Industrial control panels for the North American market

UL guidelines · 11/2010

Industrial Controls

Answers for industry.

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Industrial Control Panels for North America

Regulations, approvals, structure

Country-specific Documentation

Status V2.0

Version 11/2010
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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

with a safety alert symbol, indicates that minor personal injury **can** result if proper precautions are not taken.

CAUTION

without a safety alert symbol, indicates that property damage **can** result if proper precautions are not taken.

NOTICE

indicates that an unintended result or situation **can** occur if the corresponding information is not taken into account.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

According NEC:

One who has skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training to recognize and avoid the hazards involved.

Proper use of Siemens products

Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be adhered to. The information in the relevant documentation must be observed.

Trademarks

Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.
This manual is only intended for use within the EU.

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Preface

Note

"Industrial Control Panels for General Application and Industrial Control Panels for Industrial Machinery for the North American Market" is a guide written by panel builders for panel builders.

The information contained in the manual is intended to assist panel builders. The typical circuit diagrams and interpretations of standards are not binding and do not claim to be complete regarding configuration, equipment or any other eventuality

The typical circuit diagrams and interpretations of standards do not represent specific customer solutions, but are only intended to provide support when it comes to typical applications.

You are responsible for ensuring that the products described are used correctly.

The typical circuit diagrams and interpretations of standards do not relieve you of your responsibility to ensure safe handling when using, installing operating and maintaining the equipment. By using these typical circuit diagrams and interpretations of standards, you agree that Siemens cannot be held liable for possible damage beyond the scope of the liability outlined above. We reserve the right to make changes and revisions to these typical circuit diagrams and interpretations of standards without prior announcement.

When writing these guidelines, a lot of tables and texts were taken straight from the NEC 2008 or UL standards. All users must always check whether the items quoted are still up to date or not.

This information has been taken from various English documents and translated and interpreted back to the best of our knowledge. The original English version takes precedence in all cases. The information provided here will not in most cases be sufficient to attain approval, listing, certification or authorization. Detailed knowledge of the corresponding regulations is needed for that.

The Guidance Manual is based on the ANSI standards from the USA and largely contains regulations from the National Electrical Code, 2008 Edition,
National Fire Protection Association 79, 2002 Edition and Underwriters Laboratories, UL 508A, Revision: December 27, 2007.

Industrial control panels and equipment for machinery that is being exported to the USA shall comply with the appropriate regulations and usually has to be authorized by a "third party". The aim of this document is to assist exporting manufacturers and their suppliers.

Electrical installations are inspected by local authorities, who base their inspections on the National Electrical Code® (see 2.1). NEC® 2008 Art. 110.2 specifies that all devices and wires shall be approved. This means approved by the Authority Having Jurisdiction (AHJ)(Electrical Inspector). He may or may not ask for third-party listing. "Listing" means third-party approved.

There are no UL 508A regulations for many device applications and design guidelines. However, to meet the needs of panel builders, these instructions use regulations from other UL standards, the National Electrical Codes and the NFPA 79, Electrical Standard for Industrial Machinery.

The applications described here are generally recognized practices.

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Working with this documentation

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1.1 Scope of the guidelines

Focus

This information is mainly restricted to the construction of electrical equipment for machinery, i.e. industrial control panels and industrial control panels for industrial machinery (Industrial Control Panels) according to the UL regulations **UL 508A** (see 3.1). Industrial control panels are built by the panel builder so that they can be delivered or fitted on a machine.

Use of the UL regulations

If there is a special UL regulation for a machine or system, this shall be used.

Examples: **UL 508A, Art. 1.3 & 1.6**

- Motor Control Center; **UL 845**
- Air conditioning; **UL 1995** (Heating, Cooling, Air Conditioning)
- Frequency-dependent control units, fuel cells, photovoltaic systems; **UL 1741** (Inverters, Converters and Controllers for use in Independent Power Systems)
- Petrol pumps; **UL 1238**
- Swimming pools; **UL 1563**
- Fire pumps; **UL 218** (Standard for Fire Pump Controllers)
- Software in Programmable Components; **UL 1998**

etc.

1.2 Equipment wiring outside the industrial control panel

Equipment wiring beyond the industrial control panel

UL 508A only deals with wiring within the industrial control panel.

Scope UL 508 A

These requirements cover 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 location, in accordance with the National Electrical Code, ANSI/NFPA 70, where the ambient temperature does not exceed 40°C (104°F) maximum.

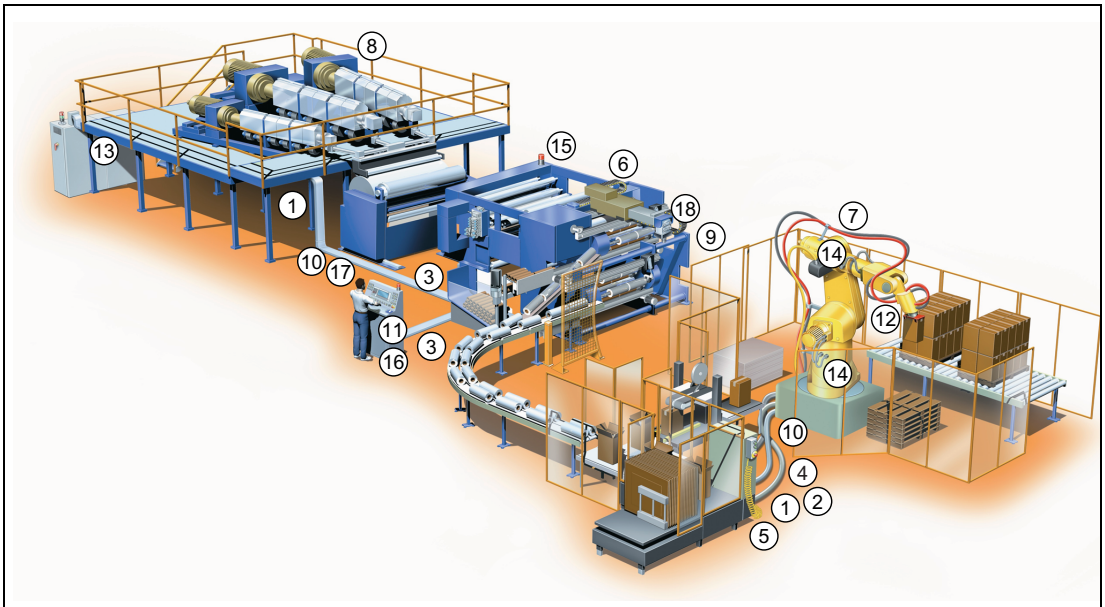
When inspecting external wiring, such as wiring for equipment with several industrial control panels and wiring that runs to loads, this can be listed as a complete system by UL, however, it is generally subject to the "Authorities having Jurisdiction" (AHJ)

The **UL 508A** standard does not cover "external wiring".

External wiring is covered by the regulations in the **National Electrical Code, Edition2008**, **chapter 3** (e.g. Art. 336 Power and Control Tray Cable: Type TC and TC-ER (Tray Cable – Exposed Run) and in the respective standard for this machine or these applications such as NFPA 79 "Electrical Standard for Industrial Machinery", Edition 2002 (e.g. Art. 13, Conductors, Cables, and Flexible Cords and Chapter 14, Wiring Practices).

Various cable types and wiring methods for an envisaged machine

(not covered by **UL 508A**)



Example of wiring for a production plant, based on a template provided by Lapp Kabel Stuttgart

No.	Name	Cable type
①	190 & 190 CY Very Flexible, Oil Resistant, Heavy Duty Control Cables SDP TC Severe Duty Power Cable, Bus Drop Cable	OLFLEX OLFLEX
②	490 P Polyurethane, Very Flexible, UV, Heavy Duty Control Cables 492 P Flexible Control Cable with Polyurethane Jacket	OLFLEX OLFLEX
③	BUS Industrial Grade Cables according to the PROFIBUS Organization for FAST CONNECT and Flexible & Continuous Flex Applications EtherLine Industrial Grade ETHERNET cable for Continuous Flex Applications 300 Multi-Conductor Low Voltage Control & Signal Cable for Industrial Applications	UNITRONIC UNITRONIC UNITRONIC
④	Servo FD Continuous Flex Servo Motor Cable Suitable for most servo motor manufacturers SDP TC Severe Duty Power Cable, Bus Drop Cable	OLFLEX OLFLEX
⑤	Coil Cords for Applications with Continuous Movement	SPIREX
⑥	FD 810, 855 P, 890, 890 P, FD 90 Continuous Flex, Heavy Duty Control Cables for Harsh Environments AUTO-X Heavy Duty Continuous Flex Control Cable	OLFLEX OLFLEX
⑦	ROBOT 900 Robotic Cables for Continuous Twisting Motion EtherLine Industrial Grade ETHERNET cable for Continuous Flex Applications	OLFLEX UNITRONIC
⑧	VFD Slim VFD Signal Super Flexible, Heavy Duty Control Cables for use VFDs SDP TC Severe Duty Power Cable	OLFLEX OLFLEX OLFLEX

No.	Name	Cable type
⑨	Tray II Flexible & Oil Resistant Tray Cable for Exposed Runs Tray II NAC Flexible & Oil Resistant Tray Cable for Exposed Runs AUTO-I Heavy Duty Flex Control Cable SDP TC Severe Duty Power Cable	OLFLEX OLFLEX OLFLEX OLFLEX
⑩	DATA Color Coded Multi-Conductor Flexible Signal & Control Cable	UNITRONIC
⑪	Hook up wire UL (MTW) "Multi Standard" Wiring cable for North America and Europe FD 90 Continuous Flex, Heavy Duty Control Cables for Harsh Environments	OLFLEX
⑫	Rectangular Connectors	EPIC
⑬	Pin & Sleeve IEC 60309 Connectors	EPIC
⑭	STRAIN RELIEF	SKINTOP
⑮	CONDUIT	SILVYN
⑯	Cable Marking System	FLEXIMARK
⑰	Remote Access Ports	
⑱	Populated Track	

Linguistic notes

Technical terms that are common in the USA and Canada are frequently used, such as "motor controller" amongst others. Switching devices which have been installed in an industrial control panel are referred to as "industrial control equipment" rather than "switchgear". The term "switchgear" refers to control panels with power circuit breaker (3WL, etc.), constructed in accordance with ANSI C37.

The term "Enclosures" refers to housings in which industrial control equipment has been installed (made from metal or molded plastic, such as industrial control panels). "Housing" is the enclosure around a device, such as an overcurrent relay.

The ground connection is known as "grounding" (not "earthing").

Motor starter types; inrush current

General motor starter types are:

- Across the line: Across-the-Line (XL) or FVNR (Full-Voltage, Non-Reversing)
- Across-the-line reversing: Across-the-Line reverse (Rev STR) or FVR (Full-Voltage, Reversing)

Inrush current reducing motor starters: Reduced-Voltage Controllers:

- Part-Winding (PW)
- Two (Multi)-Speed
- Reactor or Resistor
- Wye-Delta (Wye/delta)
- Autotransformer

Ambient temperature

Ambient temperature according to **UL 508** and **508A**:

The ambient temperatures specified in these standards are measured 3 to 4 feet (around 1.20 meters) outside the industrial control panel. This is not the temperature in the panel near the industrial control equipment. This is referred to as "surrounding air temperature".

1.3 Navigational options

- Table of contents
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Regulations and guidelines for the manufacture of industrial control panels

2

2.1 National Electrical Code (NEC)

2.1.1 NEC 2008 - Organization

National Electric Code - the basis for all electrical installations

The **NEC** contains minimum requirements!

Individual states (e.g. California Code, New York Code), cities (e.g. Chicago) and counties may specify more far-reaching regulations.

The manufacturers of devices and systems may choose to apply more stringent requirements.

NEC 2008 Art. 90.1 (B)

The **NEC 2008** contains provisions that are considered necessary for safety. Compliance therewith and proper maintenance results in an installation that is essentially free from hazard but not necessarily efficient, convenient, or adequate for good service or future expansion of electrical use.

NEC 2008 Art. 90.4

The **NEC 2008** is intended to be suitable for mandatory application by governmental bodies that exercise legal jurisdiction over electrical installations, including signaling and communications systems, and for use by insurance inspectors. The authority having jurisdiction (AHJ) for enforcement of the Code has the responsibility for making interpretations of the rules, for deciding on the approval of equipment and materials, and for granting the special permission contemplated in a number of the rules.

Exceptions

NEC 2008 Art. 90.1 (C)

The **NEC 2008** is not intended as a set of instructions for designing systems or for training persons lacking the relevant qualifications (untrained persons -> **NEC 2008 Art. 100**).

NEC 2008 Art. 90.2 (A) & (B)

The **NEC 2008** is applicable to public and private buildings, as well as prefabricated and mobile homes.
It is NOT applicable to ships, water craft (apart from "floating buildings"), railways, airplanes, underground mining, equipment controlled solely by energy producers (power stations and energy distribution, with the exception of office buildings, parking lots/garages, etc.).

Important

NEC 2008 Art. 90.7

According to the **NEC 2008**, listed devices and equipment (factory-installed wiring or the construction of equipment) do **not** have to be **inspected again** during system commissioning, as long as the systems and panels are inspected and approved by an authorized body.

2.1.2 Extracts from the NEC 2008

Marketing electrical industrial control equipment such as magnetic controllers and circuit breakers in the USA is virtually impossible unless you have UL approval
NEC 2008 Art. 110.2, NEC 2008 Art. 110.3 (B) (or approval from another NRTL).

A huge amount of Siemens' low-voltage industrial control equipment is UL-approved and can be used without modification in IEC/EN and UL applications.

Mandatory Rules, Permissive Rules and Explanatory Material

Mandatory Rules NEC 2008 90.5 (A)
Mandatory rules of this Code are those that identify actions that are specifically required or prohibited and are characterized by the use of the terms shall or shall not.
Permissive Rules NEC 2008 90.5 (B)
Permissive rules of this Code are those that identify actions that are allowed but not required, are normally used to describe options or alternative methods, and are characterized by the use of the terms shall be permitted or shall not be required.
Explanatory Material NEC 2008 90.5 (C)
Explanatory material, such as references to other standards, references to related sections of this Code, or information related to a Code rule, is included in this Code in the form of fine print notes (FPN). Fine print notes are informational only and are not enforceable as requirements of this Code. FPN: The format and language used in this Code follow guidelines established by NFPA and published in the NEC Style Manual. Copies of this manual may be obtained from NFPA.

Requirements for Electrical Installations - NEC - Definitions (excerpt only)

Approval (Article 110.2)
The conductors and equipment required or permitted by this Code shall be acceptable only if approved. FPN: See Examination of Equipment for Safety, Section 90-7, and Examination, Identification, Installation, and Use of Equipment, Section 110-3.
Identified (as applied to equipment) (Article 100)
Recognizable as suitable for the specific purpose, function, use, environment, application, etc., where described in a particular Code requirement. FPN: Suitability of equipment for a specific purpose, environment, or application may be determined by a qualified testing laboratory, inspection agency, or other organization concerned with product evaluation. Such identification may include labeling or listing (see definitions of Labeled and Listed).
Labeled (Article 100)
Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.
Listed (Article 100)
Equipment, materials, or services included in a list, published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or services meets identified standards or has been tested and found suitable for a specified purpose. FPN: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. Use of the system employed by the listing organization allows the authority having jurisdiction to identify a listed product.

Authority Having Jurisdiction (AHJ)

The AHJ has the responsibility of controlling compliance with **NEC 2008** specifications, and ensuring that only those systems which meet **NEC 2008** specifications are put into operation. Generally speaking, the AHJ reports to the relevant state or city authorities. The AHJ is often an organization such as a building or safety authority. Furthermore, more than one person or group can share responsibility for this area, particularly where larger or more complex systems are involved. For example, the head of the fire department might assume responsibility for fire hazard issues, while other parties may oversee issues relating to electrics or health and safety.
The end user of the installed equipment (e.g. Industrial Control Panel) needs to request a site inspection by the AHJ.

2.1.3 Inspection

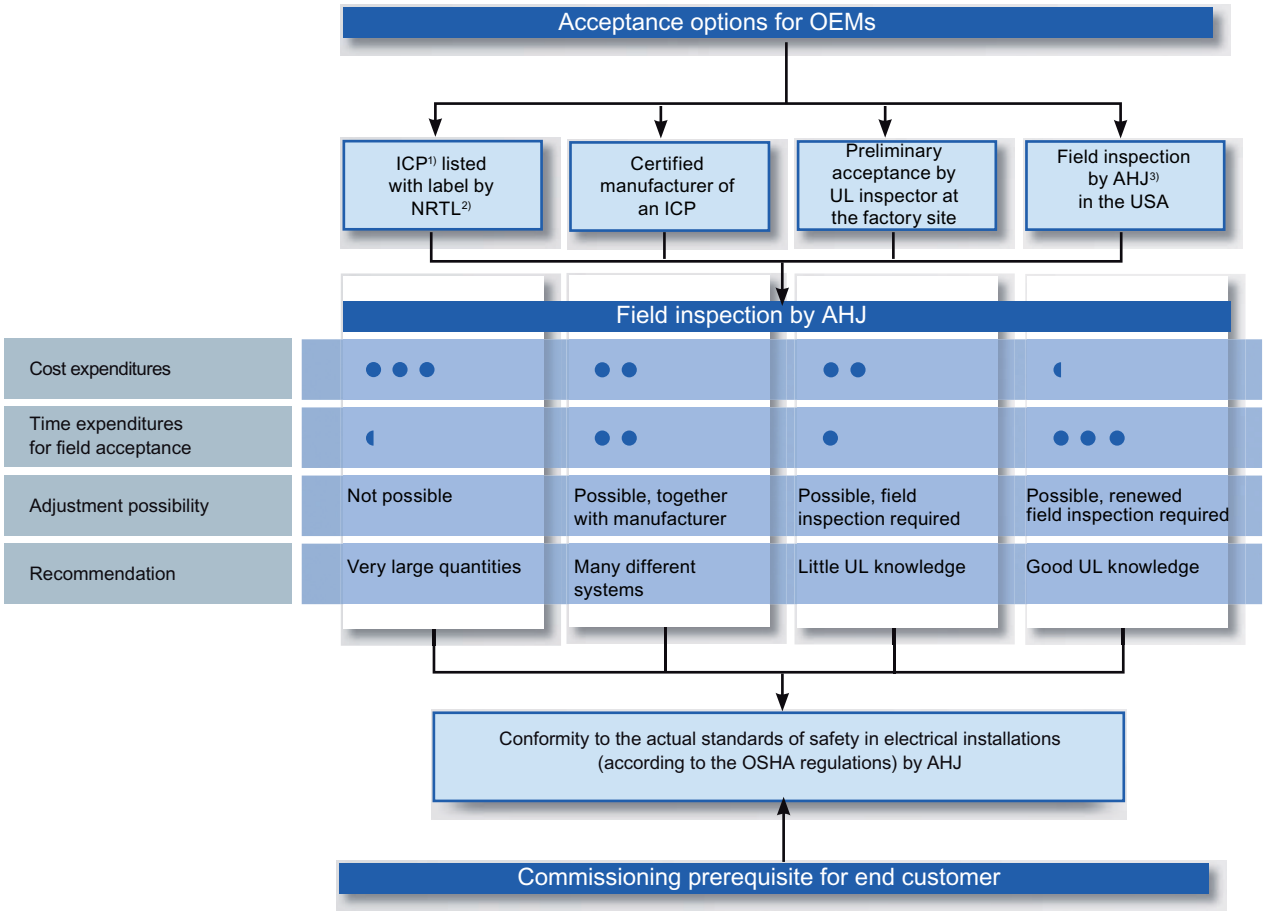
Every electrical machine or system in the USA is checked by an inspector known as the AHJ (Authority Having Jurisdiction) before it can be commissioned. Acceptance is based on the **NEC** (National Electrical Code, also known as **NFPA 70**), the relevant application-specific guidelines such as **NFPA 79**, as well as any local standards or specifications. In the USA, acceptance is a legal requirement. Any operators failing to have their machines or systems checked by an AHJ are putting both their insurance cover and energy supply at risk.

Proper configuration in accordance with the relevant regulations is crucial to the success of the on-site acceptance process. The graphic shown below outlines four possible ways of arranging acceptance.

Manufacturing an industrial control panel that meets UL requirements is more than a question of simply using UL-approved products. Other crucial factors are the ability of the devices to interact in accordance with the relevant application standards, and the process of accepting the industrial control panel within its actual application environment.

Options for inspecting industrial control panels in a commissioning context

In most cases, the customer in the USA will specify the type of acceptance. If the type of acceptance is not mentioned in the specification, you should negotiate with the customer as considerable costs may result from many forms of acceptance.



[1] Industrial Control Panel
[2] Nationally Recognized Testing Laboratories
[3] Authority having jurisdiction

1. **Panel listed with label by NRTL**
   Approval of panels by an approved test organization -
   Third-Party Certification
   (see also 2.1 – **NEC 2008 Art. 90.7**). In this case, the system does not need to be inspected again by the local inspectors. Only the connections and installation conditions in the Certification Report need to be observed. This system would be advantageous when exporting individual industrial control panels, especially where volume production is involved. This does not mean that acceptance by the AHJ is **not** required in the USA, but there is some scope for simplifying this process.
2. **Listed panel builder**
   UL-approved workshop for the manufacture of industrial control panels (Panel Builder Program **UL 508A**):
   Industrial control panel builders who construct a large number of different systems for different applications according to **UL 508A** can gain certification from UL and construct UL-listed industrial control panels under their own responsibility and also label it with a UL Panel Listing Label. They need to comply with various conditions in order to do this. The workshop is then visited several times a year by a UL inspector and checked according to **UL 508A**. Some of these visits will be announced but others will not. The panel builder then pays an annual fee plus the charges for the UL inspector's visits. The registered UL Panel Listing Label shall be bought from UL or a UL-appointed printer.
   The panel builder shall then construct systems in total compliance with the **UL 508A** specification.
   If necessary, certification can be extended to areas such as **UL 508C** (converters).
   See also 2.3.3 Label Service (Type L). This does not mean that acceptance by the AHJ is **not** required in the USA, but there is some scope for simplifying this process.
3. **Preliminary acceptance by UL inspectors at the OEM's own production facilities**
   All plant manufacturers or panel builders are able to appoint a suitable inspector, who has been approved for the particular application involved, from one of the AHJ-approved NRTLs so that their system (or part of it) can undergo a preliminary examination at their own production facilities. This allows any necessary modifications/adjustments to be made prior to delivery. Under certain circumstances, the inspector can also approve deviations from the standard and certify these in what is known as a "Deviation Note". This does not mean that acceptance by the AHJ is **not** required in the USA, but there is some scope for simplifying this process.
4. **On-site field inspection by the AHJ in the USA**
   In this case, the industrial control panel shall be inspected and accepted by a local inspector at each place of installation. In other words, the manufacturer relies on the opinion of each inspector. Complaints then have to be remedied on site. This often results in extra costs and delays during commissioning; but does save the cost of a general Third-Party Certification for the system. This could be of benefit when installing individual systems.
   Note: The decisions of individual AHJ can be disputed if a written appeal is submitted to the Electrical Board responsible within 15 days of the negative decision being made.
   NEC 2008 Annex G, 80.15 (G)

Important note
In contrast to IEC/EN, the words used in the regulations play an important role. In general, there are less possibilities for interpreting the regulations. The local inspectors (AHJ) are not authorized to negotiate with the manufacturer on deviations from the standard. Only by special permission the AHJ may waive specific requirements in this Code or may permit alternative methods when effective safety is achieved.

2.1.4 NFPA 79 Annex A "Explanatory Material" Article A.3.2.2

Authority and responsibility

NFPA 79 does not itself cover any system acceptance tests. This function is mainly handled by the local inspectors.
A wide range of local inspectors who are not always familiar with electrical systems (such as local and national inspectors, fire chief or marshal, labor department or health department, building official) may carry out commissioning in line with AHJ requirements.
NEC 2008 Art. 100

However, if UL certification is required, **UL 508A Art 65, 66, 67** stipulates the necessary regulations and also covers the inspection process.
The industrial control panel shall then also feature the label "Industrial Control Panel for Industrial Machinery".

Extract from NFPA 79 (2002 edition)

A.3.2.2 Authority Having Jurisdiction (AHJ)
The phrase "authority having jurisdiction", or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as affair chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental may be the authority having jurisdiction.

2.2 US regulations and electric power systems

2.2.1 Important US standard and approval organizations for the manufacturer of industrial control panels

US standard and approval organizations

Abbreviation	Explanations
ANSI	**American National Standards Institute.** This is the most senior authority for regulations in the US. Most regulations feature the ANSI standard. Examples are the **NEC**, or **UL 508**.
CANENA	**Council for Harmonization of Electrotechnical Standardization of North America.** This is the standards association for NAFTA. However it is currently of minor importance.
CSA	**Canadian Standards Association.** This organization publishes standards and approves products in accordance with its own and other standards (IEC, EN, UL, etc.).
EEMAC	**Electrical und Electronic Manufacturer Association of Canada.** This is the equivalent to NEMA in Canada.
ETL	**Electrical Testing Laboratory.** This is a test body that approves devices in accordance with other regulations (UL, IEC, CSA, etc.).
FM	**Factory Mutual Research.** The work of this organization mainly involves testing components for non-electrical systems, such as boilers, water heaters, oil stoves. SITOP and "LOGO!" power supplies are for example approved by FM.
IEEE	**Institute of Electrical and Electronics Engineers, Inc.** This body publishes electrical and electronic regulations.
JIC	**Joint Industrial Council.** Industrial control equipment for the automotive industry has been standardized by this body. This body is no longer active but is often specified. **NFPA 79** is the replacement regulation.
NEMA	**National Electrical Manufacturer Association.** This is an organization of manufacturers which publishes market data for its members and standardizes product features such as the size of magnetic controllers and motor frames. Siemens Energy and Automation, Inc. is a member of NEMA. (NEMA size: (00.0) 1 to 9 are standardized sizes)
NFPA	**National Fire Protection Association.** This body publishes numerous regulations and guidelines such as the **NEC and NFPA 79**.
NRTL	**National Recognized Testing Laboratory.** This is an approved (non-state) test body. Examples include UL, ETL, CSA and TUV Rheinland of North America. It is approved by the OSHA (Occupational Safety and Health Administration), a US state body.
OSHA	**Occupational Safety and Health Administration.** This body publishes guidelines for safety in plants and workplaces.
UL	**Underwriters Laboratories, Inc.** This organization publishes standards and approves products in accordance with its own and other standards, including IEC, EN, CSA.

2.2.2 Important regulations for low-voltage switching devices and control panels

US standard			Approximate IEC standard *
UL 489	Molded-Case Circuit-Breakers, Molded-Case Switches and Circuit-Breaker Enclosures	Standard for power distribution equipment, e.g. molded-case circuit breakers / MCCBs, miniature circuit breakers / MCBs, molded-case switches and instantaneous trip circuit breakers	**IEC 60947-2**
UL 508	Industrial Control Equipment	Standard for industrial control equipment, e.g. contactors, overload relays, PLCs, etc.	**IEC 60947-2, IEC 60947-4-1**
UL 508C	Power Conversion Equipment	Standard for power conversion equipment, e. g. converters	**IEC 61800-5-1**
UL 98	Enclosed and Dead Front Switches	Standard for enclosed and dead-front switches, e. g. disconnectors, main switches	**IEC 60947-3**
UL 1077	Supplementary Protectors for Use in Electrical Equipment	Standard for miniature circuit breakers (MCBs) not covered by **UL 489**; application as "Supplementary Protectors".	**IEC 60947-2, IEC 60934**
UL 248	Low-Voltage Fuses	Standard for fuses with fuse holder **UL 512**	
UL XXX	Further Codes for devices used		

Application standards			
NFPA 79	Electrical Standard for Machinery	The "Electrical Standard for Industrial Machinery" is mainly applied in the automotive and machine tool industry.	**IEC 60204-1**
UL 508A	Industrial Control Panels	Standard for industrial control panels	**IEC 60204-1**
UL 1741	Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources	Standard for installation of converters and their protection and control devices; it is particularly applicable to the testing of systems which serve the energy supply to the public network (grid connection) , e. g. wind power, photovoltaics, etc.	**IEC 60364-7-712**

General installation standards			
NEC (NFPA 70)	National Electrical Code (**NEC 2005**)	Installation standard for the USA; all electrical installations shall comply with this code; the **NEC** is generally applied by local inspectors (Authority Having Jurisdiction, AHJ) and revised every 3 years.	**IEC 60364-1**

* The **IEC standards** stated here serve as orientation. A one-to-one comparison of IEC and **UL standards** is not possible.

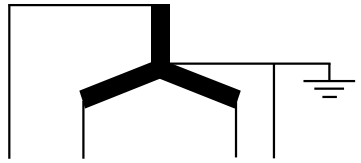
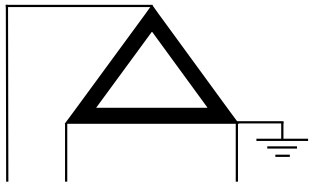
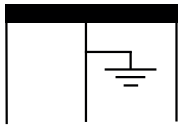
2.2.3 Low-voltage network systems in the US

Network systems in the US

There are various network systems in the US, but 3-phase networks operating at 240 and 480 V and with 3 and 4-wire systems are the most important ones. 208 V and 600 V grids are of less importance. The 208 V grid is mainly found in older US cities; 600 V is still used in Canada.

Single-phase 120 V - 240 V systems are mainly used in residential systems.

