Technology of Low Voltage Switchgear Webinar
ABB Electrification Smart Power
About Myself
Product Marketing Director

Norrarat Navaratgulchai

ABB Electrification (Thailand) Co., Ltd
Electrification business – Low Voltage Products

Responsible for

- Electrical Solution & Technical Advisor
- Products, Innovation and Marketing Strategy
About Myself
Product Marketing Specialist

/smiley/ Wor

Worawit Dechanuwong

/hammer/ 14 Year

ABB Electrification (Thailand) Co., Ltd
Electrification business – Low Voltage Products

Responsible for

- Medium Voltage and Low Voltage Switchgear
- Digital solution for Low voltage system
Agenda and The key takeaways

01 Webinar : Technology of Low Voltage Switchgear

90 Minutes training duration

The key takeaways

- IEC 61439 Standard Introduction
- Key parameters about LV Switchgear
- Brief of ABB LV Switchgear portfolio
- ABB E-design software, OTC Temp-rise assessment tool
Switchgear Design
According to IEC 61439

Low-voltage switchgear and controlgear assemblies IEC 61439
• DESIGN VERIFICATION
• ROUTINE VERIFICATION
• FORMS OF INTERNAL SEPARATION

Main Parameter According to IEC 61439
According to IEC 61439
IEC 60439 vs IEC 61439

The current IEC 60439 standard applies to enclosures for which the rated voltage is under or equal to 1000 V AC (at frequencies not exceeding 1000 Hz) or 1500 V DC.

The standard makes a distinction between type-tested assemblies (TTA) and partially type-tested assemblies (PTTA).

The following parts are mentioned and have equal weighting. There is not a formal hierarchy. Each part is a complete entity and can be used on an individual basis.

The new IEC 61439 standard applies to enclosures for which the rated voltage is under 1000 V AC (at frequencies not exceeding 1000 Hz) or 1500 V DC.

The standard defines the design verified ASSEMBLIES and eliminates completely the categories TTA and PTTA.

In order to conform to the standard, type tests have been replaced by a design verification which can be carried out by the three following equivalent and alternative methods: testing, calculation/measurement, or application of design rules.
According to IEC 61439

IEC 60439 vs IEC 61439
Switchgear Design
According to IEC 61439

Low-voltage switchgear and controlgear assemblies IEC 61439
- DESIGN VERIFICATION
- ROUTINE VERIFICATION
- FORMS OF INTERNAL SEPARATION

Main Parameter According to IEC 61439
International Electrotechnical Commission

International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national Electrotechnical committees (IEC National Committees). IEC is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

The object of IEC is to promote international cooperation on all questions concerning standardization in the electrical and electronic fields.
Low-voltage switchgear and controlgear assemblies IEC 61439

IEC 61439 Series:
- Part 0: Guidance to specifying assemblies (technical report)
- Part 1: General rules
- Part 2: Power switchgear and controlgear assemblies (PSC)
- Part 3: Distribution boards intended to be operated by ordinary persons (DBO)
- Part 4: Particular requirements for assemblies for construction sites (ACS)
- Part 5: Assemblies for power distribution in public networks
- Part 6: Busbar trunking systems (busways)
- Part 7: Assemblies for specific applications such as marinas, camping sites, market squares, electric vehicles charging stations

* IEC 61439 Certificate for LV Switchgear comply with Parts 1 and Parts 2
Switchgear Design
According to IEC 61439

Low-voltage switchgear and controlgear assemblies IEC 61439
• DESIGN VERIFICATION
• ROUTINE VERIFICATION
• FORMS OF INTERNAL SEPARATION

Main Parameter According to IEC 61439
Low-voltage switchgear and controlgear assemblies IEC 61439 : Design
Verification
Performance requirements

- Strength of materials and parts
- Degree of protection of enclosures
- Clearances
- Creepage distances
- Protection against electric shock and integrity of protective circuit
- Incorporation of switching devices and components
- Internal electrical circuits and connections
- Terminals for external conductors
- Dielectric properties
- Verification of temperature rise
- Short-circuit withstand strength
- Electromagnetic compatibility
- Mechanical operation
Performance requirements
Part: 1 General rules, Clause 10 – design verification

When there is more than one method for the same verification, they are considered equivalent and the selection of the appropriate method is the responsibility of the original manufacturer.

