Rittal – The System.

Faster – better – worldwide.

Standard-compliant switchgear and controlgear production

Application of IEC 61439

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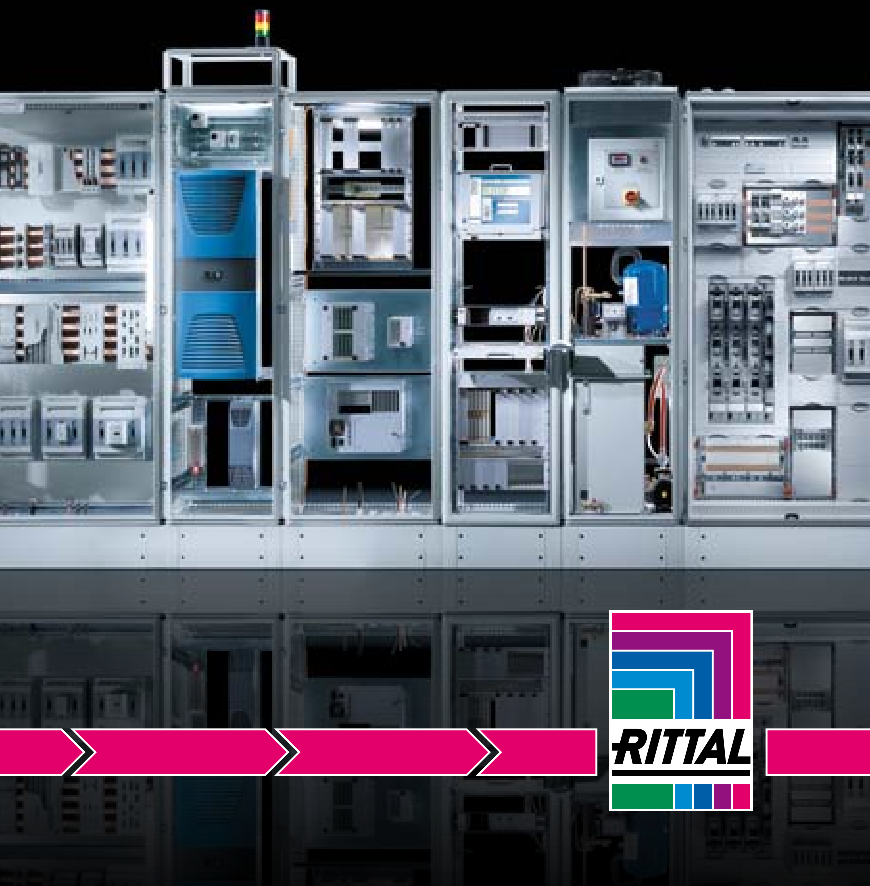

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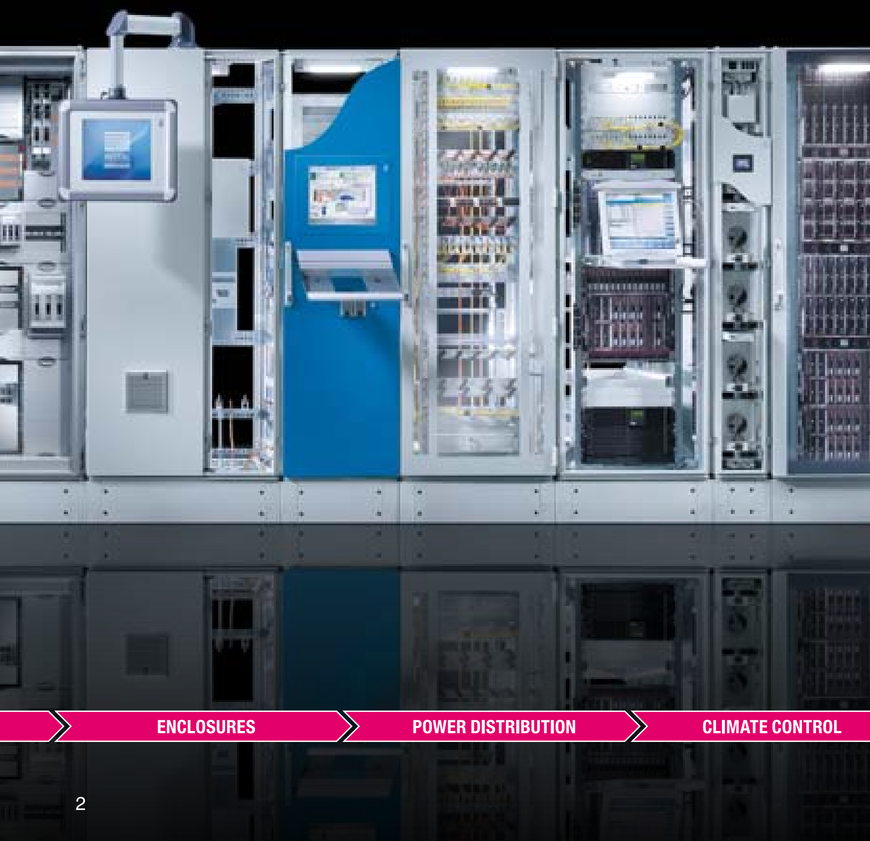

A new standard.
A new opportunity.

IEC 61439 is the new standard governing the production of switchgear and controlgear assemblies, and reinforces the holistic system concept of a low-voltage switchgear and controlgear assembly – an idea developed and successfully established over many years by Rittal. With its broad, modular range of products, **Rittal – The System.** covers virtually all plant categories, thereby offering a comprehensive approach to the construction of a switchgear and controlgear assembly and conformity with the new standard.

Rittal products already come supplied with much of the documentation currently required, e.g. for empty enclosures in accordance with **standard IEC 62208** or for the **short-circuit resistance of busbar and protective circuit systems.** Powerful **software tools** such as **"Rittal Power Engineering"** and **"Rittal Therm"** support your calculations during the planning phase.

IEC 61439 will come into force with effect from November 2014, and the previous standard IEC 60439 will be withdrawn by that date at the latest.

Rittal has produced this brochure to assist with the measures needed to comply with this standard, from an initial consultation on the use of standard-compliant system products from Rittal, through to submission of the required design and routine verification of your equipment.

Contents

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IT INFRASTRUCTURE SOFTWARE & SERVICES

One standard for all switchgear and controlgear assemblies

The new standard IEC 61439, as the successor to standard IEC 60439, outlines the requirements and verifications for all low-voltage switchgear and controlgear assemblies. The standard is applicable to power distributors, all switchgear and controlgear assemblies, meter boxes and

Meter boxes
Building distributors

Switchgear and controlgear from wall-mounted enclosures to multi-panel combinations

distribution enclosures for private and commercial buildings, assemblies for construction sites and power distribution, and switchgear and controlgear assemblies in special zones such as marinas.

Power distributors
Main distributors

Distribution boards

What has changed under the new standard?

The terms for type-tested switchgear and controlgear assemblies (TTA) and partially type-tested switchgear and controlgear assemblies (PTTA) used in IEC 60439-1 have been abolished. In future, only the system as a whole will be considered, and the term 'switchgear and controlgear assembly' will apply.

For new switchgear and controlgear assemblies, the type test report will be replaced by the design verification. The former routine test report will be replaced by the routine verification.

The user or planner describes a low-voltage switchgear and controlgear assembly by defining the interface parameters as a black-box model. The manufacturer must dimension and define the interior configuration of the low-voltage switchgear and controlgear assembly based on the interface parameters.

The new IEC 61439 is divided into two sections, one containing general requirements, the other outlining a separate product standard for specific types of switchgear and controlgear assemblies.

The following content is currently envisaged:

IEC 61439-1:	General requirements
IEC 61439-2:	Power switchgear and controlgear assemblies
IEC 61439-3:	Distribution boards (to supersede IEC 60439-3)
IEC 61439-4:	Assemblies for construction sites (to supersede IEC 60439-4)
IEC 61439-5:	Assemblies for power distribution (to supersede IEC 60439-5)
IEC 61439-6:	Busbar trunking systems (to supersede IEC 60439-2)
IEC 61439-7:	Assemblies for specific applications, rooms and installations
IEC/TR 61439-0:	Guide to the specification of switchgear and controlgear assemblies

What does the new standard mean for you?

IEC 61439 provides the basis for a clear definition of the performance promise made between the user and manufacturer of a switchgear or controlgear assembly. In this way, fulfilment of the performance promise can be assessed and documented for both parties.

Application of the new standard does not entail significantly more work than testing a TTA/PTTA assembly. The calculation method for temperature increase in systems up to 1600 A remains unchanged. For systems up to 630 A the procedure has even been simplified. IEC 61439 guides the manufacturer through the process to the required verifications in a structured manner.

By applying the new standard correctly, manufacturers can prove definitively that their products are safe and reliable to use.

Within the European trade zone, a declaration of CE conformity must be prepared for low-voltage switchgear and controlgear assemblies. The declaration makes reference to

- the Low-Voltage Directive, the EMC Directive and (where applicable) the Machinery Directive, as well as to
- product standard IEC 61439 and (where applicable) other standards such as IEC 60204 for the safety equipment of machines and plant.

Any manufacturer wishing to produce and market standard-compliant switchgear or controlgear assembly after November 2014 must prepare a design verification and a routine verification.

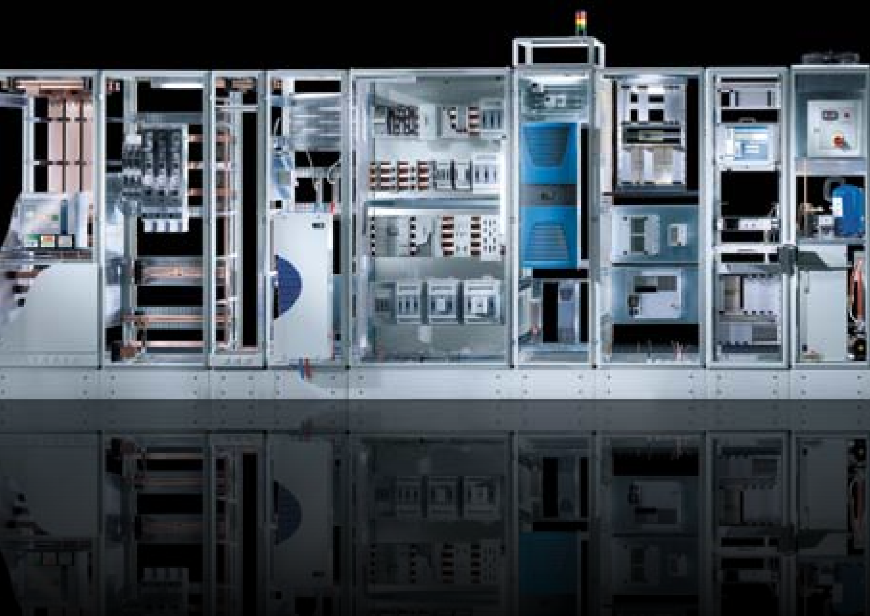
The switchgear or controlgear assembly manufacturer is responsible for preparing the design verification.

