This White Paper provides guidance for correct configuration of Industrial control panels as prescribed by US codes and standards for the required short-circuit. Moreover, it includes practical information and references additional information sources in the appendix.
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National Electrical Code (NEC)
The National Electrical Code (NEC) applies as the primary directive for electrical installations in the USA. It is legally recognized as state-of-the-art and shall therefore be strictly observed. It serves as a basis for acceptance by the AHJ (Authorities Having Jurisdiction), the electrical inspector in the USA. It is not permitted for electrical equipment to be operated in the USA without the approval of the AHJ.

A revised version of the NEC is published by the National Fire Protection Association (NFPA) as NFPA 70 every three years. The current version is the NEC 2017.

Article 409 of the NEC specifically covers industrial control cabinets, referred to as "industrial control panels".

Short-circuit at the incoming supply terminal is the responsibility of the user
Article 409.22 (A) stipulates that an industrial control panel shall not be connected to an incoming supply for which the maximum possible short-circuit exceeds the short-circuit current rating of the industrial control panel.

In accordance with Article 409.22 (B), the short-circuit at the incoming supply terminal of the industrial control panel shall be calculated and this calculation shall be documented with the respective date of calculation. This documentation shall then be submitted to the inspector upon acceptance of the equipment.

Unless otherwise agreed, this remains solely the responsibility of the user. The user shall stipulate the maximum possible short-circuit at the incoming supply to the manufacturer.

Short-circuit-based configuration of the industrial control panel shall be performed by the manufacturer
It is then the responsibility of the manufacturer to ensure that the industrial control panel is configured with the maximum short-circuit stipulated by the user for the incoming supply.

In accordance with Article 409.110 (4), the short-circuit strength, referred to as the short-circuit current rating (SCCR), is specified on the nameplate of the industrial control panel.

The SCCR can either be verified by a control panel already "listed" or "labeled", or by an alternative approved method.

The NEC proposes the method stipulated in UL 508A, Supplement SB, as an example for an approved method. The method stipulated in UL 508A, Supplement SB, is also referenced in Article 670, Industrial Machinery.

As a rule, the control panels are designed individually for specific applications, usually produced as individual units or as limited editions, and consequently a "listed" or "labeled" control panel is not practical in most cases due to time restrictions or for economic reasons. The method stipulated in UL 508A, Supplement SB, therefore provides an equivalent, approved and economic alternative.
SCCR calculation according to UL 508A, Supplement SB4.

In accordance with Supplement SB4.2, excluding certain exceptions, all components in the power circuit shall be included for SCCR consideration and shall indicate a SCCR in amperes or kiloamperes with specification of the voltage.

This includes:
- Disconnect switches
- Supplementary protectors
- Branch circuit protective devices
- Bus bars
- Fuse holders
- Current meters
- Load controllers
- Current shunts
- Motor overload relays
- Switching devices
- Receptacles
- Terminal blocks or power distribution blocks

The primary protective device of the power supply for the control circuit is still within the power circuit and therefore also applies for SCCR consideration. For control circuits which are tapped directly from the power circuit without transformer or power supply unit, the first protective device following tapping also remains a part of the power circuit, which is no longer the case for downstream components.

Components which are not relevant for SCCR consideration

The following components in the power circuit are excluded from SCCR consideration:
- Power transformers
- Reactors
- Current transformers
- Dry-type capacitors
- Resistors
- Varistors
- Voltmeters
- The “S” contactor of a wye delta combination
- Enclosure air conditioners that are cord-and-attachment-plug connected
- Ferrules
- Conductors, wires and cables (naturally, conductor protection shall nevertheless be guaranteed)
- Loads in the field (e.g. motors, heaters, etc.)

Moreover, components operated entirely within the control circuit are also not SCCR-relevant.
The weakest component in the power circuit is decisive
Of all SCCR-relevant components, the component with the lowest SCCR value generally determines the overall SCCR value for the industrial control panel. In other words: All SCCR-relevant components shall be approved for at least the short-circuit at the incoming supply.

Example of overall SCCR for an industrial control panel

If the SCCR of one or more SCCR-relevant components does not comply with the short-circuit at the incoming supply, measures shall be introduced to ensure that these components may nevertheless be used.

