Control Panel Technical Guide

How to facilitate the UL-compliant approval to your control panel

schneider-electric.com

Life Is On Schneider Electric

This guide* **explains certain points requiring special attention** for **export sales.**

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UL compliance = Your visa for

Designing and building control panels for the U.S. market

UL standards = the key to the U.S. market

UL is the main certifying organisation in the United States. It develops standards for products, functional solutions and installation rules.

UL has laboratories that certify products submitted by manufacturers who wish to export to the U.S. They also certify that locally made products comply with applicable standards.

In U.S. industry, UL standards play the same role as IEC standards in Europe. Harmonisation efforts are underway.

Approval problems are frequent

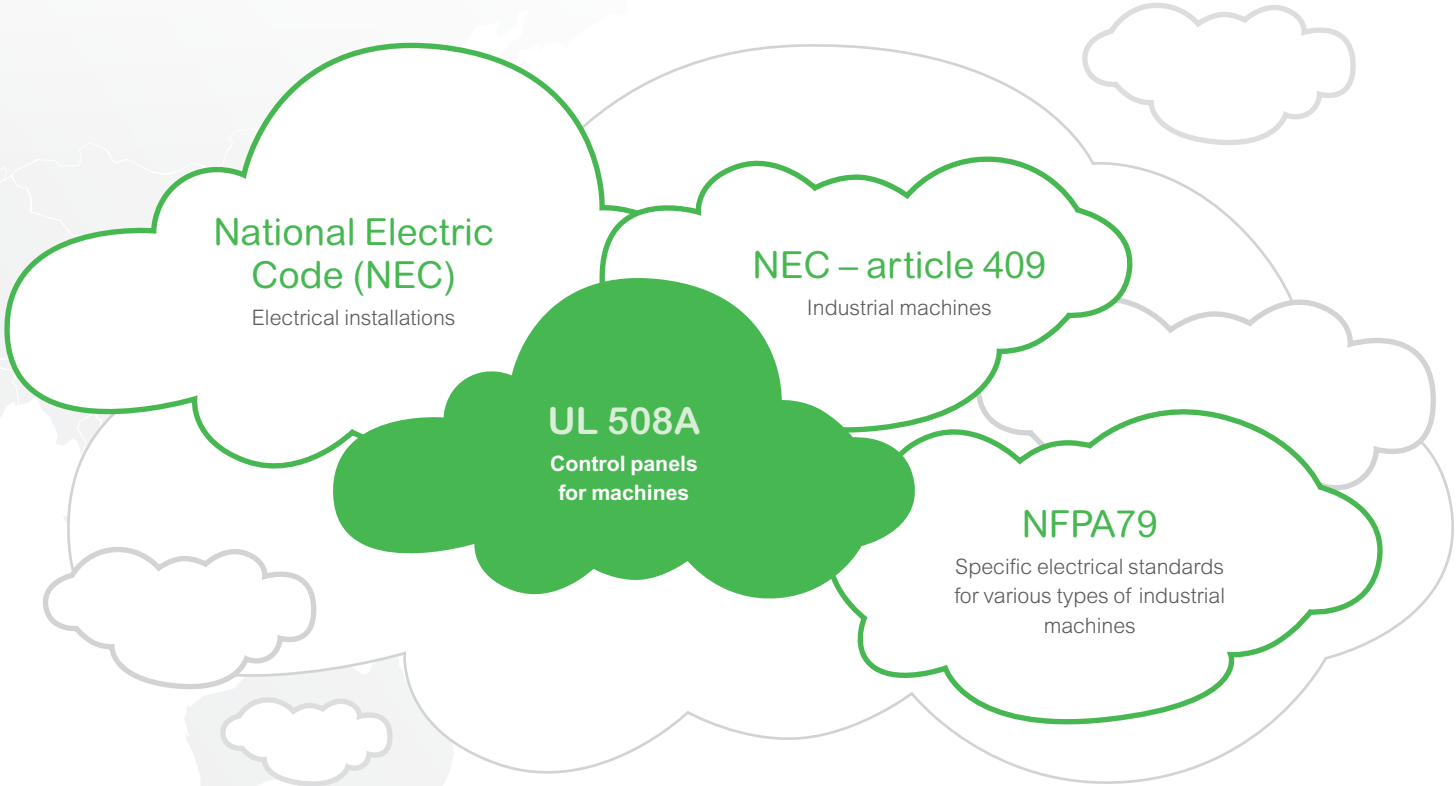
When machines are delivered in the U.S., an inspector delegated by an Authority Having Jurisdiction (AHJ) checks for compliance with UL standards and in particular with UL 508A.

The most frequently encountered problems with control panels are:

> Circuit breakers refused in spite of **UL certification**
> Non-compliant electrical clearances in a wiring distribution block, pre-wiring system or device
> Absence of name plates or incomplete indications of control panel characteristics.

the United States

Applicable standards in North America



These standards are presented on page 34.

AHJ inspections focus primarily on standard UL 508A.
This technical guide highlights certain critical aspects of this standard and proposes appropriate solutions.

The standard for Industrial Control Equipment, UL 508, has been harmonized with the relevant product standards of the IEC standard for low-voltage control and automation, IEC 60947. See details page 35.

Applicable standards from beginning to end of a project

1. **Functional design of circuits: UL 508A**
   For functional design and the calculation of ratings
2. **Product selection: UL 508-489-1077-98-508-508C-512**
   For verification of the presence of certificates of product compliance with applicable manufacturing standards.
3. **Control panel design: UL 508A**
   For wiring design, creation of name plate indications, etc.

1 UL standards and control

Definition of electrical circuits as per standard UL 508A *(chap. 2 and 6)*

Two types of power circuits are defined:

> **feeder circuits**: intended exclusively to supply power,

> **branch circuits**: connected to a load, with or without control functions.

Mandatory functions of feeder circuits

> Disconnection.

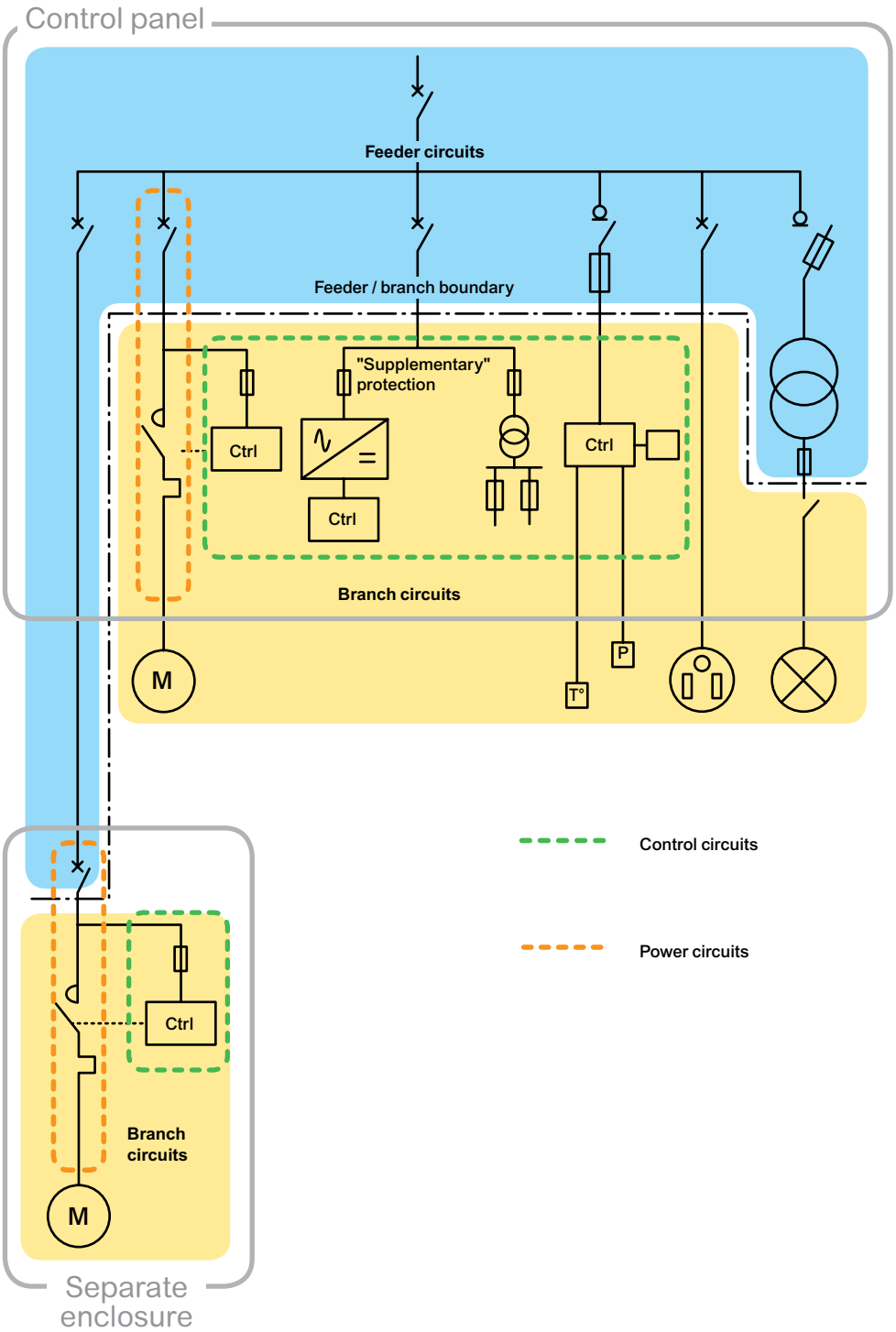
> Protection of branch circuits against overcurrents and short-circuits.
Disconnection and protection functions may be provided by a single device, e.g. a circuit breaker.

Feeder / branch circuit boundaries

Branch circuits begin **on the downstream side of the last short-circuit protective device**.

For a series of protective devices on a feeder circuit, it is the **last** device that marks the end of the feeder circuit.

For a transformer supplying a power circuit, the boundary is on the downstream terminals of the protective device on the secondary winding.



panel design

> Certifications required *(UL 508A chap. 30 to 32)* for feeder products

UL 489 for circuit breakers		UL 98 for switches (with or without fuses) UL 248 for fuses (if switches with fuses are used)	
			
PowerPact **circuit breakers**	*Multi9 C60* **miniature circuit breakers**	*Interpact* **switch-disconnectors**	*TeSys GS* **switch-disconnector-fuse**

The main disconnecting means may be supplied by the end user. In this case, the machine supplier must clearly specify the required characteristics.