Rittal – The System. Complete solutions – Customised for IEC 61439

Under the new standard IEC 61439, the complete low-voltage switchgear and controlgear assembly is a system comprised of:

Enclosure
(TS 8, SE 8, AE, …)

Climate control
(RiTherm)

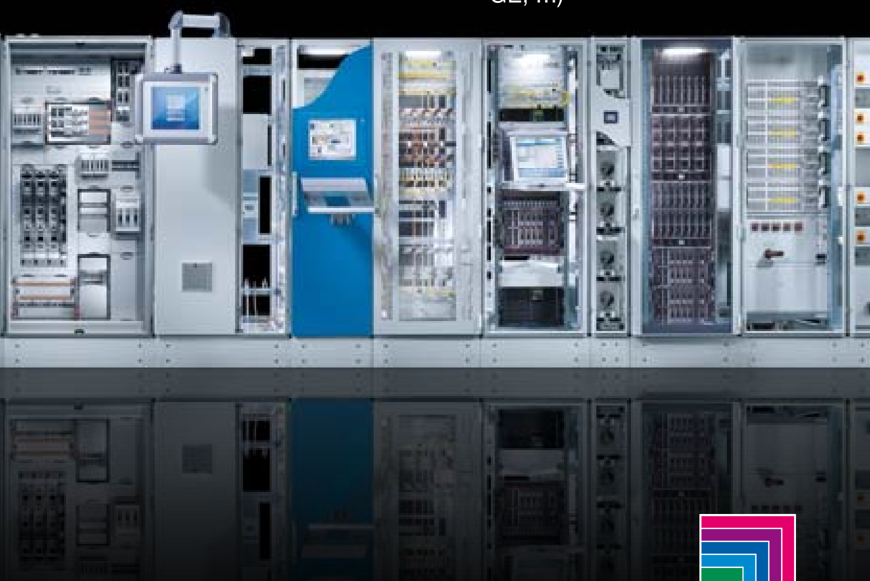


ENCLOSURES | POWER DISTRIBUTION | CLIMATE CONTROL

Preparation of a design verification is much easier with tested system solutions.

Busbars
(RiLine60, Maxi-PLS, Flat-PLS)

Equipment
(ABB, Siemens, Schneider Electric, Eaton, GE, …)



Strength of materials

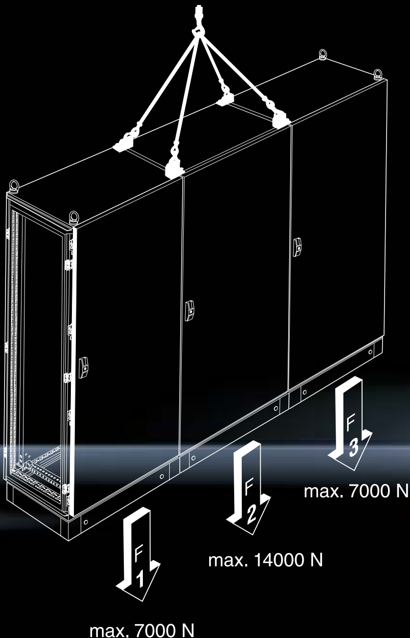
Most of the required verifications for material strength already exist, due to compliance with the requirements of standard IEC 62208 on empty enclosures. This is sufficient for the purposes of verification to IEC 61439, provided no major alterations are made to the empty enclosure. However, documentation of the mechanical properties is required.

The Rittal TS 8 load brochure contains all the required data for professional execution of the mechanical configuration.

Rittal system benefits:

- Comprehensive verifications
- TS 8 load brochure containing all the required data on load options
- Corrosion protection verifications for all enclosure types
- All information on the transportation of enclosures

Verification provided by Rittal!



Protection category of enclosures

The protection category verification for enclosures ensures long-term protection of the valuable electrical equipment. Design verification within the framework of IEC 61439 requires separate testing.

Rittal has its own laboratory division which is used, not only for one-off initial testing, but also for regular production monitoring.

ENCLOSURES POWER DISTRIBUTION CLIMATE CONTROL

Rittal system benefits:

- Top quality with Rittal enclosure systems
- Testing of original products
- Test verifications for special protection categories or enclosure assemblies

More information and direct contact with the experts is available at www.rittal.com

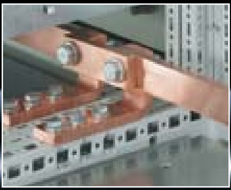
Verification provided by Rittal!

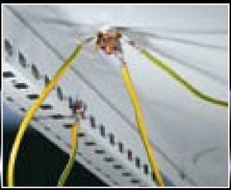
Verification of protective circuit function

The function of the protective circuit within a switchgear is particularly important. An inadequate or defective protective circuit connection can be dangerous for people and equipment.

Rittal offers tested system products for the production of protective circuit systems. Depending on the specific requirements, the required protective circuit system may be selected from a wide range of system accessories.

The admissible usage areas and all test documentation for Rittal products and components is described in detail in the Rittal protective circuit brochure.





Rittal system benefits:

- Tested Rittal system solutions eliminate the need for customer testing
- Detailed protective circuit brochure ensures the correct design
- For use only in Rittal enclosures

Verification provided by Rittal!

Insulating properties

The insulating properties of operating equipment – particularly the busbar system – are dependent, inter alia, on the application in an enclosure.

By using high-quality plastics to manufacture its busbar system components, Rittal is able to ensure compliance with the insulating properties required by IEC 61439.

Standardised construction regulations and assembly systems are another simple way of ensuring that the switchgear and controlgear manufacturer complies with the requirements. This is verified by extensive testing.

Rittal system benefits:

- Less potential for errors, thanks to tested system technology
- Use of high-quality materials
- Verification of individual busbar assemblies is far more time-consuming
- Standardised accessories make it easier to comply with the requirements

Verification provided by Rittal!

Calculation of temperature rise

For switchgear and controlgear assemblies up to 1600 A, IEC 61439 permits verification via the determination and calculation of power losses in the operating equipment used.

Successful verification requires proof that dissipation of the heat loss is guaranteed, to prevent excessively high temperatures in the enclosure interior.

Rittal system benefits:

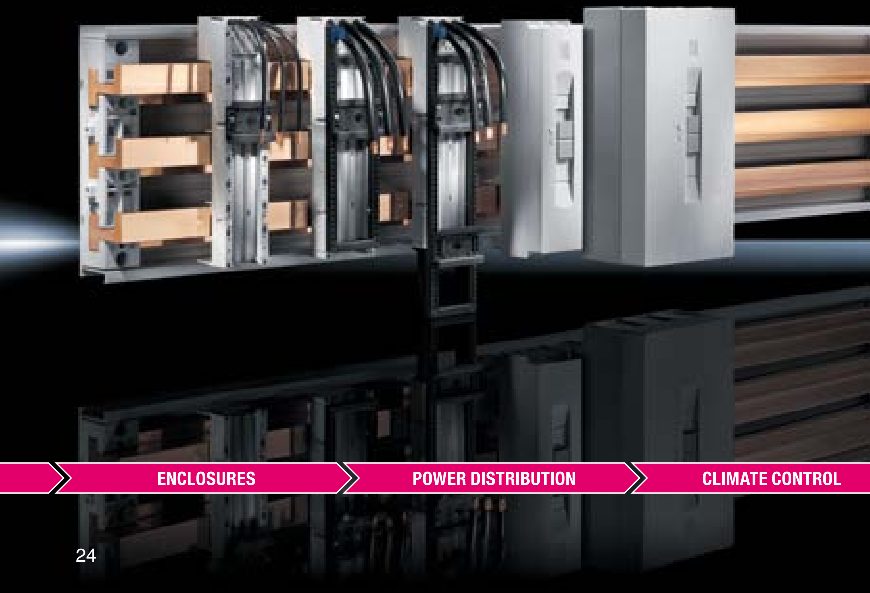
- **Rittal Power Engineering for simple heat loss calculation**
- **Rittal Therm for simple calculation of cooling with Rittal climate control technology**
- **Extensive portfolio of powerful climate control and cooling products**
- **Testing of all climate control products in Rittal enclosure solutions**

Rittal offers extensive support with calculation!

Tested busbar technology

Busbar systems should preferably be tested within enclosures, since the mechanical attachment also affects the test result.

All Rittal busbar systems are tested in Rittal enclosures and cases, and thus meet the requirements for safe, reliable operation.



Rittal system benefits:

- **Combinations of enclosure and busbar system are tested**
- **Clear design rules for assembly**
- **Every busbar system > 10 kA rms must be tested in order for it to be allowed to be used as a reference**
- **Assembly and connection components likewise comply with the standard requirements**

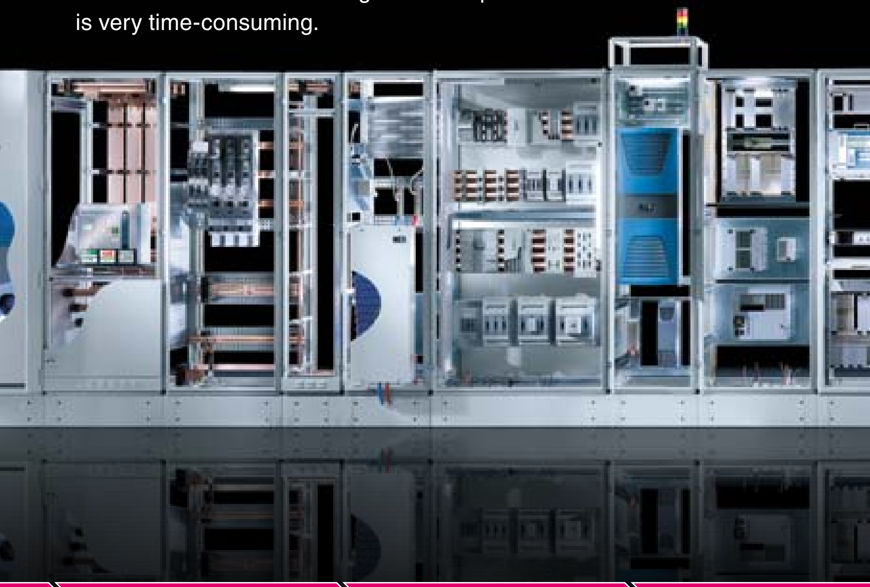
Verification provided by Rittal!

