

Inspection report

Comparative Assessment of NFPA 130 with EN 45545 for the Application Case

Railway-Antennas

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Revision history

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1.0	Final	04.11.2016	Michael Dallmer	all	Initial
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1 General

1.1 Purpose of this Document

This document deals with the comparative assessment of the Huber & Suhner Railway-Antennas in respect to compliance with NFPA130 with fulfilling the requirements EN 45545 series.

1.2 Standards

Table 1: Standards

No.	Standard	Title
[R1]	NFPA 130 2014	Standard for Fixed Guideway Transit and Passenger Rail Systems
[R2]	NFPA 130 2017	Standard for Fixed Guideway Transit and Passenger Rail Systems
[R3]	EN 45545-1 2013	Railway applications – Fire protection on rail vehicles – Part 1: General
[R4]	EN 45545-2 2013 + A1 2015	Railway applications – Fire protection on rail vehicles – Part 2: Requirements for fire behaviour of material and components
[R5]	EN 45545-3 2013	Railway applications – Fire protection on rail vehicles – Part 3: Fire resistance requirements for fire barriers
[R6]	EN 45545-4 2013 + A1 2015	Railway applications – Fire protection on rail vehicles – Part 4: Fire safety requirements for rolling stock design
[R7]	EN 45545-5 2013 + A1 2015	Railway applications – Fire protection on rail vehicles – Part 5: Fire safety requirements for electrical equipment including that of trolley buses, track guided buses and magnetic levitation vehicles
[R8]	EN 45545-6 2013 + A1 2015	Railway applications – Fire protection on rail vehicles – Part 6: Fire control and management systems
[R9]	EN 45545-7 2013	Railway applications – Fire protection on rail vehicles – Part 7: Fire safety requirements for flammable liquid and flammable gas installations
[R10]	TSI SRT 1303/2014/EU	COMMISSION REGULATION (EU) No 1303/2014 of 18 November 2014 concerning the technical specification for interoperability relating to 'safety in railway tunnels' of the rail system of the European Union

1.3 Abbreviations

Table 2: Abbreviations

Abbreviation	Definition
HL	Hazard Level
OC	Operation Category
PCB	Printed circuit board
N/A	Not Applicable
min.	Minimum
max.	Maximum
OI	Oxygen Index
chpt.	Chapter
requ.	Requirement

1.4 Management system at the time of inspection

The inspection was executed under application of the valid quality management system [M1] of the inspection body TÜV SÜD Rail GmbH accredited according to DIN EN ISO/IEC 17020:2012 [M2].

Table 3: Management System

Ref.	Designation	Title
[M1]	QMS	Quality management system of TÜV SÜD Rail GmbH
[M2]	D-IS-11190-01-00	Accreditation according to DIN EN ISO/IEC 17020:2012 as a Type A inspection body

2 Comparison of NFPA 130 and EN 45545

The focus of this report is the comparison between the requirements of the NFPA 130 and the EN 45545 series, which have to be considered for approval of operation in Europe. Taking the paragraphs of the NFPA 130 chapter 8 as the basis for comparison, the requirements of EN 45545 are allocated.

2.1 Method

The present report focuses on a comparison between the requirements applicable for Railway-Antennas of the American NFPA 130 standard (2014 and 2017 issue) and the European EN 45545 series (revision 2013 with corrections in 2015), which have to be considered for approval of operation in Europe.

Taking the paragraphs of the NFPA as the basis for comparison, the requirements of the European standard are allocated.

After having depicted the hierarchy and content of rules and standards in Europe for engineering, operation and safety of railway systems and constituents, a line-by-line comparative revision of the NFPA paragraphs is performed.

2.2 Safety Objectives

The main safety objective in NFPA130 is:

- *“Protection of occupants not to intimate with the initial fire development*
- *Maximizing the survivability of occupants intimate with the initial fire development.”*

This directly corresponds with the main objective in EN 45545, the corresponding European standard for:

“The measures and requirements specified in EN 45545 are intended to protect passengers and staff in railway vehicles in the event of a fire on board.”

2.3 Scope of NFPA 130

The standard covers “...life safety from fire and fire protection requirements for fixed guideway transit and passenger rail systems, including, but not limited to, stations, trainways, emergency ventilation systems, vehicles, emergency procedures, communications, and control systems.” (see NFPA 130, chpt. 1.1.1)

It does not cover requirements for:

- freight transport systems;
- buses and trolley buses;
- circus transport trains;
- tourist, scenic, historic or excursion operations;
- any other transport systems not grouped under expressions like fixed guideway transit system or passenger rail system;
- stop point (platform with shelter).

