Recent Fire Safety Regulations and Ongoing Processes in Europe Regarding Active Fire Proctecion Systems in Rolling Stock

Michael KLINGER[1]

Summary
There currently exist a bewildering variety of fire safety regulations for railway vehicles in Europe. In practice, the complexity of the standards and legislation makes the approval process for railway vehicles immensely complicated. Awareness of this problem has grown at the EU level – and hence it is now planned to put uniform structures in place for fire safety regulations. These regulations are, however, likely to lead to very tough requirements for fire safety systems in rolling stock. In future, therefore, a compensatory approach will become more and more important. Here, demonstration of equivalence will become more and more attractive as a way of realizing creative and efficient vehicle concepts while safeguarding fire safety. The paper presents an overview of recent standards, norms, regulations and requirements ruling the adoption of active fire protection systems in rolling stock in Europe, USA and the Middle East. The paper analyses in a non-exhaustive way the regulatory framework adopted by some notable countries and institutions, as well as current trends and potential future developments.

Keywords: standards, norms, regulations, requirements, fire protection, fire detection, fire fighting

1. Introduction

Active fire protection systems, particularly fire detection and firefighting systems, are among the few innovative subsystems introduced in the railway vehicles since years. With a likely ambitious but explicating comparison, we might say that they are the first real new subsystem introduced in railway vehicles since the development of electronics and related subsystems (traction and speed control, PIS, earth-train communication etc.), which began in the 70s and is still facing major development chances, especially in the field of communication between train and track (like the European ERTMS / ETCS systems).

[1] Consultant, Institute for Applied Fire Research, Berlin; e-mail: klinger@ifab-fire.com.

This shows that the field is still young on the technological point of view: a lot of solutions, even if widely adopted, are not yet standardized, as often in railway industry. The technologies of brake or HVAC systems for rolling stock are well known, basically standardized and widely and deeply known and understood in their functions by the car builders The same cannot be said about fire detection and firefighting systems, and even more primitive is therefore the regulatory framework (norms, standards, guidelines etc.) related to such subsystems and setting the relevant criteria of design, testing or maintenance. This is a normal situation due to the not yet completed maturation of the market and the technology.

For this purpose, this paper shows the status-quo of recent norms, guidelines, laws or other regulatory documents ruling this field in Europe, USA and the Middle East. This study has not the presumption to be exhaustive, but to give an overview of the current status in different countries based on the direct field-experience of two major players in this field, the company FOGTEC as an acknowledged leading manufacturer of such kind of systems, and the company IFAB as an expert consultant for fire protection in rolling stock.

2. The European Framework: EN 45545, EN 50553 and the Technical Specifications for Interoperability (TSIs)

At an European level the relevant standards and laws defining requirements for fire protection on the railway industry are the following:

- EN 45545:2013 „Railway applications. Fire protection on railway vehicles";
- EN 50553:2012 „Railway applications – Requirements for running capability in case of fire on board of rolling stock";
- The Technical Specifications for Interoperability (TSIs) for the vehicles and infrastructures of the Trans-European Network (TEN).

The two mentioned EN are actually mentioning active fire protection only at a minor level. The EN 45545 sets its focus on fire protection realized by special materials (no burning, no toxicity) and defined aspects regarding construction. Part 6 shows requirements for fire detection and firefight systems. The EN 50553 focuses on the running capability aspects in case of fire and therefore gives ideas regarding architectural and design aspects of the vehicle (power supply, availability of traction force), not giving indications how to deal with the fire itself.

So the European Union approached the topic of active fire protection in railway vehicles only while defining the Technical Specifications for Interoperability (TSIs) for the vehicles and infrastructures of the Trans-European Network (TEN). The aim of these technical specifications is to set a common regulatory framework between the countries of the EU having railway lines which built part of the TEN.

The introduction of such rules for safety in railway tunnels is important mainly due to the fact that:

1. Due to architectural constraints, tunnels are basically a bottle-neck for traffic and built high-danger situations, so the safety of their operations must be ensured with the highest priority;
2. Some countries of the EU (especially Italy and Austria) have a deep concentration of tunnels in their national railway lines and demand specific safety requirements;
3. One of the key-factors of the TEN is the crossing of the Alps, which is possible only with long base-tunnels which will supersede the current pass-lines. Future Brenner and Mont d'Ambin base-tunnels are relevant examples with a length of 55[2] and 57[3] km respectively.

