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Clean European Rail-Diesel

Deliverable 7.4.7 Report on regulation and standard issues

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Executive Summary

WP 7.4 of the CleanER-D project studies the INNOVATIVE ENERGY STORAGE SYSTEMS TECHNOLOGIES for diesel hybrid rail vehicles. After a state-of-the-art investigation and evaluation of the possibilities of different energy storage system technologies to address hybrid diesel configurations in DEL 7.4.1, a global mapping of different energy storage systems was performed for each selected application in DEL 7.4.2, with decision to concentrate on Li-ion technology as in case of a “pure battery” solution, as the Ni-MH technology does not fully answer the expressed needs, and therefore could not be considered in the next stages. This was the input data for DEL 7.4.3 to DEL 7.4.6, which considered in detail each technology among batteries, EDLCs, flywheels and hydrostatic accumulators.

The global goal of this DEL is the identification of the existing different regulation standards and norms applicable to energy storage systems, and then the recommendation/action with EU/CEN/IEC bodies for relevant changes and applicable rules for each application and each technology. Those constitute the 2 main parts that will be detailed hereafter.

A selection of the most relevant regulations applicable to ESS will be realized, over the many regulations applicable to Railways rolling stock. This will be separated in a common part to all ESS (eg. integration or architecture, link with fire & smoke), and a differentiated part specific for each ESS technology showing the current standardization situation of the technology itself (independently of the application), and then the current situation of its “application” standards toward railways. In both cases, concerned bodies, existing standards and standards under construction will be detailed. This will include in introduction a specific example that resulted from a previous project (MODTRAIN) for on-board auxiliaries’ emergency energy storage systems based on Lead-Acid & Ni-Cd technology, which successfully passed the stages until CENELEC standards development.

Then the conclusion will define proposed future actions that could be launched in order to allow expanding development of the evaluated technologies.

TABLE OF CONTENTS

List of Figures

List of Tables

1. Introduction

WP 7.4 of the CleanER-D project studies the INNOVATIVE ENERGY STORAGE SYSTEMS TECHNOLOGIES for diesel hybrid rail vehicles. After a state-of-the-art investigation and evaluation of the possibilities of different energy storage system technologies to address hybrid diesel configurations in DEL 7.4.1, a global mapping of different energy storage systems was performed for each selected application in DEL 7.4.2, with decision to concentrate on Li-ion technology as in case of a “pure battery” solution, as the Ni-MH technology does not fully answers the expressed needs, and therefore could not be considered in the next stages. This was the input data for DEL 7.4.3 to DEL 7.4.6, which considered in detail each technology among batteries, EDLCs, flywheels and hydrostatic accumulators.

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2. Identification of the existing regulation standards and norms applicable to ESS

2.1 Selection of the most railways relevant regulations applicable to ESS

ESS can be applied as pure traction ESS, as pure auxiliary ESS, as ESS to start a diesel engine or as a combined ESS for two or even all three applications.

Each application brings its own demands, often even its own standards. One has to differentiate between standards on a component level (mainly valid for all three applications) and standards on integration or function level.

The latter standards are often generic and not direct linked to an ESS technology, but to the function the ESS has to provide in a train. It can also happen that these standards diminish limits set by other only component relevant standards. For example a battery standard can allow a relative wide range of voltage, but due to the direct connection to a train safety system this range is diminished by another standard.

Every ESS technology needs further components, not for storage of energy but for control or safety functions – or for integration in the train like supporting frames. These kind of additional components are normally not a new technology, in principle not even new for train application. Therefore a wide range of standards can be applied on these components.

In case an ESS is built as a module – e.g. a battery container including battery cells, controller, charger and disconnector – some standards may by applied to the whole module, not just for the part the standard was originally written. An example for that would be shock and vibration tests.

The following chapters try to sort these standards thematically.

2.1.1 Mechanical

In the mechanical point of view, IEC 61373 “Railway applications - Rolling stock equipment. Shock and vibration tests” appears as very relevant for energy storage systems.

Also, EN 15085 "Railway applications - Welding of railway vehicles and components" is valid for container and supporting frames.

2.1.2 Environment

The following standards define environmental demands for railway components:

- IEC 60068-2-38: Environmental testing - Part 2-38: Tests - Test Z/AD: Composite temperature/humidity cyclic test
- IEC 60068-2-1: Environmental testing - Part 2-1: Tests - Test A: Cold (2007)
- IEC 60068-2-2: Environmental testing - Part 2-2: Tests - Test B: Dry heat
- IEC 60068-2-27: Environmental testing - Part 2-27: Tests - Test Ea and guidance: Shock

- EN 50125-1: Railway application - Environmental conditions for equipment. Part 1: Equipment on board rolling stock.
- EN 60529: Degrees of protection provided by enclosures (IP Code) is relevant for the enclosures of ESS systems.

2.1.3 Electrical

Considering the electrical point of view, the following European railway standards applicable to ESS have been selected. One has to differentiate the potential of an ESS component when applying these standards. Some are only valid for low voltage (e.g. 24 V DC for controllers), some are valid for mid voltage (e.g. 750 V DC link). The latter should be applied for electric ESS like batteries, EDLCs or flywheels as these ESS interfere with existing technologies like traction converters, what for the standards have been written.

