

Application Guide of EN 45545 for Electrical Insulating Materials



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Application Guide of EN 45545 for electrical insulating materials

Published by:
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Fig. 1: Reproduction according to DIN EN 45545-2:2016-02

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Am DIN Platz, Burggrafenstraße 6, 10787 Berlin, Germany.

December 2020, revised Version

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1 Introduction

A high value is placed on mobility in modern society. In addition to cars and airplanes, railway vehicles are an important means of transportation today.

The safety of passengers and staff is prioritised during the design of railway vehicles. This also encompasses the rare occurrence of fires on trains. Smoke and toxic gases produced by a fire on a train present the biggest risk, along with the spread of flames and great heat. Reducing these hazards is an essential aspect of EN 45545¹.

Material requirements for railway vehicles have already been specified in different national standards (e.g. DIN 5510-2:2009, NF F 16-101, BS 6853, etc.) in the past. In line with European harmonisation efforts, CEN/TS 45545 was published in 2009. Based on this standard, EN 45545-2 became effective in July 2013. After a transitional period of three years, all national standards were withdrawn and EN 45545 took effect on April 1, 2016 as the sole applicable standard.

EN 45545 specifies Europe-wide identical fire safety requirements for all materials used in railway vehicles. Consequently, it also applies to electrical and electronic components. This brochure shall be used as a guide to understand and determine the requirements for electrical and electronic insulating materials and component design. It does not supersede the standard.

¹This guideline references to DIN EN 45545-2:2016-02, and in parts to DIN EN 45545-1:2013-08 and DIN EN 45545-3:2013-08, hereinafter referred to as EN 45545.

2 Determining the Requirements – Where is the Component Used?

The standard defines a structured approach, tracing backwards from the final product (railway vehicle) to each individual component. The reason for this approach is caused by different hazards that a specific railway vehicle may pose for passengers and staff. An unmanned railway chassis for transporting containers requires a lower fire protection level than a fully occupied double deck train.

The requirements for fire behaviour of materials and components specified in the standard are based on their individual properties, but also on:

- the operation and design category of the railway vehicle,
- the general location of the material or component within the construction (e.g. interior or exterior),
- the shape and arrangement,
- the exposed surface, combustible mass and thickness,
- the specific application (furniture, electrical equipment, mechanical equipment).

A systematic approach helps determining the requirements for components and materials. The following consecutive steps have proven to be successful:

Step 1: Determining the Infrastructure

As the first step the operation and design category is to be determined for the relevant railway vehicle.

EN 45545-1, section 5 defines the relevant operation and design categories.

Classification by operation category (OC) primarily depends on the time required for evacuating vehicles that are designed or equipped for surface operation (OC1) or tunnel operations (short tunnel, long tunnel, side evacuation possible).

Whereas the design category considers if the vehicles are part of an automatic train (without emergency-trained staff on board, category A), double-decked vehicles (category D), sleeping and couchette vehicles (category S) or other vehicles (standard vehicles, category N).

The relevant category classification is primarily done by the end-customer as the component or material suppliers are normally not able to specify by their own.

Step 2: Determining the Hazard Level

Based on design and operation category, the applicable Hazard Level (HL) is determined for the relevant railway vehicle. Based on this HL, the necessary fire safety requirements (requirement sets) for materials and components are determined.

Operation Category	Design Category:			
	N (normal/standard)	A (automatic operation)	D (double deck)	S (sleeping car)
1 Surface operation	HL 1	HL 1	HL 1	HL 2
2 Tunnel < 5 km	HL 2	HL 2	HL 2	HL 2
3 Tunnel > 5 km	HL 2	HL 2	HL 2	HL 3
4 No side evacuation possible	HL 3	HL 3	HL 3	HL 3

Table 1 according to DIN EN 45545-2:2016-02

Note: The end-customer (railway vehicle manufacturer) specifies the requirements through step 1 and 2 for component or material suppliers.

