

Guidelines for the application of EN 45545 to electrical and electronic insulating materials



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

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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 fire 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 or DIN EN 45545 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 After a transitional period of three years, all national standards were withdrawn and EN 45545 took effect on April 1, 2016 as the sole applicable standard.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 uniform fire safety requirements for all materials used in railway vehicles. Consequently, it also applies to electrical and electronic components. This brochure serves as a guide to understanding and determining the requirements for electrical and electronic insulating materials and component design. It does not replace the standard.

¹This guideline makes reference 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 follows a structured approach, moving along the manufacturing chain from the final product (railway vehicle) to the individual components. The reason for this approach is rooted in the 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 decker train.

The requirements for fire behaviour of materials and components specified in the standard are based on their inherent 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 in determining the requirements for components and materials. The following consecutive steps have proven to be successful:

Step 1: Determining the infrastructure

The operation and design category must first be determined for the relevant railway vehicle.

EN 45545-1, section 5 specifies the relevant classifications into operation and design categories.

Classification by operation category (OC) mainly 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).

By contrast, the design category considers whether 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).

Classification into the relevant categories will often not be done by the component or material supplier, but specified by the end customer.

Step 2: Determining the hazard level

Hazard levels (HL) result from the combination of operation and design category determined for the relevant railway vehicle.

The hazard level identified determines the necessary fire safety requirements (requirement sets) for materials and components.

Operation Category	Design category: N (normal/standard)	A (automatic operation)	D (double decked)	S (sleeper)
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 customer (manufacturer of the railway vehicle) specifies the requirements from step 1 and 2 for the component or material manufacturer.

Step 3: Listed or non-listed components

Once the hazard level has been established, it must be checked whether the component is “listed” or “non-listed”.

3.1. Listed components

Table 2 of EN 45545-2 provides an overview of the listed components and defines the relevant requirements (R-set) which must be tested for and met by listed components. Each “R-set” covers several requirements e.g. relating to the emission of toxic gases and smoke and prescribed test methods.

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

3.2. Non-listed components

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 (see also 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 DIN 45545. An accredited testing laboratory then determines their fire behaviour according to EN 45545 and issues a certificate. This certification is recognised by all certifying bodies and systems suppliers across Europe.

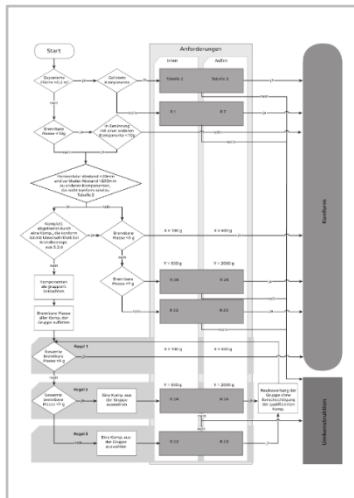
Step 4: Determining material requirements and test methods

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 limit weights specified in the standard 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 in close proximity 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 on a circuit board and another product (circuit board) is too small despite the capacitor's possibly low weight. Hence, the total mass must be considered.

The products/components used are therefore not assessed solely according to their own fire behaviour. Requirements applicable to them 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 mass*
 - interior < 100 g or < 500 g
 - exterior < 400 g or < 1,000 g
- d. *distance between the non-listed products*
 - interior 20 mm horizontal, 200 mm vertical
 - exterior 40 mm horizontal, and 400 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 electronic 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 of below 0.2 m².

The grouping rule allows the breakdown of product groups into listed components and non-listed components. For instance, individual components that comply with the requirements of R24 (e.g. chokes, transformers, coils) can be exempt from the fire safety assessment. Using the grouping rules, it is possible to check whether the relative mass of components, which do not demonstrably comply with fire safety requirements, is below 100 g / 400 g (reduction of fire load). No evidence must be provided for values below these thresholds.

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 under the grouping rule and the R24 requirement set.

As an alternative to testing all materials used in a product individually, which can be quite time-consuming and expensive e.g. for complex control units, the following compensatory and alternative measures are possible according to EN 45545:

- provision of fire safety compliant housing (steel housing, technical cabinet, < 2 m³)
- protection of housing with fire detection and fire extinguishing systems
- certification of the entire system (burning rate e.g. of a complete control unit) without verification of individual components.