The TSIs are several and covering various fields of rolling stock and railway infrastructure, the ones of major interest for fire safety are:

- TSI SRT – Safety in Railway Tunnels[4],
- TSI HS RST – High Speed Rolling Stock[5],
- TSI LOC&PAS CR – Conventional Rolling Stock[6]

which are interconnected between each other.

The TSI SRT specifies that trains running in tunnels longer than 1 km must have some specific requirement, listed in the TSIs. Especially the TSI SRT, TSH HS RST and TSI LOC&PAS CR are linked together in a quite complicated way regarding several requirements for fire protection. Among several requirements related to materials, architecture, signalization on board, the main requirements for active fire protection are set in § 4.2.10.5 of the TSI LOC&PAS:

§ 4.2.10.5 Fire barriers

This clause supplements SRT TSI clause 4.2.5.4 'Fire barriers for passenger rolling stock' for conventional rolling stock.

In addition to the provisions in the SRT TSI, for category B fire safety rolling stock, the requirement for full 'cross section partitions within passenger/staff areas' is permitted to be met by fire spreading prevention measures (FSPM):

---

[2] http://www.bbt-se.com/en/project/basic-data/.

[3] http://en.wikipedia.org/wiki/Turin%E2%80%93Lyon_high-speed_railway.

[4] Commission Decision 2008/163/EC of 20 December 2007 „Concerning the technical specification of interoperability relating to «safety in railway tunnels» in the trans-European conventional and high-speed rail system".

[5] Commission Decision 2008/232/EC of 21 February 2008 „Concerning a technical specification for interoperability relating to the «rolling stock» sub-system of the trans-European high-speed rail system".

[6] Commission Decision 2011/291/EU of 26 April 2011 „Concerning a technical specification for interoperability relating to the «locomotives and passenger vehicles» sub-system of the trans-European high-speed rail system".

If FSPM are used instead of full cross section partitions, it shall be demonstrated that:

- *they ensure that fire and smoke will not extend in dangerous concentrations over a length of more than 28 m within the passenger/staff areas inside a unit, for at least 15 minutes after the start of a fire,*
- *they are installed in each vehicle of the unit, which is intended to carry passengers and / or staff,*
- *they provide at least the same level of safety to persons on board as full cross section partitions, with an integrity of 15 minutes, which are tested in accordance with the requirements of EN 1363-1:1999 partition test and assuming the fire can start from either side of the partition.*

If the FSPM relies on reliability and availability of systems, components, or functions, their safety level shall be taken into account in the demonstration; in that case the global safety level to be met is an open point.

The technical implementation of such FSPM did remain an open point, being subject of further discussion. In the frame of a general review of the TSIs, currently ongoing, the definition „Fire Spreading Prevention Measures" has been defined as obsolete and was changed to „Fire Control and Containment Systems" (FCCS).This definition matches in a better way with the scope and safety objective of such alternatives to fire barriers. It clarifies, that these solutions must consist of a *system,* a subsystem of the vehicle, devoted to control and contain the fire event.

The assessment requirements for FCCS to close the open point in the TSI are currently defined. A European Survey Group was generated to define a list of content which need to be implemented into a European Standard for Assessment of FCCS Systems. Following this Survey Group a so called Task Force will fill the list of content with requirements.

3. The ARGE Guidelines

The absence of a European standard for ruling fire protection system became a topic starting from the beginning of years 2000, when these systems started to be introduced in the railway vehicles not for mandatory requirements but for willingness and cleverness of manufacturers and operators who did see active fire protection systems as an important improvement on the passengers safety.

The situation of not having guidance of how to assess active systems was clearly seen as critical, especially in the German-speaking area of Europe (Germany, Switzerland and Austria) where attention to fire safety has historically been a strong tradition.

In parallel the development of the Transrapid brought to relevance the issue of evacuation from vehicles in case of fire: the train was in fact conceived to run on an elevated structure, without escape ways. Furthermore the vehicles would have been difficult to reach by the fire brigade in case of a fire incident. The safety analysis demonstrated that an active fire protection system on board the vehicle reduces big fire scenarios an ensures passengers safety in case of fire.

