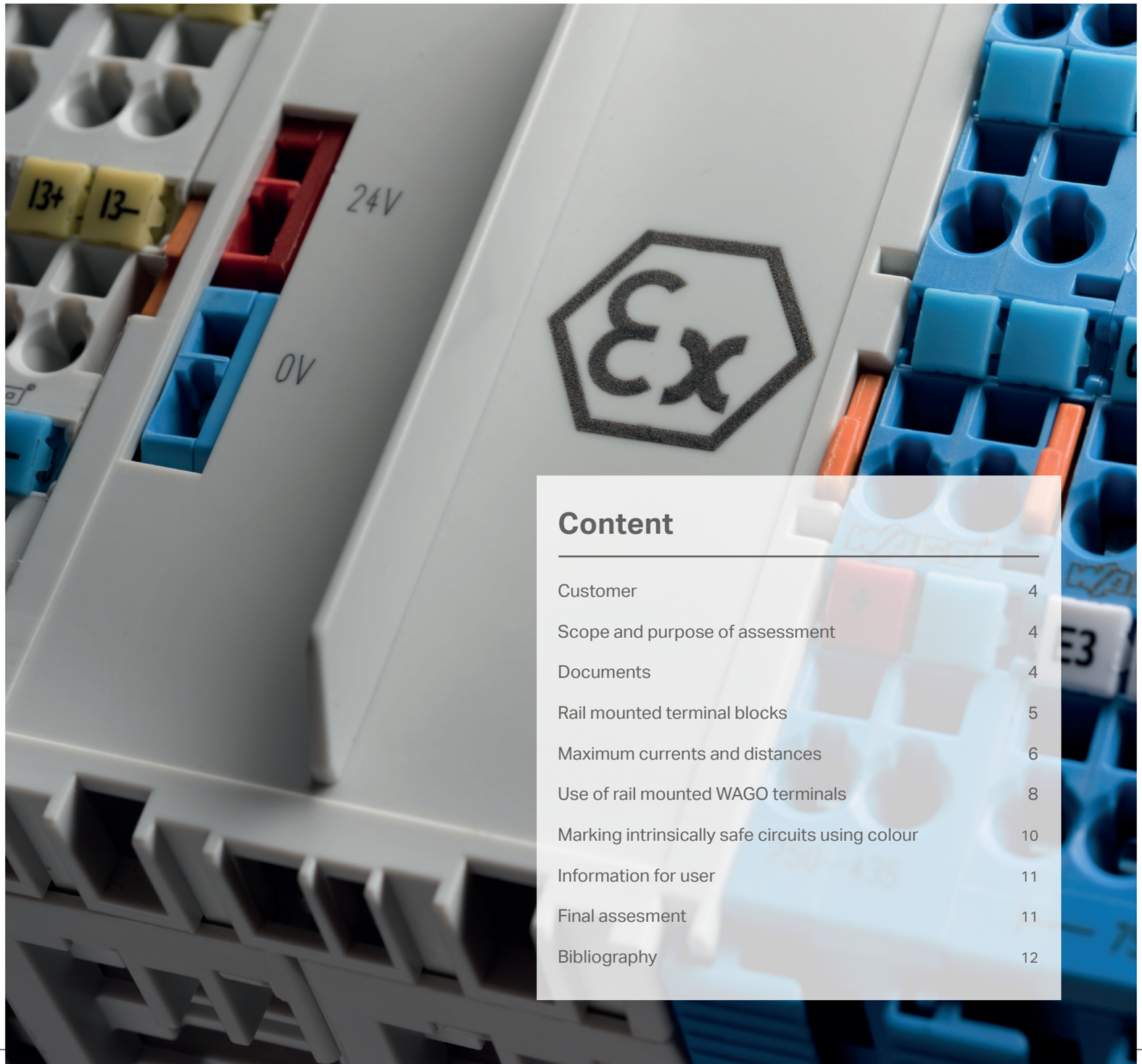
INCREASED SAFETY IN INTRINSICALLY SAFE CIRCUITS

WITH WAGO'S RAIL-MOUNT TERMINAL BLOCKS (Ex e)



Content

Customer	4
Scope and purpose of assessment	4
Documents	4
Rail mounted terminal blocks	5
Maximum currents and distances	6
Use of rail mounted WAGO terminals	8
Marking intrinsically safe circuits using colour	10
Information for user	11
Final assesment	11
Bibliography	12