Step 3: Listed or Non-listed Components

Step 3.a. Once the hazard level has been determined, the listing (“listed”) or non-listing (“non-listed”) of components shall be checked.

Listed Components

Table 2 of EN 45545-2 provides an overview of the listed components and defines the relevant requirements (R-set) which have to be tested accordingly. Each “R-set” covers several requirements e.g. smoke density and smoke toxicity. Furthermore relevant test methods are defined.

Based on the standard’s comprehensive list of components, the following table has been compiled illustrating three groups of electrotechnical products as an example:

Component No.	Name	Description	Requirement Set
EL7A	Chokes and coils – interior	Reactors for filtering supply lines, coils for air-cooled transformers including spacers and air guiding plates	R22
EL7B	Chokes and coils – exterior	Reactors for filtering supply lines, coils for air-cooled transformers including spacers and air guiding plates and traction motor winding insulation	R23
EL10	Small electrotechnical products	Low voltage circuit breakers, contactor relays, terminals, fuses	R26

Table 2, excerpt from DIN EN 45545-2:2016-02

Non-listed Components

Step 3.b.

Components not included in table 2 of EN 45545 are regarded as non-listed components. They can be treated as specified in 4.3 “Grouping rules” of EN 45545-2 (refer section 3.2 of this brochure).

Individual non-listed components such as sealing components, insulating films, impregnating resins, insulating tape, wire enamels, etc. can be tested as individual components according to EN 45545. An accredited testing laboratory determines the fire behaviour according to EN 45545 and issues a certificate. This certification is accepted by all certifying bodies and systems suppliers across Europe.

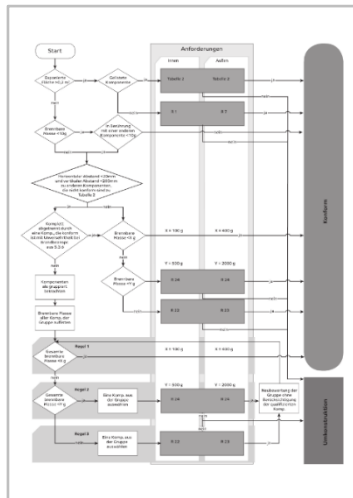
Step 4: Determining Material Requirements and Test Methods

Based on the hazard level defined in step 2 and the requirements (R-set) established in step 3, table 5 of EN 45545-2 specifies the necessary tests and limit values for the deployed components.

The R-sets R22, R23 and R24 are particularly relevant in connection with the use of insulating materials. Depending on the hazard level, the requirements differ in terms of flammability (oxygen index), smoke density and toxicity (see also EN 45545-2, table 5).

Note: In line with the grouping rule, insulating materials used in quantities below the specified weight limits, may be tested according to requirement set R24, which does not consider smoke emission and toxicity for such small quantities. An example for this is provided in section 3.2 of this brochure.

3 Grouping Rules and Compensation



Non-listed components close to each other are considered as grouped and must be treated in their entirety.

The flow chart illustrated in the standard (see figure 1) describes an approach to determine compensation options for the use of insulating materials with low classification (i.e. products that do not comply with R22/R23).

Fig. 1: Flow chart according to DIN EN 45545-2:2016-02 (click on the image to enlarge it or go to the end of the document)

Example:

The distance between a capacitor and another product (e.g. printed circuit board, where it is mounted on) is too small despite the capacitor's possibly low weight. Hence, the total weight is to be considered.

The products/components used are therefore not assessed solely according to their own fire behaviour. Applicable requirements also depend on:

- a. *the location of the materials within the system*
 - interior
 - exterior
- b. *the exposed surface area in case of fire*
 - smaller than 0.2 m²
 - greater than 0.2 m²
- c. *the relative weight*
 - interior < 100 g or < 500 g
 - exterior < 400 g or < 1,000 g
- d. *distance between the non-listed products*
 - 20 mm horizontal, 200 mm vertical

The fire behaviour of components weighing less than 10 g and not in touching contact with other non-listed products is not assessed.

