part 21: Electric vehicle requirements for conductive connection to an a.c./d.c. supply
- IEC61851-22:2001 Electric vehicle conductive charging system - Part 22: a.c. electric vehicle charging station

WG4 has been dormant since 2000, and the IEC 61851-23 on d.c. charging station requirements is still lingering at CD stage.
The same applies to the IEC 61980 documents on inductive charging, due to the fact that the interest for this technology has waned.
With the reactivation of IEC TC69 in 2007, the revision of the 61851 standards was taken on by WG4. The subject of vehicle charging infrastructure has indeed returned in the focus of interest: on one hand, the concept of "plug-in" hybrid is getting more attention due to the fact that electricity from the grid constitutes a more efficient and economical fuel; on the other hand, one should consider the poor overall energy efficiency of the hydrogen pathway (particularly if the hydrogen is generated through electrolysis) compared to the all-electric energy pathway. Plug-in hybrids are now rightly being considered as a more realistic alternative to the fuel cell vehicle.
The revision of the IEC 61851 standards by WG4 aims at defining safe and reliable infrastructures for conductive charging, taking particularly into account the safety requirements for publicly accessible infrastructure. The concept of the "control pilot", defined in the existing IEC 61851-1 as a hard-wired conductor, will be extended to other technological solutions providing the same degree of safety.
Related work in the field of infrastructure has been performed by the committees IEC SC23E and IEC SC23H which are liaised with TC69. This has resulted in two documents:

- IEC62196:2004 Plugs, socket-outlets, vehicle couplers and vehicle inlets - Conductive charging of electric vehicles - Part 1: Charging of electric vehicles up to 250 A a.c. and 400 A d.c., developed by SC23H. This document will likely need to be revised following the revision of IEC 61851.
- IEC62335 Switched protective earth portable residual current devices (SPEPCRD) for class I and battery powered vehicle applications. Work had been performed on this issue by SC23E WG7, and a NWIP to continue this work was circulated early 2007, with a tentative publication date of Spring 2008.

3.2 ISO TC22 SC21

3.2.1 Battery-electric vehicles

The ISO subcommittee dealing with electric road vehicles has been continuously active on a number of issues and has drafted a number of standards treating safety aspects of battery-electric vehicles:

- ISO6469-1:2001, Electric road vehicles - Safety specifications - Part 1: On-board electric energy storage
- ISO6469-2:2001, Electric road vehicles - Safety specifications - Part 2: Functional safety and protection against failures
- ISO6469-3:2001, Electric road vehicles - Safety specifications - Part 3: Protection of persons against electric hazards

The 6469 standards are now under revision, which should lead to a comprehensive set of standards on the safety of electrically propelled road vehicles (battery-electric, hybrid and fuel cell). One should in fact note that hybrid vehicles, which use similar drivetrain components than battery-electrics, were not covered by a specific safety standard yet.
Work was also performed on terminology and performances:

- ISO8713:2002, Electric road vehicles - Vocabulary
- ISO8714:2002, Electric road vehicles - Reference energy consumption and range - Test procedures for cars and light commercial vehicles
- ISO8715:2001, Electric road vehicles - Road operating characteristics

The ISO8713 standard will be replaced by a document now under development which will encompass comprehensive definitions of all vocabulary used in ISO TC22 SC21 standards. This document will not be published as an international standard however but as a technical report.

3.2.2 Hybrid vehicles

Performance specifications, particularly fuel consumption and emission measurement standards, are being treated by ISO TC22 SC21 WG2. which is now finalizing the following document:

- ISO 23274, Hybrid road vehicles - Exhaust emissions and fuel consumption measurements - Non-externally chargeable vehicles

The committee is now working on the more complicated issue of externally chargeable vehicles (plug-in hybrids) where several issues have to be taken into account, since these vehicles can be fuelled from two separate energy sources. The definition of suitable test cycles and the management of battery state of charge are now the subject of discussion within the working group[5].

A new work item proposal is also under preparation for the testing of lithium-ion battery systems for use in hybrid vehicles. The dynamic use of hybrid vehicle batteries calls in fact for test procedures which are not defined in conventional battery standards. The proposal takes a document by the German car industry [6] as its starting point. It should be recommended however that this work is liaised with the activities of the specific IEC battery committees as not to create conflicting standards.