For these systems the standard can be used as guideline.

2.4 Scope of EN 45545

The European Standard EN 45545 is valid for track guided public passenger land transport vehicles. Freight transportation vehicles are not covered by EN 45545. The measures and requirements specified in EN 45545 are intended to protect passengers and staff in railway vehicles in the event of a fire on board.

EN 45545 specifies:

- fire protection measures for railway vehicles;
- verification methods for these measures.

The protection of passengers and staff is essentially based on measures to:

- prevent fires occurring due to technical faults and due to equipment design or vehicle layout (Part 1, Part 4, Part 5 and Part 7);
- minimise the possibility of ignition of materials installed on railway vehicles due to accidents or vandalism (Part 1 and Part 2);
- detect a fire should it occur (Part 6);
- limit the spread of fire by specification of materials according to their operational categories (Part 2) and by measures for containment (Part 3);
- minimise the effects of fire in terms of heat, smoke and toxic gases on passengers or staff through the specification of materials installed on railway vehicles (Part 2);
- control and manage a fire, for example by means of fire detection, suppression and/or emergency energy shut down (Part 6).

2.5 Approach of Comparison

The comparison between the NFPA requirements taken as leading subjects with the European rules will be performed in a tabular form (chapter 2.6).

The legend of the table columns is explained as follows:

- On the left side, the NFPA chapters (until the 3rd level of subdivision) are depicted.
- The right side stands for Harmonized European EN 45545 standard.

These requirements will be compared in accordance to the NFPA 130 chapter 8 requirements. Thereby the assessment of the key aspects is focused on how detailed the specification of the requirement is. Only the requirements applicable to Railway-Antennas mounted in or at railway vehicles are evaluated.

The appraisal and allocation of rules will be performed in a hierarchical way: If higher level rules (like EN-standard) are comprising the NFPA requirements sufficiently, the lower level rules from operators etc. will not analysed anymore, even they contain respective requirements.

The results of comparison of the NFPA requirements with the abovementioned rules will be scored as follows:

Table 1: Description of score

Score	Description
XX	EN 45545 is more precise or demanding
X	NFPA 130 and EN 45545 standards are equivalent
0	NFPA 130 is more precise or demanding
N.C.	This requirement is not covered in EN 45545

2.6 Comparison and Evaluation of Requirements

Table 2: Comparison results - NFPA 130:2014&2017 versus European Standard EN 45545:2013 with corrections in 2015

NFPA 130			EN 45545	
Chapter	#	Requirement characteristics / Keywords	Score	Comments
Vehicle	8.			
Applicability	8.1	New and retrofitted vehicles		
New Vehicles	8.1.1	New Vehicles: "All new passenger carrying vehicles shall be, at a minimum, designed and constructed to conform to the requirements set forth in this chapter."	X	Same requirement in EN 45545
Retrofitting	8.1.2	Retrofit: "Where existing passenger-carrying vehicles are to be retrofitted, the appropriate sections of this standard shall apply only to the extent of such retrofit."	X	Same requirement in EN 45545
Compliance Options	8.2	Alternative: Fulfillment of prescriptive requirements in chpt. 8.3 - 8.10 for passenger vehicles <i>or</i> application of engineering analysis (8.11)	XX	In Europe, the vehicles have to be designed according normative (prescriptive) requirements; the analytical way is accepted only exceptionally (ref. to CSM /11/) Thus EN 45545 is more stringent than NFPA 130
Flammability and Smoke Emission	8.4	sub-divided in 8.4.1 (fire test procedures and performance criteria for materials) and 8.4.2 (fire hazard analysis for material not fulfilling the requ. of chpt. 8.4.1)	XX	EN 45545 is more detailed than NFPA 130 no requirements for toxicity of smoke in NFPA 130 high requirements for toxicity of smoke in EN 45545
Requirements and test methods	8.4.1	Material requirements, component assembly, test methods; reference to numerous ASTM codes	XX	NFPA: no material requirements on electrotechnical equipment; material requirements not specified on the same level of detail like in respective EN standards Details: see Table 3