The experience of the Transrapid Project – even if not realized and unsuccessful at commercial level – constituted a milestone on the field of active fire protection systems: the definition of a testing and validation procedure for this new system had to be set and this experience constituted the birthplace of a working group with purpose of defining a generally applicable technical guideline for the design and testing of such systems.

The so called „ARGE" working group (acronym of *Arbeitsgemeinschaft*, German term for working group) led by TÜV North and South set therefore in 2005 the base of a package of design guidelines that are known today in the following form:

- ARGE Guideline Part 1 „Fire detection in rolling stock", revision 4;
- ARGE Guideline Part 2 „Firefighting in rolling stock", revision 3;
- ARGE Guideline Part 3 „System functionality fire detection and firefighting systems in rolling stock", revision 2.

These guidelines received along the years a vast appreciation and acceptance all over the world. Often are mentioned by car builders or operators as technical requirements for the fire protection systems and constitute today, together with the draft of Italian UNI standard mentioned later on in this paper, the only exhaustive document setting requirements for testing and design of active fire protection system. The main concepts introduced by the ARGE guidelines are:

1. Adoption of validation processes based on clearly measurable results;
2. Definition of standardized testing methodologies and procedures for testing of fire detection and firefighting systems;
3. Introduction of a major concept, that the fire protection systems for railway application must be designed and assessed according not only to fire safety standards, but also according to railway specific norms;
4. Maximum detection time of 60s in passenger areas to ensure the safety of the passengers;
5. Maximum detection time of 120s in technical areas to avoid major development of fire before the activation of the firefighting system;
6. The equipment must be designed and tested according to the relevant European standard for rail-worthiness, like EN50155 and EN61373 for electromagnetic and mechanic behavior;
7. System functionality must be ensured.

4. The Italian Case: DM 28 October 2005 „Safety in Railway Tunnels"

Fire safety in railway tunnels have been in Italy a major issue since the nation started to plan a long-distance high-speed railway network across the country. The geographical nature of the country with high mountains separating economically vital regions was a clear obstacle to a national high-speed railway network which could have been faced only by boring long tunnels under the mountains.

Additionally, the turbulent recent past with the „Strategy of Tension" of the 70s with bombings targeting mainly the railway infrastructure and the trains itself created a high sensitivity in regards of safety in tunnels. When the new national high-speed network was about to open at beginning of years 2000, with the 78.5 km long Bologna-Florence section consisting of 73.8 km of tunnels, it was clear that rules for the safety in railway tunnels needed to be set with clear targets and requirements.

Result was the enactment of a *Decreto Ministeriale* (DM, Minister's Decree, equivalent to a national law) setting safety requirement for railway tunnels and for the vehicles running through them. The DM was voted on the 28 October 2005 and named as „Safety in Railway Tunnels" (original title „Sicurezza nelle gallerie ferroviarie").

Among different requirements at infrastructure point of view (escape routes, warning and signaling technologies, rescue plans and infrastructures for helicopters) the decree focuses also on the rolling stock itself, considered, together with the human action (vandalism or terrorism) as the main source of risk. Going through the document, some bullet points should be mentioned here. While the original text is in Italian language, the translation tries to keep the original meaning.

1. In § 1.1. the object and scope of the Decree are set:
   The scope of this Decree is to ensure an adequate safety level of railway tunnels, via the adoption of prevention and protection measures devoted to the reduction of critical situations which may endanger human lives, the construction and the systems of the tunnels, as well as devoted limitation of consequences in case of accidents.
2. The applicability is an important point, set in § 2.1:
   This Decree applies to all railway tunnels longer then 1000 m, already in operation as well as in construction or design phase, located on the railway network […].
3. On §3 the main aspect of rolling stock is introduced, defining the applicability to new and refurbished vehicles and referring to the technical annex containing the detail specifications:

- *§ 3.7 Safety requirements:*

The operators will put in service, starting from the 5th year of put in force of this Decree, new rolling stock respecting the safety requirements according to Annex II.

- *§3.8 Safety requirements:*

While refurbishing the existing fleet, all spare and additional parts must respect the safety requirements of Annex II. In any case, within 15 years form the day of put in force of this Decree, all rolling stock running in railway infrastructures according to §2 must respect the safety requirements according to Annex II.

