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Fire Safety Assessment Test Report

EXTERNAL LAB NAME: TÜV SÜD Rail GmbH

UUT ITEM NUMBER: M Series AC/DC and DC/DC Converter

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INSPECTION REPORT
Fire Safety Assessment according to
EN 45545-2

AC/DC and DC/DC Converter
M Series

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Rail

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Revision history

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0.1	Draft	2019-08-15	Dirk Fischer	All	Initial
1.0	Final	2019-08-29	Dirk Fischer	---	review comments
2.0	Final	2019-09-16	Dirk Fischer	---I	customer comments

1. General

1.1. Standards

This document deals with the assessment of the Bel Power AC/DC and DC/DC Converter M 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

1.2. 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

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
[M2]	D-IS-11190-01-00	Accreditation according to DIN EN ISO/IEC 17020:2012 as a Type A inspection body

2. Documents

Table 4: Documents

ID	Document	Doc./File ID	Author	Rev.	Date
[D1]	M Series Data Sheet	BCD20018-G	Bel Power	AE1	2018-04-16
[D2]	Material List Burnable_components_BM1601-9R	Burnable_components_BM1601-9R_14.8.2019.xls	Bel Power	-	2019-08-14
[D3]	Material List Burnable_components_CM3020-9	Burnable_components_CM3020-9_14.8.2019.xls	Bel Power	-	2019-08-14
[D4]	Material List Burnable_components_DM2320-9	Burnable_components_DM2320-9_14.8.2019.xls	Bel Power	-	2019-08-14
[D5]	Material List Burnable_components_LM1601-9ER	Burnable_components_LM1601-9ER_14.8.2019.xls	Bel Power	-	2019-08-14
[D6]	Material List Combustible_components_Crossreference table	Combustible_components_Crossreference table.xls	Bel Power	-	2019-08-22
[D7]	UL Certification (Crastin®) SK645FR (f2)	E41938	UL	-	2014-03-12
[D8]	Drawing Insulation; Case insulation Foil M; MYLAR A; 0.1mm	XKI170Z-G	Bel Power	AA1	2017-11-06
[D9]	Drawing Male Connector H11, EMC Version	XKK 131 Z-G	Power one	AA	2006-03-27
[D10]	Drawing Male Connector H11 EMV version, contact no. 26 leading	ZES 047 Z-G	Power one	AA	2006-04-05
[D11]	Drawing Main board CM-LM MkII and 110H/230H/LH	ZGN 01310 MZ-G	Power one	AA	2006-11-23
[D12]	Drawing PCB CM-LM Mk II Main Board	ZGN013311Z-G	Bel Power	AB	2016-10-24
[D13]	Drawing PCB Secondary Output M 2000 Mk II	ZGN01408Z-G	Bel Power	AA	2017-12-08
[D14]	Drawing PCB Double Output M 3000 Mk II	ZGN01505Z-G	Bel Power	AA	2016-10-21
[D15]	Drawing PCB AM/BM MK II Main Board	ZGN 02610 Z-G	Bel Power	AA	2016-02-17

Table 4: Documents

ID	Document	Doc./File ID	Author	Rev.	Date
[D16]	CAMPUS®Data Sheet Crastin®SK645FR NC010-PBT-GF30 FR(17) DuPont Engineering Polymers	CrastinSK645FRNC010.pdf	DuPont	-	2019-06-04
[D17]	Test Report Circuit board IT-180A	P60-18-0146en	RST	-	2018-03-07
[D18]	Test Report Circuit board S1000H	P60-18-0147en	RST	-	2018-03-07
[D19]	Test Report Circuit board IT-180A	P60-18-5532en	RST	-	2018-03-06
[D20]	Test Report Circuit board S1000H	P60-18-5533en	RST	-	2018-03-06
[D21]	Test Report Circuit board PCL370HR-HI-Tg	P60-18-0259en	RST	-	2018-04-20
[D22]	Test Report Circuit board PCL370HR-HI-Tg	P60-18-5543en	RST	-	2018-04-20
[D23]	Test Report BEL PS AlMg3 or Aluzinc metal sheet coated with powder paint Durpol epoxide 6L	TGM-VA KU 27 075/E	TGM	-	2017-04-25

3. Equipment under inspection

3.1. Description of equipment

The AC/DC and DC/DC Converter M Series was developed for application in rolling stock. It converts voltage for electronic components from 8 to 385 VDC and 85 to 264 VAC input to 5.1 to 60 VDC output.

The enclosure is made of powder coated aluminium plates. Internal components are PCBs with electronic components, conductors and plugs for output and input. LED indicators display the status of the converter and allow visual monitoring of the system. All small electrotechnical components are fixed on the PCB.



The following systems from the M-series (see Fig. 1) are part of the assessment as a reference. The inspected systems have different configurations in detail. The references selected for this fire safety assessment are listed in Table 5.

It is assumed that each of the differently equipped versions of this AC/DC and DC/DC Converter is compliant with the above devices and equipment listed.

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

In accordance with the order, this fire safety assessment deals with the assemblies of AC/DC and DC/DC converter M-Series.