The following measures are possible:

1. Increase of SCCR of the component by applying tested combinations, referred to as “High Capacity Short Circuit Ratings”.


Three steps are required, or available as an option, to determine the SCCR for the entire industrial control panel:

1. Determination of the SCCRs for all components in the power circuit which shall be included for SCCR consideration. Required!

2. Reduction of the maximum possible short-circuit for parts of the power circuit using current-limiting components in the feeder circuit. Optional, where necessary!

3. Determining the overall SCCR for the industrial control panel. Required!

Step 1: Determination of the SCCRs for the components in the power circuit (required!)
The short-circuit current rating of individual power circuit components shall be determined by applying one of the following three methods:

- Based on device markings or component data sheets
- Based on the assumed short-circuit current rating
- Based on tested device combinations

The majority of control devices and protective devices for the power circuit are marked on the front or on the nameplate with a standard SCCR.

Example: name plate Siemens contactor
For components which are not marked with a SCCR, the SCCR is to be defined on the basis of UL 508A, Table SB4.1.

Table SB4.1: Assumed minimum short-circuit current rating for unmarked components

<table>
<thead>
<tr>
<th>Component</th>
<th>Short-circuit current rating [kA]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus bars</td>
<td>10</td>
</tr>
<tr>
<td>Circuit breaker (including GFCI type)</td>
<td>6</td>
</tr>
<tr>
<td>Current limiters</td>
<td>10</td>
</tr>
<tr>
<td>Enclosures for use in Data, Signal, Control and Power Applications</td>
<td>10</td>
</tr>
<tr>
<td>Circuit shunt</td>
<td>10</td>
</tr>
<tr>
<td>Relay box</td>
<td>10</td>
</tr>
<tr>
<td>Industrial control equipment</td>
<td></td>
</tr>
<tr>
<td>a. Auxiliary devices (mounted relay)</td>
<td>5</td>
</tr>
<tr>
<td>b. Switching devices (other than relay type)</td>
<td>5</td>
</tr>
<tr>
<td>c. Relay switches</td>
<td>5</td>
</tr>
<tr>
<td>d. Relay over 10 amp to over 200 amps</td>
<td>5.5</td>
</tr>
<tr>
<td>e. Relay over 200 amp to over 500 amps</td>
<td>5.5</td>
</tr>
<tr>
<td>f. Relay over 500 amp to over 1500 amps</td>
<td>10</td>
</tr>
<tr>
<td>g. Motor controllers</td>
<td>10</td>
</tr>
<tr>
<td>Motor controller (including combination motor controllers, fuse and pressure operated reactor controllers, power conversion equipment and solid state drive controllers)</td>
<td>10</td>
</tr>
</tbody>
</table>

For components which are now identified in the power circuit which exhibit a lower SCCR than the maximum occurring short-circuit current at the incoming supply, the most practical method is generally to check whether the respective component has been checked with an upstream protective device for a high-capacity short-circuit rating.

Protective devices from Siemens, such as circuit breakers according to UL 489, manual self-protected combination motor controller according to UL 508, type E, or fuses according to UL 248 are generally capable of interrupting even high short-circuits. This does not apply for other devices such as contactors, soft starters, semi-conductor contactors, overload relays or frequency converters. For these components, a check would have to be carried out as to whether a high capacity short-circuit rating has been tested.

For many devices such as contactors, soft starters, semi-conductor contactors and overload relays, these specifications can be obtained in the "Certificate of Compliance (CoC)". The CoC is created by UL for the manufacturer of the respective components and shall be made available to the user by the equipment manufacturer. CoCs for Siemens can be obtained from the Siemens Industry Online Support.

Siemens Industry Online Support for their SINAMICS converters featuring details of the SCCR and tested protective device.

2.2 UL/CSA Type E Combination Motor Controllers

Note:
- 3R/202 motor starter protectors are approved in accordance with UL 508/UL508-34-1 in combination with the terminal blocks listed below:
  - 3R/2022 and 3R/2021 with 3R/2021-3H
  - 3R/2021 with 3R/2011-3H
  - 3R/2022 with 3R/2011-3H

3R/104 motor starter protectors are approved in accordance with UL 508/UL508-34-1 in combination with the 3R/104-300/440/417 terminal blocks.