Verification of short-circuit withstand strength to IEC 61439 section 10.11 met by testing:

Busbar system/ Version	Max. short-circuit withstand strength up to		Test report
	Ipk	Icw	
RiLine60 – Cu 30 x 10	78.1 kA	37.6 kA 1s	1579.0930.6.862
RiLine60 – PLS 800	50.9 kA	25.9 kA 1s	1579.0797.5.294
RiLine60 – PLS 1600	105 kA	50 kA 1s/3s	1579.0797.5.292
			1579.0797.5.288

The system for the standard

Many of the verifications required for IEC 61439 refer to a combination of different products and components in a switchgear and controlgear assembly. For example, evidence of protective circuit function requires testing of a defined protective circuit arrangement in a defined enclosure construction.
Tested, holistically designed system technology allows the verifications required by the standard to be successfully prepared. Clear design rules and standardised products facilitate the systematic configuration of switchgear, which in turn enables systematic record-keeping.
For individual switchgear and controlgear assembly which is not compliant with standardised, tested system solutions, record-keeping for short-circuit withstand strength and temperature rise is very time-consuming.



- **The design verification must be provided by the switch-gear and controlgear assembly manufacturer, especially for individual switchgear and controlgear assemblies.**
- **The use of system solutions significantly reduces the amount of work involved in preparing this verification.**

Preparation of the design verification
(excerpt from IEC 61439)

Foreword:

IEC 61439 defines the requirements applicable to all low-voltage electrical switchgear and controlgear assemblies for the protection of individuals and equipment. In short, this standard states that a low-voltage switchgear and controlgear assembly is a functioning system comprised of enclosures, switchgear, busbars and climate control components.
Compliance with the structural requirements of this standard should be documented by means of various individual verifications and a design verification. Individual verifications may take the form of testing representative samples, assessment techniques, or a structured comparison with a tested low-voltage switchgear and controlgear assembly.
In order to ensure the correct layout and functioning of every finished low-voltage switchgear and controlgear assembly, a routine verification should be prepared and documented when manufacturing is complete, or no later than commissioning.

The standard divides responsibility for the manufacturing of a low-voltage switchgear and controlgear assembly between the original manufacturer and the assembly manufacturer. The assembly manufacturer is the organisation which produces and markets a ready-to-use low-voltage switchgear and controlgear assembly for a customer application. The original manufacturer is the organisation that originally developed a switchgear system and who is responsible for establishing the nature of verification. The original manufacturer and the assembly manufacturer may also be one and the same organisation.

Particularly in the case of switchgear and controlgear that is individually designed and manufactured due to its application, the assembly manufacturer of the switchgear combination is also responsible for preparing the design verification.

I. The design verification:

Design verification is intended to verify that the design of an assembly or assembly system is compliant with the requirements of this series of standards.
Complete, detailed documentation of the individual design verifications for the switchgear and controlgear assembly system developed by the original manufacturer, including all test reports and records, should be prepared by the original manufacturer. The original manufacturer should also ensure the long-term (at least 10 years) archiving of this documentation.
This detailed documentation needs not be forwarded to the assembly manufacturer or user of a switchgear in order to confirm the design verification. A summary of the properties fulfilled by the switchgear and controlgear assembly is sufficient. However, this design verification summary should include the chosen verification method, the confirmed measurement data and, where available, the corresponding test report number or report number for each individual verification.

The various verifications confirm that the components combined in a switchgear and controlgear assembly operate correctly together. For this reason, certain verifications call for tests or comparisons which can only be provided by verifying the combination of different products (e.g. enclosure and busbars). The testing of individual devices or components is no substitute for the verifications required for the design verification.

Example: Short-circuit protection of the protective circuit is a test whose outcome will depend on the enclosure type selected and the protective circuit components used. With this test, the enclosure and protective circuit components are subjected to mechanical and electrical stresses which influence the test result. As such, merely testing the protective circuit components in isolation is not sufficient for verification purposes.

For verification of temperature rise, the actual achievable rated current and the rated diversity factor of the respective circuit should be indicated for both the manufacturer and the user. Merely stating the rated currents of the switchgear or individual components of the switchgear and controlgear assembly is not sufficient, since this may not make allowance for environmental influences and the influences of other components in the switchgear and controlgear assembly. Generally speaking, when defining the protection category of a switchgear and controlgear assembly, the lowest possible protection category is desirable, since with a high protection category (e.g. IP 54), a significant derating of the switchgear or busbar rated currents is likely unless further climate control measures are implemented, particularly with high currents.
The actual achievable loads of the circuits in a switchgear and controlgear assembly must be specified in order to define a clear performance promise regarding the admissible loading of the switchgear and controlgear assembly for the user and manufacturer.

II. Individual verifications and verification methods

The following table shows the admissible techniques for documenting the individual design verifications.

No.	Characteristic to be verified	Section	Available verification options		
			Testing	Comparison with a reference design	Assess-ment
1	Strength of materials and parts:	10.2			
	Resistance to corrosion	10.2.2	■	–	–
	Properties of insulating materials:	10.2.3			
	Thermal stability	10.2.3.1	■	–	–
	Resistance to abnormal heat and fire due to internal electric effects	10.2.3.2	■	–	■
	Resistance to ultra-violet (UV) radiation	10.2.4	■	–	■
	Lifting	10.2.5	■	–	–
	Mechanical impact	10.2.6	■	–	–
	Marking	10.2.7	■	–	–
2	Protection category of enclosures	10.3	■	–	■
3	Clearances	10.4	■	–	–
4	Creepage distances	10.4	■	–	–
5	Protection against electric shock and integrity of protective circuits:	10.5			
	Effective continuity of the connection between exposed conductive parts of the assembly and the protective circuit	10.5.2	■	–	–
	Short-circuit withstand strength of the protective circuit	10.5.3	■	■	–

No.	Characteristic to be verified	Section	Available verification options		
			Testing	Comparison with a reference design	Assess-ment
6	Incorporation of switching devices and components	10.6	–	–	■
7	Internal electrical circuits and connections	10.7	–	–	■
8	Terminals for external conductors	10.8	–	–	■
9	Dielectric properties: Power-frequency withstand voltage Impulse withstand voltage	10.9 10.9.2 10.9.3	 ■ ■	 – –	 – ■
10	Temperature-rise limits	10.10	■	■	■
11	Short-circuit withstand strength	10.11	■	■	–
12	Electromagnetic compatibility (EMC)	10.12	■	–	■
13	Mechanical operation	10.13	■	–	–

Taken from IEC 61439-1, Table D1, Annex D

III. Information included in the design verification

The design verification serves to document compliance with the specifications of this standard. It is comprised of 13 individual verifications. For selected individual verifications, additional sub-verifications in subcategories may be required. If selected verifications are not required due to the application, the respective verification should, as a minimum requirement, state that verification on the basis of the standard is not required in this instance.

1.) Strength of materials

Verification of material strength is divided into seven sub-points. If an empty enclosure pursuant to IEC 62208 was used and no modifications have been made which could influence the functioning of the enclosure, no further strength testing of the materials for this enclosure is required. Compliance with standard IEC 62208 should then be confirmed in the design verification. However, verification of the resistance of the insulating materials to abnormal heat and fire for the components used in the busbar system and other insulating materials should additionally be provided.

a. Resistance to corrosion

Resistance to corrosion can only be verified by testing. For resistance to corrosion, the verification should stipulate the "testing" method, the degree of severity and the test report number.

b. Properties of insulating materials – Thermal stability of enclosures

This evidence is only required for enclosures made from insulating materials, or parts made from insulating materials mounted on the outside of the enclosure, and which are relevant to the protection category. Verification should state that the test was passed at a temperature of 70 °C, for a duration of 168 h, and with a recovery time of 96 h, and should also include the method and the test report number/report number.

c. Properties of insulating materials – Resistance to abnormal heat and fire due to internal electric effects

These properties should be verified using the "testing" method on the material used, or using the "assessment" method with the data sheets for the basic plastic material. Verification should state that the properties of the insulating materials meet the requirements of the glow-wire test depending on the three intended applications:

- 960 °C for parts necessary to retain current-carrying parts in position
- 850 °C for enclosures intended for mounting in hollow walls
- 650 °C for all other parts

The design verification should include the test method, the result of the test, and the test report or report number.

d. Resistance to ultra-violet (UV) radiation

Resistance to UV radiation only applies to enclosures and external parts of switchgear and controlgear assemblies for outdoor installation. Verification may be provided by testing or by assessing the data from the original material manufacturer. The design verification should include the test method, the result of the test method, and the test report or report number.

e. Lifting
Verification for lifting can only be provided by testing. Verification should state that the test was passed, indicating the maximum number of sections that can be lifted and the maximum weight, together with the test report number.

f. Mechanical impact
The impact resistance of a switchgear and controlgear assembly is verified by testing. The design verification should state the method, the tested IK protection category, and the corresponding test report number.

g. Marking
There is no requirement to test markings made by moulding, pressing, engraving or similar, as well as labels with a laminated plastic surface. In such cases, it is sufficient to state the chosen technique in the design verification. For all other types of marking, testing is mandatory. The test outcome should be documented, stating the test report number.

2.) Protection category of enclosures

The degree of protection should be verified by testing. Where an empty enclosure pursuant to IEC 62208 has been used, verification via assessment is also admissible. The design verification should state the method and the tested protection category. Where testing is used, verification should also include the test report number.

3.) Clearances

Compliance with the required clearances can only be verified by testing (measuring). To this end, the design verification should state the method, the required minimum clearance, and the corresponding test report number. The required rated impulse withstand voltage may additionally be given.

4.) Creepage distances

Compliance with the required creepage distances can only be verified by testing (measuring). To this end, the design verification should state the method, the required minimum creepage distance, and the corresponding test report number. For a more detailed description, the rated insulation voltage, degree of contamination and material group may additionally be specified.

5.) **Protection against electric shock and integrity of protective circuits**
Verification should take the form of two separate verifications.

a. Effective continuity between exposed conductive parts of the assembly and the protective circuits
Verification can only be provided by means of testing. The design verification should include the method, the test result, and the corresponding test report number.

b. Short-circuit withstand strength of the protective circuit
The short-circuit withstand strength can be verified by testing or by way of comparison with a reference design. The design verification should state the chosen method, indication that the circuit passed the short-circuit withstand strength test, and the test report number.

6.) Incorporation of switching devices and components

The incorporation of switching devices and components can only be verified using the assessment method. To this end, compliance with the structural requirements defined in section 8.5 of IEC 61439-1 should be confirmed by means of a visual inspection. The design verification should state the method "assessment via inspection", the record number of the assessment, and the result.

7.) Internal electrical circuits and connections

The correct design of the internal electrical circuits and connections can only be verified using the assessment method. To this end, compliance with the structural requirements defined in section 8.6 of IEC 61439-1 should be confirmed by means of a visual inspection. The design verification should state the method "assessment via inspection", the record number of the assessment, and the result.

8.) Terminals for external conductors

The correctness of the connections for external conductors can only be verified using the assessment method. To this end, compliance with the structural requirements defined in section 8.8 of IEC 61439-1 should be confirmed by means of a visual inspection. The design verification should state the method "assessment via inspection", the record number of the assessment, and the result.