Table 5: AC/DC and DC/DC Converter M Series – equipment

No	Assembly	Description
1	Unit BM1601-9R [D2]	Operation input range V_i : 14 – 70 VDC
2	Unit CM3020-9 [D3]	Operation input range V_i : 28 – 140 VDC
3	Unit DM2320-9 [D4]	Operation input range V_i : 44 – 220 VDC
4	Unit LM1601-9ER [D5]	Operation input range V_i : 88 – 372 VDC, 85 – 264 VAC

Electrical Data:

Table 6: AC/DC and DC/DC Converter M Series – electrical data

No	Assembly	Operation input range	Operation output range	Internal Fuse types
1	Unit BM1601-9R [D2]	14 – 70 VDC	24 VDC	SPT 8 A / 250 V
2	Unit CM3020-9 [D3]	28 – 140 VDC	5.1 VDC	SPT 3.15 A / 250 V
3	Unit DM2320-9 [D4]	44 – 220 VDC	12 VDC	SPT 2.5 A / 250 V
4	Unit LM1601-9ER [D5]	88 – 372 VDC, 85 – 264 VAC	24 VDC	SPT 2.5 A / 250 V

3.2. Installation Conditions

The AC/DC and DC/DC Converter M Series is intended for installation in interior technical compartments. It is not regularly accessible for passengers or staff during operation.

4. Conformity assessment acc. to EN 45545

4.1. Classification according to EN 45545-1

The AC/DC and DC/DC Converter M Series is 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 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 3.2 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 according to EN 45545-2

4.2.1. Requirements

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 7: Requirement sets

No.	Name	Details	Requirement
IN2	Limited surfaces	<ul style="list-style-type: none"> - They shall have an area) $\leq 0,2 \text{ m}^2$ - they shall have a maximum dimension in any direction on the surface $\leq 1 \text{ m}$; - they shall be separated from any other limited surface or strip by a distance of R1 compliant material greater than the dimension of the limited surface, measured in the same horizontal direction as the separation direction. 	R2 ISO 5658-2 $\text{CFE} \geq 13 \text{ kWm}^2$ ISO 5660-1: 50 kWm^2 $\text{MARHE} \leq 90 \text{ kWm}^2$ ISO 5659-2: 50 kWm^2 $D_s(4) \leq 150$ $\text{VOF}_4 \leq 300$ $\text{CIT}_G \leq 0.75$

Table 7: Requirement sets

No.	Name	Details	Requirement
EL9	Printed circuit boards	Printed circuit boards with all applied coatings but 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 8: Grouping rule 1

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

Table 9: 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	R24	< 2000 g for exterior grouped products tested according to R24	Proof R24 Oxygen index

The following general rules shall be considered:

Table 10: 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
4.2. j) Coatings	where a coating (including vinyls, films and their adhesives) is applied to aluminium or steel in the end use condition and where the thickness of the metal is greater than those defined in Table 7 it is sufficient to test the coating on the reference substrate defined in Table 7;	Requirements for reference substrate Table 7: Steel sheet 0.8 mm Aluminium sheet: 1.0 mm

Table 10: General requirements EN 45545-2

Section	Requirement	Remark				
4.2. l)	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;	Reduced Requirements for nominal thickness of organic coating				
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: <table style="margin-left: 40px; border: none;"> <tr> <td style="padding-right: 20px;">$> 0.2 \text{ m}^2$</td> <td>R1 (interior), R7 (exterior)</td> </tr> <tr> <td>$\leq 0.2 \text{ m}^2$</td> <td>R22 (interior), R23 (exterior)</td> </tr> </table>	$> 0.2 \text{ m}^2$	R1 (interior), R7 (exterior)	$\leq 0.2 \text{ m}^2$	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
$> 0.2 \text{ m}^2$	R1 (interior), R7 (exterior)					
$\leq 0.2 \text{ m}^2$	R22 (interior), R23 (exterior)					
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 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 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. Material verification

The combustible materials are listed in the material lists [D2], [D3], [D4], [D5]. The housing is made from powder coated aluminium plates. The exposed surface of the paint is less than 0.2 m^2 according to the dimensions of the housing [D1].

According to the available documentation the combustible material that have been verified by test are PCBs and small electrotechnical products and the case coating. The assessment of the component came to the result that no further combustible materials require verification by test. The relevant requirements according to EN 45545-2 as well as the test results are listed in Table 11.

All other combustible materials can be grouped or 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
Main connector H11, Crastin®SK645FR (ZES047-G)	R26	fulfilled	[D7], [D16]	HL3
PCB, IT-180A, S1000H, PCL370HR-HI-Tg (ZGN02610M-G, ZGN01311G-G, ZGN01311Q-G, ZGN01505Q-G, ZGN01408Q-G)	R25, R24	fulfilled	[D17], [D18], [D19], [D20]	HL3
Case (housing), front panel of unit, panel of connector of unit powder coated aluminium Durpol epoxide 6L (XMG089-G, XMG146-G, XMG091-G, XMG085-G, XMD034-G, XMD026-G, XMD042-G, XME023-G)	R2	fulfilled	[D23]	HL3

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

- none

The combustible materials used for the AC/DC and DC/DC Converter M Series version V107 fulfil the requirements according to EN 45545-2 for HL3.



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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 by an internal fuse, see table 6. 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.

6. Summary

The assessments result is that the AC/DC and DC/DC Converter M Series version V107 meets the requirements of the listed acknowledged rule of technology:

- EN 45545-2 hazard levels HL1 to HL3

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

The assessment is based on documents provided by the costumer (see documents table).

This inspection is also valid for any other AC/DC and DC/DC Converter 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 4.2.2) 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
Dresden, 2019-09-16

TR-RS3 / Lead Fire Safety

Inspector

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