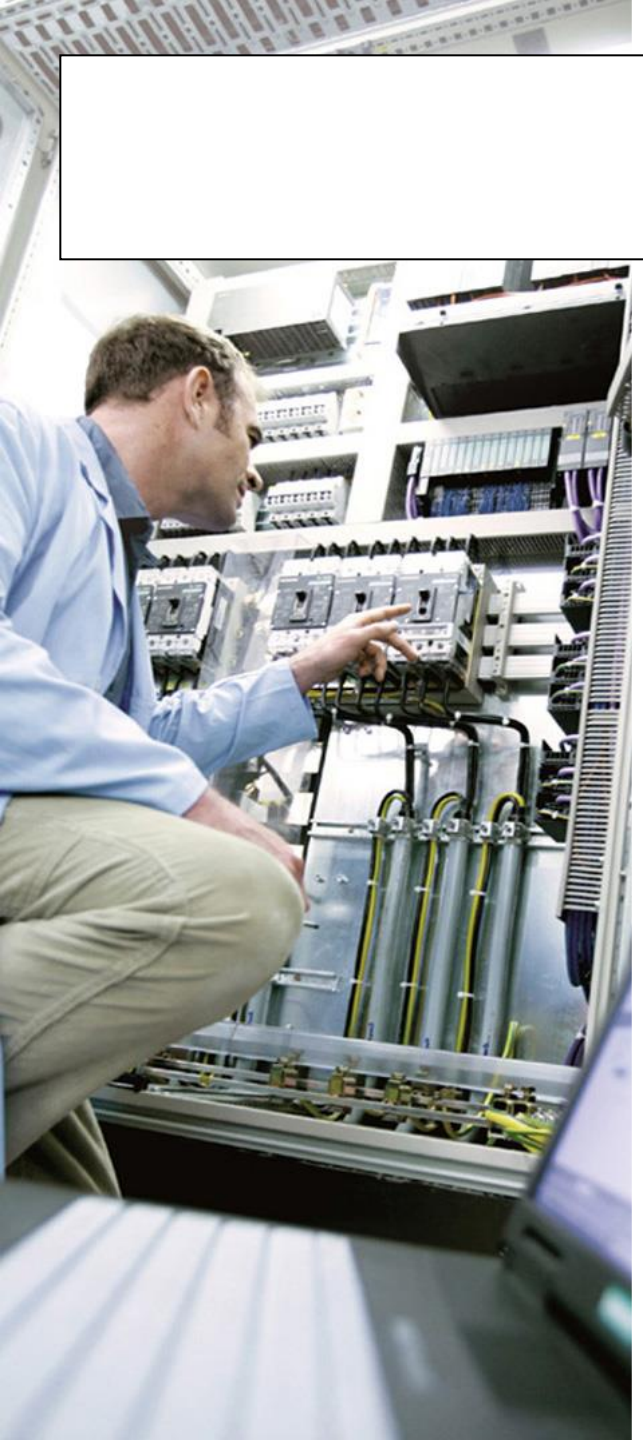

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IEC 61439 Parts 1 & 2 low-voltage switchgear and controlgear assemblies

Carrying out and documenting verification

- Introduction to verification tests
- Design verifications
- Routine verifications
- Documentation

Design verification:

Verification ***of specimens*** of a switchgear and controlgear assembly or parts of switchgear and controlgear assemblies to show the design meets the requirements of the relevant switchgear and controlgear assembly standard

Objective:

Verification of compliance with the general requirements of the IEC 61439-1 standard and the relevant IEC 61439–2….6 product standard

IEC 61439-1 §10
Design verifications are to be performed by the *original manufacturer* of the switchgear and controlgear assembly or their performance should be agreed upon.

Introduction to verification tests
Terminology

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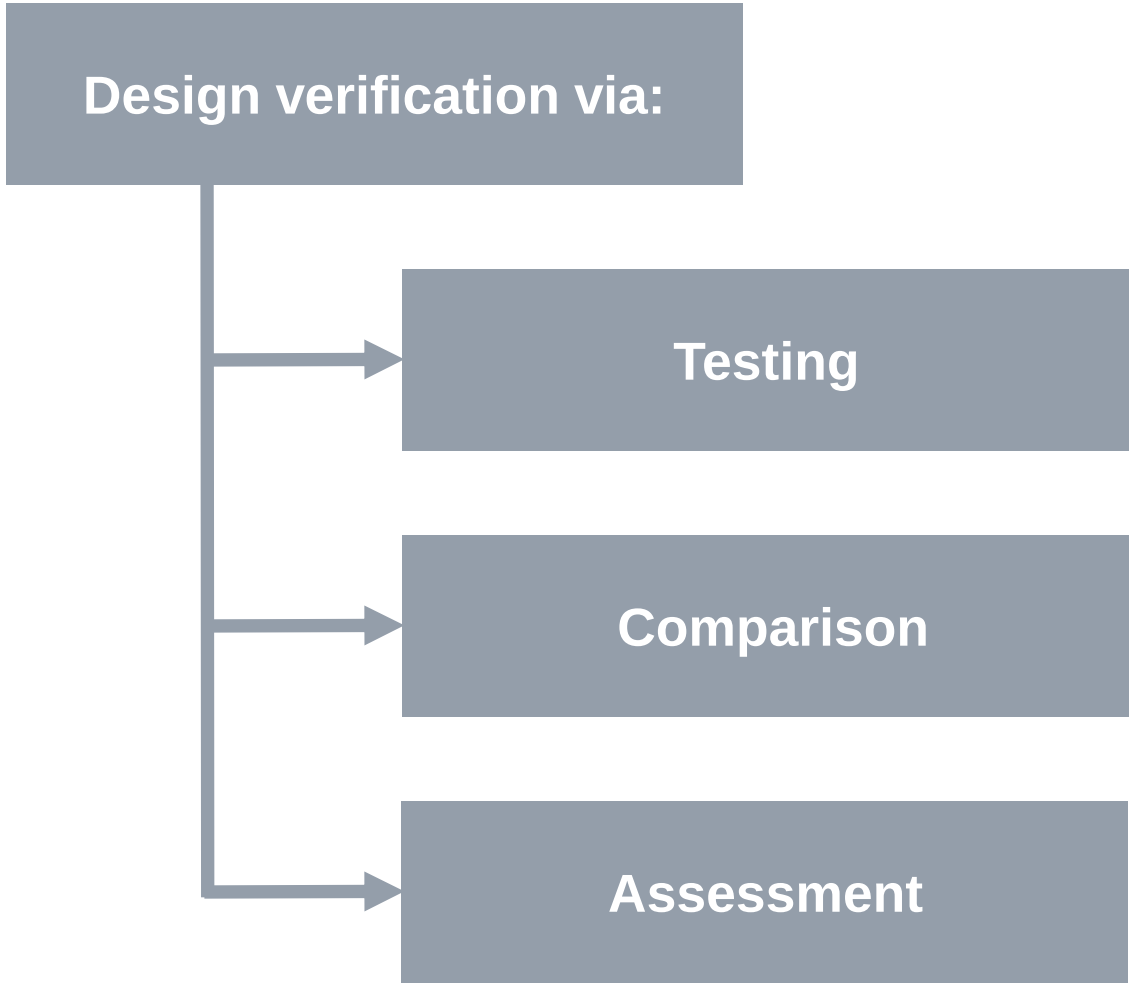