The main applicable requirement sets used for electrical insulating materials (EIM) are R22 to R26. Requirement set R23, for instance, defines the limit thresholds per hazard level (HL1...HL3) in relation to the oxygen consumption, heat emission and toxicity for interior non-listed materials with an exposed surface area below 0.2 m².

The grouping rule allows the breakdown of product groups into listed and non-listed components. For instance, individual components/materials that comply with the requirements of R24 (e.g. chokes, transformers, coils) can be exempt from the fire safety assessment. The grouping rules can be used to check, if the weight of non tested materials is below 100g/400g (fire load reduction). Below these values no certification is required.

Compensation Options

Insulating materials that do not meet the requirements of R22 or R23 for the required hazard level (HL1, 2 or 3) may still be used according to grouping rule and R24 requirement set.

As an alternative approach of testing all materials individually, which can be quite time-consuming and expensive (e.g. for complex control units), one of the following methods is acceptable in accordance with EN 45545:

- use of fire safety compliant enclosure (metal enclosure, technical cabinet/panel, < 2 m³)
- protection of enclosure by fire detection and extinguishing systems
- certification of the entire system (burning e.g. of a complete control unit) without verification of individual components.

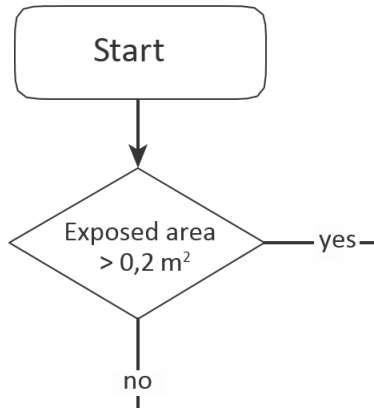
Following this approach, it is also acceptable to use non-listed components without additional tests, which allows a wider selection of alternative materials.

Step-by-Step: Use of Grouping Rule

The following example illustrates the use of the grouping rule. It explains in detail the exposed surface area, distances and combustible mass.

The use of the flow chart is explained below in 8 steps using the example of a reactor (component number EL7A):

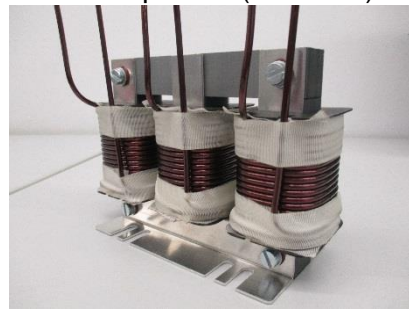
Step 1:



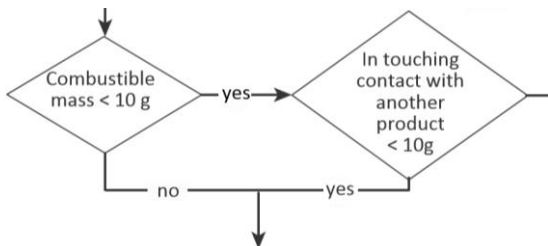
Example: reactor

Combustible mass = 150 g/ interior

- Exposed surface < 0.2 m²
 - When > 0.2 m², then table 2, since listed component (R22/R23)

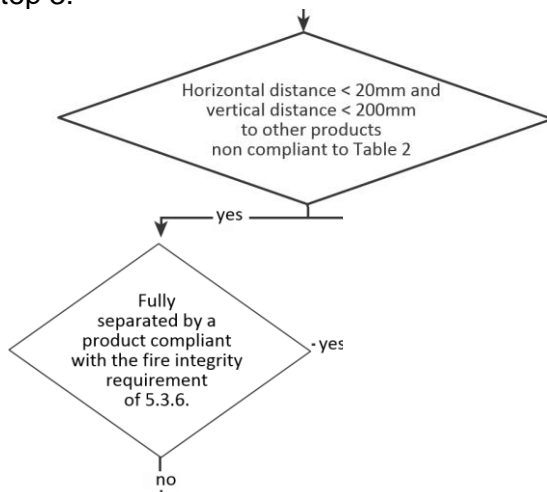


Step 2:



- Combustible mass usually exceeds 10 g since resin, bobbin and other insulation material are combined.