Principal types of networks

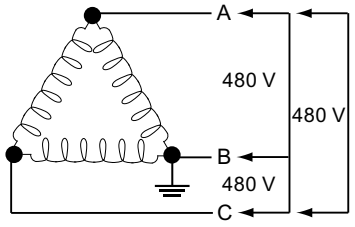
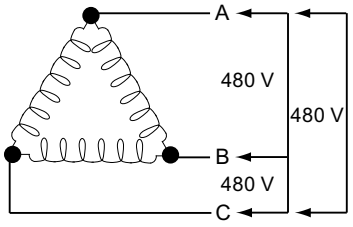
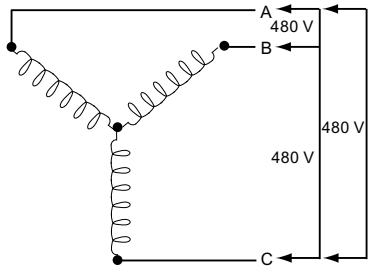
Industrial and commercial buildings (Industry and Commercial)		**Residential buildings (Residential)**
		
3 phase, 4 wire	3 phase, 3 wire	1 phase, 3 wire
solidly grounded wye **Caution:** The PE must not carry any current. There is no PEN conductor => N = grounded conductor (white or gray); separate conductors must be used for PE and N.	corner grounded Delta	Single Phase, 120 / 240 V, grounded midpoint. **Example:** 120 V are used on the wall receptacle and 240 V for household cookers, air-conditioning units and laundry dryers.
208Y / 120 V	**240 V**	240 V to phase conductor
240Y / 131 V	**480 V**	120 V to ground
480Y / 277 V	**600 V**	
600Y / 347 V		

Y describes the "solidly grounded circuit". For example, the voltage between the phases is 480 V but that between the phase and grounding is just 277 V.

Electric circuits with "straight" voltages and "slash" voltages

NEC 2008 Art. 240.85 - Use of circuit breakers

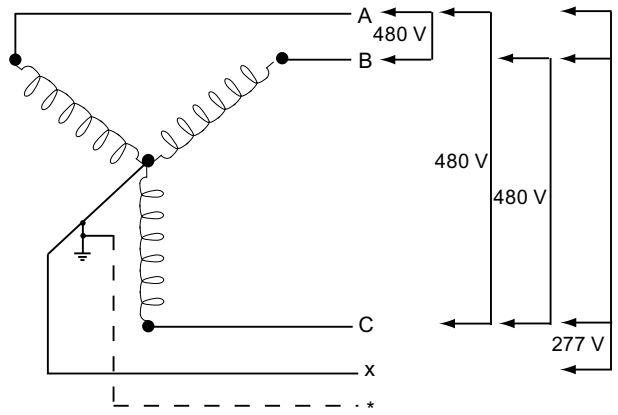
In the US, voltage levels are considered from the power supply company side or the secondary side of the power supply company transformers. The connection (wye or delta) of the electric circuit and the method of grounding play a major role here.
In ungrounded or high-resistance-grounded wye or delta electric circuits, and in corner-grounded delta electric circuits, only devices (e.g. circuit breakers) which are labeled with "straight" voltage, such as 240 V, 480 V or 600 V, may be used. These devices are able to switch the full voltage between the phases and one phase to ground.

Corner-grounded delta 480 V 3-phase, 3-wire	Ungrounded delta 480 V 3-phase, 3-wire	Ungrounded wye 480 V 3-phase, 3-wire
		

Selection of equipment: All Siemens SENTRON circuit breakers of the 3VL range. These circuit breakers can of course also be used for "slash" voltages.

In electric circuits with a grounded wye, the circuit breaker only switches the full voltage between the phases (e.g. 240 V, 480 V, 600 V). The phase to ground voltage is just 131 V, 277 V or 347 V here; the "slash" voltage is therefore 120/240 V, 480Y/277 V or 600Y/347 V. Industrial control panels in which these devices are installed, shall be marked with the following label:
"For use on a solidly grounded wye source only". **UL 508A Art 54.12**

Grounded wye, 480 Y/277 V or 208 Y/120 V, 3-phase, 4-wire, could be installed as 3-wire without a neutral wire.



Selection of equipment: Circuit breakers from ranges 3RV, 3RA11 and 3RA12, according to **UL 508**, Type E and Type F (3RV self-protected motor circuit breakers), circuit breakers, type 3RV1742 and miniature circuit breakers, type 5SJ4…HG…. In many cases, these devices shall not be used in electric circuits with "**straight**" voltages.

Note: This rule always applies even if neutral or grounding wires are not routed to the industrial control panel. The voltages between the phases and ground remain in place despite this (via the common ground).

Voltage and frequency details

The network systems in the USA are governed by ANSI C 84.1.

A 60 Hz frequency is standard in North America. The voltages may be specified as a "distribution voltage": 120, 208, 240, 480, or 600 V, as specified on circuit breakers for example (see **NEC 2008 Art. 100**, Voltages and **NEMA ICS 1, Art. 4.2**). The "utilization voltage" is always given on the nameplate of motors. This is 115, 200, 230, 460 or 575 V (see **NEC 2008 430.250**).

The reason for these details is that the motor's rated data refers to the "**utilization voltage**", which is the probable motor terminal voltage.

Be it 460 or 480 V, this is the same network. Industrial control equipment is always tested with the maximum voltage and maximum current (e.g. by UL). This means that each standard 460 V AC motor can be run from a 480 V supply.

(**utilization voltage =** distribution voltage- 4% (voltage drop))

2.2.4 Network tolerances according to ANSI and NFPA

The basic ANSI standard is C 84.1

Network tolerances

For AC: (for DC see **NFPA 79 Art. 4**)

- Voltage: 90% – 110% of rated voltage
- Frequency: 60 Hz nominal; 99% - 101% continuous; 98% - 110% intermittent
- Relative humidity: 20% - 95% not condensing
- Altitude: 1000 m (3300 ft)
- Voltage interruption: 3 ms in intervals greater than 1 s
- Voltage dip: 20% for one full wave
- Harmonics: Max. 10% of rated voltage up to the fifth harmonic
- Harmonics: Max. 2% of rated voltage between the sixth and 30th harmonic

Network specifications

Voltages	Specification
240 / 120 V	Single-phase network 240 V between the external conductors, with grounded center point, 120 V to ground
480Y / 277 V 600Y / 347 V	3-phase, 4-wire, wye distribution Phase voltage to ground (PE); sometimes the grounded wire is also managed (N), i.e. 5-wire.
208Y / 120 V 240Y / 131 V	3-phase, 4-wire, wye distribution These voltages only occur very rarely.
240, 480, 600 V	3-phase, full/high voltage to ground!

Grounding and incoming feeder

The following grounding methods are used in the US for the incoming feeder:

- Ungrounded incoming feeder: No arc in the event of a ground fault
- Solidly grounded incoming feeder:
  Suitable for 277 V industrial lighting circuits
- Resistive grounded incoming feeder
  - Low impedance
  - High impedance **NEC 2008 Art. 250**

Note: Given the increasing stringency of safety regulations relating to personal protection from dangerous arcs, grounding using resistance is becoming increasingly important. The relevant standard in the US is **NFPA 70E**. Furthermore, as of 2005, all industrial control panels have to have a warning plate, warning qualified persons of potential electrical arc flash hazards.
NEC 2008 Art. 110.16

These methods do not generally impact on the manufacture of industrial control panels.

The systems have a ground terminal located near the incoming feeder. **UL 508A , Art. 14, 15, 16,** and **17**

The ground terminal for the "Service Entrance" (the connection right behind the power supply company incoming feeder) shall be marked as "SERVICE GROUND".

The ground terminal on industrial control panels shall be marked as "EQUIPMENT GROUND".

For the smallest permissible equipment grounding conductor terminal cross sections, see **UL 508A, Table 15.1, or NEC 2008 Table 250.122**.

Industrial control panels featuring devices with "Slash Voltage Rating", 120/240 V 480Y/277 V or 600Y/347 V, shall be marked with a label stating "For use on a solidly grounded wye source only" (see also 2.2.3) **UL 508A Art. 49.6** and **54.12**.

2.3 Underwriters Laboratories (UL)

2.3.1 Basic information about UL

UL information

UL provide a number of approvals.
Listing and **Recognized** are the most common of these.

Websites	
http://www.ul.com/	The general site for UL
http://www.ul.com/database	Site that allows you to search for UL-listed devices
http://www.ul-europe.com	UL Europe
http://www.comm-2000.com/	Online access to UL standards

Classification

List of all UL-approved products: http://www.ul.com/database/
There are a number of search options: Company Name, UL File Number, etc.
Several "CCN" numbers are listed here to enable a search based on a special classification.

Note: Devices which may be fitted in industrial control panels are listed in **UL 508A**, Table SA1.1 (see also below – industrial control panels for general applications).

A huge amount of Siemens' low-voltage industrial control equipment is UL-approved and can be used without modification in IEC/EN and UL applications.

UL classifications contain 4 letters; they may also contain a digit in some cases. The 4 letters are used fairly randomly.
By contrast, the additional digit is always used in a consistent way.

Significance of the additional digit (in fifth position)

No digit 4 letters only		Listed product for the USA. Inspection/acceptance is performed by an approved NRTL according to the relevant standards.
4 letters plus the number 7		Listed product for Canada. Inspection/acceptance is performed by an approved NRTL according to the relevant UL standards for Canada (these are different from the USA).
4 letters plus the number 2		Recognized product for the USA. Inspection/acceptance is performed by an approved NRTL according to the relevant standards.
4 letters plus the number 8		Recognized product for Canada. Inspection/acceptance is performed by an approved NRTL according to the relevant UL standards for Canada (these are different from the USA).

Classification extract	UL-listed	UL-recognized
UL Industrial Control Panels (Panel Builder Program **UL 508A**)	NITW	
UL Industrial Control Components (**UL 508**)	e.g. NLDX	e.g. NLDX2
Circuit breakers (**UL 489**)	DIVQ	
Miniature circuit breakers (**UL 489**)	DIVQ	
Motor starters (Combination Starters **UL 508A**)	NKJH	----
Disconnect switches (Switch units)	----	WHTY2
Disconnect switches (Miscellaneous switches)	WPZX	----
Terminal blocks	----	XCFR2
Magnetic motor controllers	NLDX	NLDX2
Miniature circuit breakers (Supplementary Protectors **UL 1077**)	----	QVNU2
Overcurrent relays, contactor relays, etc. (Auxiliary Devices)	NKCR	NKCR2

Classification extract	c-UL-listed	c-UL-recognized
UL Industrial Control Panels (Panel Builder Program **UL 508A**)	NITW 7	
UL Industrial Control Components (**UL 508**)	e.g. NLDX7	e.g. NLDX8
Circuit breakers (**UL 489**)	DIVQ 7	
Miniature circuit breakers (**UL 489**)	DIVQ 7	
Motor starters (Combination Starters **UL 508A**)	NKJH 7	----
Disconnect switches (Switch units)	----	WHTY 8
Disconnect switches (Miscellaneous switches)	WPZX 7	----
Terminal blocks	----	XCFR 8
Magnetic motor controllers	NLDX 7	NLDX 8
Miniature circuit breakers (Supplementary Protectors **UL 1077**)	----	QVNU 8
Overcurrent relays, contactor relays, etc. (Auxiliary Devices)	NKCR 7	NKCR 8

2.3.2 UL marks

All the marks and related descriptions can be found online: www.ul.com/mark/art.htm
You will find general information about UL at: www.ul.com

The most important UL marks

Mark	Applications
For the marking of UL-certified products, a general differentiation is made between listed devices and recognized components. Further variants exist for the Canadian market.	
	**UL Listing Mark:** This is one of the most common UL Marks. If a product carries this Mark, it means UL found that representative samples of this product met UL‘s safety requirements. These requirements are primarily based on UL‘s own published Standards for Safety. This type of Mark is seen commonly on appliances and computer equipment, furnaces and heaters, fuses, electrical panelboards, smoke and carbon monoxide detectors, fire extinguishers and sprinkler systems, personal flotation devices like life jackets and life preservers, bullet resistant glass, and thousands of other products.
	**C-UL Listing Mark:** This mark is applied to products for the Canadian market. The products with this type of mark have been evaluated to Canadian safety requirements, which may be somewhat different from U.S. safety requirements. You will see this type of Mark on appliances and computer equipment, vending machines, household burglar alarm systems, lighting fixtures, and many other types of products.
	**C-UL US Listing Mark:** UL introduced this new Listing Mark in early 1998. It indicates compliance with both Canadian and U.S. requirements. The Canada/U.S. UL Mark is optional. UL encourages those manufacturers with products certified for both countries to use this new, combined Mark, but they may continue using separate UL Marks for the United States and Canada.
	**Recognized Component Mark:** These mark consumers rarely see because it is specifically used on component parts that are part of a larger product or system. These components may have restrictions on their performance or may be incomplete in construction. The Component Recognition marking is found on a wide range of products, including some switches, power supplies, printed wiring boards, some kinds of industrial control equipment and thousands of other products. They shall only be installed by experts of the manufacturer according to the so-called “Conditions of Acceptability (CoA)” apply to these devices. Amongst others, our portfolio contains the following products with UR mark: miniature circuit breakers according to UL 1077, time switches according to UL 917 and SITOR fuses.
	**Canadian Recognized Component Mark**: Similar as the Recognized Component mark (see above). Products intended for Canada carry the Recognized Component mark "C".
	**Recognized Component Mark for Canada and the United States**: This new UL Recognized Component Mark, which became effective April 1, 1998, may be used on components certified by UL to both Canadian and U.S. requirements. Although UL had not originally planned to introduce a combined Recognized Component Mark, the popularity of the Canada/U.S. Listing and Classification Marks among clients with UL certifications for both Canada and the United States has led to the new Mark.
Certifications such as  and  are issued by the so-called NRTLs (Nationally Recognized Testing Laboratories) after successful testing. The OSHA has accredited Underwriters Laboratories as NRTL.	

Application example

An "Industrial Control Panel" with this form of label will have been manufactured according to UL regulations by an approved, UL-listed panel builder. Example of a label for a panel (including devices and wiring).

Note

Use of UL-approved devices:

Devices which are UL-approved (listed or recognized) cannot be automatically installed in "Industrial control Panels" unless their intended use (approval) is known. A 3LD25 LISTED MAN MTR CNTR type switch (according to **UL 508**) cannot for example be used as a main disconnecting means. A switch with the label RECOGNIZED OPEN SWITCH on the other hand would comply with this requirement (e.g. type MCR606). Particular attention should be paid to the "Type Listings"; a listed non-metallic conduit is not also automatically listed as "liquid-tight" – even if it is classified as IP65 according to IEC.

Note

It is always important to know the product class (CCN) or to have the relevant UL file (report).

Note

UL-approved devices shall always be approved by one of the bodies known as NRTLs.
These NRTLs are approved by the OSHA (= occupational Safety and Health Administration).
Here, approval only applies to specific products/applications. It is essential that you bear in mind the nature and scope of the relevant NRTL's approval.
NRTLs operated by UL only carry out approvals in the area for which they do have the approval.

2.3.3 UL-listed

General rule

Devices which are considered to be "complete assemblies" feature this mark. They are labeled with the company name, all specified and approved data and the UL mark. Such devices can be installed by a technician without any special tools and without further instructions, e.g. a magnetic controller, circuit breaker, etc.

UL-listed variations

There are a number of variations:

- **Reexamination Service (Type R):** One or more devices are tested by UL, inspected and described in detail in a report. UL inspectors visit the production facilities periodically and check that the product is being produced in accordance with the description. (Examples: magnetic controller, coffee maker)
- **Label Service (Type L):** A special UL label, that is placed on a product once it has passed a specified check. Examples include:
  - All circuit breakers (**UL 489**) shall pass a specified test during production (such as Type R + Reassessment Tests).
  - Industrial control equipment (**UL 508A**) is accepted by a UL inspector.

    These labels are bought directly from UL, or via one of the UL-registered printers. They are administered by the manufacturer, but checked by the UL inspector in accordance with production.

2.3.4 UL-recognized

General rule

This mark is used for components. In other words devices which are assembled in a factory together with other parts and components and which gain UL approval in the form of an end product.

UL- Recognized handling

UL- Recognized components only need to feature a type and manufacturer's identification mark. Their design and application are not therefore complete.
The user shall pay attention to additional information and operating conditions which are specified in detail in the UL report (known as Conditions of Acceptability, CoA).

The UR mark does not have to be used (optional). The type number shall be included in the Recognized Component Index or "yellow book".

Note: Keep the Operating Instructions. They are part of the device.

2.3.5 Practical use of listed and recognized

Use of the marks

In some categories, you have the choice of approving a device as "Listed"or "Recognized".

Application examples

A magnetic controller for a special application without any rated data, but which features manufacturer identification and order number, can be UR approved.
Some devices can only be approved as components, i.e. with "UR", e.g.:

- Circuit breakers which only have an instantaneous trip unit, see **NEC 2008, 430.52 (C) (3)**.
- Terminal blocks according to **UL 1059**: This UL regulation does not specify distances over surface or through air. The installation determines the spacing; for industrial control panels the spacing is 3/8 of an inch (9.6 mm) through air and 1/2 an inch (12.7 mm) for over surface.
- IEC miniature circuit breakers according to **UL 1077**:
  These devices can only be used as a "supplementary protector"
  (see **NEC 2008, 430.72 (A)**).

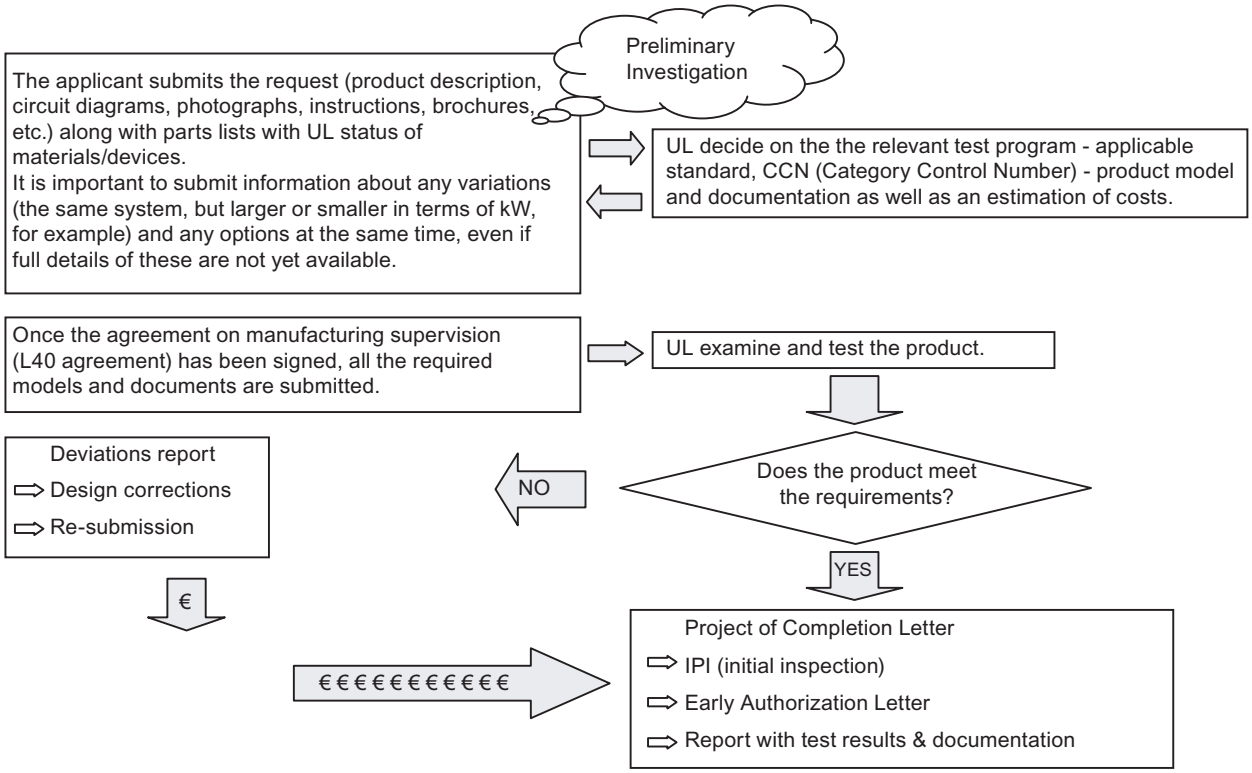
Use of UL-listed and UL-recognized

Example: A washing machine has a motor, thermostat, On and Off switch, electronic controller, cables, etc. These could all be Recognized Components, which when combined in an enclosure to create a complete assembly form a UL-listed device.

2.3.6 The UL certification process

Product presentation

Thorough preparations in the presentation phase save time and money in the inspection and test phase.



The word product covers

- Devices (e.g. a circuit breaker)
- Parts of a device (e.g. an auxiliary contact for a circuit breaker)
- Combinations of several devices (e.g. a machine control system)

2.4 National Fire Protection Association (NFPA)

Purpose of the NFPA

The **NFPA** publishes numerous regulations and guidelines.
Most of these are used in the automotive industry and specified by manufacturers of machine tools.

Especially **NFPA 79** - Electrical Standard for Industrial Machinery.

NFPA 79 applies to electrical/electronic devices, apparatus or systems of industrial machines which operate with a nominal voltage of 600 V or less. The purpose of **NFPA 79** is to provide detailed information on the use of electrical/electronic devices, apparatus or systems, supplied as part of industrial machines. This information should help to protect people and property. Standard **NFPA 79** has been officially in force since 1962. Its content is very similar to that of **standard IEC 60204-1**, issued by the International Electrotechnical Commission (IEC).

Note: The **NFPA 79** requirements, which are more stringent than those of **UL 508A**, are indicated separately in this manual.

Example of a machine typically covered by NFPA 79

Machinery for assembling and transporting materials are treated as industrial machinery according to **UL 508A**.

What are industrial control panels? 3

3.1 Industrial control panels according to UL 508A

Definition

UL 508A Art. 1.3

An industrial control panel consists of assemblies of two or more components in the power circuit, such as motor starters, circuit breakers, associated auxiliary and control units, e.g. command devices, time relays.

UL 508A Structure and content (Industrial Control Panels)

UL 508A is made up of various parts:

- Part 1: Industrial Control Panels, General Use – general applications
- Part 2: Industrial Control Panels, Specific Use – specific applications
  - Art. 62 pp: Enclosure
  - Art. 65 pp: Industrial Control Panels for use in Industrial Machinery (UL equivalent to **NFPA 79**) – industrial control panels for machine tools and plant engineering
  - Art. 68 pp: Industrial Control Panels for use in Crane Control – industrial control panels for cranes and lifting devices
  - Art. 73 pp: Industrial Control Panels for use in Service Equipment – industrial control panels for power supply
  - Art. 80: Industrial Control Panels for use in Elevator Control – industrial control panels for elevators
  - Art. 81 pp: Industrial Control Panels for use in Flame Control – industrial control panels for flame control (e.g. oil and gas stoves)
  - Art. 84 pp: Industrial Control Panels for Marine Use – industrial control panels for marine applications
  - Art. 88 pp: Industrial Control Panels for use in Air Conditioning and Refrigeration Equipment – industrial control panels for air conditioning and refrigeration applications

The requirements stated in Part 2 do not relate to the entire machine or system, but just electrical parts.

UL 508A Supplement und Appendix

- Supplement SA – Specific Component Requirements – requirements for industrial control equipment in industrial control panels. **Only** products listed here may be used.
- Supplement SB – Short Circuit Current Ratings for Industrial Control Panels – short circuit requirements for industrial control panels – see also **NEC 2008 Art. 409**.
- Annex A – Standards for Components – standards that are of relevance to industrial control equipment used in industrial control panels
- Annex B – Use of Components NOT UL Listed or Recognized in Industrial Control Panels – unlisted industrial control equipment

Industrial control panels for general applications

UL 508A Art. 1.1

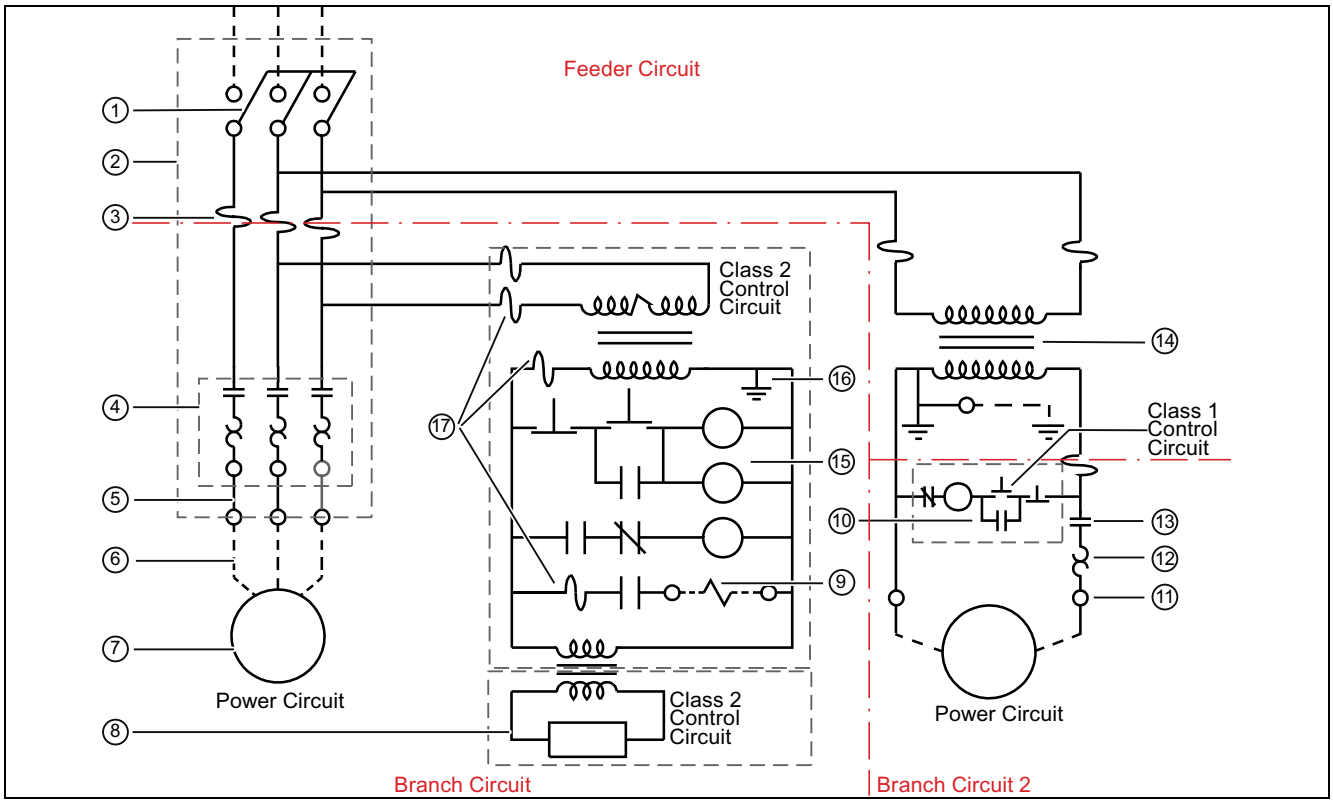
According to **UL 508A** industrial control panels are suitable for all general industrial applications, maximum 600 V, for installation in normal ambient conditions with a maximum room temperature of 40 °C [104 °F] and in accordance with the National Electrical Code, **ANSI/NFPA 70**.

Exceptions

UL 508A Art. 1.5

The standard does not apply to explosion-protected equipment (hazardous / classified locations) as defined in **NEC 2008 Art. 500**. These systems are addressed in **UL 698**. The standard does not apply to fire pump controllers. These are addressed in **UL 218** "Standard for Fire Pump Controllers".

3.2 Terms used in the manufacturing of industrial control panels



①	Fused disconnect switch acc. to **UL 98,** circuit Breaker acc. to **UL 489** miniature circuit-breaker acc. to **UL 489**.	⑩	Control circuit / class 1 circuit / common control circuit
②	Combination motor controller	⑪	Field wiring terminals
③	Branch circuit protection	⑫	Overload relay
④	Starter	⑬	Contactor / controller
⑤	Internal wiring / Factory wiring	⑭	Power transformer - for motor load and control circuit
⑥	Field wiring	⑮	Control circuit devices and wiring / class 1 circuit/isolated secondary circuit
⑦	Load (provided in the field)	⑯	Control transformer, ground (for 1,000 VA max. control transformer)
⑧	Class 2 circuit	⑰	Supplementary protection (miniature circuit breaker acc. to **UL 1077**)
⑨	Solenoid or other control devices (provided in the field)		

Feeder circuit

The conductors and circuitry on the supply side of the branch circuit overcurrent protective device.

Branch circuit

The conductors and components following the last overcurrent protective device protecting the load.

Power circuit

Conductors and components of branch and feeder circuits. The power circuit can both be connected directly to the supply or via power transformers. Motor-driven loads are mostly classified as power circuits.
Here, respective protective devices are to be used, e.g. circuit breakers according to **UL 489**.

Control circuit

A circuit that carries the electric signals directing the performance of a controller, and which does not carry the main power circuit. A control circuit is, in most cases, limited to 15 amperes. There are various ways of realizing control circuits:

- Direct tap-off upstream the branch circuit protective device.
  Here, respective protective devices are to be used, e.g. circuit breakers according to **UL 489**.
- Direct tap-off downstream the branch circuit protective device.
  Here, also so-called supplementary protectors can be used, e. g. miniature circuit breakers according to **UL 1077**.
- Via control transformers or DC power supply units. Caution: Various protective devices may not be approved for this application.

Class 2 control circuit

A control circuit supplied from a source having limited voltage (30 Vr. m. s. or less) and current capacity, such as from the secondary of a Class 2 transformer, and rated for use with Class 2 remote-control or signaling circuits.

Class 1 control circuit (acc. to UL 508A)

A control circuit on the load side of an overcurrent protective device where the voltage does not exceed 600 volts, and where the power available is not limited, or a control circuit on the load side of a power limiting supply, such as a transformer Class 1.

Branch circuit protection

Overcurrent protection with an ampere rating selected to protect the branch circuit.

For a motor branch circuit, the overcurrent protection is required for overcurrents due to short circuits and faults to ground only.

Field wiring

Conductors to be installed by others to connect the industrial control panel to source(s) of supply, remote control devices, and loads.