The Annex II – Minimum requirements – Section 2 Rolling Stock (from page 36), sets finally the relevant requirements, introducing among others the fundamental specification of fixed automatic firefighting systems to be installed on board of the vehicles:

- *§ 1.5.1 Fire protection measures (motorized and non-motorized vehicles)*

The rolling stock must be designed in such way to prevent the occurring of arsons and their spread. Especially, it must be avoided the use of materials which in case of fire will release smoke and gas in quantity beyond the limits set by the existing and in force technical standards.

- *§ 1.5.2: Fire detectors on board (motorized vehicles, night, restaurant and passenger coaches)*

In all motorized vehicles, as well as in night coaches (couchettes and wagon-lits) and in restaurant and passenger coaches, fire detection systems able to give an alarm to the train crew must be foreseen.

- *§ 1.5.5: Running capability*

In case of fire in a passenger vehicle, the train must be able to maintain the running capability for a time of at least 15' at a speed of 80km/h. At this purpose, all traction vehicles must be equipped with fire extinguishing systems and, as far as technically feasible, technical solutions allowing the running capability.

- *§ 1.5. 6: Fire extinguishers*

In all vehicles, including traction vehicles, hand fire extinguishers must be foreseen in adequate number and type.

- *§ 1.5.7: Fixed firefighting systems*

In all motorized vehicles, night coaches, and in restaurant and passenger coaches, of new construction, adequate fixed automatic fire fighting systems must be integrated […].

4.1. The technical Application of the DM

When the DM came into force, it was clear to the Italian national railway industry that an existing standard for the design and validation of such systems introduced as mandatory by the DM was not available. The only option available was to adopt the ARGE guidelines, which were indeed adopted at the very beginning, but the need of a national standard which could also express the national industrial interests was strong, being the ARGE a result of the German industry.

So starting from 2009–2010 the Italian Agency for Safety of the Railways (*Agenzia Nazionale per la Sicurezza delle Ferrovie*, ANSF, the responsible Authority) started preliminary works and in 2011 set up a working group to draft a national standard, how the firefighting systems must be designed and tested. This working group produced a draft of national standard which is now under public enquiry for comments numbered as „U94 020570" and titled „Design, installation, validation and maintenance of fire detection and fire suppression systems for railway vehicles" (*Progettazione, istallazione, validazione e manutenzione di sistemi di rilevazione ed estinzioni incendi destinati ai veicoli ferroviari)* adding to the main topics already treated by the ARGE Guidelines (design and testing) also additional aspects like installation, maintenance and operational performances of the systems.

Additional to several concepts already set by the ARGE Guidelines and adopted also by this draft, the main new requirements set are:

- Water based agents for passenger areas have to be used;
- Fire detection in passenger areas must be based on smoke detection and not on temperature detection;
- The standardization of the testing mock-ups, already set by the ARGE Guidelines, have been applied also to the mock-up of the vehicle, while ARGE Guidelines where related to the specific vehicle;
- The laboratories accepted to carry such tests must be approved according to EN 17025.

As mentioned before, the draft document as of today (April 2014) is under public enquiry and it is expected to be placed into force within end of 2014.

5. The NFPA130

Fire protection in rolling stock began to be an issue in US in the seventies, when several fire events occurred and the public opinion and the railway industry were made more aware about the issue of fire on rolling stocks. A technical com-

mittee was therefore set (*Technical Commiteet on Fixed Guideway Transit and Passenger Rail Systems*) to prepare a document to set requirements and standards concerning fire protection guided vehicles. The primary concern of the committee was to focus on solutions devoted to avoid *entrapment and injury of large number of people* [7]in the transportation facilities in case of fire.

The events did not evolve as catastrophic, but the reasons of such fortunate result were identified *to chances events more than any preconceived plan or the operation of protective systems*[8]. The US National Fire Protection Association (NFPA) adopted the Code as NFPA130 „Standard for Fixed Guideway Transit and Passenger Rail Systems", the first release was issued in 1983.

The NFPA130 treats fire protection issues on a vast field, covering among other topics stations, trainways, communication systems etc.

One specific part is devoted to vehicles too, covering traditional fire protection subjects likematerials, vehicle architecture, electrical fire safety.

Concerning active fire protection systems, a big step forward was done in the 2014 edition of the standard. In this release for the first time the concept of on-board fire suppression systems was introduced, in Annex G.