- EN 50124-1: Railway application - Insulation coordination. Part 1: Basic requirements. Clearances and creepage distances for all electrical and electronic equipment
- EN 50153: Railway applications. Rolling stock. Protective provisions relating to electrical hazards
  This regulation takes an important place considering an electrical storage supplying traction power in rolling stock. Protective provision have to be taken.
- EN 50155: Railway applications - Electronic equipment used on rolling stock
  This standard is mainly valid for the low voltage components, but it also refers to environment standards and defines applicable limits depending on the place of integration.
- EN 50163: Railway applications - Supply voltages of traction systems
  This regulation is related to the EN 50153 about storage system used to supply traction power. Regulation EN 50163 gives the requirement to guarantee quality of voltages supplied by the storage system. This standard and its voltage ranges should be applied to electric ESS.
- EN 50207: Railway applications – Electronic power converter for rolling stock
- EN 50343: Railway applications - Rolling stock - Rules for installation of cabling
- IEC 60050-826: Low-voltage installations - Part 200: Definitions
- IEC 60077-1: Railway applications - Electric equipment for rolling stock - Part 1: General service conditions and general rules
- IEC 60077-2: Railway applications - Electric equipment for rolling stock - Part 2: Electrotechnical components; General rules
- IEC 60364-5-56: Low-voltage electrical installations - Part 5-56: Selection and erection of electrical equipment - Safety services

- EN 60439: Low-voltage switchgear and control gear assemblies
  This regulation has to be taken into account in the case of a storage system used to supply auxiliaries connected to the low-voltage bus.
- IEC 60571: Electronic equipment used on rail vehicles
- IEC 60893-1: Insulating materials - Industrial rigid laminated sheets based on thermosetting resins for electrical purposes - Part 1: Definitions, designations and general requirements
- IEC 61287-1: Power converters installed on board rolling stock – Part 1: Characteristics and test methods
- UIC 550: Power Supply Installations for Passenger Stock

2.1.4 Cabling Installation

- EN 50343: Railway application - Rolling stock. Rules for installation of cabling.

Cables standards:

- EN 50264-1, EN 50264-2 , EN 50264-3
- EN 50306-1, EN 50306-2, EN 50306-3, EN 50306-4
- EN 50355

All these standards refer to Railway applications - Railway rolling stock cables having special fire performance.

- EN 50382-1, EN 50382-2, EN 50382-3, Railway applications – Railway rolling stock high temperature power cables having special fire performance

2.1.5 Integration

Considering integration of embedded energy storage, regulation EN 50272-3 titled “Safety requirements for secondary batteries and battery installations. Traction batteries” is very relevant for traction batteries. However, it doesn’t appear the same regulation about other type of energy storage system.

2.1.6 Fire protection

Considering exported safety, the series of regulation “EN/TS 45545 / prEN 45545” under vote procedure about fire protection is very relevant about the requirement on the material and components in the train. Specially the two series prEN/TS 45545-2 and prEN/TS 45545-4 titled “Railway applications. Fire protection on railway vehicles. Requirements for fire behaviour of materials and components” and “Railway applications. Fire protection on railway vehicles. Fire safety requirements for railway rolling stock design”.

As these standards are not yet published officially (drafted since years), in some countries the previous standards may be considered as well, in Germany for example the DIN 5510 "Vorbeugender Brandschutz in Schienenfahrzeugen" (fire protection on railway vehicles).

Li Ion batteries and EDLC, with metallic components and no plastic do not have specific testing in these standards. This is a gap and should be considered in future updates of EN 45545 or with application rules in a TC9XB traction battery standard.

2.1.7 Safety

This theme is more generic and has to be considered especially on the integration level. For all new and modified railway vehicles the "Commission Regulation (EC) No 352/2009 of 24 April 2009 on the adoption of a common safety method on risk evaluation and assessment as referred to in Article 6(3)(a) of Directive 2004/49/EC of the European Parliament and of the Council" has to be considered.

In this regulation common safety methods (CSM) for risk evaluation are defined. This CSM shall be applied not only on a component level, but also on an integration and functional level. Here it is a big difference whether an ESS is for traction only or also providing onboard power supply for e.g. safety relevant components like train controller or radio. A risk evaluation and assessment provides the necessary safety integrity level (SIL) for each function and finally each component.

For batteries it will be also important which cell type is used, as some types (e.g. lithium iron phosphate base) could show lower risks to have cell opening or flames in abusive situations than others. The FP7 project OSIRIS launched in January 2012 will have a specific part concerning safety if Li-ion cells, and will allow selecting the Li-ion electrochemistry taking into consideration such point.

As an EC regulation the - *COMMISSION REGULATION (EC) No 352/2009 of 24 April 2009 on the adoption of a common safety method on risk evaluation and assessment as referred to in Article 6(3)(a) of Directive 2004/49/EC of the European Parliament and of the Council* - may not be transferred to national law. Nevertheless national authorities may decree national rules how to apply it. In Germany for example this was done by the Eisenbahn Bundesamt (EBA) by the "Hinweise für die Anwendung der Verordnung (EG) Nr. 352/2009 der Kommission vom 24.04.2009 über die Festlegung einer gemeinsamen Sicherheitsmethode für die Evaluierung und Bewertung von Risiken gemäß Artikel 6 Abs. 3 Buchstabe a der Richtlinie 2004/49/EG des Europäischen Parlaments und des Rates durch das Eisenbahn-Bundesamt " (reference to apply the EC 352/2009 …).