9.) Dielectric properties

This comprises two separate verifications.

a. Power-frequency withstand voltage

This verification can only be provided by means of testing. The design verification should include the method, the test result, and the corresponding test report number.

b. Impulse withstand voltage

The impulse withstand voltage may be verified using the methods "testing" or "assessment". With the testing method, verification may be provided with

- an impulse withstand voltage test
- or a power-frequency voltage test
- or a test with DC voltage

The design verification should therefore state the precise method, the confirmed impulse withstand voltage, and the test report number. If the assessment method is used, verification should include details of the method, the confirmed rated impulse withstand voltage, the required clearance (= 1.5 times the value shown in Table 1 of IEC 61439-1), the record number of the assessment, and the result of the assessment.

10.) Verification of temperature rise

Verification of temperature rise is the most time-consuming verification, regardless of which method is used (testing, derivation or assessment). There are several methods to choose from, and these methods impose certain documentation requirements on the manufacturer.

For verification of temperature rise, the options available are

- testing
- derivation of the rated values of similar variants or
- calculation methods

With the testing method, there are three test variants to choose from:

- The "verification of the complete assembly" (pursuant to section 10.10.2.3.5, IEC 61439-1), which entails testing the entire switchgear and controlgear assembly, is less time-consuming, but can only be used for systems whose design is always identical.
- With "verification considering individual functional units separately and the complete assembly" (pursuant to section 10.10.2.3.6, IEC 61439-1), the individual outgoing functional units are tested separately, and the entire assembly is also tested with parallel operation of the outgoing functional units. This provides the manufacturer with a statement on the maximum rated current of the outgoing units, and a rated load factor for parallel operation of the outgoing units. This means that the outgoing units may be flexibly selected according to requirements. However, with this test, no modifications may be made to the main busbar system.
- The "verification considering individual functional units and the main and distribution busbars separately as well as the complete assembly" (pursuant to section 10.10.2.3.7, IEC 61439-1) is intended for systems where both the number of enclosure panels and the configuration of the panels must be modular and modifiable. The test methods previously described do not satisfy this requirement. With this verification method, as well as testing the individual circuits as previously outlined, it is also necessary to test the function of the main busbar system and the distribution busbar system to the most extreme load.

All the data produced by these test methods allows a statement to be made regarding the maximum current carrying capacity of a circuit, which may differ from the rated data of the switchgear, depending on the test conditions. This information does not constitute an integral part of the design verification but must be available to the manufacturer of a low-voltage switchgear and controlgear assembly in order to ensure standard-compliant design.

The documentation of a planned switchgear and controlgear assembly must state the permissible rated current I_{nc} for each circuit.

Verification using the method "assessment of ratings for similar variants" is based on various sets of regulations for switchgear and controlgear assemblies, busbars and functional units. However, it presupposes that the corresponding original tests are available.

Verification of heat rise using the "calculation" method is confined to low-voltage switchgear and controlgear assemblies up to 630 A and 1600 A. Low-voltage switchgear and controlgear assemblies with higher currents must be verified using one of the other methods previously described.
The calculation method for low-voltage switchgear and controlgear assemblies with a rated current of no more than 630 A is limited to enclosures with only one compartment and a maximum frequency of 60 Hz. If these conditions are met, provided the conditions listed in points a) to g) of section 10.10.4.2.1 of IEC 61439-1 are fulfilled, the temperature rise may be calculated and evaluated in accordance with section 10.10.4.2.3 of IEC 61439-1.
The calculation method for low-voltage switchgear and controlgear assemblies with a rated current of no more than 1600 A may be used for enclosures with one or more compartments and a maximum frequency of 60 Hz. If these conditions are met, provided the conditions listed in points a) to i) of section 10.10.4.3.1 of IEC 61439-1 are fulfilled, the temperature rise may be calculated and evaluated in accordance with section 10.10.4.3.1 of IEC 61439-1.

For verification of heat rise, the method should be stated in the design verification:
If verification via testing is chosen, the precise test method, the maximum rated current of the switchgear and controlgear

assembly and the test report number should be stated. In the case of verification from derivation, as well as stating the method, the referenced original type with the test report number and derivation result should also be given.
In the case of verification using one of the two calculation methods, the verification should include the precise calculation technique, the maximum rated current of the switchgear and controlgear assembly, the number of the calculation record and the calculation result.
For all temperature rise verification methods, the detailed test reports or calculation records need not be included with the design verification, but should be archived with the original manufacturer for the purposes of future traceability.

11.) Short-circuit withstand strength

Short-circuit withstand strength may be verified using the methods "verification by testing", "verification by comparison with a reference design – utilising a check list" or "verification by comparison with a reference design – utilising calculation". If the method "verification by comparison with a reference design – utilising a check list" is chosen, the design verification should state this method, the referenced original model with the corresponding test report number, and the outcome of the comparison utilising the check list provided in Table 13 of IEC 61439. The standard does not permit derivation from one tested brand of switchgear to another, untested brand.

With the method "verification by comparison with a reference design – utilising calculation", the design verification should state this method, the referenced original model with the corresponding test report number, and the outcome of the calculation. If the "testing" method is chosen, as well as stating the method, verification should also include the maximum tested rated value and the test report number. Here too, the details from the test reports, calculations and comparisons are not an integral part of the design verification, but should be archived with the original manufacturer to allow subsequent traceability.

12.) Electromagnetic compatibility (EMC)

Electromagnetic compatibility may be verified via testing or assessment. The design verification should specify the chosen method and the documented ambient condition (A or B). With the "assessment" method, the record number of the assessment and the outcome of the assessment, e.g. "EMC requirements met", should be included. With the "testing" method, the test report number should additionally be specified.

13.) Mechanical operation

Mechanical operation can only be verified by testing. The design verification should state the "testing" method, the test report number and the test result.

IV. Sample design verification

Design verification	to IEC 61439 -2
Manufacturer	Model/code number

Section	Verification description	Criterion
10.2.2	Resistance to corrosion	Severity test A for interior siting
10.2.3.1	Thermal stability of enclosures	70 °C for a duration of 168 h with a recovery time of 96 h
10.2.3.2	Resistance of insulating materials to abnormal heat and fire due to internal electric effects	960 °C for parts necessary to retain current-carrying conductors in position; 850 °C for enclosures intended for mounting in hollow walls; 650 °C for all other parts
10.2.4	Resistance to ultra-violet (UV) radiation	
10.2.5	Lifting	Test run with the maximum mechanical load
10.2.6	Mechanical impact	IK 10
10.2.7	Marking	Engraving
10.3	Protection category of enclosures	IP 54
10.4	Clearances	5.5 mm for U_{imp} 6.0 kV
10.4	Creepage distances	16.0 mm for U_i 1000 V, VSG 3, WSG IIIa
10.5.2	Effective continuity between exposed conductive parts of the assembly and the protective circuits	< 0.1 Ohm
10.5.3	Short-circuit withstand strength of the protective circuit	Up to 30 kA with Rittal PE system 30 x 10 mm

	Date
Created by	Design verification number

Verification method	**Product**	**Report no.**
Testing	Rittal baying system TS 8	B100712010008
Testing	Rittal baying system TS 8	B100712010008
Testing	Rittal SV components	Verification via manufac-turer data sheet
Assessment	Rittal baying system TS 8	B100712010008
Testing	Rittal baying system TS 8	B100712010008
Testing	Rittal baying system TS 8	B100712010008
Not required		
Testing	Rittal baying system TS 8	B100712010008
Testing	Rittal RiLine60	1579.0263.7.163 / 1579.0797.5.293
Testing	Rittal RiLine60	1579.0263.7.163 / 1579.0797.5.293
Testing	Rittal PE system 30 x 10 mm	1579.0263.7.289
Testing	Rittal PE system 30 x 10 mm	1579.0263.7.289

Design verification	to IEC 61439 -2
Manufacturer	Model/code number

Section	**Verification description**	**Criterion**
10.6	Incorporation of switching devices and components	Compliance with the structural requirement in section 8.5 for the incorporation of switching devices and components and the response requirements for EMC.
10.7	Internal electrical circuits and connections	Compliance with the structural requirement in section 8.6 for internal electrical circuits and connections
10.8	Terminals for external conductors	Compliance with the structural requirement in section 8.8 for terminals for external conductors
10.9.2	Power-frequency withstand voltage	Main circuits (Table 8, IEC 61439-1)
		2200 VAC/3110 VDC for 800 V $< U_i \leq$ 1000 V
		Auxiliary circuits (Table 9, IEC 61439-1)
		1500 VAC/2120 VDC for 60 V $< U_i \leq$ 300 V
10.9.3	Impulse withstand voltage	U1.2/50‘ 7.3 kV for U_{imp} 6.0 kV
10.10	Temperature-rise limits	Verification by calculation for systems up to 1600 A to 10.10.4.3
		I_{nA} = 800 A
10.11	Short-circuit withstand strength	
10.12	Electromagnetic compatibility (EMC)	Ambient condition A
10.13	Mechanical operation	

	Date
Created by	Design verification number

Verification method	**Product**	**Report no.**
Assessment via inspection	Report	....
Assessment via inspection	Report	....
Assessment via inspection	Report	....
Testing	Rittal SV components	243/2011
Impulse withstand voltage test	Rittal SV components	1579.2100.157.0530
Calculation to 10.10.4.3	Proof of calculation from the assembly manufac-turer	....
Testing	Rittal RiLine60 – PLS1600	1579.0797.5.292 / 1579.0797.5.288 / 1579.0263.7.289
Assessment	Report	....
Not required		

V. Verification of temperature rise using calculations

The following two chapters contain a more detailed description of the verification of temperature rise using calculations and the verification of short-circuit withstand strength. These verifications merit a more in-depth description, since several additional requirements must be observed.

There are two variations for the verification of temperature rise utilising calculations, depending on the rated current of the assembly I_{nA} and the design of the enclosure. As this technique lends itself to multiple small or individual low-voltage switchgear and controlgear assemblies, it is described in greater detail below. A distinction is made between the simpler technique for low-voltage switchgear and controlgear assemblies with rated assembly currents I_{nA} < = 630 A which are housed in a single enclosure, and a more detailed technique where the rated assembly current must be I_{nA} < = 1600 A. With this technique, more than one enclosure may be used to accommodate the equipment. Both calculation techniques may only be used for applications with a predominant internal current distribution frequency of up to 60 Hz. However, certain rules regarding the engineering of the low-voltage switchgear and controlgear assemblies must be observed when applying this calculation technique. Verification cannot always be retrospectively prepared via calculation for an existing low-voltage switchgear and controlgear assembly, since certain basic requirements may be lacking.