THE USE OF INCREASED SAFETY (Ex e) RAIL MOUNTED TERMINAL BLOCKS MANUFACTURED BY WAGO IN INTRINSICALLY SAFE (Ex i) CIRCUITS

Content

1. CUSTOMER **4**

2. SCOPE AND PURPOSE OF ASSESSMENT **4**

3. DOKUMENTS **4**

4. RAIL MOUNTED TERMINAL BLOCKS **5**
as Ex e (increased safety) Ex components

5. MAXIMUM CURRENTS AND DISTANCES **6**
on intrinsically (Ex i) equiptment and circuit terminals

6. USE OF RAIL MOUNTED WAGO TERMINALS **8**
in intrinsically safe apparatus and circuits

a. Intrinsically safe Equipment **9**
b. Intrinsically safe systems **10**
c. Intrinsically safe circuits temperatures **10**

7. MARKING INTRINSICALLY SAFE CIRCUITS USING COLOUR: **10**
light blue rail mounted terminal blocks

8. INFORMATION FOR USER **11**

9. FINAL ASSESMENT **11**

Bibliography **12**

List of Annexes **12**

1. CUSTOMER AND AUTHOR

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Author: Present paper has been prepared on the basis of the technical assessment ExKTK 21.13 ed.1 issued by ExKontakt in Katowice, Poland (ExKontakt.eu). The author of the technical assessment is Michał Górny, PhD.

2. SCOPE AND PURPOSE OF ASSESSMENT

The increased safety rail mounted terminal blocks (Ex e) produced by WAGO are successfully used in many explosion-proof devices. These terminals, mainly intended for rail mounting, are producedin many types and current ranges. They are also subject to certification (third party assessment)according to the requirements of various certification systems (conformity assessment according to the ATEX directive, certification according to IECEx and others).

Rail mounted terminal blocks are Ex components within the meaning of the 60079-01 standard and components within the meaning of the ATEX2 directive. The purpose of this assessment is to clarify under what conditions and whether WAGO rail mounted terminal blocks (Ex e – increased safety) can be used in intrinsically safe devices and circuits (Ex i).

3. DOCUMENTS

For the purposes of this assessment, the commissioner has provided:

- Overview drawings and information brochures

Michał Górny, PhD.

[1] The standards referred to in the text are given in the bibliography at the end of the document
[2] 2014/34/UE Directive reference in report as „ATEX Directive", transposed into Polish law by Regulation on conformity assessment and market surveillance (Dz. U. No 2016/542 dated 19.04.2016) and by Regulation of Minister of Economic Development of 6 June 2016 .... (Dz.U. No 2016/817 dated 9.06.2016)

4. RAIL MOUNTED TERMINAL BLOCKS

AS Ex e (INCREASED SAFETY) EX COMPONENTS

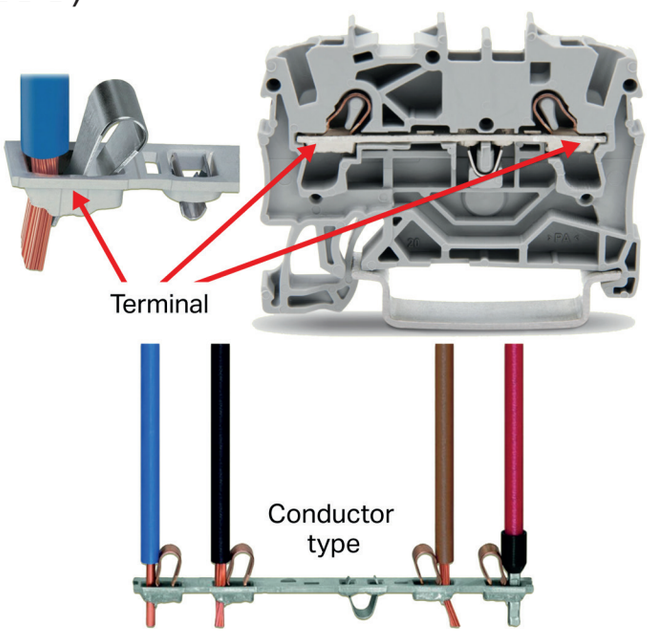
According to the definition given in the standard 60079-7, an increased safety is a Type of Protection applied to electrical equipment or an Ex Component in which additional measures are applied so as to give increased security against the possibility of excessive temperatures and the occurrence of arcs and sparks. So, in practice, it is such a construction in which the cross sections of conductors and, insulation distances (creepages and clearances) are increased and sparking elements (e.g. connectors) are eliminated. So “increased” refers to the “better” electrical design.