2.2.1 Active Line Modules

Excerpt from the Certificate of Compliance for Siemens contactors 3RT202:

Frequency converters are to be protected in accordance with manufacturer’s specifications as prescribed in UL 508A, section 31.3.2. Siemens offer corresponding manuals in the Siemens Industry Online Support.
Step 2: Reduction of maximum possible short-circuit for parts of the power circuit by using current-limiting components in the feeder circuit (optional, where necessary!)

In accordance with UL 508A Supplement SB4.3, the maximum possible short-circuit current for parts of the power circuit can be reduced by using current-limiting components in the feeder circuit. It is imperative here, however, that the current-limiting components are situated entirely within the feeder circuit.

The power circuit is subdivided into branch circuit and feeder circuit. The exact threshold between branch circuit and feeder circuit forms the first short-circuit protective device, upstream as viewed from the load, or more precisely, the feeder terminal of the protective device. The feeder terminal is still a part of the feeder circuit; anything below this is part of the branch circuit.

Transformers with known relative short-circuit voltage (= Impedance Z according to UL 508A)

The short-circuit current which can occur on the secondary side of the transformer is calculated as follows:

\[
I_{sl} = \frac{P}{U_{sec} \times \sqrt{3}}
\]

Factor \(\sqrt{3}\) is not applicable for single-phase transformers.

Transformers with unknown relative short-circuit voltage (impedance Z according to UL 508A)

The maximum secondary short-circuit current can either be calculated in accordance with the aforementioned formulas with the assumed impedance \(Z = 2.1\%\), or determined using the tables SB4.3 "Secondary short-circuit current single-phase transformers" or SB4.4 "Secondary short-circuit current three-phase transformers" as follows:

1. The transformer capacity shall be \(\leq\) that of column 1 and
2. The secondary voltage may not be less than the values in column 2. If the secondary voltage is between values, the column with the next lowest voltage shall be selected.

### Table SB4.3

<table>
<thead>
<tr>
<th>Transformer Max kVA</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>400</th>
<th>500</th>
<th>600</th>
<th>800</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Transformer Secondary Voltage (V)</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Transformer performance (P) [VA]</td>
<td>100</td>
<td>200</td>
<td>300</td>
<td>400</td>
<td>500</td>
<td>600</td>
<td>800</td>
</tr>
<tr>
<td>Secondary voltage (Usec) [V]</td>
<td>100</td>
<td>200</td>
<td>300</td>
<td>400</td>
<td>500</td>
<td>600</td>
<td>800</td>
</tr>
</tbody>
</table>

Source: UL 508A, Table SB4.3

### Table SB4.4

<table>
<thead>
<tr>
<th>Transformer Max kVA</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>400</th>
<th>500</th>
<th>600</th>
<th>800</th>
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<td>800</td>
<td>1000</td>
</tr>
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<td>100</td>
<td>200</td>
<td>300</td>
<td>400</td>
<td>500</td>
<td>600</td>
<td>800</td>
<td>1000</td>
</tr>
</tbody>
</table>

Source: UL 508A, Table SB4.4

In this regard, a distinction is to be made between:

1. Transformers with known relative short-circuit voltage
   (= Impedance Z according to UL 508A)
   and
2. Transformers with unknown relative short-circuit voltage
   (= Impedance Z according to UL 508A)

Possible current-limiting components in the feeder circuit include:

- Transformers
- Listed circuit breakers according to UL 489 marked with "current limiting"
- Fuses, Class CC, G, J, L, RK1, RK5 or T

Current limitation by transformers

Transformers limit the short-circuit for all components on the load side of the transformer.

Figure "Short-circuit current-limiting components in the feeder circuit"

Source: UL 508A, Table SB4.3
The values from the tables or the calculation with an assumed impedance Z of 2.1% are also suitable for transformers with impedance Z ≥ 2.1%.

All components on the load side of the transformer shall be configured ≥ the determined short-circuit current (Isc).

The disadvantage of this method, however, is the additional spatial requirement and the additional costs for the transformer.

Current limitation by using listed circuit breakers according to UL 489 with “Current Limiting” marking

The current-limiting effect may only be incorporated for components in the branch circuit when using listed circuit breakers according to UL 489 with the “Current Limiting” marking.