1.) Calculation method with I_{nA} < = 630 A and max. 1 enclosure

Application of this technique is subject to the following requirements:

a. The rated assembly current I_{nA} must not exceed 630 A.

b. The low-voltage switchgear and controlgear assembly must only be installed in one enclosure.

c. Power loss figures for all planned operating equipment must be available.

d. The switchgear and other heat loss producers must be evenly distributed in the switchgear and controlgear assembly.

e. All operating equipment must be dimensioned so as not to exceed a maximum 80% load from the intended rated current of the circuit I_{nc}. The 80% refers to the device specifications for the conventional free air thermal current I_{th} or the rated current I_n. Example: If the rated current I_{nc} of the circuit is 8.0 A, the devices selected for this circuit must be capable of carrying a minimum current of 10 A according to the manufacturer's specifications.

f. The installed mechanical parts and operating equipment must not significantly impair free air convection.

g. As far as possible, current-carrying conductors for more than 200 A must be laid in such a way that they do not create additional temperature rise as a result of eddy currents and hysteresis losses.

h. The conductors used in the main current paths must be designed for at least 125% of the intended rated current I_{nc} of the circuit. The conductor cross-section is selected in conformity with IEC 60364-5-52. Busbar dimensioning may either be based on a tested design or selected in accordance with Annex N of IEC 61439-1. If the equipment manufacturers prescribe larger cross-sections for connecting their devices, these should be used.

i. The heat loss capacity of the enclosure used must be known depending on the assembly type, or determined by means of testing.

j. For additional active cooling measures, the cooling output must be known from the manufacturer of the cooling unit as per the type of application and usage conditions.

If the information referred to in points a) to j) is known, the calculation can begin. The power loss of every circuit is calculated based on the rated current I_{nc} of that circuit. The power loss of the devices (coils and current tracks) as well as the losses of the conductors must be ascertained for this purpose. The power loss of the conductors can be calculated in accordance with Annex H of IEC 61439-1. Depending on the conductor cross-section and length and how it is laid, the power loss can be calculated from the information in this table.

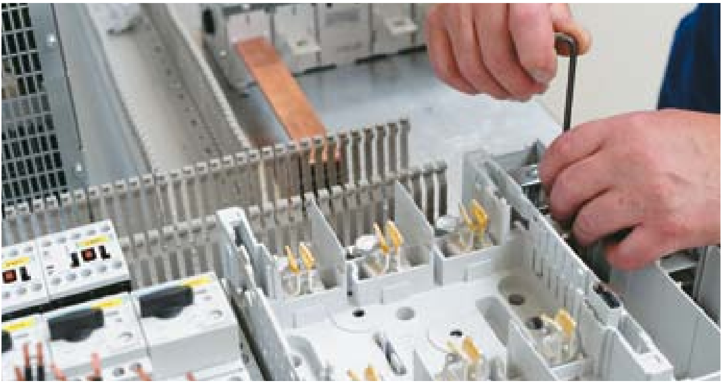
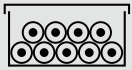


Table H.1 – Operating current and power loss of single-core copper cables with a permissible conductor temperature of 70 °C (ambient temperature inside the assembly 55 °C)

Conductor arrangement		 **Single-core cables in a cable trunking, on a wall, run horizontally. 6 of the cables (2 three-phase circuits) continuously loaded**		 **Single-core cables touching in free air or on a perforated tray. 6 of the cables (2 three-phase circuits) continuously loaded**		**Spacing at least one cable diameter**  **Single-core cables, spaced horizontally, in free air**	
Cross-sectional area of conductor mm^2	**Resistance of conductor at 20 °C, R_{20} [a] mΩ/m**	**Max. operating current I_{max} [b] A**	**Power losses per conductor P_v W/m**	**Max. operating current I_{max} [c] A**	**Power losses per conductor P_v W/m**	**Max. operating current I_{max} [d] A**	**Power losses per conductor P_v W/m**
1.5	12.1	8	0.8	9	1.3	15	3.2
2.5	7.41	10	0.9	13	1.5	21	3.7
4	4.61	14	1.0	18	1.7	28	4.2
6	3.08	18	1.1	23	2.0	36	4.7
10	1.83	24	1.3	32	2.3	50	5.4
16	1.15	33	1.5	44	2.7	67	6.2
25	0.727	43	1.6	59	3.0	89	6.9
35	0.524	54	1.8	74	3.4	110	7.7
50	0.387	65	2.0	90	3.7	134	8.3
70	0.268	83	2.2	116	4.3	171	9.4
95	0.193	101	2.4	142	4.7	208	10.0
120	0.153	117	2.5	165	5.0	242	10.7
150	0.124	–	–	191	5.4	278	11.5
185	0.099 1	–	–	220	5.7	318	12.0
240	0.075 4	–	–	260	6.1	375	12.7

[a] Values from IEC 60228:2004, Table 2 (multi-core conductors).
[b] Current carrying capacity I_{30} for a three-phase circuit to IEC 60364-5-52:2009, Table A-52-4, column 4 (laying type: point 6 in Table B.52-3). k_2 = 0.8 (point 1 in Table B 52-17, two circuits).
[c] Current carrying capacity I_{30} for a three-phase circuit to IEC 60364-5-52:2009, Table B-52-10, column 5 (laying type: point F in Table B.52-1). Values calculated for cross-sections below 25 mm^2 to Annex D of IEC 60364-5-52:2009, k_2 = 0.88 (point 4 in Table B.52-17, two circuits).
[d] Current carrying capacity I_{30} for a three-phase circuit to IEC 60364-5-52:52, Table B-52-10, column 7 (laying type: point G in Table B.52-1). Values calculated for cross-sections below 25 mm^2 to Annex D of IEC 60364-5-52:2009, k_2 = 1.

Source reference: IEC 61439-1, Table H1

The total power loss is obtained by adding together all the calculated power losses. However, it is important to remember that the total load current is limited to the rated current I_{nA} of the low-voltage switchgear and controlgear assembly.
The temperature rise of the low-voltage switchgear combination is determined from the total power loss, the enclosure's capacity to dissipate heat, and where applicable, any additional active cooling output. The Rittal Power Engineering software is very useful for determining the total power loss of the busbar system, the adaptors and equipment mounted on it, and other power loss producers, since many of the calculation functions are already included. Verification of temperature rise is considered to apply provided the interior temperature calculated from the power loss does not exceed the maximum admissible operating temperatures of the switchgear. Rittal Therm allows the user to select a suitable device for enclosure cooling, and then calculate the temperature rise in the enclosure interior.

Example: Calculated power loss 630 A

Verification of temperature rise via calculation in accordance with 10.10.4.2 (up to 630 A):							
Report no.:							
Section height 2000 mm							
Section width 800 mm							
Enclosure depth 500 mm							
Infeed and equipment data						**Protective switch**	
Circuit no.	Description of circuit	No. of poles in circuit	I_{nc}	RDF	I_{nc} *RDF	Rated device current I_n	Power loss of main contacts per pole
			A			A	W
1	Infeed	3	315	1	261.8	400	24
2	Busbar calculated	3	261.8	1	261.8	-	-
3	Busbar (values from Rittal Power Engineering)	3		1	0	-	-
4	Total outgoing circuits (values from Rittal Power Engineering)	3			0	-	-
5	Screw conveyor 1	3	6.6	0.8	5.3	10	2
6	Screw conveyor 2	3	6.6	0.8	5.3	10	2
7	Crusher drive 1	3	60	1	60	80	7
8	Crusher drive 2	3	60	1	60	80	7
9	Vibrating chute	3	15	0.8	12	22.5	4
10	Vibrating screen drive	3	21.5	0.8	17.2	30	5.5
11	Filter drive	3	9.8	0.8	7.9	12.5	2.2
12	Elevator	3	22	0.8	17.6	30	2.4
13	Air dryer	3	45	1	45	60	5.3
14	Building distributor	3	63	0.5	31.5	80	7
15					0		
16					0		
17					0		
18					0		

Section no.	Section description
Created by:	Date:
Enclosure siting type 1	Ambient temperature surrounding the enclosure 35 °C
Effective enclosure surface area 5.240 m²	Maximum admissible enclosure internal temperature 55 °C

Switchgear, contactor			**Connection conductor circuit**				**Power losses**		
Rated device current I_n	Power loss of main contacts per pole	Power loss of coil, converter	No. of conductors	Laying type [1)]	Length	Cross-section	Effective conductor power loss	Effective device power loss	Total circuit power loss
A	W	W			m	mm²	W	W	W
			3	3	3	10 x 24 x 1	63.37	23.14	86.51
-	-	-	3	4	4	30 x 10			6
-	-	-	-	-	-		-	-	
-	-	-	-	-	-	-	-	-	68
10	0.42	1	3	3	2.2	1.5	2.64	3.04	5.68
10	0.42	1	3	3	2.2	1.5	2.64	3.04	5.68
80	5	3	3	3	2.2	25	20.7	23.25	43.95
80	5	3	3	3	2.2	25	20.7	23.25	43.95
22.5	1.24	2	3	3	2.2	2.5	7.98	6.48	14.46
30	1.24	2	3	3	2.2	4	10.47	8.65	19.12
13	0.7	1	3	3	2.2	1.5	5.86	4.42	10.28
30	2.4	2	3	3	2.2	4	10.96	6.96	17.92
60	4	2	3	3	2.2	16	18.46	17.7	36.16
			3	3	2.2	25	5.71	3.26	8.97
						0	0	0	0
						0	0	0	0
						0	0	0	0
						0	0	0	0

Infeed and equipment data						Protective switch	
Circuit no.	Description of circuit	No. of poles in circuit	I_{nc}	RDF	I_{nc} *RDF	Rated device current I_n	Power loss of main contacts per pole
			A			A	W
19					0		
20					0		
21					0		
22					0		
23					0		
24					0		
25					0		
26					0		
27					0		
28					0		
29					0		
30	Other power loss producers, such as power packs, transformers etc.				0		
		Total I_{nc} * RDF			**261.8**		

[1] **Input options for laying type**
1 = Single-core conductors in sealed trunking
2 = Single-core conductors in a perforated tray
3 = Single-core conductors in free air with spacing in the conductor diameter
4 = Main busbar system

Area calculation	Individual areas A_0		Area factor b	A_0 * b
	m²			m²
Roof	0.400		1.4	0.560
Front	1.600		0.9	1.440
Back	1.600		0.9	1.440
Left side	1.000		0.9	0.900
Right side	1.000		0.9	0.900
		Effective surface area A_E		5.240 m²

Switchgear, contactor			Connection conductor circuit				Power losses		
Nominal device current	Power loss of main contacts per pole	Power loss of coil, conver-ter	No. of conduc-tors	Laying type [1]	Length	Cross-section	Effec-tive con-ductor heat loss	Effec-tive device power loss	Total circuit power loss
A	W	W			m	mm^2	W	W	W
						0	0	0	0
						0	0	0	0
						0	0	0	0
						0	0	0	0
						0	0	0	0
						0	0	0	0
						0	0	0	0
						0	0	0	0
						0	0	0	0
						0	0	0	0
						0	0	0	0
		105				0	0	105	105

Enclosure siting type
1 = Individual enclosure, free-standing
2 = Individual enclosure for external wall-mounting
7 = Individual enclosure for in-wall mounting (roof covered)

Total power loss [W]	**463.4**
Additional power loss dissipation from ventilation/ climate control [W]	**200**
Power loss difference [W]	**263.4**
Temperature rise of, enclosure [K]	**9.2**
Enclosure internal temperature [°C]	**44.2**

2.) Calculation method with I_{nA} <= 1600 A

This calculation method is rather more time-consuming, and the temperature of the enclosure interior must be calculated in accordance with IEC 60890. To this end, the previously mentioned requirements for the method with I_{nA} up to 630 A must be met, and various other information must be available in order to apply this method:

a. The rated current of the system I_{nA} must not exceed 1600 A.

b. The low-voltage switchgear and controlgear assembly may be fitted in an enclosure or multiple enclosure panels bayed together.

c. Details of the heat losses of all planned equipment must be available.

d. The switchgear and other power loss producers must be evenly distributed.

e. All operating equipment must be dimensioned so as not to exceed a maximum 80% load from the intended rated current of the circuit I_{nc}. The 80% refers to the device specifications for the conventional free air thermal current I_{th} or the rated current I_n.

