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Fire Safety Assessment Test Report

EXTERNAL LAB NAME: TÜV SÜD Rail GmbH

UUT ITEM NUMBER: LBC Series

COVER SHEET FOR PAGES: 1 to 14

| | | | |
|-------------------------|-------------------|-----------------------|----------------------------|
| Opening date: | 12-July-2023 | Created by: | Vladimír Šimún |
| Approval date: | 09-September-2023 | 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

Battery Charger LBC Series

Report-No.: BD94964G, Version 2.0

Report Date: 2023-09-06, Scope: 14 pages

Customer:

Bel Power Solutions & Protection
Areál ZŽS 924
01841 Dubnica nad Vahom
Slovakia

Order Date: 2023-08-14

Project No.: 717520772 / 717528499

Inspector:

Dipl.-Ing. (FH) Christian Dettlaff
Christian.Dettlaff@tuvsud.com

Inspection body:

TÜV SÜD Rail GmbH
Barthstraße 16
80339 Munich
Germany

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Revision history

| Version | Status | Date | Author | Modified clauses | Modifications |
|---------|-----------|------------|--------------------|------------------|-------------------------------|
| 0.1 | Draft | 2020-03-27 | Christian Dettlaff | --- | --- |
| 1.0 | Withdrawn | 2020-05-28 | Christian Dettlaff | All | Initial |
| 2.0 | Released | 2023-09-04 | Christian Dettlaff | All | Update verification documents |

1. Client

Bel PowerSolutions & Protection
 Areál ZŽS 924
 01841 Dubnica nad Vahom
 Slovakia

2. General

2.1. Contract

The fire safety assessment for the Bel Power Battery Charger LBC Series in version 2.0 was commissioned by the company Bel Power to TÜV SÜD Rail GmbH on 2023-08-14. The assignment included the implementation of new verification documents.

The assessment was carried out in the period from 2023-08-14 to 2023-09-04 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 Battery Charger LBC 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] | EN 45545-1: 2013-08 *) | Railway applications – Fire protection on rail vehicles – Part 1: General |
| [R02] | EN 45545-2: 2016-02*) | Railway applications – Fire protection on rail vehicles – Part 2: Requirements for fire behaviour of material and components |
| [R03] | EN 45545-2: 2020-10 | 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 |



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Table 2: Abbreviations

| Abbreviation | Definition |
|--------------|--|
| 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 | Title | Author | Doc./File ID | Date | Rev. |
|-------|---|-----------|--|------------|------|
| [D1] | LBC Series 3-phase PSU / Battery Charger | Bel Power | BCD.00821 | 2021 | AM |
| [D2] | BURNABLE MATERIALS | Bel Power | TXP4000-1110G | 2016-08-04 | 001 |
| [D3] | BURNABLE MATERIALS LBC8000-1110S102G (LBC12000-1110S101G) | Bel Power | LBC12000-1110S101G | 2020-03-27 | 003 |
| [D4] | LBC12000_Harnes | Bel Power | LBC12000_Harnes_YVD.00975_111016 - Copy.xlsx | --- | --- |
| [D5] | OPERATION MANUAL LBC Series: LBC8000-1110SxxxG, LBC12000-1110SxxxG Battery Charger / PSU | Bel Power | BCM.00432 | 2023 | AR |
| [D6] | Test report S1000-2M (SHENGYI)+ PSR-2000 (TAIYO) + AVR80 BA CONFORMAL COATING, AB CHIMIE | Bel Power | CR-001451 | 2021-04-01 | 01 |
| | | RST | P60-21-5519 | 2021-03-10 | --- |
| | | RST | P60-21-0154 | 2021-03-10 | --- |
| | | Crepim | 2904/91/060 C | 2021-03-25 | --- |
| [D7] | Test report PCL370HR (ISOLA) FR4; ELPEMER-2467 (PETERS) SOLDER MASK + AVR80 BA CONFORMAL COATING, AB CHIMIE | Bel Power | CR-001453 | 2021-04-01 | 01 |
| | | RST | P60-21-5520 | 2021-03-10 | --- |
| | | RST | P60-21-0155 | 2021-03-10 | --- |
| | | Crepim | 2904/91/060 B | 2021-03-25 | --- |
| [D8] | Test report S1000H (SHENGYI) + PSR-2000 (TAIYO) + AVR80 BA CONFORMAL COATING, AB CHIMIE | Bel Power | CR-001475 | 2021-04-01 | 01 |
| | | RST | P60-21-5521 | 2021-03-10 | --- |
| | | RST | P60-21-0156 | 2021-03-10 | --- |
| | | Crepim | 2904/91/060 D | 2021-03-25 | --- |
| [D9] | UL Test report Dupont Nomex 410 | UL | E34739 | 2023-01-01 | --- |
| [D10] | UL Test report BT-RG301(r1) | UL | E171666 | 2023-08-01 | --- |
| [D11] | Test report XEE.01106.0 RCM1000 enclosure | Bel Power | CR-002062 | 2021-08-10 | 01 |
| | | RST | P60-21-0423 | 2021-07-26 | --- |
| [D12] | Test report RADOX TENUIS-TW/600V 2X0.5 MM T09.01 | RISE | 9P02078-16 | 2019-04-02 | --- |
| | Test report RADOX TENUIS-TW/600V 2X0.5 MM T09.04 | RISE | 9P02078-2 | 2019-04-02 | --- |
| | Test report RADOX TENUIS-TW/600V 2X0.5 MM T13 | RISE | 9P02078-9 | 2019-04-02 | --- |



