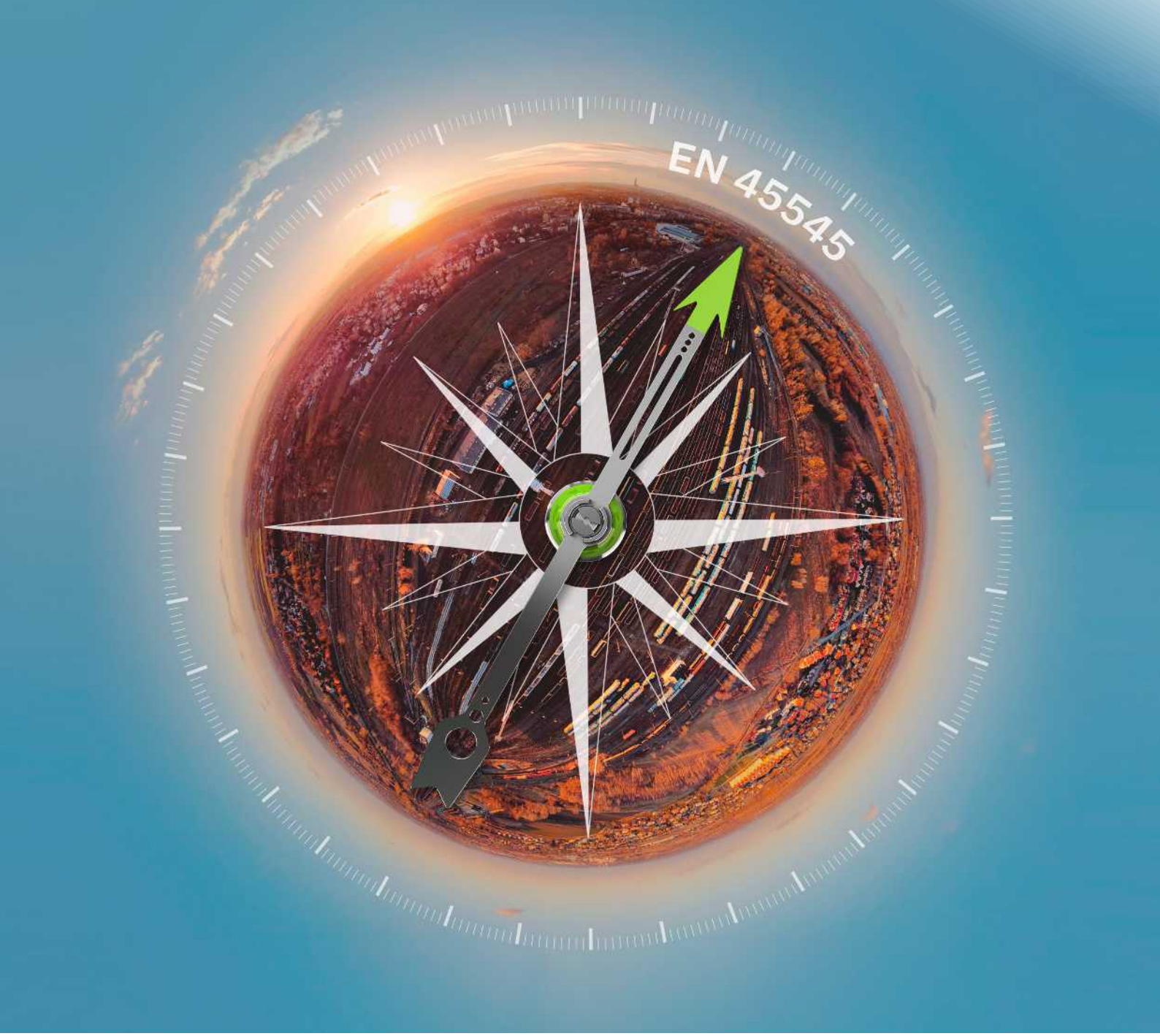


Railway Guide – EN 45545

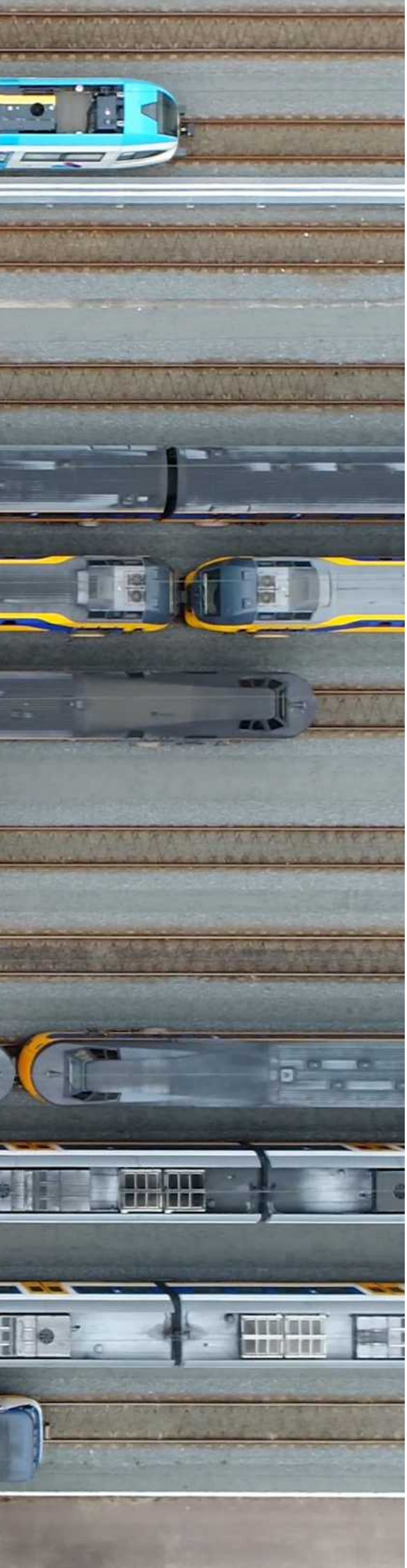
Practical guide with focus on “electrotechnical equipment”

PHOENIX CONTACT

Foreword

Quite a few excellent technical articles have already been written on the different trades of and undertakings by the railway. They deal with the topics from the author's specific perspective in a competent manner and with the necessary level of detail. As a component supplier for the railway sector, however, we need to consider another perspective. Components are not tied to a specific trade, but instead are used in a large variety of applications. We need to have an understanding of the entire bandwidth of applications in order to implement these components correctly. Relevant standards are a key element connecting the applications and individuals involved in railway operations. Recognition of this served as the motivation to create this document.

Regulations and standards create a common global foundation for suppliers, the railway industry, railway operators, and relevant official agencies. A good understanding and correct application of relevant standards are essential and help ensure smooth and safe railway operation. This document provides an overview of EN 45545 – Fire protection on railway vehicles – and offers basic information intended to give a better understanding.



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Railway technology products
Clear, compact, and to the point

A large number of high requirements apply to railway technology products, such as requirements for fire protection, shock and vibration, temperature range, and electromagnetic compatibility. We offer a compact summary, available for download, that shows you which of these normative requirements are met by the respective product groups.