Example: If the rated current I_{nc} of the circuit is 8.0 A, the devices selected for this circuit must be capable of carrying a minimum current of 10 A according to the manufacturer's specifications.

f. The installed mechanical parts and operating equipment must not significantly impair free air convection.

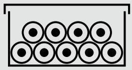
g. As far as possible, current-carrying conductors for more than 200 A must be laid in such a way that they do not create additional temperature rise as a result of eddy currents and hysteresis losses.

h. The conductors used in the main current paths must be designed for at least 125% of the intended rated current I_{nc} of the circuit. The conductor cross-section is selected in conformity with IEC 60364-5-52. Busbar dimensioning may either be based on a tested variant, or selected in accordance with Annex N of IEC 61439-1. If the equipment manufacturers prescribe larger cross-sections for connecting their devices, these should be used.

i. If natural ventilation is provided, the area of the air outlet opening should be at least 1.1 times the air inlet opening.
j. The enclosure panels should have no more than three horizontal divisions or dividing plates.
k. If the low-voltage switchgear and controlgear assembly has compartments and is to be cooled with natural ventilation, the ventilation openings for each horizontal subdivision should be at least 50% of the cross-section of the compartment footprint.

If the information referred to in points a) to k) is known, calculation of the heat loss can begin. The power loss of every circuit is calculated based on the rated current I_{nc} of that circuit. The power loss of the devices (coils and current tracks) as well as the losses of the conductors must be ascertained for this purpose. The power loss of the conductors can be calculated in accordance with Annex H of IEC 61439-1. Depending on the conductor cross-section and length and how it is laid, the power loss can be calculated from the information in this table.

Table H.1 – Operating current and power loss of single-core copper cables with a permissible conductor temperature of 70 °C (ambient temperature inside the assembly: 55 °C)

Conductor arrangement		 **Single-core cables, in a cable trunking, on a wall, run horizontally. 6 of the cables (2 three-phase circuits) continuously loaded**		 **Single-core cables touching in free air or on a perforated tray. 6 of the cables (2 three-phase circuits) continuously loaded**		**Spacing at least one cable diameter**  **Single-core cables, spaced horizontally, in free air**	
Cross-sectional area of conductor mm²	**Resistance of conductor at 20 °C, R_{20} [a] mΩ/m**	**Max. operating current I_{max} [b] A**	**Power losses per conductor P_v W/m**	**Max. operating current I_{max} [c] A**	**Power losses per conductor P_v W/m**	**Max. operating current I_{max} [d] A**	**Power losses per conductor P_v W/m**
1.5	12.1	8	0.8	9	1.3	15	3.2
2.5	7.41	10	0.9	13	1.5	21	3.7
4	4.61	14	1.0	18	1.7	28	4.2
6	3.08	18	1.1	23	2.0	36	4.7
10	1.83	24	1.3	32	2.3	50	5.4
16	1.15	33	1.5	44	2.7	67	6.2
25	0.727	43	1.6	59	3.0	89	6.9
35	0.524	54	1.8	74	3.4	110	7.7
50	0.387	65	2.0	90	3.7	134	8.3
70	0.268	83	2.2	116	4.3	171	9.4
95	0.193	101	2.4	142	4.7	208	10.0
120	0.153	117	2.5	165	5.0	242	10.7
150	0.124	–	–	191	5.4	278	11.5
185	0.099 1	–	–	220	5.7	318	12.0
240	0.075 4	–	–	260	6.1	375	12.7

[a] Values from IEC 60228:2004, Table 2 (multi-core conductors).
[b] Current carrying capacity I_{30} for a three-phase circuit to IEC 60364-5-52:2009, Table A-52-4, column 4 (laying type: point 6 in Table B.52-3). k_2 = 0.8 (point 1 in Table B 52-17, two circuits).
[c] Current carrying capacity I_{30} for a three-phase circuit to IEC 60364-5-52:2009, Table B-52-10, column 5 (laying type: point F in Table B.52-1). Values calculated for cross-sections below 25 mm² to Annex D of IEC 60364-5-52:2009, k_2 = 0.88 (point 4 in Table B.52-17, two circuits).
[d] Current carrying capacity I_{30} for a three-phase circuit to IEC 60364-5-52:52, Table B-52-10, column 7 (laying type: point G in Table B.52-1). Values calculated for cross-sections below 25 mm² to Annex D of IEC 60364-5-52:2009, k_2 = 1.

Source reference: IEC 61439-1, Table H1

The total power loss is obtained by adding together all the calculated power losses. However, it is important to remember that the total load current is limited to the rated current I_{nA} of the low-voltage switchgear and controlgear assembly.
The temperature rise of the low-voltage switchgear and controlgear assembly is calculated using the total power loss ascertained, applying the technique to IEC 60890. Here too, the Rittal Power Engineering software can be used to determine total power loss. However, the enclosure internal temperature must be calculated using one of the methods specified in IEC 60890.
Verification of temperature rise is considered to apply provided the interior temperature calculated from the power loss does not exceed the maximum admissible operating temperatures of the switchgear. In derogation of the technique for currents up to 630 A, with this method, different temperatures are determined via a diagram, which means that when testing switchgear and its maximum operating temperature in the upper section of a switchgear and controlgear assembly, higher temperatures are ascertained than in the lower section. For assessment purposes, this means that the maximum admissible temperatures should be taken into account for different sections of a switchgear and controlgear assembly.

Example: Calculated power loss 1600 A

Verification of temperature rise via calculation in accordance with 10.10.4.3 (up to 1600 A):							
Report no.:							
Section height 2000 mm							
Section width 1600 mm							
Enclosure depth 500 mm							
Infeed and equipment data						**Protective switch**	
Circuit no..	Description of circuit	No. of poles in circuit	I_{nc}	RDF	I_{nc} *RDF	Rated device current I_n	Power loss of main contacts per pole
			A			A	W
1	Infeed	3	800	1	525.8	1000	91
2	Busbar calculated	3	525.8	1	525.8	-	-
3	Busbar (values from Rittal Power Engineering)	3		1	0	-	-
4	Total outgoing circuits (values from Rittal Power Engineering)	3			0	-	-
5	Screw conveyor 1	3	6.6	0.8	5.3	10	2
6	Screw conveyor 2	3	6.6	0.8	5.3	10	2
7	Crusher drive 1	3	180	1	180	250	41
8	Crusher drive 2	3	60	1	60	80	7
9	Vibrating chute	3	15	0.8	12	22.5	4
10	Vibrating screen drive	3	21.5	0.8	17.2	30	5.5
11	Filter drive	3	9.8	0.8	7.9	12.5	2.2
12	Elevator	3	22	0.8	17.6	30	2.4
13	Air dryer	3	45	1	45	60	5.3
14	Building distributor	3	63	0.5	31.5	80	7
15	Supply to conveyor switchgear	3	180	0.8	144	250	35
16					0		
17					0		
18					0		

Section no.	Section description
Created by:	Date:
Enclosure siting type 1	Ambient temperature surrounding the enclosure 35 °C
Effective enclosure surface area 8.680 m^2	Maximum: Admissible enclosure internal temperature 55 °C
Air inlet openings 0 cm^2	No. of horizontal divider panels 0

Switchgear, contactor			**Connection conductor circuit**				**Power losses**		
Rated device current I_n	Power loss of main contacts per pole	Power loss of coil	No. of conduc-tors	Laying type [1)]	Length	Cross-section	Effective conduc-tor power loss	Effec-tive device power loss	Total circuit power loss
A	W	W			m	mm^2	W	W	W
			3	3	1.4	60 x 10	51.04	76.31	127.35
-	-	-	3	4	4	30 x1 0			22
-	-	-	-	-	-		-	-	
-	-	-	-	-	-	-	-	-	
10	0.42	1	3	3	2.2	1.5	2.64	3.04	5.68
10	0.42	1	3	3	2.2	1.5	2.64	3.04	5.68
250	28	3	3	3	2.2	120	39.07	110.31	149.38
80	5	3	3	3	2.2	25	20.7	23.25	43.95
22.5	1.24	2	3	3	2.2	2.5	7.98	6.48	14.46
30	1.24	2	3	3	2.2	4	10.47	8.65	19.12
13	0.7	1	3	3	2.2	1.5	5.86	4.42	10.28
30	2.4	2	3	3	2.2	4	10.96	6.96	17.92
60	4	2	3	3	2.2	16	18.46	17.7	36.16
			3	3	2.2	25	5.71	3.26	8.97
			3	3	2	120	22.74	34.84	57.58
						0	0	0	0
						0	0	0	0
						0	0	0	0

Infeed and equipment data						Protective switch	
Circuit no.	Description of circuit	No. of poles in circuit	I_{nc}	RDF	I_{nc} *RDF	Rated device current I_n	Power loss of main contacts per pole
			A			A	W
19					0		
20					0		
21					0		
22					0		
23					0		
24					0		
25					0		
26					0		
27					0		
28					0		
29					0		
30					0		
		Total I_{nc} * RDF			**525.8**		

[1)] **Input options for laying type**

1 = Single-core conductor in sealed trunking

2 = Single-core conductor in a perforated tray

3 = Single-core conductor in free air with spacing in conductor diameter

4 = Main busbar system

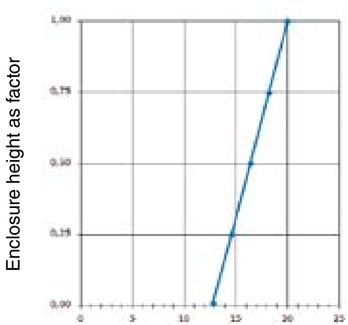
Area calculation	Individual areas A_0		Area factor b	A_0 * b
	m²			m²
Roof	0.800		1.4	1.120
Front	3.200		0.9	2.880
Back	3.200		0.9	2.880
Left side	1.000		0.9	0.900
Right side	1.000		0.9	0.900
		Effective surface area A_E		8.680 m²