Tests on a specimen of a switchgear and controlgear assembly or parts of switchgear and controlgear assemblies

Structured comparison of the planned design or parts of a switchgear and controlgear assembly with a reference design, verification via testing

Design verification of set design rules or calculations based on a specimen or parts of a switchgear and controlgear assembly

Routine verification

Verification process to which ***each*** switchgear and controlgear assembly is subjected during and/or after its manufacture to ensure it meets the requirements of the relevant switchgear and controlgear assembly standard

Objective:

- To identify material and manufacturing defects
- Ensure operability

DIN EN 61439-1 §11
Routine verifications are to be performed by the manufacturer of the switchgear and controlgear assembly.

Design verifications

Verification options in accordance with IEC 61439-1 Annex D

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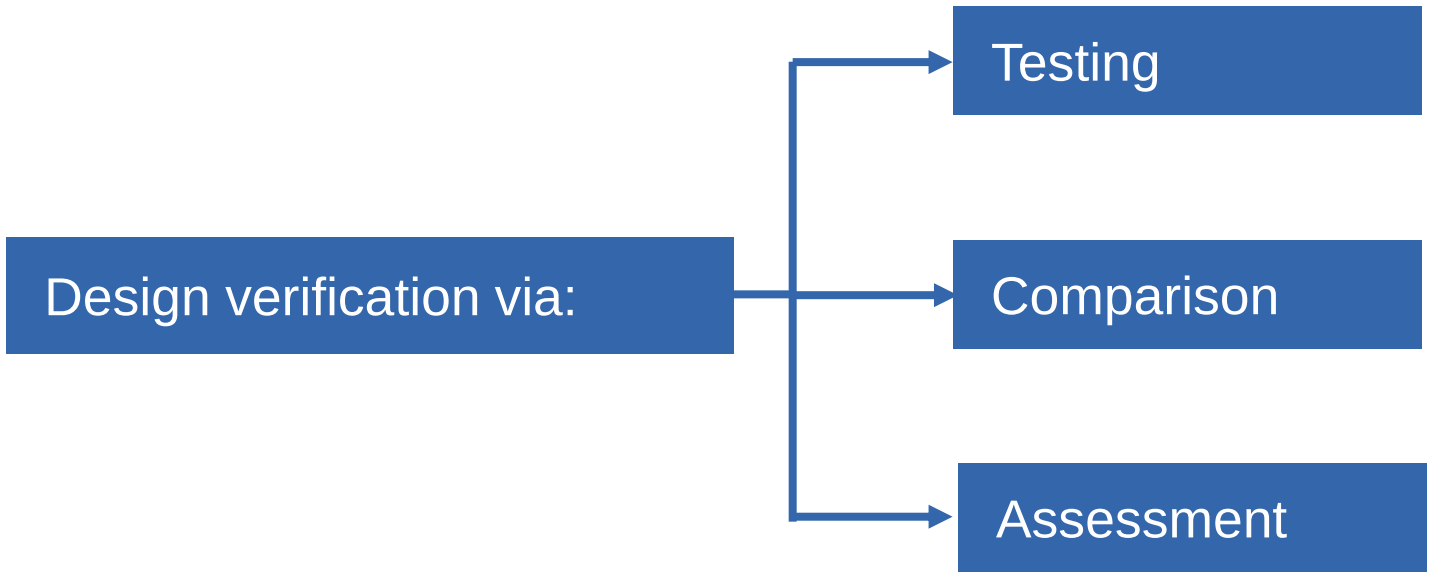
- There are alternative processes for some design verifications.
- Alternative processes are treated as being equivalent.
- The original manufacturer makes the choice.



Annex D
(informative)

Design verification

Table D.1 – List of design verifications to be performed

No.	Characteristic to be verified	Clauses or subclauses	Verification options available		
			Testing	Comparison with a reference design	Assessment
1	Strength of material and parts:	10.2			
	Resistance to corrosion	10.2.2	YES	NO	NO
	Properties of insulating materials:	10.2.3			
	Thermal stability	10.2.3.1	YES	NO	NO
	Resistance to abnormal heat and fire due to internal electric effects	10.2.3.2	YES	NO	YES
	Resistance to ultra-violet (UV) radiation	10.2.4	YES	NO	YES
	Lifting	10.2.5	YES	NO	NO
	Mechanical impact	10.2.6	YES	NO	NO
	Marking	10.2.7	YES	NO	NO
2	Degree of protection of enclosures	10.3	YES	NO	YES
3	Clearances	10.4	YES	NO	NO
4	Creepage distances	10.4	YES	NO	NO
5	Protection against electric shock and integrity of protective circuits:	10.5			
	Effective continuity between the exposed conductive parts of the ASSEMBLY and the protective circuit	10.5.2	YES	NO	NO
	Short-circuit withstand strength of the protective circuit	10.5.3	YES	YES	NO
6	Incorporation of switching devices and components	10.6	NO	NO	YES
7	Internal electrical circuits and connections	10.7	NO	NO	YES
8	Terminals for external conductors	10.8	NO	NO	YES
9	Dielectric properties:	10.9			
	Power-frequency withstand voltage	10.9.2	YES	NO	NO
	Impulse withstand voltage	10.9.3	YES	NO	YES
10	Temperature-rise limits	10.10	YES	YES	YES
11	Short-circuit withstand strength	10.11	YES	YES	NO
12	Electromagnetic compatibility (EMC)	10.12	YES	NO	YES
13	Mechanical operation	10.13	YES	NO	NO

Design verifications
Verification options in accordance with IEC 61439-1 Annex D

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Property requiring verification	Verification options		
	Testing	Comparison	Assessment
Strength of materials	YES	NO	NO 1.)
Degree of protection of the enclosure	YES	NO	YES
Clearances	YES	NO	NO
Creepage distances	YES	NO	NO
Protection against electric shock and integrity of protective circuits	YES	NO 2.)	NO
Incorporation of switching devices and components	NO	NO	YES
Internal electrical circuits and connections	NO	NO	YES
Terminals for external conductors	NO	NO	YES
Dielectric properties	YES	NO	NO 3.)
Temperature rise limits	YES	YES	YES
Short-circuit withstand strength	YES	YES	NO
Electromagnetic compatibility (EMC)	YES	NO	YES
Mechanical function	YES	NO	NO