Details for the required insulation distances depending on the material used are given in the 60079-7. The temperature issues (increase of the clamp temperature during current flow) are related to the general industrial requirements. A properly selected rail mounted terminal block (according to the data specified by the manufacturer, i.e. the maximum current allowed by the manufacturer) does not heat up above the permissible values.

Only the grouping of terminal blocks in a limited space (e.g. inside a general-purpose junction box) and connecting the wires may result in excessive temperatures. But these aspects are the responsibility of the manufacturer of the final equipment (in this case the manufacturer of a general purpose junction box) - after using the connectors in the final equipment, it is required to measure the temperature rise.

In the case of WAGO rail mounted terminal blocks in the scope of increased safety, the manufacturer is responsible for:

- selecting the insulating material;
- providing insulation distances (clearances and creepages) - to other conductive elements (in
- the vicinity and in the adjacent terminal blocks);
- ensuring the correct structure of the clamp - ensuring the correct clamping of the wire that does not deteriorate during use.



An example of a WAGO rail mounted terminal block is shown in Figure 1.

The required insulation distances depend on the insulation material used. 60079-7 distinguishes 4 groups of materials depending on CTI - see Table 1.

Material group	Comparative tracking index (CTI)
I	600 ≤ CTI
II	400 ≤ CTI < 600
IIIa	175 ≤ CTI < 400
IIIb	100 ≤ CTI < 175
NOTE: It should not be confused material groups (I, II, IIIa and IIIb) with equipment’sgroups (I, II, III) according to 60079-0 and 80079-36.	

Table 1: Tracking resistance of insulating materials [60079-7]. The material used by WAGO is the material group I (CTI ≤ 600).

The minimum insulation distances applied in WAGO rail mounted terminal blocks, depending on thevoltage (most connectors are 800 V, some double decked rail mounted terminal blocks are 500 V) meet the requirements of 60079-7, see Table 2.

Voltage URMS AC / DC [V]	Minimum creepage distance [mm]								Minimum clearances and separations [mm]		
	Material group										
	I		II		IIIa		IIIb		Clearance		Distance under I II IIIa IIIb coating
	„eb"	„ec"	„eb"	„ec"	„eb"	„ec"	„eb"	„ec"	„eb"	„ec"	„ec"
≤ 500	10	6,3	12,5	7,1	16	8	-	8	8,0	5	2,4
≤ 800	16	10	20	11	25	12,5	-	-	12	7	4
NOTE: Mentioned WAGO rail mounted terminal blocks have EPL "eb"											

Table 2: Minimum creepage distances, clearances and separations [60079-7].

Clearance in mentioned WAGO rail mounted terminal blocks is not less than 8 mm.

5. MAXIMUM CURRENTS AND DISTANCES

ON INTRINSICALLY (Ex i) EQUIPMENT AND CIRCUIT TERMINALS

As defined in 60079-11, an intrinsically safe circuit is a circuit, in which any spark or any thermal effect produced under specific conditions, which include normal operation and specified fault conditions, is not capable of causing ignition of a given explosive atmosphere. An intrinsically safe apparatus is an electrical apparatus in which all the circuits are intrinsically safe.

In practice, the concept of intrinsic safety is based on ensuring that the energy released from the circuit as a result of defined faults (including short circuits and breaks) in the form of an electric spark does not lead to the ignition of a specific explosive atmosphere. Taking the above into account, the currents in intrinsically safe circuits are many times lower than the currents in ordinary control or power circuits. The permissible values of intrinsically safe currents also depend on the nature of the circuit (resistive, inductive, capacitive ...). Details including relevant characteristics curves:

- minimum igniting current for resistive circuits depending on the source voltage for equipment's groups I, IIA, IIB and IIC (maximum voltage 300 V, maximum current 5 A);
- permissible value of the circuit inductance depending on the minimum igniting current for the inductive circuits of equipment's group I, IIA, IIB and IIC (maximum ignition current depending on the equipment's group: from approx. 0.3 A to 6 A);

and the tabulated values of the maximum current under short circuit conditions (5 A maximum) are given in 60079-11.