The SCCR of branch circuits which are additionally protected by a listed circuit breaker according to UL 489 in the feeder circuit corresponds with:

1. The breaking capacity of the feeder circuit breaker, referred to as the “interrupting rating”, if:
   a. SCCR of each individual component in the branch circuit is ≥ the peak let-through current of the feeder circuit breaker and
   b. Interrupting ratings of all branch circuit protective devices (BCPDs) or SCCRs of the combination motor controller ≥ the interrupting rating of the feeder circuit breaker

For BCPDs which are not marked with an interrupting rating or combination motor controllers which are not marked with a SCCR, the values from UL 508A, Table SB4.1 apply.

or

2. The lowest interrupting rating of a BCPD or lowest SCCR of a combination motor controller on the load side of the feeder circuit breaker if this is less than the interrupting rating of the feeder circuit breaker.

or

3. The lowest SCCR of a branch circuit on the load side of the feeder circuit breaker if neither condition 1 nor condition 2 applies.

The let-through currents of the circuit breakers are to be obtained from the peak let-through curve provided by the manufacturer.

The utilization of circuit breakers according to UL 489 with the “Current Limiting” marking does not generally offer any significant advantages for the following reasons:

1. Short-circuit current limitation for components in the feeder circuit is not possible (busbar systems, including adapters, from which one or more load circuits are tapped, are still situated in the feeder circuit, for example).

2. As the SCCR of each individual component in the branch circuit shall be ≥ the let-through value of the circuit breaker, this requires relatively low let-through values of the circuit breaker.

Individually, many components feature only low SCCRs. Thus, for example, a contactor of up to 50 hp or an overload relay only has a SCCR of 5 kA, a terminal block has 10 kA, etc. These low let-through values are only found in smaller circuit breakers within the low rated current range.

The following diagram from UL 508A shows an example of let-through current curves of a current limiting circuit breaker for rated voltages of 240, 480 and 600 V. This shows that a voltage of 480 V, for example, and a prospective short-circuit of 15 kA will only be limited to 10 kA. This would be too much for a contactor up to 50 hp or an overload relay. A let-through current of 5 kA is not depicted at all in this example.

Source: UL 508A, Figure SB4.1
Current limitation by using fuses, Class CC, G, J, RK1, RK5 or T

Only Class CC, G, J, RK1, RK5 or T fuses may be used as a current-limiting component.

The same conditions as those for circuit breakers apply, with the exception that the let-through currents shall be obtained from UL 508A, Table SB4.2. Manufacturer’s specifications may not be applied as a let-through current. "Worst-case values" are depicted in Table SB4.2. UL-approved fuses generally provide considerably superior let-through values. Application of the values from UL 508A, Table SB4.2, however, ensures that the current-limiting effect is still guaranteed, even if the fuse is replaced with that of a different manufacturer.

Even when using fuses, let-through currents of 5 kA are exceeded relatively quickly, and thus will also only prove practical under certain conditions. A Class CC fuse with a rated current of 30 A features a let-through current of 6 kA with a prospective short-circuit of 50 kA, thus already demonstrating an excessive let-through current for most components.

Excerpt from UL 508A, Table SB4.2

Step 3: Determining the overall SCCR for the industrial control panel (required)

Following conclusion of Step 1, and where necessary Step 2, it is possible to determine the SCCR for the entire industrial control panel.

The SCCR of the industrial control panel is determined by the component in the power circuit with the lowest SCCR which is not additionally protected by a current-limiting component in the feeder circuit, in accordance with Step 2.
Summary

The weakest component in the power circuit determines the overall SCCR for the industrial control panel.

The simplest practical solution is to use components which have already been tested inherently for the required value. Protective devices are self-protecting and are tested for a specific breaking capacity. Components which do not trip automatically in the event of a short-circuit shall be tested together with an upstream protective device for a SCCR.

We recommend the utilization of components which fulfill the desired short-circuit automatically, or with an upstream protective device. In this case, the utilization of current-limiting components is not necessary.

A common misconception in this regard is that circuit breakers according to UL 489 shall feature the additional “Current Limiting” approval. As the explanations provided in this White Paper attest, this is only one of several possibilities, and is in no way mandatory. On the contrary: in practice, this option is only applicable with restrictions.
Further information from Siemens

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