Fire Safety Assessment Test Report

EXTERNAL LAB NAME: TÜV SÜD Rail GmbH

UUT ITEM NUMBER: Q-P-HP-Series

COVER SHEET FOR PAGES: 1 to 15

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INSPECTION REPORT

Fire Safety Assessment according to DIN EN 45545-2

Converters
Q-Series, P-Series and HP-Series

Report-No.: BU88937T, Version 6.0

Scope: 15 pages

Customer:

Bel Power Solutions & Protection

Areál ZŤS 924

01841 Dubnica Nad Vahom

Slovakia

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Revision history

Version	Date	Author	Amended sections	Amendment and reason for amendment
1.0	2016-07-01	Michael Dallmer	All	Initial
2.0	2016-07-04	Michael Dallmer	3.2.2	Editorial changes
3.0	2018-06-08	Michael Dallmer	All	Update Documents, add P- and Q-Series
4.0	2018-07-10	Christian Dettlaff	3.1	Update pictures
5.0	2021-05-10	Christian Dettlaff	All	Update material verification for connector H15-4TE and PCBs, formal changes
6.0	See release date	Christian Dettlaff	All	Documents Table 4 updated

Version 6.0 replaces all previous versions.

Assessors involved in this report

Name	Activity
Christian Dettlaff	Assessment
Kangyi Xu	Review of assessment report

1. Client

Bel PowerSolutions & Protection

Areál ZŤS 924

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2. General

2.1. Contract

The fire safety assessment for the Converters Q-Series, P-Series and HP-Series in version 6.0 was commissioned by the company Bel Power to TÜV SÜD Rail GmbH on 2024-02-12. The assignment included the implementation of new verification documents.

The assessment was carried out in the period from 2024-02-12 to the release of this inspection report by inspection of the documents provided by the client Bel Power or its subcontractors.

The expert involved is an employee of TÜV SÜD Rail GmbH and is not instructed by the preparation of the inspection report.

2.2. Standards

This document deals with the assessment of the Bel Power Converters Q-Series, P-Series and HP-Series in respect to compliance with the fire safety requirements according to the following acknowledged rules of technology:

Table 1: Standards

No.	Standard	Title
[R01]	DIN EN 45545-1: 2013-08 *)	Railway applications – Fire protection on rail vehicles – Part 1: General
[R02]	DIN EN 45545-2: 2016-02 *)	Railway applications – Fire protection on rail vehicles – Part 2: Requirements for fire behaviour of material and components
[R03]	DIN EN 45545-2: 2020-10	Railway applications – Fire protection on rail vehicles – Part 2: Requirements for fire behaviour of material and components
[R04]	DIN EN 45545-2: 2023-12	Railway applications – Fire protection on rail vehicles – Part 2: Requirements for fire behaviour of material and components

*) This standard is part of the accreditation D-IS-11190-01-00

2.3. Abbreviations

Table 2: Abbreviations

Abbreviation	Definition
HL	Hazard Level
LOC&PAS	Locomotives and passenger rolling stock
max.	Maximum
min.	Minimum
N/A	Not Applicable
OC	Operation category
OI	Oxygen Index
PCB	Printed circuit board
TSI	Technical specification for interoperability

2.4. 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 by the DAkkS according to DIN EN ISO/IEC 17020:2012 as a Type A inspection body. The accreditation is only valid for the scope of accreditation listed in the document annex D-IS-11190-01-00.