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Table 4: Documents

| ID | Title | Author | Doc./File ID | Date | Rev. |
|-------|--|--------|-----------------|------------|------|
| [D13] | Test report RADOX TENUIS-TW 600V 30X1.5 MM T09.01 | RISE | 9P02078-18 | 2019-04-02 | --- |
| | Test report RADOX TENUIS-TW 600V 30X1.5 MM T09.02 | RISE | 9P02078-4 | 2019-04-02 | --- |
| | Test report RADOX TENUIS-TW 600V 30X1.5 MM T13 | RISE | 9P02078-11 | 2019-04-02 | --- |
| [D14] | Test report RADOX EI303 T15 | LAPI | 1510.1CI0165/20 | 2020-09-29 | --- |
| [D15] | Test report RADOX 125 REC T15 | LAPI | 609.1CI0165/20 | 2020-04-07 | --- |
| [D16] | Test report RADOX EI109 | LAPI | 411.1CI0110/22 | 2022-03-15 | --- |

4. Equipment under inspection

4.1. Description of equipment

The Battery Charger LBC Series was developed for application in rolling stock.

The Battery Charger consists of chargers for 110 V Batteries with 400 / 480 VAC input in an aluminium housing. The rack dimensions (W x H x D) are 347/406 mm x 166 mm x 600 mm. The weight is 23.5 kg (LBC8000) / 29.7 kg (LBC12000).