Exceptions:

1.) UV radiation / resistance to exceptional heat and fire

2.) Short-circuit withstand strength of the protective conductor

3.) Surge voltage strength

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13 design verifications to be performed in accordance with IEC 61439-1

1	Design	2	Performance
1.1	Strength of materials and parts	2.1	Dielectric properties
1.2	Degree of protection of the enclosure	2.2	Verification of temperature rise
1.3	Clearances and creepage distances	2.3	Short-circuit withstand strength
1.4	Protection against electric shock and integrity of protective circuits	2.4	Electromagnetic compatibility
1.5	Incorporation of switching devices and components	2.5	Mechanical function
1.6	Internal electrical circuits and connections		
1.7	Terminals for external conductors		

Verification objective:

Verification of the mechanical, electrical, and thermal suitability of materials and parts

Generally speaking:

If an enclosure in accordance with IEC 62208 is used, no further ***"strength of materials"*** tests will be required!

Note:
IEC 62208 – Empty enclosures for low-voltage switchgear and controlgear assemblies – General requirements

SIEMENS example:
IEC Alpha Box wall-mounted distribution board in accordance with IEC 62208

If no IEC 62208 enclosure is being used:

- **Corrosion resistance;** for ferrous metal enclosure
- **Properties of insulating materials;** thermal stability and resistance against exceptional heat
- **Resistance against ultraviolet (UV) radiation;** only for enclosure installed outdoors coated with insulating material
  Exception: This test does not need to be performed if the original manufacturer can provide data from the material supplier showing the material satisfies the requirements in the same type and thickness or thinner.
- **Lifting;** optional, if requested
- **Impact testing;** optional for power switchgear and controlgear assemblies in accordance with IEC 61439-2, if requested
- **Labels;** only for labels manufactured by molding, injection, engraving

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Generally speaking:

The degree of protection (**IP**) does not need to be tested for enclosure already tested to IEC 62208!

Assessment:

- If an empty enclosure is used in accordance with IEC 62208, a verification in the form of an expert appraisal must be performed to ensure that all external changes made do not impair the degree of protection. In this case, no additional test is necessary.

Test:

- If no IEC 62208 enclosure is being used:

  → Performance of IEC 60529 testing (degree of protection offered by enclosure – IP Code)

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Objective:

To ensure dielectric properties are appropriate for installations where contamination (creepages) and excess voltage levels (clearances) are an issue

Generally speaking:

Clearances and creepage distances need to be measured in line with Annex F for IEC 61439-1!

Measurement of clearances and creepage distances – Table F.1 Annex F

Table F.1 – Minimum width of grooves

Pollution degree	Minimum values of width X of grooves mm
1	0,25
2	1,0
3	1,5
4	2,5

Pollution degree 3 is the standard industry value!

Objective: Effectiveness of protective function in the event of a fault

- For internal faults in the switchgear cabinet **(1)**
- For external faults within electrical circuits supplied by the switchgear cabinet **(2)**

(1) Continuous connection of the protective conductor to the conductive parts in the switchgear cabinet (protection in the event of internal faults)

- All conductive parts must be connected to the protective conductor.
- Max. resistance R ≤ 0.1Ω of the electrical circuit
- Verification using a resistance meter (AC or DC) at a minimum of 10A; current flows from any component to the terminal for the external protective conductor.

(2) Short-circuit withstand strength of the protective circuit (protection in the event of external faults)

a) Verification via ***comparison with a tested reference design*** –

I. Based on a checklist (Table 13 IEC 61439-1)
Satisfaction of Points 1-6 and 8-10

II. Based on a calculation

- Equivalent to "**verification of the short-circuit withstand strength of busbar arrangements via comparison with a tested reference design"**
- Plus satisfaction of Points 6-10 in the checklist (Table 13 IEC 61439-1)

b) Verification by ***testing*** short-circuit withstand strength to IEC 61439-1 paragraph 10.11.5.6 Testing the protective circuit

Note: *There is no need to test electrical circuits which can be discounted in terms of short-circuit withstand strength – the relevant condition is described under Point 2.3 of the design verification section.*

Generally speaking:

Verification is based on an assessment of constructional requirements (IEC 61439-1 Chapter 8). The manufacturer specifications need to be followed at the time of installation!

Electromagnetic compatibility:

a) Testing by inspecting the environment defined (A or B) with the incorporated switching devices and components which are relevant from an EMC perspective

b) Or, if necessary, confirmation via EMC testing

- Indication of whether terminals for copper and/or aluminum
- Unless agreed otherwise, copper cross sections (min. and max. terminal sizes) must be devised as per Annex A (does not apply to circuits where Icn ≤ 1A and Udc ≤ 120V or Uac ≤ 50V).
- If aluminum terminals are being used, agreement needs to be reached on the type, size, and terminal technology.
- N-conductor at least 50% of the external conductor cross section, but no less than 16mm²
  N-conductor cross-section reduction only permitted from 16mm² of the phase conductor
- Marking of terminals for external PE conductors with  ; not necessary if there is green/yellow marking
- Terminal cross section for external copper PE conductors as per Table 5

Objective: Testing by inspecting the terminals for external conductors (IEC 61439-1 Chapter 8)

Generally speaking:

a) ***Each circuit*** must be designed for the following kinds of excess voltage.
   - Temporary excess voltages
     → tested based on power-frequency withstand voltage
   - Transient excess voltages
     → tested based on surge voltage strength

b) ***All electrical switching devices and components*** must be connected.
   Exception:
   - Devices designed for a small test voltage
   - Devices which induce a current flow (windings, measuring instruments, devices protecting against excess voltages, etc.)

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b) **Verification via expert appraisal:**

- Clearances must be at least 1.5 times the Table 1 value.
- Rather than measuring clearances, the dimensions in the design drawings can be checked instead.
- Switching devices and components must be appropriate for the rated surge voltage strength U_{imp} defined.

Table 1 – Minimum clearances in air [a] (8.3.2)

Rated impulse withstand voltage U_{imp} kV	Minimum clearance mm
≤ 2,5	1,5
4,0	3,0
6,0	5,5
8,0	8,0
12,0	14,0

[a] Based on inhomogeneous field conditions and pollution degree 3.