3. Documents

Table 4: Documents

ID	Document	Author	Doc./File ID	Date	Rev.
[D1]	HP Series Data Sheet 120-192 Watt 10:1 DC-DC Converters	Bel Power	BCD.00316	2023-06-21	AR
[D2]	P Series Data Sheet 90 – 192 Watt DC-DC Converters	Bel Power	BCD20010-G	2021-05-10	AR
[D3]	Q Series Data Sheet 66 – 132 Watt DC-DC Converters	Bel Power	BCD20011-G	2020-10-28	AM
[D4]	BEL PS - P Burnable Material - BP1001-9RK	Bel Power	BEL PS - P Burnable Material - BP1001-9RK.XLS	2021-05-10	–
[D5]	EP3020-9RG BEL PS Rail PSU related specification of materials	Bel Power	BEL PS - P Burnable Material - EP3020-9RG.XLS	2021-05-10	–
[D6]	BQ1001-9RG Specification of combustible material	Bel Power	BQ1001-9RG_Combustible_material.xlsx	2021-05-10	–
[D7]	HP4660 - burnable material - 03	Bel Power	HP4660 - burnable material - 03.xlsx	2021-05-10	–
[D8]	Fire & Smoke Test Report XEE.01106.0	Bel Power	CR-002062	2021-08-21	01
		RST	P60-21-0423	2021-07-26	–
[D9]	Fire & Smoke Test Report PCB material ZGN.00523.3	Bel Power	CR-000038	2020-01-30	01
		RST	P60-20-0055	2020-01-17	–
[D10]	Fire & Smoke Test Report PCB material ZGX.FXX01.0: S1000-2M (SHENGYI) FR4 + PSR-2000 (TAIYO) SOLDER MASK + AVR80B CONFORMAL COATING	Bel Power	CR-001451	2021-04-01	01
		RST	P60-21-5519	2021-03-10	–
		RST	P60-21-0154	2021-03-10	–
		Crepim	2904/91/060C	2021-03-25	–
[D11]	Fire & Smoke Test Report PCB material ZGX.FXX01.0: PCL370HR (ISOLA) FR4; ELPEMER-2467 (PETERS) SOLDER MASK + AVR80B CONFORMAL COATING	Bel Power	CR-001453	2021-04-01	01
		RST	P60-21-5520	2021-03-10	–
		RST	P60-21-0155	2021-03-10	–
		Crepim	2904/91/060B	2021-03-25	–
[D12]	Fire & Smoke Test Report PCB material ZGX.FXX01.0: S1000-H (SHENGYI) FR4 + PSR-2000 (TAIYO) SOLDER MASK + AVR80B CONFORMAL COATING	Bel Power	CR-001475	2021-04-01	01
		RST	P60-21-5521	2021-03-10	–
		RST	P60-21-0156	2021-03-10	–
		Crepim	2904/91/060D	2021-03-25	–
[D13]	Fire & Smoke Test Report PCB material	Bel Power	CR-001476	2021-04-01	01

Table 4: Documents

ID	Document	Author	Doc./File ID	Date	Rev.
	ZGX.FXX01.0: S1000-2M (SHENGYI) FR4 + H-9100GH40 (RONGDA) SOLDER MASK + AVR80B CONFORMAL COATING	RST	P60-21-5522	2021-03-10	–
		RST	P60-21-0157	2021-03-10	–
		Crepim	2904/91/060A	2021-03-25	–
[D14]	Fire & Smoke Test Report PCB material ZGX.FXX01.0: S1151G (SHENGYI) FR4 + PSR-4000 (TAIYO) SOLDER MASK + AVR80B CONFORMAL COATING	Bel Power	CR-001580	2021-04-28	01
		RST	P60-21-5527	2021-03-16	–
		RST	P60-21-0185	2021-03-17	–
		Crepim	2904/92/081A	2021-04-16	–
[D15]	Fire & Smoke Test Report PCB material ZGX.FXX01.0: NY3150HC (NANYA) FR4 + PSR-4000 (TAIYO) SOLDER MASK + AVR80B CONFORMAL COATING	Bel Power	CR-001602	2021-04-28	01
		RST	P60-21-5528	2021-03-16	–
		RST	P60-21-0186	2021-03-17	–
		Crepim	2904/92/081B	2021-04-16	–
[D16]	Test Report Material LCP E130i – Connector H15-4TE ZES.00312	Bel Power	CR004423	2023-06-14	001
		CZ testing	0064-23-F	2023-06-14	01

4. Equipment under inspection

4.1. Description of equipment

The Converters Q-Series, P-Series and HP-Series was developed for application in rolling stock.

Bel Power develops and produces DC-DC and AC-DC converters in various series. Following series are considered under this assessment:

- Q-Series (Models beginning with BQ, CQ, DQ, EQ, GQ)
- HP-Series (Models beginning with HP)
- P-Series (Models beginning with BP, CP, DP, EP, GP)

The DC-DC converters of the above-mentioned series are constructed similar with use of identical materials. They consist of a coated metallic housing, internal PCBs with electronic components and connectors.



