Technical information

General remarks

When developing the Rittal busbar systems and their components, Rittal drew on the latest state of the art and the currently valid standards and regulations. These applications are used by specialist companies worldwide. As well as permanent in-house controls at Rittal, the quality of the SV components is further reinforced by a vast array of tests and approvals.

As product development is an on-going process, we reserve the right to make amendments in line with technical progress.

Application

In order to avoid injury and damage to property, busbar systems must only be assembled and used by suitably trained and qualified personnel. The valid technical regulations, standards and provisions must, of course, be observed.
Users are required to carefully observe the information and instructions supplied by Rittal, and where necessary to forward them to downstream users and/or customers with a special advice note. In particular, the specified tightening torques of electrical terminal connections must be observed in order to achieve an optimum contact pressure. After transportation the connections must be checked and retightened if necessary.

As a general principle, NH fuses are intended for use by electricians or persons who have received training in electrical engineering.

Please observe the following regulations and instructions regarding the connection of NH equipment:

- Observe the specifications to VDE 0105 – 100
- Before switching on, ensure that the cover is precisely located in the chassis
- If the cover is not fully open, the fuse inserts may be live, depending on the direction of infeed
- Connect quickly

Technical data and catalogue information/operating conditions

Power distribution components are used in conjunction with a wide range of different switchgear, assemblies and components for power distribution. These various assemblies and components necessitate a wide range of different operating and ambient conditions which are, firstly, outside of Rittal's sphere of influence, and secondly, must be guaranteed in order to allow safe operation by the plant manufacturer.

Unless otherwise indicated, IEC 61 439-1/IEC 61 439-2 and the specified ambient conditions for interior sitings up to contamination level 3 and overvoltage category IV apply as the basis for Rittal power distribution components in the IEC market. At enclosure internal temperatures of > 35°C, application-specific derating should be provided where necessary.
Specifically in relation to the limit temperatures specified in IEC/EN 61 439-1 (table 5) the following factors should be given critical consideration by the plant manufacturer:

- Arrangement of components in respect of the thermally interactive influences in the overall structure
- Heat loss of the circuit-breakers and fuses used
- Active/passive ventilation measures
- Required cable cross-sections according to standard and/or manufacturer data
- Operating mode of plant (switching cycles etc.)
- Consideration of the operating and ambient conditions
- Consideration of the simultaneity factor
- Consideration of the rated load factor (RDF)
- Consideration of the load factor

It should also be noted that the horizontal installation position is the standard installation position for busbar systems, and this therefore produces the vertical installation position for top-mounted equipment. Once assembly of the system has been completed, the minimum creepage distances and clearances to IEC/EN 60 664-1 should be checked.

Chemical contamination caused by direct contact with substances or an excessively chemically charged atmosphere during transportation, storage and operation of the components should be avoided, since this can lead to contact corrosion and other lasting negative influences.

Specifically for the UL market, the requirements to UL 508A apply to plant manufacturers. In particular, depending on the application, the required creepage distances and clearances must be taken into account.

Glossary of frequently used basic/user regulations for busbar systems and components

- **IEC/EN 60 269-1**
  Low-voltage switchgear
  Part 1: General requirements
- **IEC/EN 61 439-1**
  Low-voltage switchgear and controlgear assemblies
  Part 1: General specifications
  Replaces IEC/EN 60 439-1
- **IEC/EN 61 439-2**
  Low-voltage switchgear and controlgear assemblies
  Part 2: Power switchgear and controlgear assemblies
  Replaces IEC/EN 60 439-1
- **IEC/EN 61 439-3**
  Low-voltage switchgear and controlgear assemblies
  Part 3: Distribution boards intended to be operated by ordinary persons
- **IEC/EN 60 947-1**
  Low-voltage switchgear controlgear assemblies
  Part 1: General specifications
- **IEC/EN 60 947-3**
  Low-voltage switchgear and controlgear
  Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units
- **IEC/EN 60 664-1**
  Coordination of insulation for electrical operating equipment in low-voltage systems
  Part 1: Basic principles, requirements and tests
- **IEC/EN 60 999-1**
  Connector parts – Electrical copper conductors – Safety requirements for screw terminals and screwless terminals
  General and specific requirements for terminals for conductors from 0.2 mm^2 up to and including 35 mm^2
- **IEC/EN 60 999-2**
  Connector parts – Electrical copper conductors –
  Safety requirements for screw terminals and screwless terminals
  Part 2: Special requirements for terminals for conductors greater than 35 mm^2 up to and including 300 mm^2
- **DIN 43 671**
  Copper busbars, dimensioning for constant current
- **DIN 43 673-1**
  Busbar drill holes and screw fastenings, busbars with rectangular cross-section
- **IEC/EN 60 715**
  Dimensions of low-voltage switchgear –
  Standardised support rails for the mechanical attachment of electrical components in switching systems
- **DIN EN 13 601**
  Copper and copper alloys –
  Copper rods and wires for general use in electrical engineering
- **UL 248**
  Low-Voltage Fuses
- **UL 4248-1**
  Fuseholders Part 1: General Requirements
- **UL 486 E**
  Equipment Wiring Terminals for use with Aluminium and/or Copper Conductors
- **UL 489**
  Molded-Case Circuit breakers, Molded-Case Switch and Circuit-Breaker Enclosures
- **UL 508**
  Industrial Control Equipment
- **UL 508A**
  Industrial Control Panels
- **UL 512**
  Fuseholders
- **UL 845**
  Motor Control Centers
- **UL 891**
  Switchboards