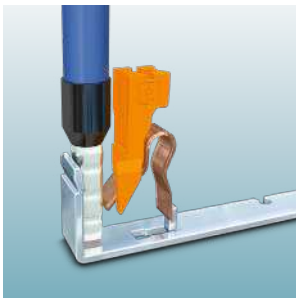
You can download our product list at the following link:
phoenixcontact.com/railway_product_list

The Railway product list provides the following:

Application-specific presentation by product group

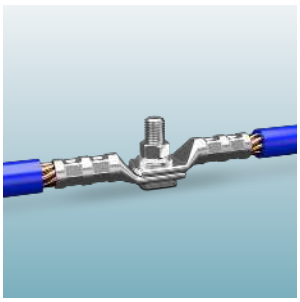
The connection technologies relevant for railway applications and one potential product use are shown in an easy to understand overview for the connection technology product portfolio. These items are listed in a separate list and can be downloaded.

The product list provides a clear overview of the each of the relevant standards and their fulfillment for the other product groups, such as power supplies.



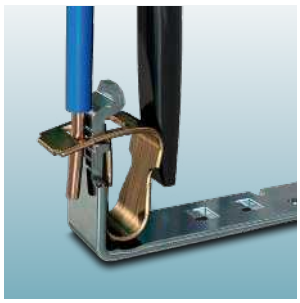
Push-in connection

Plug-in connection

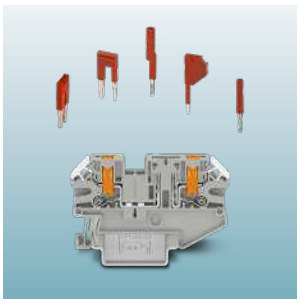


Bolt connection

Fast connection



Spring-cage connection



Accessories

Table of normative requirements

Individual tables for each product group

Clear overview of standards

List of items

DC/DC converter for preferred use on railway vehicles

Input voltage	Output voltage	Output current	EN 45545-2	EN 50155	EN 61373	EN 50121-3-2	Protective coating	-40°C start, type-tested	Description	Item no.
12 … 24 V DC	24 V DC	1.3 A	X			X		X	QUINT4-PS/12-24DC/24DC/1.3/PT	1066716
24 V DC	24 V DC	5 A	X		X	X	X	X	QUINT4-PS/24DC/24DC/5/PT/CO	2910132
24 V DC	24 V DC	10 A			X	X	X	X	QUINT4-PS/24DC/24DC/10/PT/CO	2910133
24 V DC	24 V DC	20 A			X	X	X	X	QUINT4-PS/24DC/24DC/20/SC/+	1046881
24 V DC	48 V DC	10 A			X	X		X	QUINT-PS/24DC/48DC/10	2320128
48 … 110 V DC	24 V DC	2.5 A			X	X		X	QUINT4-PS/48-110DC/24DC/2.5/PT	1066708
60 … 72 V DC	24 V DC	10 A	X	X	X	X	X	X	QUINT-PS/60-72DC/24DC/10/CO	2905011
96 … 110 V DC	24 V DC	10 A	X	X	X	X	X	X	QUINT-PS/96-110DC/24DC/10/CO	2905012

Basic technical information

Fulfillment of normative requirements for each item

1 EN 45545 – Fire protection on railway vehicles

Conformity with the EN 45545 requirements determines whether a component may be used in a railway vehicle from a fire-protection standpoint. For this reason, both the manufacturer and the user must have a good understanding of EN 45545. The objective of this section is to provide you guidelines that will be useful in your particular applications. This makes it easier to become familiar with the topic, makes the structure and design of the standard easier to understand, and explains it in a practical way.

The standard defines fire protection technology requirements for all flammable materials used on railway vehicles. Because we also produce these components for the railway industry, they apply to our railway-specific product portfolio as well. This document has been prepared based on many years of practical experience in using electrical installation materials and is therefore restricted to these. Relevant topics such as conformity, classification, and certification are addressed for these products.

1.1 History of EN 45545

EN 45545-2, "Railway applications – Fire protection on railway vehicles – Part 2: Requirements for fire behavior of materials and components" defines the fire protection requirements for materials and components used on railway vehicles. As such, it is purely a material testing standard and therefore does not constitute a certification from a manufacturer. Its ratification standardized the various national fire protection standards in Europe. It replaces, for instance, the German standard DIN 5510, the French standard NF F 16-101/-102, British standard BS 6853, and Italian standard UNI-CEI 11170-1/-2/-3. EN 45545 is also accepted and applied in many parts of the world outside of Europe.

EN 45545 replaces national fire protection standards

1.2 Integration into EU law through the TSI LOC&PAS

Fire protection requirements for railway vehicles are defined in an EU specification. Typically, it is referred to as TSI LOC&PAS. Clause 4.2.10.2 of the annex describes the measures to prevent fire.

For material requirements, please refer to TSI LOC&PAS Annex J-1, clause 58. In it, EN 45545-2 is referenced as the normative document.

Therefore, the binding regulation within the EU is that Part 2 of EN 45545 (EN 45545-2 Railway applications – Fire protection on railway vehicles – Part 2: Requirements for fire behavior of materials and components) is to be applied.

Standard EN 45545 consists of seven parts. The fire protection technology requirements are discussed in Part 2, or EN 45545-2. This means that conformity with these requirements is certified in accordance with EN 45545-2.

Commission Regulation Commission Regulation (EU) No 1302/2014
of November 18, 2014

concerning a technical specification for interoperability relating to the subsystem "rolling stock - locomotives and passenger rolling stock" of the rail system within the European Union.

4.2.10.2. Measures to prevent fire

4.2.10.2.1. Material requirements

(1) The selection of materials and components shall take into account their fire behavior properties, such as flammability, smoke opacity and toxicity.

(2) Materials used to construct the rolling stock unit shall comply with the requirements of the specification referenced in Annex J-1, index 58 for the "Operation Category" as defined below:
- "Operation Category 2" for Category A passenger rolling stock (including passenger locomotive);
- "Operation Category 3" for Category B passenger rolling stock (including passenger locomotive);
- "Operation Category 2" for freight locomotives, and self-propelling units designed to carry other payload (mail, freight, etc.);
- "Operation Category 1" for OTMs, with requirements limited to areas which are accessible to staff when the unit is in transport running configuration (see Section 2.3 of this TSI).

(3) In order to ensure constant product characteristics and manufacturing process, it is required that:
- The certificate to prove compliance of a material with the standard, which shall be issued immediately after testing of this material, shall be reviewed every 5 years.
- In case there is no change in the product characteristics and manufacturing process, and no change in the requirements (TSI), it is not required to perform new testing of this material. In this case, the certificate needs only to be updated regarding its date of issue.

J.1 Standards or normative documents

	TSI		Normative document	
Number	Characteristics to be evaluated	Section	Document no.	Mandatory points
58	Measures to prevent fire – Material requirements	4.2.10.2.1	EN 45545-2:2013	Relevant section (1)

Excerpt from Commission Regulation (EU) No. 1302/2014 of November 18, 2014
(Source: eur-lex.europa.eu)

1.3 Basic terms

1.3.1 Requirement set

Each requirement set contains a list of the fire protection technology requirements to be taken into consideration.
The requirement sets are designated with the letter R (requirement set) and a serial number, such as R22. In total, there are 26 requirement sets (R1 to R26), each containing between one and six requirements.

There are three requirements in requirement set R22: the oxygen index, the smoke gas toxicity, and the smoke gas development.

Requirement set	Requirement (assessment parameter)
R22	Oxygen index
	Smoke gas development
	Smoke gas toxicity

Requirement set with assessment parameters

The primary requirement sets relevant for Phoenix Contact are:
- R26 as listed material for terminals and M12 connectors
- R15 as listed material for internal cables
- R22, R23, and R24 for the grouping rules

→ The dependencies between the requirement sets are discussed in Section 1.4.4 Multiple classification.