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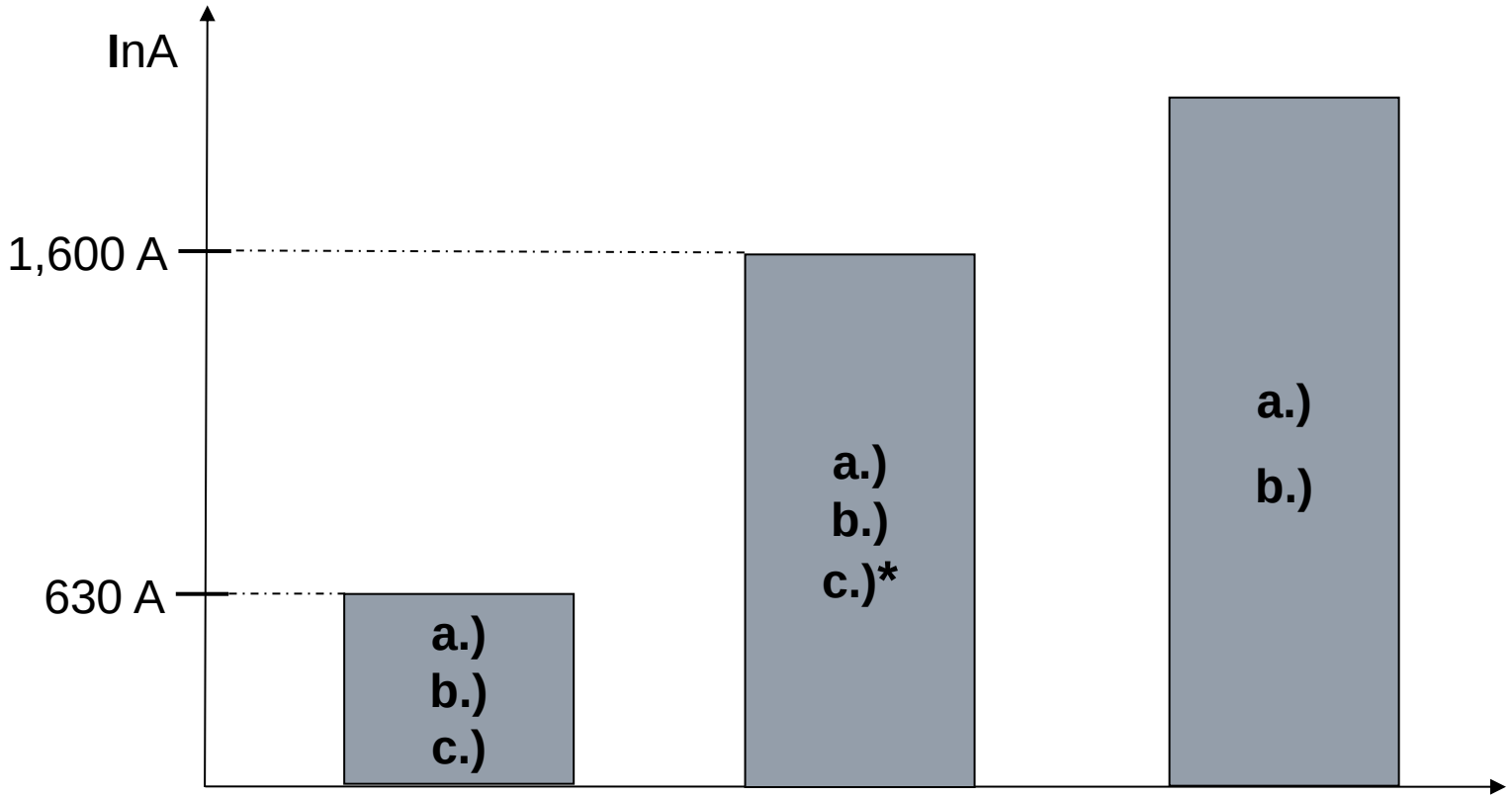
3 Verification options: testing, comparison, assessment

a.) Testing

b.) Comparison

c.) Assessment



different InA for the switchgear and controlgear assembly

***) Restrictions**

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Table 6, IEC 61439 – applies with a max. ambient temperature ≤ 35°C

Parts of the switchgear and controlgear assembly		Temperature-rise limit [K]
In-built switching devices and components		As per specifications
Terminals for incoming/outgoing insul. conductors		70 K (e.g. 35 + 70 = 105°C)
Current bars, conductors, plug-in contacts, replaceable parts		Limited by: ▪ Mechanical strength ▪ Influence on adjacent switching devices and components ▪ Limit temperature of insulating materials ▪ Connected switching devices and components ▪ Contact material for isolating contacts
Controls	Metal Insulating material	15 K (e.g. 35 + 15 = 50°C) 25 K (e.g. 35 + 25 = 60°C)
Exterior surfaces exposed to the touch	Metal Insulating material	30 K (e.g. 35 + 30 = 65°C) 40 K (e.g. 35 + 40= 75°C)
Plug connections		Limited by incoming switching devices and components
Within switchgear and controlgear assemblies, higher temperatures may occur at grounded metal parts if damage involving built-in switching devices and components can be ruled out.		

2 calculation methods are allowed:

1. **I_{nA} ≤ 630 A**
   Comparing the resulting power loss with the power loss associated with the enclosure

2. **I_{nA} ≤ 1600 A**
   Calculating the power loss and radiation via the enclosure in accordance with **IEC 60890** for switchgear and controlgear assemblies **I_{nA} > 630 A to 1600 A** (maximum of 3 internal partitions)

Generally speaking:

- The rated current for the circuits may not exceed 80% of the conventional thermal rated currents for switchgear and electrical switching devices and components in free air within the circuit.
- All conductors must have a minimum cross section equivalent to 125% of the permissible rated current.

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Verification of rated currents for short circuits via

- Comparison with a reference construction (checklist or calculation)
- Testing

Verification of the short-circuit withstand strength of circuits *is not required* for:

a) Switchgear and controlgear assemblies with a rated short-term withstand current ***Icw*** or a conditional rated short-circuit current ***Icc with a root mean square value of 10 kA at the most***;

b) Switchgear and controlgear assemblies *or* circuits of switchgear and controlgear assemblies, protected by current-limiting devices, whose ***peak-let through current*** at the highest permissible uninfluenced short-circuit current at the in-feed terminals of the switchgear and controlgear assembly ***does not exceed 17 kA***;