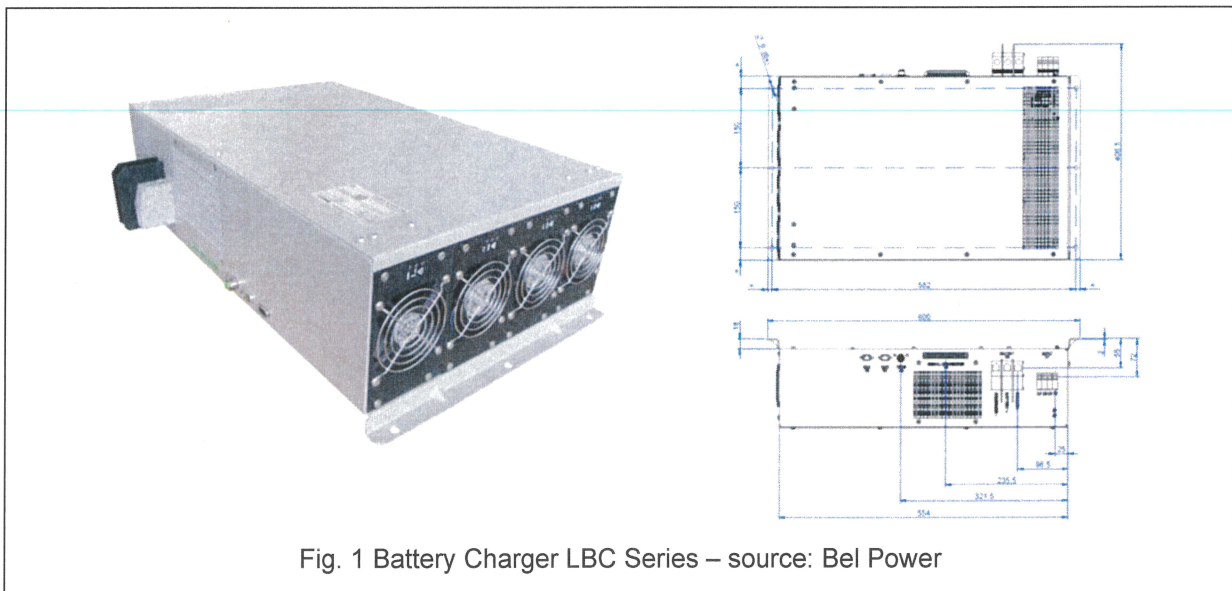


Fig. 1 Battery Charger LBC Series – source: Bel Power

Connection cables of the vehicle wiring or brackets for mounting are not part of this assessment. In accordance with the assignment, this fire safety assessment deals with the following models:

Table 5: Battery Charger LBC Series – models

| No | Model | Power | Battery voltage | Communication |
|----|--------------------|---------|-----------------|-----------------|
| 1 | LBC8000-1110SxxxG | 8000 W | 110 V | CAN or Ethernet |
| 2 | LBC12000-1110SxxxG | 12000 W | 110 V | CAN or Ethernet |

4.2. Electrical Data

- AC-Input: Voltage: 400 / 480 Vrms, 3-phase 50/60 Hz, Fuse: 3 x 20 A, fast acting in each power unit
- DC-Output: 110 V (adjustable 80 – 137.5 VDC), output power up to 12 kW
- Max. failure power: 16 kW

4.3. Installation Conditions

The Battery Charger LBC Series is intended for installation in technical compartments. It is not regularly accessible for passengers or staff during operation.

5. Conformity assessment acc. to EN 45545

5.1. Classification according to EN 45545-1

The Battery Charger LBC 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 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, 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.

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 EN 45545-2 presents the correlation between 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 EN 45545-2

5.2.1. 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 6: Requirement sets 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 $\geq 20 \text{ kWm}^{-2}$ ISO 5660-1: 50 kWm^{-2} MARHE $\leq 60 \text{ kWm}^{-2}$ ISO 5659-2: 50 kWm^{-2} $D_s(4) \leq 150$ $VOF_4 \leq 300$ $CIT_G \leq 0.75$ [R02] EN 17084: 50 kWm^{-2} $CIT_G \leq 0.75$ [R03] |
| IN2 | Limited surfaces | They shall have an area $\leq 0,20 \text{ m}^2$; 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 CFE $\geq 13 \text{ kWm}^{-2}$ ISO 5660-1: 50 kWm^{-2} MARHE $\leq 90 \text{ kWm}^{-2}$ ISO 5659-2: 50 kWm^{-2} $D_s(4) \leq 150$ $VOF_4 \leq 300$ $CIT_G \leq 0.75$ [R02] EN 17084: 50 kWm^{-2} $CIT_G \leq 0.75$ [R03] |
| EL9 | Printed circuit boards | Printed circuit boards with all applied coatings but without any attached technical equipment | R26 [R03] EN 60695-11-10 Classification = V0 or R25 EN 60695-2-11 Glow Wire $850 \text{ }^\circ\text{C}$ or R24 ISO 4589-2 $OI \geq 32\%$ |
| EL10 | Small electrotechnical products | All electrotechnical equipment, including protection against contact and similar | R26 EN 60695-11-10 Classification = V0 |

Table 6: Requirement sets EN 45545-2

| No. | Name | Details | Requirement |
|------|---------------------|---|--|
| EL1A | Cables for interior | Cables not compliant with one of the standards referenced in 4.2 c) | R15 EN 60332-1-2 burned part ≤ 540 mm and unburned part > 50 mm EN 50305 burned part ≤ 1.5 m EN 61034-2 Transmission ≥ 70% EN 50305 ITC ≤ 6 |

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 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 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 | R24 | < 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 <ul style="list-style-type: none"> - products classified as A1 according to EN 13501-1 - all products described in commission decision 96/603/EC (as amended) | --- |
| 4.2. i) Coatings | EN 45545-2:2016: 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; EN 45545-2:2020: 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) | EN 45545-2:2016: where a coating (including vinyls, films | Requirements for |