1.3.2 Hazard level

The hazards levels are used to define the limit values to be complied with when testing the fire protection technology. The hazard level is defined by the operating class and design classification of a train. These terms are defined in EN 45545-1. Tunnel operation and evacuation options, for instance, are considered in the operating class. Design classifications differ, for instance, between double-decker vehicles or sleeper cars.

Operating class	Design classification			
	Standard vehicles	Vehicles for automatic driving operation	Double decker vehicles	Sleeper and couchette cars
1	HL1	HL2	HL2	HL3
2	HL2	HL2	HL2	HL3
3	HL2	HL2	HL2	HL3
4	HL3	HL3	HL3	HL3

Simplified representation of assignment to hazard levels

Examples of the hazard level determined with the operating class and design classification:
- Above-ground operation, standard vehicle → HL1
- No side evacuation option, sleeper car → HL3

HL1 thus designates the lowest and HL3 the highest requirements. The actual HL required, however, is defined by the manufacturer and/or the operator.

* The English terms hazard level and requirement set are also used frequently in German.

1.3.3 Fire protection technology requirements

The requirements included in the requirement sets consist of the assessment parameters (e.g., the oxygen index), the test procedure (standard) and the limit values to be complied with. Each of the limit values are assigned to hazard levels HL1 to HL3. The values for HL1 designate the lowest and the values for HL3 the highest requirements. The fire protection technology test defined must be performed for each requirement.

Connection technology from Phoenix Contact for the railway industry is allocated to the classifications HL1 to HL3 in accordance with the requirement sets R22, R23, R24, and R26.

Designating HL3 would be sufficient, as it includes the lower-level requirements defined in HL2 and HL1. However, to prevent any misunderstandings, HL1 and HL3 are typically mentioned in the documentation.

→ The fire protection technology tests that are relevant for Phoenix Contact products are described in more detail in the brochure "Expertise in connection technology."

Requirement set	Requirement		HL1	HL2	HL3
	Assessment parameter	Test procedure			
R24	Oxygen index	EN ISO 4589-2			
R22	Smoke gas development	EN ISO 5659-2			
	Smoke gas toxicity	EN 17084 (NF X70-100-1/-2)			
R26	Vertical small burner test	UL94 or EN 60695-11-10	V0	V0	V0

Requirement sets with test procedures

Fire protection on railway vehicles (DIN EN 45545-2)	Hazard Level
R22	HL1 to HL3
R23	HL1 to HL3
R24	HL1 to HL3
R26	HL1 to HL3

Documentation of the hazard level in the Phoenix Contact eShop

1.4 Fire protection technology verifications for conformity assessment

Conformity with fire protection technology requirements must be verified for the components and materials to be used in rolling stock. The certifications necessary for verification and validation of the design must conform to the specifications of EN 45545.
These specifications apply to both the testing and classification reports as well as to the required accreditation of the laboratory.

To assess conformity, the various parts of EN 45545 each refer to EN 45545-1. Thus, Part 1 includes regulations relating to the conformity assessment for all standard parts. EN 45545-1 requires different verifications, depending on the standard part that references this. Clause 8.2 Design verification and validation stipulates that for EN 45545-2, the declarations of conformity must include a verification of the test reports and/or the results from test reports on the fire behavior of materials and/or components. In typical cases, EN 45545-2 is relevant for the Phoenix Contact portfolio.

The declaration of conformity can therefore be completed with the results of the fire protection technology tests in the test reports. The FCIL (Fire Certificate Inventory List) from Unife is one option for doing this. The alternative verification option mentioned may also be provided in the form of a classification report. This is not a normative requirement, though.

A component or material is classified upon issuance of the declaration of conformity. Classification is therefore the process of determining and documenting the hazard level (HL1-HL3) for a requirement set.
Typically, the materials from which the item is produced are classified for Phoenix Contact products.

In addition to the specifications on the declaration of conformity, EN 45545-1 also defines under clause 8.2 Design verification and validation that testing laboratories that conduct the tests must be accredited in accordance with EN ISO/IEC 17025.

1.4.1 Test reports

To verify the fire protection technology characteristics, the tests indicated in the relevant requirement set must be performed, while taking the applicable testing parameters into account. The test report contains the values measured for the tests to be completed as the testing result. It must also include a unique test report number and the date of issue.

1.4.2 Classification reports

The classification report is prepared based on the test report(s). It must include a unique classification report number, date of issue, and reference to the test reports.

1.4.3 Validity period

The validity period for the reports is defined by TSI LOC&PAS (see 1.2 Integration into EU law through the TSI LOC&PAS).

The test reports, or the classification reports based on them, must not be more than five years old.
It is possible, however, to declare conformity with the fire protection technology requirements after the five-year period has expired with a declaration of manufacture. One important requirement for this is that the manufacturing process for the products and the product characteristics have not changed.

4.2.10.2. Measures to prevent fire

4.2.10.2.1. Material requirements

(3) In order to ensure constant product characteristics and manufacturing process, it is required that:
- The certificate to prove compliance of a material with the standard, which shall be issued immediately after testing of this material, shall be reviewed every 5 years.
- In case there is no change in the product characteristics and manufacturing process, and no change in the requirements (TSI), it is not required to perform new testing of this material. In this case, the certificate needs only to be updated regarding its date of issue.

Excerpt from Commission Regulation (EU) No. 1302/2014 of November 18, 2014
(Source: eur-lex.europa.eu)

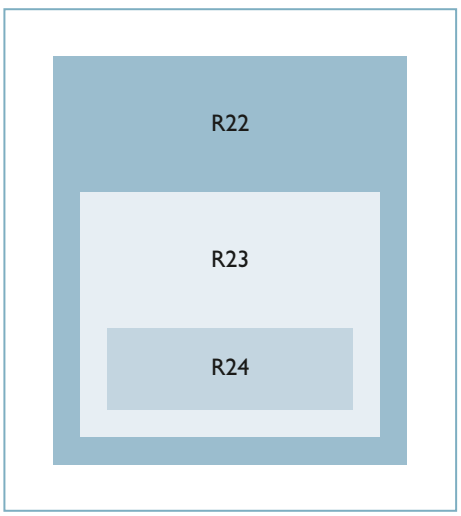
1.4.4 Multiple classification

Test procedures are included in several requirement sets. After the test is completed, a component may be classified for all requirement sets that are based on the same tests. This process is referred to as multiple classification.

For example
Requirement sets R22 and R23 include the same test procedures. These are the oxygen index, smoke gas toxicity, and smoke gas development. The measured value for each test is indicated in the test report for a component as the result. This makes it possible to classify a component in accordance with the criteria for R22 and R23 after the tests have been completed.

For R22, the requirements for achieving the respective hazard level are more stringent than those for requirement R23. So, a classification for R22 therefore always includes a classification for R23.

Requirement set R24 includes only the oxygen index as the test procedure.
A classification under R22 and R23 therefore includes the R24 classification in turn.