> Certifications required *(UL 508A chap. 40.1)* for supplementary protection

UL 1077	UL 512 + UL 248
	
Multi9 C60 **miniature circuit breakers**	*TeSys DF* **fuseholder + fuses**

Required electrical clearances differ considerably depending on the intended use of the product:

> Larger clearances for products on feeder circuits.

> Standard clearances for products on branch circuits.

Many approval problems arise because a product is not suited to the type of circuit (feeder, branch or control circuit).

UL certifies that the product meets UL safety requirements for general use.

UL certifies that the system component meets UL safety requirements for use under restricted conditions known by the manufacturer.

2 UL standards and circuit

Design of a motor circuit as per standard UL 508 part IV and UL 508A *(chap. 31.3)*

Standard UL 508A distinguishes circuits according to their intended applications. For each, protection and control functions are stipulated. In the case of a motor feeder, a number of component combinations may be used to ensure the functions, however **six are recommended, namely A, B, C, D, E and F.**

The products used must satisfy a reference standard.

Recommended functions and devices

Disconnection

This function must disconnect all ungrounded conductors of a circuit from their electrical supply.

Approved devices

> Switches complying with UL 98.
> Moulded-case switches complying with UL 489.
> Instantaneous-trip (magnetic-only) or inverse-time (thermal-magnetic) circuit breakers complying with UL 489.
> Self-protected combination motor controllers complying with UL 508 (type E).

Alternatively, standard UL 508A allows the disconnecting means to be installed in the branch circuit.

Cable protection against overcurrents and short-circuits

Approved devices

> Fuses complying with UL 248 and approved for motor protection.
> Circuit breakers complying with UL 489 and UL 508.

Disconnection and protection functions may be provided by a single device.

Motor control

Approved devices

> Contactor.
> Manual self-protected combination motor controller.
> Any type of power-circuit controller (variable-speed drive, etc.).

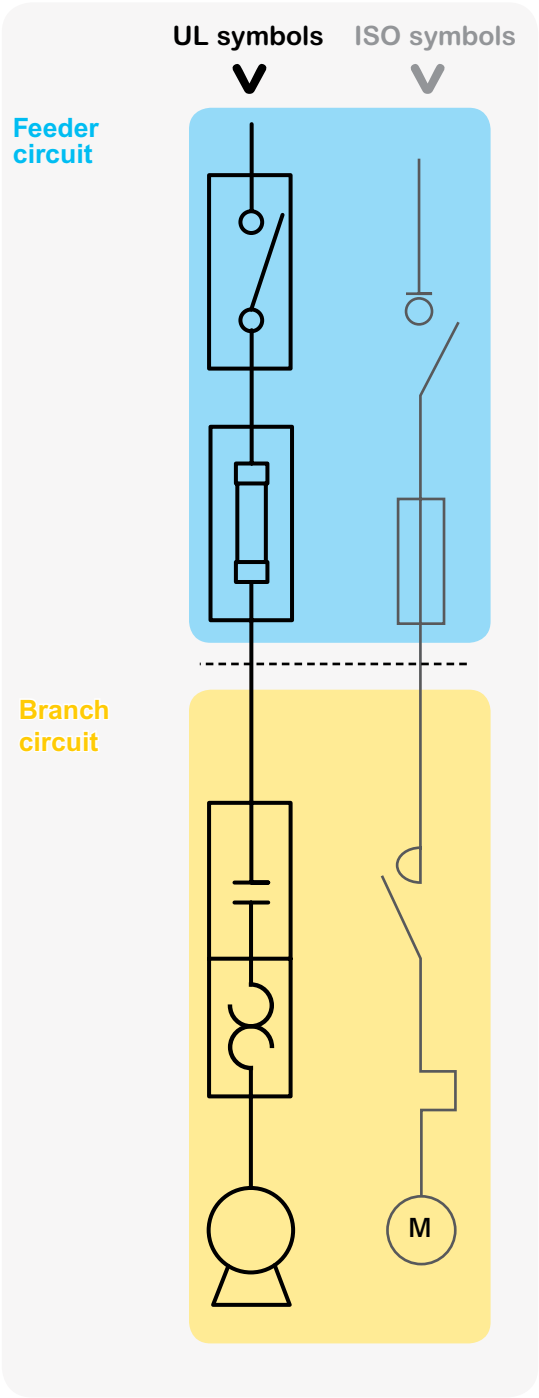
It may be advisable to select a product providing a disconnecting means as well. It must be certified as "suitable as motor disconnect" as per UL 508.

Motor protection against overloads

Approved devices

> Thermal relay or other type of device.
> Protective device built into the motor.

No particular requirements apply when the motor is "self-protected" by its design, e.g. by the impedance of the windings.



design

Standardised typical solutions for motor circuits *(UL 508 part IV and UL 508A chap.31.3, 33, 34)*

Separate protection and control devices[1]		Combination protection and control devices[2]	
UL 508 type A	**UL 508 type C or D**	**UL 508 type E**	**UL 508 type F**
Feeder circuit			
 Disconnection: UL 98 Fuses: UL 248 *Tesys GS*	 C: Inverse-time circuit breaker UL 489 *PowerPact* D: Instantaneous-trip circuit breaker UL 489	Self-protected combination motor controller: UL 508 Manual starter *Tesys GV2P*  Combined starter controller *TeSys U*	Manual self-protected combination motor controller: UL 508 *TeSys GV2P*  Contactor: UL 508 *TeSys D or TeSys D green*
Branch circuit			
 Contactor: UL 508 *TeSys D or TeSys D green*	 Contactor: UL 508 *TeSys D or TeSys D green*		
 Overload protection: UL 508 *TeSys LRD*	 Overload protection: UL 508 *TeSys LRD*		

[1] *Type B: UL 508 instantaneous-trip (magnetic-only) circuit breaker - rarely used.*
[2] *These solutions simultaneously provide the necessary functions for the feeder and branch circuits.*

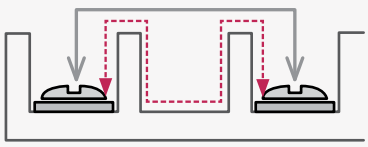
Warning
When choosing each product, **check that it complies with its reference standard** and that it is suitable for motor control and/or protection.

TeSys D Green
The new contactor with innovative coil

- Best in class coil consumption
- Only 4 product references per rating covering 24-500 V AC and DC and additional special offer (24 V DC BBE) for PLC application.

Visually distinguish between feeder and branch products

The required clearances for the terminals of devices connected to feeder circuits are greater. This rule applies to all devices, e.g. distribution blocks, fuseholders, circuit breakers, switches, etc.

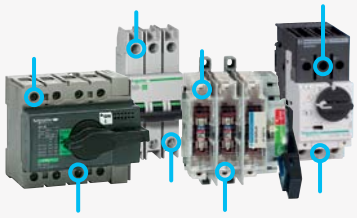


Minimum clearances

⟷	In air: 1 inch (25.4 mm)
◂----▸	Creepage distance: 2 inches (50.8 mm)

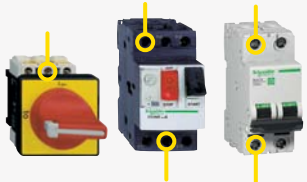
Products certified UL 489, UL 98 and UL 508 type E comply with these clearances, often through the use of spacing accessories.
It is necessary to check that the accessories are included.

> Terminals with larger clearances = Products for use on feeder circuits



Interpact, Multi9 C60,TeSys GS, TeSys GV2P

> Terminals with standard clearances = Products for use on branch circuits



Vario,TeSys GV2ME, Multi9 C60

2 UL standards and circuit

Sizing single-motor protective devices *(UL 508A chap. 31.3)*

Protective devices avoid damage to conductors in the event of overcurrents or short-circuits. For maximum protection ratings, see the table below. Use of certain types of devices imposes significant oversizing.

Protection performance is the main criterion

Overcurrent/short-circuit protection is optimised when its rating is equal to the full-load current of the motor.

Why are UL 508 type E and F solutions preferred?

UL 508 type E and F solutions are highly effective because they are the only ones for which the maximum rating = motor full-load current.

They combine all the mandatory protection functions in a very compact format:

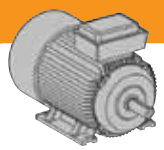
- **protection of the branch circuit** against short-circuits and overcurrents,
- **protection of the motor cable,**
- **protection of the motor against overloads.**

These solutions saves space by using special installation systems (comb busbars, terminal blocks).

Maximum rating of motor branch circuit device, % of full-load amperes

Type of branch circuit protective device	Ampere rating	Maximum rating	Type of protection (UL 508)
	(A)	% full load	
Nontime-delay fuse	0-600	300	A
	> 600	300	A
Dual-element fuse (time delay) except class CC	All	175	A
Class CC dual-element fuse (time delay)	0-30	300	A
Inverse-time (thermal-magnetic) circuit breaker	0-100	250	C
	> 100	250	C
Instantaneous-trip (magnetic) circuit breaker	All	800	D
Self-protected combination motor controller	All	100	E
Manual self-protected combination motor controller	All	100	F

Example: **What are the solutions for this 10 A motor?**



design (cont.)

Design of a single-motor circuit controlled by a variable-speed drive (VSD)

Required functions and devices (UL 508A chap. 31.3.2)

Disconnection

This function must disconnect all ungrounded conductors of a circuit from their electrical supply.

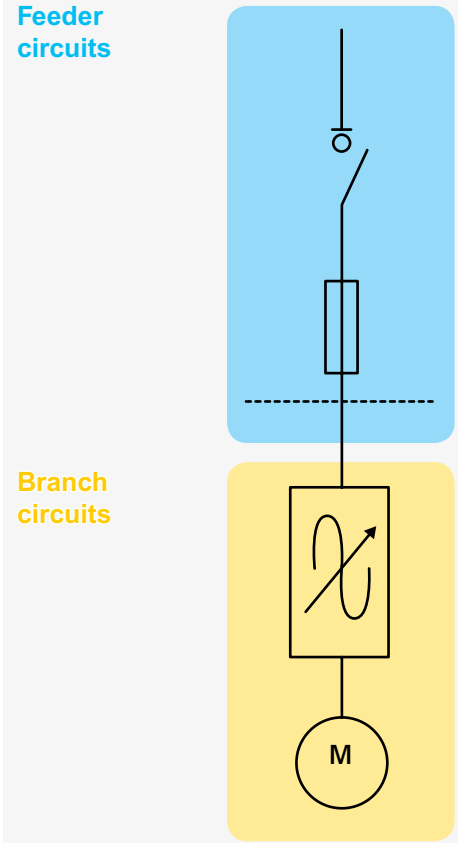
Approved devices

> Switch complying with UL 98.
> Moulded-case switch complying with UL 489.
> Inverse-time (thermal-magnetic) circuit breaker complying with UL 489.
> Self-protected combination motor controller complying with UL 508 type E or F.