* Annex D
Design verification

<table>
<thead>
<tr>
<th>No.</th>
<th>Characteristic to be verified</th>
<th>Classes or subclasses</th>
<th>Verification options available</th>
<th>Comparison with a reference design</th>
<th>Assessment</th>
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<tbody>
<tr>
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<td>10.2</td>
<td>Testing</td>
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<td>10.2.4</td>
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<td>10.2.5</td>
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<td>10.2.7</td>
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<td>Clearances</td>
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<td>Conduction distances</td>
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<td>9</td>
<td>Dielectric properties</td>
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<td></td>
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<td>Temperature rise limits</td>
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<td>11</td>
<td>Short-circuit withstand strength</td>
<td>10.11</td>
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<td>12</td>
<td>Electromagnetic compatibility (EMC)</td>
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<td>13</td>
<td>Mechanical operation</td>
<td>10.13</td>
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## Performance requirements

### Part: 1 General rules, Clause 10 – design verification

<table>
<thead>
<tr>
<th>No.</th>
<th>Characteristic to be verified</th>
<th>Clauses or subclauses</th>
<th>Verification options available</th>
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<tr>
<td></td>
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<td>Testing</td>
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<td>Strength of material and parts:</td>
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<td>Resistance to corrosion</td>
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<td>Properties of insulating</td>
<td>10.2.3.1, 10.2.3.2</td>
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<td></td>
<td>materials:</td>
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<td>Thermal stability</td>
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<td>Resistance to abnormal heat</td>
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<tr>
<td></td>
<td>and fire due to internal</td>
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<td>(UV) radiation</td>
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<td>Lifting</td>
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<td>Mechanical impact</td>
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<td>Degree of protection of</td>
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<tr>
<td>3</td>
<td>Clearances</td>
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<td>Creepage distances</td>
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<tr>
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<td></td>
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</tbody>
</table>
## Performance requirements

**Part: 1 General rules, Clause 10 – design verification (cont.)**

|   | Protection against electric shock and integrity of protective circuits:  
|   | Effective continuity between the exposed conductive parts of the ASSEMBLY and the protective circuit  
|   | Short-circuit withstand strength of the protective circuit | 10.5 | YES | NO | NO |
| 5 | | 10.5.2 | YES | NO | 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:  
|   | Power-frequency withstand voltage  
|   | Impulse withstand voltage | 10.9 | YES | NO | NO |
|   | | 10.9.2 | 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 |
Performance requirements

Part: 1, Clause 10.10.4.2 - Verification of temperature rise

Verification shall be made by one or more of the following methods

- a) testing (10.10.2);
- b) derivation (from a tested design) of ratings for similar variants (10.10.3);
- c) calculation for a single compartment ASSEMBLY not exceeding 630 A according to 10.10.4.2 or for ASSEMBLIES not exceeding 1600 A according to 10.10.4.3.

A very simple method of temperature rise verification that requires confirmation that the total power loss of the components and conductors within the ASSEMBLY do not exceed the known power dissipation capability of the enclosure. The scope of this approach is very limited and in order that there are no difficulties with hot spots, all components must be de-rated to 80 % of their free air current rating and all conductors shall have a minimum cross-sectional area based on 125 % of the permitted current rating of the associated circuit.
Performance requirements
Part: 1, Clause 10.11 - Short-circuit withstand strength

A verification of the short-circuit withstand strength is not required for the following:

a) ASSEMBLIES having a rated short-time withstand current (see 5.3.4) or rated conditional short-circuit current (see 5.3.5) not exceeding 10 kA r.m.s;

b) ASSEMBLIES, or circuits of ASSEMBLIES, protected by current-limiting devices having a cut-off current not exceeding 17 kA with the maximum allowable prospective short-circuit current at the terminals of the incoming circuit of the ASSEMBLY;

c) Auxiliary circuits of ASSEMBLIES intended to be connected to transformers whose rated power does not exceed 10 kVA for a rated secondary voltage of not less than 110 V, or 1,6 kVA for a rated secondary voltage less than 110 V, and whose short-circuit impedance is not less than 4 %.