Based on the CSM the EBA together with the sector has developed the SIRF method ("Sicherheitsrichtline Fahrzeug", in English "safety rule vehicle"), which has to be applied in Germany since 2011, as a detailed definition of the CSM. Nevertheless EBA also allows performing safety analysis according comparable standards like ISO 13849 or EN 61062.

2.1.8 Electromagnetic compatibility EMC

The common EMC standards for rail should be applied to ESS:

- EN 50121: Railway application - Electromagnetic compatibility (all parts)

2.1.9 Software

Software in ESS components must fulfil the common rail standards:

- EN 50126: Railway Applications - The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS)
- EN 50128: Railway Applications - Software for railway control and protection systems

2.1.10 Miscellaneous / Sundries

The following standards do not fit in the above structure, but should be applied as well:

- IEC 62079: Preparation of instructions - Structuring, content and presentation Instructions and manuals
  are an important input for safety analysis, as the manufacturer has to describe here risks and how to deal with them during operation.
- IEC 61123: Reliability testing; compliance test plans for success ratio
  This standard can by important if a risk assessment is asking for a certain reliability for an ESS.
- UIC 640 Motive power units - Inscriptions, marks and signs
  Here are the correct labels (e.g. "Danger, high voltage") described.
- EN 50215: Railway applications. Rolling stock. Testing of rolling stock on completion of construction and before entry into service
  This standard describes the test procedures for the complete train.
- EN 50272-2-3: Ventilation requirements on batteries
  Although this standard is not valid for Li Ion batteries, ventilation might be a topic for this type of batteries as well. At present there is no rail standard dealing with this topic, this could be an issue for future standardisation.
- Verwaltungsrichtlinie für Überwachungsbedürftige Anlagen (administrative regulation for safety relevant components)
  In this regulation the EBA defined rules for homolgation and operation of components with safety aspects like pressure vessels (brake), fuel tanks or batteries. The latter were included due to the risk of explosive gases (H2 and O2) which can occur with lead acid batteries. Although Li Ion batteries show a much lower risk of producing explosive gases, at the moment the complying with this regulation has to be discussed with the EBA, as there are no rail standards for this topic. Especially the annex 4.7 and 6 should be considered.

Common regulations in Europe are very poor as each country has its own railway regulation. Even if these regulations are very similar, they are not necessary regrouped in one European

regulation. Considering France, it exist many railway regulations applicable to EES that could be relevant in this study.

2.1.11 Environmental

Standards to be applied with regard to environmental conditions are:

- EN 50125-1: Railway applications – Environmental conditions for equipment – Part 1: Equipment on board rolling stock
- EN 60721-3-2 Classification of environmental conditions - Part 3: Classification of groups of environmental parameters and their severities; section 2: Transportation (IEC 60721-3-2)

2.2 Example of a successful case from EU project to EN standards in railways application

One of the outputs of the MODTRAIN project was to define target architectures as well as to standardize components to be considered for building of new train generations. Some extract are provided hereafter in order to illustrate the process that did apply to a subject similar to the one we are concerned with in the present deliverable (energy storage), source: http://www.modtrain.com/files/final_conference/

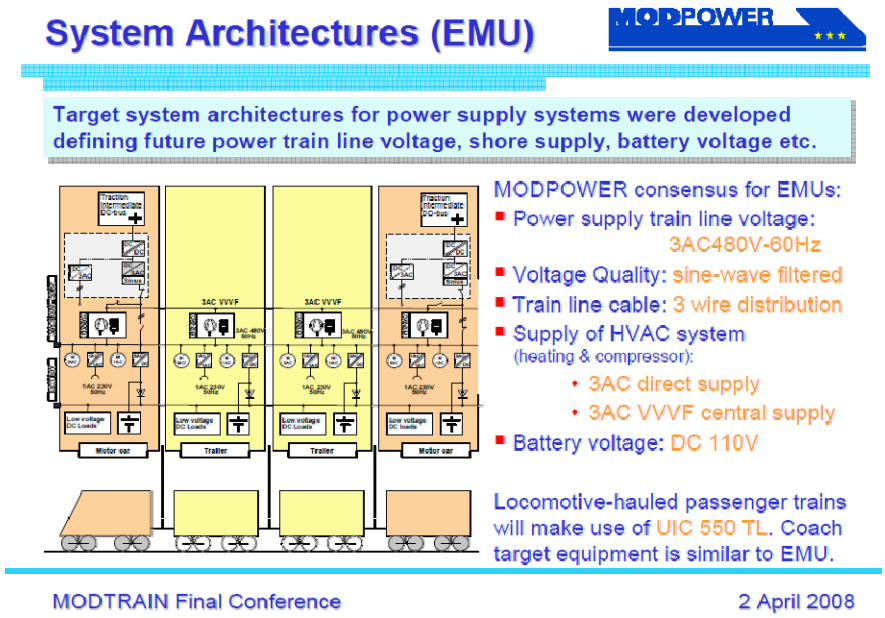

Figure 1: example of target for auxiliary energy storage in MODTRAIN project

Some Working Groups creation within TC9XB were proposed and called for creation during this project:

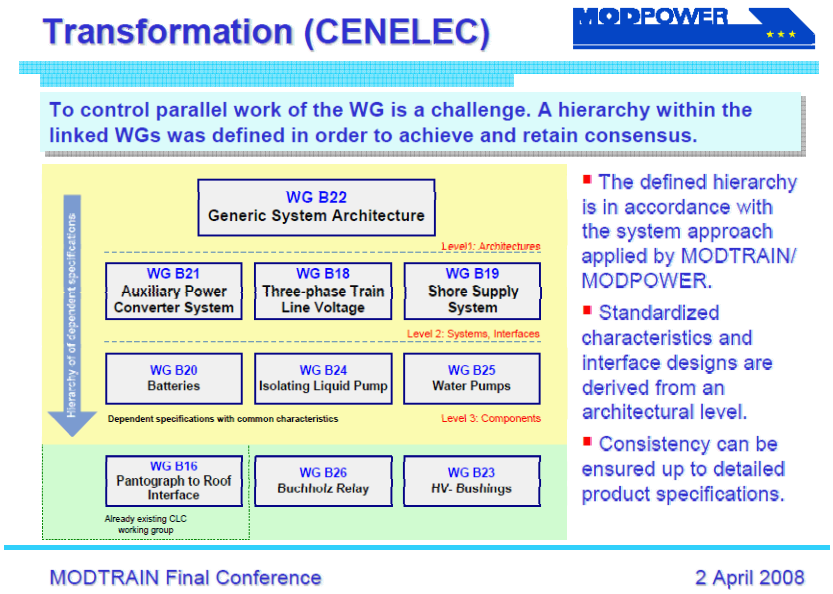

Figure 2: standardization Working Groups created in TC9XB

Following steps might be similar to traction batteries, being concerning onboard auxiliary backup energy storage (batteries) case,

CENELEC
TC9X/SC9XB

CLC/SC9XB/Sec0299/DC
October 2007

Call for experts for SC9XB/WG B20 "Batteries for rail vehicles"

Dear Madam or Sir,

In accordance with Resolution 32/09 of the last SC9XB Meeting in June 2007 (see below) we kindly invite the National Committees to propose experts for cooperation in WG B20. Representatives of operators and manufacturers are urgently needed, in particular those with prior experience in the respective working group of the European Research Project ModPower.

The new WG is instructed to carry out the work of producing a standard with the following scope:

- Description of mechanical interfaces: dimensions of the cells including terminals, and of trays,
- Description of electrical interfaces: current, voltage, capacity, charging characteristic.

The basis of the work of WG B20 will be a more detailed ModPower Specification which will be distributed as soon as possible.

Nominations should be sent to the secretary of SC9XB and to the convenor of WG B20, Mr. Thomas Rausch (thomas.rausch@siemens.com) by 2007-12-02 at the latest. However in order to be able to provide the relevant informations concerning this WG at the next SC9XB Meeting in November, it would be very helpful to receive your nominations until 2007-11-05.

Dr. Holger Segerer
Secretary SC9XB
Holger.Segerer@siemens.com

The expert group created did gather 3 operators (DB, Trenitalia, SNCF), 4 OEMs (Alstom Transportation, Ansaldo Breda, Bombardier Transportation and Siemens), and 3 battery manufacturers (Exide, Hoppecke, Saft), under convenorship from Siemens.

The kick-off meeting took place on April 14th, 2008 in Brussels, and 12 meeting were conducted to create the final proposal, proposed to the concerned National Committees in July 2011. Enquiry results (SC9XB_21418enq1_res1) were finalized end of 2011, consisting of 21 National Committees considering the draft of prEN50547 mature for vote, and 10 abstentions.

2.3 ESS technology specificities: case of batteries

2.3.1 Situation concerning the technology itself (all applications common): Description of the concerned regulation bodies

The International Electrotechnical Commission (IEC) is the leading global organization that publishes consensus-based International Standards and manages conformity assessment systems for electric and electronic products, systems and services, collectively known as electrotechnology. IEC publications serve as a basis for national standardization and as references when drafting international tenders and contracts.

IEC TC21 is a technical committee established in 1931. Its scope is to prepare product standards for all secondary cells and batteries, irrespective of type or application (all electrochemical systems are considered), as well as to support other technical committees standardizing application oriented systems using secondary cells and batteries.

In 1965 the Sub-committee SC 21A was established, which scope is to prepare product standards for all sealed and vented secondary cells and batteries **containing alkaline or other non-acid electrolytes**. This sub-committee therefore deals with alkaline and secondary lithium cells & batteries, whether for portable or industrial market.

As per the scope of the current DELiverable, SC 21A would be the concerned regulation body at IEC level.

In the field of mobility, and the specific segment on “Road applications”, TC21 and SC21A are involved in joint working groups with TC69 for Secondary batteries for propulsion of electric and hybrid-electric. This is clearly outside of the present work, targeted on “Non Road” as for the Non Road Machinery Directive.

CENELEC is the European Committee for Electrotechnical Standardization and is responsible for standardization in the electrotechnical engineering field. CENELEC prepares voluntary standards, which help to facilitate trade between countries, create new markets, cut compliance costs and support the development of a single European market. CENELEC creates market access at European level but also at international level, adopting international standards wherever possible, through its close collaboration with the International Electrotechnical Commission (IEC).

At European level for CENELEC, TC21X covers both TC21 and SC21A fields as defined at IEC level. There is no specific work at TC21X level concerning secondary lithium cells, the tasks being dealt directly at IEC level. As per the scope of the current DELiverable, TC 21X would be the concerned regulation body at CENELEC level.