Temperature calculation		
Air inlet openings of the panel	0	cm²
Enclosure constant k	0.107	
Factor for horizontal divider panels d	1.00	
Effective power loss	518.53	Watts
Exponent for P_V	0.804	
$P^X = P_V$^exponent	153	Watts
$\Delta t0.5 = k*d*P^X$	16.4	K
Temperature distribution factor c	1.222	
$\Delta t1.0 = c*\Delta t0.5$	20	K

Switchgear. contactor			Circuit conductor connection				Power losses		
Rated device current	Power loss of main contacts per pole	Power loss of coil	No. of conductors	Laying type [1]	Length	Cross-section	Effective conductor power loss	Effective device power loss	Total circuit power loss
A	W	W			m	mm²	W	W	W
						0	0	0	0
						0	0	0	0
						0	0	0	0
						0	0	0	0
						0	0	0	0
						0	0	0	0
						0	0	0	0
						0	0	0	0
						0	0	0	0
						0	0	0	0
						0	0	0	0
						0	0	0	0

Enclosure siting type
1 = Individual enclosure, free-standing
2 = Individual enclosure for external wall-mounting
3 = First or last enclosure in a suite, free-standing
4 = First or last enclosure in a suite for wall mounting
5 = Middle enclosure, free-standing
6 = Middle enclosure for external wall-mounting
7 = Individual enclosure for in-wall mounting (roof covered)

Total power loss [W]	**518.53**
Additional heat loss dissipation from ventilation/ climate control [W]	**0**
Power loss difference [W]	**518.53**
Top section of the enclosure	
Temperature rise of enclosure [K]	20.0
Enclosure internal temperature [°C]	55.0
Middle section of the enclosure	
Temperature rise of enclosure [K]	16.4
Enclosure internal temperature [°C]	51.4



Excess air temperature
inside the enclosure (K)

VI. Verification of short-circuit withstand strength

Short-circuit withstand strength may be verified by means of a comparison with a reference design (via calculation or use of a check list) or by testing.
Please note that it is not necessary to verify all circuits separately. Instead, by observing a few rules, a few selected circuits may be verified using the techniques described.
Under certain conditions, verification may not even be necessary.

a. Low-voltage switchgear and controlgear assemblies with a rated short-circuit withstand strength or a conditional rated short-circuit withstand current up to a maximum of 10 kA effective value need not be verified.

b. If a low-voltage switchgear and controlgear assembly or a circuit is protected by a current-limiting safety device which limits the cut-off current to a maximum of 17 kA, verification is not required.

c. Auxiliary circuits connected to transformers with a secondary rated voltage of 110 V or above and a rated output of no more than 10 kVA, and auxiliary currents with less than 110 V and a rated output of no more than 1.6 kVA are likewise exempt from verification.

Particularly for many smaller equipment outputs, therefore, verification is not required, since protective gear up to 630 A, such as moulded-case circuit-breakers and motor circuit-breakers, often has current-limiting functions that limit the cut-off current to below 17 kA. With regard for the specified short-circuit current present at the supply point, it is relatively easy to check, using the cut-off characteristics for the device, whether or not verification is required for the circuit in question. If the prospective short-circuit current of the supply system in a low-voltage switchgear and controlgear assembly is not known, and the

assembly is to be manufactured for a maximum cut-off current of 17 kA, the documentation should state that the supply to this low-voltage switchgear and controlgear assembly must be limited to a maximum cut-off current of 17 kA. However, it is also important to ensure that it is technically feasible to implement such a limited power supply.
A further criterion governing which circuits are subject to testing is derived from application of the check list in Table 13 of IEC 61439-1. If a tested low-voltage switchgear and controlgear assembly is available to serve as a reference design, the check list allows the user to determine whether verification using this method is admissible. The fact that the check list was applied should likewise be recorded in the report.
If complete verification or verification of individual circuits is not possible because not all the requirements on the checklist can be answered with "Yes", the method "Comparison via calculation or testing" should be used to obtain the missing verification.

For verification by comparison, please note that the standard does not permit derivation from one tested brand of switchgear to another, untested brand (see also point 6 of the checklist on page 68).

Table 13 – Short-circuit verification by comparison with a reference design: Check list (10.5.3.3, 10.11.3 and 10.11.4)

Point No.	Elements to be assessed	YES	NO
1	Is the short-circuit withstand rating of each circuit in the assembly to be assessed, less than or equal to the reference design?		
2	Are the cross-section dimensions of the busbars and connections of each circuit of the assembly to be assessed, greater than or equal to those of the reference design?		
3	Is the centre line spacing of the busbars and connections of each circuit of the assembly to be assessed, greater than or equal to those of the reference design?		
4	Are the busbar supports of each circuit of the assembly to be assessed of the same type, shape and material, and do they have the same or smaller centre line spacing across the length of the busbar as the reference design?		
5	Are the material and the material properties of the conductors of each circuit of the assembly to be assessed the same as those of the reference design?		
6	Are the short-circuit protective devices of each circuit of the assembly to be assessed equivalent, i.e. of the same make and series [a] with identical or superior current limitation characteristics (I^2t, I_{pk}) based on the device manufacturer's data, and with the same arrangement as the reference design?		
7	Is the length of unprotected live conductors, in accordance with 8.6.4, of each non-protected circuit of the assembly to be assessed less than or equal to those of the reference design?		
8	If the assembly to be assessed includes an enclosure, did the reference design include an enclosure when verified by test?		
9	Is the enclosure of the assembly to be assessed of the same design and type, and does it at least have the same dimensions, as the reference design?		
10	Are the compartments of each circuit of the assembly to be assessed of the same mechanical design and at least have the same dimensions as those of the reference design?		

"YES" to all requirements – No other verification required.
"NO" to any one requirement – Further verification required.

[a] Short-circuit protective devices of the same manufacturer but a different series may be considered equivalent where the device manufacturer declares the performance characteristics to be the same or better in all relevant aspects to the series used for verification, e.g. breaking capacity, current limitation characteristics (I^2t, I_{pk}) and critical distances.

Taken from IEC 61439-1 Annex H

For verification by comparison utilising calculation, the short-circuit withstand strength of busbar systems or solid busbar connections should be verified by a calculation pursuant to IEC 60865-1. However, calculation may only produce a lower peak short-circuit current withstand or a lower temperature rise than for the low-voltage switchgear and controlgear assembly used as a reference. With this verification method, points 6, 8, 9 and 10 of Table 13 must also be met for verification purposes. If verification cannot be obtained with this method either, the "testing" method must be used.
The test is carried out on a low-voltage switchgear and controlgear assembly as a reference. Identical functional units need not be re-tested, provided they can be considered equivalent in accordance with Table 13. When testing circuits with fuses, the make and model must be specified in the documentation of the manufactured low-voltage switchgear and controlgear assembly. During the test, the outgoing circuits, incoming circuits and main busbar systems are tested separately. Neutral conductors may be tested with reduced short-circuit currents but no less than 60% of the three-phase short-circuit current.
In particular, the testing of busbar systems in the enclosure with the mechanical assembly components should be available as a tested reference, since this is a requirement for testing (with the exception of low-voltage switchgear and controlgear assemblies in all-insulated enclosures). With short-circuit testing, an indicator should be used to verify that no fault current of more than 1500 A has discharged via the enclosure. For this reason, once again, testing the busbar system without a corresponding enclosure is insufficient for verification purposes.
As verification by testing necessitates the most cost-intensive record-keeping, it is important to consider the intended usage of tested system components during the planning and engineering stage of a low-voltage switchgear and controlgear assembly.

VII. Verification records of individual switchgear and controlgear assemblies

In the area of switchgear and controlgear assembly for machines, processes and plants, no two switchgears are usually the same. As such, it is not usually possible to make derivations from a tested assembly unless compiled from a modular system, such as the Rittal Ri4Power system. However, design verification is required for such individual systems in order to meet conformity assessment requirements and other statutory requirements.

This is also the point at which the manufacturer of the switchgear and controlgear assembly becomes the original manufacturer and becomes responsible for preparing the design verification. This may give rise to some debate over who within the manufacturer's organisation is responsible for preparing the design verification. Generally speaking, depending on the individual verifications, responsibility will rest with the engineering department, since it performs the selection and dimensioning of products, from which data is obtained which is later incorporated into the documentation of the switchgear and controlgear assembly. The company's manufacturing division is responsible for compliance with the production guidelines and preparation of the routine verification.

Some verifications are easily met and documented, provided system technology from Rittal is used. Rittal already has individual verifications for the mechanical strength of materials in Rittal components, which are available to switchgear manufacturers for design verification purposes. Similarly, verifications of protection category, clearance and creepage distances as well as verifications of the functioning of protective circuits are available to switchgear and controlgear assembly manufacturers for the Rittal system.

Verifications for the incorporation of operating equipment, for internal wiring and for external connections of lines and cables can only be

prepared by the manufacturer of the switchgear and controlgear assembly. Rittal can supply prepared check lists to assist manufacturers with record-keeping, and make the design verification process much simpler. Insulating properties must be verified by the manufacturer of the switchgear and controlgear assembly by testing the dielectric strength at operating frequency. Surge voltage resistance can be verified by Rittal by testing the system technology in its enclosures. Temperature rise can be verified using the calculation methods outlined in chapter V. Rittal Power Engineering and Rittal Therm are two extremely useful software tools featuring a host of valuable, time-saving functions to assist you with this task.
Short-circuit withstand strength can be verified by Rittal if using Rittal system products for power distribution, since these have all been verified by testing in Rittal enclosures. The relevant technical data is freely available in the relevant documentation.
Electromagnetic compatibility is relatively easy to verify, provided EMC-relevant devices are installed and used in accordance with the manufacturer's instructions. This will eliminate the need for time-

consuming tests, and the project planner can easily meet and confirm verification using the "assessment" method.
Verification of mechanical function is only necessary if the switchgear and controlgear assembly has particular mechanical functions. The mechanical function of devices such as the insertion function of a circuit-breaker need not be tested, since this function has already be verified by the device manufacturer via the device. If there are no additional mechanical functions, the comment "not required" should be included with this individual verification.

Particularly in the case of individual switchgear and controlgear assembly, for easier identification, as well as providing details of individual verifications, the design certificate should also contain the following information:

- Manufacturer of the assembly,
- a type designation or identification number,
- date of preparation of the design verification and
- name of the person preparing the design verification.