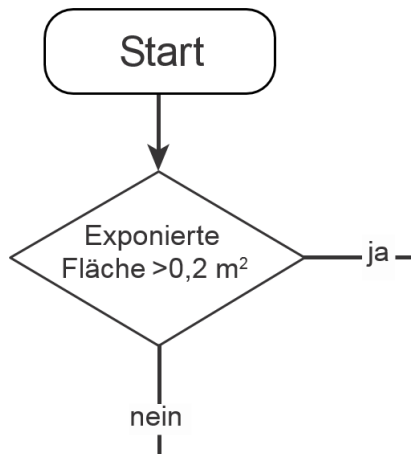
In this way, it is also possible to use non-listed components without additional tests, for instance, which increases the selection of alternative materials.

Step-by-step: Applying the grouping rule

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

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

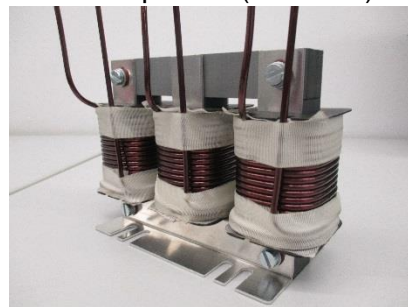
Step 1:



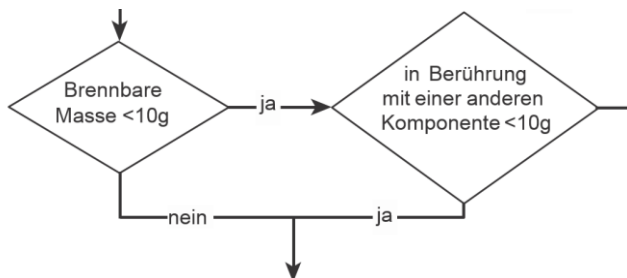
Example: reactor

Combustible mass = 150 g/ interior

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

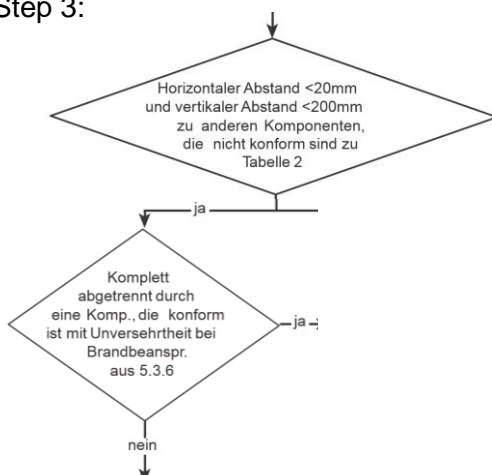


Step 2:



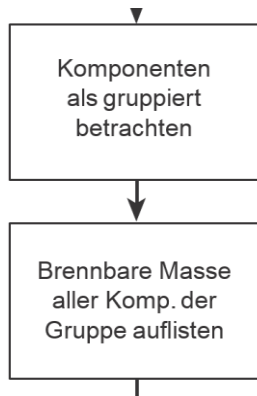
- Combustible mass usually exceeds 10 g since resin, coil body and other insulation material are combined.

Step 3:



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

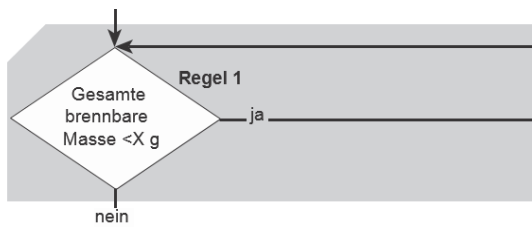
Step 4:



- “Breakdown” of reactor into its components

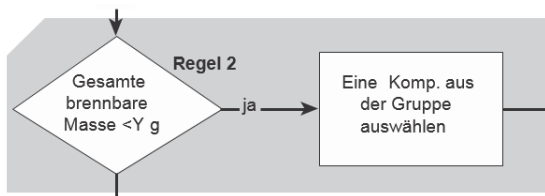


Step 5:



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

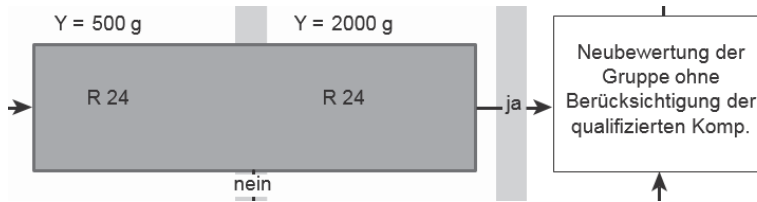
Step 6:



1 component complies with R24 requirements



Step 7:

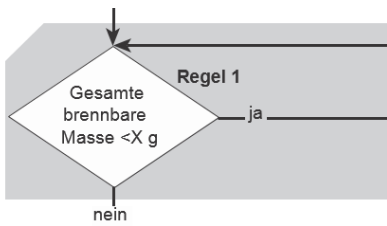


The certified component (coil body (all)) has an individual weight of 75 g.