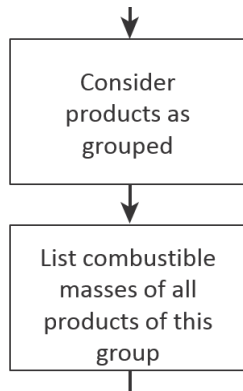
Step 3:



- Normal installation does not maintain minimum distances and is not protected by fire barrier¹

¹ In case of an appropriate fire protection enclosure a classification possibly isn't required any longer.

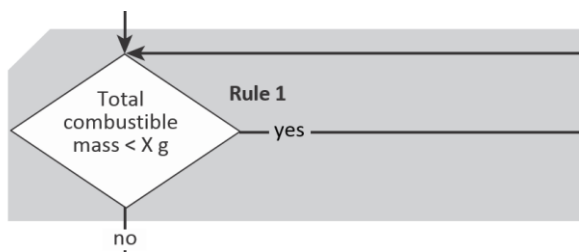
Step 4:



- “Breakdown” of reactor into its components

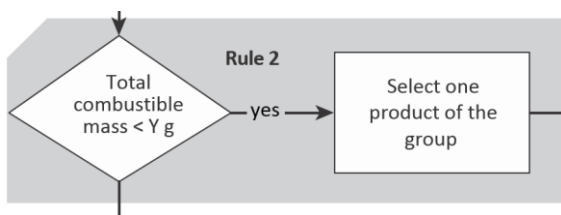


Step 5:



- Application of rule 1 not possible since combustible mass >100 g

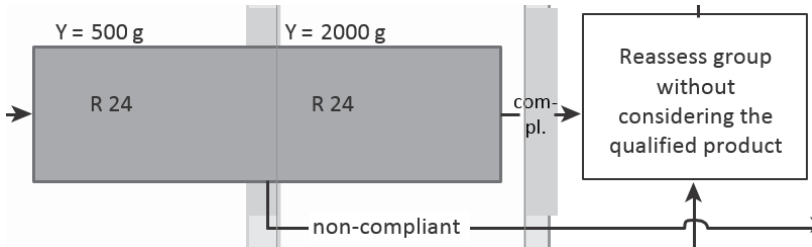
Step 6:



Bobbin is R24 certified



Step 7:

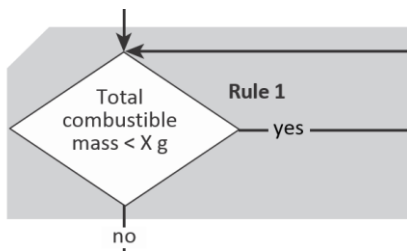


The certified component (bobbin (all)) has an individual weight of 75 g.



Re-assessment of all other materials in total, without the bobbin.

Step 8:



Now it's possible to use rule 1 as total combustible mass is <100g

Design is compliant with EN 45545-2

4 Conclusion

In order to avoid restricting the choice of materials unnecessarily, manufacturers and users are well advised to request the highest hazard levels possible only when they are required. It should also be borne in mind that many of the effective flame retardants used today will no longer be available in the future due to legal frameworks such as REACH and RoHS.

EN 45545 railway standard is a complex set of rules. It is therefore important to point out the main intention of the document: fire-protection and limited fire-spread. When keeping this in mind, the classification into hazard levels and the assessment of individual materials and product groups in terms of fire behaviour becomes easier to understand.

The EN 45545 will be consequently evaluated in the future. The next revision will be released soon and is likely to follow the increasing requirements for operational safety.

For external support, please contact national certification body.