Cable protection against overcurrents and short-circuits

> Comply with the devices and ratings recommended by the VSD manufacturer, e.g. fuse (UL 248), circuit breaker (UL 489) or self-protected combination motor controller (UL 508 type E).

> If no recommendations are made, then use fuses (UL 248) or circuit breakers (UL 489). See the ratings in the table on page 10 *(250% of VSD full-load current for a circuit breaker)*.



In addition to protection using fuses or a circuit breaker, Schneider Electric **Altivar** VSDs have been **certified for TeSys GV2P and GV3P UL 508 type E self-protected combination motor controllers**.

Disconnection / protection using a TeSys GV2P motor starter and an Altivar ATV320 VSD.

2 UL standards and circuit

Protecting a group of motors using a single device *(UL 508A chap. 31.4)*

The standard authorises a group of motors to be supplied by a single feeder circuit, in which case there is a single protective device.

Rules to check that the rating of the single device complies with the standard

1

This rule is applicable when:
the protection setting for the group does not exceed 20 A / 125 V or 15 A / 240, 480 or 600 V, and the rated current of each motor is less than 6 A.

> Each component in the circuits must be effectively protected by the device protecting the group.
> Other non-motor loads must have their own short-circuit protection.

2

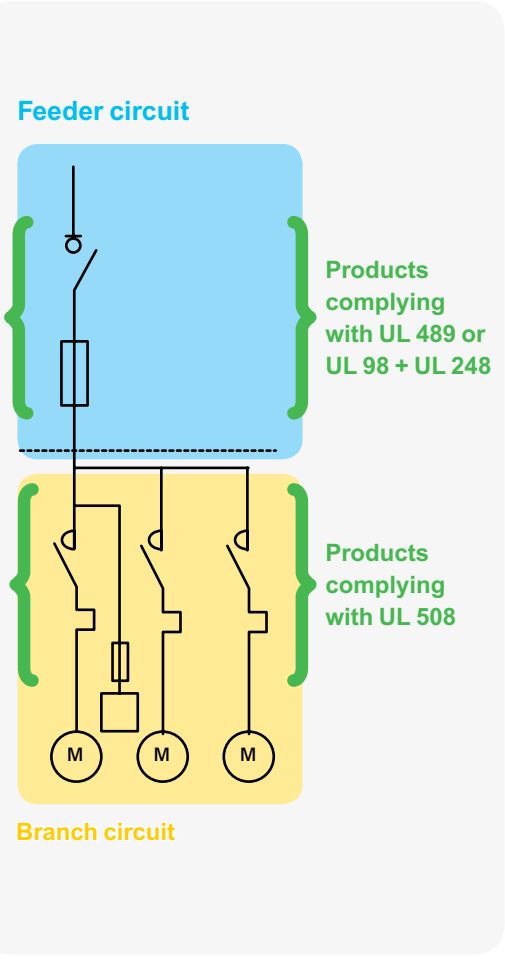
This rule is applicable when:
the circuit of the smallest motor in the group is protected.

> The size of cables in each circuit of the group must be ≥ 1/3 the size of the upstream cable.
> Other non-motor loads must have their own short-circuit protection.

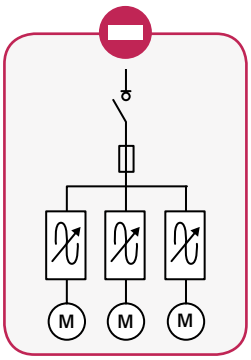
3

This rule is applicable when:
all components (contactors and overload protection) on the downstream side of the group protection are certified for "group installation".

The rating of the group protection is less than both of the following:
> the protection rating for the largest load (similar to the method for a single-motor circuit) + the total of the currents of all other loads in the group,
> the maximum protection rating indicated for each component on the downstream side.



Protection for a group of VSDs



This configuration is not authorised.

design (cont.)

Typical solutions for protection and control of a group of motors

Group protection

Protection against overcurrents and short-circuits: UL 489

Circuit breakers or fuses

PowerPact

Multi9 C60

Single-motor protection and control

Contactor + thermal relay (UL 508)

TeSys D or TeSys D green

TeSys LRD

Manual starter + contactor (UL 508)

TeSys GV2ME

+

TeSys K

Combined starter controller (UL 508)

TeSys U

Application example

Protecting and controlling a group of six motors

> 1 motor 1.1 kW / 480 V (2.7 A)

> 5 motors 0.55 kW / 480 V (1.1 A)

The selected rule is the "each motor < 6 A" rule.

Group protection

> Multi9 C60 C curve circuit breakers, certified UL 489

> Maximum current = (250% x 2.7) + (5 x 1.1) = 12.25 A

> Next lowest rating selected = 10 A

Protection for single-motor circuits

> Distribution via 2 busbars (GV2G345 + GV2G445) + 1 terminal block (GV1G09)

> 1 x GV2ME07 and 5 x GV2ME06 motor starters, can be coordinated with protection rated up to 125 A, 6 x LC1K09 contactors

> Direct link between GV2ME starters and contactors using GV2AF01 manual starter combo blocks

2 UL standards and circuit

Sizing single-load protective devices **for other circuits** *(UL 508A chap. 31.6, 31.7, 31.8)*

Heater loads
UL 508A – chap. 31.6

Maximum protection rating = 60 A
> 125% of the heater load current.

Appliance loads
UL 508A – chap. 31.7

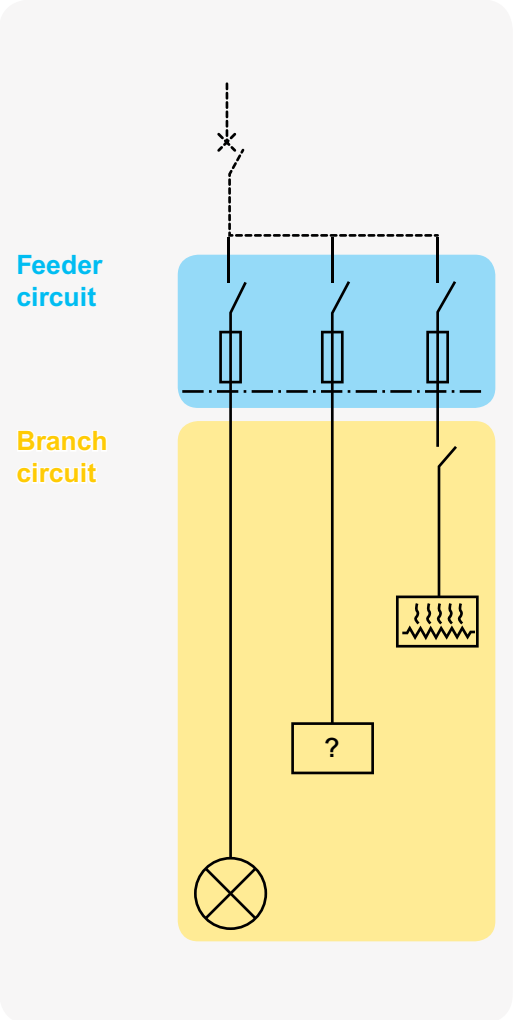
Sizing shall be based on the required branch protection as marked on the appliance AND:

Maximum protection rating = 20 A
> for loads rated less than 13.3 A:
- 100% of the load ampere rating
> for loads rated 13.3 A and more:
- 150% of the load ampere rating.

Lighting loads
UL 508A – chap. 31.8

Standard-duty lighting
> Incandescent lampholders
> Fluorescent ballasts
- Maximum protection rating = 20 A

Heavy duty lighting
> Incandescent lampholders
> Infrared lamps
- Maximum protection rating = 50 A.



The protection rating may **never** exceed the ampacity of the anticipated field wiring.

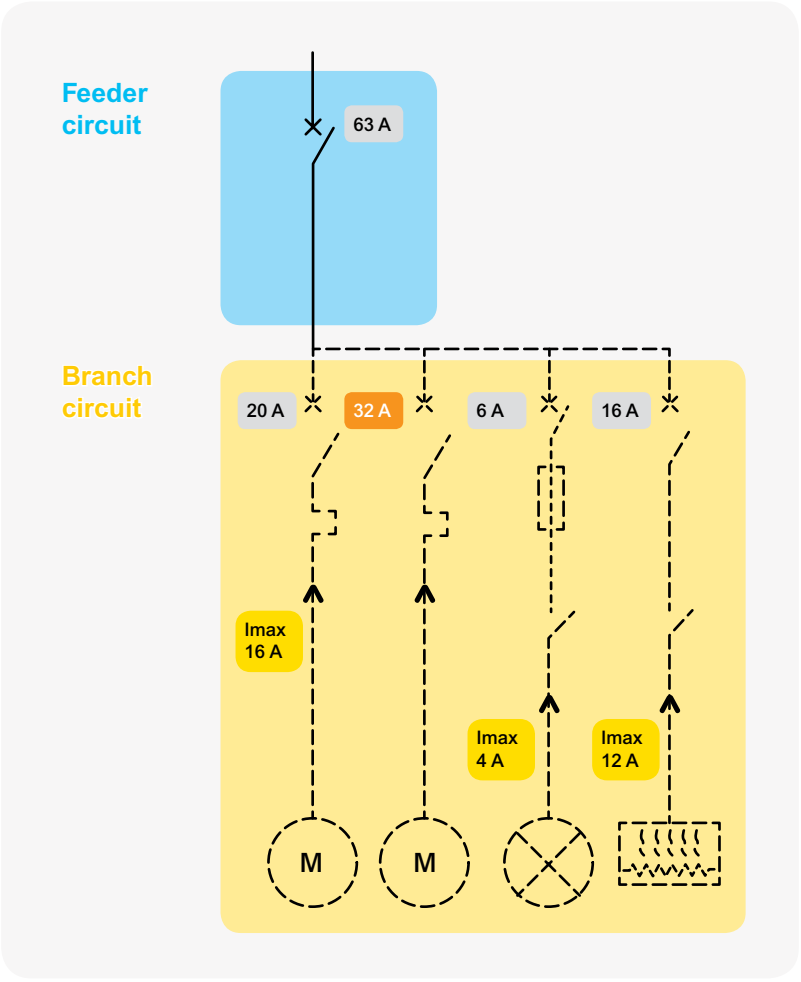
design (cont.)