2.3.2 Situation concerning the technology itself (all applications common): Existing standards

Concerning secondary lithium technology, as per the market started it development mainly with portable batteries in the 90’s, existing standards are currently available focused on those smaller batteries than considered in the present document:

- IEC 61960 Ed. 2: Secondary cells and batteries containing alkaline or other non-acid electrolytes - Secondary lithium cells and batteries for portable applications
- IEC 62133 Ed. 1: Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable application.

Those standards are not covering the large cells and batteries for industrial applications, used in railway applications, which are non-portable, with a mass of hundreds of kilograms. Therefore, they will not be mentioned in the following parts.

Not a standard, but nevertheless a regulation to be observed is UN38.3 “Classification Procedures, Test Methods and Criteria Relating to Class 9, Lithium Batteries” (UN transport testing for lithium batteries) issued by the United Nations. Since ESS batteries for railway systems will typically consist of (redundant) battery branches, which are made up of several battery modules, which in turn consist of several battery cells, some clarification would be welcome as to what units (cells/modules/battery branch/complete battery system) need to pass the tests specified herein.

2.3.3 Situation concerning the technology itself (all applications common): Standards under construction

In March 2007, it was decided to start work on large capacity lithium cells & batteries, during the general meeting of TC 21 & SC 21A in Beijing (China). Works done from then led to the following standards under construction:

Project at CD (Committee Draft) level for IEC 62620: Secondary cells and batteries containing alkaline or other non-acid electrolytes - Large format secondary lithium cells and batteries for use in industrial applications. This Committee Draft project has been circulated to the National Committees in October 2011, and expectation time to arrive to a document for vote is for end 2012 or 2013.

Project at WD (Working Document) level for IEC 62619: Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for large format secondary lithium cells and batteries for use in industrial applications. This Working Document expectation time to arrive to a document for vote is for end 2013 or 2014.

It is on interest to mention that railways are specifically mentioned as an example in those standards, to illustrate the scope difference versus portable.

2.3.4 Situation concerning the technology adaptation for Railways: Description of the concerned regulation bodies

IEC TC9 (Electrical equipment and systems for railways) is a technical committee established in 1924 under former title “Electric traction equipment”. Its scope is to prepare international standards for the railway field which includes rolling stock, fixed installations, management systems (including communication, signalling and processing systems) for railway operation, their interfaces and their ecological environment. IEC and CENELEC have agreed upon a merging strategy between IEC TC9 and CENELEC TC 9X, therefore for the following we will consider TC9X situation.

As mentioned earlier, a specific Working Group has been created as per resolution 32/09 of the CENELEC SC9XB (Electromechanical material on board rolling stock) meeting in June 2007, dedicated to “Batteries for rail vehicles”, following the request of the EU-funded project ModPower (WG20 had its kick off meeting on April 14th, 2008), under German convenor (Siemens). This resulted in a standard for railways specificities (versus TC21 standards for Lead-Acid and SC21A

standards for NiCd) for on-board Lead-Acid and NiCd batteries circulated in July 2011 (prEN 50547, “Railway applications – Batteries for auxiliary power supply systems”).

Such process might be adapted for specifying railways specificities concerning large format secondary lithium cells and batteries for use in industrial applications, following SC21A current work.

2.3.5 Situation concerning the technology adaptation for Railways: Existing standards

There are currently no standard at IEC or CENELEC level specific to Railways secondary lithium batteries.

2.3.6 Situation concerning the technology adaptation for Railways: Standards under construction

There are currently no standard under construction at IEC or CENELEC level specific to Railways secondary lithium batteries. Target of the present DELiverable is to identify if a need for such standardization is existing.

2.4 ESS technology specificities: case of EDLCs

2.4.1 Situation concerning the technology itself (all applications common): Description of the concerned regulation bodies

The norm *IEC 62391-1: Fixed electric double layer capacitors for use in electronic equipment - Part 1: Generic specification* has been published by the *International Electrotechnical Commission IEC*. The latest valid version known is from 01.04.2006. Please refer to the foreword of the norm for further information on the *IEC.* For further information about regulation bodies please also refer to chapter 2.3.1, chapter 2.3.4 and chapter 2.5.1 part ISO-Standards.
The working group 611.0.1 (AK 611.0.1) named "Doppelschicht-Kondensatoren" (German expression for "double layer capacitors") prepared *IEC 62391-1*. Participants of the working group were:

- Panasonic
- Epcos AG
- BMW AG
- Frolyt

The development of the final draft was supervised by the institution *DKE - Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE,* which is a German commission and German member of *IEC* and *CENELEC.*
The final draft was reviewed by the German committee 611 (K611) and checked by TC40, see appendix 5.1. See the list below for some review members:

- Nippon Chemi-con Corporation
- Alcatel SEL
- Hella
- Vishay Electronic
- Murata Elektronik
- Bosch
- Westermann
- Arcotronics
- VDE-Institution

2.4.2 Situation concerning the technology itself (all applications common): Existing standards

IEC 62391-1 "Fixed electric double-layer capacitors for use in electronic equipment - Part 1: Generic specification"

2.4.3 Situation concerning the technology itself (all applications common): Standards under construction

There are currently no standards under construction.

2.4.4 Situation concerning the technology adaptation for Railways: Description of the concerned regulation bodies

The norm *IEC 61881-3 Railway Applications – Rolling Stock Equipment – Capacitors For Power Electronics, part 3: Electric double-layer capacitors* has been published by the *International Electrotechnical Commission IEC* in November 2011. Please refer to the foreword of the norm for

further information on the *IEC*. For further information about regulation bodies please also refer to chapter 2.3.1, chapter 2.3.4 and chapter 2.5.1 part ISO-Standards.