c) For ***auxiliary circuits:*** $U_N \geq 110$ V, $P_N \leq 10$ kVA and uk ≥ 4%

$U_N < 110$ V, $P_N \leq 1.6$ kVA and uk ≥ 4%

Design verification – performance

2.3 Verification of short-circuit withstand strength is not required – case a.)

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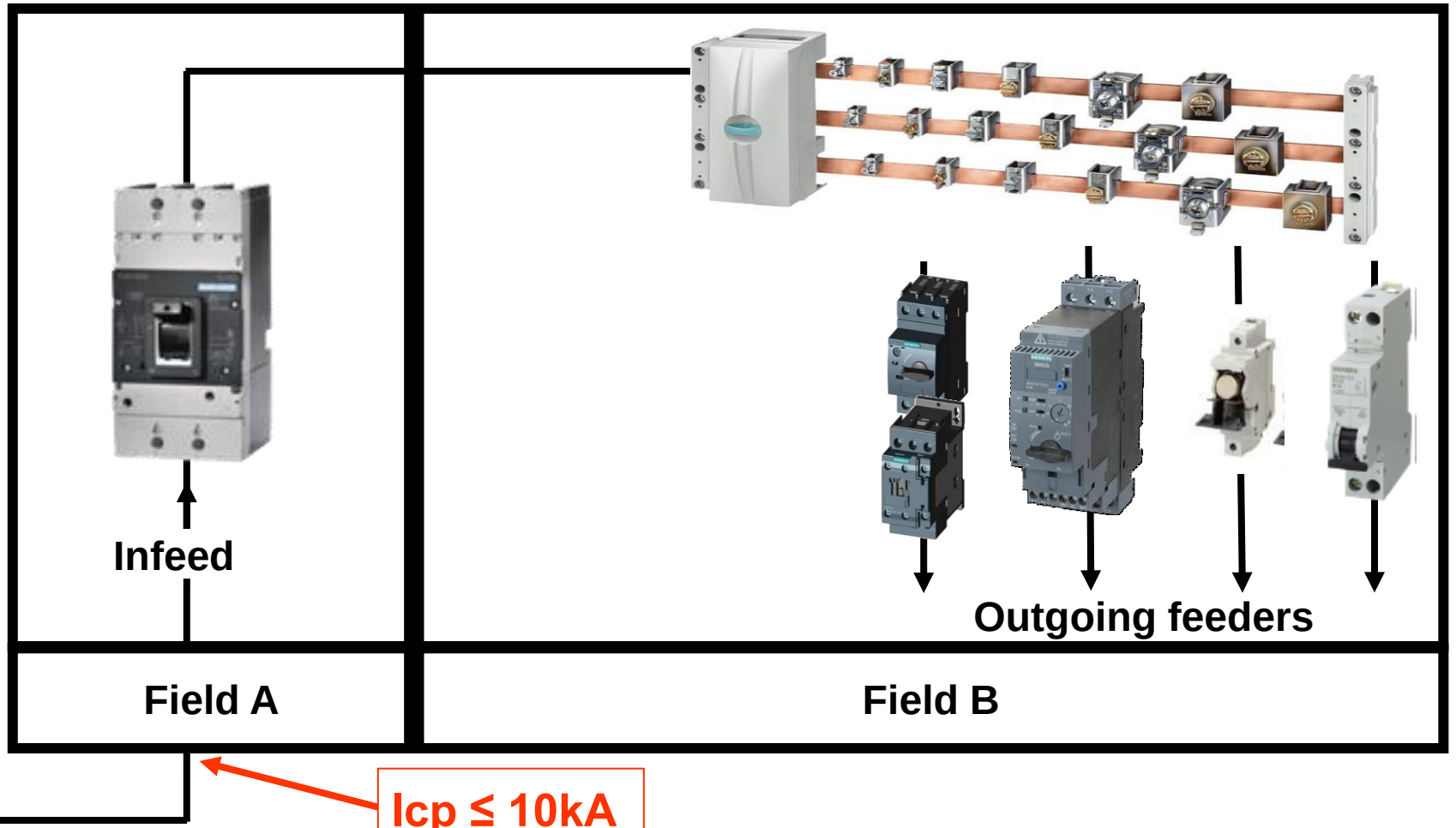
A rated short-term current tolerance *Icw*

or

conditional rated short-circuit current *Icc*

≤ 10 kA



Design verification – performance

2.3 Verification of short-circuit withstand strength is not required – case b.)

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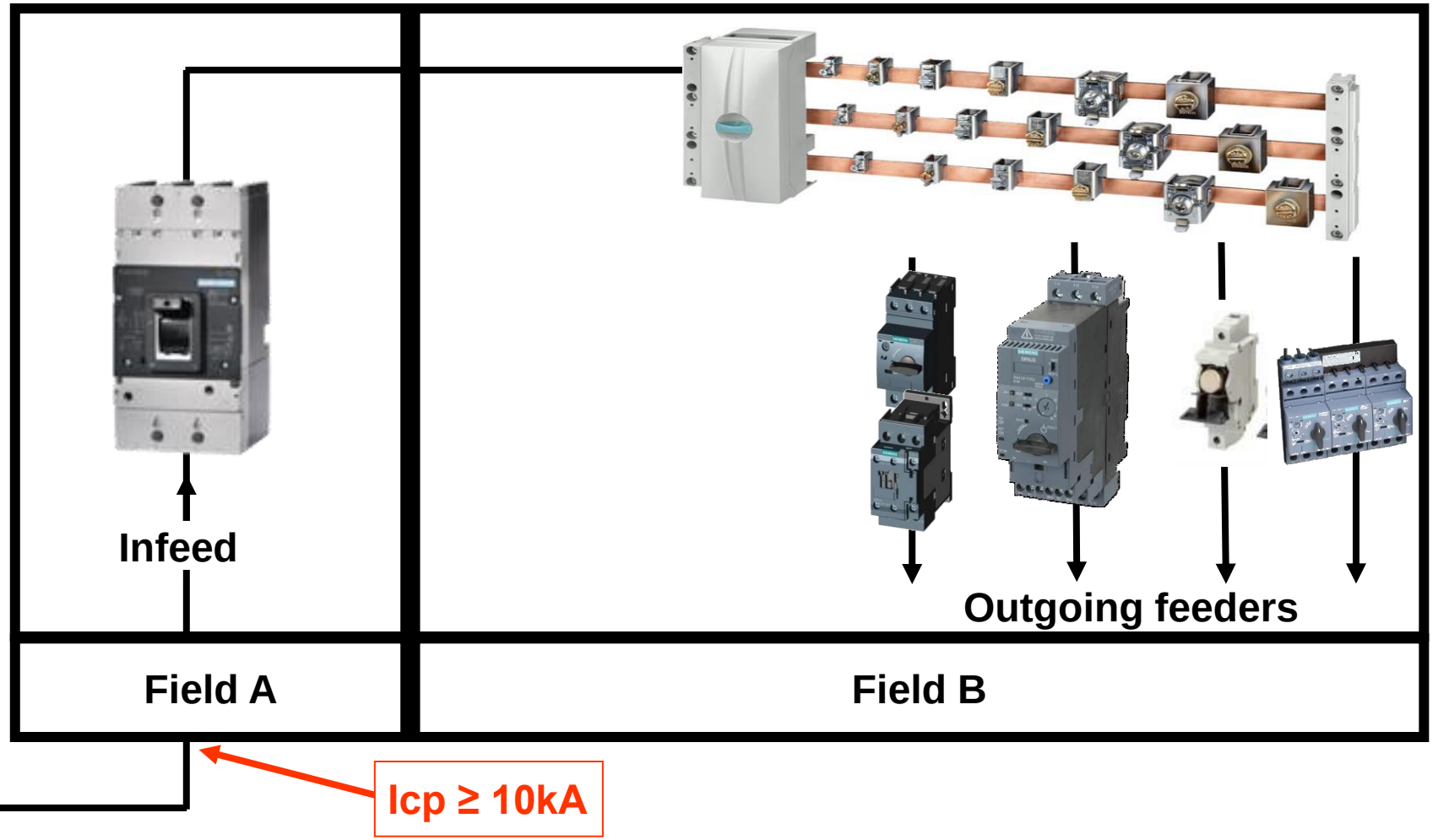
Overcurrent protection devices:

Ipeak ≤ 17kA
at Icp ≥ 10kA



Design verification – performance

2.3 Verification of short-circuit withstand strength is not required – case c.)

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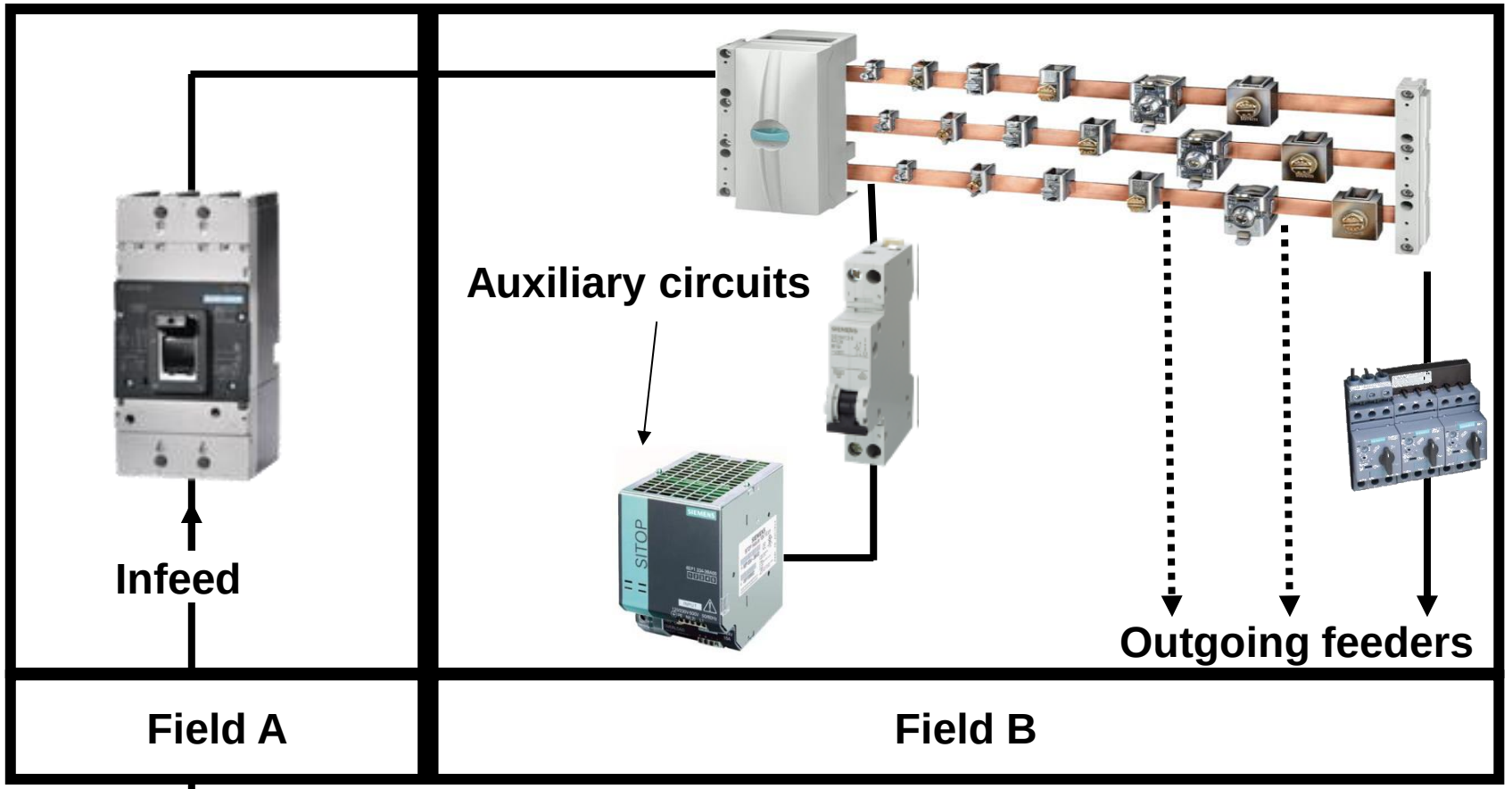
Auxiliary circuits:

$U_N \geq 110$ V, $P_N \leq 10$ kVA and uk ≥ 4%

$U_N < 110$ V, $P_N \leq 1.6$ kVA and uk ≥ 4%



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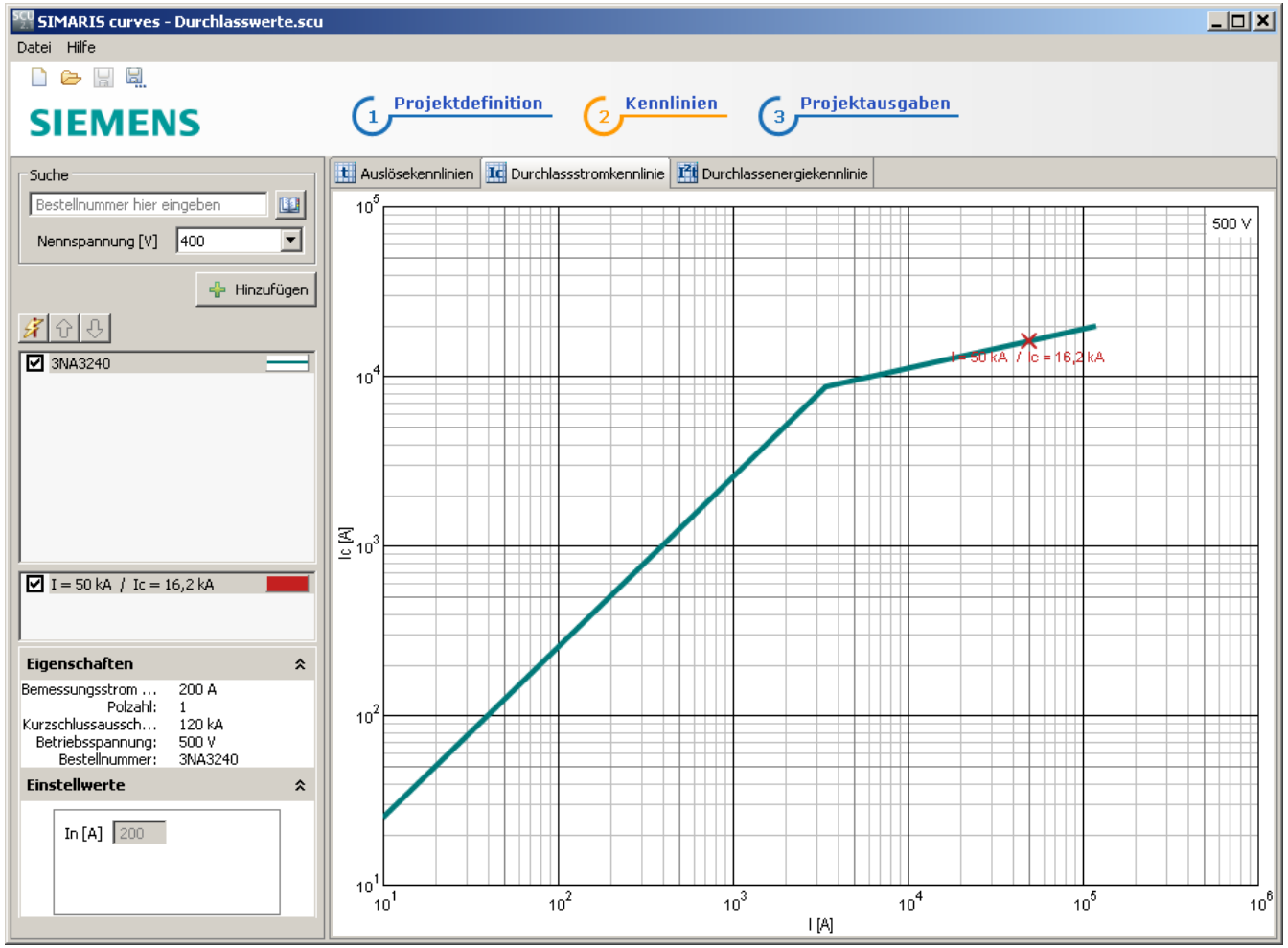
Example with SIMARIS curves:

- NH fuse 3NA..., 200 A,
  Icu = 120 kA
- Icp = 50 kA → Ipeak = 16.2 kA

→Ipeak ≤ 17 kA

→No verification of the short-circuit withstand strength necessary!



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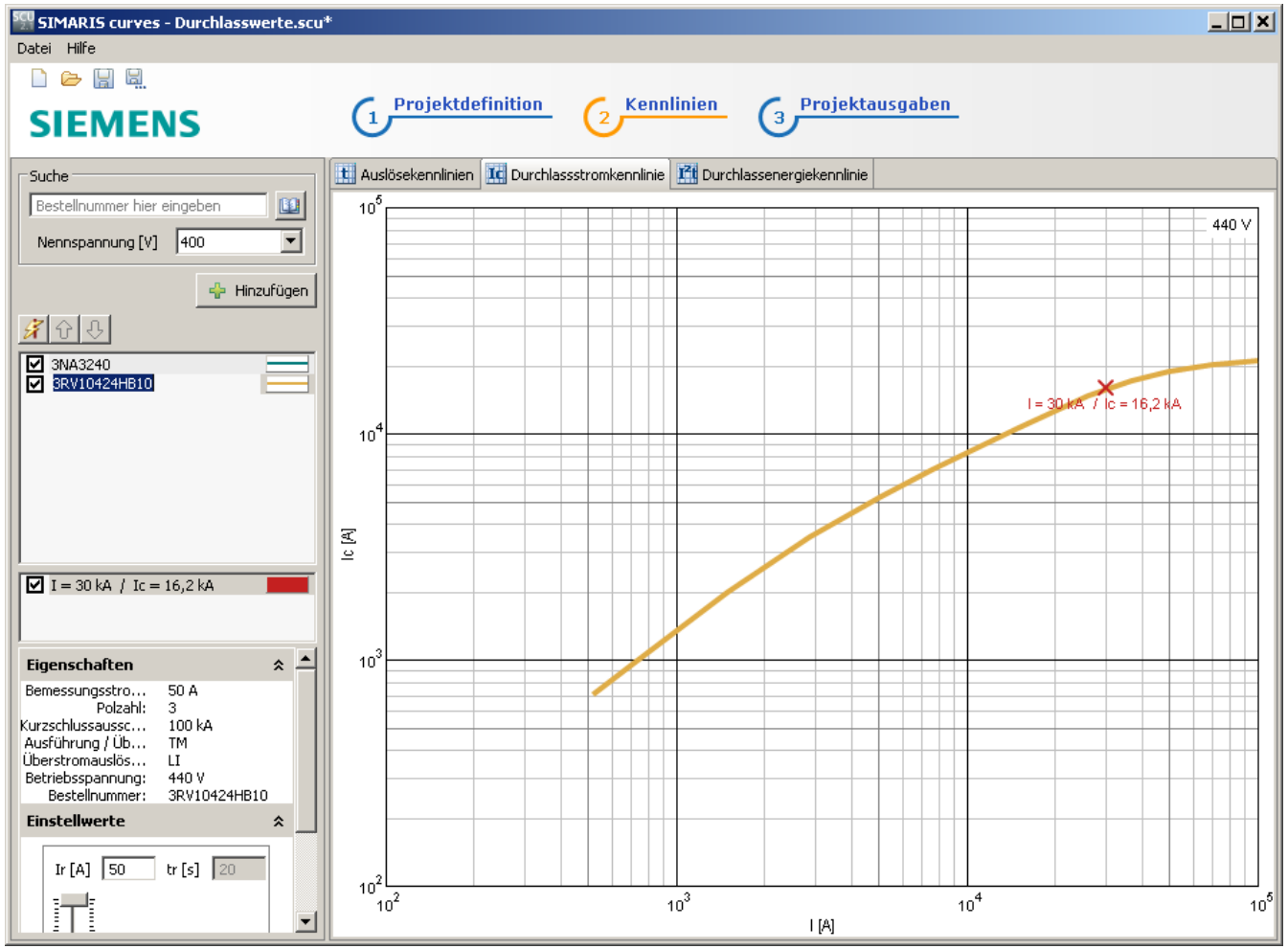
Example with SIMARIS curves:

- Circuit breaker 3RV1042, 50 A, Icu = 100 kA
- Icp = 30 kA → Ipeak = 16.2 kA

→ Ipeak ≤ 17 kA

→ No verification of the short-circuit withstand strength necessary!