All other circuits shall be verified.
Performance requirements
Part: 1, Clause 10.11 - Short-circuit withstand strength

Assembly \( I_{cw} \leq 10 \, \text{kA} \) or assembly \( I_{cc} \leq 10 \, \text{kA} \)

- YES

YES

In correspondence with the maximum admissible prospective short-circuit current, the peak current is limited by the protective circuit-breaker to the value \( |I_{pk}| \leq 17 \, \text{kA} \)

- NO

Verifications not required

Verifications required
Switchgear Design
According to IEC 61439

Low-voltage switchgear and controlgear assemblies IEC 61439
• DESIGN VERIFICATION
• ROUTINE VERIFICATION
• FORMS OF INTERNAL SEPARATION

Main Parameter According to IEC 61439
ROUTINE VERIFICATION
Part: 1, Clause 11 – Routine verification

Verification shall comprise the following categories:

a) Construction (see 11.2 to 11.8):
   • 1) degree of protection of enclosures;
   • 2) clearances and creepage distances;
   • 3) protection against electric shock and integrity of protective circuits;
   • 4) incorporation of built-in components;
   • 5) internal electrical circuits and connections;
   • 6) terminals for external conductors;
   • 7) mechanical operation.

b) Performance (see 11.9 to 11.10):
   • 1) dielectric properties;
   • 2) wiring, operational performance and function.
Switchgear Design
According to IEC 61439

Low-voltage switchgear and controlgear assemblies IEC 61439
• DESIGN VERIFICATION
• ROUTINE VERIFICATION
• FORMS OF INTERNAL SEPARATION

Main Parameter According to IEC 61439
FORMS OF INTERNAL SEPARATION: FORM 1

Forms of separation/Types of construction
The Forms of internal separation and the associated Types of construction are illustrated

Form 1
No internal separation
FORMS OF INTERNAL SEPARATION : FORM 2A, 3A

Forms of separation/Types of construction
The Forms of internal separation and the associated Types of construction are illustrated

Form 2A
Terminals not separated from busbars

Form 3A
Terminals not separated from busbars

Arc fault containment certification for the Fixed portfolio utilising the TVOC – 2 shall available early 2019.
FORMS OF INTERNAL SEPARATION: FORM 2B

Forms of separation/Types of construction

The Forms of internal separation and the associated Types of construction are illustrated

Form 2B

Terminals separated from busbars

Arc fault containment certification for the Fixed portfolio utilising the TVOC – 2 shall available early 2019.
Forms of separation/Types of construction

The Forms of internal separation and the associated Types of construction are illustrated.

Form 3B
Terminals and external conductors separated from busbars

Arc fault containment certification for the Fixed portfolio utilising the TVOC – 2 shall available early 2019.
FORMS OF INTERNAL SEPARATION : FORM4A

Forms of separation/Types of construction
The Forms of internal separation and the associated Types of construction are illustrated

Terminals in same compartment as associated functional unit (common glanding)
FORMS OF INTERNAL SEPARATION : FORM4B

Forms of separation/Types of construction
The Forms of internal separation and the associated Types of construction are illustrated

Form 4B
Terminals for external conductors NOT in the same compartment as associated functional unit (common glanding)
FORMS OF INTERNAL SEPARATION
The differences IEC and BS EN 61439-2

IEC 61439

Type 1: Busbar separation is achieved using an insulated covering e.g. Sleeving or wrapping

Type 2: Busbar separation is achieved using metallic or non-metallic rigid barriers or partitions.

BS EN 61439

Form 3B:
Terminals and external conductors separated from busbars
FORMS OF INTERNAL SEPARATION
The differences IEC and BS EN 61439-2

IEC 61439

Form 4a: Terminals in same compartment as associated functional unit

BS EN 61439

Type 1: Busbar separation is achieved using an insulated covering e.g. Sleeving or wrapping. Cables may be ganded elsewhere.

Type 2: Busbar separation is achieved using metallic or non-metallic rigid barriers or partitions. Cables may be ganded elsewhere.
FORMS OF INTERNAL SEPARATION
The differences IEC and BS EN 61439-2

Form 4a

IEC 61439

BS EN 61439

Type 3: Busbar separation is achieved using metallic or non-metallic rigid barriers or partitions. The termination for each functional unit has its own integral glanding facility.
# FORMS OF INTERNAL SEPARATION

The differences IEC and BS EN 61439-2

**Form 4b**

**IEC 61439**

- **Type 4:** Busbar separation is achieved using an insulated covering e.g. Sleeving or wrapping. Cables may be glanded elsewhere.
- **Type 5:** Busbar separation is achieved using metallic or non-metallic rigid barriers or partitions. Terminals may be separated by insulated coverings. Cables may be glanded in common cabling chambers.
- **Type 6:** All separation requirements are achieved using metallic or non-metallic rigid barriers or partitions. Cables are glanded in common cabling chambers.