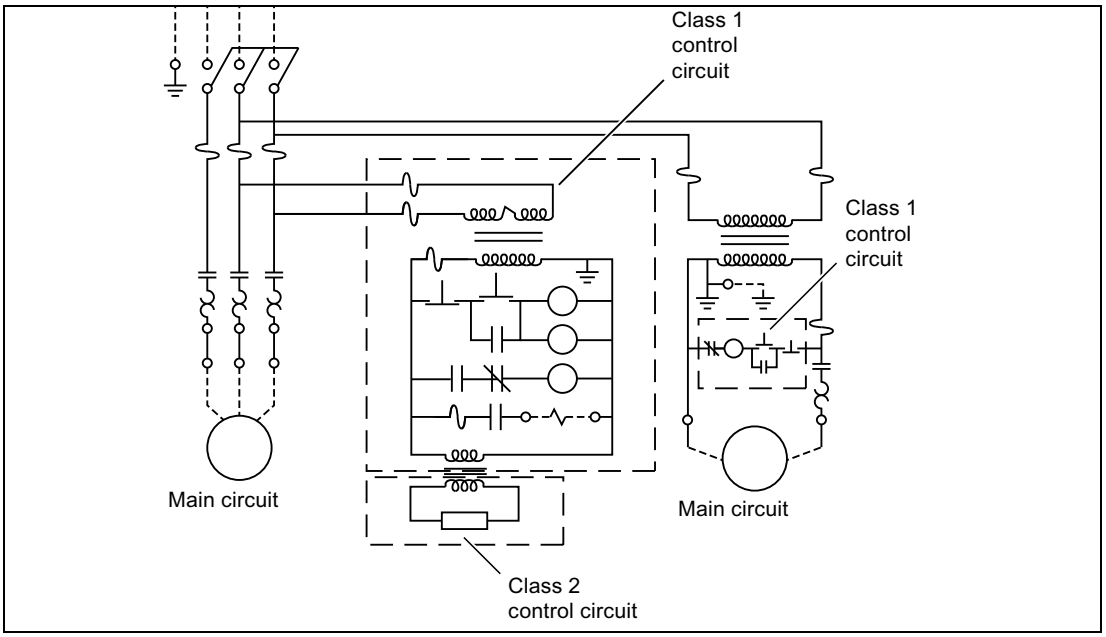
Factory wiring/Internal wiring

The devices shall only be connected by the factory.

Note

The term "Overcurrent" refers to the overload, short circuit and ground fault currents.

Definition of power and control circuit



The relevant definitions can be found in **UL 508A** Chapter 2 "Glossary". Here is a limited selection.

§ 2.38 Power Circuit - Conductors and components of branch and feeder circuits.

§ 2.31 Load
The load is a device external to the industrial control panel that is connected to the power circuit.

§ 2.11 Control circuit
The control circuit is a circuit that carries the electric signals directing the performance of a controller, and which does not carry the main power circuit. A control circuit is, in most cases, limited to 15 amperes.

Note

Motors are generally considered to be loads.
This may also apply to fan motors.
If smaller motors are connected directly to the control circuit, the control circuit can then be treated as the power circuit. This can sometimes have an impact in terms of the kinds of devices that can be installed.

Electric circuits

4

4.1 Power circuits, external

4.1.1 Field wiring

Field wiring terminals

There shall be one termination point for each external wire requiring connection. Terminals for copper wires shall be approved according to **UL 486A**, and those for aluminum wires according to **UL 486B**. All terminals intended for the field wiring shall be marked in terms of the wire material (Cu, Alu, etc.) for which they are intended.
Torques: (Torque in lb-in [1 Nm = 8.85 lb-in]; 1 lb-ft = 12 lb-in)

Terminals for industrial control equipment shall be tested according to **UL 486E**.

New: All terminals for finely stranded wires, such as welding cables, Diesel Locomotive Cable (DLC) or those marked as "Flexing" or "Class K", shall be tested according to **UL 486A and UL 486B** and labeled accordingly.

Marking field wiring

Marking field wiring: **UL 508A Art. 54**

Line or Load Terminal.
Torques of terminal screws.
Temperatures of wire.
Note: Only a current carrying capacity of 75 ºC is really ever used now for terminal sizing (60 ºC is hardly used any more); wires approved for higher temperatures, such as 90 ºC or 105 ºC, may only be loaded (calculated) for 75 ºC current carrying capacity.
Wire material includes copper, aluminum and copper-clad aluminum.

Labeling and marking field wiring terminals

Example:

LINE TERMINALS
AWG # 14 – AWG # 3/0
Use 75 °C Copper Wire Only,
Terminal Torque: 45 - 50 Lb.-in.

Ground terminals, marking: "G", "GR", "GRD", "Ground", "Grounding" or IEC symbol 5019; New: PE **UL 508A Art. 54.5**

Ground terminals for equipment connection shall also be identified as "Equipment Ground".

4.1.2 Terminal size for field wiring (external conductor feeder)

Sizing

NEC 2008 Art. 215.2(A) (1)

The field wiring terminals shall be designed for a wire size of 125% of the load current, but shall not be smaller than No. 14 AWG (2.1 mm^2).

The terminals for field wiring shall be suited to terminating non-pre-fabricated wires and shall be approved accordingly; in other words, do not use crimp connections with screw connections on the busbars.

NEC 2008 Art. 430.22 & 24

For several motors or motors and other loads: 125% of the full-load amps of the largest motor plus the sum of the currents of all other loads.

UL 508A, Art. 28.3

If there are lighting or heater loads present, these shall also be taken into account with 125%.

Wire size and rated load carrying capacity for field wiring

UL 508A Table 28.1

The following table contains the wire sizes and rated load carrying capacity according to **NEC 2008, Table 310.16** to **310.20**, the maximum permissible load currents and the maximum short circuit protection for non-motor branch circuits. The short circuit protection for motor branch circuits can be found in chapter 6.

Wire size and rated load carrying capacity

Rated values, insulated cables AWG (mm²)	① Permissible current carrying capacity according to NEC 2008, Tab. 310.16 Cu 75 °C [A]	② Permissible current carrying capacity for load feeders = Column (1)/1.25 [A]	③ Maximum short-circuit protection for non-motor loads: circuit breakers or fuses [A]
14 (2.1)	15	12	15
12 (3.3)	20	16	20
10 (5.3)	30	24	30
8 (8.4)	50	40	50
6 (13.3)	65	52	65
4 (21.2)	85	68	85
3 (26.7)	100	80	100
2 (33.6)	115	92	115
1 (42.2)	130	104	130
1/0 (53.5); (also # 0)	150	120	150
2/0 (67.4); (also # 00)	175	140	175
3/0 (85); (also # 000)	200	160	200
4/0 (107); (also # 0000)	230	184	230
250 kcmil (127)	255	204	255
300 kcmil (152)	285	228	285
350 kcmil (177)	310	248	310
400 kcmil (203)	335	268	335
*500 kcmil (253)	380	304	380

* 500 kcmil (MCM) is (usually) the largest external wire

① Values apply for not more than 3 wires routed in a conduit. Terminals for larger conductor cross sections shall be provided for systems with 2 or more conductors per phase in one conduit, e.g. 6 or 9. **NEC 2008, Tab. 310.16**

② Wires should be sized for 125% of the load current. **NEC 2008 Art. 430.22 (A)**

③ According to **NEC 2008 Art. 240.3**

4.1.3 Ground and neutral conductors

Ground and neutral wires in the USA

In the USA, the following terms are used:
grounding wire (PE wire) and
grounded wire (N wire).

The grounding wire (green or green/yellow) shall not carry operational current. Each power circuit shall have a separate ground terminal. The grounded wire (white or gray) is used for the N wire (IEC). There are no PEN wires (PE and N) in the USA. If neutral wires (N) are used, these shall be clearly identified and fitted to a separate, insulated terminal.

Ground terminals and grounding wires

Ground terminal sizes (minimum!) - Equipment Grounding.
Table 15.1 in **UL 508A** shows the smallest permissible grounding wire cross sections. Larger cross sections can be selected at any time.

The grounding wire shall not, however, be any smaller than that in **UL 508A, Table 15.1**.

Series wiring of grounding wires

Within industrial control panels, the grounding wires may be routed in series (Daisy-Chaining), if mechanisms are in place to ensure that removing one device will not interrupt grounding. **NFPA 79 Chapter 8 Art. 8.2.3.2.**

Options for plugging in grounding wires

Grounding wires for equipment grounds can be plugged into a terminal strip if mechanisms are in place to ensure that the ground contact is always the first to make contact and the last to break contact (first-make, last-break of the equipment grounding conductor). In other words, the connector's ground contact should be longer.
NFPA 79 Chapter 8 Art. 8.2.4

This requirement applies to all standard connectors (NEMA connectors listed according to **UL 498**).

Downstream of the equipment ground, the grounding wires of individual devices can also be plugged into the industrial control panel, as can loads outside the industrial control panel (e.g. connection to a motor). In accordance with the standard, these ground contacts should also be the first to make contact and the last to break contact, e.g. **UL 498, Art. 24.3**.

Size of equipment ground terminal UL 508A, Table 15.1

Maximum ampere rating of overcurrent protection for field wires supplying the industrial control panel	Size of equipment grounding or bonding wire of grounded parts (minimum)			
	Copper		Aluminum	
	AWG or kcmil	[mm²]	AWG or kcmil	[mm²]
15	14	2.1	12	3.3
20	12	3.3	10	5.3
30	10	5.3	8	8.4
40	10	5.3	8	8.4
50	10	5.3	8	8.4
100	8	8.4	6	13.3
200	6	13.3	4	21.2
300	4	21.2	2	33.6
400	3	26.7	1	42.4
500	2	33.6	1/0	53.5
600	1	42.4	2/0	67.4
800	1/0	53.5	3/0	85.0
1000	2/0	67.4	4/0	107.2
1200	3/0	85.0	250 kcmil	127
1500	4/0	107.2	350	177
2000	250 kcmil	127	400	203
2500	350	177	600	304
3000	400	203	600	304
4000	500	253	800	405
5000	700	355	1200	608
6000	800	506	1200	608

4.1.4 General regulations on cable installation outside control panels

Number of cables in conduits

NEC 2008 Annex C specifies how many cables shall be installed, the cross section and installation types, and the cable conduit cross sections.

This determines both the size and number of cable conduits. The information provided makes it possible to determine the number and size of the "Knock outs". The "Knock outs" shall then be set up in the enclosure according to **UL 508A Art. 19**.

Comments:

Please consider the issue of spare cables.

Openings for external wiring

Up to type 3R, there are already openings in the enclosure. These are, however, only permitted on the underside of the panel (e.g. for cable entry), or on the sides, below current-conducting parts.

4, 4X, 12, 13 enclosure types do not have openings. During installation, these are provided by an electrician as needed. See **UL 508 Art. 25.2**.

Take care with the dimensions: The cable conduit sizes are given in inches, e.g. conduit size 3/4", 1", 1-1/4". These are not the outer diameters of the conduits!
These figures are trade sizes.

Exception: Grounding wires are not current-conducting and may be laid outside the cable conduit under certain circumstances. **NEC 2008 Art. 300.3 (B) (2)**

4.1.5 Relation between conduit size and diameter of knockout (KO)

Conduit size and diameter of the Knockouts (KO)

Conduit size [inch]	KO diameter [inch]	Metric size designation
1/2	0.859	16
3/4	1.094	21
1	1.359	27
1-1/4	1.719	35
1-1/2	1.958	41

4.1.6 Number and size of wires per cable conduit

Regulations for cable conduit size

The number of wires per cable conduit is stated in **NEC 2008 ANNEX C**.

Example

Extract from **NEC 2008 Annex C**

Maximum Number of Conductors or Fixture Wires in Rigid Metal Conduct (RMC)

Conductors														
			Metric Designator (Trade Size)											
Type	mm²	Con-ductor Size (AWG kcmil)	16 (1/2)	21 (3/4)	27 (1)	35 (1 ¼)	41 (1 ½)	53 (2)	63 (2 ½)	78 (3)	91 (3 ½)	103 (4)	129 (5)	155 (6)
RHH, RHW, RHW-2	2.1	14	4	7	12	21	28	46	66	102	136	176	276	398
	3.3	12	3	6	10	17	23	38	55	85	113	146	229	330
	5.3	10	3	5	8	14	19	31	44	68	91	118	185	267
	8.4	8	1	2	4	7	10	16	23	36	48	61	97	139
	13.3	6	1	1	3	6	8	13	18	29	38	49	77	112
	21.1	4	1	1	2	4	6	10	14	22	30	38	60	87
	26.7	3	1	1	2	4	5	9	12	19	26	34	53	76
	33.3	2	1	1	1	3	4	7	11	17	23	29	46	66
	42.4	1	0	1	1	1	3	5	7	11	15	19	30	44
	53.5	1/0	0	1	1	1	2	4	6	10	13	17	26	38
	67.4	2/0	0	1	1	1	2	4	5	8	11	14	23	33
	85.0	3/0	0	0	1	1	1	3	4	7	10	12	20	28
	107.2	4/0	0	0	1	1	1	3	4	6	8	11	17	24
	127	250	0	0	0	1	1	1	3	4	6	8	13	18
	152	300	0	0	0	1	1	1	2	4	5	7	11	16
	177	350	0	0	0	1	1	1	2	4	5	6	10	15
	203	400	0	0	0	1	1	1	1	3	4	6	9	13
	253	500	0	0	0	1	1	1	1	3	4	5	8	11

Notes on above table:

- The table above is only **ONE EXAMPLE** among many tables for different conduit types.
- Conduit refers to the cable surround.
  Tubing refers to the cables within the conduits.
- The table shows the (theoretically) maximum possible number of wires, assuming all wires have the same cross section.
- Where all wires have the same cross section, the actual permissible number of wires and the size of the conduit required can be obtained from Table 2 in Chapter 9 of **NEC 2008**.

Number of conductors	Filling rate for all conductor types (as %)
1	53 %
2	31 %
>2	40 %

Example

Wire size AWG 10 Type RHH,
number of wires 6,
gives a 40% filling rate.
This means (in theory) that at least 15 wires could be contained in the Conduit (6 ≙ 40% of 15).
Taken from table for conduit type RMC ≙ Rigid Metal Conduit.
Conduittyp RMC ≙ Rigid Metal Conduit

Wires with different cross sections in a conduit.
The actual permissible number of wires can be obtained using Tables 5 and 5a (diameter and cross sections) and Table 4.
All tables are contained in **NEC 2008 Chapter 9**.

The calculation method is as follows:

a) Determine the relevant cross section according to the NEC tables.
b) Add together the "individual" cross sections obtained.
c) Extrapolate the "total" cross section calculated in step b) in terms of an filling rate (in precentage) based on the required conduit cross section.
d) The conduit cross section to be used shall be greater than or equal to the value derived under step c).

Example

Number	Wire size and type	Cross section according to Table 5 [inch²]	Total cross section [inch²]
4	12 AWG THWN	0.0133	0.0532
3	8 AWG TW	0.0437	0.1311
3	6 AWG THW	0.0726	0.2178
			∑ 0.4021

Table 1 gives an filling rate of 40%.
Table 4 gives:

Conduit size 1 1/4 or 35.
Conduit type RMC ≙ **Rigid Metal conduit**

Maximum usable cross section at 40% filling rate is 0.61 inch²

4.1.7 Diameter of knockouts (KO)

UL 508A Tab. 11.1 – Knockouts or hole sizes and dimensions of bushings

Trade size of conduits		Knockout or hole diameter		Dimensions of bushings			
				Overall diameter		Height	
[mm]	[inch]	[mm]	[inch]	[mm]	[inch]	[mm]	[inch]
21.3	1/2	22.3	7/8	25.4	1	9.5	3/8
26.7	3/4	27.8	1-3/32	31.4	1-15/64	10.7	27/64
33.4	1	34.5	1-23/64	40.5	1-19/32	13.1	33/64
42.3	1-1/4	43.7	1-23/32	48.2	1-15/32	14.3	9/16
48.3	1-1/2	50.0	1-31/32	56.0	2-13/64	15.1	19/32
60.3	2	62.7	2-15/32	68.7	2-45/64	15.9	5/8
73.0	2-1/2	76.2	3	81.3	3-7/32	19.1	3/4
88.9	3	92.1	3-5/8	96.4	3-7/8	20.6	13/18
101.6	3-1/2	104.8	4-1/8	112.7	4-7/16	25.8	15/16
114.0	4	117.5	4-5/8	126.2	4-31/32	25.4	1
127.0	4-1/2	130.2	5-1/8	140.9	5-35/64	27.0	1-1/16
141.3	5	142.9	5-5/8	158.0	6-7/32	30.2	1-3/16
168.3	6	171.5	6-3/4	183.4	7-7/32	31.8	1-1/4

4.1.8 Cable conduit types

Regulations for cable conduit types

RMC	Rigid Metal Conduit: **NEC 2008 Art. 344**
RNC	Rigid Nonmetallic Conduit: **NEC 2008 Art. 352**
EMT	Electrical Metallic Tubing: **NEC 2008 Art. 358**
FMT	Flexible Metallic Tubing: **NEC 2008 Art. 360**
FMC	Flexible Metal Conduit: **NEC 2008 Art. 348**
LFMC	Liquidtight Flexible Metal Conduit: **NEC 2008 Art. 350**
LFNC	Liquidtight Flexible Nonmetallic Conduit: **NEC 2008 Art. 356**

Practical application for panel builders

Outside the industrial control panel, but inside the machine/equipment, use:

Liquidtight Flexible Metal Conduit and Liquidtight Flexible Nonmetallic Conduit (Type LFNC-A, B or C):

Note

Flexible Metal Conduit: Sizes from 3/8" to 4"
Liquidtight Flexible Nonmetallic Conduit: Sizes from 3/8" to 2" (4" is permitted under **NEC 2008**, but it is difficult to buy it).

The "Chicago Code" does not allow Liquidtight Flexible Nonmetallic Conduit
⇒ use Liquidtight Flexible Metallic Conduit.

4.2 Power circuits, internal

4.2.1 Basic requirements

All wires and busbars shall be made of copper. **UL 508A Art.29**

All internal wiring shall be approved for the voltage involved. This means that all wires in the same wiring duct/conduit should not be used with more than the minimum operating voltage.

4.2.2 Wires and conductors

Internal wires

See also **UL 508A Art. 29** and **NFPA 79, Chapter 13**

All internal wires should be approved for at least 90 °C and shall correspond to one of the following types:

1. Machine tool wire (MTW) according to **UL 1063**
2. Rubber insulated wire according to **UL 44**
3. Thermoplastic insulation according to **UL 62**
4. Appliance wiring material (not under **NFPA 79**)
5. Welding cable / diesel-locomotive wire
   . New: The terminals for finely stranded wires shall be approved for this application (**UL 486A** and **486B**) and be labeled accordingly. **UL 508A Art. 29.3.11**

Note: The terminal temperature details and the current carrying capacity (ampacity) remains at 75 ºC, even if the wire insulation is approved for 90 ºC or 105 ºC.

4.2.3 Wiring methods

Comparison of regulations

The regulations are similar to the methods which are common practice in Europe. Ferrules might possibly be used in UL applications. Currently, UL standards do not contain any rules on the use of ferrules. This should be agreed with UL in advance. The terminals on all UL-approved devices are suitable for connecting non-pre-fabricated wire ends (stranded wire) and are approved accordingly.
UL 508A, Art. 29.3

Internal wiring – details and exceptions

Note: Some UL-recognized devices are only suitable for "factory wiring". This means that the terminals may only be wired in the factory or by the panel builder. Instructions can then be found in the UL report.

Within the industrial control panel, **UL 508A** accepts several wires per termination point provided that these are safely connected. Safe connection is established by the UL inspector using a manual pull test. **UL 508A, Art. 29.3.6**

The wires shall be routed away from sharp edges; all points of contact should be free of burrs (use edge protection); rubber sleeves should be used for holes.
UL 508A, Art. 29.4

Wires for different voltages shall either be laid separately or all wires shall be designed for the highest voltage.

Field wiring: **UL 508A Art. 25** and **NEC Chapter 3**

Wiring within the industrial control panel: **Table 25.1** in **UL 508A** specifies the distance between the field wiring terminal and the enclosure wall within the industrial control panel.

Wire bending space

Size of wire AWG or MCM [mm²]		Minimum bending space, terminal to wall, inches [mm]							
		Wires per terminal[a]							
		1		2		3		4 or more	
14 – 10	(2.1 – 5.3)	Not specified		a		a		a	
8 – 6	(8.4 – 13.3)	1-1/2	(38)	a		a		a	
4 – 3	(21.2 – 26.7)	2	(51)	a		a		a	
2	(33.6)	2-1/2	(64)	a		a		a	
1	(42.4)	3	(76)	a		a		a	
1/0	(53.5)	5	(127)	5	(127)	7	(178)		
2/0	(67.4)	6	(152)	6	(152)	7-1/2	(191)		
3/0	(85.0)	7	(178)	7	(178)	8	(203)		
4/0	(107.2)	7	(178)	7	(178)	8-1/2	(216)		
250	(127)	8	(203)	8	(203)	9	(229)	10	(254)
300	(152)	10	(254)	10	(254)	11	(279)	12	(305)
350	(177)	12	(305)	12	(305)	13	(330)	14	(356)
400	(203)	12	(305)	12	(305)	14	(356)	15	(381)
500	(253)	12	(305)	12	(305)	15	(381)	16	(406)
600	(304)	14	(356)	16	(406)	18	(457)	19	(483)
700	(355)	17	(356)	16	(406)	20	(508)	22	(559)
750 – 800	(380 – 405)	18	(457)	19	(483)	22	(559)	24	(610)
900	(456)	18	(457)	19	(483)	24	(610)	24	(610)
1000	(506)	20	(508)	-		-		-	
1250	(633)	22	(559)	-		-		-	
1500 – 2000	(760 – 1013)	24	(610)	-		-		-	

NOTE: ″–″ indicates no value established

a Conductors smaller than 1/0 AWG shall not be connected in parallel

4.2.4 Conductor size (internal of the industrial control panel)

Basic requirements

UL 508A Art. 29.6

UL 508A Art. 66.5.4

Wires in the power circuit must not be any smaller than 14 AWG (2.1 mm^2).

All internal wires shall be approved for a temperature of 90 °C (194 °F) or higher (see marking on wire).

Determining the wire sizes

The following table shows the wire sizes in AWG and mm^2. If metric wire sizes are used, these shall be the same or greater than the values given.

Note:

- All wires, be they AWG or metric, shall be UL-approved.
  The UL mark is located on the insulation directly or on the coil (package).
- If the UL mark is on the coil (package), the UL label shall not be discarded but retained for a possible UL inspection, or kept with the industrial control panel documentation.

The sum of the rated currents of all loads shall be taken into account when determining the wire current. For motor loads, the rated values from **UL 508A, Table 38.1** and **38.2** or **NEC 2008, Art. 430, Tables 247** to **251** must be used (also see the component selection tables in the Annex).

Note:

- Rated data, provided on the motor's nameplate, shall not be used (see motor currents in **UL 508A, Table 50.1**).
- The type of routing (e.g. individual, bundled, in cable ducts) is not currently taken into account by UL.

4.2.5 Ratings for conductor sizes

General rule

Internal wires (ambient temperature of up to 40 °C, measured approx. 1.2 m outside the industrial control panel) **UL 508A, Chapter 29.6**

Wire sizes and current carrying capacity - UL 508A, Table 28.1

Wire size		60 °C (140 °F)		75 °C (167 °F)	
AWG	[mm²]	Copper [A]	Aluminum [A]	Copper [A]	Aluminum [A]
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 [1)]	(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

NOTES –
1 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

UL 508A, Art. 66.5.4
Wires in the power circuit shall not be any smaller than # 14 AWG (2.1 mm^2).

Exceptions

Only for control panels for "Industrial Machinery".

Wires in the power circuit may be designed using # 16 AWG and # 18 AWG if they comply with the conditions stated in Table 66.1A.

Wire size and current carrying capacity – exceptions

UL 508A, Table 66.1A				
Current load and protection for power circuits with 16 AWG and 18 AWG cables				
Cable		Load type	Max branch circuit protection in amps	Trip class of motor overload protection c)
Size	[A]			
16 AWG	8	Not motor	a) 10 A	-
	8	Motor	a) - see UL 508A Tab. 31.1	Class 10
	5.5	Motor	a) - see UL 508A Tab. 31.1	Class 20
18 AWG	5.6	Not motor	b) - 7 A	-
	5	Motor	b) - see UL 508A Tab. 31.1	Class 10
	3.5	Motor	b) - see UL 50 A Tab. 31.1	Class 20

a) Circuit breaker with thermal delay labeled for protecting 16 AWG or 18 AWG or class CC, J or T fuses

b) Circuit breaker with thermal delay labeled for protecting 18 AWG or class CC, J or T fuses

c) Class 10: Overload protection trips in 10 seconds at 6 times the current setting.
Class 20: Overload protection trips in 20 seconds at 6 times the current setting.

Application example for up to 600 V

Practical application for up to 600 V:

- Internal wiring according to **UL 508A Tab. 28.1**
- External wiring, **NEC 2008 Table 310.16**, up to # 1 AWG (110 A) = 60 °C column, from # 1/0 AWG (150 A) = 75 °C column PLUS 25% (or x 125%)
  - Temperature in excess of 30 °C; see correction factor under **NEC 2008 Table 310.17**
  - Correction factor for more than 3 conductors in one cable route, see **NEC 2008 Table 310.15 (B) (2) (a)**
- Conductors in parallel: # 1/0 AWG and larger, **NEC 2008 310.4**, conditions for parallel cables: same cable materials, same cross section, same insulation, same connecting type.

4.2.6 Bus bars

Using busbars

UL 508A, Art. 29.1.1&2, 29.1, 29.2.2, 29.3.9, 29.3.10 and 29.6.2 b

Practical application:

We would recommend using the already listed 8US (Fast Bus) busbar kits. These bars are checked per cross section for higher currents. They display the necessary distances through air and over surface and are approved for higher short-circuit currents.
The revised design complies with the latest requirements of **UL 508A** in terms of distances through air and over surface.

Conditions for using busbars according to **UL 508A**:

- All busbars shall be made of copper.
- The busbars shall be fitted on insulators which are approved for the voltage and temperature (at least 90 °C) (for distances through air and over surface, see 4.6).
- As a minimum requirement, the contact surfaces of busbars intended to carry over 600 A shall be plated with tin, silver or nickel.

Exception 1: Bars which have been treated with an appropriate agent for preventing oxide.

Exception 2: Copper bars with less than 225 A per contact/supporting surface.

- For distances through air and over surface on the bars, see 4.6. In feeder circuits, the bars, power port and output devices, such as terminals or adapters, shall be spaced to allow a large clearance.
- Busbars which are not UL-type tested can have a maximum current carrying capacity of 1000 A per square inch (6.45 cm²) of cross section.
- Non-tested bars can be subjected to a maximum short-circuit current rating of 10 kA (see short-circuit strength rating calculation for the industrial control panel, see 5.9.2 and 5.9.3).

Note: UL does not distinguish between the current carrying capacity of insulated and uninsulated bars. Flexible busbars shall be separately approved for use by UL. Even if they are UL-Recognized, they shall be included in the procedure (UL file) of the panel builder.

4.2.7 Ampacity of bus bars

As far as **UL 508A**, **NFPA 79** or **NEC 2008** are concerned, there are currently no clear rules for dealing with "non type-tested" busbars. The only guidance in this area is provided by the **November 1, 2002 version of UL 1741**.

Conditions for using busbars according to UL 1741

UL 1741 (Inverters, Converters and Controllers for use in Independent Power Systems) contains further requirements:

Note: UL 1741 permits the use of aluminum busbars; **UL 508A** only permits copper busbars.

UL 1741, Table 23.2

Size of individual bars up to maximum 800 A

Current	Copper busbars				Aluminum busbars ②			
	Size ①		Cross section ③		Size ①		Cross section ③	
	[mm]	[inch]	[mm²]	[inch²]	[mm]	[inch]	[mm²]	[inch²]
225	3.2 x 22.2	0.125 x 0.875	70.3	0.109	6.4 x 22.2	0.250 x 0.875	141.3	0.219
400	6.4 x 38.1	0.125 x 1.500	242.,0	0.375	6.4 x 50.8	0.250 x 2.000	322.6	0.500
600	6.4 x 50,8	0.250 x 2.000	322.6	0.375	See table 23.1	See table 2 3.1	518.1	0.800
800	6.4 x 76.2	0.250 x 3.000	483.9	0.750	See table 23.1	See table 2 3.1	688.4	1.067

① Bars with other dimensions can be approved if they have the same cross section and an equivalent mechanical strength.

② Minimum of 55% copper conductivity (not for **UL 508A**)

③ The cross section can be reduced by 5% using corners, shapes and tolerances.

Note: Several parallel busbars shall have a minimum contact supporting surface (overlap) of no less than 6.45 cm² (1 square inch) per 200 A.

UL 1741 Art. 23.2.10

The cross sections of bars may be reduced using slots and holes (with or without screws), if:

- The remaining material is at least 70% of the cross section given above.
- The remaining material volume is at least 93% over any 152 mm (6 inch) length.

For the requirements relating to fixing elements, such as screws, rivets, spring rings, cup washers and shims, see **UL 1741 Art. 23**.