[3] EPL: Equipment Protection Level (Geräteschutzniveau)

The specificity of intrinsically safe circuits (the use of intrinsically safe voltages and currents) requires appropriate protection against the penetration of voltages and currents from other circuits. Hence, the 60079-11 requires appropriate insulation distances at the terminals, not less than 6 mm between the intrinsically safe circuits, 3 mm between the intrinsically safe circuit and the earthed elements, and 50 mm between the terminals of the intrinsically safe circuits and the terminals of the nonintrinsically safe circuits (see Table 3).

Distance (at least)	Terminals
6 mm	Between separate intrinsically safe circuits
3 mm	Between separate intrinsically safe circuits and earthed parts where connection to earth would invalidate intrinsic safety
50 mm	The clearance between bare conductive parts of intrinsically safe and nonintrinsicallysafe terminals

Table 3: Terminals clearance and creepage distances [60079-11].

The rules for determining the spacing between the terminals of separate intrinsically safe circuits and to the terminals of non-intrinsically safe circuits are shown in Figure 2. In practice, in place of a separating partition, the terminals may be separated by a distance of 50 mm.

The distances provided by WAGO rail mounted terminal blocks are greater than the required by 60079-11 (see Table 2).

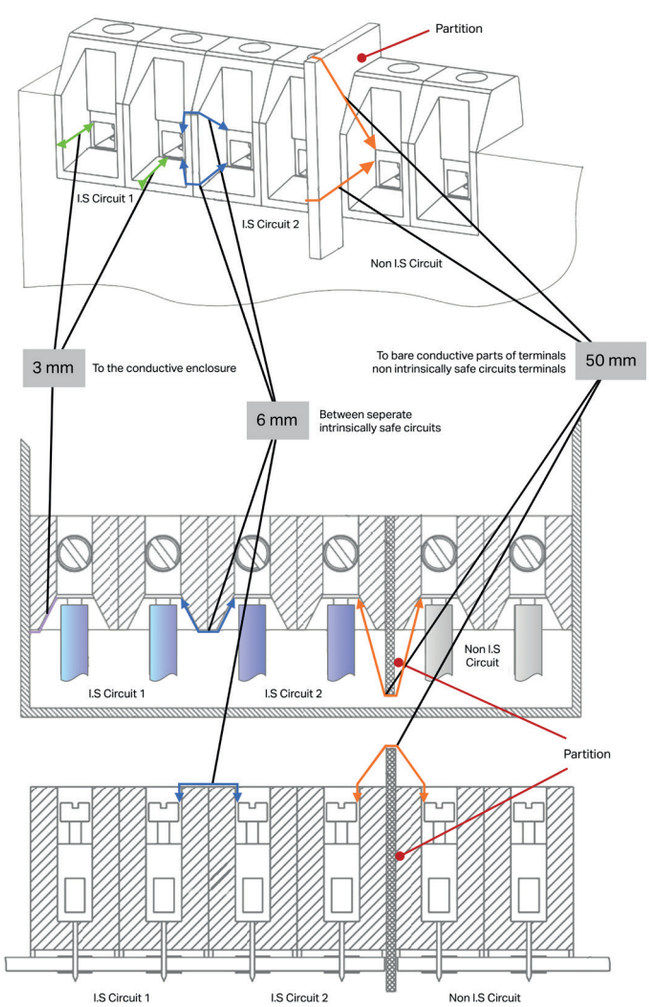
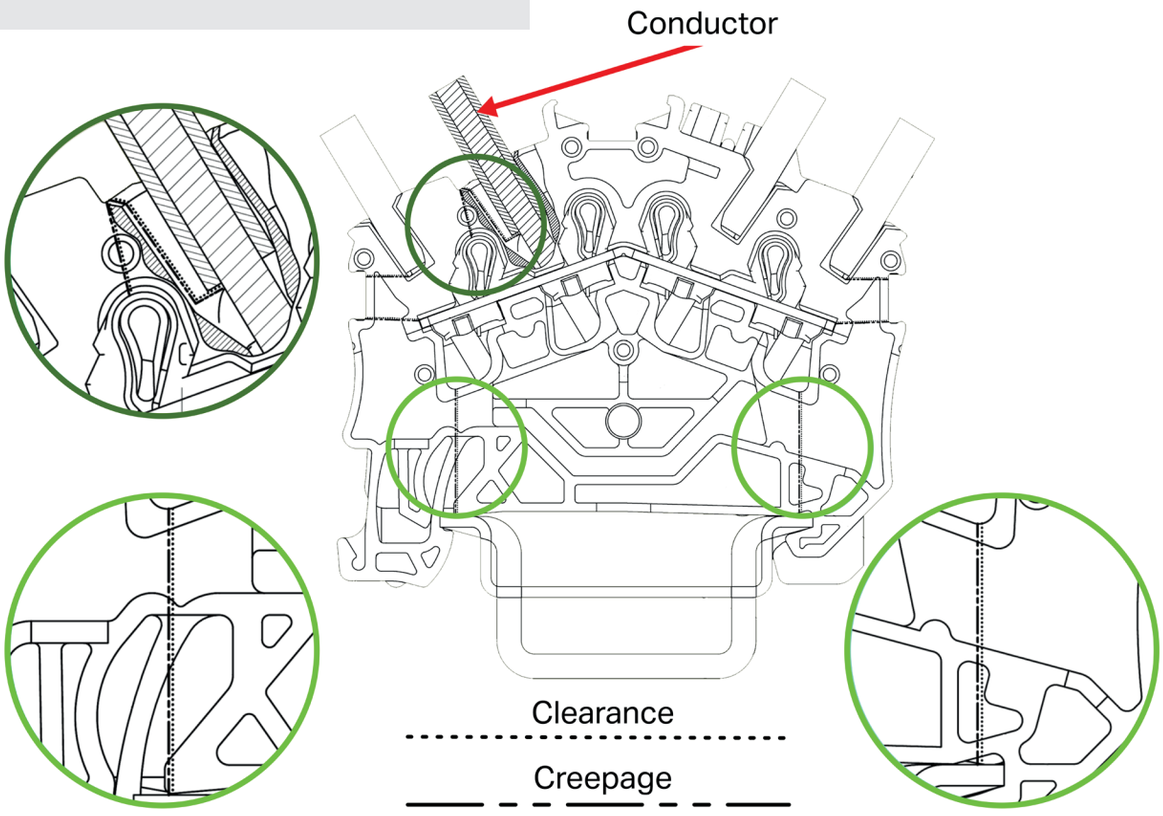