Annex: Flow chart

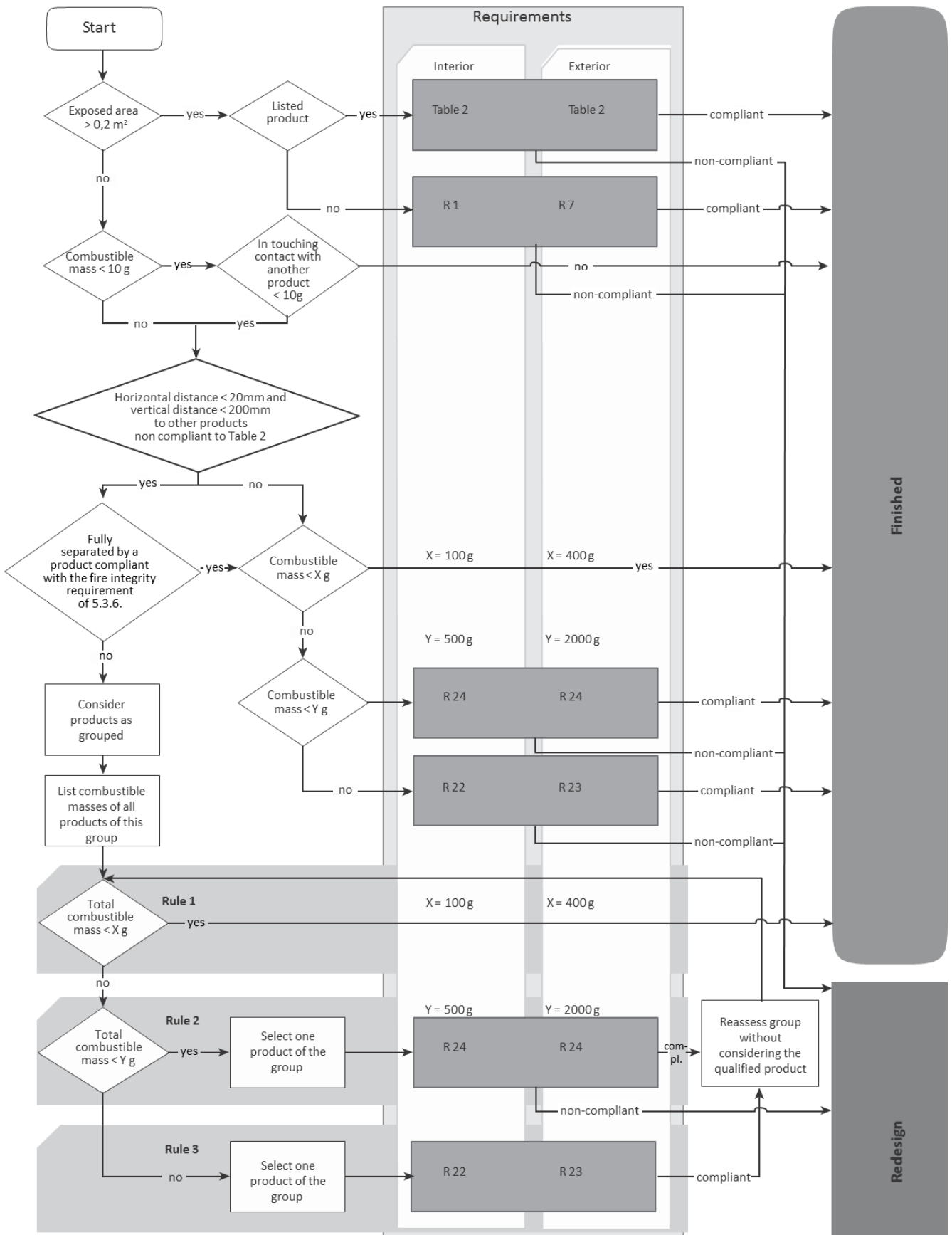


Fig. 1: Flow chart according to DIN EN 45545-2:2016-02



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