Sizing the protection for a control panel incomer (feeder circuit)

Protection using a circuit breaker
As part of the feeder circuit, the disconnection and protection circuit breaker must be **certified UL 489.**

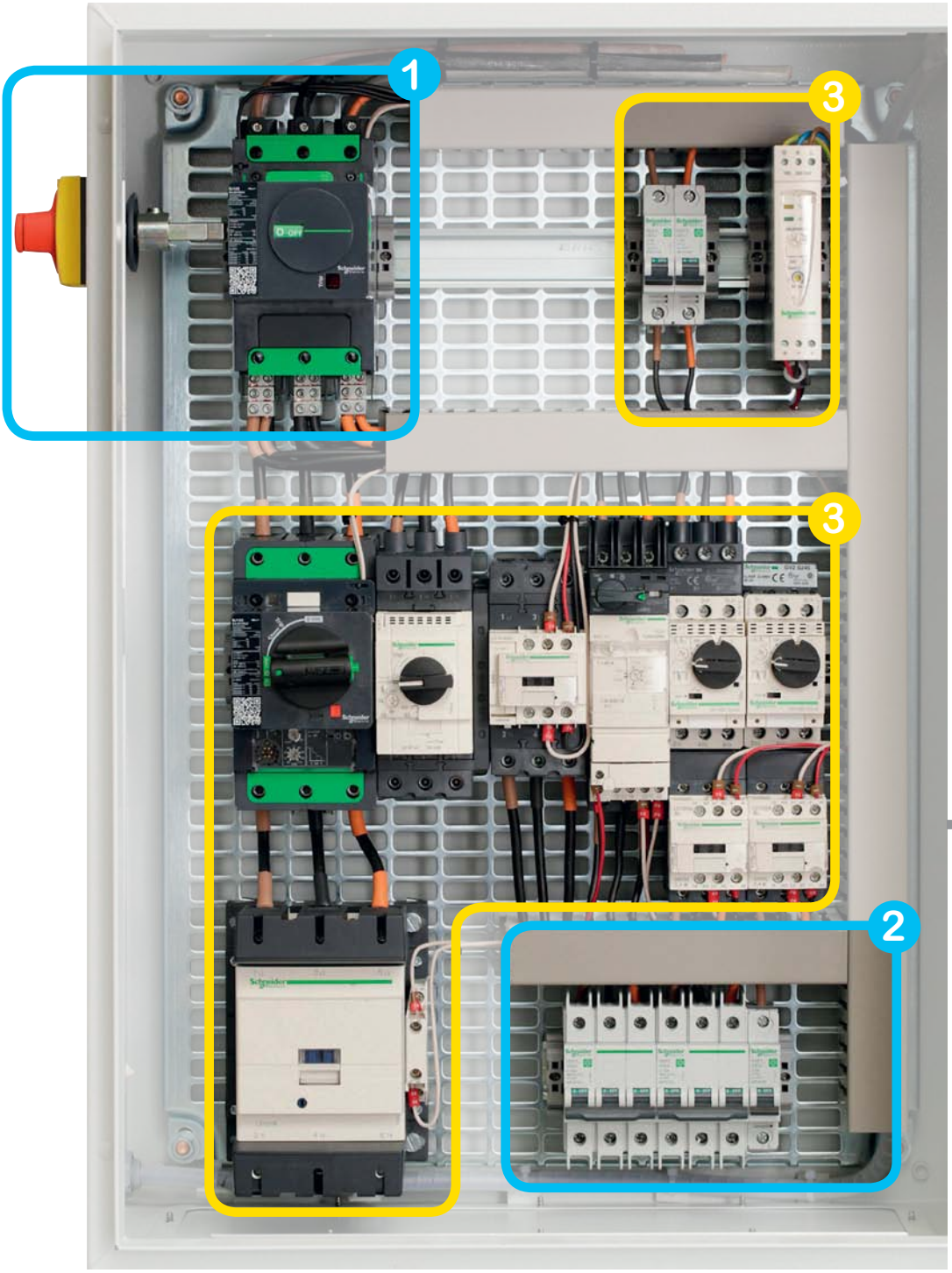
Maximum rating
Protection rating of the largest load **+** the sum total of the maximum currents of the other loads

Example (see opposite)
32 *+* ***16*** *+* ***4*** *+* ***12*** *= 64*
I.e. ***rating = 63 A***



The protection rating must **never** exceed the ampacity of the anticipated field wiring.

Selecting products for UL control panels



1

Feeder circuits

Disconnection devices

Incoming protective devices.

2

Feeder circuits

Branch circuit protective devices.

3

Branch circuits

Motor control and overload protection devices

Variable-speed drives

Supplementary protection.

1 Feeder circuits / panel incomer

Moulded-case circuit breakers
PowerPact UL 489 / IEC 947-2

> With its robust design and many innovative features, the **PowerPact** range is intended mainly for **industrial applications**.

> Range from **15 to 600 A**.

> Auxiliary devices and accessories for maximum flexibility of use.

PowerPact		B			H			J			L			
Breaker type		**BD**	**BG**	**BJ**	**HD**	**HG**	**HJ**	**JD**	**JG**	**JJ**	**LD**	**LG**	**LJ**	**LL**
Number of poles		1-4	1-4	1-4	3	3	3	3	3	3	3	3	3	3
Current range		15-125	15-125	15-125	15-150	15-150	15-150	150-250	150-250	150-250	250-600	250-600	250-600	250-600
Interrupting ratings														
UL/CSA/NOM rating (kA RMS) (50/60 Hz AC)	240 Vac	25	65	100	25	65	100	25	65	100	25	65	100	125
	480 Y/277 Vac	18	35	65	…	…	…	…	…	…	…	…	…	…
	480 Vac (1)	18	35	65	18	35	65	18	35	65	18	35	65	100
	600 Y/347 Vac (2)	14	18	25	…	…	…	…	…	…	…	…	…	…
	600 Vac	…	…	…	14	18	25	14	18	25	14	18	25	50
DC ratings	250 Vdc	…	…	…	20	20	20	20	20	20	…	…	…	…
	500 Vdc	…	…	…	…	…	…	…	20	…	…	…	…	…
IEC 60947-2 kA RMS (50/60 Hz AC) Icu/Ics	220/240 Vac	25/25	65/65	100/100	25/25	65/65	100/100	25/25	65/65	100/100	25/25	65/65	100/100	150/150
	380/415 Vac	18/18	35/35	65/65	18/18	35/35	100/100	25/25	65/65	100/100	25/25	65/65	100/100	125/125
Accessories														
Shunt Trip		●	●	●	●	●	●	●	●	●	●	●	●	●
Undervoltage Trip		●	●	●	●	●	●	●	●	●	●	●	●	●
Auxiliary Switches		●	●	●	●	●	●	●	●	●	●	●	●	●
Handle Operators		●	●	●	●	●	●	●	●	●	●	●	●	●
Mechanical Interlocks		...	...	...	●	●	●	●	●	●	●	●	●	●
Handle Padlock Attachment		●	●	●	●	●	●	●	●	●	●	●	●	●
Trip System Type														
Thermal magnetic		●	●	●	●	●	●	●	●	●	…	…	…	…
Electronic		...	...	...	●	●	●	●	●	●	●	●	●	●
Enclosure														
Dimensions (3-pole unit mount)	Height mm (in.)	137 (5.4)			163 (6.4)			191 (7.5)			340 (13.38)			
	Width mm (in.)	81 (3.2)			104 (4.1)			104 (4.1)			140 (5.51)			
	Height mm (in.)	80 (3.1)			87 (3.4)			87 (3.4)			110 (4.33)			

(1) 480 Vac on 2 - 4P only
(2) 600Y Vac on 2 - 4P only

Moulded-case switches
InterPact UL 489 / IEC 947-3

> The InterPact UL 489 provides the **mandatory disconnection** function, in particular when the branch circuit protection is installed outside the control panel.

> Range from **40 to 400 A**

> Auxiliary devices and accessories for maximum flexibility of use.

InterPact	Short-circuit current rating (SCCR)	Associated upstream protective device
INSE80 – 3, 4 poles 40, 60, 80 A		
	10 kA / 600 V	All protective devices
	100 kA / 240 V	PowerPact H 100 A circuit breaker
	65 kA / 480 V	
	18 kA / 600 V	
	50 kA / 600 V	Special Class T or RK 100 A fuse
INSJ400 – 3, 4 poles 250, 400 A		
	20 kA / 600 V	All protective devices
	150 kA / 240 V	PowerPact L 400 A circuit breaker
	100 kA / 480 V	
	25 kA / 600 V	
	50 kA / 600 V	Special Class T or RK 100 A fuse

2 Feeder circuits / branch circuit

Miniature circuit breakers
Multi 9 C60 UL 489 / IEC 947-2

Installation system for Multi9 C60 UL

Comb busbars with accessories, e.g. terminal blocks, terminal shields, tooth-caps, etc.

Miniature circuit breakers							
Breaker type		**Multi 9 C60BP and Multi 9 C60BPR - UL489**					
Number of poles		1		2		3	
Current range		0.5…35 A	40…63 A	0.5…35 A	40…63 A	0.5…35 A	40…63 A
Interrupting ratings							
UL/CSA rating (kA RMS) (50/60 Hz AC)	120 Vac	14	10	…	…	…	…
	120/240 Vac	…	…	…	…	…	…
	240 Vac	14	10	14	10	14	10
	277 Vac	10	…	…	…	…	…
	480 Y/277 Vac	…	…	10	…	10	…
	480 Vac	…	…	…	…	…	…
	600 Y/347 Vac	…	…	…	…	…	…
	600 Vac	…	…	…	…	…	…
DC ratings (UL)	48 Vdc	…	…	…	…	…	…
	60 Vdc	10	10	…	…	…	…
	65 Vdc	…	…	…	…	…	…
	125 Vdc	…	…	10	…	…	…
	250 Vdc	…	…	…	…	…	…
	500 Vdc	…	…	…	…	…	…
IEC 60947-2 (50/60 Hz AC)	240 V	10	10	20	20	20	20
	415 V	3	3	10	10	10	10
	440 V	…	…	6	6	6	6
DC ratings (IEC)	60 Vdc	20	20	…	…	…	…
Accessories							
Shunt Trip		●	●	●	●	●	●
Undervoltage Trip		●	●	●	●	●	●
Auxiliary Switches		●	●	●	●	●	●
Handle Operators		●	●	●	●	●	●
Handle Padlock Attachment		●	●	●	●	●	●
GF Protection (GFP)		●	●	●	●	●	●
Enclosures							
Dimensions (3-pole unit mount)	Height mm (in.)	Box lug: 103 (4.XX) Ring tongue terminal: 127 (X.XX)					
	Width mm (in.)	18 (0.71)		36 (1.42)		54 (2.13)	
	Depth mm (in.)	76 (3.00)					

protection

Switch-disconnector-fuses
TeSys GS UL 98 / IEC 947-3

Switches					
Type	**GS1DDU3**	**GS1DU3**	**GS1 EERU**		**GS2…**
Number of poles	3	3	2	3	3
Interrupting rating	30	30	30	30	30… 80
Fuse type	J	CC	CC	CC	CC, J, L
Handle operator					
Front	●	●	●	●	●
Side			●	●	
Direct	●	●	●	●	●
Remote	●	●			●
Auxiliaries					
	Early-break contacts On/off and test position indication contacts				