Figure 2: Distances required on intrinsically apparatus / circuit [60079-11]

WAGO (terminal block's manufacturer) indicated appropriate creepages and clearances for all Ex e rail mounted terminal blocks of its production.An example of the designated distances is shown in Figure 3 (the figure shows only some of the designated distances).

Figure 3: Some designated clearances and creepages of sample rail mounted terminal block (WAGO)



6. USE OF RAIL MOUNTED WAGO TERMINALS

IN INTRINSICALLY SAFE APPARATUS AND CIRCUITS

Rail mounted terminal blocks are "components" within the meaning of the ATEX Directive and "Ex components" within the meaning of 60079-0. This means that they do not fully protect against explosion and cannot be autonomously used in a hazardous area. However, they provide a part (fragment) of protection against explosion. Components (according to the ATEX directive) are used by equipmentmanufacturers or users to construct a complete device. The manufacturer of the equipment combines elements of its own production, components and sometimes also other devices and produces a new device (of its own production). Due to the fact that the terminal blocks are components, their use by the manufacturer is much easier. However, it should be remembered that the manufacturer of the component is responsible for his product, also when used in another device.

a) INTRINSICALLY SAFE EQUIPMENT

The requirements for intrinsically safe devices do not include special requirements for terminals. In addition, the standard 60079-0 also only gives general connection requirements - it does not specify spacing or construction. Detailed requirements for the construction of connections, including terminals, are given in the standard 60079-7 (increased safety). Terminals constructed in such a way (Ex e) can be used in any type of explosion-proof construction. Hence, meeting the requirements of the standard 60079-7 (Ex e) gives a pass for use in many devices and types of protection. The decision on the selection of a terminal (component) is made by the manufacturer of the equipment on the basis of its own analysis (risk assessment).

WAGO rail mounted terminal blocks marked with Ex e meet these requirements. Ensuring the required distance of 50 mm is possible both by sliding apart and by using a partition (see Figure 4).