Subcommittee 9 *Electrical equipment and systems for railways* has prepared *IEC 61881-3* and consists of following companies/institutions:

- RTRI *Railway Technical Research Institute* – Japanese research institute
- batScap – French EDLC manufacturer
- previously INRETS now IFSTTAR *L'Institut national de recherche sur les transports et leur sécurité* – French research institute
- Maxwell – US EDLC manufacturer
- Bombardier – Canadian rolling stock manufacturer
- Raytheon – US electronic and system integrations company
- Nippon Chemi-con – Japanese EDLC manufacturer
- SNCF *Société nationale des chemins de fer français* – French rolling stock society
- Siemens AG – German rolling stock manufacturer
- Toshiba – Japanese EDLC manufacturer
- CSR – Chinese EDLC manufacturer
- Alstom – French rolling stock manufacturer

2.4.5 Situation concerning the technology adaptation for Railways: Existing standards

IEC 61881-3 "Railway Applications – Rolling Stock Equipment – Capacitors For Power Electronics, part 3: Electric double-layer capacitors" dedicates itself especially to EDLC cells, modules and banks in railway applications.

2.4.6 Situation concerning the technology adaptation for Railways: Standards under construction

Subcommittee 9 is planning to publish an amendment for IEC 61881-3 within the next years. Other standards under construction are not known.

2.5 ESS technology specificities: case of flywheels

2.5.1 Situation concerning the technology itself (all applications common): Description of the concerned regulation bodies

Up to now, the most relevant standards regarding the Flywheels at present are to be found in the aerospace domain. 2 standards are published:

ISO 21648:2008: Space systems -- Flywheel module design and testing

> ISO 21648:2008 establishes the design, analysis, material selection and characterization, fabrication, test and inspection of the flywheel module (FM) in a flywheel used for energy storage in space systems. These requirements, when implemented on a flywheel module, will ensure a high level of confidence in achieving safe operation and mission success. With appropriate modifications, ISO 21648:2008 can also be applied to similar devices, such as momentum and reaction wheels and control-moment gyroscopes.
>
> The requirements set forth in ISO 21648:2008 are the minimum requirements for flywheel modules in flywheels used in space flight applications. They are specifically applicable to the parts in the flywheel rotor assembly (FRA), including rim, hub and/or shaft and other associated rotating parts, such as the bearings and the motor generator rotor. The requirements are also relevant to the non-rotating parts, such as module housing, main suspension assembly (magnetic or rolling element bearings, superconductor bearings, etc.), motor stator, caging mechanism and sensors within the module housing, and backup bearings, if applicable. However, control and interface electronics are not covered in ISO 21648:2008.

ANSI/AIAA S-096-2004 Space System – Flywheel rotor assemblies.

> This document establishes a top level certification standard for the design, analysis, material selection and characterization, fabrication, test, inspection of the FRA in a flywheel used for energy storage and/or attitude control in manned and unmanned space systems. This standard, when implemented in a FRA in a particular flywheel system, can assure a high level of confidence in achieving safe and reliable operation. This document may also be applicable to flywheel systems used in aircraft, mobile, stationary and subterranean applications if appropriate changes are agreed to between the responsible authority and the flywheel developer.

In the UK a process is in course to develop a British standard for composite flywheels, which is expecting to evolve to EN & ISO. It is at the stage where the committee is being formed.

2.5.2 Situation concerning the technology itself (all applications common): Existing standards

ISO 21648:2008: Space systems -- Flywheel module design and testing

ANSI/AIAA S-096-2004 Space System – Flywheel rotor assemblies

2.5.3 Situation concerning the technology itself (all applications common): Standards under construction

A British standard for composite flywheels is in progress.

2.5.4 Situation concerning the technology adaptation for Railways: Description of the concerned regulation bodies

There is no process in course to define a standard for flywheels system used in the railway applications.

2.5.5 Situation concerning the technology adaptation for Railways: Existing standards

There are currently non standards under construction specific to railways for flywheel EES.

2.5.6 Situation concerning the technology adaptation for Railways: Standards under construction

There are currently no standards under construction specific to railways.

2.6 ESS technology specificities: case of hydrostatic accumulators

2.6.1 Situation concerning the technology itself (all applications common): Description of the concerned regulation bodies

EC-Directives[1]

The Pressure Equipment Directive (97/23/EC) was adopted by the European Parliament and the European Council in May 1997. It has initially come into force on 29 November 1999. From that date until 29 May 2002 manufacturers had a choice between applying the pressure equipment directive or continuing with the application of the existing national legislation. From 30 May 2002 the pressure equipment directive is obligatory throughout the EU.

The directive provides, together with the directives related to simple pressure vessels (2009/105/EC), transportable pressure equipment (99/36/EC) and Aerosol Dispensers (75/324/EEC), for an adequate legislative framework on European level for equipment subject to a pressure hazard.

The PED Directive arises from the European Community's Program for the elimination of technical barriers to trade and is formulated under the "New Approach to Technical Harmonisation and Standards". Its purpose is to harmonise national laws of Member States regarding the design, manufacture, testing and conformity assessment of pressure equipment and assemblies of pressure equipment. It therefore aims to ensure the free placing on the market and putting into service of the equipment within the European Union and the European Economic Area. Formulated under the New Approach the directive provides for a flexible regulatory environment that does not impose any detailed technical solution. This approach allows European industry to develop new techniques thereby increasing international competitiveness. The pressure equipment directive is one of a series of technical harmonisation directives for machinery, electrical equipment, medical devices, simple pressure vessels, gas appliances etc.