Fuseholders
TeSys DF UL 512 / IEC 947-3

Fuseholders					
Type	**DF8**	**DF10**	**DF14**	**DF22**	**DFCC**
Number of poles	1-2-3-N 1+N-3+N	1-2-3-N 1+N-3+N	1-2-3-N 1+N-3+N	1-2-3-N 1+N-3+N	1-2-3-N
Maximum rating (A)	25	32	50	125	30
Fuse type	8.5 x 31.5	10 x 38	14 x 51	22 x 58	CC
UL certification	UR	UR	UR	UR	UL
Auxiliaries					
	Early-break contacts Fuse-blown indication contacts				

2 Feeder circuits + 3 Branch

Motor starters – Type E UL 508 – Type F UL 508 / IEC 947-4-1

TeSys GV2P motor starters – TeSys LC1D contactors

TeSys GV2P with GV2GH7 line spacer for one motor starter or with GV1G09 terminal block and GV2G busbars for several motor starters — File UL E164871.

Maximum horsepower ratings						Manual Self protected starter	Overload trip range (A)	Type of contactor required	SCCR (KA)	
Single-Phase		Three-Phase							480Y/277V	600Y/347V
120 V	240 V	208 V	240 V	480 V	600 V					
-	-	-	-	-	-	GV2P01	0.10 - 0.16	LC1D09 or D12	100	-
								LC1D09	100	50
-	-	-	-	-	-	GV2P02	0.16 - 0.25	LC1D09 or D12	100	-
								LC1D09	100	50
-	-	-	-	-	-	GV2P03	0.25 - 0.40	LC1D09 or D12	100	-
								LC1D09	100	50
-	-	-	-	-	-	GV2P04	0.40 - 0.63	LC1D09 or D12	100	-
								LC1D09	100	50
-	-	-	-	-	0.5	GV2P05	0.63 - 1	LC1D09 or D12	100	-
								LC1D09	100	50
-	1/10	-	-	0.75	0.75	GV2P06	1 - 1.6	LC1D09 or D12	100	-
								LC1D09	100	50
-	1/5	0.5	0.5	1	1.5	GV2P07	1.6 - 2.5	LC1D09 or D12	100	-
								LC1D09	100	50
1/8	1/3	0.75	0.75	2	3	GV2P08	2.5 - 4	LC1D09 or D12	100	-
								LC1D09	100	50
0.25	0.5	1	1.5	3	5	GV2P10	4 - 6.3	LC1D09 or D12	100	-
								LC1D09	100	50
0.5	1.5	2	3	5	7.5	GV2P14	6 -10	LC1D09 or D12	100	-
								LC1D09	100	50
0.75	2	3	3	10	10	GV2P16	9 - 14	LC1D12 or D18	42	-
								LC1D18	50	50
1	3	5	5	10	15	GV2P20	13 - 18	LC1D12 or D18	42	-
								LC1D18	50	50
1.5	3	5	7.5	15	20	GV2P21	17 - 23	LC1D25 or D32	42	-
								LC1D25	50	50
2	-	7.5	7.5	15	20	GV2P22	20 - 25	LC1D25 or D32	42	-
								LC1D25	50	50

TeSys GV3P UL 508 motor starters – TeSys LC1D contactors

TeSys GV3P with GV3G66 line spacer and GVAM11 magnetic trip unit for one motor starter — File UL E164871.

Standard motor ratings for motors 50/60 Hz (HP)						Manual self-protected starter	Overload trip range (A)	Type of contactor required	SCCR (kA)	
Single-Phase			Three-Phase			Type E			480Y/277V	600Y/347V
120 V	240 V	208 V	240 V	480 V	600 V					
0.5	1.5	3	3	7.5	10	GV3P13	9 - 13	LC1D18, D25, D32, D40A, D50A or D65A	65	25
0.75	2	5	5	10	15	GV3P18	12 - 18	LC1D18, D25, D32, D40A, D50A or D65A	65	25
1.5	3	5	7.5	15	20	GV3P25	17 - 25	LC1D25, D32, D40A, D50A or D65A	65	25
2	5	7.5	10	20	25	GV3P32	23 - 32	LC1D32, D40A, D50A or D65A	65	25
3	-	10	-	25	30	GV3P40	30 - 40	LC1D40A, D50A or D65A	65	25
-	7.5	10	15	30	40	GV3P50	37 - 50	LC1D50A or D65A	65	25
5	10	15	20	40	50	GV3P65	48 - 65	LC1D65A or 80	65	25

Note: GV2P, GV3P are only UL 508 certified, not viewed as circuit breakers by UL.

circuits

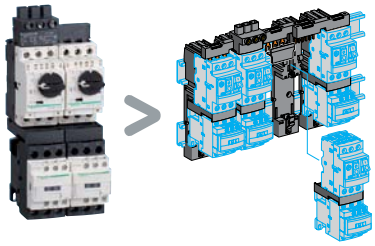
TeSys U combination motor starters

TeSys U with LU9SPO line spacer for one motor starter or with GV1G09 terminal block and GV2G09 busbars for several motor starters — File UL E164871.

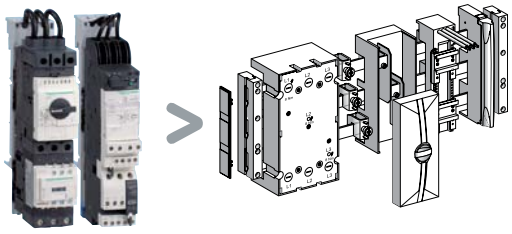
Standard motor ratings for motors 50/60 Hz (HP)						Associated cable	Type of self protected combination starter	Overload trip range (A)	SCCR (kA)		
Single-Phase		Three-Phase				Type 75°C-Cu	Type E		480Y/277V	480 V with LUALB1 limiter	600 V with LUALB1 limiter
120 V	240 V	200 V	240 V	480 V	600 V						
1.5	2	3	3	10	10	AWG8	LUB12	... 12	65	130	65
2	5	10	10	20	25	AWG8	LUB32	... 32	65	130	

SCCR values are for one motor starter or several starters (with GV1G09 terminal block + GV2G busbars) when a limiter block is used.
TeSys U comprises a power control base and functional modules, e.g. alarms, measurement, communication. A reverser unit is available for reverse operation (see illustration below). Certification obtained with LU9SP0 line spacer on LUB12 and LUB32.

Mounting and connection systems for several motor starters



TeSys GV2AF, GV2G for GV2: supports, comb busbars, terminal blocks, etc.



TeSys LA9Z for TeSys U and GV2: supports, busbars, terminal blocks, etc.

Starter + VSD combination

GV2P or GV3P motor starter with ATV320 variable-speed drive

Type E manual self-protected combination motor controllers protect circuits controlled by a variable-speed drive. Schneider Electric has had a number of combinations certified.

Power rating		Drive model (2)	Line reactor, Mini. value	Type E combination motor controller			
(kW)	(HP)		(mH)	Model (1)	Rating at 500 V (A)	SCCR (kA)	Rating
208/230 V - Single-Phase							
0.18	1/4	ATV320U02M2x	2.5	GV2P08	4	65	Under 240 V ac
0.37	1/2	ATV320U04M2x		GV2P10	6.3	65	
0.55	3/4	ATV320U06M2x		GV2P14	10	65	
0.75	1	ATV320U07M2x		GV3P13	12	65	
1.1	1-1/2	ATV320U11M2x	1	GV3P18	18	65	
1.5	2	ATV320U15M2x		GV3P25	25	65	
2.2	3	ATV320U22M2x		GV3P25	25	65	
4	5	ATV320U75M2x	0.4	GV3P50	50	65	
5.5	8	ATV320D11M2x	0.3	GV3P65	65	65	
7.5	10	ATV320D15M2x	0.2	HxL36090 (3)	90	65	
480 V - Three-Phase							
0.37	1/2	ATV320U04N4x	12	GV2P07	2.5	65	Under 480Y/277 V ac
0.55	3/4	ATV320U06N4x		GV2P07	2.5	65	
0.75	1	ATV320U07N4x		GV2P08	4	65	
1.1	1-1/2	ATV320U11N4x	6.8	GV2P08	4	65	
1.5	2	ATV320U15N4x		GV2P10	6.3	65	
2.2	3	ATV320U22N4x	5	GV2P14	10	65	
3	4	ATV320U30N4x	3	GV2P14	10	65	
4	5	ATV320U40N4x		GV3P13	12	65	
5.5	8	ATV320U55N4B	2.5	GV3P18	18	65	
7.5	10	ATV320U75N4B	1.5	GV3P25	25	65	
11	15	ATV320D11N4B	1.2	GV3P32	32	65	
15	20	ATV320D15N4B	0.8	GV3P40	40	65	

(1): Large spacing adapter GV2GH7 to be added to GV2, GV3G66 to GV3. Short circuit signalling contact GVAM11 to be added to GV3.
(2): replace "x" by B or C.
(3): replace "x" by the right short circuit current rating. For 208/230 V range use | x = | D for 25 kA | G for 65 kA | J for 65 kA | L for 65 kA |

3 Branch circuits

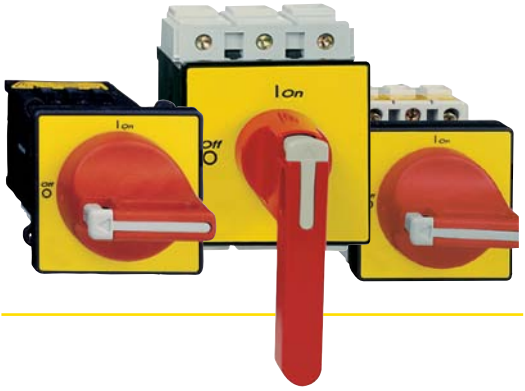
Miniature circuit breakers for supplementary protection
Multi 9 C60 UL1077 / IEC 947-2

In addition to the PowerPact molded case circuit breakers offer, IEC 947-2/ UL 489 miniature circuit breakers and UL 248 fuses should be used to protect loads like power transformers, the power supply, appliances, and heating and lighting.