General remarks

Ri4Power low-voltage switchgear assemblies with design certificate

The section types of Ri4Power low-voltage switchgear combinations comply with the design certificate to IEC 61 439-1 and IEC 61 439-2. If planned and executed in accordance with the specifications and assembly instructions for Ri4Power systems, the combination of section types corresponds to a low-voltage switchgear combination with design certificate to IEC 61 439-1 and IEC 61 439-2.

Testing of Ri4Power systems was carried out with the following switchgear brands:

- ABB
- Eaton
- Jean Müller
- Mitsubishi
- Schneider Electric
- Siemens
- Terasaki

and with RiLine components from Rittal. In contrast to a non-tested switchgear combination, the requirements for the selection of components and switchgear are linked to the tested types. When planning air circuit-breakers, where necessary, reduction factors should be taken into account for use at increased temperatures in the enclosure interior.

Before planning and assembling a tested switchgear combination, the technical parameters of a tested switchgear combination should be coordinated between the user and switchgear manufacturer. For tested execution of the Ri4Power system, we recommend use of the Rittal Power Engineering software. All parameters are integrated into this software, which guides users to the required solution.
Design testing of a switchgear combination confirms the combination of enclosure, busbar system and switchgear as a functioning unit, and verifies compliance with all technical limits.
The technical data of a switchgear combination with design certificate may deviate from the tested values of the individual components, since these components are often subject to different test requirements.

For busbar systems, too, the data within a tested switchgear combination may deviate from the data pursuant to DIN 43 671, since in addition to the enclosure and busbar system, testing also makes allowance for heat loss in switchgear. For this reason, the technical system data on pages 166 to 171 is decisive for the switchgear and controlgear assemblies with design certificate.
If field types with different ratings data are combined, please note that the lowest values for the main busbar system and the overall enclosure protection category prescribe the ratings for the overall switchgear combination.

Ri4Power low-voltage switchgear assemblies without design certificate

Ri4Power components may also be used outside of switchgear and controlgear assemblies with design certificate.

However, the technical data for the products and the short-circuit protection data and ratings data of the busbar systems must be observed.

Planning and project management in line with regulations

As a general principle, low-voltage switchgear and distributors should be planned to meet the operating conditions of their final installation site. To this end, the operator of the plant, in collaboration with the manufacturer, should stipulate the operating and ambient conditions. Moreover, as a general rule, the operator or planning office should also supply the manufacturer with full electrical specifications of both the mains supply end and the distributor outlet end. This makes it possible to plan and manufacture a cost-effective system with optimum adaptation to the technical requirements.

