Fire Safety Assessment Test Report

EXTERNAL LAB NAME: TÜV SÜD Rail GmbH

UUT ITEM NUMBER: Q-Series, P-Series, HP-Series

COVER SHEET FOR PAGES: 1 to 14

Opening date:	18-Mar-2021	**Created by:**	Ivan Vavrík
Approval date:	14-May-2021	**Approved by:**	Marián Hostačný
Design Location:	DCA, Slovakia	**Test Location:**	TÜV SÜD Rail GmbH, Germany

Rail

INSPECTION REPORT

Fire Safety Assessment according to EN 45545-2

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

Report-No.: BU88937T, Version 5.0

Report Date: 2021-05-10, Scope 14 pages

Customer:

Bel Power Solutions & Protection

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Order Date: 2021-04-16

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Rail

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Revision history

Version	Status	Date	Author	Modified clauses	Modifications
1.0	Withdrawn	2016-07-01	Michael Dallmer	All	Initial
2.0	Withdrawn	2016-07-04	Michael Dallmer	3.2.2	Editorial changes
3.0	Withdrawn	2018-06-08	Michael Dallmer	All	Update Documents, add P- and Q-Series
4.0	Withdrawn	2018-07-10	Christian Dettlaff	3.1	Update pictures
5.0	Final	2021-05-10	Christian Dettlaff	All	Update material verification for connector H15-4TE and PCBs, formal changes

1. General

1.1. 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 (accredited according to 2013-08)
[R03]	STM-S-001 2014	SNCF/RATP: COMPORTEMENT AU FEU - CHOIX DES MATERIAUX (This document specifies the implementation by S.N.C.F. and R.A.T.P. companies of standard NF EN45545.)

1.2. Abbreviations

Table 2: Abbreviations

Abbreviation	Definition
HL	Hazard Level
max.	Maximum
min.	Minimum
N/A	Not Applicable
OI	Oxygen Index
PCB	Printed circuit board

1.3. 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

Table 3: Management System

[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.

2. 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	2020-12-14	AP
[D2]	P Series Data Sheet 90 – 194 Watt DC-DC Converters	Bel Power	BCD20010-G	2019-08-19	AP
[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]	SPREAD of FLAME TEST REPORT EXTERNAL LAB NAME: TGM TECHNOLOGISCHES GEWERBE MUSEUM, VIENNA UUT MODEL NUMBER: N/A (110RCM150-24DMQF) COVER SHEET FOR PAGES: 1 to 5	Bel Power	TR000999	---	01
		tmg	VA KU 27 075/E	2017-04-25	---
[D9]	Fire & Smoke Test Report EXTERNAL LAB NAME: RTS Rail System Testing GmbH, Hennigsdorf UUT ITEM NUMBER: PCB material ZGN.00523.3 COVER SHEET FOR PAGES: 1 to 5	Bel Power	CR-000038	2020-01-30	01
		RST	P60-20-0055	2020-01-17	---
[D10]	Fire & Smoke Test Report EXTERNAL LAB NAME: RTS Rail System Testing GmbH, Hennigsdorf UUT ITEM NUMBER: PCB material ZGX.FXX01.0: S1000-2M (SHENGYI) FR4 + PSR-2000 (TAIYO) SOLDER MASK + AVR80B CONFORMAL COATING COVER SHEET FOR PAGES: 1 to 13	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	---