Rail mounted Ex e terminal blocks by WAGO meet the requirements of the intrinsically safe design and can be used in intrinsically safe devices. However, the selection should be the result of an analysis (risk assessment) of the manufacturer of the final device.

b) INTRINSICALLY SAFE SYSTEMS

Intrinsically safe systems are defined in the standard 60079-25 as two types:

- As a combination of intrinsically equipment (equipment + cables + simply apparatus) for which it can be shown by analysis (calculations) that such a system is intrinsically safe.
- As a distributed (extensive) intrinsically safe equipment, which is individually assessed (certified).

In the first case, rail mounted terminal blocks may be used in equipment (already assessed) or simple apparatus (user assessed). As previously shown, WAGO rail mounted terminal blocks provide adequate (required) distances and can be successfully used.

The requirements of the 60079-11 standard include requirements for distances - see Table 3.

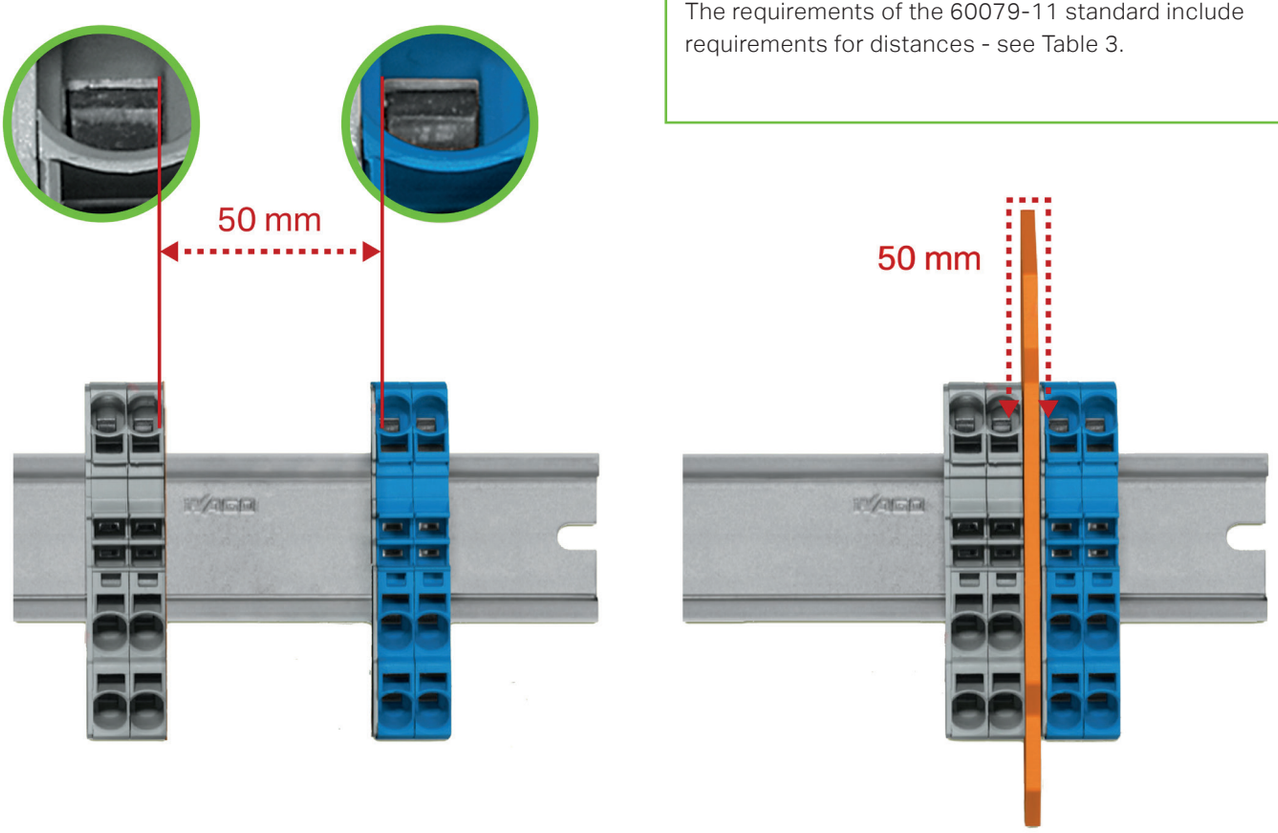


Figure 4: Required distances between bare conductive parts of intrinsically circuit terminals and bare conductive parts of non-intrinsically safe circuit terminals ensured by sliding apart (left) and by using a partition (right).