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

Step 8:



Application of rule 1 now possible since combustible mass < 100 g

Design 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 be aware of the underlying purpose of the document, the prevention of the outbreak and spreading of fires. 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 standard will continue to evolve in the future. The next revision is coming soon and is likely to adjust to the rising requirements for operational safety.

For external support, please contact the German certification body www.DAKkS.de.

Appendix: Flow chart

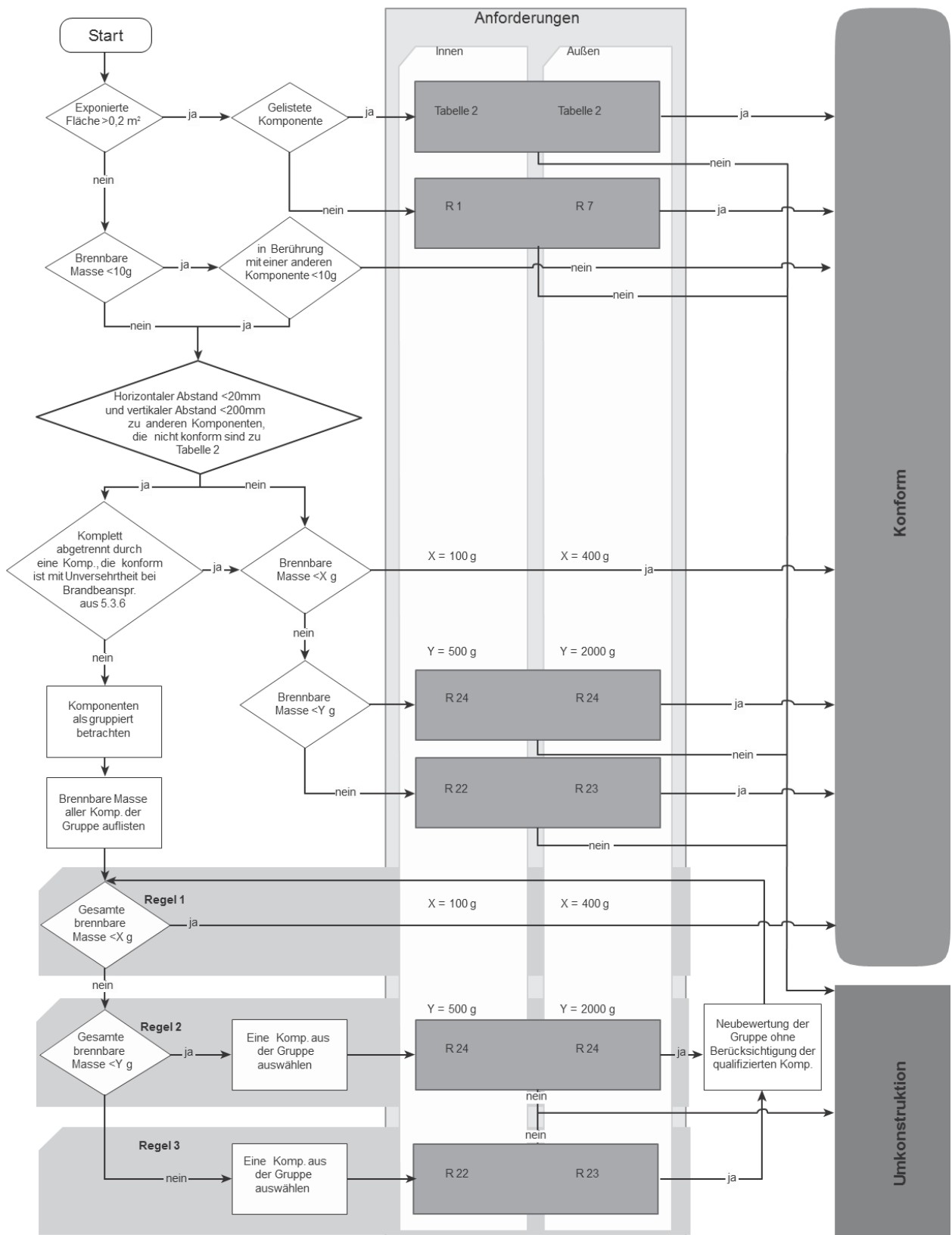


Fig. 1: Flow chart according to DIN EN 45545-2:2016-02



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