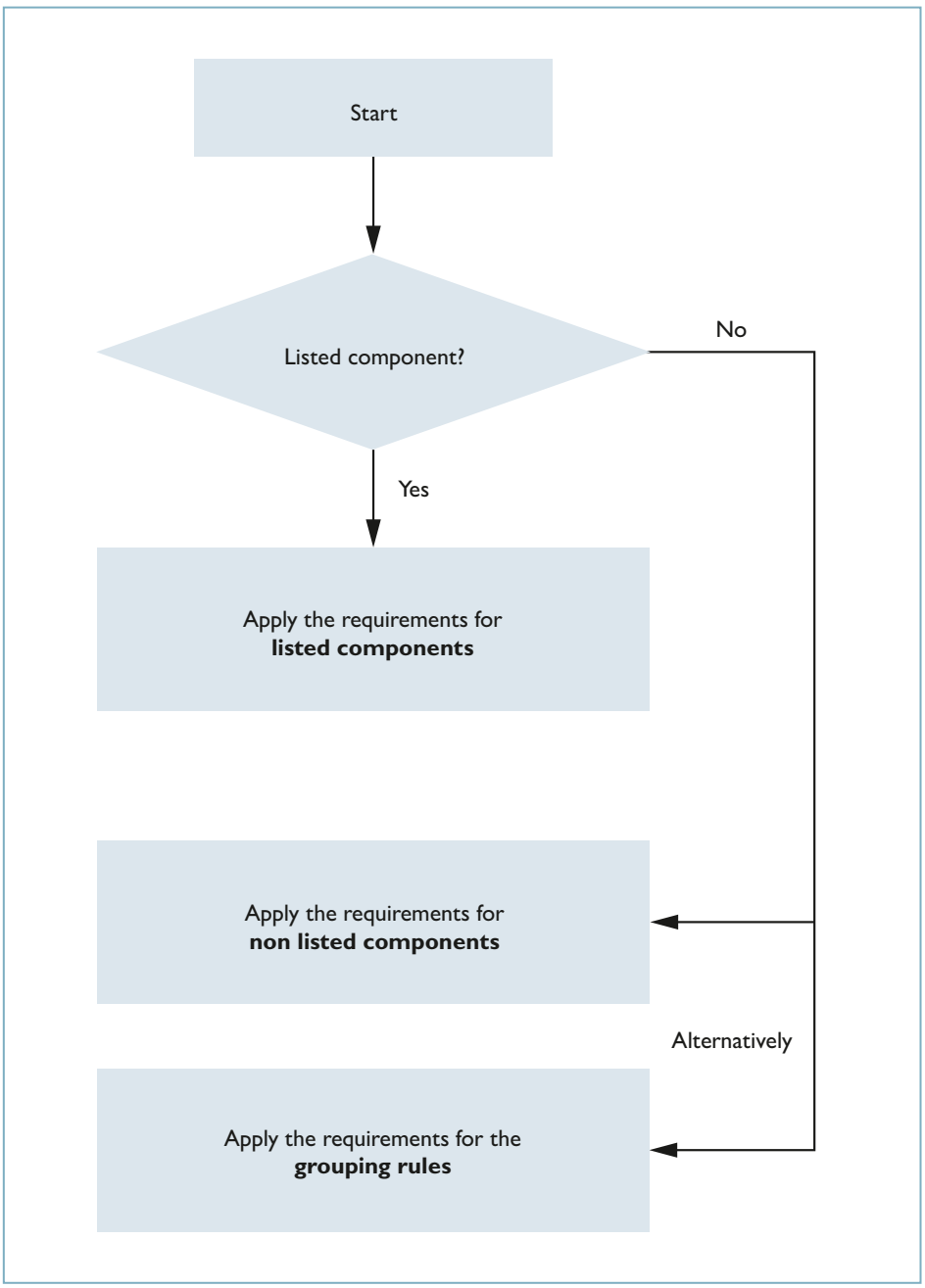


Multiple classification for R22, R23, and R24

1.5 Fire protection technology assessment process

EN 45545-2 requires a step-by-step process for completing the fire protection technology assessment. First, the assessment must determine whether the component is a so-called listed component. What this means is that the component is included in a tabulated list included in the standard. If this is the case, the relevant requirements must be taken from this list and applied. The procedure for listed components is described in Section 1.5.1.

If the component is not listed material, there are two options. First, there is the option to apply the requirements for non-listed components, see Section 1.5.2 "Non-listed components." Alternatively, the standard offers another option of applying the so-called grouping rules. They are explained in Section 1.5.3 "Grouping rules."



Flow chart of the procedure

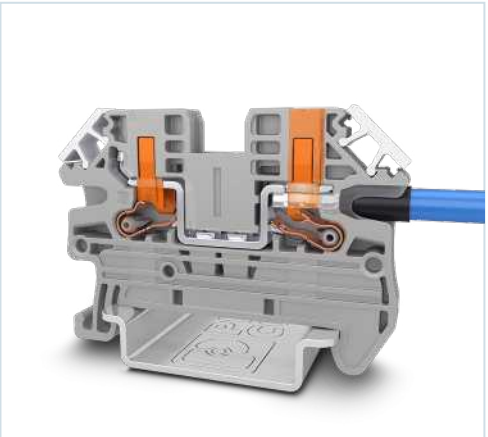
1.5.1 Listed components

The normative term of a listed component refers to table 2 “Requirements for listed components.” If a component is included in this table, it should be treated as a listed component.

EL10	Electrotechnical and electronic low power components	R26

Excerpt from table 2 – Requirements for listed components of DIN EN 45545-2:2020-10

Products in the Phoenix Contact product portfolio are included in the group Electrotechnical equipment (Electrotechnical E1-E10). Typically, they are found in the subgroup “Low-power electrotechnical and electronic components” (EL10). Requirement set R26 applies to this subgroup.



The Phoenix Contact products relevant for railway use fulfill the requirements of R26 and, depending on the product group, also requirement sets R22, R23, and R24, which are relevant for the grouping rules.

1.5.2 Non-listed components

There are separate normative requirements for components that are not listed components. They depend on the exposed area and installation location (interior/exterior).

Typically, requirement set R22 applies to Phoenix Contact products. Alternatively, the standard offers the option of applying the grouping rules. These are explained in the following sections.

Exposed area	Installation location	Requirement set
>0.2 m²	Interior	R..
>0.2 m²	Exterior	R..
≤0.2 m²	Interior	R22
≤0.2 m²	Exterior	R..

Excerpt from table 3 – Requirements for non-listed components of DIN EN 45545-2:2020-10

1.5.3 Grouping rules

The grouping rules provide a way to classify components that are not part of the listed components but also cannot be classified as non-listed components.

Various factors such as the flammable mass, distance, fire protection technology separation, and existing classifications must be taken into consideration and combined when applying the grouping rules. The fire protection technology requirements become more stringent as the mass of the components to be assessed increases. They range from "no requirements" to those listed under requirement set R22.