Multi 9™ C60 is the first extensive range of DIN rail-mounted miniature circuit breakers to be UL 489 listed for branch circuit protection. Other Multi 9 devices are UL recognized as supplementary protectors suitable for applications where branch circuit protection is already provided or not required. Multi 9 C60 products also have IEC ratings. Other IEC-rated products complement the UL line up to 125 A at 440 VAC.

Miniature circuit breakers

Breaker type	Multi 9	C60BP and C60BPR UL489						C60SP UL1077						UL 1077 C60H-DC	
Number of poles		1		2		3		1		2		3		1	2
Current range		0.5…35 A	40…63 A	0.5…35 A	40…63 A	0.5…35 A	40…63 A	0.5…35 A	40…63 A	0.5…35 A	40…63 A	0.5…35 A	40…63 A	0.5-40	0.5-40
Interrupting ratings															
UL/CSA rating (kA RMS) (50/60 Hz AC)	120 Vac	14	10					14	10						
	120/240 Vac														
	240 Vac	14	10	14	10	14	10	14	10	14	10	14	10		
	277 Vac	10						10	5						
	480 Y/277 Vac			10		10				10	5	10	5		
	480 Vac														
	600 Y/347 Vac														
	600 Vac														
DC ratings (UL)	48 Vdc													5	5
	60 Vdc	10	10											5	5
	65 Vdc							10	10						
	125 Vdc			10						10				5	5
	250 Vdc													5	5
	500 Vdc														5
IEC 60947-2 (50/60 Hz AC)	240 V	15	15	30	30	30	30	15	15	30	30	30	30	10	20
	415 V	3	3	15	15	15	15	3	3	15	15	15	15		
	440 V			10	10	10	10			10	10	10	10		10
DC ratings (IEC)	60 Vdc	20	20					20	20						
Accessories															
Shunt Trip		●		●		●		●		●		●		●	●
Undervoltage Trip		●		●		●		●		●		●		●	●
Auxiliary Switches		●		●		●		●		●		●		●	●
Handle Operators		●		●		●		●		●		●		●	●
Handle Padlock Attachment		●		●		●		●		●		●		●	●
GF Protection (GFP)		●		●		●		●		●		●		●	●
Enclosures															
Dimensions	Height mm (in.)	Box lug: 103 (4.XX) - Ring tongue terminal: 127 (X.XX)						81 (3.19)						81 (3.19)	
	Width mm (in.)	18 (0.71)		36 (1.42)		54 (2.13)		18 (0.71)		36 (1.42)		54 (2.13)		18 (0.71)	36 (1.42)
	Width mm (in.)	76 (3.00)						76 (3.00)						76 (3.00)	



Switches
TeSys Vario UL 508 / IEC 947-3

> **UL 508 certified**

In accordance with sections 30.1.4 and 30.3.3, Vario should be used as a load break switch, downstream of the Branch circuit protection. Thus, it is not able to be used in the Feeder circuit as a main panel disconnect switch.

Warning
NOT UL 98 certified

May not be used in a feeder circuit.

TeSys Vario loadbreak switches				
Vario range	**Standard Mini-Vario**	**Vario High performance**		**Vario High performance**
Thermal current	12 – 20 A	12 – 20 A	63 – 80 A	125-175 A
Number of poles	3…5	3…6	3…6	3 + N + PE
Handle attachment	Diam. 22.5 or 4 screws	Diam. 22.5 or 4 screws	4 screws	4 screws

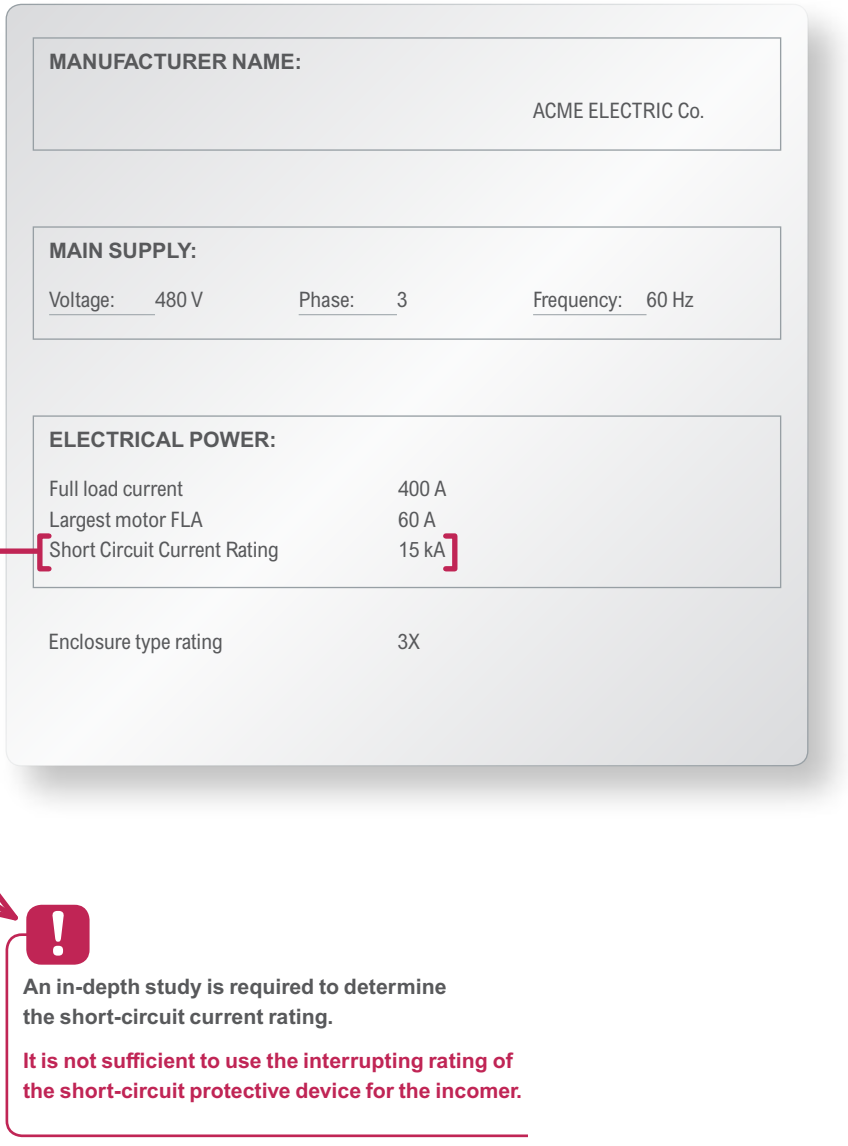
Control panel name plate

> All control panels containing power circuits must have a name plate indicating:

- the main characteristics, in particular the **Short Circuit Current Rating (SCCR)**,
- any specific characteristics concerning its functions.

The name plate must be **clearly visible** after installation, with the door open.

Control panels containing only control devices are exempted.



An in-depth study is required to determine the short-circuit current rating.

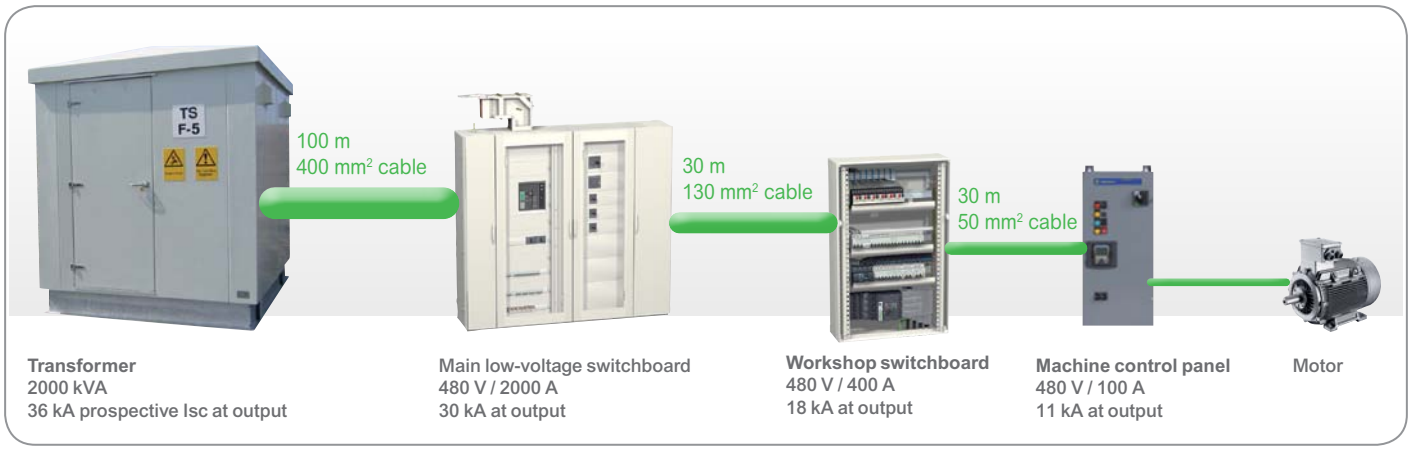
It is not sufficient to use the interrupting rating of the short-circuit protective device for the incomer.

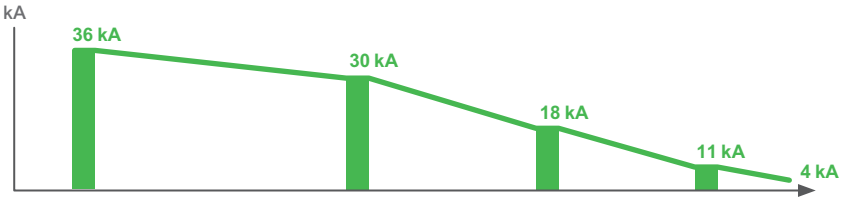
SCCR (short-circuit current rating) of the control panel
- UL 508A supplement SB

SCCR, a critical characteristic for safety

If the design calculations do not take the electro-dynamic effects of short-circuits into account, they can result in deformation, destruction of connectors and even the explosion of certain components.

The SCCR is an essential characteristic in the technical specifications of the control panel that contributes to overall dependability.
It is used when sizing the power conductors and components.