Table 4: Documents

[D11]	Fire & Smoke Test Report EXTERNAL LAB NAME: RTS Rail System Testing GmbH, Hennigsdorf UUT ITEM NUMBER: PCB material ZGX.FXX01.0: PCL370HR (ISOLA) FR4; ELPEMER-2467 (PETERS) SOLDER MASK + AVR80B CONFORMAL COATING COVER SHEET FOR PAGES: 1 to 13	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 EXTERNAL LAB NAME: RTS Rail System Testing GmbH, Hennigsdorf UUT ITEM NUMBER: PCB material ZGX.FXX01.0: S1000-H (SHENGYI) FR4 + PSR-2000 (TAIYO) SOLDER MASK + AVR80B CONFORMAL COATING COVER SHEET FOR PAGES: 1 to 13	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 EXTERNAL LAB NAME: RTS Rail System Testing GmbH, Hennigsdorf UUT ITEM NUMBER: PCB material ZGX.FXX01.0: S1000-2M (SHENGYI) FR4 + H-9100GH40 (RONGDA) SOLDER MASK + AVR80B CONFORMAL COATING COVER SHEET FOR PAGES: 1 to 13	Bel Power	CR-001476	2021-04-01	01
		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 EXTERNAL LAB NAME: RTS Rail System Testing GmbH, Hennigsdorf UUT ITEM NUMBER: PCB material ZGX.FXX01.0: S1151G (SHENGYI) FR4 + PSR-4000 (TAIYO) SOLDER MASK + AVR80B CONFORMAL COATING COVER SHEET FOR PAGES: 1 to 13	Bel Power	CR-001580	2021-04-28	01
		RST	P60-21-5527	2021-03-16	---
		RST	P60-21-0185	2021-03-16	---
		Crepim	2904/92/081A	2021-04-16	---
[D15]	Fire & Smoke Test Report EXTERNAL LAB NAME: RTS Rail System Testing GmbH, Hennigsdorf UUT ITEM NUMBER: PCB material ZGX.FXX01.0: NY3150HC (NANYA) FR4 + PSR-4000 (TAIYO) SOLDER MASK + AVR80B CONFORMAL COATING COVER SHEET FOR PAGES: 1 to 13	Bel Power	CR-001580	2021-04-28	01
		RST	P60-21-5528	2021-03-16	---
		RST	P60-21-0186	2021-03-16	---
		Crepim	2904/92/081B	2021-04-16	---
[D16]	Test Report Material LCP E130i – Connector H15-4TE ZES.00312	Bel Power	TR001882	2018-03-27	01
		OFI	1800160-1	2018-03-27	---
		OFI	1800160-2	2018-03-27	---
		OFI	1800160-3	2018-03-27	---

3. Equipment under inspection

3.1. Description of equipment

Bel Power Solutions (former Power One) 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 PCB's with electronic components and connectors.