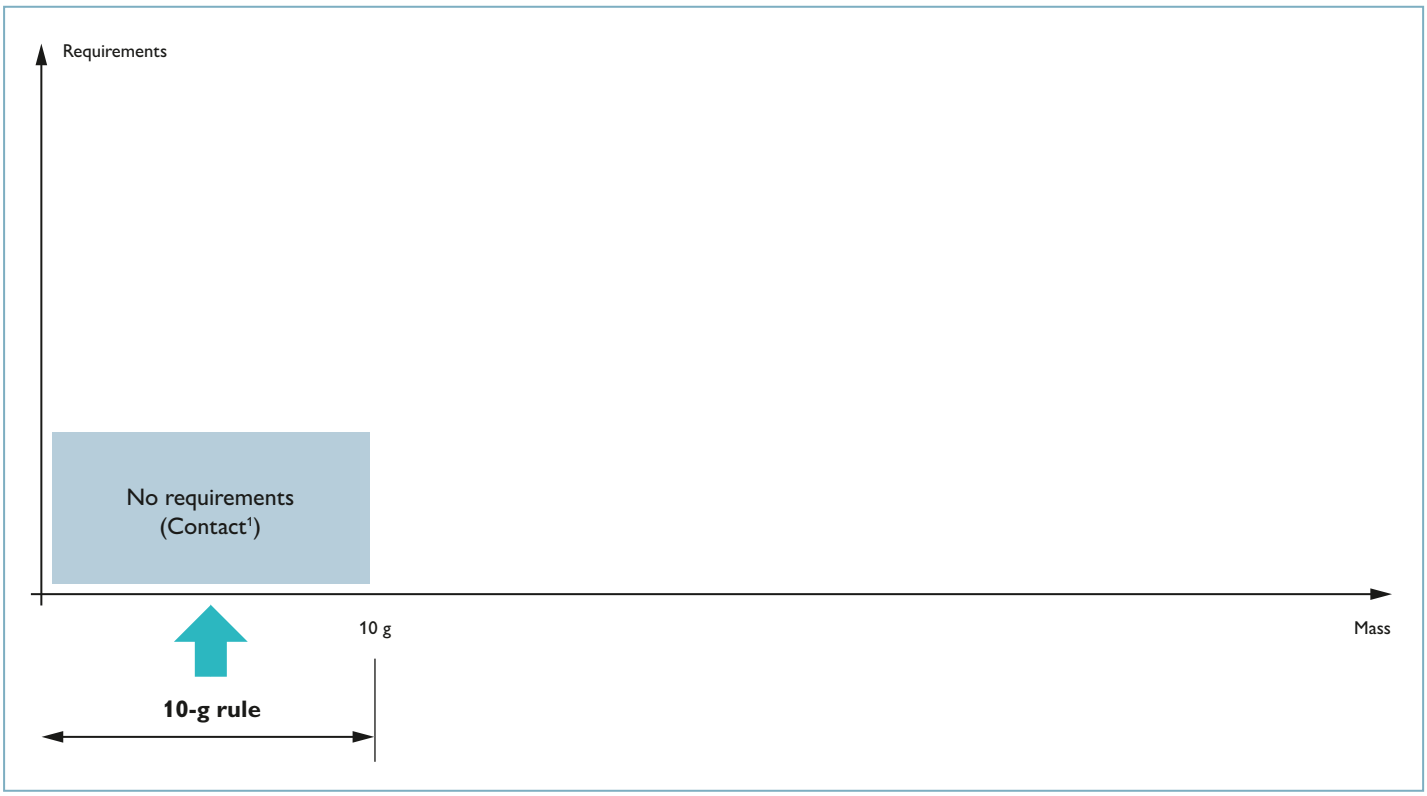
Grouping as understood under EN 45545-2 means adding up the flammable masses of all components under consideration. The fire protection technology assessment must be performed for the calculated (grouped) flammable mass.

Typically, the grouping rules can be applied to Phoenix Contact products. The following apply to the components under consideration:

- The exposed area must be ≤0.2 m².
- The mass must be >10 g.
- The distance regulation must be considered.

Components that have an effective separation through fire protection technology do not need to be taken into consideration.

The limit values for the flammable mass must be taken into consideration when applying the respective grouping rule. The following section uses the values for interior use to explain the system. The limit values for exterior use are listed in the summary at the end of this section.

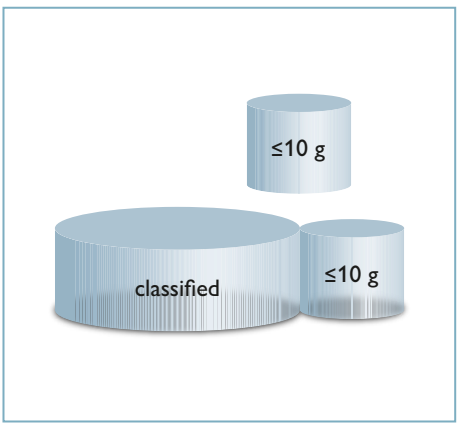


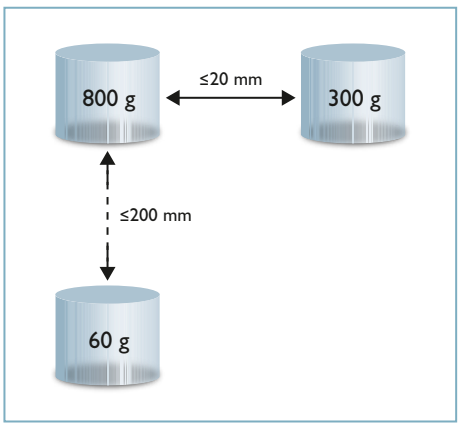
[1] Contact permitted only with classified components

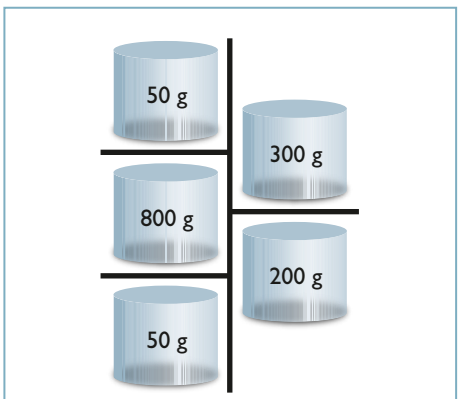
10-g rule
Components with a flammable mass of up to 10 g are not included in the fire protection technology assessment. The requirement for this is that no other components are touched, or only classified ones.