Important basic data for planning and project management

- Applicable regulations and standards, both regional and international
- Electricity supply company conditions
- Operator-specific regulations
- Mains-specific protective measures/mains type
- Rated voltage and frequency
- Rated current with due regard for the number of conductors (infeed and busbars)
- Rated insulation voltage
- Short-circuit current at the point of installation
- Location of incoming cables, from above or below
- Number of incoming cables, specifying the type and cross-section
- Number of outlets, specifying the operating load and the envisaged outgoing cables with type and cross-section
- For the outlet side, specification of the simultaneity factor and rated load factor of the relevant equipment items

Important operating and ambient conditions

- Rated operating voltage U_e
- Mains frequency f_n
- Rated insulation voltage U_i
- Rated surge voltage resistance U_{Imp}
- Rated current of switchgear assemblies I_{nA}
- Rated current of circuits I_{nc}
- Load factor
- Conditional rated short-circuit current I_{cc}
- Busbar rated current I_{sas}
- Rated surge current resistance I_{pk}
- Rated short-time current resistance I_{cw}
- Ambient temperature condition ϑ
- Atmospheric climatic stress, specifying the relative humidity and temperature
- Protection category of the overall system IP . . .
  Specification to IEC 60 529
- Protection category

Load factor

The load factor of a switchgear enclosure or part thereof (e.g. a field) comprising several main circuits refers to the ratio between the largest sum total of all currents anticipated at any given time in the affected main circuits and the sum total of the rated currents of all main circuits of the switchgear enclosure or observed part thereof.

Number of main circuits	Load factor
2 and 3	0.9
4 and 5	0.8
6 and 7	0.7
10 or more	0.6

Conductor connections

Unless mentioned separately in the Rittal product documentation or on the product itself, the conductor connections apply solely to the connection of Cu conductors. Connections with aluminium conductors are subject to special conductor preparation and must be serviced at regular intervals.
Please observe the torque specified on the product or in our documentation. In accordance with the valid regulation IEC/EN 60 999-1 and -2, terminal connections must not be subjected to any tensile loads. For this reason, in order to ensure proper installation, appropriate strain relief should be provided for the application in question. The clamping ranges specified in the Rittal documents represent the absolute figure for the minimum/maximum supply lead that may be used. When using wire end ferrules, because of the different crimping types, universal clearance cannot be given, since deviations for the clamping zone or electromagnetically unfavourable connections may occur. Generally speaking, care must be taken to ensure that the force effect of the terminal does not loosen or even counteract the natural compression of the wire end ferrule. For example, square and trapezoid compression is preferable for flat-compression terminals. For terminals with a circular action, round compression is the most suitable. Particularly with larger cross-sections, for example, the use of square or trapezoid-compressed conductors in terminals with a circular action may create an electromechanically inadequate connection. The reason for this is the self-release effect, since when the terminal is screwed together, the corners of the wire end ferrule are reshaped in a circular direction, and as a result, the actual compression between the conductor and ferrule can be rendered ineffective. Mechanically speaking, terminals have not been designed to impose a new compression form on the conductor. Such an application would be a classic example of inadmissible temperature rises, which in a worst case could lead to arcing as a result of ionisation of the immediate ambient air, and ultimately to complete destruction of the plant.

Names of conductor types to IEC/EN 60 228:

rs Round conductor, single-wire
ss Sector conductor, single-wire
rm Round conductor, multi-wire
sm Sector conductor, multi-wire
f Fine-wire

UL 486E applies to clamping connections to UL. We distinguish between clamping connections for field-wiring or factory-wiring.
All clamping connections in Rittal RiLine60 busbar connection and component adaptors have been tested for the more stringent licensing requirements for field-wiring. Under UL 486E, no wire end ferrules must currently be used for cable preparation. The version with wire end treatment is being revised by UL.

Designation of conductor types to UL 486E:

s stranded (multi-wire)
sol solid (single-wire)

The following table shows the allocation of AWG and MCM cross-sections to conductor cross-sections in mm^2:

Conductor size	Absolute cross-section in mm^2	Next standard cross-section in mm^2
AWG 16	1.31	1.5
AWG 14	2.08	2.5
AWG 12	3.31	4
AWG 10	5.26	6
AWG 8	8.37	10
AWG 6	13.3	16
AWG 4	21.2	25
AWG 2	33.6	35
AWG 0	53.4	50
AWG 2/0	67.5	70
AWG 3/0	85	95
MCM 250	127	120
MCM 300	152	150
MCM 350	178	185
MCM 500	254	240
MCM 600	304	300

AWG = American Wire Gauges
MCM = Circular Mils (1 MCM = 1000 Circ. Mils = 0.5067 mm^2)

Current carrying capacity of connection cables

The current carrying capacity of cables and lines depends on various factors. In addition to the actual insulation, i.e. the design of the cable sheathing, factors such as

- How the cable is laid
- Clustering
- Ambient temperatures

are decisive for the actual current carrying capacity of a conductor. Based on the following tables, it is possible to calculate the current carrying capacity of conductor cross-sections between 1.5 and 35 mm^2 with due regard for the aforementioned factors.