While such systems are considered as a new technology in the railway industry, the standard points out how they *have been successfully used on a number of passenger rail and diesel powered light rail systems outside of the United States*[9]. The advantages of adoption of on-board fire suppression systems are also listed. It is in fact explained, how the use of fire suppression systems may:

- *save lives in the incident vehicle during a fire condition*[10]*,*
- *minimize damage to the train, tunnel and the station which it has entered*[11]*,*

As well as several benefic effects at infrastructure side, like reduction of fire safety requirements at station, or reduction of ventilation systems' capacities.

The Annex G focuses also on the boundary challenges to be adopted by the vehicle manufacturer or designer, like costs, maintenance, testing and commissioning, as well as the aspect of technical challenge for retrofit works.

Even if the NFP130 Code is developed in the USA, it is used very often also for other parts in the World, e.g. lots of fire protection designs done in the Middle East are based on the NFPA130 Code.

---

[7] NFPA® 130 Standard for Fixed Guideway Transit and Passenger Rail Systems, 2014 Edition, 130–1.

[8] Op. cit., p. 130–1.

[9] NFPA® 130 Standard for Fixed Guideway Transit and Passenger Rail Systems, 2014 Edition, Annex G, 130–59.

[10] Op. cit., p. 130–59.

[11] Op. cit., p., 130–59.

Literature and Property Rights

Standards / Norms

1. ARGE Guideline – Part 1 „Fire detection in rolling stock", Functional proof procedure for the positioning of fire detectors in rooms accessible to persons, in electric cabinets and in areas of combustion engine, rev 4.0, 2012.
2. ARGE Guideline – Part 2 „Firefighting in Rolling Stock", Functional assessment procedure for the effectiveness of firefighting systems in rooms accessible to persons, in electric cabinets and in areas of combustion engines. rev 3.0, 2012.
3. ARGE Guideline – Part 3 „System functionality fire detection and firefighting systems in rolling stock", Functional proof for detection and control of system functions, rev 2.0, 2012.
4. Commission Decision 2008/163/EC of 20 December 2007, „Concerning the technical specification of interoperability relating to 'safety in railway tunnels' in the trans-European conventional and high-speed rail system".
5. Commission Decision 2008/232/EC of 21 February 2008 „Concerning a technical specification for interoperability relating to the «rolling stock» sub-system of the trans-European high-speed rail system".
6. Commission Decision 2011/291/EU of 26 April 2011 „Concerning a technical specification for interoperability relating to the «locomotives and passenger vehicles» sub-system of the trans-European high-speed rail system".
7. Decreto Ministeriale N. 89–2005, Sicurezza nelle gallerie ferroviarie, Gazzetta Ufficiale della Repubblica Italiana, Roma, Sabato 8 Aprile 2006.
8. EN 45545:2013 „Railway applications. Fire protection on railway vehicles".
9. EN 50553:2012 „Railway applications; Requirements for running capability in case of fire on board of rolling stock".
10. NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail Systems, 2014 Edition.

Article in Magazines / Journals

1. Recent Fire Safety Regulations for Rolling Stock, M. Klinger, Der Eisenbahningenieur, May 2012.
2. Recent Fire Safety Regulations for Rolling Stock, M. Klinger, ZEVrail, August 2012.
3. Recent Regulations & Validation Procedures for Rolling Stock, M. Klinger, EURAILmag, Issue 26 (2013).

Symposia

1. European Regulations regarding Fire Detection and Firefighting Systems in Rolling Stock, M. Klinger, Fire Safety Conference of Currenta in Leverkusen (Germany) 2013.
2. Fire Safety in Rolling Stock, M. Klinger, Harting Technology Day in Berlin (Germany) 2013.
3. Fire Detection Systems for Rolling Stock Applications, M. Klinger, Modern Trends of Fire Protection in Rolling Stock 2013 in Warsaw (Poland).
4. Verification and Approval Procedures regarding Fire Protection Systems in Rolling Stock, M. Klinger, Fire Safety Conference of IFV in Rostock (Germany) 2013.

Books

1. Barbagli M.: *Rolling Stock and fire protection – An overview of aspects, solutions and requirements*, MBA Edizioni, Sesto Fiorentino, Italy, 2011, ISBN 978-88-906180-6-2.
2. *Verband Deutscher Verkehrsunternehmen, Brandschutz in Fahrzeugen und Tunneln des ÖPNV*, Alba Fachverlag, Cologne, Germany, 2005, ISBN 978-3--87094-664-7.