**BS EN 61439**

- **Form 4b:** Terminals not in same compartment as associated functional unit.
Switchgear Design
According to IEC 61439

Low-voltage switchgear and controlgear assemblies IEC 61439
- DESIGN VERIFICATION
- ROUTINE VERIFICATION
- FORMS OF INTERNAL SEPARATION

Main Parameter According to IEC 61439
## Main Parameter According to IEC 61439

### Voltage ratings

<table>
<thead>
<tr>
<th>Description</th>
<th>Symbol</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated voltage</td>
<td>Un</td>
<td>highest nominal voltage of the electrical system, a.c. (r.m.s.) or d.c., declared by the ASSEMBLY manufacturer, to which the main circuit(s) of the ASSEMBLY is (are) designed to be connected</td>
</tr>
<tr>
<td>Rated operational voltage</td>
<td>Ue</td>
<td>value of voltage, declared by the ASSEMBLY manufacturer, which combined with the rated current determines its application.</td>
</tr>
<tr>
<td>Rated insulation voltage</td>
<td>Ui</td>
<td>r.m.s withstand voltage value, assigned by the ASSEMBLY manufacturer to the equipment or to a part of it, characterising the specified (long-term) withstand capability of the insulation.</td>
</tr>
<tr>
<td>Rated impulse withstand voltage</td>
<td>Uimp</td>
<td>impulse withstand voltage value, declared by the ASSEMBLY manufacturer, characterising the specified withstand capability of the insulation against transient overvoltages.</td>
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## Main Parameter According to IEC 61439
### Current Ratings

<table>
<thead>
<tr>
<th>Description</th>
<th>Detail</th>
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<tbody>
<tr>
<td>Rated current</td>
<td>value of current, declared by the ASSEMBLY manufacturer which can be carried without the temperature-rise of various parts of the ASSEMBLY exceeding specified limits under specified conditions</td>
</tr>
<tr>
<td>Rated current of the ASSEMBLY</td>
<td>The rated current of the ASSEMBLY is the smaller of:</td>
</tr>
<tr>
<td></td>
<td>– the sum of the rated currents of the incoming circuits within the ASSEMBLY operated in parallel;</td>
</tr>
<tr>
<td></td>
<td>– the total current which the main busbar is capable of distributing in the particular ASSEMBLY arrangement. This current shall be carried without the temperature rise of the individual parts exceeding the limits specified.</td>
</tr>
<tr>
<td>Rated current of a circuit</td>
<td>The rated current of a circuit is the value of the current that can be carried by this circuit loaded alone, under normal service conditions. This current shall be carried without the temperature rise of the various parts of the ASSEMBLY exceeding the limits specified.</td>
</tr>
<tr>
<td>Rated peak withstand current (Ipk)</td>
<td>value of peak short-circuit current, declared by the ASSEMBLY manufacturer, that can be withstood under specified conditions</td>
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<tr>
<td>Rated short-time withstand current (Icw)</td>
<td>r.m.s value of short-time current, declared by the ASSEMBLY manufacturer, that can be withstood under specified conditions, defined in terms of a current and time</td>
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<tr>
<td>Rated conditional short-circuit current of an ASSEMBLY (Icc)</td>
<td>value of prospective short-circuit current, declared by the ASSEMBLY manufacturer, that can be withstood for the total operating time (clearing time) of the short-circuit protective device (SCPD) under specified conditions</td>
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</table>
### Main Parameter According to IEC 61439

#### Other parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
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<tbody>
<tr>
<td>Rated diversity factor (RDF)</td>
<td>per unit value of the rated current, assigned by the ASSEMBLY manufacturer, to which outgoing circuits of an ASSEMBLY can be continuously and simultaneously loaded taking into account the mutual thermal influences.</td>
</tr>
<tr>
<td>Rated frequency (fn)</td>
<td>value of frequency, declared by the ASSEMBLY manufacturer, for which a circuit is designed and to which the operating conditions refer.</td>
</tr>
</tbody>
</table>
Brief of ABB Low Voltage Distribution Solution
Low Voltage Distribution Solutions – ABB Portfolio (Thailand Market)

Key segments for example:
- MCC, COG, Generation, Process Automation, Marine, DTC, etc.