Busbar size and current carrying capacity

UL 1741, Table 23.1 (November 1st 2002 version)

Conductivity of individual and multiple busbars and their connections

Busbar material ①	Current	Maximum current density in A per square inch (6.45 $cm^{2)}$	
		Busbar cross section ⑤	Contact/supporting surface
Copper	0 - 600 A	1000 ③	200
Copper	Above 600 A	1000 ③	200 ④⑤
Aluminum ②	Any amperage	750 ③	200 ④⑤

① Where there are several bars per phase running in parallel, they shall be made of the same material.
② Minimum of 55% copper conductivity (not for **UL 508A**)
③ See also **NFPA 79, Table 23.2** for 800 A individual bars
④ See **NFPA 79 Art. 23.1.1, 23.2.10, 23.2.11**
⑤ The cross section can be reduced by 5% using corners, shapes and tolerances

Note

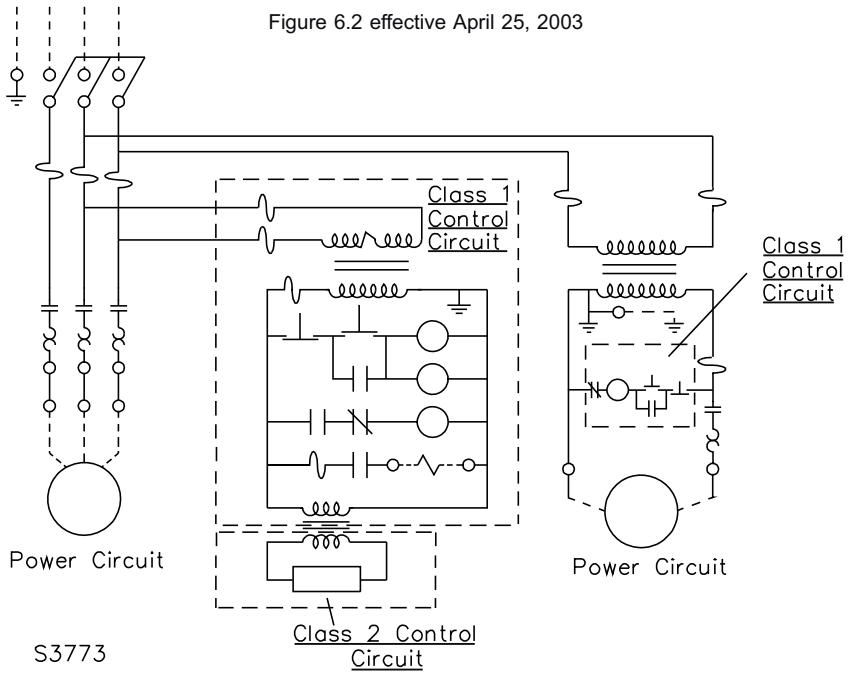
UL 508A only requires that busbars are made from copper only and that the maximum current density for untested systems shall not exceed 1000 A per square inch (6.45 cm^2). **UL 508A § 29**

4.3 Control circuits, UL 508A § 37 to 48

4.3.1 Definitions

UL 508A Figure 6.2
Description of control circuits and power circuits

Figure 6.2 effective April 25, 2003



- **Class 1 Control Circuits (UL 508A § 2.6) ≙ general control circuits**
  - A control circuit connected to the load side of a Branch Circuit Protective Devices (for branch circuit protection).
    Maximum voltage: 600 V.
    Maximum current/power: unlimited.
  - Control circuit connected to the load side of a load transformer

Note

If the machine is covered by **NFPA 79**, the control voltage is limited to 115 VAC.

- **Class 2 Control Circuit(UL 508A § 2.7) ≙ control circuit with limited energy**
  This control circuit is supplied by a source with a maximum of 30 Vrms and limited energy. Devices approved "for use with class 2" or similar should only be connected to this type of energy source.

- **Low-Voltage Limited Energy Circuit(UL 508A § 2.32)**
  ≙ control circuit with a "protected" low voltage
  A circuit with a maximum of 42.4 V peak or DC voltage and maximum power of 100 VA or 5 A at voltages of 20 V or less.
  The circuit shall also be protected against overcurrent.
  With this type of circuit, it is not permissible to use a power supply connected to the load voltage via a voltage divider.

4.3.2 Control circuit

UL 508A, Art. 37, 38, 39, 40, 41, 42, 45. NEC 2008 Art. 430.72

The motor control circuit is the circuit which branches off the load side of the branch circuit protection and is used to control the connected industrial control equipment for the motor.
This circuit is not itself considered to be a branch.

No short-circuit protection is specified for auxiliary switches.

4.3.2.1 External wire cross sections UL 508A §37

Wire sizes in control circuits

The permissible wire cross sections are given in **Tables 28.1** and **38.1** of **UL 508A**.

In general, the minimum size of AWG 14 is not, however, smaller than that of the upstream protective device.
Table 28.1 of **UL 508A** provides details of the relationship between the current and the wire cross section.

Exception

For circuits smaller than 10 A, the field wiring terminal (and, therefore, the wire cross section) may be selected according to **Tab. 37.1** of **UL 508A**.

Table 37.1
Ampacities of field wiring conductors smaller than 14 AWG (2.1 mm^2)

Table 37.1 revised December 28, 2007

Maximum control circuit terminal ampacity, amperes	Minimum terminal wire range		Marking required
	AWG	(mm^2)	
10	16	(1.3)	yes
10	16 – 14	(1.3 – 2.1)	no
7	18	(0.82)	yes
7	18 – 14	(0.82 – 2.1)	no
5	20 – 18	(0.52 – 0.82)	yes
5	20 – 14	(0.52 – 2.1)	no
3	22 – 18	(0.32 – 0.82)	yes
3	22 – 14	(0.32 – 2.1)	no
2	24 – 18	(0.20 – 0.82)	yes
2	24 – 14	(0.20 – 2.1)	no
1	26 – 18	(0.13 – 0.82)	yes
1	26 – 14	(0.13 – 2.1)	no
0.8	28 – 18	(0.08 – 0.82)	yes
0.8	28 – 14	(0.08 – 2.1)	no
0.5	30 – 18	(0.05 – 0.82)	yes
0.5	30 – 14	(0.05 – 2.1)	no

If the column "Marking required" shows "Yes", the connecting diagram for external cables shall clearly show the size of this terminal.

4.3.2.2 Internal wire cross sections UL 508A §38

Sizing depends on the

1. rated current of the protective device, or the
2. rated current of the secondary side of the transformer/power supply

The relevant cross section is selected according to the current load (see previous) using **Tables 28.1** or **38.1** in **UL 508A**.

Revised 38.2.1 effective March 1, 2007

Table 38.1
Ampacities of control circuit conductors

Revised Table 38.1 effective March 1, 2007

Ampacity, amperes	Conductor size	
	AWG	(mm^2)
10	16	(1.3)
7	18	(0.82)
5	20[b]	(0.52)
3	22[b]	(0.32)
2	24[b]	(0.20)
1	26[b]	(0.13)
0.8	28[a, b]	(0.08)
0.5	30[a, b]	(0.05)

[a] Where these conductors are contained in a jacketed multi-conductor cable assembly.

[b] These sizes of conductors are only for connection of control circuits for electronic programmable input/output and static control (having no moving parts).

a) Only if the wire is contained in a closed connector or bush housing when connected.

b) Only for connecting electronic signals.

4.3.2.3 Isolating device

A control circuit supplied by an isolated (independent) power supply unit shall have a "Disconnecting Means" (isolating device). This device shall meet **UL 508A § 30**.

4.3.2.4 Overcurrent Protection UL 508A § 40

Components which can be used

1. Branch circuit protection according to **UL 508A § 31.1.2**
2. Circuit breaker (Inverse Time) - **UL 508A § 31.1.1**; e.g. 3VL, 3RV, 5SJ4 ... HG
3. Special fuse according to **UL 248 - 14**
4. Supplementary Protector according to **UL 1077**; e.g. 55J

If fuse holders are being used, they shall be approved according to **UL 512**.

Installation

Branch circuit protection (see (1) + (2) above) shall be installed in each ungrounded "conductor" if the control voltage is provided by an independent (isolated) source.

If the wire cross section is smaller than it should be for the upstream protective device, a suitable overcurrent protection device needs to be installed where the wire cross section is reduced.

Sizing

The maximum size of the branch circuit protection is set to 20 A.

Sizing depends on the

- current carrying capacity of the wire
- maximum permissible current consumption of the connected devices

A standard (general use) socket in the control circuit shall be equipped with branch circuit protection that does not exceed the socket's rated current.

In addition, the socket should only be used for programming and diagnostic devices, and must be marked accordingly.

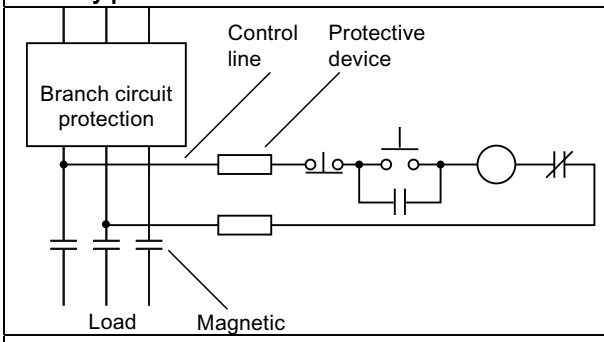
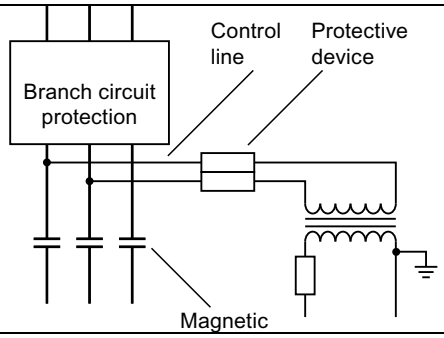
Typical motor control circuits ("Common Control")

This electric circuit is not considered to be a branch and can either be protected using a UL-listed branch circuit protective device, e.g. miniature circuit breaker, Siemens types 5SJ4..HG... (**UL 489**), or an auxiliary protective device (**UL 1077**) (e.g. Siemens type 5SY, 5SX or 5SP). No short-circuit protection is specified for auxiliary switches.

If an auxiliary protective device (**UL 1077**) is used, the electric circuit shall not contain any loads and shall not go outside the industrial control panel.

Exception: If the system is marked for a prospective short-circuit current rating of more than 10 kA, then a UL-listed branch circuit protective device shall be used.
UL 508 Art. 18.2.4

Typical motor control circuit

Auxiliary protective device	Protective device - control transformer
	
3-wire, common control (same voltage as power circuit)	With control transformer

The protective device for the control line shall be designed in accordance with the cross section of the control lines.

Exception 1: Control circuit connected downstream of the branch circuit protection (in the panel)

If this control circuit **does not leave** the Industrial Control Panel , the wire cross section can be selected according to **Table 41.1 (UL 508A)**. Here, the "Maximum Protective device rating" is the rated current of the "motor branch circuit protection".

Table 41.1
Motor branch circuit protection of common control circuit without remote control devices

Table 41.1 effective April 25, 2003

Control circuit wire size		Maximum protective device rating, amperes
AWG	(mm^2)	
22	(0.32)	12
20	(0.52)	20
18	(0.82)	25
16	(1.3)	40
14	(2.1)	100
12	(3.3)	120

Exception 2: Control circuit connected downstream of the branch circuit protection (outside the panel)

If this control circuit leaves the "Industrial Control Panel", the wire cross section can be selected according to Table 41.2 (UL 508A). Here, the "Maximum Protective device rating" is the rated current of the "motor branch circuit protection".

Table 41.2
Motor branch circuit protection of common control circuit with remote control devices

Table 41.2 effective April 25, 2003

Control circuit wire size		Maximum protective device rating, amperes
AWG	(mm^2)	
22	(0.32)	3
20	(0.52)	5
18	(0.82)	7
16	(1.3)	10
14	(2.1)	45
12	(3.3)	60

Note

The "Field wiring Terminals" are to be marked according to UL 508A § 54.

4.3.3 Control circuit with transformer, UL 508A § 42, Control Circuit - Isolated Secondary

4.3.3.1 Control transformers

Device requirements

The control transformer shall conform to either the

- Standard for speciallity transformer **UL 506**

or

- Standard for Dry-typ Purpose and Powertransformers **UL 1516**

The line side shall have its own overcurrent protective device. Sizing according to **Table 42.1 (UL 508A)**.

Table 42.1
Sizing of primary winding only overcurrent protection of a control transformer

Table 42.1 effective April 25, 2003

Control transformer primary current, amperes	Rating of overcurrent protection, maximum percentage of primary current
9 or more	125[a]
2 – 8.99	167
less than 2	500
[a] Where the calculated size of the overcurrent protection, branch circuit or supplementary type, does not correspond to a standard size protective device, the next larger size is able to be used. See 31.3.8 for standard sizes of branch circuit protection.	

a) If the rated current obtained here is not a "standard value" (see **UL 508A 31.3.6**), the next highest standard value may be used.

Exception

An additional form of branch circuit protection can then be dispensed with, if the upstream protective device (Tab. 42.1) already meets the above conditions.

Sizing the overcurrent protection

Both the primary and secondary sides are protected by their own device. Sizing is determined by **UL 508A Tab. 42.2**.

A transformer with several secondary side connections requires a protective device for each of these connections.

Table 42.2
Sizing of primary and secondary overcurrent protection of a control transformer

Table 42.2 effective April 25, 2003

Primary winding		Secondary winding	
Rated amperes	**Overcurrent protection percent of rated amperes**	**Rated amperes**	**Overcurrent protection percent of rated amperes**
9 or more	250	9 or more	125[a]
2 – 8.99	250	less than 9	167
less than 2	500	–	–

[a] Where the calculated size of the overcurrent protection, branch circuit or supplementary type, does not correspond to a standard size protective device, the next larger size is able to be used. See 31.3.8 for standard sizes of branch circuit protection.

a) If the rated current needed here is not a "standard value" (see UL 508A 31.3.6), the next highest standard value may be used.

Exception

An additional form of branch circuit protection can then be dispensed with, if the upstream protective device (Tab. 42.2) already meets the above conditions.

Here the secondary side can be protected by **one** protective device or by a number of parallel protective devices.

Where a number of (parallel) protective devices are being used, the total sum of their rated currents shall **not** exceed the value in Tab. 42.2 (see above).

NOTICE

Control transformers which ONLY operate control circuits may be protected on the primary and secondary sides using "Supplementary Protectors" according to **UL 1077** (e.g. glass fuses, miniature circuit breakers, Siemens type 5SY).

⚠ CAUTION

Control transformers, which switch motors or mixed loads with consumers (e.g. fans, heaters, lights, air conditioning systems, etc.), shall only be safeguarded on the primary and secondary sides using branch circuit protection, i.e. UL-listed fuses (**UL 248**, e.g. class CC) type 3NW1…,2…,3… or circuit breakers (e.g. Siemens, circuit breaker, **UL 489**, type 3RV1742-5..D10 up to 480 V or 5SJ41... up to 240 V).

NOTICE

NEW: For "Industrial Control Panels for Industrial Machinery" only.
UL 508A, Art. 66.3.2.
The secondary side does not have to be grounded if the transformer only supplies the machine's devices (not those of other machines too) and has either a ground-fault signaling lamp or ground-fault circuit breaker.

Practical application

Control transformer, 50 VA and higher, with 230/460 V primary and 120 V secondary. Two primary fuses, class CC type 3NW1…,2…,3… (up to 30 A), and one secondary fuse, Supplementary Fuse, or one miniature circuit breaker are usually used.

- Fuses and fuseholders, class CC, e.g. Siemens type series 3NW1...-OHG., 3NW3...-OHG, and type series 3NW7…-OHG.
- 4AM type control transformer.
- Siemens type 5SY, 5SX or 5SP miniature circuit breaker.

For control elements outside the control panel:
cables shall be laid in conduits.

No conduits needed: When using class 2 transformers (up to 80/100 VA)
or class 2 power supplies (e.g. Siemens type series 3NW7...-OHG), control circuit with power supplies.

4.3.3.2 DC power supply units

Devices up to 10 A

Power supplies for 24 VDC with rated currents of up to approx. 10 A are normally configured for a single-phase infeed voltage of 120 VAC. These are connected to the secondary side of control transformers. Siemens SITOP series power supplies have short-circuit proof inputs and outputs. No protective devices are necessary according to the regulations.

Devices of more than 10 A

Power supplies for currents of more than 10 A are configured for 3-phase input voltages and are connected to the load side of the branch circuit protection in the same way as control transformers.
The same conditions (as for control transformers) shall be met. SITOP power supplies of the old generation are UL-listed with the condition that upstream unit protection is needed. The 3RV is not approved for use as line protection in the USA. We would recommend either fitting a UL-listed fuse or a type 5SJ4 miniature circuit breaker upstream.

Device requirements

- Power supply with isolating transformer according to **UL 1012** or **UL 1950**
- Rectifier bridge with cooling enclosure according to **UL 1012** or **UL 1557**

These devices are installed in enclosures with either

- No ventilation openings
- Ventilation openings without fans, or
- Ventilation openings with filter fans

Sizing

A standard power supply should be loaded with no more than 50% of its rated current. If the device has a number of outputs, each output should be loaded with no more than 50%.

Exception:

Power supplies tested according to **UL 508** can be loaded with up to 100%. As "SITOP" from Siemens is tested according to UL 508, it can be loaded up to 100%.

Each output circuit shall have its own protective device if

- The total sum of the load currents exceeds the power supply's output current

or

- The output circuit leaves the **"Industrial Control Panel"**.

The wire cross section for the output circuit should be sized **according to UL 508A Tab. 28.1** or **UL 508A 38.1**.

4.3.4 Control circuits with low voltages and limited energy

(Low-Voltage Limited Energy Circuits)
For DC and AC circuits

Conditions

UL 508A, Art. 43.2.2

Cable materials that are not listed shall be routed separately. Listed cable materials can be routed in one cable duct with other electric circuits if they are designed for the maximum voltage of all electric circuits.

1. These electric circuits shall be routed in such a way that they are insulated from other electric circuits (see above for exception) and shall be operated by insulated secondary current sources (e.g. control transformers, DC power supplies, batteries (**UL 1989**), lithium batteries (**UL 1641**), current transformers (**UL 506**), current transformers with 5 A on secondary side).
2. The maximum open circuit secondary voltages shall not exceed an rms value of 30 VAC or 42.4 V (DC or AC peak value). **UL 508A, Art. 43.1.2**
3. The overload protection equipment shall not be larger than specified in **UL 508A, Table 43.1**,
(glass fuse, 5SX, 5SY or 5SP miniature circuit breaker, "Supplementary Protectors", **UL 1077**").

Device requirements

- Transformer according to Chapter 4.3.3.1
- Power supply according to Chapter 4.3.3.2
- Sealed battery according to **UL 1989**
- Lithium battery according to **UL 1642**
- Current transformer according to **UL 506**
- Current transformer with 5 A secondary current (...A/5 A)

The maximum no-load or open circuit voltage shall not exceed 30 Vrms, 42.4 V peak value or 42.4 VDC.

Each of these circuits shall have overcurrent protection according to **UL 508A Tab. 43.1**.

UL 508A, Table 43.1

Secondary peak voltage in volts (open)	Overload protection equipment, amperes
0 – 20	5
20.1 – 42.4	100/V [A] ①

① V equals the peak voltage or, with DC, the secondary no-load or open circuit voltage.

Several "limited-energy circuits" can be installed on the secondary side of a control transformer or power supply provided that they meet the conditions of Table 43-1.

A maximum current of up to 20 A or a control transformer of up to maximum 1 kVA is usually applicable to control circuits. **UL 508A, Art. 40.3.1**

Note: The peak voltage shall be used to calculate the overload protection: e.g. Vp (peak) = Vrms x √2;
rms = root mean square

In general, cables with "Class 1 Conductor" approval should be used here.

Outside the industrial control panel, cables do not need to be routed in cable conduits (e.g. for signal lamps, sensors and actuators).

In addition, these terminals shall be marked as described below or in a similar manner (**UL 508A § 54.6**).

- Class 1 control circuit
- Use Class 1 conductors
- For connection to a Class 1 remote control circuit

If these terminals are isolated from the terminals of all the other circuits, there is no need to comply with the sizing requirements described above.

If not, these sizing requirements shall be observed.

Note: UL 508A, Art. 43.2.1

Devices and cables which are located entirely within these control circuits are not required to be investigated by UL. These may feature unlisted devices and cables.

4.3.5 Class 2 electric circuits

Definition

These circuits shall be used if required by the devices involved (e.g. sensors).

Requirements for class 2 devices:

1. Class 2 and class 3 control transformers according to **UL 1585**
2. Class 2 power supplies according to **UL 1310**
3. Temperature sensors (PTC thermistor sensors)
4. Computer power supplies for **"Information Technology Equipment"**
5. Any number of class 2 control transformers (for example) can be installed in an industrial control panel.

Note

Special features UL 508A, Art. 44.2.1

Devices and cables which are located entirely within these control circuits are not required to be investigated by UL. These may feature unlisted devices and cables.

Wiring

Internal wiring only has to be routed separately if the cable or wire used has a lower insulating voltage than the highest voltage in the relevant cable duct or conduit. See **UL 508A § 29.5** (internal wiring).

Terminals (Field wiring terminals of class 2 circuits)

Recommendation

We also recommend isolating the field wiring terminals for Class 2 circuits from the other terminals. A minimum distance of 2 inches (50.8 mm) from the other terminals would be appropriate here. See **UL 508A § 37.4; 37.5; 28.4.1; 28.4.2**.

These terminals should also be marked accordingly. **UL 508A § 54**.

4.3.6 Industrial control equipment in control circuits UL 508A § 45

Device requirements

- Auxiliary contacts according to **UL 508** recommended for "General industrial use"
- Special switching devices according to **UL 1054**
- Time switches according to **UL 917**
- Temperature controllers according to **UL 873**

Sizing of control devices

- Rated voltage not lower than control voltage
- Rated current not lower than the total of all rated currents flowing through this device
- A "Rating" according to **Table 45.1** (**UL 508A**)

Table 45.1
Required controller ratings for various load types

Table 45.1 effective April 25, 2003

Controller rating		Control circuit load types	Sizing
Type	Units		
ac resistive	ac amperes	ac control transformer, power supply, solid-state circuit device, pilot lamp or LED, annunciator or buzzer	up to 10 percent of ampere rating
ac general-use	ac amperes	ac non-motor-operated device-controlled transformer, power supply, ac solid-state circuit device, ac pilot lamp or LED, ac annunciator or buzzer	up to 100 percent of ampere rating
ac general-use	ac amperes	solenoid, valve, relay coil	up to 10 percent of ampere rating
dc general-use	dc amperes	dc non-motor operated device, dc solid-state circuit device, dc pilot lamp or LED	up to 100 percent of ampere rating
ac pilot duty	contact rating code,	ac relay or contactor coil,	VA rating per Table 45.2
	″light duty,″	control transformer,	125 VA
	″standard duty,″	solid-state circuit device,	360 VA
	″heavy duty,″	pilot lamp or LED,	720 VA
	horsepower	annunciator or buzzer	VA rating per Table 45.4
dc pilot duty	contact rating code	dc relay or contactor coil	VA rating per Table 45.3

Group categorization of industrial control equipment in control circuits

Industrial control equipment in control circuits is also categorized by **NEMA, ICS-5**:

- Suitable for Heavy Duty: A150, A300 and A600 as well as N150, N300 and N60
- Suitable for Standard Duty: B, C, D and E as well as P, Q, and R in different voltages **UL 508A, Table 45.2/45.3**

- Fuse details do not have to be marked on the nameplate for control circuit devices.

Groups for alternating current

Rating codes for AC control circuit contacts at 50 and 60 Hz;
(**UL 508A Table 45.2**)

*) Contact rating Code designation	Thermal continuous test current [A]	Maximum make or break current [A]								Maximum volt-amperes	
		120 V		240 V		480 V		600 V			
		Make	Break	Make	Break	Make	Break	Make	Break	Make	Break
A150	10	60	6.0	-	-	-	-	-	-	7200	720
A300	10	60	6.0	30	3.0	-	-	-	-	7200	720
A600	10	60	6.0	30	3.0	15	1.5	12	1.2	7200	720
B150	5	30	3.0	-	-	-	-	-	-	3600	360
B300	5	30	3.0	15	1.5	-	-	-	-	3600	360
B600	5	30	3.0	15	1.5	7.5	0.75	6	0.60	3600	360
C150	2.5	15	1.5	-	-	-	-	-	-	1800	180
C300	2.5	15	1.5	7.5	0.75	-	-	-	-	1800	180
C600	2.5	15	1.5	7.5	0.75	3.75	0.375	3.0	0.30	1800	180
D150	1.3	3.6	0.6	-	-	-	-	-	-	432	72
D300	1.0	3.6	0.6	1.8	0.30	-	-	-	-	432	72
E150	0.5	1.8	0.3	-	-	-	-	-	-	216	36

*) The numerical suffix designates the maximum voltage design values, which shall be 600, 300, 150 volts for suffixes 600, 300, and 150, respectively.

Groups for direct current

Contact rating codes for DC control circuit contacts
(**UL 508A Table 45.3**)

*) Contact rating code designation	Thermal continuous test current	Maximum make or break current [A]			Maximum make or break VA at 300 volts or less
		125 V	250 V	301 to 600 volts	
	[A]				[VA]
N150	10	2.2	-	-	275
N300	10	2.2	1.1	-	275
N600	10	2.2	1.1	0.40	275
P150	5.0	1.1	-	-	138
P300	5.0	1.1	0.55	-	138
P600	5.0	1.1	0.55	0.20	138
Q150	2.5	0.55	-	-	69
Q300	2.5	0.55	0.27	-	69
Q600	2.5	0.55	0.27	0.10	69
R150	1.0	0.22	-	-	28
R300	1.0	0.22	0.11	-	28

*) The numerical suffix designates the maximum voltage design values, which shall be 600, 300, 150 volts for suffixes 600, 300, and 150, respectively.

Table for converting horsepower (hp) to volt-amperes (VA)

UL 508A § Table 45.4
Conversion of horsepower to VA load ratings

Table 45.4 effective April 25, 2003

Switch rating, horsepower	Corresponding volt-ampere rating, VA
1/10	144
1/8	182
1/6	211
1/4	278
1/3	345
1/2	470
3/4	662
1	768

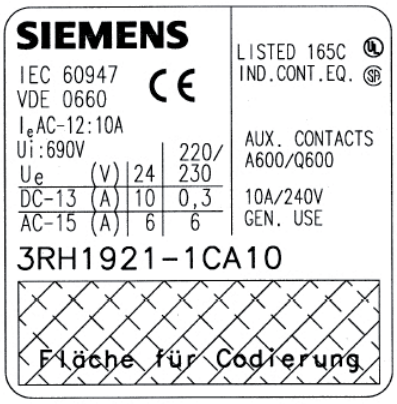
Information on the nameplate

Power coding of the switching capacity of control circuit devices, such as auxiliary switches, position switches, pushbuttons, auxiliary contactors, time relays, overcurrent relay contacts, time counters, insta contactors, position switches, etc. are stated with the letters A to E for AC and N to R for DC devices, plus the voltages 150 V, 300 V and 600 V; this means, for example, the 150 V switching capacity shall be selected for devices in 24 V control circuits.

A device, marked with a switching capacity of A600, can make at 460 V 15 A and break at 1.5 A.

The make and break capacity of these devices is stated on the nameplate for different voltage levels. It is similar to the details according to IEC e.g. AC-15.

Fuse details do not have to be marked on the nameplate for control circuit devices.



Arranging control circuit contacts

In principle, ungrounded circuits shall always be switched.

Exceptions

1. Electrical interlock for "multi-speed" motor controllers where these do not leave the controller's enclosure
2. Bi-metal/contacts within the device enclosure
3. Items of multi-pole industrial control equipment which simultaneously open both "sides" of the control circuit
4. Ground fault detectors
5. Test switches/buttons, solenoid valves in these cases
6. Contacts or solenoids in electronic contacts
7. Start-buttons for two-hand operation where both "sides" are protected by an overcurrent protective device

Undervoltage protection

After an undervoltage tripping, phase failure or overload trip, neither motors nor motor-driven loads shall be allowed to start up automatically.

Exceptions

1. Fans, as long as the moving parts are protected against contact
2. Pumps
3. Lighting installations

4.3.7 Control circuit loads

Device requirements

- Indicator lights according to **UL 508A**
- Lampholders according to **UL 496**
- Solenoid valves **UL 429**
- Magnet coils, if approved for this purpose (see UL report for the relevant device). Siemens magnetic controllers and relays are approved for this purpose.
- Timing devices and counters according to **UL 863**
- Acoustic signal transmitters according to **UL 464**

Note

Every electromechanical part (e.g. magnet coils, solenoid valves, indicator lights, etc.) shall be directly connected by means of a connection to the grounded side of the control supply voltage.

Exception: See Industrial control equipment in control circuits UL 508A § 45

Determining the control circuit load

- Device performance data (A, VA, W)
- For devices without performance data, see **UL 508A Table 46.1**

Table 46.1
Relay or contactor coil ratings

Table 46.1 effective April 25, 2003

Relay or contactor maximum ampere rating of contacts	Coil, VA
10	30
30	30
50	75
100	100
150	100
300	125
Load contact switching capacity	Solenoid power consumption

4.3.8 Other devices

General devices

- Overvoltage protection according to **UL 1449**
- EMC filters according to **UL 1283**
- Dry capacitors according to **UL 508**

Sizing

All devices shall be approved, as a minimum, for the voltage of the control circuit where they are to be used.

EMC filters shall be designed, at least, for

- The total of all load currents flowing through them, and
- The rated current of the wire connected to them

Resistors

As far as resistors are concerned, the same rules apply as for resistors in load circuits **(UL 508A § 36.2)**.

If they have to be operated from outside, they should only be connected to isolating transformers or power supplies with isolating transformers.
In these cases, the maximum voltage is 30 VAC or 42.4 VDC.

4.3.9 Unlisted devices in electric circuits

UL 508A, B1

(Use of components not UL Listed or Recognized in Industrial Control Panels)

These devices, which have not been inspected by UL, shall always correspond to the standards of **UL 508A**.

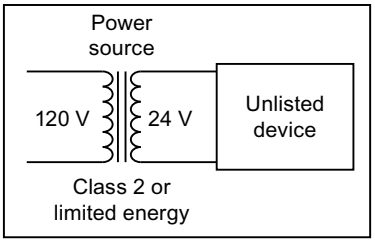
Unlisted components and devices

An unlisted component can be submitted to UL for inspection. The person submitting the component shall submit all electrical and material data (e.g. the parts list of all electrical components on a **PCB and the PCB material, etc.)**.
Unlisted electrical devices can be installed according to UL 508A B2 in the following electric circuits:

- Up to 30 VAC rms (42.4 V peak value) and 42.4 VDC
- For 115/120 V and 230/240 V

Electric circuits of up to 30 VAC rms (42.4 V peak value) and 42.4 VDC

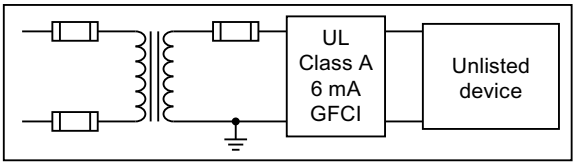
These are electric circuits that are supplied with limited energy (see "low-voltage limited energy control circuits") by one current source (LVLE – Low Voltage Limited Energy) or by a class 2 transformer or class 2 DC power supply (see class 2 electric circuits).



115/120 V and 230/240 V electric circuits

If they are operated by a listed ground-fault circuit interrupter (GFCI) (UL class A, 6 mA). The unlisted components shall also be totally encapsulated within the panel. Alternatively, they can protrude from the panel if they are no larger than 30 square inches (194 cm^2) for plastic and 100 square inches (645 cm^2) for metal or glass.