Table 2: Comparison results - NFPA 130:2014&2017 versus European Standard EN 45545:2013 with corrections in 2015

NFPA 130			EN 45545	
Chapter	#	Requirement characteristics / Keywords	Score	Comments
Material handling, that not complies with 8.4.1	8.4.2	In case of deviation refers to a risk based approach	XX	Material requirements as specified in EN codes are mandatory; the analytical way is accepted only exceptionally (/11/) Thus EN standard is more stringent than NFPA
Electrical Fire Safety	8.6	requirements for fire & smoke: see Table 3 physical, mechanical, and electrical performance of cables: ICEA S-95-658/NEMA WC-70 or ICEA S-73-532/NEMA WC-57, as applicable wire size: 2.1mm ² or 0.33mm ² respectively Air clearance, creepage from Annex F	X	Environmental and mechanical tests acc. to EN 50155 Wiring: EN 50343 Air clearance, creepage: EN 50124 ¹
Engineering Analysis Option	8.11	Option for analysis (refer to 8.2) if prescriptive requirements are not applicable; general (qualitative) requirements; need for independent review or approval	XX	The NFPA determines how an alternative interpretation has to be performed by an analytical approach. Some normative minimum requirements have to be fulfilled and the safety goals according 4.2 and 4.3 have to be met. In contrast, the European fire safety rules (e.g. in TSI Rolling Stock, EN 45545) are related to a risk based approach only indirectly (different requirement classes based on operation categories). However, with the CSM /11/ an explicit risk analysis and risk evaluation process has been implemented alternatively.

¹ Note: NFPA 130 proposes EN 50124 as alternative

Table 3: Cross check comparison of material requirements

#	Description	SET	Test Standard EN 45545-2	Test NFPA 130	Standard	Description	Score
IN16 EX12	Interior and exterior seals	R22 R23	ISO 4589-2 Oxygen index % EN ISO 5659-2: 25 kWm ⁻² D _s max NFX70-100-1&2 600°C CIT _{NLP}	ASTM C 1166 ASTM E 662			XX
EL10	Small electrotechnical products	R26	EN 60695-11-10 Vertical small flame test	none			XX
EL1A EL1B	Cables for exterior and for interior	R15 R16	EN 60332-1-2: min in mm EN 60332-3-24 for d ≥ 12 mm EN 50305 §9.1.1: for 6<d<12 EN 50305 for d ≤ 6mm EN 61034-2 EN 50305, CIT _{Cable}	NFPA 262 or FT4/IEEE 1202 and ANSI/UL 1685		wire and cable	XX
EL9	Printed circuit boards	R25	EN IEC 60695-2-11 Glow Wire Temperature°C	none			XX
NLP	Non listed product interior < 0.2m ²	R1	ISO 5658-2 CFE: CFE kWm ⁻² ISO 5660-1: 50 kWm ⁻² MARHE EN ISO 5659-2: 50 kWm ⁻² D _s (4) EN ISO 5659-2: 50 kWm ⁻² VOF ₄ EN ISO 5659-2: 50 kWm ⁻² CIT _G	ASTM E 162 ASTM E 662		component boxes and covers, plus adhesives and sealants (in EN done in end use conditions)	XX
	exterior < 0.2m ²	R7	ISO 5658-2 CFE: CFE kWm ⁻² ISO 5660-1: 50 kWm ⁻² MARHE EN ISO 5659-2: 50 kWm ⁻² D _s max EN ISO 5659-2: 50 kWm ⁻² CIT _G	ASTM E 162 ASTM E 662		component boxes and covers, plus adhesives and sealants (in EN done in end use conditions)	XX

Table 3: Cross check comparison of material requirements

#	Description	SET	Test Standard EN 45545-2	Test NFPA 130	Standard	Description	Score
	interior exterior $\leq 0.2\text{m}^2$	R22 R23	ISO 4589-2 Oxygen index % EN ISO 5659-2: 25 kWm ⁻² D _s max NFX70-100-1&2 600°C CIT _{NLP}	none: miscellaneous and dis- continuous		Small part with surface < 100cm ² fire hazard analysis 8.4.1.10	XX ²
	$\leq 0.2\text{m}^2$ and $\leq 500\text{g}$ (interior) or $\leq 2000\text{g}$ (exterior)	R24	EN ISO 4589-2: LOI	none: miscellaneous and dis- continuous		Small part with surface < 100cm ² fire hazard analysis 8.4.1.10	X ²
	$\leq 0.2\text{m}^2$ and $\leq 100\text{g}$ (interior) or $\leq 400\text{g}$ (exterior)	none		none: miscellaneous and dis- continuous		Small part with surface < 100cm ² fire hazard analysis 8.4.1.10	X ²

² Note: The requirements of NFPA130 for products to be considered as small parts are stricter for size and weaker for weight.