Key Segment for example:
- Building, DTC, Infrastructure, F&B, Water, etc.

- DB Formular
  - Current rating: 250 A
  - Sub Distribution

- Pro E Energy
  - Current rating: 800 A
  - Main Distribution

- System Pro E
  - Current rating: 6300 A
Specifications:

- Rated Current main busbar: 200A and 250A
- Rated Voltage: 240/415V 50Hz
- Versions: 2 types
  - with main circuit breaker type
  - with main lugs type
- Rated Current outgoing: 63A Max.
- Number of outgoing: 12, 24, 36, 48
- Degree of protection: IP40
- Structure & Cover Formed: AlZn Sheet Steel
- Color: RAL 7035 (Textile), Epoxy Polyester Power Paint Coat
**System pro E® energy**

Easy, Flexible and Safe

**Specifications:**

- Rated Current: up to 800A
- Rated Voltage: up to 690V
- Rated Insulation Voltage: 1000V
- Rated Short-circuit current: 32KA
- Versions: 2 types
  - wall-mounted version
  - Floor-standing version
- Depth: 250
- Width: 400/600/800
- Height: 600-2000 (+200)
- Segregation: Form 1/2b
- Degree of protection: up to IP43
System pro E® Power
Complete solution for main distribution of infrastructures and industry & building complexes

Specifications:

- Rated Current: up to 6300A
- Rated Voltage: up to 1000Vac
- Rated Impulse Withstand voltage: 12KV
- Short-time withstand current (Icw): Up to 120KA
- Versions: 2 types
  - Glass door version
  - Blind door version
- Depth (internal): 200-900
- Width (internal): 250-1250
- Height (internal): 1800/2000
- Segregation: Form up to 4b
- Degree of protection: up to IP65
MNS Low-voltage switchgear

Energy distribution and motor control

**Specification**

- Fully certified to IEC 61439 -1/-2 up to 690V, 6300A, 100kA
- Arc proof certified to IEC TR 61641 Ed.3:2014 criteria 1 to 7 up to 690 V, 100 kA, 0.3 s
- Segregation up to form 4b type 7
- Modular construction, extendable at both ends
- Single front, back-to-back or duplex (most space saving design)
- Two bus bar designs, rear and top bus bar arrangement
  100% maintenance free
- Universal panel design for different technologies: Fixed, Compact, Plug-in, Slimline and Withdrawable
- Global life time support through EL Service.

**Highest safety, flexibility and lowest operational expenditure**
MNS Low-voltage switchgear
Complete product range portfolio

MNS 3.0
Front access

MNS Compact
Most compact MCCB distribution panel

MNS Fixed
Cost efficient fixed mounted panel

MNS iS
I/U sensors and segregation, most digital solution

MNS-Up
Integrated UPS and energy distribution

MNS Rear
Rear access

MNS Digital
Makes any MNS digital, includes on-premise condition monitoring

MNS RPP/PDU
Final distribution in DtC

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June 2, 2021 | Slide 42
ABB Ability™ Energy & Asset Manager
Optimize your energy efficiency and operational resilience and start journey to sustainability

- Understanding where and how your business is consuming energy
- Continuously Monitoring energy consumption and power quality across multiple sites, power sources and users
- Optimize the health and performance of assets to reduce operational costs and waste, while increasing efficiency
- Integrating unpredictable renewable energy sources – such as wind and solar – while lowering the use of carbon generating sources as much as possible
- Finding a sustainability solution that is cost effective and easy to implement
ABB E-design software, OTC Temp-rise assessment tool
OTC Temperature-Rise Assessment tool
ABB e-Design software (Freeware available to download at ABB.com)
The thermal calculation module makes it possible to evaluate the thermal behavior of ABB boards and – if desired – to dimension the fans and air-conditioning units to be installed in the board. It can also be used on sets of boards obtained by installing several units side by side.