In terms of ventilation openings, this component should be treated like an arcing device. The power supply shall come from a transformer with an insulated secondary winding; grounded on one side. The GFCI shall also be tested. This test shall be recorded in a report and the report submitted to UL on request. **UL 508A Table B3.1**. A warning sign on the industrial control panel shall indicate this unlisted component.



Unlisted devices are not permitted as:

UL 508A, B1

- Devices that switch power circuits (e.g. motor loads, short circuit and ground fault)
- Devices in electric circuits with particular safety regulations (e.g. cathode ray tubes, flammable gases, high pressure [greater than 300 psi – 2.08 Mpa])
- Devices which are tested for other applications
- Devices with links to power circuits (i.e. do not correspond to UL 508A)
- Devices which are installed insulated from the ground fault circuit interrupter

Plastic parts in direct contact with live parts (installation parts) shall be tested in accordance with UL 508A (flame class according to UL 94).

4.4 Cabinet lighting for repairs and service

Lighting regulations UL 508A § 27

If industrial control panel lights are fitted in enclosures, the following conditions shall be met:

- An illuminant for incandescent lamps shall meet the conditions laid down in **UL 496**.
- Voltage for incandescent lamps shall not exceed 150 V.
- A fluorescent lamp shall meet the conditions laid down in **UL 1598**.
- An incandescent lamp or fluorescent lamp, used as a kit for enclosures in industrial control panels, shall correspond to the standards of **UL 508** "Industrial Control Equipment".

Panel lighting circuits shall be sized in accordance with the conditions for power circuits (**UL 508A 28...36**).

Exception

A 120 V light which is **only** suitable for use within the enclosure can be connected to a transformer with an insulated secondary circuit and sized in the same way as a power circuit (**UL 508A 37 - 44**). For example, it is possible to use devices according to **UL 1077**.

Regulations for lighting with receptacles

The conditions for receptacles, **UL 508A § 31.5** and **§ 40.35**, shall also be observed.

4.5 Receptacles in industrial control panels

Receptacles in industrial control panels

- Lighting with one or more receptacles:

  Note: Receptacles shall be listed. An example is the type 5TE6804 receptacle according to **UL 498**. SCHUKO receptacles in accordance with the VDE standard shall not be used in the USA. Examples include receptacles for use in feeders 5TE6800 or 5TE6801. Receptacles in industrial control panels for outdoor use, type 3R (rainproof), shall be fitted with fault current tripping (Class A, Ground Fault Circuit Interrupters).

Note

Most industrial control panel makers offer a range of lights and receptacles which can be used in the USA.

- Power circuit **UL 508A Art. 31.5**
  These electric circuits shall be protected using branch circuit protection (devices according to **UL 489**, fuses according to **UL 248**, such as Class CC).
  The protection equipment shall have the same rating as the receptacle.

Exception 1

20 A branch circuit protection can be used to protect a 15 A receptacle.

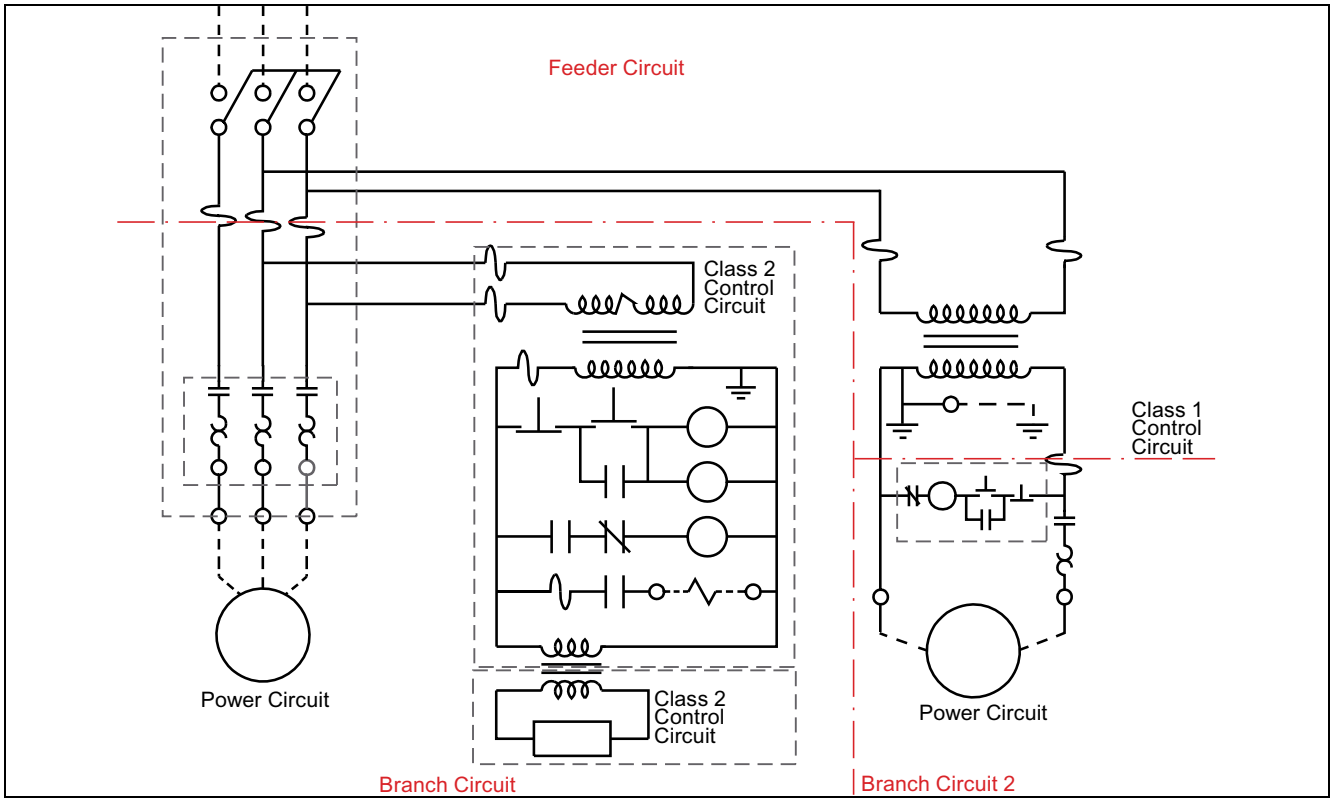
Exception 2

If a branch circuit protection with a lower rated current than the receptacle is used, the receptacle shall be marked with the lower rating in accordance with **UL 508A § 59.1** and may only be used for a "special" device.

5TE6804 receptacles according to UL 498


4.6 Branch circuit - Feeder circuit - Distances through air and over surface

Definition



Feeder circuit

Starting from the load, all devices and components upstream of the first "overcurrent" branch circuit protective device.

Branch circuit

Starting from the load, all devices and components up to the first "overcurrent" branch circuit protective device.

Note

The Feeder Circuit details also apply to the power supply terminals of the branch circuit protective device.

Feeder and branch spacing - distances through air and over surfaces

The new edition of **UL 508A** defines in detail and for the first time ever the difference in distances through air and over surfaces between electric circuits in feeder circuits and branch circuits. This difference also determines the selection of protective and control devices.

- **Feeders:**
  Special field wiring terminals, fuseholders and busbars shall be spaced far apart. Protection devices shall be listed. These include Listed Circuit Breakers, SIRIUS type 3RV17/3RV18 and 5SJ..HG.. miniature circuit breakers, and SENTRON type 3VL or listed fuses, such as class J, CC or RK5.
  The following shall NOT be used: Supplementary Protectors such as 5SX, 5SY or 5SP miniature circuit breakers, which are approved as Supplementary Protectors or 3RV10 motor circuit breakers marked with MAN. MTR. CNTRL.

Spacing in feeder circuits: Extract from UL 508A Table 10.2

	125 V or less		126 - 250 V		251 - 600 V	
	inch	mm	inch	mm	inch	mm
Distance through air	1/2	12.7	3/4	19.1	1	25.4
Distance over surface	3/4	19.1	1-1/4	31.8	2	50.8
Between uninsulated live parts and enclosure	1/2	12.7	1/2	12.7	1 *1/2	25.4
*) For details and exceptions, see **UL 508A**						

- **Branches:**
  Devices and busbars with smaller spacings can be selected within the branch. The input terminals of the branch circuit protective device (BPCD) shall, however, have larger spacings. See table below.
  Downstream of the BCPD, control devices such as SIRIUS 3RT magnetic controllers, 3RU and 3RB overload relays, 3RV motor circuit breakers (marked with MTR. CNTRL.) and 3LD disconnect switches (repair switches) can be used depending on their ratings. **UL 508A Art. 10**.

Spacings in branch circuits: Extract from UL 508A Table 10.1

	51 - 150 V		151 - 300 V		301 - 600 V		0 - 50 V	
	inch	mm	inch	mm	inch	mm	inch	mm
Distance through air	1/8	3.2	1/4	6.4	3/8	9.5	1/16	1.6
Distance over surface	1/4	6.4	3/8	9.5	1/2	12.7	1/16	1.6
Between live wire and enclosure	1/2	12.7	1/2	12.7	1/2	12.7	1/4	6.4
For details and exceptions, see **UL 508A Table 10.1**								

Example of Branch Circuit Protective device with large distances through air and over surface

3RV als LISTED COMBINATION MOTOR CONTROLLER , TYPE E

Nameplate of 3RV as LISTED COMBINATION MOTOR CONTROLLER , TYPE E

MAN. SELF-PROT.COMB.MTR.CNTR.
SHORT-CIRCUIT CURRENT RATING
RMS, SYM: 65KA, 240V, 480Y/277V;
30KA, 600Y/347V
UL CERTIFIED: WITH 3RV1928-1H
ADAPTER ONLY OR WITH 3RV1925-5EB
AND 3RV1915 AND AS TYPE F COMB.
WITH 3RT1.2 OR 3RW3.2

MAN. MTR. CNTR. SUITABLE FOR USE IN
GROUP APPLICATION.
FOR WIREPROT. MAX. FUSE OR CB 90A.
SHORT CIRCUIT CURRENT RATING
RMS, SYM: 65KA, 480V; 30KA, 600V
UL CERTIFIED: AS TAP CONDUCTOR PROT.
DEVICE IN GROUP APPLICAT. AND AS MOTOR
DISCONNECT. MAX. FUSE OR CB 250A

LISTED 165C 600 V, 6.3 FLA MAX.

V AC 50/60HZ	200-208	230	460	575
HP,3ph	2	2	5	5

DIAL IS FLA.TRIP AMPS 125%; USE 75°CU WIRE ONLY; BREAK ALL LINES

WARNING: IF AN OVERLOAD OR A FAULT CURRENT INTERRUPTION OCCURS, CIRCUITS MUST BE CHECKED TO DETERMINE THE CAUSE IN A FAULT CONDITION, THE CONTROLLER SHOULD BE EXAMINED AND REPLACED IF DAMAGED TO REDUCE THE RISK OF FIRE OR ELECTRIC SHOCK. TO MAINTAIN OVERCURRENT, AND SHORT-CIRCUIT PROTECTION, THE MANUFACTURER'S INSTRUCTIONS FOR SELECTION OF OVERLOAD AND SHORT CIRCUIT PROTECTION MUST BE FOLLOWED.

Note

The large spacings in feeder circuits apply up to and including the input terminals on the branch circuit protective devices (BCPD). Large terminal blocks shall therefore be fitted; one example is when using 3RV motor circuit breakers as type E and F starters.

Special case of power supply company infeed

Spacings for 251V to 600V
max.
2"/1" - distance through air and over surfaces

For an industrial control panel that also serves as a power supply company infeed ("Service Entrance" or "Service Equipment"), the larger spacings according to Table 10.2 (Feeder Circuit) should always be selected. Other, additional conditions for "Lighting for repairs and service" shall also be met: See **UL 508A § 75.2**

Industrial control panels

5

5.1 Regulations for industrial control panel manufacturing

The actual enclosures are usually approved or tested according to **UL 50/UL 50E**. This standard also defines the "Enclosure Type ratings" (degrees of protection). If a panel with Enclosure Type 1 is sufficient, the panel can also be manufactured according to **UL 508A Art. 62-64**.

Industrial control panel markings

UL 508A Art. 52 pp

The industrial control panel shall have the following information (minimum requirement):

- Name of the manufacturer
- Full electrical characteristics for each incoming feeder
- Field wiring diagram number or designation
- Place of manufacture (only if the manufacturer produces industrial control panels at various locations)
- Industrial control panel degree of protection ≙ Enclosure Type rating
- Short-circuit current rating (**UL 508A SB5.1** and **NEC 2008 Art 409.110**)
- Warning of hazardous arcs
  (Flash Protection – **NEC 2008 Art. 110.16** and **NFPA 70E**)
- Field connections: Power, control current, grounding, neutral
- Fuse table along with class and size of fuses
- Cautionary markings, e.g. multiple feed-ins, capacitor discharge, electric circuits that are not deactivated by the main disconnecting means.
- All devices which are not part of the industrial control panel but which have to be connected to the panel at the site of installation (e.g. circuit breakers).

For other markings, see **UL 508A Table 52.1**.

Technical documentation

UL 508A contains few requirements of the documentation supplied with the industrial control panel. It is generally expected that a circuit diagram, parts list or spare parts list and Operating Instructions for the devices fitted will be supplied with the industrial control panel (e.g. in a pocket in the door).

NFPA 79 on the other hand specifies in Chapter 18 that depending on the complexity of the system, a number of test documents, installation regulations, block diagrams, circuit diagrams, electric circuit characteristics, operating instructions, maintenance instructions and spare parts lists shall be supplied.

The manufacturer and user shall agree on which documents are needed. If the user accepts, circuit diagrams according to the IEC standard can be shipped with the industrial control panel or equipment.

Regulations for open industrial control panels

UL 508A Art. 18

Industrial control panels that are not completely enclosed are considered to be open industrial control panels. The general conditions, such as protection against corrosion, do not differ greatly from other ANSI regulations (e.g. external systems, surface protection with 500-hour salt spray test – is defined by the user).

The North American regulations differ from the IEC standards in this respect.

5.2 Enclosures, accessories for enclosures with a high degree of protection

IP and UL degree of protection

UL 508A Art. 26

Precondition: Enclosure accessories such as fans, air-conditioning equipment, heaters etc. shall be UL-approved.

Comments: Most manufacturers of UL-listed enclosures have also tested all the accessories needed.

A comparison between IP degree of protection and enclosure ratings is nothing more than a rough estimation because the tests and the pass and fail criteria are different. The table below gives you an overview of the different degrees of protection. The correlation was published by NEMA. This can only be used for the direction from the NEMA to IP degree of protection, but not vice versa.

According to UL, enclosures with IP data alone are automatically awarded Enclosure rating 1 only, whatever the level of their IP degree of protection.

Enclosure identification and enclosure rating Type Protection vs. IP Ingress Protection

UL/NEMA *)		Place of installation (typical application)	Protection against	Comparable IP degree of protection
Type				
1	General use	Indoor	Accidental contact with live parts and ingress of falling dirt	IP20
2	Protection against dripping water	Indoor	Ingress of dripping water and falling dirt	IP22
3R	Rain, hail, ice	Outdoor (starter for pump)	Ingress of dust and rain blown by the wind, and protection from icing over	
4	Dustproof, waterproof	Indoor/outdoor (food industry)	Ingress of falling rain, splashwater and jet-water, no damage should ice form	IP65
4x	Dustproof, waterproof, resistant to corrosion	Indoor/outdoor (water treatment plants, manure production)	Ingress of falling rain, splashwater and jet-water, no damage should ice form, anti-corrosion protection	Does not exist
12	Protection against dripping water, dustproof, oil and cooling-water proof	Indoor (machine tools)	Ingress of dripping water, dust, oil and cooling liquid	IP54 (IP55)
13	Protection against dripping water, dustproof, oil and cooling-water proof	Indoor (command devices on machine tools)	Ingress of dripping water, dust, spraying oil and cooling liquid	IP54+

*) **New:** In **UL 508A** – 3RX, 3SX and 3X are type 3 with extra corrosion protection requirements (not listed).

Special features:

Degrees of protection are specified both in **NEC 2008** and by UL using type numbers, such as type 12. The degree of protection is, however, stated in most manufacturers' catalogs using the NEMA designation, such as NEMA type 12 (**NEMA ICS-6**).

Note:

- UL vs. NEMA: An enclosure built in accordance with NEMA (standard ICS-6) is not automatically UL-listed. It shall be examined by UL for the enclosure rating (UL type 1) and tested (UL type 3R, 12, 4, etc.).
- For UL / NEMA type 1: If there are uninsulated, current-carrying conductors in the industrial control panel, the panel shall have a roof to protect against falling dirt.
  UL 508A, Art. 21.2.1
- If a water-cooled converter is installed in an industrial control panel, mechanisms shall be put into place to ensure that water does not touch any of the current-conducting parts should a water pipe burst (preferably fit these in a separate panel).
  [not in **UL 508A** – but applied] **UL 1741**
- New: In **UL 508A** – swiveling mounting panels (only for "Industrial Control Panels for use in Industrial Machinery"). It shall be possible for these mounting panels to swivel by more than 110 degrees.
  UL 508A, Art. 66.1.3
- New: In **UL 508A** – 3RX, 3SX and 3X are type 3 with extra corrosion protection requirements.

Extract from UL 50E:
List of all currently applicable "Enclosure ratings" for "NON-Hazardous" locations

Table 1
Comparison of specific applications of enclosures for indoor and outdoor nonhazardous locations
(See 6.3)

Provides a degree of protection against the following environmental conditions	Type of enclosure												
	1[a]	2[a]	3	3R[a]	3S	4	4X	5	6	6P	12	12K	13
Incidental contact with the enclosed equipment	X	X	X	X	X	X	X	X	X	X	X	X	X
Falling dirt	X	X	X	X	X	X	X	X	X	X	X	X	X
Dripping and light splashing of non-corrosive liquids		X	X	X	X	X	X	X	X	X	X	X	X
Rain, snow, and sleet[b]			X	X	X	X	X		X	X			
Sleet[c]					X								
Circulating dust, lint, fibers, and flyings[d]			X		X	X	X		X	X	X	X	X
Settling airborne dust, lint, fibers, and flyings[d]			X		X	X	X	X	X	X	X	X	X
Windblown dust			X		X	X	X		X	X			
Hosedown and splashing water						X	X		X	X			
Oil and coolant seepage											X	X	X
Oil or coolant spraying and splashing													X
Corrosive agents							X			X			
Occasional prolonged submersion										X			

[a] These enclosures may be ventilated.

[b] External operating mechanisms are not required to be operable when the enclosure is ice covered.

[c] External operating mechanisms are operable when the enclosure is ice covered. See 8.5.2

[d] These fibers and flyings are nonhazardous materials and are not considered Class III type ignitable fibers or combustible flyings.
(For Class III type ignitable fibers or combustible flyings, see the Canadian Electrical Code, Part I, Section 18, the National Electrical Code, Article 500, or Mexico`s NOM-001-SEDE, Electrical installations (utility), Article 500)

5.3 General issues concerning device selection

Selection of devices for industrial control panels (Table SA1.1 in UL 508A)

Devices that can be installed in industrial control panels in accordance with **UL 508A** are listed in **UL 508A** Supplement SA, **Table SA1.1**. The table shows the paragraph reference, the UL standard in accordance with which these devices are listed, the category control number (CCN) and the conditions under which the devices may be used.

The CCN shall be used to search the UL website for the devices (manufacturer, catalog number) which are to be fitted in the industrial control panel. It shall be established whether these devices can be used for the "Industrial Control Equipment" application.

Not all devices which are UL-listed or UL-recognized can be automatically installed in an industrial control panel according to **UL 508A**. The devices shall be approved for the application. For example, terminal blocks "recognized" for "Communication Equipment" cannot be used. Only terminal blocks "recognized" for "Industrial Control Equipment" may be fitted in industrial control panels according to **UL 508A**. The user shall however also take into account the distances through air and over surfaces (see feeder circuits and branch circuits).

Table SA1.1
Components that comply with specific requirements

Table SA1.1 revised September 1, 2005

Paragraph reference	Component description	UL Standard	Category control number(s)	Notes
Section 12 – Insulating Barriers meeting component selection requirements of 12.2				
12.2(a)(1)	Generic materials	–	–	Type and minimum thickness as specified in Table 12.1, dimensions of barrier shall also comply with 12.1
12.2(a)(2)	Recognized Sleeving	UL 1441	UZFT2	90°C (194°F) minimum and for voltage involved, as noted on Recognition Information Page, dimensions of sleeving applied shall also comply with 12.1

Part of the SA1.1 table

5.4 Regulations for noncurrent carrying metal parts in an industrial control panel

All non-current carrying metal parts shall be conductively connected to one another if there is the risk of them becoming energized for reasons such as a breakdown of insulation or loose wiring connections and if they could thereby produce a dangerous situation. **UL 508A Art. 14**. If command devices (pushbuttons, indicator lights) are fitted on doors on which devices with voltages of more than 30 Vrms are installed, these shall be connected to the industrial control panel using grounding wires. **UL 508A Art. 66.3.4**

For the minimum cross section of connecting wires, see **4.1.3** or **UL 508A Table 15.1**.

Exception: When using "piano hinges" as the door hinges, no extra grounding cables need be used. Special, listed shims which penetrate the paint on metal parts are authorized as grounding shims for screwed connections.

Checking continuity of connections between metal parts (Protective Bonding)

Two methods are used:

1. According to **UL 508**, [not **UL 508A**] Industrial Control Equipment, Art. 6.7:
   Resistance measurement across two points of one connection: The resistance shall not exceed 0.1 Ohm, measured using a resistance measuring instrument. If the results are not acceptable, the resistance can also be calculated as follows:
   Between the metal part in the enclosure and the ground terminal of the incoming, the resistance is calculated by measuring the voltage drop, if there is a current of at least 20 A AC or DC, fed from the supply (not more than 12 V). The resistance is calculated by dividing the voltage drop by the current.
2. According to **NFPA 79 Art. 18/18.2**:
   Resistance measurement across two points of one connection: The resistance shall not exceed 0.1 ohms.
   A current of 10 A is provided, produced by an SELV (safety extra low voltage) current source; the voltage drop is measured between the equipment ground terminal and specified points on the industrial control panel; the voltage drop shall not exceed that given in the table, compared with the cross section of the equipment grounding conductor:

Maximum authorized voltage drop on grounding conductor at 10 A testing current

Minimum equipment grounding conductor	Maximum authorized drop in voltage
18 AWG	3.3 V
16 AWG	2.6 V
14 AWG	1.9 V
12 AWG	1.7 V
10 AWG	1.4 V
> 8 AWG	1.0 V

5.5 Doors and cover plates

Regulations for doors and cover plates

UL 508A Art. 63.2

Industrial control panel doors should have captive fasteners which can be operated by hand or using a simple tool (e.g. screwdriver).

The interlock should lock the door over its entire length. A door, more than 48 inches (1.2 m) in length, measured from the hinged end, should have two or more interlocks.

It shall be possible for the door to open by 90º.

UL 508A Art. 18.4

A door should be present if the industrial control panel contains the following devices:

- Power fuses
- Circuit breakers requiring actuation.
- Motor overload relays which require replacement or actuation.
- Other components, such as time relays or recording appliances which require maintenance or actuation within the panel.

Exceptions

A door is not required; a cover plate is sufficient:

- If the fuse only has to be replaced in the event of a short circuit.
- If the fuse only protects control circuits located in the panel.
- If there are fixtures in place to actuate the overload relay from the outside.
- If a removable cover plate has an interlock with operating handle which allows the panel to be disconnected from the power source (free of hazardous voltage) before the cover is removed

5.6 Fitting components in enclosure openings

5.6.1 Regulations for fitting components

Permitted types

UL 508A, Table 19.1 & 2

Devices which are fitted in industrial control panel openings shall be of the same Enclosure rating Type (e.g. operating handles, ammeters and voltmeters, pushbuttons, indicator lights, fans, filters, and fasteners for openings, etc.). The type definitions and types of device authorized for special enclosures are stated in **UL 508A Table 19.1 & 2**.

Alternative applications

UL 508A, Table 19.3

If different types of devices are to be fitted in an enclosure (alternative applications), the resulting type of the entire enclosure is specified.

Example of practical application

1. IEC/IP degrees of protection

Panel:	IP54
Measuring device:	IP42
Pushbutton:	IP64

⇒ Overall degree of protection: IP42

2. UL-Enclosure rating – Openings for Cable conduits

Tab. 19.1 Indicates how openings should be dealt with here, depending on the enclosure type rating.

3. UL-Enclosure rating – Retaining current panel Ratings

Tab. 19.2 Indicates the "enclosure rating" devices shall have if they are **not** to lose the desired (target) enclosure rating.

4. UL-Enclosure rating – Device installation with other Enclosure ratings

Differs from Tab. 19.2 (see above)

Tab. 19.3 Indicates which overall degree of protection can be attained.

5.6.2 Ventilation openings

Regulations for ventilation openings

Ventilation openings are permitted with restrictions.

UL 508 Art. 7.9, UL 508A Art. 21

Ventilation openings and covers (barriers) for fan openings

UL 508A Art. 21.2

Ventilation openings:

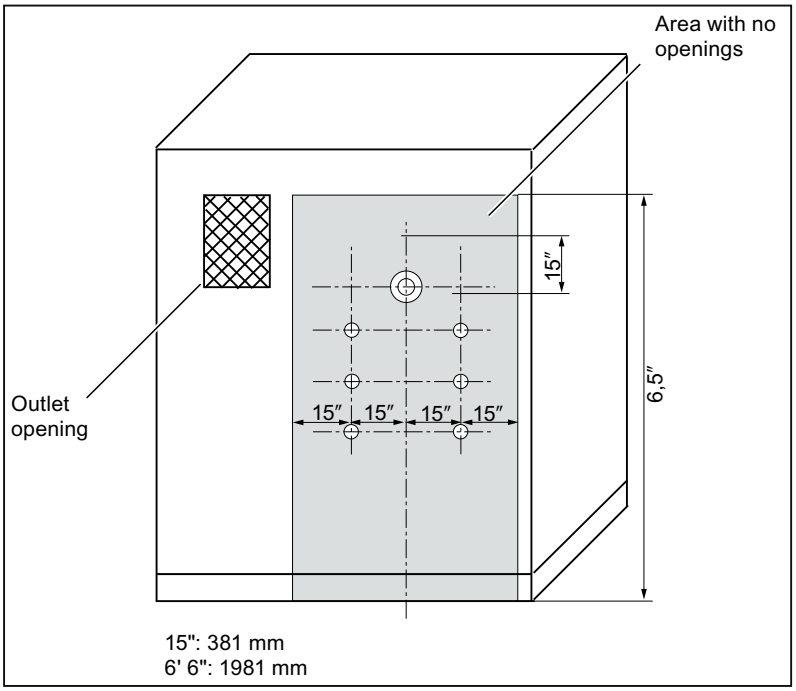
- Shall not be located on top of the industrial control panel unless they are fitted with a cover plate ("Hood or Shield") to protect against falling dirt.
  Exception: A hood or protective shield is not required over ventilation openings to a compartment of an industrial control panel where no uninsulated live parts are present.
  UL 508A Art. 21.2.1
- Shall not be directed at the area occupied by the equipment operator i.e. there shall not be any control elements (such as operating handles, pushbuttons, indicator lights) next to the outlet opening.
  UL 508A Art. 21.2.2
- The minimum distance between devices with arcing parts (e.g. circuit breakers, magnetic controllers) and openings is 12 inches (305 mm). If this distance is not observed, barriers shall be fitted. **UL 508A Art. 22.1, Fig. 22.1**

Note

The size of metal or plastic mesh panels for ventilating the industrial control panel shall not be more than 12 inches (305 mm) long and the area shall not exceed 200 square inches (0.129 m^2), etc.
See **UL 508A, Art. 21.3.**

Fan outlet openings (forced air outlet)

Shall not be directed at the area occupied by the equipment operator (i.e. there shall not be any control elements such as operating handles, pushbuttons, indicator lights next to the outlet opening). Horizontally, this range covers 30 inches (762 mm) in total for the areas to either side of the center line of each control element or indicator (15 inches either side of this line). Vertically, this range covers the entire height of a wall-mounted enclosure or in the case of an enclosure that is standing on the ground, a maximum of 6 1/2 feet (1,981 mm).
UL 508A Art. 21.2.2



5.6.3 Observation window

Regulations for observation windows

UL 508A, Art. 23

Only approved for type 1 or UL shall test the application.

Glass window: No more than 102 mm (4 inches) in any dimension (including the diagonal: shall not be less than 1.4 mm (0.055 inch) thick or more than 305 mm (12 inches) in any dimension (including the diagonals): shall not be less than 2.92 mm (0.115 inch) thick

Plastic window: Size not exceeding 2.452 mm^2 (380 square inches): minimum thickness 3.2 mm (1/8 inch) & flammability rating 5 VA

5.6.4 Fans / blowers

Regulations for fans and fan motors

Approval according to **UL 507** is needed for fans.

UL 508A Art. 26.2

Approval according to **UL 1004** is needed for fan motors.

UL 508A Art. 26.2.2

Overload protection

UL 508A Art. 26.2.4

Each fan or motor shall incorporate one of the following forms of overload protection to protect against a locked rotor:

1. Thermal protection complying with **UL 2111**, where the motor is marked "thermally protected" or "T.P."
2. Impedance protection according to **UL 2111**, where the motor is marked "Impedance protected" or "Z.P."
3. Conventional motor protection, e.g. bi-metal or PTC thermistor detector.

5.7 Other built-in panel devices

5.7.1 Cabinet air conditioner

Regulations for fitting cooling apparatus / heat exchangers (Cabinet air conditioner)

UL 508A Art. 26.3

A panel air conditioner fitted in the enclosure shall comply with the conditions of **UL 484** and be declared as a cooling device for industrial control panels. It shall also be entered in the UL file (Panel Listing File) of the industrial control panel builder, under "special type".

5.7.2 Cabinet heaters

Regulations for fitting industrial control panel heating (Cabinet heater)

UL 508A Art. 26.4

Electrical industrial control panel heating shall comply with the conditions of **UL 499** and shall be installed at least 2 inches (50.8 mm) away from plastic parts and wiring. The internal wiring shall be approved for a temperature rating of >200 °C (only applies if the wires are connected to the heater itself, e.g. "Strip Heaters").