Current carrying capacity of insulated PVC cables at an ambient temperature of +40°C, installation type E (IEC/EN 60 204-1:1998-11)	
Nominal cross-section mm^2	Current capacity A
1.5	16
2.5	22
4	30
6	37
10	52
16	70
25	88
35	114

Conversion factors K_2 for the load capacity of cables (IEC/EN 60 204-1:1998-11)	
Ambient temperature °C	Factor
30	1.15
35	1.08
40	1.00
45	0.91
50	0.82
55	0.71
60	0.58

Reduction factor for clustering of cables/lines K_1				
How the cable is laid	No. of affected circuits			
E	2	4	6	9
	0.88	0.77	0.73	0.72

Sample calculation:
Calculate the maximum permissible conductor current for a 16 mm^2 PVC-insulated H07 connection cable for connection to a D 02-E 18 fusible element (SV 3418.000), based on the following conditions:

Ambient and cable-laying conditions:

- Cable laid in a cable duct with 6 loaded circuits
- Ambient temperature inside the enclosure 35°C
- Direct ambient temperature of the cable in the cable duct 50°C

$$\mathbf{I_{max} = I_{(40°C)} \cdot K_1 \cdot K_2 = 70\ A \cdot 0.73 \cdot 0.82 = 41.9\ A}$$

Summary:
At these ambient conditions, the load of the connection cable from the fusible element must not exceed a maximum of 41.9 A. In certain circumstances, this figure may be further reduced by additional influences such as baying of the components, unfavourable convection conditions in the layout etc.

Rated currents and short-circuit currents of standard transformers

Rated voltage U_N = 400 V	400 V		
Short-circuit voltage U_k		4%[1]	6%[2]
Power consumption S_{NT} [kVA]	Rated current I_N [A]	Short-circuit current $I_{k''}$[3] [kA]	
50	72	1.89	1.20
100	144	3.61	2.41
160	230	5.77	3.85
200	288	7.22	4.81
250	360	9.02	6.01
315	455	11.36	7.58
400	589	14.43	9.62
500	722	18.04	12.03
630	910	22.73	15.15
800	1156	28.86	19.24
1000	1444	36.08	24.05
1250	1805	45.09	30.06
1600	2312	57.72	38.48
2000	2882	72.15	48.10
2500	3613	90.32	60.21

1) U_k = 4% standardised to DIN 42 503 for S_{NT} = 50 . . . 630 kVA
2) U_k = 6% standardised to DIN 42 511 for S_{NT} = 100 . . . 1600 kVA
3) $I_{k''}$ = Initial symmetrical short-circuit current of transformer when connecting to a mains supply with unlimited short-circuit lead

Information on the topic of “whiskers”

The EU electric scrap regulation RoHS prohibits the addition of lead to tin. In tin-plated busbars, this poses a major risk of whisker formation which can result in dangerous short-circuits between 2 phases or between a phase and earthed parts in switchgear.

Whiskers are hair-like, electrically conductive crystals which grow out of the tin layer in tin-plated busbars under defined conditions. Their diameter is generally in the region of 1 – 2 µm, and whiskers may be 10 to 12 mm in length. Whiskers grow as a result of mechanical stresses in the molecular tin structure, i.e. the migration of individual molecules leads to thread formation. The speed of growth is approximately 750 µm/month, with the growth rate being most favourable at 50°C. The ambient medium does not influence whisker growth. Whiskers can occur both in a high vacuum and under various atmospheres and humidities. The highest internal stresses occur in thin layers of tin, so that increased whisker growth is likely under such conditions.

The risk of whisker formation can be minimised by ensuring that the tin-plated surface is as matt as possible, and layer thicknesses of at least 10 – 20 µm are applied. These measures are fulfilled by the tin-plated flat bars that may be ordered on request from Rittal, as well as by the PLS 800 and PLS 1600. Additionally, the RiLine60 base tray and adaptor technology, based on the high level of contact hazard protection, is ideally designed in terms of insulation between the different potentials.