The algorithms used by the software are as described in Standard IEC 60890. If the use of air-conditioning of fans is specified (a situation not considered in the Standard 60890), the program still uses computation algorithms that are compatible with Standard on low-voltage boards.
The proposed method makes it possible to determine the overtemperatures, or the air temperatures, inside the enclosure, but is unable to determine the temperatures of individual equipment, devices and cables contained in it.

The temperatures of the air inside the board is the same as that of the ambient air outside the enclosure plus the overtemperatures of the air inside the board due to power dissipated by the devices installed.
The value assumed by the calculation target selected.

The table shows an overview of the parameters calculated by the software depending on type of cooling system and the calculation target selected by the user.
# Reference – Table 6 Temperature Rise Limits

<table>
<thead>
<tr>
<th>Parts of assemblies</th>
<th>Temperature-rise limit (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Built-in components</strong>&lt;sup&gt;a&lt;/sup&gt;</td>
<td>In accordance with the relevant product standard requirements for the individual components or, in accordance with the component manufacturer's instructions&lt;sup&gt;b&lt;/sup&gt;, taking into consideration the temperature in the assembly</td>
</tr>
<tr>
<td><strong>Terminals for external insulated conductors</strong></td>
<td>70&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Busbars and conductors</strong></td>
<td>Limited by:</td>
</tr>
<tr>
<td></td>
<td>- mechanical strength of conducting material&lt;sup&gt;c&lt;/sup&gt;;</td>
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<td></td>
<td>- possible effect on adjacent equipment;</td>
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<tr>
<td></td>
<td>- permissible temperature limit of the insulating materials in contact with the conductor;</td>
</tr>
<tr>
<td></td>
<td>- effect of the temperature of the conductor on the apparatus connected to it;</td>
</tr>
<tr>
<td></td>
<td>- for plug-in contacts, nature and surface treatment of the contact material</td>
</tr>
<tr>
<td><strong>Manual operating means:</strong></td>
<td></td>
</tr>
<tr>
<td>- of metal</td>
<td>15&lt;sup&gt;d,h&lt;/sup&gt;</td>
</tr>
<tr>
<td>- of insulating material</td>
<td>25&lt;sup&gt;d,h&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Accessible external enclosures and covers:</strong></td>
<td></td>
</tr>
<tr>
<td>- metal surfaces</td>
<td>30&lt;sup&gt;d,h&lt;/sup&gt;</td>
</tr>
<tr>
<td>- insulating surfaces</td>
<td>40&lt;sup&gt;d,h&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
Reference – Table 6 Temperature Rise Limits

<table>
<thead>
<tr>
<th>The temperature-rise limits given in this table apply for a daily average ambient air temperature up to 35 °C under service conditions (see 7.1). During verification a different ambient air temperature is permissible (see 10.1.2.3.4).</th>
</tr>
</thead>
</table>
| a The term "built-in components" means:  
  - conventional switchgear and controlgear;  
  - electronic sub-assemblies (e.g. rectifier bridge, printed circuit);  
  - parts of the equipment (e.g. regulator, stabilized power supply unit, operational amplifier). |
| b The temperature-rise limit of 70 K is a value based on the conventional test of 10.10. An assembly used or tested under installation conditions may have connections, the type, nature and disposition of which will not be the same as those adopted for the test, and a different temperature-rise of terminals may result and may be required or accepted. Where the terminals of the built-in component are also the terminals for external insulated conductors, the lower of the corresponding temperature-rise limits shall be applied. The temperature-rise limit is the lower of the maximum temperature-rise specified by the component manufacturer and 70 K. In the absence of manufacturer's instructions, it is the limit specified by the built-in component product standard but not exceeding 70 K. For terminals of the built-in component that are terminals for external insulated conductors, the thermocouple for the temperature-rise test shall not be placed on the test conductor insulation. |
| c Manual operating means within assemblies which are only accessible after the assembly has been opened, for example draw-out handles which are not operated while the assembly is in normal service, are permitted to sustain a 25 K increase on these temperature-rise limits. |
| d Unless otherwise specified, in the case of covers and enclosures, which are accessible but need not be touched during normal operation, a 10 K increase on these temperature-rise limits is permissible. External surfaces and parts over 2 m from the base of the assembly are considered inaccessible. |
| e This allows a degree of flexibility in respect of equipment (e.g. electronic devices) which is subject to temperature-rise limits different from those normally associated with switchgear and controlgear. |
| f For temperature-rise tests according to 10.10, the temperature-rise limits have to be specified by the original manufacturer. It is the responsibility of the original manufacturer to take into account any additional measuring points and limits imposed by the component manufacturer. |
| g Assuming all other criteria listed are met, a maximum temperature-rise of 105 K for copper busbars and conductors shall not be exceeded. The 105 K relates to the temperature above which annealing of copper is likely to occur. In the absence of a declaration from the original manufacturer, regarding the reliability and stability of the ageing behaviour of the electrical contact or joint, a maximum temperature-rise of 55 K for bare (uncoated) aluminium busbars and conductors is applicable. |
| h Where an assembly is installed in an ambient air temperature exceeding a daily average of 35 °C, a higher absolute temperature (°C) may be permitted. Temperature-rise (K) shall not exceed the values given in this table. See also 9.2. In such a case warning label according to ISO 7010 W017 shall be provided. |
Reference – Annex K Operating current and power loss of bare copper bars