5.7.3 Air filters

Regulations for fitting air filters

UL 508A Art. 26.5

All ventilation openings shall be fitted with filters to reduce the level of pollution if the enclosure contains PLCs, power supplies, IT equipment or power conversion equipment (converters).

Exceptions

UL 508A Art. 26.5.1

Air filters are not required over ventilation openings if there is no fan in either the enclosure or any device within the enclosure.

5.7.4 Thermal insulation in enclosures

Regulations for thermal insulation

If temperature-insulating or noise-insulating materials are fitted inside the enclosure, these shall:

- Be supported by mechanical means (i.e. not adhesive).
- Be 1/2 inch (12 mm) or more away from uninsulated, live parts and 12 inches (305 mm) away from arcing parts (use barriers). UL 508A Art. 26.6

Insulation material

- Materials for barriers: UL 508A Art. 12
- Are used between live parts and to ground to increase the distances through air and over surface.
- The material may be in direct contact with live parts.
- The material does not serve to physically support the installation of devices and parts or to maintain electrical spacing.
- For suitable materials and their minimum thicknesses, see Table 12.1 (e.g. "Fish Paper [electoral grade paper]", Epoxy, Mica, Mylar, "Silicone Rubber", etc.).

Materials that are used for the direct support of uninsulated, live parts:
UL 508A Art. 13. These materials are used for assembly and to maintain electrical spacing. A number of these insulators are available: for example: as thread-bearing spacers (for busbars and terminals) such as "Johnny Balls", and glass-fibre reinforced plates (e.g.Glastic).

5.8 Maximum permissible short-circuit current for "Industrial Control Panels"

5.8.1 General

It is not unusual for industrial control panels to require much higher short-circuit current ratings than the minimum values specified in **UL 508**; see **Table SB4.1** in **UL 508A**. For example: Some GM factories in Detroit have a general requirement that industrial control equipment and panels are approved for 65 kA and 480 V by UL.

Article 409.110 of the **NEC 2008** describes the requirements for the short-circuit withstand ratings marked on industrial control panels (referring to **UL 508A, SB**).

NEC 2008, Art. 409.110 – Marking

An industrial control panel shall be marked with the following information that is plainly visible after installation:

1. Manufacturer´s name, trademark, or other descriptive marking by which the organization responsible for the product can be identified.
2. Supply voltage, phase, frequency, and full-load current.
3. Short-circuit current rating of the industrial control panel based on one of the following:
   a. Short-circuit current rating of a listed and labeled assembly.
   b. Short-circuit current rating established utilizing an approved method
   FPN: **UL 508A**, Supplement SB, is an example of an approved method.
4. If the industrial control panel is intended as service equipment, it shall be marked to identify it as being suitable for use as service equipment.
5. Electrical wiring diagram or the number of the index to the electrical drawings showing the electrical wiring diagram.
6. An enclosure type number shall be marked on the industrial control panel enclosure.

Number 3 of **NEC 2008 Article 409.110** details three different ways of determining the SCCR value of a panel or panel unit (Industrial Control Panel):

Option 1:

Each panel (unit) is officially listed by UL in terms of its SCCR value, a process that is performed by a suitable laboratory in the presence of UL test engineers.
This method makes sense if a large number of panels identical to the tested version are required. A new test may be required if there is any deviation from the tested version.

Option 2:

Using pre-tested versions or buying such pre-tested Standard Industrial Control Panels. This option only seems to be possible when there is access to panels from earlier production runs, and if the panel is listed in the manner described under Option 1.

Option 3:

Full analysis of the Industrial Control Panels according to **UL 508A SB4**.
This seems likely to be the most popular option.
This method is described below.

Comments:

The following description strictly follows the process outlined in **UL 508A, SB4 – Ratings**.

Note

As this point has been completely revised in this edition of **UL 508A** (April 2006), it may well be that this section will need to be modified to a certain extent. Therefore, we strongly recommend that all users check the relevant chapters themselves and decide how **UL 508A** could be interpreted.

5.8.2 Where can you find the short circuit values for industrial control equipment?

Short circuit values in UL device documents

All **UL 508** devices in the power circuit shall be labeled with the UL "Standard short circuit current rating" (this is the lowest short circuit current rating of the UL minimum requirement, based on the device's kW or horsepower values). Under certain circumstances, the protection devices used shall also be identified.

Example: A Siemens magnetic controller, size S2, features Type 3RT103 "5 kA, 600 V MAX. RK5 FUSE / CB: 150 A". This means that the magnetic controller has to be protected using a class RK5 fuse or a circuit breaker of maximum 150 A with thermal delay.

In the case of the UL "Standard short circuit current rating" (**UL 508** – Standard Interrupting Capacity) no indication is given regarding the catalog number of the protection device to be used. A listed device from any manufacturer can be used provided that the specified values are not exceeded.

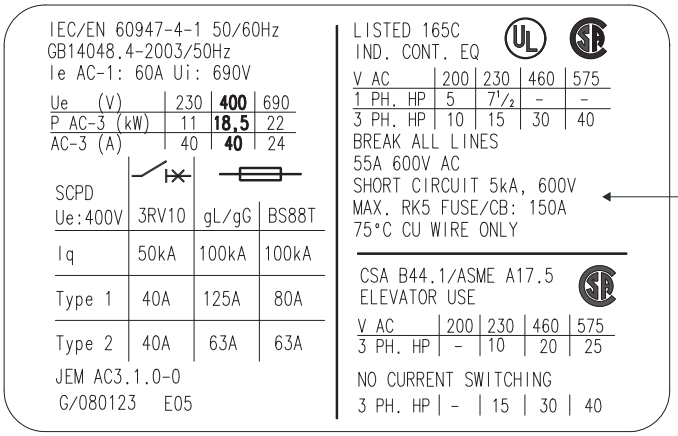
For industrial control equipment which has been tested for the higher short circuit current rating (**UL 508** High Interrupting Capacity), these values are documented in the individual UL reports. When using circuit breakers or miniature circuit breakers, you shall use the specified manufacturer types. The "Class" is specified for fuses (e.g. 100 A, class RK5). **UL 508A Table SB4.2**

Note: A better fuse (class) (i.e. the same or smaller let-through and peak current) of the same class or even a larger fuse of a better class can be used (e.g. instead of 200 A class RK5, you can select 400 A class J). The peak currents (Ip) and let-through currents (I^2t) of the alternative fuse shall be the same as or less than the fuse rating marked on the device. See **Table SB4.2** for the current values of the various fuse classes and their let-through values.

In the following example, the largest fuse is class RK5, 150 A (see nameplate). As **Table SB 4.2** of **UL 508A** has no 150 A fuse of type RK5, the next smaller fuse shall be selected. This would be the 100 A fuse in our example. When we look in the "up to 50 kA" column, we come across an I^2t value of 500 kA^2s and an Ip value of 22 kA. The "up to 50 kA" column has only been selected for illustration purposes. This means that a 200 A class J fuse can be used without testing since this fuse has an I^2t of 200 kA^2s and an Ip of 16 kA.

Example:

Siemens magnetic controller, size S2, type 3RT1035 UL 508A Table SB4.2.3 Exception No. 1



All UL-listed industrial control equipment from Siemens does, of course, meet the minimum short circuit requirements specified in **UL 508**. A great deal of Siemens industrial control equipment is, however, also tested and approved for higher values. The industrial control panel builder shall either determine these values from the corresponding UL report or contact Technical Assistance for them.

Conditions

UL publishes the short circuit ratings for Combination Starters (fuse or circuit breaker plus contactor plus if necessary an overload relais) of the individual manufacturers on a special website. If higher short-circuit ratings are specified than in **Table SB4.1**, the following should be noted: (**UL 508A Art. SB4.2.2 c**)

- All devices in the power circuit shall be listed for the short circuit rating specified. It shall be possible for evidence to be provided of the values (e.g. from the UL report).
- The same applies to the main disconnecting means; either a circuit breaker, miniature circuit breaker (**UL 489**) or disconnect switch (**UL 98**) shall be approved for these values.
- In industrial control panels with a short circuit current rating of more than 10 kA, protection devices in the control circuit which are connected in such that they are not insulated from the power circuit (e.g. by use of control transformers), shall also be approved for these higher values.

Note

All control circuit connections in the feeder circuit, with or without control transformer, shall have branch circuit protective devices (circuit breakers **UL 489** or fuses **UL 248**). These protection devices shall have at least the same SCCR (Short Circuit Current Rating) as the entire industrial control panel (e.g. fuses of class CC are approved for up to 200 kA).

5.8.3 UL 508A - SB 4.1 - "Short circuit current rating" - Overview

The maximum permissible **short circuit current rating (referred to below as SCCR)** of Industrial Control Panels can be determined as follows. It is given as a root-mean-square (rms) value.

- First, the maximum permissible SCCR rating of each individual device has to be listed. This only concerns devices connected directly to the power circuit, including the protection devices for any control transformers. This is described in **UL 508A SB4.2** (see later in document).
- The maximum permissible SCCR rating for the whole or individual parts of the panel can then be modified (increased). This is always possible if short-circuit limiting devices are being used. This is described in **UL 508A - SB4.3** (see later in document). Here too, it is worth identifying and listing each circuit.
- The final step is to determine the maximum permissible SCCR rating for the whole industrial control panel. This is described in **UL 508A SB4.4** (see later in document).

5.8.4 "UL 508A - SB 4.2 - Short circuit current rating of individual power circuit components" - Determining the maximum permissible SCCR of all the devices in the power circuit

A maximum permissible SCCR value shall be given for each device connected directly to the power circuit. These devices include disconnect switches, main disconnecting means, branch circuit protection devices, fuseholders, magnetic controllers, motor starter combinations, overload relays, busbars and terminals.

Exception I:

Power transformers, converters, dry capacitors, resistors, varistors and voltmeters

Exception II:

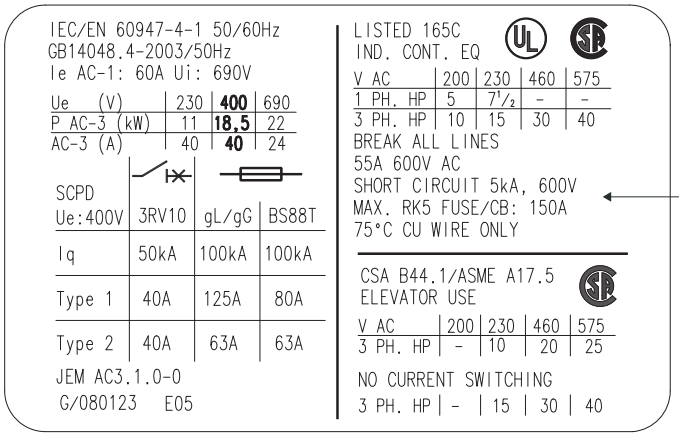
Similarly, there is no need to show the maximum permissible short-circuit current rating for "S" magnetic controllers on wye-delta combinations.

There are three ways of determining the maximum permissible SCCR value for the devices.

Note

The three methods described below can be adopted individually or in combination.

If a maximum permissible SCCR value is given for a particular device, this should be used. These values are usually displayed on the device's nameplate or in the UL report. Values are given in amperes or kiloamperes, and in terms of one or more voltages **(e.g.: 15 kA@480 V)**.



If there is no SCCR value available for a device (on the nameplate or in the UL report), the lower standard value from **UL 508A Table SB4.1** shall be used.
The following table shows an **extract** from the table in **UL 508A SB4.1**.

Table SB4.1
Assumed maximum short circuit current rating for unmarked components

Table SB4.1 effective April 25, 2006

Component	Short circuit current rating, kA
Bus bars	10
Circuit breaker (including GFCI type)	5
Current meters	a
Current shunt	10
Fuseholder	10
Industrial control equipment:	
a. Auxiliary devices (overload relay)	5
b. Switches (other than mercury tube type)	5
c. Mercury tube switches	
Rated over 60 amperes or over 250 volts	5
Rated 250 volts or less, 60 amperes or less, and over 2 kVA	3.5
Rated 250 volts or less and 2 kVA or less	1
Motor controller, rated in horsepower (kW)	
a. 0 – 50 (0 – 37.3)	5[c]
b. 51 – 200 (38 – 149)	10[c]
c. 201 – 400 (150 – 298)	18[c]
d. 401 – 600 (299 – 447)	30[c]
e. 601 – 900 (448 – 671)	42[c]
f. 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 limited to 125-volt circuits.

[c] Standard fault current rating for motor controller rated within specified horsepower range.

The maximum short-circuit current rating for starter combinations that are both UL tested and listed (UL report shall be available). In the case of device combinations such as these, the values from the relevant UL report can be used even if the value for the combination is higher than that for the individual devices involved in this combination. The combination shall be configured and used in accordance with the manufacturer's specifications.

Note

This rule can also be applied to any other device combination tested under UL supervision and listed in the UL report. Any combination of devices can be connected (Series rating or Series rated combinations).

A maximum permissible SCCR value which is higher than the standard value in **UL 508A** for magnetic controllers, bi-metal relays or starter combinations can only be applied if the BCPD (branch circuit protective device) specified in the UL report is being used.

Exception 1

The BCPD specified for high SCCR values is a Class CC, G, J, C, RK1, RK5 or T fuse. Other fuses are also permitted provided their let-through current (I_p = peak value) and let-through energy (I^2t) are less than or equal to the specified standard fuse according to **Table SB4.1** in **UL 508A**.

Exception 2

The BCPD specified can also be installed outside the panel ("provided in the field"), as long as the panel is marked according to **UL 508A, SB5.1.2.**.

Exception 3

If the BCPD specified (for high SCCR) is a short-circuit current limiting circuit breaker listed according to UL, this device shall be marked with "Current Limiting" on the nameplate and indicated in the UL report. In addition, the relevant let-through currents (I_p = peak value) and let-through energy values (I^2t) shall be specified. If alternative short-circuit current limiting circuit breakers are used, their I_p and I^2t shall be less than or equal to the values of the device specified.

The let-through values of the circuit breakers shall be published by the manufacturers (in the form of tables or graphs).

5.8.5 "UL 508A - SB 4.3 - Feeder components"

Devices that can limit the short-circuit current available

Note

Cables, busbars, bi-metal devices and similar equipment should NOT be thought of as devices that limit the short-circuit current rating according to **UL 508A**.

A) For branch circuits supplied by a power transformer with an isolated secondary (not an autotransformer!), the following applies as far as the maximum permissible short-circuit current rating on the primary side of the transformer is concerned:

1. For a power transformer rate of not more than 10 kVA, and a maximum permissible short-circuit current rating of all devices on the secondary side of the transformer not less than 5 kA, the maximum permissible short-circuit current value of the protection device on the primary side of the transformer can be used for the SCCR value of all secondary circuits (including the transformer).
2. For a power transformer rated not more than 5 kVA, and a 120 V maximum secondary voltage, with a maximum permissible short-circuit current rating of all devices on the secondary side of the transformer not less than 2 kA, the maximum permissible SCCR value of the protection device on the primary side of the transformer can be used for the SCCR value of all secondary circuits (including the transformer).
3. For circuits that do not comply with condition 1 or 2, the lowest maximum permissible short-circuit current rating of all devices on the secondary side applies when determining the SCCR value.

B) For branch circuits supplied by a circuit breaker in the feeder circuit which limits the short-circuit current, the maximum permissible SCCR value is as follows:

1. The maximum permissible short-circuit current rating of the feeder circuit breaker if
   - All devices on the load side of the circuit breaker have a larger short-circuit rating than the circuit breaker's let-through current

     and
   - The maximum permissible short-circuit current rating of the branch circuit protective device is not less than the feeder circuit breaker's short-circuit rating.

   Note

   Here, UL make a clear distinction between devices which are unable to respond automatically in the event of a short circuit ("short-circuit inactive") and those which are able to respond automatically in the event of a short circuit ("short-circuit active"). If two short-circuit active devices are connected in series, the lower maximum permissible short-circuit rating of the two devices will usually apply. Examples of short-circuit active devices include circuit breakers with short-circuit trip units or fuses. UL assume that it is practically impossible to demonstrate (on the basis of the technical data for the devices) which of the two devices will respond in full, taking up the high short-circuit energy in the process. However, if such a combination of devices has been tested for a specific short-circuit value and listed by UL (in other words, a relevant UL report is available), the maximum permissible short-circuit rating value given in the report can be used, even if it is higher than the short-circuit value for the individual device. These are known as "Series rated combinations".
2. The smallest short circuit current rating of all BCPDs on the load side of the feeder circuit breaker, if the first part of condition 1 is met, but the maximum permissible short-circuit current rating of at least one of the BCPDs is less than that of the feeder circuit breaker.
3. The smallest short-circuit current rating of any Branch Circuit Protective Device when the conditions under 1 or 2 are not met.

C) For branch circuits supplied via a class CC, G, J, L, RK1, RK5 or T fuse, the maximum permissible short-circuit current rating is determined as follows:

1. The maximum permissible short-circuit current rating of the feeder fuse if
   - All devices on the load side of the fuse have a higher short-circuit rating than the fuse's let-through current (only the values in **UL 508A, Tab. SB4.2** should be used in such cases)

     and
   - The maximum permissible short-circuit current rating of the BCPD (branch circuit protective device) is not less than the feeder fuse's short-circuit rating.

Note 1

The same principle that applies to circuit breakers also applies here. See the relevant note (section B).

Note 2

Only those let-through values given for the relevant fuse in **Table SB4.2** in **UL 508A** should be used. UL assume that a fuse from any manufacturer would be appropriate, and that only the worst case scenario should be applied as a result. This is incorporated into **Table SB4.2**.

Extract: Table UL 508A SB4.2

Fuse types	Fuse rating amperes	Between threshold and 50 kA		100 kA		200 kA	
		$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$
Class CC	15	2	3	2	3	3	4
	20	2	3	3	4	3	5
	30	7	6	7	7.5	7	12
Class G	15	-	-	3.8	4	-	-
	20	-	-	5	5	-	-
	30	-	-	7	7	-	-
	60	-	-	25	10.5	-	-
300 volt Class T	30	3.5	5	3.5	7	3.5	9
	60	15	7	15	9	15	12
	100	40	9	40	12	40	12
	200	150	13	150	16	150	20
	400	500	22	550	28	550	35

2. The smallest short-circuit current rating of all BCPDs applies if the first part of 1 also applies, but the maximum permissible short-circuit current rating of the BCPDs is less than that of the Feeder element.
3. The smallest short-circuit current rating of all devices in the branch when the conditions under 1 and 2 are not met.

5.8.6 "UL 508A - SB 4.4 - Determination of the overall short-circuit current rating of the overall Industrial Control Panel"

As far as all branch circuits, protected by a BCPD within a panel unit are concerned, this is the smallest maximum permissible short-circuit current rating of all power-circuit devices on the load side of the BCPD including the maximum permissible short-circuit current rating of the protection for the control circuit.

The maximum permissible SCCR value of the panel unit is determined as follows:

1. For panel units with one branch only and no BCPD within the panel, this is the maximum permissible short-circuit current rating of all power circuit devices including the protection device for the control circuit.
2. As above, but with a BCPD within the panel.
   The value is determined according to **SB4.4**.
3. For panels (panel units) with a number of branch circuits or feeder circuits such as disconnect switches, fuses and overcurrent protection devices (Feeder and/or Branch), the maximum permissible short-circuit current rating is determined as follows:
   - The lowest maximum permissible short-circuit current rating of all branches according to **SB4.4** which has not been modified by the rules under **SB4.3**
   - The maximum permissible short-circuit current rating of the feeder device where it was not possible to modify this according to **SB4.4.4** and the protection for the control circuit is connected on the load side of the feeder device.
   - The modified maximum permissible short-circuit current rating according to **SB4.3** for each branch circuit if the associated feeder device from the UL report is being used.

5.8.7 Marking the short-circuit value

UL 508 SB5.1.1

Industrial control panels nameplates shall include the maximum short-circuit current rating: It is given as follows:

"**Short-circuit current: ____kA rms symmetrical, ___V maximum**" or equivalent

An Industrial Control Panel marked with a "high" SCCR value which does not specify the relevant BCPD in the case of the exception under **SB4.2.3** shall also provide details of which BCPD is to be connected upstream of the panel.

Devices

6

6.1 Supply circuit disconnecting device

(Main Disconnecting Means)

6.1.1 Regulations for the main disconnecting means

Systems according to NFPA

In accordance with **NFPA 79 Chapter 5** and **UL 508A Art. 30:** Each system shall be fitted with a main disconnecting means. Two or more main disconnecting means shall be installed where there are two or more systems. The main disconnecting means shall switch off all electric circuits, including the control circuits.

Exception: Separate circuits such as service receptacles and panel lighting.

Main disconnecting means

General:
In the USA, it is standard practice to design the devices and cables from the load upwards.

The main disconnecting means can be fitted in the industrial control panel, or the panel is provided with a label stating that a main disconnecting means needs to be connected upstream during installation.

All the devices used shall be approved.

If there is no need to safely shut down (isolate) other industrial control panels for maintenance and repair purposes, no other disconnecting means need to be installed.

However if the individual panels need to be switched off separately, the industrial control equipment referred to under sub-part 6.1.2 can be used. A redundantly driven magnetic controller with an electrical interlock can also be used if it is approved (listed) for this isolating function. **NFPA 79 Chapter 5.5.4 (3)**

For systems with 2 hp or less, the main disconnecting means may be fitted at a distance of not more than 6 m (20 ft), provided that it is visible and can be easily reached.

EMERGENCY STOP

If main disconnecting means are used as emergency stop switches, these shall: **(NFPA 79 Chapter 10.7.5)**

- Be visible and easy to access,
- The operating handle shall be red and the background around the handle shall be yellow,
- The switch shall be a switch listed for combination motor controllers (**UL 508 Type E or F**), or a listed circuit breaker (with Inverse Time Trip unit; Siemens types 3RV17, 3RV18 or 3VL), or a listed circuit breaker without tripping unit (Molded-Case Switch such as Siemens SENTRON series).

Exceptions

Exception rule for main disconnecting means in circuits separate from the power circuit, such as panel lights, receptacles for maintenance, devices for undervoltage protection, temperature monitoring, heaters, programmable storage devices, etc. **NFPA 79 Chapter 5.3.5**.

Industrial control panels with these electric circuits shall have a warning sign next to the operating handle of the main disconnecting means which states that these electric circuits have to be switched off separately.

6.1.2 Types and size

The following devices are approved as main disconnecting means (**UL 508A Art. 30.1 and Art. 30.2**):

a) Circuit breakers according to UL 489

(inverse time circuit breaker); e.g. Siemens types 3VL, 3WL, 3RV17/18, 5SJ4 ... - ... HG ...

Sizing

Standard circuit breakers should only be loaded with 80% of their rated current. For example, a 125 A circuit breaker should only be loaded with 100 A.

Exception

Certain circuit breakers are approved for 100% loads. However, as a minimum requirement these shall be named in the UL report for the circuit breaker (e.g. some Siemens types 3RV17/18).

b) Molded-case switches

according to **UL 489**. These are switches without an overload trip unit. They may, however, have a not adjustable (fixed) instantaneous trip unit.

Sizing

I) One or more non-motor loads
- 100% for switches with no integrated fuse
- 80% for switches with an integrated fuse

II) One motorized load only
- hp-rating greater than or equal to that of the motor
- Minimum 115% of motor's full-load current according to **UL 508A Tab. 50.1**
- Minimum rated input current of a frequency converter

III) For more than one motor or for mixed loads (motor and non-motor)
- Minimum 115% of motor's full-load current according to **UL 508A Tab. 50.1**
- Rated input current of the frequency converter plus the total of all other rated currents of the non-motorized loads
- The permissible LRC (locked rotor current) of the switch shall not be lower than the total of all the LRC currents from every motor plus the rated currents of all the other loads.
  For 1-phase motors: LRC = 6 x full-load current according to **UL 508A Tab. 50.1**
  For 3-phase motors the LRC is based on **UL 508A Tab. 50.3**.

c) Type E motor starters

Self-protected combination motor controllers may be used as the main disconnecting means according to **UL 508A** if only **one** motor is being operated in the industrial control panel (including any associated control circuits).

Sizing

A type E motor starter should be sized with 100% of the motor's full-load current according to **UL 508A Tab. 50.1** in such cases.

d) Disconnect switches according to UL 98

(disconnect switch or switch unit)

Sizing

I) One or more non-motor loads
- 100% for switches with no integrated fuse
- 80% for switches with an integrated fuse

II) One motorized load only
- hp-rating greater than or equal to that of the motor
- Minimum 115% of motor's full-load current according to **UL 508A Tab. 50.1**
- Minimum rated input current of a frequency converter

III) For more than one motor or for mixed loads (motor and non-motor)
- Minimum 115% of motor's full-load current according to **UL 508A Tab. 50.1**
- Rated input current of the frequency converter plus the total of all other rated currents of the non-motorized loads
- The permissible LRC (locked rotor current) of the switch shall not be lower than the total of all the LRC currents from every motor plus the rated currents of all the other loads.
  For 1-phase motors: LRC = 6 x full-load current according to **UL 508A Tab. 50.1**
  For 3-phase motors the LRC is based on **UL 508A Tab. 50.3**.

e) Disconnect switches according to UL 977

For currents greater than 600 A

Sizing

I) One or more non-motor loads
- 100% for switches with no integrated fuse
- 80% for switches with an integrated fuse

II) One motorized load only
- hp-rating greater than or equal to that of the motor
- Minimum 115% of motor's full-load current according to **UL 508A Tab. 50.1**
- Minimum rated input current of a frequency converter

III) For more than one motor or for mixed loads (motor and non-motor)
- Minimum 115% of motor's full-load current according to **UL 508A Tab. 50.1**
- Rated input current of the frequency converter plus the total of all other rated currents of the non-motorized loads
- The permissible LRC (locked rotor current) of the switch shall not be lower than the total of all the LRC currents from every motor plus the rated currents of all the other loads.
  For 1-phase motors: LRC = 6 x full-load current according to **UL 508A Tab. 50.1**
  For 3-phase motors the LRC is based on **UL 508A Tab. 50.3**.

f) Air circuit breakers according to UL 1066

(power circuit breakers)

Sizing

I) One or more non-motor loads
- 100% for switches with no integrated fuse
- 80% for switches with an integrated fuse

II) One motorized load only
- hp-rating greater than or equal to that of the motor
- Minimum 115% of motor's full-load current according to **UL 508A Tab. 50.1**
- Minimum rated input current of a frequency converter

III) For more than one motor or for mixed loads (motor and non-motor)
- Minimum 115% of motor's full-load current according to **UL 508A Tab. 50.1**
- Rated input current of the frequency converter plus the total of all other rated currents of the non-motorized loads
- The permissible LRC (locked rotor current) of the switch shall not be lower than the total of all the LRC currents from every motor plus the rated currents of all the other loads.
  For 1-phase motors: LRC = 6 x full-load current according to **UL 508A Tab. 50.1**
  For 3-phase motors the LRC is based on **UL 508A Tab. 50.3**.

Note 1

Industrial control panels with no main disconnecting means shall have some form of marking which gives the maximum fuse size and fuse class or the maximum permissible circuit breaker.

Note 2

Manual motor controllers (maintenance switches): (e.g. Siemens types 3LB and 3LD)

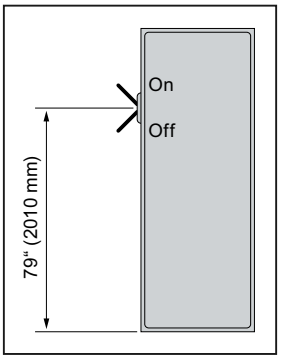
Shall meet **NEC 2008 430-109 (A) (6)** and be labeled with the words "Suitable as Motor Disconnect". These manual motor controllers should only be used in the motor branch circuit (i.e. downstream of the branch circuit protection). They shall not be used as main disconnecting means.

6.1.3 Arrangement of main disconnecting means

(Operating handles)

Main requirements of operating handles according to UL 489 and UL 98

- When actuated vertically, the "ON" position shall be at the top.
- The "ON" and "OFF" positions shall be clearly marked.
- If two or more main disconnecting means are used, they shall be grouped together.
- It shall be possible for the operating handle to be locked in the OFF position.
- The installation position shall not be any higher than 79 inches (2010 mm), measured from the surface that the operating personnel stand on to the center position of the operating handle (according to **UL 508A**).



6.1.4 Door interlocking for the main disconnecting means

Main disconnecting means according to **UL 508A**

Based on **UL 508A Art. 65-67** (effective March 1, 2007) the following functions meet the relevant requirements in terms of the "**UL 508A** mounting set" available as an accessory (Siemens 8UC9400) in combination with the rotary operating mechanism and industrial control equipment.

UL 508A approves three options for door interlocking:

- Mechanical (see our 8UC9400 Siemens installation kit)
- Electrical
- A combination of mechanical and electrical.

  The electrical interlocking shall meet the same conditions as the mechanical interlocking. Therefore, the following components are minimum requirements when installing the electrical interlocking:

  – 1 key-operated pushbutton for starting the defeat mechanism
  – 1 time relay (adjustable time approx. 0-10 s), the defeat mechanism is active during this period
  – Undervoltage release for each main disconnecting means
  – Various auxiliary relays
  – A position switch for each door, preferably with (solenoid) interlocking

Switches which are position switches only (without (solenoid) interlocking) should not be used, as **UL 508A** clearly states that it should only be possible to open the door if the main disconnecting means is switched off.

The key-operated pushbutton should only be used to bypass the door position switches with (solenoid) interlocking and the undervoltage releases for a very short time. Any doors not opened during this period are interlocked once more. On the open doors, the position switches with (solenoid) interlocking shall remain open and lock again once these doors have been closed.

During opening and while the doors are actually open, the undervoltage release shall not result in tripping.

A similar type of switching should also be used for "switching on" when the doors are open.