Table 4: Cross check of test procedures

Fire technological criteria	Parameter	NFPA 130	EN 45545-2	Score
Flammability	Test method	ASTM C 1166 (ASTM C 542)	ISO 4589-2	X
	Thermal level stress	Exposition to a gas flame at the lower end	Flame in a controlled atmosphere in [O ₂]	
	Duration of test	5 or 15 min	Max 3 min	
	Specimen configuration	Vertical	Vertical	
	Specimen size	25 mm x 460 mm x 13 mm	150 x 10 x 4 mm	
	Measured parameters	Propagation of flame along the specimen	Minimum concentration of oxygen required to support combustion of the material	
	Ranking Criteria	FP flame propagation	LOI (% O ₂)	
Horizontal spread of flame	Test method	ASTM E648	ISO 9239-1	X
	Thermal level stress	11 kW/m ²	11 kW/m ²	
	Duration of test	Until the flame goes out	30 min	
	Specimen configuration	Horizontal	Horizontal	
	Specimen size	250 mm x 1050 mm	1050 mm x 230 mm	
	Measured parameters	Flame Spread	Flame Spread	
	Ranking Criteria	CRF	CHF	

Table 4: Cross check of test procedures

Fire technological criteria	Parameter	NFPA 130	EN 45545-2	Score
Vertical spread of flame	Test method	ASTM E162 / ASTM D 3675	ISO 5658-2	XX
	Thermal level stress	max. 40 kW/m ²	max. 50 kW/m ²	
	Duration of test	15 min	30 min	
	Specimen configuration	60°	Vertical	
	Specimen size	152 x 457 mm	800 mm x 155 mm	
	Measured parameters	Flame spread, droplets, smoke temperature	Flame Spread, droplets	
	Ranking Criteria	Is (Fs, Q) - Flaming dripping	CFE	
Heat release	Test method	ASTM E1354	ISO 5660-1	X
	Thermal level stress	50 kW/m ²	25 kW/m ² , 50 kW/m ²	
	Duration of test	20 min	20 min	
	Specimen configuration	Horizontal	Horizontal	
	Specimen size	100 x 100 mm	100 x 100 mm	
	Measured parameters	Heat released	Heat released	
	Ranking Criteria	q ₁₈₀	MARHE	

Table 4: Cross check of test procedures

Fire technological criteria	Parameter	NFPA 130	EN 45545-2	Score
Optical smoke density	Test method	ASTM E662	ISO 5659-2	X
	Thermal level stress	25 kW/m ² F and NF	25 kW/m ² , 50 kW/m ²	
	Duration of test	20 min	20 min	
	Specimen configuration	Vertical	Horizontal	
	Specimen size	76.2 x 76.2 mm	75 mm x 75 mm	
	Measured parameters	Smoke opacity	Smoke opacity	
	Ranking Criteria	D _s (1,5) – D _s (4)	D _s (4) – VOF ₄ – D _s (max)	
Toxic potential of flue gases	Test method	Not mentioned	ISO 5659-2+FTIR	XX
	Thermal level stress		25 kW/m ² , 50 kW/m ² for NF	
	Duration of test		at 4 and 8 min – 20 min	
	Specimen configuration		Horizontal	
	Specimen size		75 mm x 75 mm	
	Measured parameters		CO, CO ₂ , HCN, SO ₂ , NO _x , HCl, HBr, HF	
	Ranking Criteria		ITC _G	