The Directive concerns items such as vessels, pressurised storage containers, heat exchangers, steam generators, boilers, industrial piping, safety devices and pressure accessories. Such pressure equipment is widely used in the process industries (oil & gas, chemical, pharmaceutical, plastics and rubber and the food and beverage industry), high temperature process industry (glass, paper and board), energy production and in the supply of utilities, heating, air conditioning and gas storage and transportation.

[1] Source: http://ec.europa.eu/enterprise/sectors/pressure-and-gas/documents/ped/index_en.htm

Under the Community regime of the Directive, pressure equipment and assemblies above specified pressure and/or volume thresholds must:

- be safe;
- meet essential safety requirements covering design, manufacture and testing;
- satisfy appropriate conformity assessment procedures; and
- carry the CE marking and other information.

Pressure equipment and assemblies below the specified pressure / volume thresholds must:

- be safe;
- be designed and manufactured in accordance with the sound engineering practice of a Member State; and
- bear specified markings (but not the CE marking).

ISO-Standards

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization. International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

2.6.2 Situation concerning the technology itself (all applications common): Existing standards

Pressure Equipment Directive (PED)[2]

In order to ensure a coherent application of the pressure equipment directive Guidelines are currently being established and agreed in the framework of the Commission's working group "Pressure". This working group is composed of representatives of Member States, European federations, the Notified Bodies Forum and CEN and chaired by a representative of the Commission services.

Status of the guidelines

[2] Source: http://ec.europa.eu/enterprise/sectors/pressure-and-gas/documents/ped/guidelines/index_en.htm

The guidelines are not a legally binding interpretation of the directive. The legally binding text remains that of directive 97/23/EC. However the guidelines represent a reference for ensuring consistent application of the directive by all those involved. They represent, unless indicated differently in the respective guideline text, the unanimous opinion of the member states experts.

Guidelines set out under this chapter

Guidelines set out under this chapter have been agreed by the Commission's working group "Pressure". They are of the format Question-Answer. Whenever a listed question has no answer, this means that the discussion on this guideline has not been finalised yet. The relevant answer will appear as soon as the Guideline is adopted. Their presentation is likely to be modified in the future. Further guidelines are currently being developed and will be set out as soon as they are agreed.

Classification of the guidelines

The guidelines carry a x/y type numbering. The first number (x) relates to the subject, the second (y) is a sequential numbering. The numbers x relate to the following subjects:

1. Scope and exclusions of the directive
2. Classification and categories
3. Assemblies
4. Evaluation assessment procedures
5. Interpretation of the essential requirements on design
6. Interpretation of the essential requirements on manufacturing
7. Interpretation of the essential requirements on materials
8. Interpretation of other essential requirements
9. Miscellaneous
10. General/Horizontal issues

Especially for hydrostatic applications (incl. ESS) there are several international, European and German standards. The table below gives a rough overview of the actual standards.

Standard	Description	Publication date
DIN EN 10208-1	Steel pipes for pipelines for combustible fluids - Technical delivery conditions - Part 1: Pipes of requirement class A	Jul-2009
DIN EN 10208-2	Steel pipes for pipelines for combustible fluids - Technical delivery conditions - Part 2: Pipes of requirement class B	Jul-2009
DIN EN 10217-1	Welded steel tubes for pressure purposes - Technical delivery conditions - Part 1: Non-alloy steel tubes with specified room temperature properties	Oct-2009
DIN EN 764-1	Pressure equipment - Part 1: Terminology - Pressure, temperature, volume, nominal size	Sep-2004
DIN EN 764-2	Pressure equipment - Part 2: Quantities, symbols and units	Sep-2002
DIN EN 764-3	Pressure equipment - Part 3: Definition of parties involved	Sep-2002
DIN EN 764-4	Pressure equipment - Part 4: Establishment of technical delivery conditions for metallic materials	Jan-2003
DIN EN 764-5	Pressure equipment - Part 5: Inspection documentation of metallic materials and compliance with the material specification	Jan-2003
DIN EN 764-7	Pressure equipment - Part 7: Safety systems for unfired pressure equipment	Sep-2002
DIN EN 1333	Flanges and their joints - Pipework components - Definition and selection of PN	Jun-2006
DIN EN 10305-1	Steel tubes for precision applications - Technical delivery conditions - Part 1: Seamless cold drawn tubes	Mai-2010
DIN EN 10305-2	Steel tubes for precision applications - Technical delivery conditions - Part 2: Welded cold drawn tubes	Mai-2010
DIN EN 10305-3	Steel tubes for precision applications - Technical delivery conditions - Part 3: Welded cold sized tubes	Mai-2010
DIN EN 10305-4	Steel tubes for precision applications - Technical delivery conditions - Part 4: Seamless cold drawn tubes for hydraulic and pneumatic power systems	Apr-2011
DIN EN 10305-5	Steel tubes for precision applications - Technical delivery conditions - Part 5: Welded cold sized square and rectangular tubes	Mai-2010
DIN EN 10305-6	Steel tubes for precision applications - Technical delivery conditions - Part 6: Welded cold drawn tubes for hydraulic and pneumatic power systems	Aug-2005
DIN EN 1591	Flanges and their joints - Design rules for gasketed circular flange connections	Aug-2011
DIN EN 1514	Flanges and their joints - Dimensions of gaskets for PN-designated flanges	Aug-1997
DIN EN 14382	Safety devices for gas pressure regulating stations and installations - Gas safety shut-off devices for inlet pressures up to 100 bar	Jul-2009
DIN EN ISO 8434-1	Metallic tube connections for fluid power and general use - Part 1: 24 degree cone connectors	Feb-2008
DIN 51524	Pressure fluids - Hydraulic oils	Apr-2006
DIN EN ISO 4413	Hydraulic fluid power - General rules and safety requirements for systems and their components	Apr-2011
DIN 2445-1	Seamless steel tubes for dynamic loads - Part 1: Hot finished	Sep-2000