Annex K
(normative)

Operating current and power loss of bare copper bars

Table K.1 and Table K.2 provide values for conductor operating currents and power losses under ideal conditions within an assembly (see 10.10.2.2.3, 10.10.4.2.1 and 10.10.4.3.1). Annex K does not apply to conductors verified by testing.

The calculation methods used to establish these values are given to enable values to be calculated for other conditions.

Table K.1 – Operating current and power loss of bare copper bars with rectangular cross-section, run horizontally and arranged with their largest face vertical, frequency 50 Hz to 60 Hz (ambient air temperature inside the assembly: 55 °C, temperature of the conductor 70 °C)

| Height × thickness of bars | Cross-sectional area of bar | One bar per line | | Two bars per line (space between the two bars is equal to the thickness of one bar) |
|---------------------------|----------------------------|------------------|------------------|
|                           | mm × mm                    | A                | W/m              | A                | W/m              |
| 12 × 2                    | 23.5 mm²                   | 1.00             | 70               | 1.01             | 118              | 6.4              |
| 15 × 2                    | 29.5 mm²                   | 1.00             | 83               | 1.01             | 138              | 7.0              |
| 16 × 3                    | 44.8 mm²                   | 1.01             | 105              | 1.02             | 183              | 8.3              |
| 20 × 2                    | 39.6 mm²                   | 1.01             | 105              | 1.01             | 172              | 8.1              |
| 20 × 3                    | 59.5 mm²                   | 1.01             | 133              | 1.02             | 226              | 9.4              |
| 20 × 5                    | 99.1 mm²                   | 1.02             | 178              | 1.04             | 325              | 11.9             |
| 29 × 10                   | 199 mm²                    | 1.03             | 270              | 1.07             | 530              | 10.0             |
| 25 × 5                    | 124 mm²                    | 1.02             | 213              | 1.05             | 381              | 13.2             |
| 30 × 5                    | 149 mm²                    | 1.03             | 246              | 1.06             | 437              | 14.5             |
| 30 × 10                   | 299 mm²                    | 1.05             | 372              | 1.11             | 689              | 16.0             |
| 40 × 5                    | 199 mm²                    | 1.03             | 313              | 1.07             | 543              | 17.0             |
# Example - ABB Air circuit Breaker Emax2 Power Losses

## Power losses

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<tr>
<th>Circuit-breaker type</th>
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<th>1250A</th>
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### Example - ABB MCCB Tmax Power Losses

#### Power losses

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</table>

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June 2, 2021 | Slide 53
ABB Webinar in June 2021

- June 9  | ระบบ ABB KNX building automation และ DALI ระบบควบคุมแสงสว่างสำหรับสมาร์ทโฮม
- June 17 | วิธีการเลือกใช้อุปกรณ์เบรกเกอร์ และสวิตช์สำหรับการใช้งานที่แรงดัน 800VAC และ แรงดัน DC
- June 24 | เทคนิโค้ด และการเลือกใช้อุปกรณ์ป้องกันไฟรั่วไฟดูด
- June 30 | โซลูชันการสตาร์ทและป้องกันมอเตอร์ด้วยผลิตภัณฑ์ ABB Softstarter

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