Value calculated at the connection point to the switchboard/control panel

= Decrease of short-circuit current with the size and length of the conductor

An over-designed SCCR = money down the drain

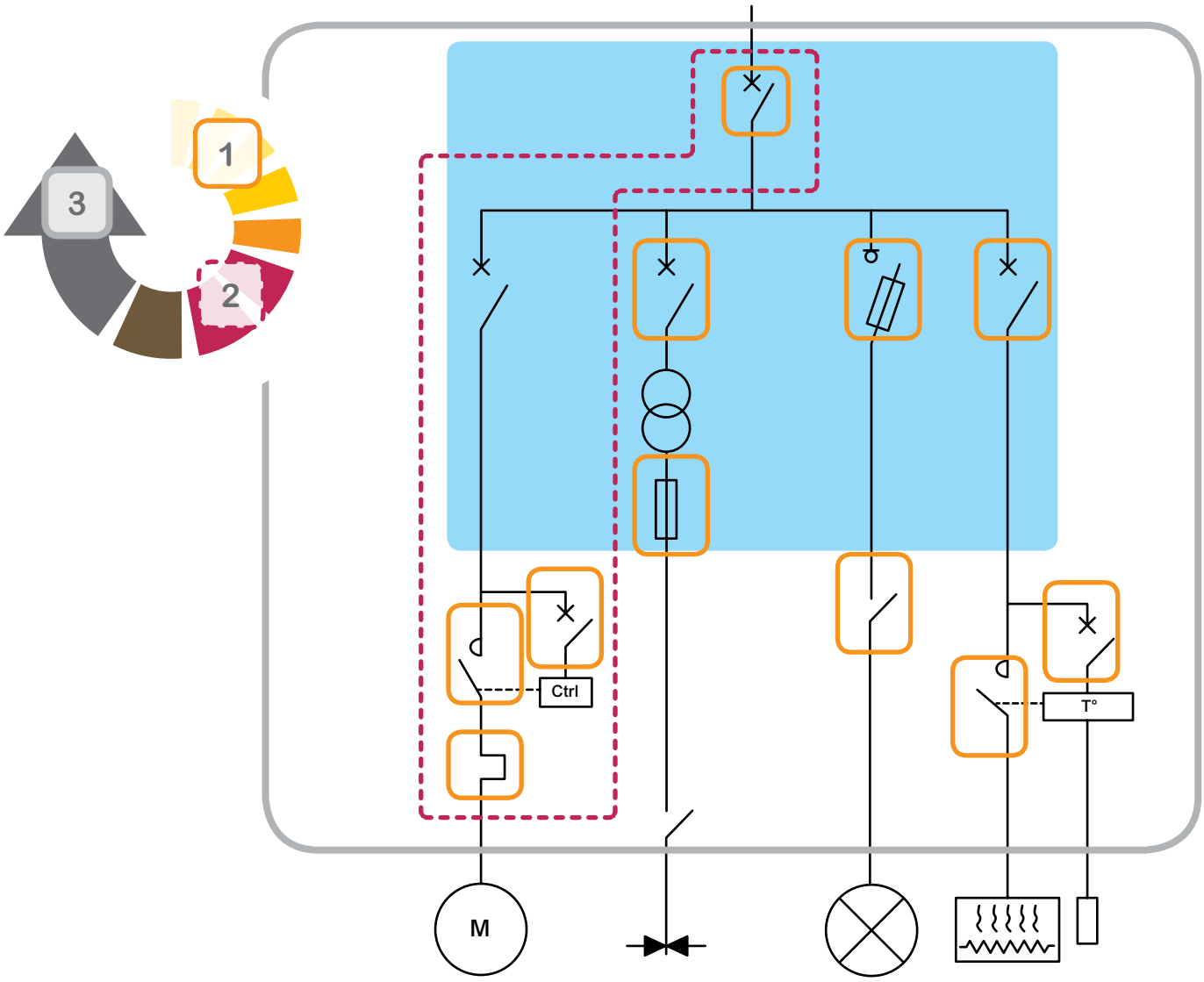
Designing panels with high SCCR values impacts heavily on technological choices (connection systems, type and size of conductors) and on the selection of components. The cost of a control panel is directly proportional to the SCCR imposed by the customer.

It is important in terms of cost effectiveness to check that the requested SCCR is consistent with the expected characteristics of the electrical installation. If in doubt, discuss the matter with the customer.

A control panel with an SCCR of 5 kA is just as safe as a panel with an SCCR of 65 kA if the short-circuit current is correctly calculated.

SCCR calculation method

> Three design phases



1 **SCCR of components**

Identify the SCCR of **each protection and/or control component and each distribution block and element in the distribution system**. Use manufacturer data if available or standard values.

2 **SCCR of circuits**

Determine the SCCR of **each branch circuit**. Use the values of the components of the circuit and apply the rules provided by UL 508A.

3 **SCCR of the control panel**

Determine the SCCR of **the complete control panel**. Use the values of the circuits and apply the rules provided by UL 508A.

> Phase 1. Identify the SCCR of each component

What is the SCCR of this component?

UL LISTED

No

Ok

Yes

SCCR not required for this component

No

Exists

Use the SCCR on the name plate or in the manual

Applicable for a circuit not supplying more than:

Prot. type	I max.	V max.	SCCR (kA)	Group installation*	
C.I. fuse	90	600	100	480Y/277V	600Y/347V
C.B.	110	480	100	50 kA	25 kA
C.B.	-	600	25	50 kA	25kA

** With GV3P motor starter, maximum rating 300 A.*

Does not exist

Yes

UL 508

Yes

Use the SCCR indicated by the manufacturer's test. Use only products tested together.

No

No

Use the standard value shown in table SB4.1 (see annex)

Other component?

No

Phase 2. Determine the SCCR of each branch circuit

> Phase 2. Determine the SCCR of each branch circuit

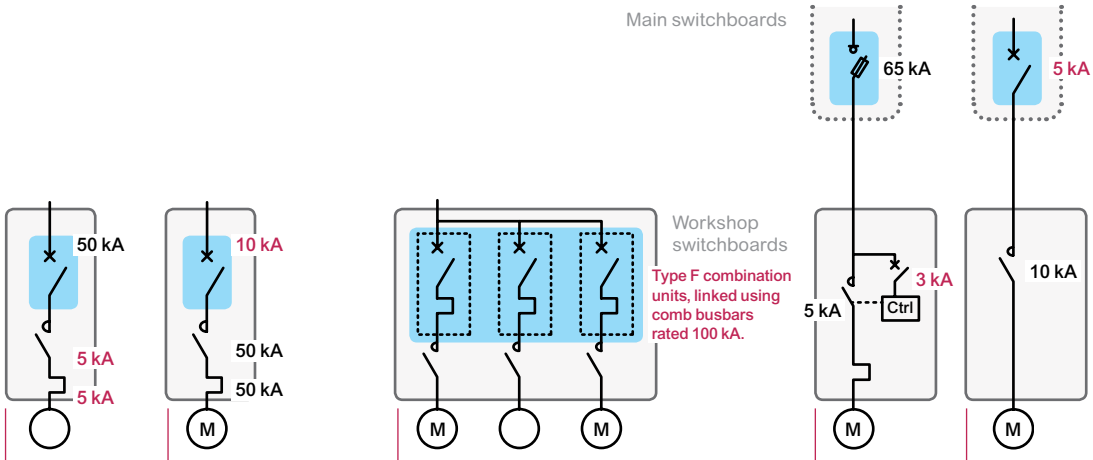
General rule

Use **the lowest SCCR value** of each component in the circuit and the SCCR of the branch circuit protective device.

> Take into account the SCCR values of distribution blocks, comb busbars, etc.

Example

What is the SCCR of these circuits?



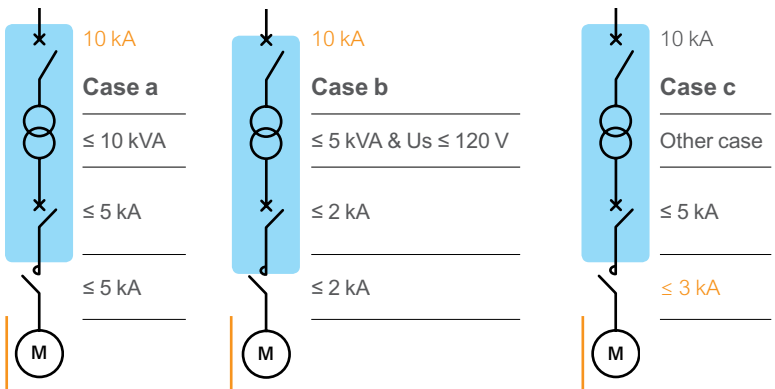
Answers

5 kA	10 kA	100 kA	3 kA	5 kA

Special case of **transformer circuits (UL 508A chap. SB4.3.1)**

Take into account the characteristics of the:

- **> transformer**
- **> downstream protection**
- **> downstream control components,**
- **> if applicable, the upstream protection.**



SCCR =	10 kA	10 kA	3 kA
	SCCR of the upstream protection		Lowest SCCR of the downstream components

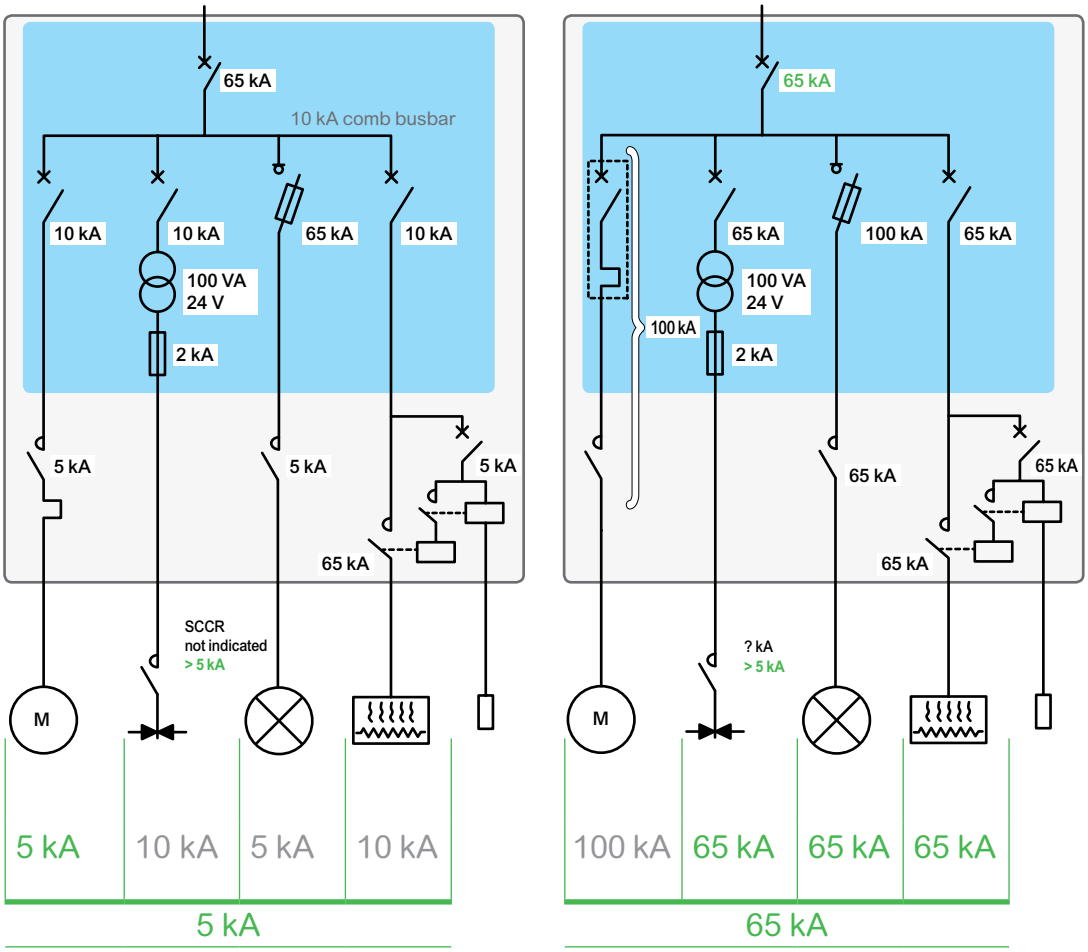
> Phase 3. Determine the SCCR of the control panel