Fig. 1: DC-DC Converter Q-Series [D3]



Fig. 2: DC-DC Converter P-Series [D2]



Fig. 3: DC-DC Converter HP-Series [D1]



Fig. 4: Installation examples (plate, rail, panel)

4.2. Electrical Data

Table 5: Converters Q-Series, P-Series and HP-Series - Electrical data

No	Series	Input Voltage	Nom. Power	Fuse
1	Q Series	16-36, 21.6-54, 33.6-75, 43-100.8, 66-137.5 VDC	66-132 W	Internal input fuse
2	P Series	16-36, 21.6-54, 33.6-75, 40-90, 67.2-137.5 VDC	90-192 W	Internal input fuse
3	HP Series	16.8-137.5 VDC	120-192 W	External fuse

4.3. Installation Conditions

The Converters Q-Series, P-Series and HP-Series are intended for installation in technical compartments. They are not regularly accessible for passengers or staff during operation.

5. Conformity assessment acc. to DIN EN 45545

5.1. Classification according to DIN EN 45545-1

The Converters Q-Series, P-Series and HP-Series are to be used in vehicles of all design categories and for operation in all environments corresponding to operation categories 1 to 4.

The safety objectives according to DIN EN 45545-1, Section 4.2 "Fire resulting from accidental ignition or arson", Section 4.3 "Fires caused by technical defects" as well as Section 4.4 "Fire resulting from larger ignition models than those described in 4.2 and 4.3" have been incorporated in the assessment in a risk-oriented approach.

Section 4.2 refers to typical ignition models involving newspaper, matches, cigarettes and gas lighters. Those will be taken into consideration for any areas that are freely accessible to passengers and staff (ignition models 1 and 2 in accordance with Annex A, DIN EN 45545-1). According to the intended installation conditions in 4.3 of this report, the access for passengers is regularly not intended. Hence this ignition model has not been considered in the following assessment.

Section 4.3 refers to ignition models comparable to electrical arcing or overheating and the spread of fire by any potentially flammable gases and liquids present (ignition models 3 and 4 in accordance with Annex A, DIN EN 45545-1).

Section 4.4 refers to larger ignition models (model 5 in accordance with Annex A, DIN EN 45545-1) than those defined in sections 4.2 and 4.3 of DIN EN 45545-1. The assessment of this ignition model was made with focus on the material selection and the intended installation conditions.

According to section 8, the proof of conformity must be provided for the defined fire protection requirements. Proof of conformity for the fire behaviour of materials and/or components can be provided in the form of test reports or certificates.

- Test reports must be issued by testing laboratories that are accredited for the respective tests according to EN ISO/IEC 17025.
- Certificates must be issued by certification bodies, which are accredited for the respective testing or classification standards according to EN ISO/IEC 17065.

Annex ZA of DIN EN 45545-2 presents the correlation between DIN EN 45545-2 and Interoperability Directive (EU) 2016/797 as well as the TSI LOC&PAS (Regulation (EU) No. 1302/2014). For a vehicle approval according to the TSI LOC&PAS, test reports or certificates, with a maximum validity of 5 years from the date of issue, must be submitted.

For test reports or certificates with an issue date older than 5 years, the verification can alternatively be issued by a corresponding manufacturer's declaration according to section 4.2.10.2.1 of TSI LOC&PAS, paragraph 3 in connection with the application guideline for the TSI LOC&PAS (GUI/LOC&PAS TSI/2021) in addition to the present test report or certificate.