	tubes in fluid systems, 100 to 500 bar	
DIN 2445-2	Seamless steel tubes for dynamic loads - Part 2: Steel tubes for precision application in fluid systems, 100 bar to 500 bar	Sep-2000
DIN 2353	Non-soldering compression fittings with cutting ring - Complete fittings and survey	Dez-1998
DIN EN 853	Rubber hoses and hose assemblies - Wire braid reinforced hydraulic type - Specification	Feb-1997
DIN EN 854	Rubber hoses and hose assemblies - Textile reinforced hydraulic type - Specification	Feb-1997
DIN EN 855	Plastic hoses and hose assemblies - Thermoplastics textile reinforced hydraulic type - Specification	Feb-1997
DIN EN 856	Rubber hoses and hose assemblies - Rubber-covered spiral wire reinforced hydraulic type - Specification	Feb-1997
DIN EN 857	Rubber hoses and hose assemblies - Wire braid reinforced compact type for hydraulic applications - Specification	Feb-1997
DIN EN 12515	Machinery and plants for the preparation of concrete and mortar - Safety requirements	Mai-2008
ISO 12151-1	Connections for hydraulic fluid power and general use - Hose fittings - Part 1: Hose fittings with ISO 8434-3 O-ring face seal ends	Jun-2010
DIN ISO 12151-2	Connections for hydraulic fluid power and general use - Hose fittings - Part 2: Hose fittings with ISO 8434-1 and ISO 8434-4 24° cone connector ends with O-rings	Jan-2004
DIN ISO 12151-3	Connections for hydraulic fluid power and general use - Hose fittings - Part 3: Hose fittings with ISO 6162 flange ends	Jan-2004
DIN 20066	Fluid power systems - Hose assemblies - Dimensions, requirements	Okt-2002

Table 1: overview standards for hydrostatic applications

2.6.3 Situation concerning the technology itself (all applications common): Standards under construction

There are currently no standards under construction.

2.6.4 Situation concerning the technology adaptation for Railways: Description of the concerned regulation bodies

See 2.5.1

2.6.5 Situation concerning the technology adaptation for Railways: Existing standards

There are currently no need for standards specific to railways for hydrostatic ESS.

2.6.6 Situation concerning the technology adaptation for Railways: Standards under construction

There are currently no standards under construction specific to railways for hydrostatic ESS.

3. CONCLUSION: Recommendation/action with EU/CEN/IEC bodies for relevant changes and applicable rules for each application and each technology

As a conclusion, it appears that for EDLC and hydrostatic types of ESS the existing standardization has been created and can support the introduction of those technologies and is already started. For Li Ion batteries, although the battery part itself is under creation, a standard specifying the specific rules to be applied for rolling stock would be requested, as done for EDLCs. For flywheel: There is no current use of such ESS on rolling stock and the maturity of the technology does not currently require any recommendation for standardization.

In addition, an integration standard for all those storage technology could be useful, especially concerning the electrically connected ones. A call for expert has just been issued in that direction, as mentioned in the TC 9 CAG Recommendation 14/02 decided on April 18th, 2012. The Japanese TC9 NC proposed convenor for this “NP on hybrid system with energy storage for rolling stock”.

4. List of abbreviation

DMU	Diesel Multiple Unit
ESS	Energy Storage System
SOC	State Of Charge
DOD	Depth Of Discharge
EDLC	Electrical Double Layer Capacitor
CD	Committee Draft
WD	Working Document
WP	Work Package
CCA	Cold Cranking Amperes
CSM	Common Safety Methods
EBA	Eisenbahn BundesAmt
FRA	Flywheel Rotor Assembly

5. Appendix

5.1 Excerpt: Description of TC 40

IEC has published a strategic business plan on 16.12.2010. Presented here is an excerpt.

Title of TC: Capacitors and resistors for electronic equipment

A Background:… TC 40 was established in London in 1954 as the parent committee for electronic components of 5 Subcommittees. In 1961 during the Interlaken meeting this sub-division was given up and most of the existing component committees then started to work as individual committees.

…Current scope and working groups: TC 40 is responsible for the preparation and maintenance of international standards for:

a. Capacitors, resistors, thermistors and varistors for use in electronic equipment.

b. Capacitors, resistors, inductors and complete filter units for interference suppression.

c. Passive integrated circuits or networks containing resistors, capacitors, inductors or their combinations.

d. Packaging of electronic components for automatic handling, which is an activity undertaken on behalf of all relevant component technical committees.

e. Electric double layer capacitors for use in electrical and electronic equipment.

The strategic business plan contains chapters called *Business Environment, System Approach aspects, Objectives and Strategies* and *Action Plan* which will shall not be described in detail here.