General rule

The SCCR is obtained using the lowest SCCR value in each of the branch circuits.

Example

What is the SCCR of these panels?



Answers

For the panel on the right, compliance with a 65 kA SCCR required selection of different components:

> Combination motor controller certified 100 kA, instead of separate components
> Circuit breakers with higher short-circuit ratings
> Components with higher SCCR.

Annexes

Acceptance procedure for electrical equipment

> One-of-a kind equipment or special specifications

> The manufacturer or component supplier must be UL certified.

and

> Prior to commissioning, the electrical equipment must be checked by an inspector from the AHJ (Authority Having Jurisdiction).

> Mass-produced equipment

> The complete control panel must be UL certified by a national recognised testing laboratory (NRTL).

or

> The equipment must be UL certified on the basis of manufacturer tests, with or without UL supervision. In all cases, the manufacturer must have received UL approval to do so.

and

> Prior to commissioning, the electrical equipment must be checked by an inspector from the AHJ (Authority Having Jurisdiction).

Reference texts

NEC – National Electric Code, also called NFPA70 (edited by the National Fire Protection Association)

Set of legally binding rules applicable in all 50 states of the United States. They may be locally filled out, amended or replaced by other texts. That is the case for the UL Standards for Safety.

NEC contains the rules for electrical conductors in electrical installations and switchboards.

Article 409 deals in particular with control panels.

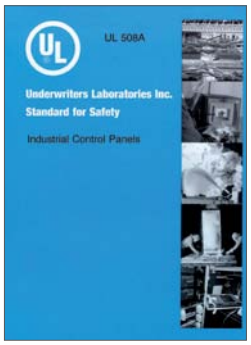
NFPA79 (edited by the National Fire Protection Association)

The provisions of this standard apply to the electrical/electronic equipment, apparatus or systems for industrial machines operating from a nominal voltage of 600 volts or less.

They are intended to minimize the potential hazard of electrical shock and electrical fire hazards.

The term "industrial machinery" refers to:

- metalworking machine tools, including machines that cut or form metal,
- plastics machinery, including injection moulding, extrusion, blow moulding, specialised processing, thermoset moulding and size reduction machines
- woodworking equipment, including laminating and sawmill machines,
- assembly machines,
- material-handling machines, including industrial robots and transfer machines,
- inspection and testing machines, including coordinate measuring and in-process gauging machines.



Standards for safety – UL 508A Underwriters Laboratories Inc. (UL)

Set of safety standards covering industrial control panels intended for general industrial use, operating from a voltage of 600 volts or less.

This equipment is intended for installation in ordinary locations, where the ambient temperature does not exceed 40°C maximum.

Controlled equipment (motors, heaters, lighting) and equipment mounted remotely from the panel are not subject to these rules unless specifically noted on the wiring diagram of the industrial control panel.

UL 508 Transition to UL 60947

The standard for Industrial Control Equipment, UL 508, has been harmonized with the relevant product standards of the IEC standard for low-voltage control and automation, IEC 60947.

This harmonization work was undertaken with the intent of creating standards that, while being based upon and adopting IEC requirements, would incorporate sufficient national differences to ease the transition from UL 508 to UL 60947-4-1.

This goal has largely been accomplished in all cases. While the UL 508 and UL 60947 series standards do not look the same, when taking into account the national differences included in the harmonized standards, they are essentially technically identical.

Products originally listed to UL 508 will maintain their listing with no expiration. UL 508 and UL 60947 products can be used interchangeably. The following industrial control categories are affected by this harmonization effort.

Industrial Control Categories

Standard	Product description	Category control number
UL 60947-4-1	Magnetic Motor Controllers	NLDX
	Manual Motor Controllers	NLRV
	Combination Motor Controllers	NKJH
	Auxiliary Devices (overload relays only, thermal & electronic)	NKCR
UL 60947-5-1	Industrial Control Switches	NRNT
	Auxiliary Devices (relays, pilot devices, limit switches)	NKCR

For more information on this transition,
please refer to UL's website for Industrial Control Equipment Transition to IEC Standards.
http://industries.ul.com/industrial-systems-and-components/industrial-control-products-and-systems/industrial-control-equipment-transition-to-iec-standards

Standard SCCR values as per UL 508A

Table SB4.1

In the absence of SCCR values indicated by the manufacturer on the name plate or in the installation manual, this table specifies the standard values to be used for each type of component.

Component			SCCR in kA
Busbars			10
Circuit breaker (including GFCI type)			5
Current meters			(a)*
Current shunt			10
Fuse holder			10
Industrial control equipment	Auxiliary devices (overload relay)		5
	Switches (other than mercury-tube type)		5
	Mercury-tube switches		
		rated > 60 A or > 250 V	5
		rated ≤ 250 V, ≤ 60 A and > 2 kVA	3.5
		rated ≤ 250 V and ≤ 2 kVA	1
Motor controllers (including combination motor controllers, float and pressure operated motor controllers, power conversion equipment and solid state motor controllers), rated in horsepower (kW)	0-50 (0 – 37.3)		5(c)
	51-200 (38-149)		10(c)
	201-400 (150-298)		18(c)
	401-600 (299-447)		30(c)
	601-900 (448-671)		42(c)
	901-1500 (672-1193)		85(c)
Meter socket base			10
Miniature or miscellaneous fuse			10(b)
Receptacle (GFCI type)			2
Receptacle (other than GFCI type)			10
Supplementary protector			0,2
Switch unit			5
Terminal block or power distribution block			10

* ***a)*** *A short-circuit current rating is not required when connected via a current transformer or current shunt. A directly connected current meter shall have a marked short-circuit current rating.*

b) *The use of a miniature fuse is several motor startersed to 125 V circuits.*

c) *Standard fault-current rating for motor controller rated within specified horsepower range.*

Table of authorised ampacities of insulated conductors

Determining conductor sizes

Control-circuit conductors *(UL 508A chap. 38.2)*

> Minimum size control circuit conductors is per Table 38.2 which goes down to No. 30 AWG (0.05 mm²) with stipulations.

Power conductors *(UL 508A chap. 28.3)*

> The minimum size is 14 AWG (2.1 mm²).
> If there is only one down-line load, the conductor must be sized to 125% of the maximum calculated current.
> If there is more than one down-line load, the conductor must be sized to 125% of the current of the largest load + 100% of the other loads.

Grounding conductor *(UL 508A chap. 15.1)*

> The minimum size is 14 AWG (2.1 mm²).

Table 28.1. Ampacities of insulated conductors

Wire size		60°C (140°F)		75°C (167°F)	
AWG	(mm²)	Copper	Aluminum	Copper	Aluminum
14	(2.1)	15	-	15	-
12	(3.3)	20	15	20	15
10	(5.3)	30	25	30	25
8	(8.4)	40	30	50	40
6	(13.3)	55	40	65	50
4	(21.2)	70	55	85	65
3	(26.7)	85	65	100	75
2	(33.6)	95	75	115	90
1	(42.4)	110	85	130	100
1/0	(53.5)	-	-	150	120
2/0	(67.4)	-	-	175	135
3/0	(85.0)	-	-	200	155
4/0	(107.2)	-	-	230	180
250 kcmil	(127)	-	-	255	205
300	(152)	-	-	285	230
350	(177)	-	-	310	250
400	(203)	-	-	335	270
500	(253)	-	-	380	310
600	(304)	-	-	420	340
700	(355)	-	-	460	375
750	(380)	-	-	475	385
800	(405)	-	-	490	395
900	(456)	-	-	520	425
1000	(506)	-	-	545	445
1250	(633)	-	-	590	485
1500	(760)	-	-	625	520
1750	(887)	-	-	650	545
2000	(1013)	-	-	665	560

Note. For multiple-conductors of the same size (1/0 AWG or larger) at a terminal, the ampacity is equal to the value in this table for that conductor multiplied by the number of conductors that the terminal is able to accommodate.

Useful links

Below are various sources of additional information (in English) on system design in compliance with standards NEC 409 and UL 508A.

Multistandard offer. The control protection solution that meets standards worldwide

http://www.schneider-electric.com/b2b/en/products/product-launch/multistandard/

http://www.schneider-electric.com/en/download/document/LVCATM9OEM_EN

UL 508A support. Welcome to the Schneider Electric NEC 409/UL 508A Support Web Site

http://www.schneider-electric.us/sites/us/en/support/product-support-resources/ul-508a-support/understanding-the-impact-of-nec-article-409-ul-508a.page

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UL approved, tested combination spreadsheets with SCCR data

http://www.schneider-electric.us/sites/us/en/support/product-support-resources/ul-508a-support/ul-approved-tested-combination-spreadsheets-with-sccr-data.page

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Motor-control solution for the North American market

http://www.schneider-electric.us/en/download/document/8536DB0901/

Data Bulletin 8536DB0901. Technical characteristics of our solutions

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Schneider Electric Industries SAS

35, rue Joseph Monier
CS 30323
92506 Rueil Malmaison Cedex (France)

RCS Nanterre 954 503 439
Capital social 896 313 776 €
www.schneider-electric.com

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