2.3 Verification of short-circuit withstand strength – comparison

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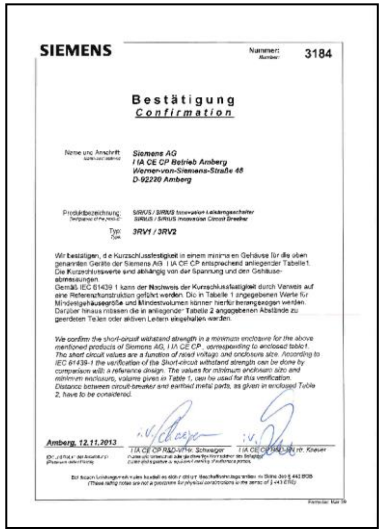

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Nummer: 3184

Bestätigung
Confirmation

Name und Anschrift: *Siemens AG*
I IA CE CP Betrieb Amberg
Werner-von-Siemens-Straße 48
D-92220 Amberg

Produktbezeichnung: SIRIUS / SIRIUS Innovation Leistungsschalter
SIRIUS / SIRIUS Innovation Circuit Breaker

Typ: *3RV1 / 3RV2*

Wir bestätigen, die Kurzschlussfestigkeit in einem minimalen Gehäuse für die oben genannten Geräte der Siemens AG, I IA CE CP entsprechend anliegender Tabelle1. Die Kurzschlusswerte sind abhängig von der Spannung und den Gehäuseabmessungen.
Gemäß IEC 61439-1 kann der Nachweis der Kurzschlussfestigkeit durch Verweis auf eine Referenzkonstruktion geführt werden. Die in Tabelle 1 angegebenen Werte für Mindestgehäusegröße und Mindestvolumen können hierfür herangezogen werden. Darüber hinaus müssen die in anliegender Tabelle 2 angegebenen Abstände zu geerdeten Teilen oder aktiven Leitern eingehalten werden.

We confirm the short-circuit withstand strength in a minimum enclosure for the above mentioned products of Siemens AG, I IA CE CP, corresponding to enclosed table1. The short circuit values are a function of rated voltage and enclosure size. According to IEC 61439-1 the verification of the Short-circuit withstand strength can be done by comparison with a reference design. The values for minimum enclosure size and minimum enclosure, volume given in Table 1, can be used for this verification. Distance between circuit-breaker and earthed metal parts, as given in enclosed Table 2, have to be considered.

Amberg, 12.11.2013

I IA CE CP R&D-VI Hr. Schweiger

I IA CE CP R&D-VN Hr. Knauer

1. **Comparison based on a checklist**
   - Comparison using 10 questions in the IEC 61439 checklist
   - If an element in the checklist is not satisfied, then comparison based on calculations or testing

2. **Comparison using calculation (only for busbars!)**
   - Verification of the short-circuit withstand strength of busbar arrangements via comparison based on calculations (Annex P IEC 61439) and
   - Points 6,8,9, and 10 in the checklist also need to be satisfied

Notice: Comparison may only be based on a reference design which has been tested already!

Generally speaking:

Verification is based on

- Assessment (of constructional requirements – Chapter 8)
- Tests as per Annex J

Verification based on **tests** is not required if an **Assessment** finds that:

- Switching devices and components are designed for the specified environment.
- Installation and wiring have respected manufacturer specifications.

In all other cases → testing as per Annex J.10.12

→ The requirements of EMCD 2004/104/EC for the control panel are thus fulfilled.

Design verification – performance
2.4 Electromagnetic compatibility (EMC)

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- EMC withstand testing on finished switchgear and controlgear assemblies may ***only be forgone*** if the following conditions are met:
  - The installed equipment is manufactured for the respective environment in accordance with the applicable EMC standards
  - The installation and wiring of the components has been performed in accordance with the specifications of the relevant manufacturer (arranged with respect to mutual interference, shielded cable, grounding, etc.)
- **2 ambient conditions are considered**
  - **Environment A:** industrial networks / areas / devices (including strong sources of interference)
    → Equates to class A devices
  - **Environment B:** public networks such as residential areas, businesses, small industry. Strong sources of interference (arc welding machines) are not covered here
    → Equates to class B devices

The switchgear and controlgear assembly manufacturer must specify which ambient condition its switchgear and controlgear assembly is suited to.

Interference immunity

Switchgear and controlgear assemblies without installed electronic equipment are considered immune to interference under normal operating conditions.

- → No verification necessary for this
- → Furthermore these devices do not usually have any specification on the environment to which they are best suited

Emitted interference

Switchgear and controlgear assemblies without installed electronic equipment only produce electromagnetic interference during switching operations. However, this is only for a few milliseconds. It is also a part of the normal electromagnetic environment.

- → No verification necessary for this
- → Furthermore these devices do not usually have any specification on the environment to which they are best suited

Verification via testing

- There is no need to test previously type-tested arrangements or switchgear and controlgear assembly parts (e.g. slide-in circuit breakers).
- Testing of any mechanical locking devices
- The energy used before and after testing must remain practically unchanged.
- Parts to be tested need to undergo at least 200 activation cycles.

- The parts to be tested are:
  - Enclosure or partition walls
  - Hinges and locking devices for doors
  - Removable parts including encoding devices
  - Matching demands (see also 10.13)
  - The mechanical function of removable parts, including any encoding device

Routine verifications **to be performed in accordance with IEC 61439-1**

1	Constructional requirement	2	Performance
1.1	Degree of protection of the enclosure	2.1	Dielectric properties
1.2	Clearances and creepage distances	2.2	Wiring, operating performance, and function
1.3	Protection against electric shock and integrity of protective circuits		
1.4	Incorporation of switching devices and components		
1.5	Internal electrical circuits and connections		
1.6	Terminals for external conductors		
1.7	Mechanical function		

A test report must be created for the conducting of verifications as per DIN EN 61439-1.

Chapter 10.1

"The reference design, the number of switchgear and controlgear assemblies used for the verifications, or parts of these, the choice of verification methods, providing they are applicable, and the sequence of verifications are the responsibility of the original manufacturer.

The data used, the calculations, and the comparisons conducted when verifying the switchgear and controlgear assemblies are to be documented in a test report."

Important reference in the IEC 60204-1 – Electrical equipment of machines

4.2.2 Electrical equipment in compliance with the IEC 60439 series [also applicable to the new IEC 61439 series]

The electrical equipment of the machine shall satisfy the safety requirements identified by the risk assessment of the machine. Depending upon the machine, its intended use and its electrical equipment,

the designer may select parts of the electrical equipment of the machine that are in compliance with relevant parts of the IEC 60439 series (see also Annex F).

NOTE:

The IEC 60439 series specifies requirements for equipment covering a wide range of possible applications of low-voltage switchgear and controlgear assemblies.

Any questions?

Note / Exclusion of liability

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