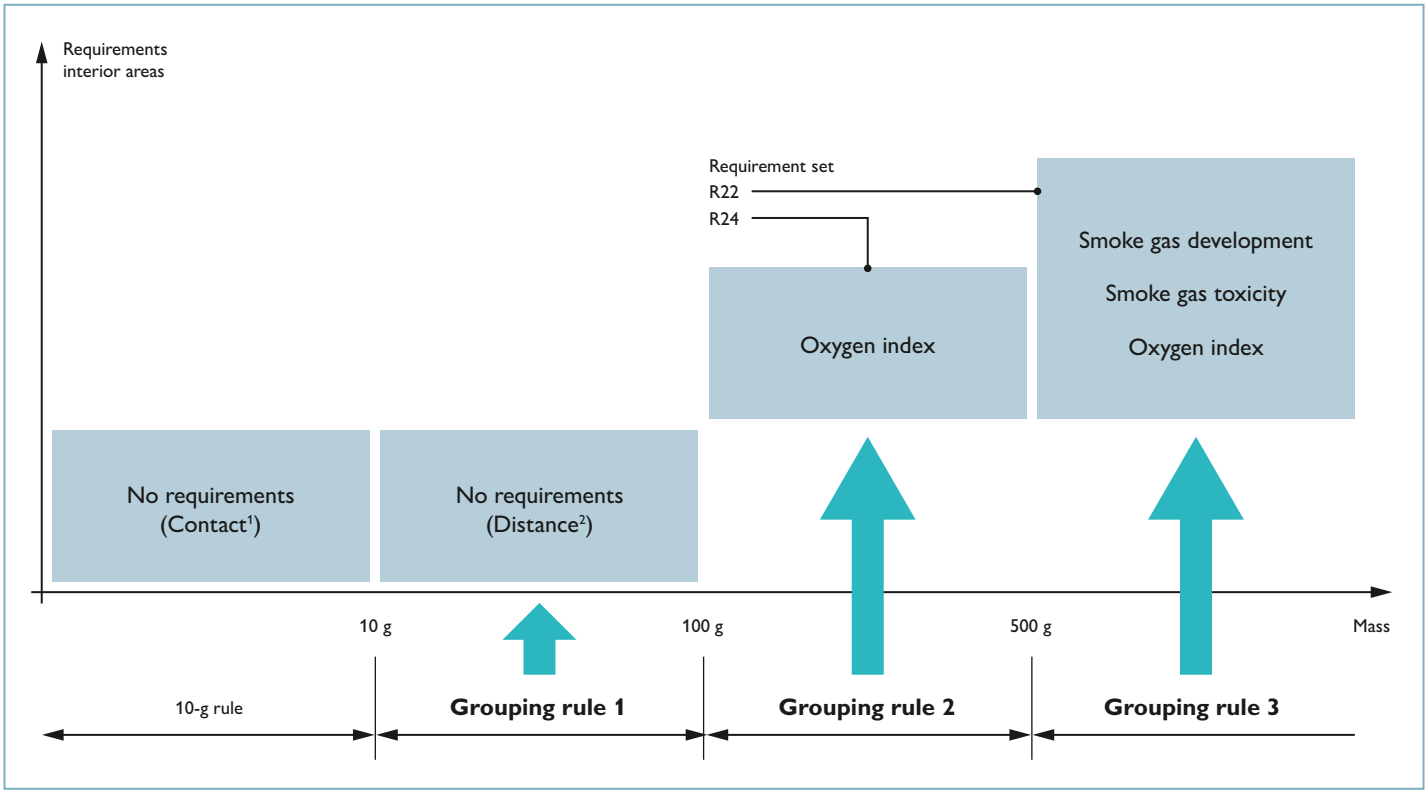
Distance rule
Components (>10 g) with a horizontal distance of up to 20 mm and vertical distance of up to 200 mm must be grouped. This means that the entire flammable mass of these components must be taken into consideration in the assessment.

Effective separation through fire protection technology
Components that have effective separation through fire protection technology should not be grouped. This means that each individual component must be assessed individually.







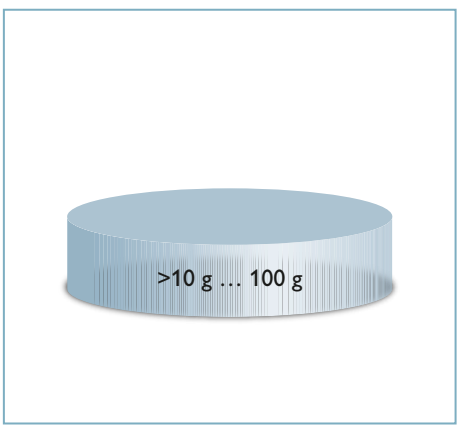


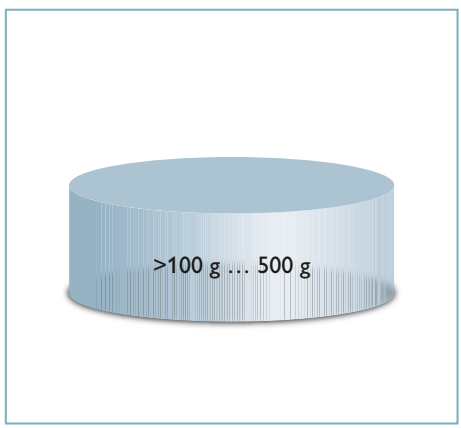
[1] Contact permitted only with classified components
[2] The distance rule must be observed

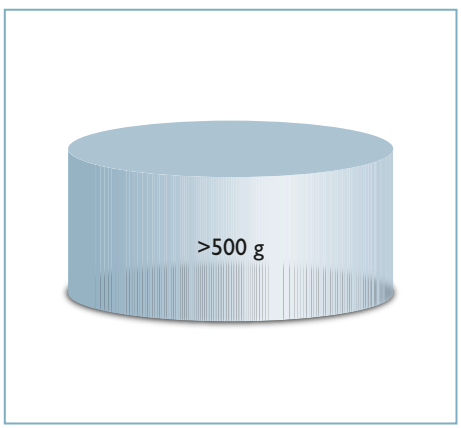
Grouping rule 1
Individual components or grouped components with a flammable mass of up to 100 g are not included in the fire protection technology assessment. The minimum distances indicated in the distance rule must be complied with here.

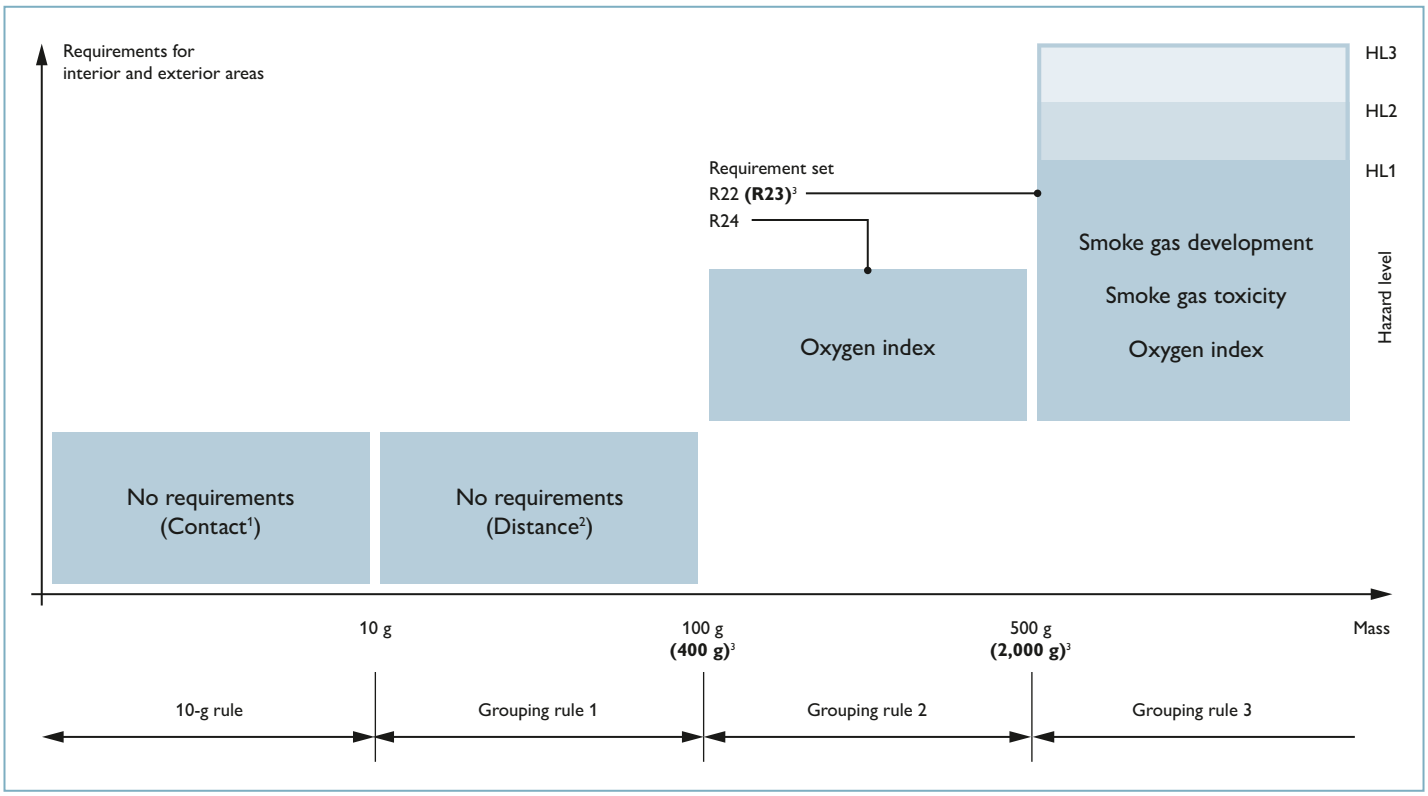
Grouping rule 2
Individual components or grouped components with a flammable mass of up to 500 g must fulfill the requirements of requirement set R24. However, this requirement only applies for a mass exceeding 100 g.