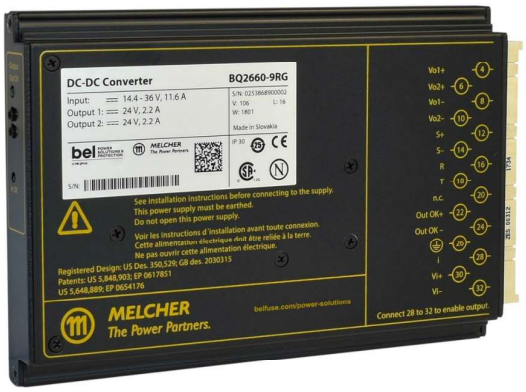

Fig. 1: DC-DC Converter Q-Series

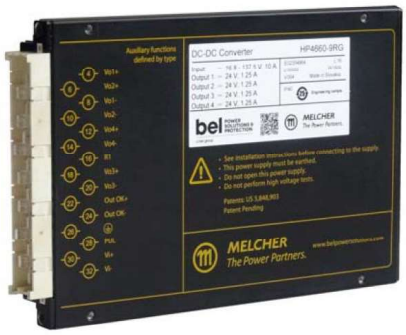

Fig. 2: DC-DC Converter P-Series

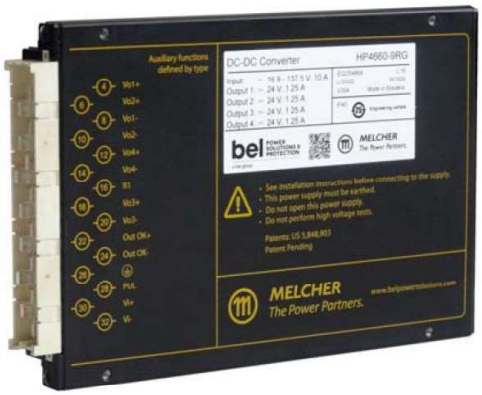

Fig. 3: DC-DC Converter HP-Series

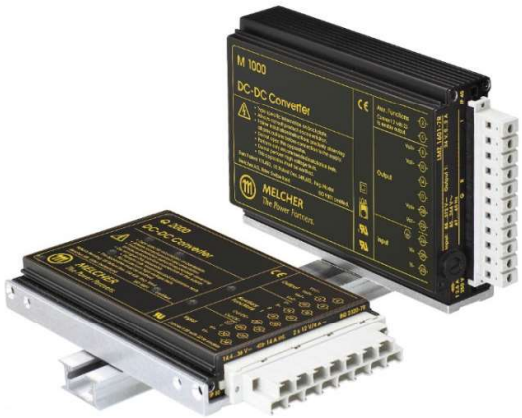

Fig. 4: Installation examples (plate, rail)

Connection cables of the vehicle wiring or brackets for mounting are not part of this assessment.

3.2. Electrical Data

Table 5: Electrical Data

Series	Input Voltages	Nom. Power	Fuse
Q Series	16-36, 21.6-54, 33.6-75, 43-100.8, 66-137.5 VDC	66-132 W	Internal input fuse
P Series	16-36, 21.6-54, 33.6-75, 40-90, 67.2-137.5 VDC	90-194 W	Internal input fuse
HP Series	16.8-137.5 VDC	120-192 W	External fuse

3.3. Installation Conditions

The Converters Q-Series, P-Series and HP-Series are intended for use in technical compartments. They are not accessible for passengers.

4. Conformity assessment acc. to EN 45545

4.1. Classification according to EN 45545-1

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

The safety objectives according to 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, EN 45545-1). According to the intended installation conditions in 3.3 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, EN 45545-1).

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

4.2. Assessment

4.2.1. Requirements of EN 45545-2

Based on the classification according to 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 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

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

Table 6: Requirement sets

No.	Name	Details	Requirement
EL9	Printed circuit boards	Printed circuit boards without any attached technical equipment	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 (EN 45545-2 section 4.3.1).

Table 7: Grouping rule1

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 rule2

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 EN 45545-2

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. i) Coatings	all coating systems shall be tested in end use condition. This means inclusion of levelling fillers at a thickness estimated at mean end use application, primers and finish coatings with specified coating thickness and number of layers;	Coated products

Table 9: general requirements EN 45545-2

Section	Requirement	Remark
4.2. l) Coatings	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;	Can also be applied to non-listed products.
4.2. n)	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 any product that cannot be tested according to the requirements of listed products such as EL10-parts not made of plastic
5.3.6 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.

4.2.2. Requirements of STM-S-001

STM-S-001 defines rules for the application of EN 45545-2 at SNCF. The relevant parts are listed below:

Table 10: Requirement sets

No.	Name	Details	Requirement
EL9	Printed circuit boards	Printed circuit boards without any attached technical equipment. With varnish saving and finishing or topicalization identical to the conditions of use.	R25 completed by an CIT test defined in the requirement R22: The optional R24 requirement in the published version of EN 45545 is not retained

Table 10: Requirement sets

No.	Name	Details	Requirement
EL10	Small electrotechnical products	This type of components only exists on circuits, low power (<20Kw) Examples: low-power micro-circuit breakers, contactors, all types of relays and their bases, limit switches, sensors, inverters, control or signalling switches, terminals and terminal blocks, fuses, connectors, pushbuttons, LEDs, electrical outlets, telephone handsets and their supports, loudspeakers	See text for products EL10

Since plugs are not covered by the description for small electrotechnical products, they must be treated as non-listed parts.

Test reports are not to be older than 5 years.

Note on the EL10 products:

The small electrotechnical products identified as EL10 table 2 of EN 45545-2 will be treated according to the rules of non-listed products of Chapter 4.3 and 4.5 (in this same part 2). It is indeed necessary to ensure that their surface, their cumulative and unit mass are not likely to compromise the essential requirements in Chapter 4.1. The latter, referred also to part 1 of the same standard, specifies the measures to protect the passengers and the train crew and in particular the measures outlined in § 1 Scope to "minimize the fire effects in terms of heat, smoke and toxic gases on the passengers and the train crew by the specifications of the materials installed in the railway vehicles (Part 2)";

The requirement R26 not giving rise to any smoke control in terms of opacity or toxicity and whatever the fuel mass product, it cannot be considered in all its applications to comply with the essential requirement of the standard referred to above.