5.2. Assessment according to DIN EN 45545-2

5.2.1. Requirements

Based on the classification according to DIN EN 45545-1, the materials / components shall meet the requirements of Hazard Level 3 (HL3). The components are to be regarded as electrotechnical equipment covered by the DIN EN 45545-2 standard. Generally, the requirement sets are listed in section 4.4 "Listed products". The applicable requirements are the following:

Table 6: Requirement sets DIN EN 45545-2

No.	Name	Details	Requirement
IN1E	External surfaces of enclosures containing technical equipment	Enclosures which are located inside the body shell and directly attached to passenger or staff area	R1 ISO 5658-2 CFE ≥ 20 kWm^{-2} ISO 5660-1: 50 kWm^{-2} MARHE ≤ 60 kWm^{-2} ISO 5659-2: 50 kWm^{-2} D_S (4) ≤ 150 VOF_4 ≤ 300 CIT_G ≤ 0.75 [R02] EN 17084: 50 kWm^{-2} CIT_G ≤ 0.75 [R03] [R04]
EL9	Printed circuit boards	Printed circuit boards with all applied coatings but without any attached technical equipment	R26 [R03] [R04] EN 60695-11-10 Classification = V0 or R25 EN 60695-2-11 Glow Wire 850 °C or R24 ISO 4589-2 OI ≥ 32%
EL10	Small electrotechnical products	All electrotechnical equipment, including protection against contact and similar	R26 EN 60695-11-10 Classification = V0

In addition to the requirements of listed products, the grouping rules according to section 4.3 for components with low combustible mass and/ or surfaces are applicable.

No requirements apply to products with a combustible mass of < 10 g not in touching contact with another unclassified product (DIN EN 45545-2 section 4.3.1).

Table 7: Grouping rule 1

No.	Section	Requirement	Remark
1-1	4.3.2. Grouping rule 1 Products without requirements	< 100 g for interior grouped products	No requirements
1-2		< 400 g for exterior grouped products	No requirements

Table 8: Grouping rule 2

No.	Section	Requirement	Remark
2-1	4.3.3. Grouping rule 2 Products tested according to R24	< 500 g for interior grouped products tested according to R24	Proof R24 Oxygen index
2-2		< 2000 g for exterior grouped products tested according to R24	Proof R24 Oxygen index

The following general rules shall be considered:

Table 9: General requirements EN45545-2

Section	Requirement	Remark
4.2. a) General	Products which comply with the highest level of reaction to fire performance and therefore need no further testing are - products classified as A1 according to EN 13501-1 - all products described in commission decision 96/603/EC (as amended)	–
4.2. l) [R02] 4.2. k) [R03] [R04] Coatings	EN 45545-2:2016: for products which are classified in Table 2 as IN2, IN3A, IN3B, IN10, IN11, EX1C, EX5, EX6A, EX6B, EX8, EX11, or EL2, where surfaces have organic coatings applied on metal or glass surfaces, ISO 5658-2 or EN ISO 9239-1 flame spread tests shall be carried out, but other test requirements such as heat release, smoke emission and toxic gas emission tests are not required if the nominal coating thickness, including any surfacing filler for exterior products is < 0.3 mm, or for interior products the nominal thickness of organic coating is < 0.15 mm; EN 45545-2:2020/ EN 45545-2:2023: for organic coatings applied to products conforming to 4.2 a), ISO 5658-2 or EN ISO 9239-1 flame spread tests shall be carried out, but other test requirements such as heat release, smoke emission and toxic gas emission tests are not required if the nominal coating thickness, including any surfacing filler for exterior products is < 0,3 mm, or for interior products the nominal thickness of organic coating is < 0,15 mm;	Can also be applied to non-listed products.
4.2. n) [R02] 4.2. m) [R03] [R04]	If listed products are used in an application below the mass and area thresholds given in 4.3, they may be treated as non-listed products.	–
4.5 non-listed products	Any product not listed in EN 45545-2 Table 2 shall be considered as a non-listed product or shall be assessed using the grouping rules stipulated in EN 45545-2 section 4.3. The requirements of non-listed products are the following: > 0.2 m² R1 (interior), R7 (exterior) ≤ 0.2 m² R22 (interior), R23 (exterior)	This requirement can also be applied to products that cannot be tested according to the requirements for listed products, provided that the exposed area is < 0.2 m².
4.7 Products to be approved on functional necessity	If it can be shown that any of the requirements specified above are not technically achievable with functionally suitable products, then existing	–

Table 9: General requirements EN45545-2

Section	Requirement	Remark
	commercially available products can be used until and unless a suitable product is developed. There shall be no requirement to consider products made available after the date after the date of the contract.	
5.3.6 [R02] 5.3.7 [R03] [R04] Fire integrity test	There shall not be more than one hole after the test T03.01. or T03.02. This hole shall have no dimension in the plane of the test piece greater than 3 mm. Alternatively, the material fulfils the requirements of Conventional Classified Products acc. to EN 45545-3. Those products are considered to meet the integrity requirements.	Materials that are fully separated with those products shall be grouped separately.