The aim is to

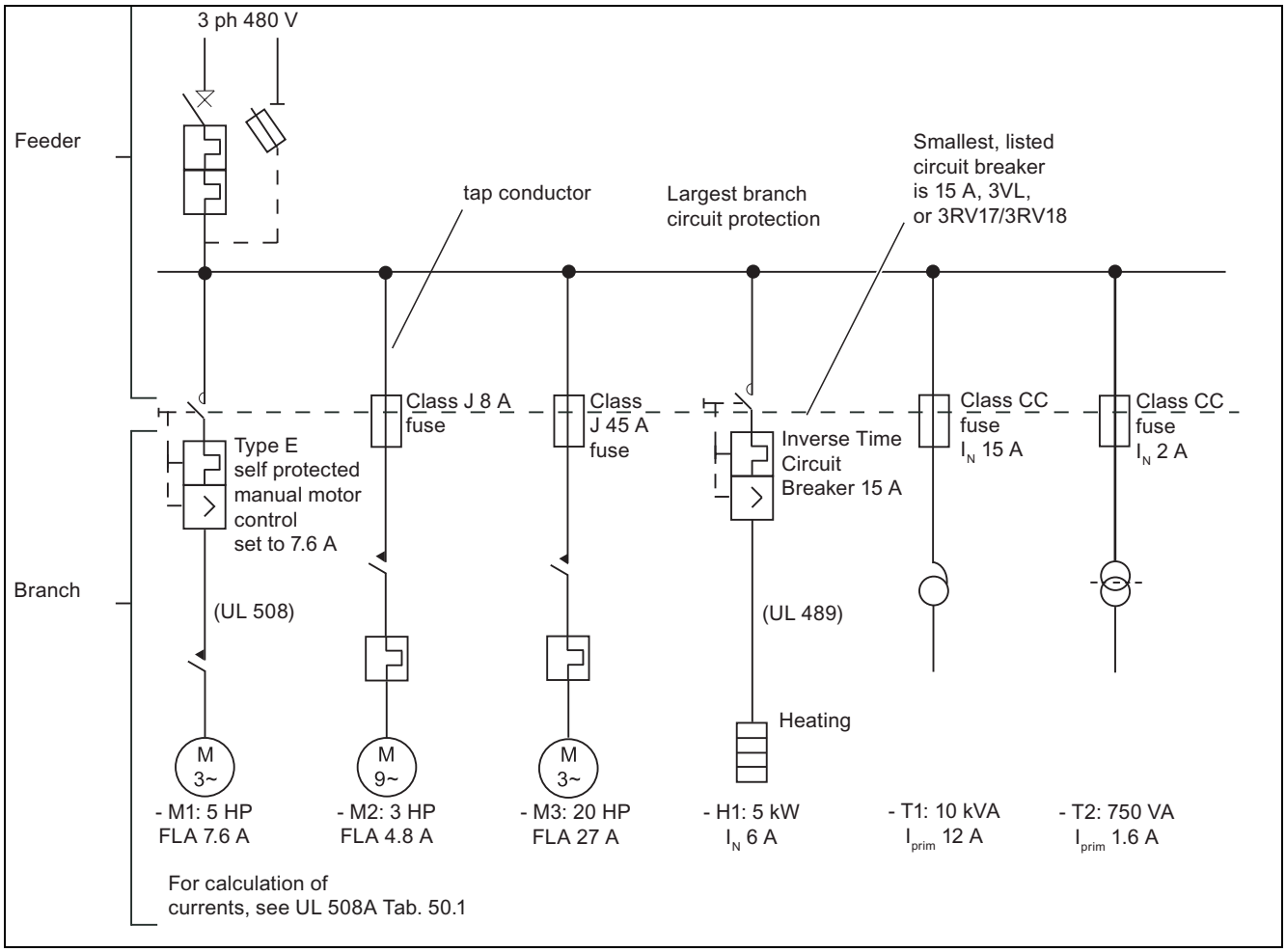
1. Prevent an unauthorized person from opening the panel door(s), as he/she will either not know how to do this or will not have the key for the button.
2. Prevent any "unintentional" or "accidental" switching on by a "deliberate" action (defeat mechanism) when the doors are open.

Detailed description of the functions

1. The mechanism (the operator lever, etc.) shall be accessible (and able to be operated) at any time regardless of the position of the door
   ⇒ **UL 508A: 66.6.3 (a)**
   ⇒ **NFPA 79: 5.3.4.2 (1)**
2. The switching device and rotary operating mechanism form a single unit and cannot be separated under normal operating conditions.
   ⇒ this follows from number 1
   ⇒ **UL 508A: 66.6.3 (c); (d)**
   ⇒ **NFPA 79: 5.3.3.1 (3)**
   ⇒ **NFPA 79: 5.3.4.2 (3)**
3. Industrial control panel doors/ALL doors shall be interlocked in the "ON" position of the main disconnecting means so that none of the doors can be opened.
   ⇒ **UL 508A: 66.1.5**
4. It shall be possible to defeat the interlocking referred to in number 3 so that the industrial control panel doors can also be opened for servicing and maintenance work when the main disconnecting means is in the "ON" position. A tool shall be required for this purpose (e.g. a small, flat screwdriver).
   ⇒ **UL 508A: 60.1.5.1 (a)**
5. The interlocking referred to in number 3 shall be automatically activated on closing the industrial control panel door without the need for any additional measures.
   ⇒ **UL 508A:6.1.5.1 (c)**
6. Tripping a circuit breaker while the door is closed moves the handle to the "Trip" position. In this "Trip" position, the door can only be opened by defeating the door interlocking. If the mechanism is in the "OFF" or "Reset" position, it must be possible to open the door without defeating it. Any conscious turning of the rotary handle (while main disconnecting means stays in "ON" position) shall not enable the door interlockings unless the main disconnecting means switches off.
   ⇒ **Recommendation by Siemens**
7. It shall be possible to switch "OFF" the rotary operating mechanism at any time, whether the door is open or closed.
   ⇒ **UL 508A: 66.6.3 (a); (b)**
8. It shall only be possible to lock the rotary operating mechanism with a padlock in the "OFF" position.
   ⇒ **UL 508A: 30.4.4**
   ⇒ **NFPA 79: 5.3.3.1. (3)**
9. It shall be possible to switch on the main disconnecting means without any tools or defeat mechanism. All that should be required is to remove any padlock that may be present.
   ⇒ **UL 508A: 66.1.5**
   ⇒ **NFPA 79: 5.3.3.1 (3)**
10. The panel door can be opened completely if the main disconnecting means is in the "OFF" position without the need to remove any padlock that might be present. If more than one padlock is used, there is no need to meet the condition that padlocks shall pass through the doors.
    ⇒ **UL 508A: 66.1.5** in reverse.
11. When the industrial control panel door is open, mechanical interlocking shall be used to block any switching on of the main disconnecting means. It shall be possible to defeat this interlocking without tools; it shall also be deactivated when the door(s) is/are closed again.
    ⇒ **UL 508A: 66.1.5.1 (b)**
    ⇒ **NFPA 79: 5.3.3.1 (3)**

6.1.5 Examples

Calculating the main disconnecting means in the feeder circuit



Disconnect switch (UL 98) with or without fuses

1. Calculate the full-load current (FLC) of each motor using **Table 50.1** in **UL 508A**; **Exception:** For special motors, use the FLA on the nameplate.
2. Multiply the total of all motor FLC values by 1.15 (115% of all rated motor currents).
3. Add the currents of all other loads.
4. Use the total of all the currents (virtual motor) calculated to establish the hp of the disconnect switch according to **Table 50.1 in UL 508A**.

Example:

Main disconnecting means [A]	= ∑ motors x 1.15 + ∑ loads
	= (M1 + M2 + M3) x 1.15 + H1 + T1 + T2
	= (7.6 + 4.8 + 27) x 1.15 + 6 + 12 + 1.6 = 64.9
Main disconnecting means [A]	= **64,9**

Note

According to **UL 508A, Table 50.1**. A motor carries 64.9 A at 480 V, which corresponds to 50 hp. In other words, the main disconnecting means shall be selected for a minimum of 50 hp.

Circuit breaker (UL 489) only for isolating function; not for overload protection

1. Calculate the full-load current (FLC) of each motor using **Table 50.1 in UL 508A** (attached); **Exception:** For special motors, use the FLC on the nameplate.
2. Add together the FLC of all motors and other loads.
3. Multiply the total of these currents by 1.25 (125% of all rated currents; circuit breakers may only be loaded up to 80% of their rated current).

Example:

Main disconnecting means [A]	= ∑ loads ≤ 80% current of circuit breaker
	= (M1 + M2 + M3 + H1 + T1 + T2)
	= (7.6 + 4.8 + 27 + 6 + 12+ 1.6) x 1.25
Main disconnecting means [A]	= **73,8**

Note

A standard circuit breaker should only be designed to operate at a maximum of 80%.

Sizing of disconnect switch with fuse (UL 248) or circuit breaker (UL 489) as overload protection for feeder circuits

Calculating the circuit breaker or fuse size using the branch overload protection.

1. Select the largest branch circuit protection of all the branches (BCPD – Branch Circuit Protective Device); fuse or circuit breaker.
2. Add together the rated currents of all loads.
3. Select a circuit breaker or fuses according to the load current calculated.

Example:

Protection [A]	≤ I largest protection + ∑ loads
Protection [A]	≤ 45 + 7,6 + 4,8 + 6 + 12 + 1,6 = **77,0**

Calculating the size using the feeder and the wire cross section (in AWG)

For industrial control panels according to UL 508A	**Motor loads, select the rated currents from Table 50.1 in UL 508A**
Add together the rated currents of all loads.	For industrial control panels according to **NFPA 79** (or **UL 508A Art. 66.5.6**) (see above for areas of use): **Note**: For ambient temperatures of more than 30 °C, see temperature correction in **NEC 2008 Table 310.16**
	Add together all loads for the resistor heaters and multiply the total by 1.25 (125% of the rated currents).
	Determine the rated current of the largest motor and multiply this by 1.25 (125% of the FLA rated motor current).
	Add together the rated currents of all other motors and loads.
Select the wire size (AWG - American Wire Gauge)) according to the current calculated (or the next largest wire) from **Table 28.1** in **UL 508A** (**Table 29.1** is being removed on March 1, 2007).	

Example:

UL 508A: Feeder ∑ Loads
= M1 + M2 + M3 + H1 + T1 + T2
= **59 A**

UL 508A, Table 28.1: 6 AWG (65 A)

NFPA 79: Feeder = ∑ heater loads x 1.25 + FLC of largest motor x 1.25 + M1 + M2 + T1 + T2
= (6 x 1.25) + (27 x 1.25) + 7.6 + 12 + 1.6
= **67.25 A**

UL 508A, Table 28.1: 4 AWG (85 A)

Note

The circuit breaker/fuse shall be equal to or less than the current carrying capacity of the wire.

Incompatibility of sizing in terms of disconnect switch

Where the smallest circuit breaker, sized as a disconnect switch, is greater than that permitted for the system's overcurrent protection, there are two possible options:

1. Use a disconnect switch for the isolating function and fuses for the protective function.
2. Adapt the capacity of the feeder conductor to the overcurrent protection (in other words, increase the size of the feeder conductor).
   In other words, a 4 AWG wire should be used in the previous example.

Note

Under certain conditions, the number of branches should be restricted to 6 per feeder in feeder circuits.

6.2 Configuring and sizing combination motor controllers according to UL 508A

6.2.1 Definitions - Terms

Motor starter

UL 508A § 2.33

Any assembly of an overload relay and a contactor

Combination motor controller

UL 508A § 2.10

One or more devices assembled to provide:

- Disconnecting means
- Branch circuit protection
- Motor control
- Motor overload protection

for a single motor circuit.

Branch Circuit Protection

UL 508A § 2.4

Overcurrent protection with an ampere rating selected to protect the branch circuit.
For a motor branch circuit, the overcurrent protection is required for overcurrents due to short circuits and faults to ground only,
(see **UL 508A§ 2.5; § 2.33; § 2.28**).

Overload Protection

UL 508A § 2.36

Protection for motor branch circuits to prohibit motor overloads (during operation and start-up)

Overcurrent Protection

A device designed to open a circuit when the current through it exceeds a predetermined value in order to protect the devices and cables attached to it.
Overcurrent can be caused by overloads, short circuits and faults to ground.

Note

Please do NOT confuse overcurrent with overload or use them interchangeably. The term overcurrent covers overload, short circuit and, if applicable, ground-fault current!

6.2.2 Possible combination motor controllers ("Construction Types"), versions A to F

UL 508 specifies the protecting and isolating functions separately. The functional criteria to be met relate to disconnecting means, branch circuit protection, motor control, and overload protection. An enclosed combination starter is installed in an enclosure with a door-coupling operating mechanism as the isolating function. Traditionally, a combination starter consists of a circuit breaker, a magnetic controller and an overload relay installed within an enclosure, with a door-coupling operating mechanism (usually a lever) mounted on a flange on the front side. Rotary operating mechanisms are used much less frequently.

Various construction types are listed, divided into types "A" to "F", in the following table. Types "A" to "D" are not commonly referred to as such.

The fusible links (fusible links, motor short-circuit protector, UL 508) listed under type "B" are rarely used nowadays.

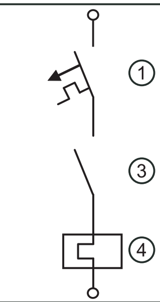
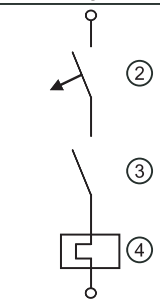
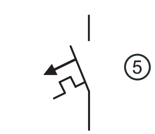
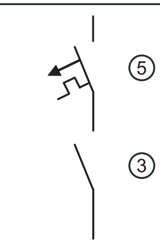
Extract from UL 508

Table 76.2
Various constructions of combination motor controllers
Table 76.2 revised December 17, 2001

Construction Type	Construction Requirements, Paragraphs	Component[a]	Component Standard	Component Function			
				Disconnect	Branch Circuit Protection	Motor Control	Motor Overload
A	76.4 – 76.8	Manual Disconnect	UL 98 or UL 1087	X			
		Fuse	UL 248 series		X		
		Magnetic or Solid State Motor Controller	UL 508			X	
		Overload Relay	UL 508				X
B	76.4 – 76.8	Manual Disconnect	UL 98 or UL 1087	X			
		Motor Short-Circuit Protector	UL 508		X		
		Magnetic or Solid State Motor Controller	UL 508			X	
		Overload Relay	UL 508				X

Disconnect ⇒ Isolating function Branch Circuit Protection ⇒ Branch circuit Motor Control ⇒ Motor control Motor Overload ⇒ Overload relay or device	Example for device types	Block diagram
Manual Disconnect according to UL 98 ⇒Disconnect switch from SE&A Manual Disconnect acc. to UL 1087 ⇒ Molded Case Switch acc. to UL 489 Fuse according to UL 248 ⇒Standard fuse from USA ! No SITOR fuse Magnetic Motor Control acc. to UL ⇒Magnetic contactor Solid State Motor Control acc. to UL ⇒Power converter; soft-starter, etc. Overload Relay nach UL508 ⇒Bi-metal or other devices approved for this purpose	⑪ Siemens USA ⑫ 3VL ⑬ ③ 3RT ③ 3RW ④ 3RB;3RU 3RV;	
This version is barely used anymore.		This type of combination motor controller is barely used these days for industrial machinery
Manual Disconnect according to UL 98 ⇒Disconnect switch from SE&A Manual Disconnect acc. to UL ⇒ Molded Case Switch acc. to UL Motor short-circuit protector acc. to UL 508 ⇒Motor starter protector ONLY with short-circuit release Magnetic Motor Control according to UL 508 ⇒Magnetic contactor Solid State Motor Control according to UL 508 ⇒Power converter; soft-starter, etc. Overload Relay according to UL 508 ⇒Bi-metal or other devices approved for this purpose		

Extract from UL 508

Type	Sections	Device	Standard					Description	Products	Symbol
C	76.4 – 76.8	Inverse-Time Circuit Breaker	UL 489	X	X			Inverse Time Circuit Breaker according to UL 489 ⇒Circuit breaker ①	3VL; 3RV; 5SJ4	
		Magnetic or Solid State Motor Controller	UL 508			X		Magnetic Motor Control according to UL 508 ③ ⇒Magnetic contactor	3RT	
								Solid State Motor Control according to UL 508 ③ ⇒Power converter; soft-starter, etc.	3RW	
		Overload Relay	UL 508				X	Overload Relay according to UL 508 ④ ⇒Bi-metal or other devices approved for this purpose	3RB;3RU 3RV;	
D	76.4 – 76.9	Instant-aneous-Trip Circuit Breaker	UL 489	X	X			Instantaneous Trip Circuit Breaker according to UL 489 ② ⇒Circuit breaker for starter combinations	3VL	
		Magnetic or Solid State Motor Controller	UL 508			X		Magnetic Motor Control according to UL 508 ③ ⇒Magnetic contactor	3RT	
								Solid State Motor Control according to UL 508 ③ ⇒Power converter; soft-starter, etc.	3RW	
		Overload Relay	UL 508				X	Overload Relay according to UL 508 ④ ⇒Bi-metal or other devices approved for this purpose	3RB;3RU 3RV;	
E[b]	76.3.1 – 76.6, 76.8 – 76.13	Self-Protected Control Device	UL 508	X	X	X	X	Self-Protected Control Device according to UL 508 ⑤ ⇒Motor starter protector approved for ALL tasks in the combination motor controller	3RV „Self...“	
F	76.3.1 – 76.9	Manual Self-Protected Combination Controller	UL 508	X	X		X	Self-Protected Control Device according to UL 508 ⑤ ⇒Motor starter protector approved for ALL tasks in the combination motor controller	3RV „Self...“	
		Magnetic or Solid State Motor	UL 508			X		Magnetic Motor Control according to UL 508 ③ ⇒Magnetic contactor	3RT	
								Solid State Motor Control according to UL 508 ③ ⇒Power converter; soft-starter, etc.	3RW	

③ The magnetic contactor shown here can be replaced at any time
a) By a manual motor control (3RV)
b) By a manual motor control (3RV) plus a 3RT magnetic contactor
If the manual motor control is also approved for motor overload, the bi-metal device referred to in ④ is not required.

Note

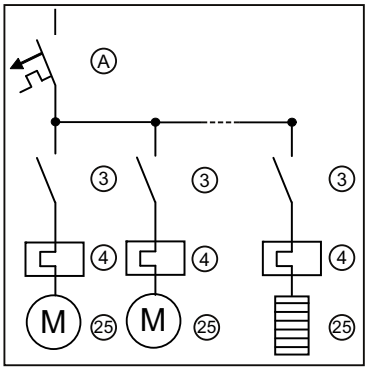
The typical circuit diagrams above should be regarded as a schematic representation.
The numbers used can be found both below and in the tables in Annex A.

6.2.3 Group installation

According to UL 508A, it is possible to group loads together in what is known as a ""Group Installation"". This is based on ""construction type C"".

Typical circuit diagram

Ⓐ Branch circuit protection
③ Motor control
④ Overload protection
㉕ Load



In terms of Ⓐ branch circuit protection, only the following devices are approved for use in "Group Installation":

UL 508A § 31.4.1

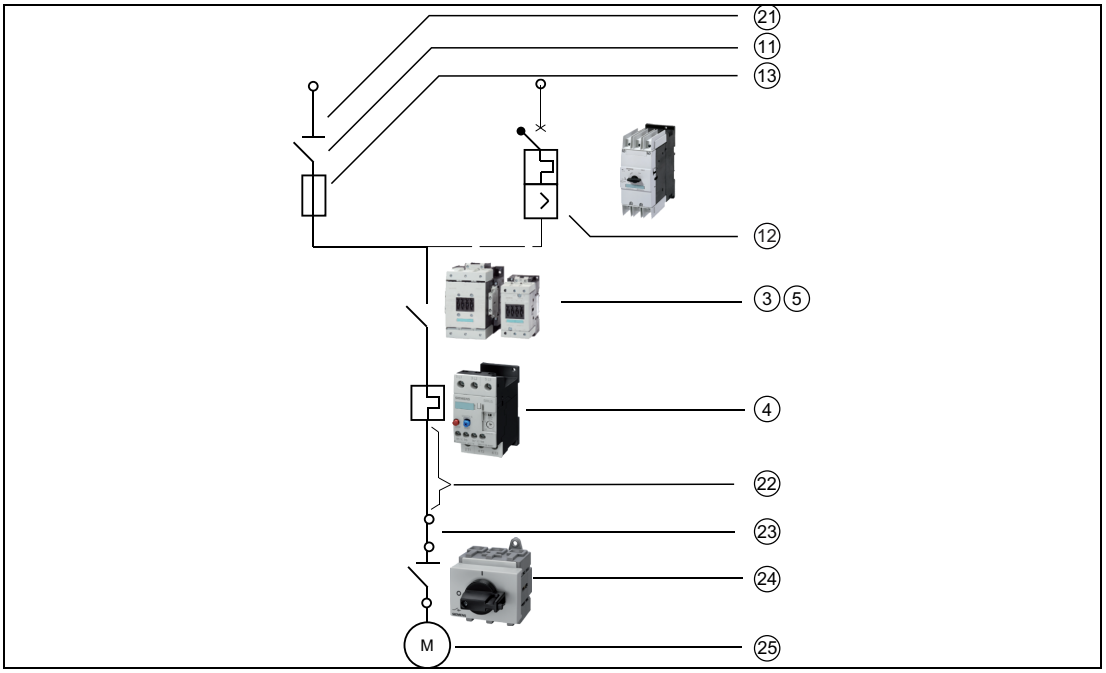
- Standard fuses, either 1 x 3-pole or 3 x 1-pole, according to **UL 248**

Note

Semiconductor fuses according to **UL 248-13** (SITOR type) are only approved in a very few exceptional cases as branch circuit protection.

- Circuit breakers according to **UL 489** (Inverse Time Circuit Breaker) with overload and short-circuit protection

6.2.4 Example of motor branch circuit protection



Pos.	Branch circuit protection	Siemens type e.g.	Nameplate inscription	UL std.
㉑	Field wiring terminal	Connection to the switch		
⑪	Disconnect switch, 20 hp	MCS 606R	Recognized Switch, Open Type	**UL 98**
⑬	Fuse, e.g. class J	FCJK606	Recognized Fuse Holder	**UL 98** **UL 512**
⑫	Circuit breaker	3RV1742 or 3VL2	Listed Circuit Breaker	**UL 489**
③⑤	Contactor (Controller)	3RT	Listed Ind.Cont.EQ	**UL 508**
④	Overload relay (overload protection)	3RU1136-4EBO	Listed Ind.Cont.EQ	**UL 508**
㉒	Internal wiring			**UL 508A** **NEC 2008 310**
㉓	Field wiring terminal	8WA1011-1NH02	Recognized Terminal Block	**UL 1059**
㉔	Repair switch (option) (Motor disconnect)	3LD2264-0TB51	Listed Man. Mtr. Cntr.	**UL 508**
㉕	Motor, 460 V SF 1.15 (nameplate)			

6.2.5 Basis for the dimensioning of combination motor controllers according to UL 508A

6.2.5.1 Information on different motor currents

"Full load current (FLC)" and "Full load ampere (FLA)"

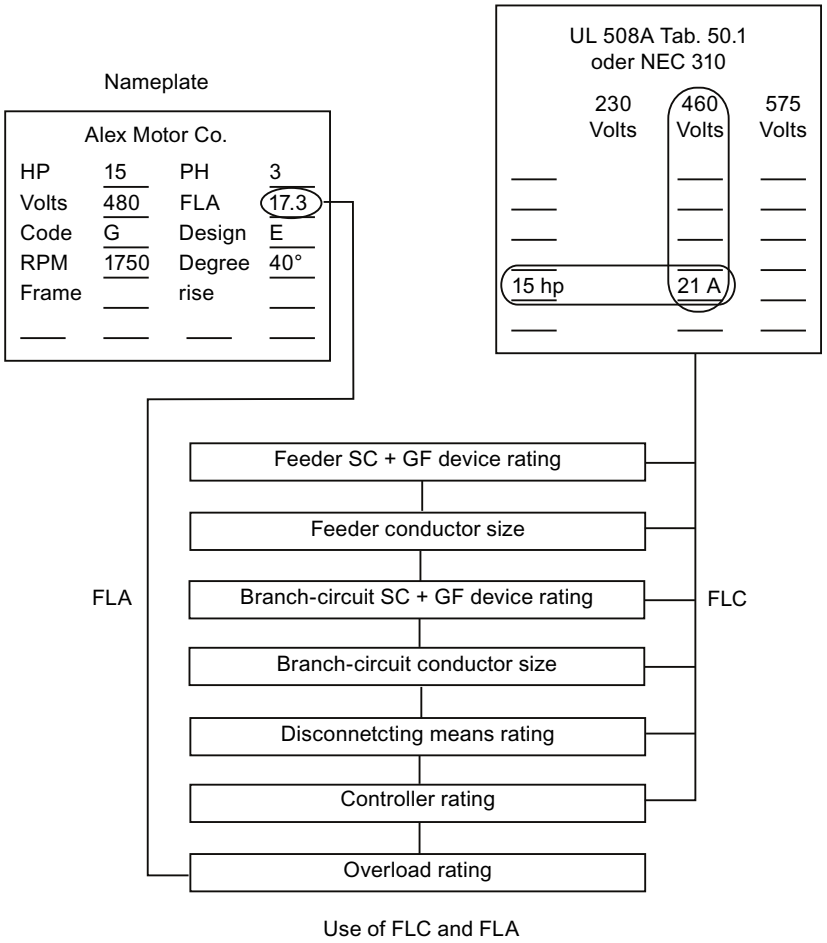
FLC ≙ full-load current according to the standard

FLA ≙ full-load ampere according to the nameplate

According to **UL 508A**, only the FLC should be used for sizing combination motor controllers. In this context, it is advisable to consult **Table 50.1 (UL 508A)**. **NEC 2008 § 310** applies when sizing cables outside the panel.

The only exception relates to motor overload protection – in this case, the FLA on the nameplate should be used instead.

The following image should make this clear:



Source: "Electrical Inspection Manual" (Fig. 7.4)

Note

"GF device rating" is only required for specific applications.

Here, the FLA value gives the motor's rated current from the motor's nameplate.

The FLC value gives the "standard" rated current from **UL 508A, Tables 50.1** and **50.2**. The values from these tables should be used for devices and wiring within the panel. The **NEC** standard contains similar tables for the cabling outside the panel (e.g. **NEC 2008 Tab. 310.16**)

6.2.5.2 Table 50.1 in UL 508A

UL 508A Table 50.1
Full-load motor-running currents in amperes corresponding to various a-c horsepower ratings*
Table 50.1 revised September 1, 2005

Horse power	110 – 120 Volts		200 Volts		208 Volts		220 – 240 Volts[a]		380 – 415 Volts		440 – 480 Volts		550 – 600 Volts	
	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase
1/10	3.0	–	–	–	–	–	1.5	–	1.0	–	–	–	–	–
1/8	3.8	–	–	–	–	–	1.9	–	1.2	–	–	–	–	–
1/6	4.4	–	2.5	–	2.4	–	2.2	–	1.4	–	–	–	–	–
1/4	5.8	–	3.3	–	3.2	–	2.9	–	1.8	–	–	–	–	–
1/3	7.2	–	4.1	–	4.0	–	3.6	–	2.3	–	–	–	–	–
1/2	9.8	4.4	5.6	2.5	5.4	2.4	4.9	2.2	3.2	1.3	2.5	1.1	2.0	0.9
3/4	13.8	6.4	7.9	3.7	7.6	3.5	6.9	3.2	4.5	1.8	3.5	1.6	2.8	1.3
1	16.0	8.4	9.2	4.8	8.8	4.6	8.0	4.2	5.1	2.3	4.0	2.1	3.2	1.7
1-1/2	20.0	12.0	11.5	6.9	11.0	6.6	10.0	6.0	6.4	3.3	5.0	3.0	4.0	2.4
2	24.0	13.6	13.8	7.8	13.2	7.5	12.0	6.8	7.7	4.3	6.0	3.4	4.8	2.7
3	34.0	19.2	19.6	11.0	18.7	10.6	17.0	9.6	10.9	6.1	8.5	4.8	6.8	3.9
5	56.0	30.4	32.2	17.5	30.8	16.7	28.0	15.2	17.9	9.7	14.0	7.6	11.2	6.1
7-1/2	80.0	44.0	46.0	25.3	44.0	24.2	40.0	22.0	27.0	14.0	21.0	11.0	16.0	9.0
10	100.0	56.0	57.5	32.2	55.0	30.8	50.0	28.0	33.0	18.0	26.0	14.0	20.0	11.0
15	135.0	84.0	–	48.3	–	46.2	68.0	42.0	44.0	27.0	34.0	21.0	27.0	17.0
20	–	108.0	–	62.1	–	59.4	88.0	54.0	56.0	34.0	44.0	27.0	35.0	22.0
25	–	136.0	–	78.2	–	74.8	110.0	68.0	70.0	44.0	55.0	34.0	44.0	27.0
30	–	160.0	–	92	–	88	136.0	80.0	87.0	51.0	68.0	40.0	54.0	32.0
40	–	208.0	–	120	–	114	176.0	104.0	112.0	66.0	88.0	52.0	70.0	41.0
50	–	260.0	–	150	–	143	216.0	130.0	139.0	83.0	108.0	65.0	86.0	52.0
60	–	–	–	177	–	169	–	154.0	–	103.0	–	77.0	–	62.0
75	–	–	–	221	–	211	–	192.0	–	128.0	–	96.0	–	77.0
100	–	–	–	285	–	273	–	248.0	–	165.0	–	124.0	–	99.0
125	–	–	–	359	–	343	–	312.0	–	208.0	–	156.0	–	125.0
150	–	–	–	414	–	396	–	360.0	–	240.0	–	180.0	–	144.0
200	–	–	–	552	–	528	–	480.0	–	320.0	–	240.0	–	192.0
250	–	–	–	–	–	–	–	604	–	403.0	–	302.0	–	242.0
300	–	–	–	–	–	–	–	722	–	482.0	–	361.0	–	289.0
350	–	–	–	–	–	–	–	828	–	560.0	–	414.0	–	336.0
400	–	–	–	–	–	–	–	954	–	636.0	–	477.0	–	382.0
450	–	–	–	–	–	–	–	1030	–	–	–	515	–	412
500	–	–	–	–	–	–	–	1180	–	786.0	–	590.0	–	472.0

[a] To obtain full-load currents for 265 and 277 volt motors, decrease corresponding 220 – 240 volt ratings by 13 and 17 percent, respectively.