In the second case (extensive system), the selection of rail mounted terminal blocks is as in the case of the equipment - assessment by the system manufacturer. The rating is identical to that for an intrinsically safe equipment. Here, too, WAGO rail mounted terminal blocks provide the required (required) distances and can be used successfully.

c) INTRINSICALLY SAFE CIRCUITS TEMPERATURES

In addition to the requirement of the maximum electric spark energy that can be released as a result of a short circuit or break (or more generally in fault condition) in the intrinsically safe circuit, the temperatures achieved by the intrinsically safe equipment during operation are also assessed (taking into account the fault conditions).

Rail mounted Ex e terminal blocks by WAGO are intended for use in circuits with much higher currents than in intrinsically safe circuits (the maximum typical current in an intrinsically safe circuit does not exceed 5 A - see page 8) and in these conditions the temperature at the terminals does not exceed the temperature of the T6 temperature class.

7. MARKING INTRINSICALLY SAFE CIRCUITS USING COLOUR:

LIGHT BLUE RAIL MOUNTED TERMINAL BLOCKS

Historically, intrinsically safe circuits and equipment have been marked with a light blue colour. This was marked with equipment, parts of equipment, covers of junction / terminal boxes for intrinsically safe circuits, cables, cable entries, of course, terminals. Explosion protection and prevention specialists have this knowledge.

At the same time, this practical requirement is not indicated in any current standard from the 60079 series. To put it simply, it is not the colour of the marking that determines the type of protection: intrinsically safe.

Thus, the use of light blue marking of intrinsically safe circuits may be required by the user, but it is not a requirement of the standard. So, in intrinsically safe circuits, rail mounted terminal blocks of any colour can be used (excluding colours reserved for general safety reasons, e.g. yellow-green). Grey or orange Ex e marked connectors can also be used in intrinsically safe circuits (or equipment).

8. INFORMATION FOR USER

Components (rail mounted terminal blocks are components) do not bear the CE marking, no EU declaration of conformity (reserved for completed equipment) and no user instructions manual attached. Instead, Ex e rail mounted terminal blocks are marked in accordance with the ATEX directive, an attestation of conformity and installation conditions (how they must be incorporated into equipment) are attached.

In the case of rail mounted terminal blocks with appropriate clearances and creepages, the manufacturer also specifies how to properly connect the wires. An example of a connection recommended by WAGO is shown in Figure 1.

9. FINAL ASSESSMENT

A. WAGO rail mounted terminal blocks, marked with Ex e, meet the relevant requirements and can be used in intrinsically safe circuits and devices.

B. Ex e rail mounted terminal blocks are components according to Directive 2014/34/EU (ATEX) and Ex components according to 60079-0 and their use should be preceded by an analysis (risk assessment) of the end equipment's manufacturer or user.

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EN 60079-7:2015	**Explosive atmospheres**	–	Part 7:	Equipment protection by increased safety “e”
EN 60079-11:2012	**Explosive atmospheres**	–	Part 11:	Equipment protection by intrinsic safety “i”
EN 60079-14:2014	**Explosive atmospheres**	–	Part 14:	Electrical installations design, selection and erection
EN 60079-25:2010	**Explosive atmospheres**	–	Part 25:	Intrinsically safe electrical systems

ANNEX 1 – Frequently asked questions

1. Can Ex e II connectors be used in equipment of group I?

Explosion protection techniques (appropriate insulation material, creepages and clearances, clamp design) used in Ex e terminal blocks, including WAGO rail mounted terminal blocks, are not differentiated for group I (mining) and group II (other, except for mining) . Therefore, no specific additional requirements are defined for rail mounted terminal blocks for group I. All increased safety rail mounted terminal blocks are marked Ex e II (or Ex e IIC). The use of these terminal blocks in a group I equipment is a decision made by the equipment manufacturer. Ex e connectors ensure that: there is a place for connection, connection is easy, security of connection, therefore they are very often also used in devices of group I.

YES, Ex e terminal blocks can be used in group I.

NOTE: In some countries and some certification systems, certification of equipment (products) for group I (mining) is carried out by bodies other than group II certification.