VIII. The routine verification

The routine verification for a switchgear and controlgear assembly is used to ascertain material defects or manufacturing defects during the production of a switchgear and controlgear assembly. Any switchgear and controlgear assembly that is marketed must have its function and safety confirmed by a routine verification. The results of the tests for the routine verification must be documented. In addition to the individual verifications, the routine verification must also contain manufacturer data about the switchgear and controlgear assembly and a type designation or identification number which must match the rest of the documentation.

The individual verifications for the routine verification are divided into construction requirements and performance requirements.
The following individual verifications must be provided:

1.) Protection category of enclosures

The degree of protection should be verified by means of a visual inspection. Checks must be carried out to ensure that all measures for compliance with the designated degree of protection have been implemented. The routine verification contains the individual verification, the test specification, the test result, the name of the person performing the test, and the documentation date.

2.) Clearance and creepage distances

If the clearance distances are less than the values specified in IEC 61439-1 or the data in the assembly documentation, an impulse voltage withstand test must be carried out.
If the clearance distances are not evident by visual inspection to be larger than specified in Table 1 of IEC 61439-1 or the data in the assembly documentation, verification can either be provided by physically measuring the clearance distance or by carrying out an impulse voltage withstand test.
If the clearance distances are evident by visual inspection to be larger, this should be noted in the verification, and more detailed testing is not necessary in such cases.

The clearance distances should also be verified by means of a visual inspection. If the creepage distance is not evident by visual inspection to be larger than the required value, compliance with the specification must be confirmed by physical measurement. The routine verification contains the individual verification, the test specification, the test result, the name of the person performing the test, and the documentation date.

3.) Protection against electric shock and integrity of protective circuits

The prescribed measures for compliance with basic protection and fault protection must be verified by means of a visual inspection. Screw-fastened connections in the protective circuit system must be checked on a random sample basis. The routine verification contains the individual verification, the test specification, the test result, the name of the person performing the test, and the documentation date.

4.) Incorporation of built-in components
The installation and identification of built-in components must comply with the specifications in the manufacturing documentation. This shall also include the specifications from the respective component manufacturer. The routine verification contains the individual verification, the test specification, the test result, the name of the person performing the test, and the documentation date.

5.) Internal electrical circuits
The internal connections of the circuits should be tested. Connections, especially screw connections, should be checked on a random sample basis. The conductors used must comply with the production documents. The routine verification contains the individual verification, the test specification, the test result, the name of the person performing the test, and the documentation date.

6.) Terminals for external conductors
The number, type and identification of the terminals must be complete and consistent with the production documents. The routine verification contains the individual verification, the test specification, the test result, the name of the person performing the test, and the documentation date.

7.) Mechanical operation
The mechanical operation of fasteners, actuator elements and locks, including those associated with removable parts, must be checked. For the routine verification, this should include, for example, the mechanical operation of a withdrawable circuit-breaker, even if this was not relevant in the design verification. The routine verification contains the individual verification, the test specification, the test result, the name of the person performing the test, and the documentation date.

8.) Dielectric properties

Dielectric properties must be tested for a duration of at least 1 second on all circuits in a switchgear and controlgear assembly, except circuits that are suitable for a lower test voltage. These should then be tested separately with the test voltage applicable to them. Auxiliary circuits that are protected with short-circuit protective gear up to 16 A or which have already undergone electrical operation testing at the rated operating voltage need not be additionally tested. Alternatively, in systems with a protective device in the infeed up to max. 250 A, insulation resistance may be verified with a test voltage of at least 500 V DC. In this case, the insulation resistance per circuit should be at least 1000 Ohm/V.
The routine verification contains the individual verification, the test specification, the test result, the name of the person performing the test, and the documentation date.

9.) Wiring, operational performance and function

Verify that the rating data of the switchgear and controlgear assembly is complete. A functional test should also be carried out. The amount of work involved and the number of tests depends on the complexity of the switchgear and controlgear assembly. Verification of function can also be carried out in situation after the switchgear and controlgear assembly has been installed.
The routine verification contains the individual verification, the test specification, the test result, the name of the person performing the test, and the documentation date.

The following example of a routine verification lists the required verifications in tabular form.

Description	Test specification	Test result	Tested by	Date
Verification pursuant to 11.2 Degree of protection of enclosures (visual inspection only).	IP__	IP__		
Verification pursuant to 11.3 Clearances and creepage distances. Physical measurement or impulse voltage withstand test in conformity with 10.9.3.	Clearance: > = __ mm Creepage distance: > = __ mm			
Verification pursuant to 11.4 Protection against electric shock and integrity of protective circuits. Visual inspection of measures.	ok			
Verification pursuant to 11.5 Incorporation of built-in components. Verify compliance of components with the manufacturing documents.	ok			
Verification pursuant to 11.6 Internal electrical circuits. Check the connections and conductors on a random sample basis.	ok			
Verification pursuant to 11.7 Terminals for external conductors. Check external conductors against the manufacturing documents.	ok			
Verification pursuant to 11.8 Mechanical operation. Test mechanical functions on the switchgear and controlgear assembly in conformity with 10.9.3.	ok			
Verification pursuant to 11.9 Dielectric properties. Test in accordance with 10.9.2.	__kV			
Verification pursuant to 11.10 Wiring, operational performance and function. Completeness of information and markings plus functional testing, where applicable additional test record of functional testing.	ok			

IX. Complete verification of a switchgear and controlgear assembly

Complete verification is comprised of an assembly cover sheet, the design verification and the routine verification. The assembly cover sheet comprises the rating data and usage conditions of the respective switchgear and controlgear assembly.
For each individual verification, the design verification should include the chosen verification method, the verification criterion, and the test report number or number of another report or the calculation. This document should be submitted together with the routine verification and the other documentation. There is no need to include the detailed test reports or calculations. These may only be inspected by a supervisory authority. All documents must be kept for a minimum of 10 years from the date of the switchgear or controlgear assembly's entry into circulation.

The declaration of conformity (which must be prepared if the assembly is intended for use within the European Economic Area) does not constitute part of the assembly documentation. This is to be prepared by the manufacturer, but can only be requested by a supervisory authority.

X. Assembly cover sheet and design verification form

Design verification to	☐ DIN EN 61439	☐ IEC 61439	Date
	Part 1 – General requirements ☐ Part 2 – Power switchgear and controlgear assembly ☐ Part 3 – Distribution enclosures up to 250 A ☐ Part 4 – Construction power distributors ☐ Part 5 – Cable distributor enclosure ☐ Part 6 – Bar distributors ☐ Part 7 – Special areas, e.g. marinas		Design verification number

Manufacturer of switchgear and controlgear assembly	
Address:	
Postcode, town:	
E-mail:	
Description of switchgear and controlgear assembly	

Rated voltage U_n	V		
Rated operating voltage of circuits U_e	V		
Rated insulation voltage U_i	V		
Rated impulse withstand voltage U_{imp}	kV		
Rated current of assembly I_{nA}	A		
Rated current of busbar system $I_{nc\ busbar}$	A		
Rated surge current withstand strength of assembly I_{pk}	kA		
Rated short-time withstand current of assembly I_{cw}	kA		sec.
Conditional rated short-circuit current of assembly I_{cc}	kA		
Rated diversity factor of assembly RDF			
Rated frequency f_n	Hz		

Network type	☐ TN-C	☐ TN-S	☐ TN-C-S
	☐ IT	☐ TT	☐ Other
Protection against electric shock			
Basic protection	☐ through insula-ting materials	☐ Cover or housing	☐ Total insulation
Fault protection	☐ through automatic switch off	☐ Electrical separation	☐ Total insulation
Protection category IP	☐ IP XX	☐ IP 2X	☐ IP 4X
	☐ IP 41	☐ IP 54	☐ IP 55
	☐ IP 65	☐ IP 66	☐ IP ...
Protection category IK	☐ IK 09	☐ IK 10	☐ IK ...
Type of assembly	☐ Fixed installation	☐ Insert technology	☐ Fully withdrawable
Siting area	☐ Indoors	☐ Outdoors	
Siting type	☐ Stationary	☐ Mobile	
Usage by	☐ Qualified electrician	☐ Instructed individual	☐ Layperson
Type of short-circuit protective device	☐ Circuit-breaker	☐ Fuse	☐ Other:

Overall dimensions	Width mm	Height mm	Depth mm
Total mass	kg		
EMC classification	☐ Environment A	☐ Environment B	
Level of contamination	☐ 1	☐ 2	☐ 3
Special operating conditions			

Sample design verification

Design verification	to IEC 61439__
Manufacturer	Type/identification number

Section	**Verification description**	**Criterion**
10.2.2	Resistance to corrosion	Severity __ for ________________
10.2.3.1	Thermal stability of enclosures	70 °C for a duration of 168 h with a recovery time of 96 h
10.2.3.2	Resistance of insulating materials to abnormal heat and fire due to internal electrical effects	960 °C for parts necessary to retain current-carrying conductors in position; 850 °C for enclosures intended for mounting in hollow walls; 650 °C for all other parts
10.2.4	Resistance to ultra-violet (UV) radiation	
10.2.5	Lifting	Test run with the maximum mechanical load
10.2.6	Mechanical impact	IK __
10.2.7	Markings	
10.3	Protection category of enclosures	IP __
10.4	Clearances	__ mm for U_{imp} __ kV
10.4	Creepage distances	__ mm for U_i __ V, VSG 3, WSG IIIa
10.5.2	Continuity of the connection between exposed conductive parts in the assembly and the protective circuits	< 0.1 Ohm
10.5.3	Short-circuit withstand strength of the protective circuit	

	Date
Created by	Design verification number

Verification method	Product	Report no.
Testing		
Testing		
Testing		
Testing		
Testing		
Testing		
Testing		

Design verification	to IEC 61439__
Manufacturer	Type/identification number

Section	**Verification description**	**Criterion**
10.6	Incorporation of switching devices and components	Compliance with the structural requirement in section 8.5 for the incorporation of switching devices and components and the response requirements for EMC.
10.7	Internal electrical circuits and connections	Compliance with the structural requirement in section 8.6 for internal electrical circuits and connections
10.8	Terminals for external conductors	Compliance with the structural requirement in section 8.8 for terminals for external conductors
10.9.2	Power-frequency withstand voltage	Main circuits (Table 8, IEC 61439-1)
		__ VAC / __ VDC for __ V < U_i ≤ __ V
		Auxiliary circuits (Table 9, IEC 61439-1)
		__ VAC / __ VDC for __ __ V
10.9.3	Impulse withstand voltage	U1.2/50‘ __ kV for U_{imp} __ kV
10.10	Temperature-rise limits	Verification by ________________ ____________________________
		I_{nA} = __ A
10.11	Short-circuit withstand strength	
10.12	Electromagnetic compatibility (EMC)	Ambient condition __
10.13	Mechanical operation	

	Date
Created by	Design verification number

Verification method	**Product**	**Report no.**
Assessment via inspection		
Assessment via inspection		
Assessment via inspection		
Testing		

ENCLOSURES POWER DISTRIBUTION CLIMATE CONTROL

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