Grouping rule 3
Individual components or grouped components with a flammable mass over 500 g must fulfill the requirements of requirement set R22. However, this requirement only applies for a mass exceeding 500 g.









[1] Contact permitted only with classified components
[2] The distance rule must be observed
[3] Values in parentheses () apply to outdoor areas

Summary

The graphic is a complete illustration of the grouping rules, supplemented with values for exterior areas. Lower requirements apply to exterior areas than to interior areas. Therefore, the limit values for flammable mass are significantly higher. Furthermore, requirement set 23 applies to exterior areas for grouping rule 3, with lower requirements than R22.

The stringency of the requirements, which depends on the flammable mass, is defined by the applicable requirement set. However, there are also various levels within a requirement set. These levels are expressed by the respective applicable hazard levels HL1-HL3. The graphic illustrates this, using requirement set R22 as an example.

1.6 Application examples for grouping rules

The application examples make it easier to understand and thus to apply the grouping rules. They show that the use of a component in a train depends not only on the material characteristics and mass, but also on the distance and any existing separation by fire protection technology.

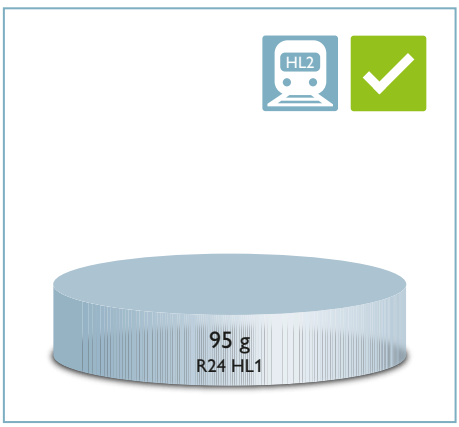
The applicable hazard level is specified by the manufacturer or operator. It is a static requirement for the project. HL2 is defined as the requirement for all of the examples in this section.

The HL rating of a component for a requirement set is a material characteristic that has been determined through fire protection technology tests. However, the fact that a component can have different HL ratings for different requirement sets must be taken into account. For example, RL24 HL3 classification and R22 HL1 classification are possible at the same time.

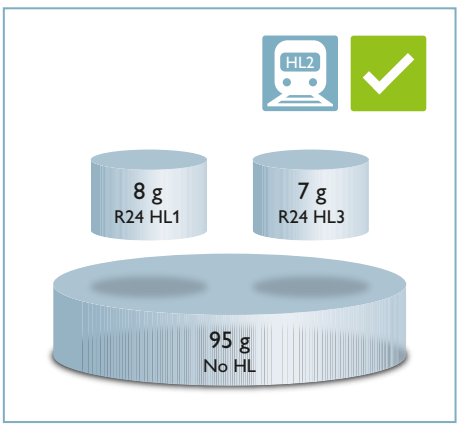
Which requirement set applies to a certain use case is determined by applying the grouping rules. Examples 5 and 6 show that a different requirement set will apply to the same components if the distance is reduced.

After determining the applicable requirement set, refer to the product documentation for the appropriate HL rating. This HL rating must be greater than or equal to the HL rating in the requirement.

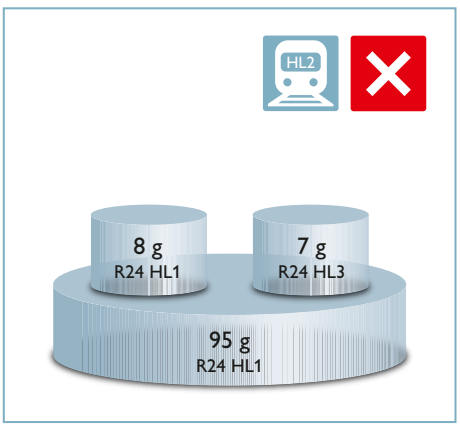
With the exception of example 7, all of the following examples are designed for interior areas inside the train. The relevant limit values for flammable mass apply to implementation of the grouping rules.



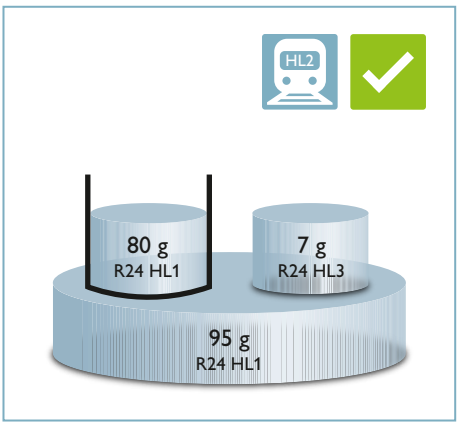
Example 1
The HL1 classification of the components does not conform to the HL2 requirement. However, pursuant to grouping rule 1, no requirements apply to the component under consideration of the distance rule. Use is permitted.



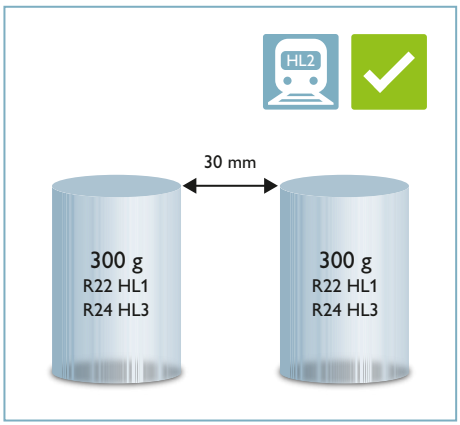
Example 2
There are no requirements for components <10 g, since they do not come into contact with any other components. The 95 g component is not classified. Grouping rule 1 should be applied. Therefore, there are no requirements for the components. Use is permitted.



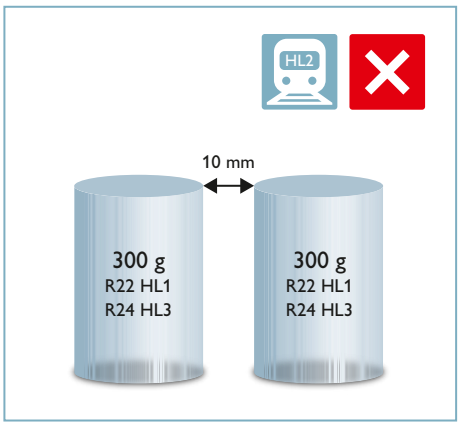
Example 3
The HL1 components should be grouped, but not the HL3 components. The grouped mass is 103 g. Therefore, pursuant to grouping rule 2, requirement set R24 applies. The grouped components are classified as HL1 for R24. The HL2 requirement is not fulfilled and use is not permitted.