5.2.2. Material verification

The combustible materials are listed in the material lists [D4], [D5], [D6] and [D7]. The housing is made from powder coated metal.

According to the available documentation the combustible material required to be verified by test are coating, PCBs and electrotechnical parts. The relevant requirements according to DIN EN 45545-2 as well as the test results are listed in Table 10. All other combustible materials have a combustible mass of less than 10 g with no touching contact with any other unclassified material and are therefore not required for verification by test.

Table 10: Listing of material testing

Material	Requirement	Result	Certificate	HL
EL9 – PCB:	*R25 / R24 (R26)*			
PCB material ZGN.00523.3		fulfilled	[D9]	HL3
PCB S1000-2M		fulfilled	[D10]	HL3
PCB PCL370HR		fulfilled	[D11]	HL3
PCB S1000-H		fulfilled	[D12]	HL3
PCB S1000-2M		fulfilled	[D13]	HL3
PCB S1151G		fulfilled	[D14]	HL3
PCB NY3150HC		fulfilled	[D15]	HL3
Component acc. 4.3.3: Connector H15-4TE	*R24*	fulfilled	[D16]	HL3
4.2 l) / 4.2 k) – Coating for housing: XEE.01106.0 – Durpol epoxide 6L	*R1 (T02 (CFE < 20kW/m²))*	fulfilled	[D8]	HL3

Material treated according to the grouping rules > 10 g but < 100 g:

- None

The combustible materials used for the Converters Q-Series, P-Series and HP-Series fulfil the requirements according to DIN EN 45545-2 for HL3.

6. Plausibility check of the ignition sources

6.1. Fire development starting from the component

The maximum power is limited to < 200 W (see table 5). The theoretical ignition potential in the event of a failure, irrespective of the technical cause, is below the relevant ignition model 4 (max. 1 kW over 30 seconds) in accordance with Annex A, DIN EN 45545-1. Due to the small amount of combustible mass, the predominantly qualified materials and the low electrical power, ignition and fire development in the event of an electrical failure are sufficiently prevented from "fire caused by technical defects", in accordance with DIN EN 45545-1, Chapter 4.3. In addition, the metal housing protects against further fire spread in the unlikely event of ignition.

6.2. Fire involvement of the component by external ignition source

An external fire event, starting from a vandalism or technique fire, can affect the materials with thermal radiation (ignition models 2 and 3 according to Annex A, DIN EN 45545-1) and additionally with direct flame or arc action (see ignition models 1 and 4 according to Annex A, DIN EN 45545-1) and involve them in the fire. The materials have been qualified in terms of ignition prevention at low ignition power, which does not completely prevent fire involvement in major fire events. The component housing is made of non-combustible material and the combustible mass of the component is very low, which greatly limits the promotion of fire spread.

7. Summary

The assessments result is that the Converters Q-Series, P-Series and HP-Series meets the requirements of the listed acknowledged codes of practice:

- DIN EN 45545-2:2016 hazard levels HL1 to HL3
- DIN EN 45545-2:2020 hazard levels HL1 to HL3
- DIN EN 45545-2:2023 hazard levels HL1 to HL3

No Groupings to be considered for installation in the vehicles (see section 5.2.2).

For regular intended operation the required level of safety for passengers and staff is ensured.

The assessment is based on documents provided by the customer (see table 4). At the time of the inspection and based on the test reports provided, the validity of the fire protection technical verification within the framework of EC conformity test procedures is confirmed until 2025-01-16 [D9].

This inspection is also valid for any other Converters of the evaluated types as long as Bel Power confirms with manufacturer declaration that the material used did not change and the mass and surface of the material treated according to grouping rules (see section 5.2.2) is not higher than for the inspected items.

This inspection report was written under the specified accreditation without influence of third party.

TÜV SÜD Rail GmbH, Unit Rolling Stock

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