2. Do connectors in intrinsically safe circuits have to be light blue?

The light blue marking is not decisive in determining the intrinsic safety of the circuit or device. Colour marking is used to distinguish intrinsically safe circuits from other circuits, and this is only one of the methods. Other methods are also possible (appropriate tag numbers, cable labels, text warning, etc.). The decision to use light blue connectors for intrinsically safe circuits is up to the manufacturer of the final device and the user.

So the connectors in intrinsically safe circuits may be light blue in colour, but it is not required.

3. Is additional assessment by a certification body required when using Ex e terminal blocks?

The use of Ex e terminal blocks in the equipment requires, first of all, the own assessment of the manufacturer of the final device. If the terminals are Ex components (they have a component certificate - with the letter “U” after the certificate number), it means that the safety aspects of the component (Ex e terminal blocks) have been assessed. None of the known certification systems (ATEX, IECEx) requires repeated verification of the aspects included in the component certificate. However, it should be noted that the Ex component cannot be used alone (it is not an equipment) and additional aspects should be assessed. Junction boxes with terminal blocks are such an example. Although terminal blocks can be Ex components (marked with Ex e and “U” in the certificate number), the entire equipment and other aspects (not assessed in the certificate of the component) should be subject to additional assessment (tests). It should be taken into account that the heating of such a junction box depends not so much on the terminal blocks used (although this is also important), but on the number and length of conductors inside the box.

The additional assessment during the certification of equipment with Ex e terminal blocks will not cover the aspects assessed during the assessment of the terminal blocks themselves.

4. Can WAGO Ex e terminal blocks be used together (on one rail) with terminal blocks from other manufacturers?

The construction of Ex e terminal blocks ensures, among others ensuring appropriate insulation distances (creepages and clearances). These distances are determined, among others to adjacent connectors conductive elements. Therefore, placing a terminal block of another manufacturer directly adjacent to the connector of one manufacturer does not ensure that the distances are kept.
However, it is possible to use different manufacturers connectors in spaced groups on one rail.

Terminal blocks from different manufacturers may be used on one rail, but only if they are grouped in such a way that the connectors of one manufacturer form one group. Groups should be spaced (spacedapart, with suitable dividers, etc.) to ensure distance between groups.

5. Can terminal blocks of a different design than screw terminal blocks be used in intrinsically safe circuits / equipment?

The requirements for intrinsically safe devices and circuits do not include requirements for the constructionof terminals. Hence, there are no restrictions on the use of terminals of a different design than screw terminals. However, it is required to maintain appropriate distances (to the metal housing, to terminals of other intrinsically safe circuits, to non-intrinsically safe circuits).

Terminal blocks of a construction other than screw terminal blocks may be used in intrinsically safe devices and circuits.

6. Do terminal blocks for intrinsically safe applications have to be in the enclosure?

The equipment enclosure provides, among others, protection against the influence of the external environmen (depending on the degree of pollution) and against access to hazardous parts. The parameters of intrinsic safety do not depend on the ingress protection of the housing. However, in the case of an increased safety Ex e (mentioned terminal blocks manufactured by WAGO are increased safety), the ingress protection IP54 is required. Detailed information is given is Ex component certificate.

So the Ex e connectors used in intrinsically safe circuits require the use of an IP54 enclosure.

7. May rail mounted terminal blocks without Ex marking be used in intrinsically safe circuits?

Requirements for the intrinsically safe design for terminals are limited only to ensuring minimum distances to the terminals of other intrinsically safe circuits, non-intrinsically safe circuits and earthed housing. It is up to the manufacturer of the final device to decide how to ensure that these requirements are met. The simplest solution is to use terminals (e.g. rail-mounted terminal blocks) that are Ex components for which these aspects (distances) have already been assessed. It is permissible to use non-Ex marked terminals (e.g. rail mounted terminal blocks), but then the responsibility for ensuring and maintaining the required distances is by manufacturer of the device.

Rail mounted terminal blocks without Ex marking may be used in intrinsically safe devices and circuits, but then the responsibility for maintaining the required clearances rests with the producer of the final product. Some certification systems may also refer to sub-suppliers, including the manufacturer of such terminal blocks, when assessing the production system of a product. The use of Ex-marked (preferably certified) terminal blocks is a simpler solution.

Space for notes

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