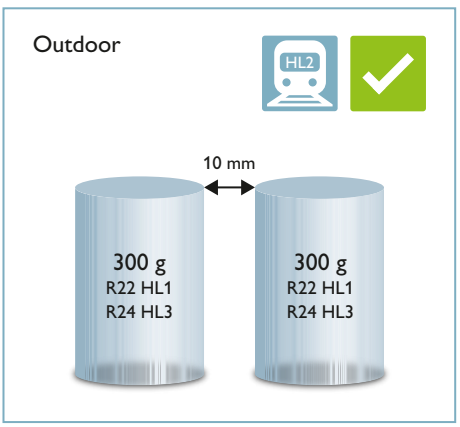
Example 4
The 80 g component has effective separation through fire protection technology. Therefore, it and the HL3 component should not be considered when calculating the grouped mass. No requirements apply to the components. Use is permitted.



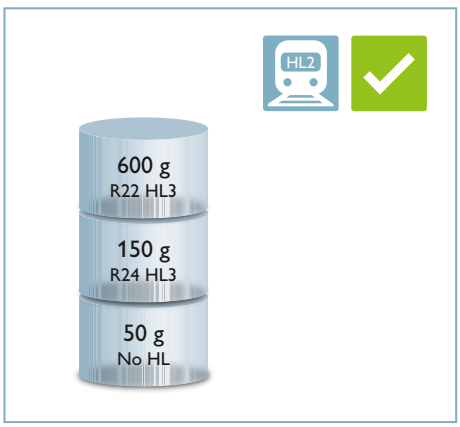
Example 5
There are two components of 300 g each installed for which the distance rule is considered. The components should not be grouped. Therefore, requirement set R24 applies, respectively. The components are classified for R24 with HL3. Requirement HL2 is fulfilled and use is permitted.



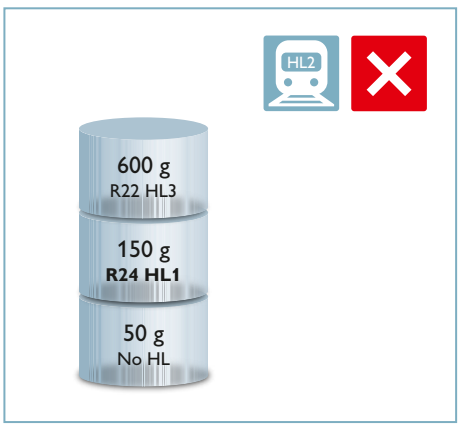
Example 6
The same components as in example 5 are installed for which the distance rule is not considered. The grouped mass is 600 g. Therefore, requirement set R22 applies. The components are classified for R22 with HL1. The HL2 requirement is not fulfilled and use is not permitted.



Example 7
The same components with the same distance as in example 7, however they are used in an exterior area! Therefore, requirement set R24 applies. The components are classified for R24 with HL3. Requirement HL2 is fulfilled and use is permitted.



Example 8
R22 applies for the mass exceeding 500 g, and R24 applies for the mass exceeding 100 g. The HL3 classification of these components fulfills the HL2 requirement. Use according to grouping rule 1 is permitted for the remaining non-classified 50 g component.



Example 9
As opposed to example 8, the 150 g component is classified only as HL1 for R24. Therefore, the HL2 requirement for the mass exceeding 100 g is not fulfilled. Any consideration of the other components is therefore not relevant. Use is not permitted.

Closing remarks

This document provides an overview of EN 45545-2. The objective is to provide an introduction to help readers understand and correctly apply the standard.

Many years of practical experience among Phoenix Contact specialists have been incorporated in the selection and structure of the content. This experience is reflected in the section on grouping rules, for instance. Correctly applying the grouping rules requires considering the complex interactions between flammable mass, material properties, distances of the components to one another, the installation location, and effective separation through fire protection technology. To ensure a solid understanding for this, we not only explained the rules, but we also added simple graphic elements to provide additional practical examples.

However, dealing with all aspects of EN 45545-2 in full is not the goal of this document. Readers should have the standard at hand in order to compare the information provided here with the content of the standard and to expand and deepen their knowledge. When deciding on which components to use in railway vehicles, it is absolutely essential to obtain the standard, as it is the only one that is authoritative in this respect. This document is not meant as a replacement for the standard.

Disclaimer

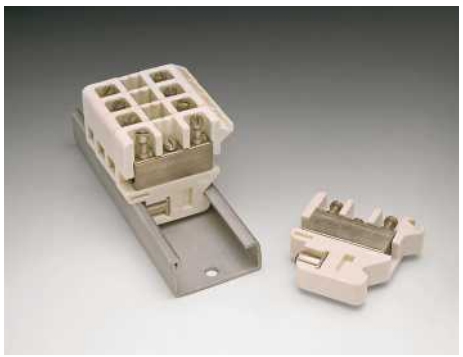
The contents of this brochure were prepared with the utmost care. However, the information provided here is not binding. The current product documentation is always decisive for correct, complete, and up-to-date information.

Your partner for the railway industry

We offer products and solutions that satisfy the stringent requirements of the railway industry. As a competent partner with decades of experience, we are at your side with advice.

1923: Company founded

Hugo Knümann founds a commercial agency for electrical products in Essen and sells contact wire terminals for streetcars.



1928: Terminal block

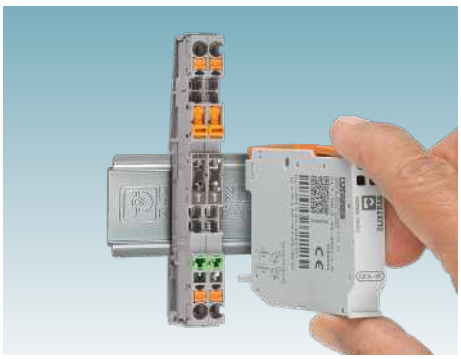
With the development of the terminal block, Phoenix Contact shaped standards for electrical connection technology. Many other innovations were to follow.

1983: Surge protection

The first marshalling yard was equipped with SPDs in 1985. The high-performing pulse and high-current laboratory for lightning and surge protection was opened in 2014.

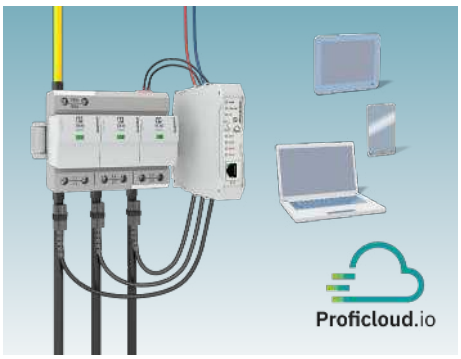
1990: Power supply

With in-house development and production of power supply solutions, we are able to react quickly and flexibly to market and customer requirements.



Today

Phoenix Contact has been developing innovative and reliable products for over 95 years. By doing so, the company fulfills the unique requirements of the railway industry.



In the future

We want to work with our customers to fully utilize digitalization options, for instance to increase system availability and reduce workloads.

Open communication with customers and partners worldwide

Phoenix Contact is a global market leader based in Germany. We are known for producing future-oriented products and solutions for the electrification, networking, and automation of all sectors of the economy and infrastructure. With a global network reaching across more than 100 countries with over 22,000 employees, we maintain close relationships with our customers, something we believe is essential for our common success.

Our wide range of innovative products makes it easy for our customers to implement the latest technology in a variety of applications and industries. This especially applies to the target markets of energy, infrastructure, industry, and mobility.

You can find your local partner at

phoenixcontact.com

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