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Table 9: General requirements EN45545-2

| Section | Requirement | Remark |
|--|---|--|
| Coatings | 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; EN 45545-2:2020: for organic coatings applied to non-metallic surfaces, the full specified test requirements of chapters 4.3 till 4.5 are mandatory; | reference substrate Table 7: Steel sheet 0.8 mm Aluminum sheet: 1.0 mm |
| 4.2. l) [R02] 4.2. k) [R03] 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: 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 p+roducts. |
| 4.2 m) [R02] 4.2. l) [R03] Size of test specimen | If the end use condition does not allow sizes of test specimen for ISO 5658-2 (if this is part of the requirement set): R6 interior use R9 exterior use | --- |
| 4.2. n) [R02] 4.2. m) [R03] | 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 m ² R1 (interior), R7 (exterior) ≤ 0.2 m ² 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 m ² . |
| 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 [R02] 5.3.7 [R03] 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 | Materials that are fully separated with those products shall be grouped separately. |



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Table 9: General requirements EN45545-2

| Section | Requirement | Remark |
|---------|---|--------|
| | Conventional Classified Products acc. to EN 45545-3. Those products are considered to meet the integrity requirements. | |

5.2.2. Material verification

The combustible materials are listed in the documents [D2], [D3] and [D4]. The housing is made from powder-coated metal.

According to the available documentation the combustible material required to be verified by test are PCBs, small electrotechnical products and cables. The relevant requirements according to EN 45545-2 as well as the test results are listed in Table 10. 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.

The input connector HDFK 10-HV/Z and the output connector HDFK 50/Z have been verified according to requirement set R22. Requirement set R24 is a partial test of requirement set R22. With the fulfilment of requirement set R22, requirement set R24 is also fulfilled.

Table 10: Listing of material testing

| Material | Requirement | Result | Certificate | HL |
|---|---|-------------------------------------|----------------------|-------------------|
| <i>EL10 - Small electrotechnical product</i> Insulator; Foil – Nomex Fan, DC axial - PBT-RG301(r1) | R26 R26 | fulfilled fulfilled | [D9] [D10] | HL3 HL3 |
| <i>EL9 - PCB</i> S1000-2M (SHENGYI)+ PSR-2000 (TAIYO) PCL370HR (ISOLA) FR4; ELPEMER-2467 S1000H (SHENGYI) + PSR-2000 (TAIYO) | R26, R25, R24 R26, R25, R24 R26, R25, R24 | fulfilled fulfilled fulfilled | [D6] [D7] [D8] | HL3 HL3 HL3 |
| <i>EL1A – Cable for inside</i> RADOX TENUIS-TW 600V MM | R15 | fulfilled | [D12] - [D16] | HL3 |
| <i>IN2 - Limited surfaces</i> Coating for housing | T02 ISO 5658-2 | fulfilled | [D11] | HL3 |

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

- None

The combustible materials used for the Battery Charger LBC Series fulfil the requirements according to EN 45545-2 for HL3.



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6. Plausibility check of the ignition sources

6.1. Fire development starting from the component

The maximum failure power is limited to 16 kW by internal fuse. Due to the small amount of combustible mass, the predominantly qualified materials, and the electrical power, which is limited in time by the existing fuse, ignition and fire development in the event of an electrical failure are sufficiently prevented from "fire caused by technical defects", in accordance with 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, EN 45545-1) and additionally with direct flame or arc action (see ignition models 1 and 4 according to Annex A, 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.



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7. Summary

The assessments result is that the Battery Charger LBC Series meets the requirements of the listed acknowledged codes of practice:

- EN 45545-2:2016 hazard levels HL1 to HL3
- EN 45545-2:2020 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 2024-04-01 [D12], [D13].

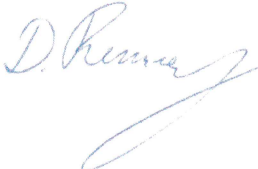

This inspection is also valid for any other Battery Charger of the evaluated types as long as Bel Power confirms with manufacturer declaration that the material used did not change and the mass and surface of the material treated according to grouping rules (see section 5.2.2) is not higher than for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

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

TÜV SÜD Rail GmbH, Unit Rolling Stock

Release

Created

| | |
|--|---|
|  David Rummeny Teamlead 2023.09.07 08:35:29 +02'00' |  Christian Dettlaff Inspector 2023.09.06 10:07:56 +02'00' |
|--|---|