Table 4: Cross check of test procedures

Fire technological criteria	Parameter	NFPA 130	EN 45545-2	Score
Toxic potential of flue gases	Test method	Not mentioned	NF X 70-100	XX
	Thermal level stress		600 °C	
	Duration of test		20 min	
	Specimen configuration		/	
	Specimen size		30 g	
	Measured parameters		CO, CO ₂ , HCN, SO ₂ , HCl, HBr, HF	
	Ranking Criteria		ITC _{NLP}	
Toxic potential of flue gases	Test method	BSS-7239 ³	ISO 5659-2+FTIR	X
	Thermal level stress	Test procedure of ASTM E 662 can be used	25 kW/m ² , 50 kW/m ² for NF	
	Duration of test		at 4 and 8 min – 20 min	
	Specimen configuration		Horizontal	
	Specimen size		75 mm x 75 mm	
	Measured parameters	CO, HCN, SO ₂ , NO ₂ , HCl, HF	CO, CO ₂ , HCN, SO ₂ , NO _x , HCl, HBr, HF	
	Ranking Criteria	max. concentration for each gas	ITC _G	

³ Note: BSS-7239 is not a requirement of NFPA 130. However, it is often required for vehicles built according to NFPA 130.

Table 4: Cross check of test procedures

Fire technological criteria	Parameter	NFPA 130	EN 45545-2	Score
Toxic potential of flue gases	Test method	BSS-7239 ³	NF X 70-100	X
	Thermal level stress	Test procedure of ASTM E 662 can be used	600 °C	
	Duration of test		20 min	
	Specimen configuration		/	
	Specimen size		30 g	
	Measured parameters	CO, HCN, SO ₂ , NO ₂ , HCl, HF	CO, CO ₂ , HCN, SO ₂ , HCl, HBr, HF	
	Ranking Criteria	max. concentration for each gas	ITC _{NLP}	

2.7 Conclusions

Summarizing the main results, we conclude with the following statements:

- The main safety objectives in both standards are identical.
- All requirements rendered in the NFPA could be allocated to respective requirements in European standard.
- The degree of detail was found different. The requirements are more specific in EN 45545 series.
- The infrastructure has higher requirements in NFPA 130 in order to allow the evacuation of a train at any point whereas the EN 45545 requires the train to keep operable to reach the next access/egress facility to a safe area.
That leads to higher requirements in the EN 45545 for the train.
- NFPA 130 allows direct deviation from specified material characteristics by adequate analysis. EN 45545 standard series does not offer such an “escape clause”. In Europe, this alternative is only given by regulation.
- The comparison of booth standards has shown that goals, methods and requirements are at the same level of exigency.
- The requirements for the materials and the fire resistance and smoke production of components are at the same level of exigency. There are no requirements on smoke toxicity in the NFPA 130 whereas the EN 45545 has high requirements on smoke toxicity.

Table 5 European requirements to be fulfilled to reach the safety level required in NFPA 130

Requirement in NFPA130	Fulfilment of the requirement European Standard
Burning behaviour	EN 45545-2: HL1 ⁴ the exposed surface of parts without proven burning behaviour shall not be greater than 100 cm ² ⁵
Clearance / Creepage	EN 45545-5: fulfilment of EN 50124
Minimum Wire Size	EN 45545-5: fulfilment of EN 50343
Cable and Wires	EN 45545-5: fulfilment of EN 50155 Conductor size: see minimum wire size

⁴ Operating conditions in NFPA 130: Direct stop of the train in an event of fire and full evacuation inside the infrastructure wherever the train stops.

This corresponds with OC 1 in EN 45545-1 for the train which leads to HL1 for EN 45545-2.

⁵ The adherence of grouping rules according to EN 45545-2 will not be verified with installation in the vehicle. The limits for surface of NFPA 130 apply.

3 Summary

The verification for Railway-Antennas acc. to NFPA130 using the “engineering analysis option” can be done as described in section 8.2 of NFPA130. The way described in this document is to use corresponding European standards for the applicable requirements of NFPA130 and therefore meeting safety objectives in section 4.2 and 4.3 of NFPA130.

The verification was done regarding the principle of equivalency (section 1.4 NFPA 130).

With fulfilling the following requirements Railway-Antennas mounted in or at railway vehicles fulfil the NFPA130 as this document shows that at least the same safety level is reached:

Table 6 European requirements to be fulfilled

Requirement in NFPA130	Fulfilment of the requirement European Standard
Burning behaviour	EN 45545-2: HL1 the exposed surface of parts without proven burning behaviour shall not be greater 100 cm ²
Clearance / Creepage	EN 45545-5: fulfilment of EN 50124
Minimum Wire Size	EN 45545-5: fulfilment of EN 50343
Cable and Wires	EN 45545-5: fulfilment of EN 50155 Conductor size: see minimum wire size

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