For the small electrotechnical products, identified as EL 10 that refer only to the R26 requirements, the demonstration of the product compliance in real conditions of use, would be required based on the rules of Chapters 4.3 and 4.5 (EN 45545-2) to ensure that this product in its environment allows the achievement of the essential requirements described above. For example, the compliance with the R22 requirement allows the satisfaction of the "smoke" criterion.

4.2.3. Material verification

The combustible materials are listed in the material lists [D4] to [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 EN 45545-2 as well as the test results are listed in Table 11.

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 11: Listing of material testing

Material	Requirement	Result	Certificate	HL
Component acc. 4.3.2: • Connector H15-4TE	R24	fulfilled	[D16]	HL3
Plugs (only for STM-S-001): • Connector H15-4TE ZES.00312 – LCP 130iE	R22	fulfilled	[D16]	HL3
EL9 – PCB: • PCB material ZGN.00523.3 • PCB S1000-2M • PCB PCL370HR • PCB S1000-H • PCB S1000-2M • PCB S1151G • PCB NY3150HC	 R25, R24 R25, R24 R25, R24 R25, R24 R25, R24 R25, R24 R25, R24	 fulfilled fulfilled fulfilled fulfilled fulfilled fulfilled fulfilled	 [D9] [D10] [D11] [D12] [D13] [D14] [D15]	 HL3 HL3 HL3 HL3 HL3 HL3 HL3
PCB (only for STM-S-001): • PCB S1000-2M • PCB PCL370HR • PCB S1000H • PCB S1000-2M • PCB S1151G • PCB NY3150HC	 ITC of R22 ITC of R22 ITC of R22 ITC of R22 ITC of R22 ITC of R22	 fulfilled fulfilled fulfilled fulfilled fulfilled fulfilled	 [D10] [D11] [D12] [D13] [D14] [D15]	 HL3 HL3 HL3 HL3 HL3 HL3
Coating for housing: • Durpol epoxide 6L	 T02 (CFE < 20kW/m²)[1]	 fulfilled	 [D8]	 HL3

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

- None

EL10 according to STM-S-001:

The small electrotechnical products (apart from plugs) are placed inside a closed metal housing with a total combustible mass of less than 50 g. Here the basic requirements of EN 45545-2 chapter 4.1 are not compromised without prove of opacity and toxicity of combustion products. In this case STM-S-001 is fulfilled for EL10 with the prove of R26 only.

The combustible materials used for the Converters Q-Series, P-Series and HP-Series fulfil the requirements according to EN 45545-2 for HL3 and STM-S-001.

[1] EL10: R26 not applicable to coated metal → acc. to 4.5: R1 is applicable requirement set; with 4.2. l) T02 is sufficient for prove of conformity

5. Fire risk analysis

A) Ignition and spread of fire starting from device – material and failure analysis for the ignition source

The maximum-failure power is limited to 500 W by internal/ external fuse. Due to the small amount of combustible mass and the small electrical power, an ignition in case of an electric failure of the component is improbable. The severity of such fire incident is insignificant due to the closed metallic housing as the fire could not spread.

B) Fire inclusion of devices due to external/neighbouring fire – material and constrictive analysis

The enclosure is non-combustible. The combustible mass is very limited and with validated fire performance. Thus, the materials will not considerably add to an external fire and the flame spread is limited.

Rail

6. Summary

The assessments result is that the Converters Q-Series, P-Series and HP-Series meet the requirements of the listed acknowledged rule of technology:

- EN 45545-2 hazard levels HL1 to HL3
- STM-S-001

Groupings to be considered for installation in the vehicles (see section 4.2.3):

- None

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 documents table).

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

TÜV SÜD Rail GmbH

Dresden, 2021-05-10

TR-RS3 / Lead Fire Safety

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Inspector

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