3.2.3 Fuel cell vehicles

The ”fuel cell” can be quite rightly considered an ”electrical device” since it generates electricity; its standardization would thus be a task of the IEC. To this effect, IEC Technical Committee 105 ”Fuel Cell Technologies” was put charge of preparing international standards regarding fuel cell technologies for all applications.
However, the international standardization work on fuel cell powered road vehicles has been mostly concentrated within ISO TC22 SC21. For this reason, road vehicles were excluded from the scope of the standard IEC 62282-2 ”Fuel cell modules” the work was transferred to ISO.

This discussion underlines once more again the special case of the electrically propelled road vehicle, which unites automotive technology (typically standardized under the auspices of ISO) and electrical technology (typically standardized under the auspices of IEC). This dichotomy has caused similar discussions in the past about who exactly was to perform the standardization work; such discussions can only be resolved by mutual collaboration and recognition of the characteristics of each technology being put to use.

ISO TC22 SC21 has published several standards for fuel cell vehicles:

- ISO23273-1:2006, Fuel cell vehicles - Safety specifications - Part 1: Vehicle functional safety
- ISO23273-2:2006, Fuel cell vehicles - Safety specifications - Part 2: Protection against hydrogen hazards for vehicles fuelled with compressed hydrogen
- ISO23273-3:2006, Fuel cell vehicles - Safety specifications - Part 3: Protection of persons against electric shock

It is the intention to replace Parts 1 and 3 of this standard with the appropriate parts of the revised ISO6469 when these are published.
As for performance standards, the following document is now under preparation:

- ISO23828-1, Fuel cell hybrid electric road vehicles - Energy consumption measurement - Part 1: Using compressed hydrogen

The main discussion on this document concerns the choice of methods to measure hydrogen consumption, where several methods can be used[7], each of which has its specific advantages and accuracy:

- the electrical method, where the electricity production by the fuel cell is a measure for the hydrogen consumption
- the weight method, where the mass of the hydrogen vessel is a measure of its contents
- the pressure method, where pressure and temperature of the hydrogen vessel are a measure for its contents (ideal gas law)
- the flowmeter method, where the hydrogen flow to the fuel cell is measured with a suitable device
- the gas method, where the vehicle is tested in an enclosure, and oxygen and water concentrations are measured before and after the test

4 Conclusions

The standardization and regulation activities on electrically powered vehicles are on a high level worldwide. Experts can be found working together in the various committees in order to realize a set of documents with the aim to provide the international community with a consistent family of standards that are contextualized into a systemic approach of the Regulations, Codes & Standards problem as a whole.

In a sense, a number of approaches to this problem can be discerned; an effective solution however will have to take into account both the mere technological evolutions and the innate opposition between standards on one hand and regulations on the other. In this framework, a key factor is the behaviour of relevant stakeholders such as government services, research centers, R&D programs and trade associations, which are in a position to provide relevant input to the standardization bodies on one hand and the regulation bodies on the other hand. Furthermore, with several standardization organizations active on the same subject, there is a real danger that much effort will be lost through parallel work, leading to different and potentially conflicting standards on the same topic. Such "standards" are a source of confusion and are of no useful purpose. The collaboration between different organizations, if implemented efficiently, will however allow standardization work to advance and to obtain positive results. To avoid the proliferation of RCS conflicts, it is recommended to put in place a mechanism to facilitate global harmonization.

It should be stressed that the different standardization bodies involved, both on organizational level (IEC and ISO), as on committee level within these organizations, should not consider themselves as competitors, but as complementary bodies, each bringing their expertise to the field. The division of standardization work on a specific subject like the electrically propelled vehicle, often grown for historical reasons, has involved a lot of discussions, which can run out of hand when each party keeps defending its turf, reasoning out of tradition and emotion.

It is essential that the future standardization work is performed in a spirit of collaboration and joint effort toward a common goal which is the drafting of clear and useful standards which benefit both the manufacturer and the user. For the electrically propelled vehicle, the idea to have vehicle aspects treated by ISO and electrical aspects treated by IEC is a reasonable solution. This whole issue needs to be followed closely at all levels, in order to optimize mutual information exchange and collaboration between ISO and IEC and their relevant individual technical committees (in particular IEC TC69 and ISO TC22 SC21). Although past experiences have led to the defining of effective liaisons and a good standard of collaboration between these committees, the definition of work for new standardization shall be tackled with great care as to avoid parallel and conflicting work. This is an issue of paramount value that should never be relinquished.

The mutual collaboration of competent engineers will always remain the keystone of effective standardization work to the benefit of society as a whole.

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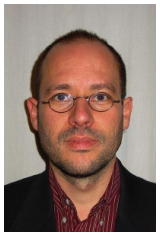

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