* Standardized motor full-load amps

Table 50.2 in **UL 508A** applies to direct voltage motors

NEC 2008 § 430 applies to all other motors

6.2.5.3 Locked rotor current ≙ LRC

Motor blocking current

This is the maximum current the motor could take up when the motor shaft is blocked. This value should be given on the nameplate or on the motor's data sheet. If there are no details on either, **Table 50.3 (UL 508A**) may be used. For single-phase motors, the LRC is normally 6 times $I_{rated.}$

Table 50.3 in UL 508A

UL 508A Table 50.3
Locked-rotor motor currents corresponding to various a-c horsepower ratings (3-phase)*
Table 50.3 added September 1, 2005

HP	110 – 120 V	200 V	208 V	220 – 240 V	380 V – 415 V	440 – 480 V	550 – 600 V
	Motor designations	Motor designations	Motor designations	Motor designations	Motor designations	Motor designations	Motor designations
	B, C, D	B, C, D	B, C, D	B, C, D	B, C, D	B, C, D	B, C, D
1/2	40	23	22.1	20	20	10	8
3/4	50	28.8	27.6	25	20	12.5	10
1	60	34.5	33	30	20	15	12
1-1/2	80	46	44	40	27	20	16
2	100	57.5	55	50	34	25	20
3	128	73.6	71	64	43	32	25.6
5	184	105.8	102	92	61	46	36.8
7-1/2	254	146	140	127	84	63.5	50.8
10	324	186.3	179	162	107	81	64.8
15	464	267	257	232	154	116	93
20	580	334	321	290	194	145	116
25	730	420	404	365	243	183	146
30	870	500	481	435	289	218	174
40	1160	667	641	580	387	290	232
50	1450	834	802	725	482	363	290
60	–	1001	962	870	578	435	348
75	–	1248	1200	1085	722	543	434
100	–	1668	1603	1450	965	725	580
125	–	2087	2007	1815	1207	908	726
150	–	2496	2400	2170	1441	1085	868
200	–	3335	3207	2900	1927	1450	1160
250	–	–	–	3650	–	1825	1460
300	–	–	–	4400	–	2200	1760
350	–	–	–	5100	–	2550	2040
400	–	–	–	5800	–	2900	2320
450	–	–	–	6500	–	3250	2600
500	–	–	–	7250	–	3625	2900

* LRC of different 3-phase AC motors

6.3 Detailed information about sizing combination motor controllers

The following provides a description of the individual "parts" and "functions" of a combination motor controller. In each case, the respective approved devices and groups are given, as well as information on what needs to be considered during sizing.

6.3.1 Wiring and cables within the industrial control panel - UL 508A § 29

Only copper cables are allowed.

All cables within the same conduit or duct shall be approved for the highest occurring voltage in this location. This means that a 24 VDC and a 480 VAC circuit can always be installed within one duct/conduit. If other conditions (e.g. EMC) make it necessary to lay the circuits separately, this can be done at any time.

Sizing

UL 508A Table 28.1

Minimum cross section is 14 AWG in the load circuit (≈ 2.1 mm^2)

The wire's insulating material shall be designed for temperatures of at least 90 °C (154 °F).

Approved cables

- Machine Tool Wire according to **UL 1063**
- Thermoset Insulated Wire according to **UL 44**
- Thermoplatic Insulated Wire according to **UL 83**
- Appliance Wiring Material according to **UL 758 (not NFPA 79)**
- Welding Cable

Note

More than one wire can be connected to all internal (≙ Factory Wiring) terminals, as long as the terminal is approved for this (manufacturer information).

Only **1** wire should to be connected to each terminal at all external (≙ Field wiring) terminals.

6.3.2 Disconnecting/isolating function

This function is also sometimes referred to as the Feeder. **UL 508A § 30**

6.3.2.1 Approved devices

- Circuit breakers according to **UL 489**, terms in the standard
  - Inverse time circuit Breaker
  - Circuit Breaker

  Siemens device types: 3VL, 3RV17/18, 5SJ4... HG
- Non-automatic circuit breakers for starter combinations according to **UL 489**.
  These are circuit breakers without overload trip units ("bi-metal") but with adjustable short-circuit trip units (instantaneous). These are referred to as Instantaneous Circuit Breaker according to **UL 489**.
  Siemens device types: 3VL
- Non-automatic circuit breakers according to **UL 489** terms in the standard: Molded Case Switch according to **UL 489**.
  These are a type of industrial control equipment in the form of a circuit breaker, although they have no protective function. They may, however, feature a short-circuit trip unit, which shall not be adjustable.
  Siemens device types: 3VL

6.3.2.2 Sizing

The sizing is the same as the sizing for the main disconnecting means.

A single device can provide this disconnecting/isolating function for a number of motors. See the "Group Installation" description.

6.3.3 Branch circuit protection UL 508A

6.3.3.1 Approved devices UL 508A § 31.1

- Circuit breakers according to **UL 489** (Inverse Time Circuit Breaker or Circuit Breaker)
  Siemens device types: 3RV17, 3RV18, 3VL, 5SJ4... HG
- Circuit breakers for starter combinations according to **UL 489** ("Instantaneous Trip Circuit Breaker").
  These circuit breakers only have short-circuit trip units (NO overload protection).
  Siemens device types: 3VL
- Fuse according to **UL 248** together with the corresponding fuseholders according to **UL 512**.
  Fuse classes: CC, J, T, RK1, RK5, etc.

Note

Semiconductor fuses according to **UL 248 - 13**. "Semiconductor" fuses should only be used to protect semiconductor devices; this also assumes the relevant device allows this and is documented in the UL report.

- Self Protected Combination Motor Controllers according to **UL 508** have this function.

Note

The following are not approved:

Miniature circuit breakers according to **UL 1077** (Supplementary Protectors)

Motor starter protectors according to **UL 508** (Manual Motor Controller)

Other fuses or miniature fuses according to **UL 248 - 14**

6.3.3.2 Sizing

UL 508A Table 31.1
Maximum rating of motor branch circuit device percent of full load amperes *

Table 31.1 revised September 1, 2005

Type of Branch Circuit Protective Device	Ampere Rating	Nominal rating of motor branch circuit protective device, percent of full load amperes	Notes UL 508A § ...
Nontime delay fuse	0 – 600	300	See 31.3.7, 31.3.8, 31.3.9(a)
Nontime delay fuse	Over 600	300	See 31.3.7, 31.3.8, 31.3.9(b)
Dual element fuse (time delay) except Class CC	All	175	See 31.3.7, 31.3.8, 31.3.9(c)
Class CC Dual element fuse (time delay)	0 – 30	300	See 31.3.7, 31.3.8, 31.3.9(a)
Inverse-time circuit breaker	0 – 100	250	See 31.3.7, 31.3.8, 31.3.9(d)
Inverse-time circuit breaker	Over 100	250	See 31.3.7, 31.3.8, 31.3.9(e)
Instantaneous-trip circuit breaker	All	800	See 31.3.4, 31.3.9(f)
Self-protected Combination Motor Controller	All	100	See 31.3.3
Manual Self-protected Combination Motor Controller	All	100	See 31.3.3

* Maximum rated current range for the branch circuit protection as a % of FLC

Single motor

UL 508A Art. 31.3

- Circuit breakers with delayed and instantaneous trip units (inverse-time circuit breaker): when making your selection, up to 250% of the rated motor current should be considered, and certainly nothing lower than 125%.
  Exception 1:
  These maximum values do not apply if the controller or overload relay is marked with a maximum size of fuse or circuit breaker which is less than these values.
  Exception 2:
  If the motor's start-up current trips the circuit breaker, the circuit breaker can be overdimensioned.
  - Up to 100 A rated current ⇒ 400% max
  - Above 100 A rated current ⇒ 300% max
- Circuit breakers with instantaneous trip units only (instantaneous-trip circuit breaker – only UL-Recognized): The circuit breaker should be configured for 115% of the thermal rated trip unit; the magnetic release should be configured for a maximum of 800% of the FLA.
  Exception:
  If the motor's start-up current trips the circuit breaker, the circuit breaker can be overdimensioned.
  - Up to 1300% for all motor types
  - Up to 1700% for Design B (High efficiency Motors)
- Fuses with time delay. The fuses shall be configured for at least 125% and no more than 175% of the rated motor current; the rated fuse current may however be increased to 225% of the rated motor current.
- Type E and F combination Controller: This selection is based on 100% of the rated motor current.

6.3.3.3 Specialities and practical advice

Specialities

Note: Type E and F combination starters, such as Siemens types 3RV102, 103 and 104, may only be used for individual motor branch circuits (not for other loads such as heaters, lighting or power transformers, etc.).

- They shall not be used as "Service Disconnect" (directly downstream of the meter).
- These devices have a "slash voltage rating", such as 480Y/277 or 600Y/347, and are therefore only appropriate "For use on a solidly grounded wyes source only", or in circuits with the lower voltage value.
- Manual Starter & Protectors (MSP) and miniature circuit breakers (Siemens types 5SY, 5SX or 5SP) shall not be used as "Service Disconnect".
- Self-Protected Combination Motor Controllers / Starter (types E and F) shall have the larger feeder terminals. (≙ Feeder Circuit).
- 3RV1 may be used for protecting control transformers in the Branch Circuit.

Fuses:

- Class RK5, different versions depending on the voltage (250 V, 600 V)
- Class J, smaller than RK5 and offering better protection
- Class CC (up to 30 A) for small loads

Fuse sizes:

Up to 30 A

Between 30 and 60 A

Between 60 and 100 A

Between 100 and 200 A

Between 200 and 400 A

Between 400 and 600 A

Greater than 600 A

Circuit breaker (as main disconnecting means and branch circuit protection): Thermal/magnetic trip unit (inverse-time)

- In applications of 1000 A and above, the circuit breaker shall have ground-fault protection. **UL 508A, Art. 31.1.7**
- UL-approved up to 40 °C only (approval available above this level, with reduced power, on request)

6.3.4 Magnetic controllers and industrial control equipment

(Load Controller, Motor Controller)

6.3.4.1 Regulations for contactors and switching devices (load controllers)

Devices for direct switching

UL 508A Art. 33

All devices used for direct switching of loads shall be approved according to **UL 508**.

Siemens magnetic controllers

Siemens type 3RT contactors are authorized for a large number of applications. In addition to the IEC/EN version, they can also be used in UL applications as general magnetic motor controllers, magnetic motor controllers for elevators (elevator ratings), magnetic controllers for lighting and heating, and as magnetic controllers for a Definite Purpose (e.g. for air conditioning). Certain Siemens types also show on their nameplate the relevant NEMA size (according to **NEMA ICS-2**). These range from NEMA size 00 to NEMA size 6.

Magnetic controllers for special applications

1. Magnetic controllers for lighting: Shall be approved according to **UL 508** for "Tungston-Load" or other lamp loads. Magnetic controllers with a nameplate for motors (e.g. in hp) cannot be used.
2. Magnetic controllers for heating: Shall be approved according to **UL 508** for "Resistive Heating Load". Magnetic controllers with a nameplate for motors cannot be used.
   Each individual heating circuit may be fused to a maximum of 60 A (in other words, they can be operated at a maximum of 48 A). (60 A * 80% = 48 A)
3. DP magnetic controllers (Definite Purpose): These magnetic controllers are the preferred variants for HVAC (HVAC-Heating, Ventilation, Air-Conditioning). They are configured on the basis of full-load amps and start-up current rather than on the basis of hp. They may only be used to switch hermetically sealed cooling system compressor motors.

Selecting industrial control equipment on the basis of rated power

Industrial control equipment is selected on the basis of its rated power, which shall be equal to or greater than that of the load of the voltage used. For magnetic motor controllers, the rated power shall be stated in hp.

Conversion from kW to hp (horsepower)

The power conversion factor is as follows:

1 kW = 1.3410 hp

1 hp = 0.74570 kW

6.3.4.2 Sizing

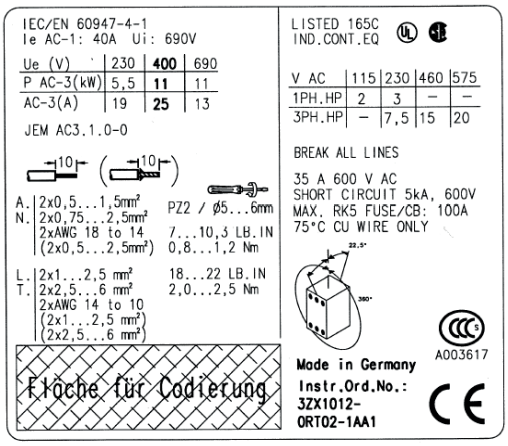
To calculate the switching capacity of magnetic controllers, the hp for the corresponding voltage shall be selected and the associated current taken from Table 50.1 in **UL 508A**.

Example: Siemens magnetic controller size S0, 3RT1026: 15 hp when 440-480 V => 21 A (3-phase), which means this magnetic controller can switch a maximum of 21 A at 460 V.

AC-1 and AC-3

The AC-1 and AC-3 details are for reference purposes only. They are of no practical value for calculating the switching capacity according to **UL** or **NEC**.
Exception: **NFPA 79, Table 7.2.10.1**

Example of a nameplate



The "BREAK ALL LINES" note on the nameplate indicates the switching capacity of the overload test. **UL 508 Art. 45.17**

A magnetic controller with this label breaks all phases at the same time. In other words, it cannot be used in a wye-delta switch with two magnetic controllers (the motor is connected directly to three phases – without 1M). In this case, the voltage that the magnetic controller has to break is 480 V × √3 = 832 V. The magnetic controller is not tested for this voltage.

6.3.4.3 Semiconductor switching devices

Semiconductor relays and semiconductor contactors are alternatives for applications involving a high switching frequency. Thanks to their long service lives, they can easily be used with very fast switching cycles throughout the entire machine service period without the need for replacement. They are mainly used for switching ohmic loads. Semiconductor switching devices for ohmic loads are approved as "general purpose" contactors and as motor magnetic controllers for switching motors according to **UL 508**.

Siemens type: 3RF

Solid state controllers are sized in the same way as mechanical magnetic controllers. There are no differences between the two according to **UL 508A**.

Note

When selecting branch circuit protection, please always take note of the details provided by the manufacturer.

6.3.5 Overload protection of motors

Motor overload

According to **UL 508A**, separate overload protection is required for each motor.
This will typically take the form of a bi-metal relay.

Exceptions

1. Motors with "T.P." approval
   ≙ thermal protected
2. Motors with "Z.P." approval
   ≙ impedance protected
3. Motors with an integrated form of overload protection which is also approved as such (e.g. thermistor protection)
4. If using "Motor Controller" (soft starting, frequency converters) with approved integrated overload protection.

Note

This should be specified in the relevant UL report for all exceptions.

Most common types according to IEC/EN

See UL 508A § 34; NEC 2008 Art. 430

Nowadays, the most common types are (as in the case of IEC/EN) the adjustable, directly heated and temperature compensated, bi-metal overload relays, and the electronic (solid-state) overload relays.

Trip classes

In the USA, there are various overload relays for motors: Solder-Pot, Heater-Type, Bi-Metall, etc. Alongside thermal overload relays, type 3RU11 for up to 100 A, Siemens also supplies electronic overload relays, type 3RB2 for up to 630 A, in trip classes 5, 10, 20 and 30. See the component selection tables in the annex to this documentation.

These relays are offered on the basis of trip classes.

The trip classes state the maximum number of seconds in which 6 times the motor current shall be tripped (e.g. class 10; 6 x full-load amps trip in 10 seconds or less).

Tripping settings

According to **UL 508A § 34.2** the motor overload protection shall be set in such a way that it responds at 115% (SF 1.0) or 125% (SF ≥ 1.15).

In accordance with NEMA, motors are specified with a service factor (SF), i.e. a motor can be overloaded by the percentage specified (e.g. SF 1.15)

Siemens overload relays (approved for UL and IEC) usually trip at 125% of the set value. This means:

- **A motor with SF1.0**: 0.92 times the motor's full-load amps (FLA – from the nameplate) is set on the overload relay. The overload relay then trips at 115% of the motor's full-load amps.
- **A motor with a service factor (SF) of no less than 1.15:**: The motor's full-load amps is set on the overload relay itself. The overload relay then trips at 125% of the motor's rated current.

For heavy starting, the overload relay can be set for up to 140% of the motor's full-load amps.

Overload relays for wye-delta switches should be connected to the load side of the M1 magnetic controller. They are set to 0.577 of the motor's full-load amps. The trip class should be noted. **UL 508A Art. 34.3.6**

All Siemens thermal overload relays have phase loss protection and are compensated at an ambient temperature of up to 60 ºC (see catalog for reduction factor for temperatures of up to 80 ºC).

6.3.6 UL type coordinations 1 and 2

According to UL 60947-4-1

The coordination is defined as in IEC:

- Type 1 coordination:

Persons and equipment shall not suffer any injury or damage under short-circuit conditions. The devices may be unusable after the short circuit, i.e. they will need to be repaired or replaced. This type 1 coordination corresponds roughly to the conditions for approval according to **UL 508**.

- Type 2 coordination:

Persons and equipment shall not suffer any injury or damage under short-circuit conditions. The combination shall however remain fully functional.
Contact welding of the magnetic controller may arise. The manufacturer shall provide details of how the contacts can be opened in such cases.

Operating conditions

UL gives permission in **UL 508E** (Outline of Investigation for Type 2 Coordination; please note that this is not to be confused with type E) for the self-certification of combination starters according to EN 60947-4-1 and has even adopted this standard in **UL 60947**. Since the test conditions differ from those in **UL 508**, these type coordinations are not yet recognized in the USA without further investigations into their use by UL.

Siemens supplies a complete range of magnetic controllers: type 3RT10 with overload relay, type 3RU11 to 100 A and 3RB20/3RB21 to 630 A.
These starter combinations are approved for up to 100 kA and up to 600 V if they are protected by fuses (**UL 248**) of class J.

6.3.7 Motor Controller types E and F

Type E

UL 508 Part IV, Section 76

The term "type E" (manual self - protected combination motor controller, self-protected control device) is commonly used. Here all the functions are met by one integrated device in the motor circuit. This is not the case with types "A" to "D". The term "self-protected" comes from the fact that this device is tested and approved for all functions in the combination motor controller. This means it does everything itself.

Type F

UL 508 Part IV, Section 76

The function of a combination starter with type F motor controller is similar to that of a type E motor controller.

The difference compared with type E is that type F (self-protected combination controller) consists of a combined 3RV10 circuit breaker and a Siemens 3RT10 contactor.

In this case, the 3RV circuit breaker handles the following functions

- Disconnect = isolating function
- Branch protection = branch circuit protection
- Motor overload = bimetal function

The 3RT10 contactor handles the function.

- Motor control

Type 3RV Siemens motor starter protector solution for type F

Siemens offers a complete type F product range (Siemens type 3RA11).
This range can be ordered in full (under type 3RA11) or as individual devices (types 3RV10 + 3RT10 + 3RA19), and is also available in a reversing magnetic controller-starter combination.

The products can be installed using fittings or by mounting on bars (35 mm standard mounting rail), or they can be snapped onto 40 mm or 60 mm busbars (Siemens FastBus/type 8US).

The combination is listed by UL for the following maximum short-circuit interrupting rating.

- 65 kA at 240 V and 480Y/277 V
- 30 kA at 600Y/347 V (the 3RV103 is only listed for up to 25 kA at 600Y/347 V)

Siemens type 3RV listed for type E and type F:
Siemens size S00 not listed for types E and F.
Siemens size S0: 3RV102 to 22 A, with larger input terminals.
Siemens size S2: 3RV103 11 A to 50 A.
Siemens size S3: 3RV104 28 A to 100 A, with larger input terminals

Supplementary provisions

Since July 2001, type E and F devices require large spacing at the input terminals: 25.4 mm (1") distance through air and 50.4 mm (2") distance over surfaces. UL-listed devices have since been provided with extra input terminals (Siemens 3RV1928-1H for 3RV102 and 3RT1946-4GA07 for 3RV104; the 3RV103 needs no extra input terminals. The terminal spacing in the standard device is sufficient).

6.3.8 Group installation

UL 508A § 31.4

UL 508A takes "Group Installation" to mean:

- 2 or more motors
- 1 motor and other loads

This kind of "group" can be protected by a single Branch Circuit Protective device (≙ branch circuit protection).

6.3.8.1 Approved devices

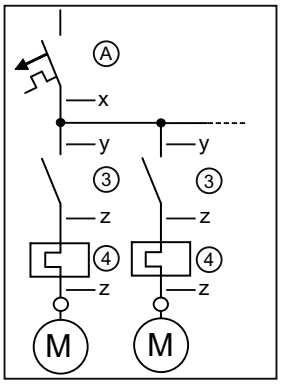
- Branch Circuit Fuse according to **UL 248**
  standard branch fuse
- Inverse Time-Circuit Breakeraccording to **UL 248**
  type 3VL, 3RV17/18, 5SJ4... HG circuit breakers

6.3.8.2 Structure

Based on the approved devices (see above), only version "A" and "C" combination motor controllers can be used.
The following example is based on version "C".

Typical circuit diagram

Ⓐ Branch circuit protection
③ Motor control
④ Overload protection
x Supply line to the motor group
y Supply line to the Manual Motor Controller
z Load side of the Manual Motor Controllers (cables)



6.3.8.3 Sizing

The Motor Controller ③ (magnetic controllers) and Motoroverload ④ (overload relays) are sized in the same way as for single branches (see Chapter 6.3 Detailed information about sizing combination motor controllers (Page 143)).

Generally speaking, the branch circuit protection is sized as follows:

The rated current of the largest single motor multiplied by a factor of 1.25, PLUS the total of all the other loads.

Cables within the Industrial Control Panels

1. "Power cable" (x) ≙ branch wire.
   This is designed according to the current value of the branch circuit protective device (1).
2. Cables in the single branch (y) + (z)
   according to the load (see Chapter Basis for the dimensioning of combination motor controllers according to UL 508A (Page 139)), but with at least 1/3 of the current carrying capacity of the branch wire (x).

Note

For non-motor loads, the conditions in **UL 508A § 31.5 ... 31.8** shall also be observed.

6.3.8.4 Add on: "...suitable for tap conductor protection"

UL 508A § 31.4.3 (b)

This phrase makes "Group Installation" easier.
As long as devices have passed this additional test according to **UL 508** and this additional wording is printed on the device, the following deviations are allowed.

1. Motor control function ③.
   Either a
   - Manual Motor Controller according to **UL 508** shall be used here.
     Siemens type 3RV.
   - Or a Manual Motor Controller in combination with a magnetic controller (both according to **UL 508**) can be used.
     This is known as a "Manual / Magnetic Motor Controller". Siemens type 3RV combined with 3RT.
2. "Power cable" (x).
   Unchanged, as per 6.3.8.3
3. In this case, multiwire terminals linked to the branch circuit protective device are often used.
4. Supply cable to the Manual Motor Controller
   (cable y).
   This can be reduced to 1/10 of the supply line, but shall be at least appropriate for the load. (The larger value applies.) If multiwire terminals are being used on the load side of the BPCD (see number 2), the total current (at least) should be determined and used as the basis.
5. Load side of the Manual Motor Controllers
   (cable z).
   This shall be at least inside the Industrial Control Panel appropriate.

Note

The values from the tables should also be used when sizing any "Group Installation" (does not apply to bi-metal).

6.3.8.5 Rules outside the industrial control panel

NEC 2005 new ruling

The National Electrical Code introduced a new rule as part of the 2005 edition:

Tap rule according to the **NEC**

1. For feeder taps, **NEC 2008 Art. 430.28** and **NEC 2008 Art. 240.21**
2. For branches (Group Installation) **NEC 2008 Art. 430.53 (C) and (D)**

This new rule relates to the cross section relationship between the feeder conductor/branch conductor and tap conductor/tap motor conductor. The cable length and ratio between size of feeder circuit protection and branch circuit protection influence the size of the tap conductor.

The tap rule basically means:

1. If the wire from the tap point to the branch circuit protection (GTCP) is longer than L > 7.5 m, the tap conductor (B) shall be exactly the same size (cross section) as the feeder conductor (A).
2. If the wire from the tap point to the branch circuit protection (GTCP) is shorter than L < 7.5 m but longer than L > 3 m, the tap conductor (B) can be exactly the same size (cross section) as the feeder conductor (A), but shall never be smaller than 1/3 of the size of the feeder conductor.
3. If the wire from the tap point to the branch circuit protection (GTCP) is shorter than L < 3 m, the tap conductor shall never be smaller than 1/10 of the rated current (or current setting) of the feeder circuit protective device (BCPD).

The third of these rules applies:

- In the **NEC 2008** for all loads
- In **UL 508A**, but only for motor loads which contain a listed overload relay

General:

The tap conductor (B) shall always be large enough to carry the load current.

Combination motor controllers

The size L (current carrying capacity) of the motor "Tap Conductor" depends:

1. On its length (for any load, such as motors, heaters, transformers etc.):
   - L > 7.5 m (25 ft) => A = B
   - 3 m (10 ft) < L > 7.5 m => A = B, but not less than B = 1/3 A
2. On the size of the feeder/branch circuit protection (BCPD):
   only for motor circuits, protected with Manual / Motor Controller (type 3RV) marked as "suitable for Tap conductor protection in group applications". **NEC 2008, 240.21 (B)** does not feature this restriction.
   - L < 3 m: BCPD => B ≥ 1/10 BCPD

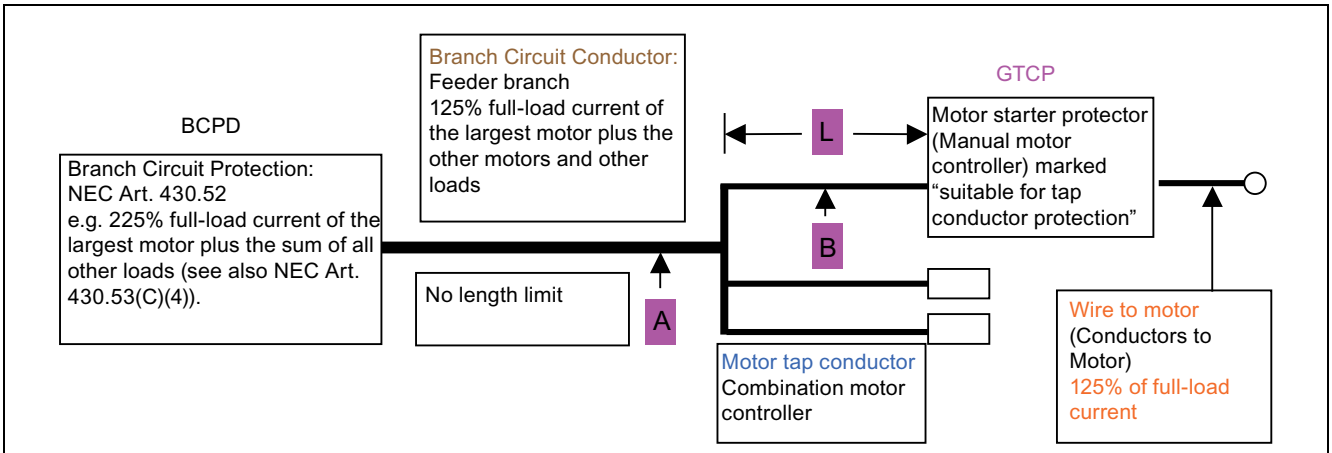
The length is measured from the branch point to the GTCP (Group Tap-Circuit Protector) (motor branch circuit protection = Manual Motor Controller). Since the GTCP (Siemens type 3RV10) is tested and listed for cable protection, the current carrying capacity of the wire to the motor only needs to be 125% of the motor's full-load amps.

Note:

New – Manual Motor Controllers (motor starter protectors, type 3RV) and Combination Motor Controllers, types E and F (3RV with and without magnetic controller), may now be used for motor loads.

Use of terminal blocks with large spacing is NOT needed here.

Note: The cable length rule applies to feeder and branch circuits. This means that a FCPD (Feeder-Circuit Protective Device) has to be installed in the feeder circuit instead of a BCPD (Branch-Circuit Protective Device).



Establishing the current carrying capacity of the motor wire

6.3.9 Comparison between group installation and type E/F

Type E and F combination starters are becoming increasingly important in the USA. They are however restricted to electric circuits with a solidly grounded wye. But in many cases the future location of use for industrial control panels is not prescribed or other infeeds are specified (e.g. corner-grounded delta). **NEC 2008 Art. 430.52 (C) (6)**

Nameplate of 3RV102

Combination starter type E / F	Group Installation

MAN. SELF-PROT.COMB.MTR.CNTR.
SHORT-CIRCUIT CURRENT RATING
RMS, SYM: 65KA, 240V, 480Y/277V;
30KA, 600Y/347V
UL CERTIFIED: WITH 3RV1928-1H
ADAPTER ONLY OR WITH 3RV1925-5EB
AND 3RV1915 AND AS TYPE F COMB.
WITH 3RT1.2 OR 3RW3.2

MAN. MTR. CNTR. SUITABLE FOR USE IN
GROUP APPLICATION.
FOR WIREPROT. MAX. FUSE OR CB 90A.
SHORT CIRCUIT CURRENT RATING
RMS, SYM: 65KA, 480V; 30KA, 600V
UL CERTIFIED: AS TAP CONDUCTOR PROT.
DEVICE IN GROUP APPLICAT. AND AS MOTOR
DISCONNECT. MAX. FUSE OR CB 250A

LISTED 165C 600 V, 6.3 FLA MAX.

V AC 50/60HZ	200-208	230	460	575
HP,3ph	2	2	5	5

DIAL IS FLA.TRIP AMPS 125%; USE 75°CU WIRE ONLY; BREAK ALL LINES

WARNING: IF AN OVERLOAD OR A FAULT CURRENT INTERRUPTION OCCURS, CIRCUITS MUST BE CHECKED TO DETERMINE THE CAUSE IN A FAULT CONDITION, THE CONTROLLER SHOULD BE EXAMINED AND REPLACED IF DAMAGED TO REDUCE THE RISK OF FIRE OR ELECTRIC SHOCK. TO MAINTAIN OVERCURRENT, AND SHORT-CIRCUIT PROTECTION, THE MANUFACTURER'S INSTRUCTIONS FOR SELECTION OF OVERLOAD AND SHORT CIRCUIT PROTECTION MUST BE FOLLOWED.

Group - Installation

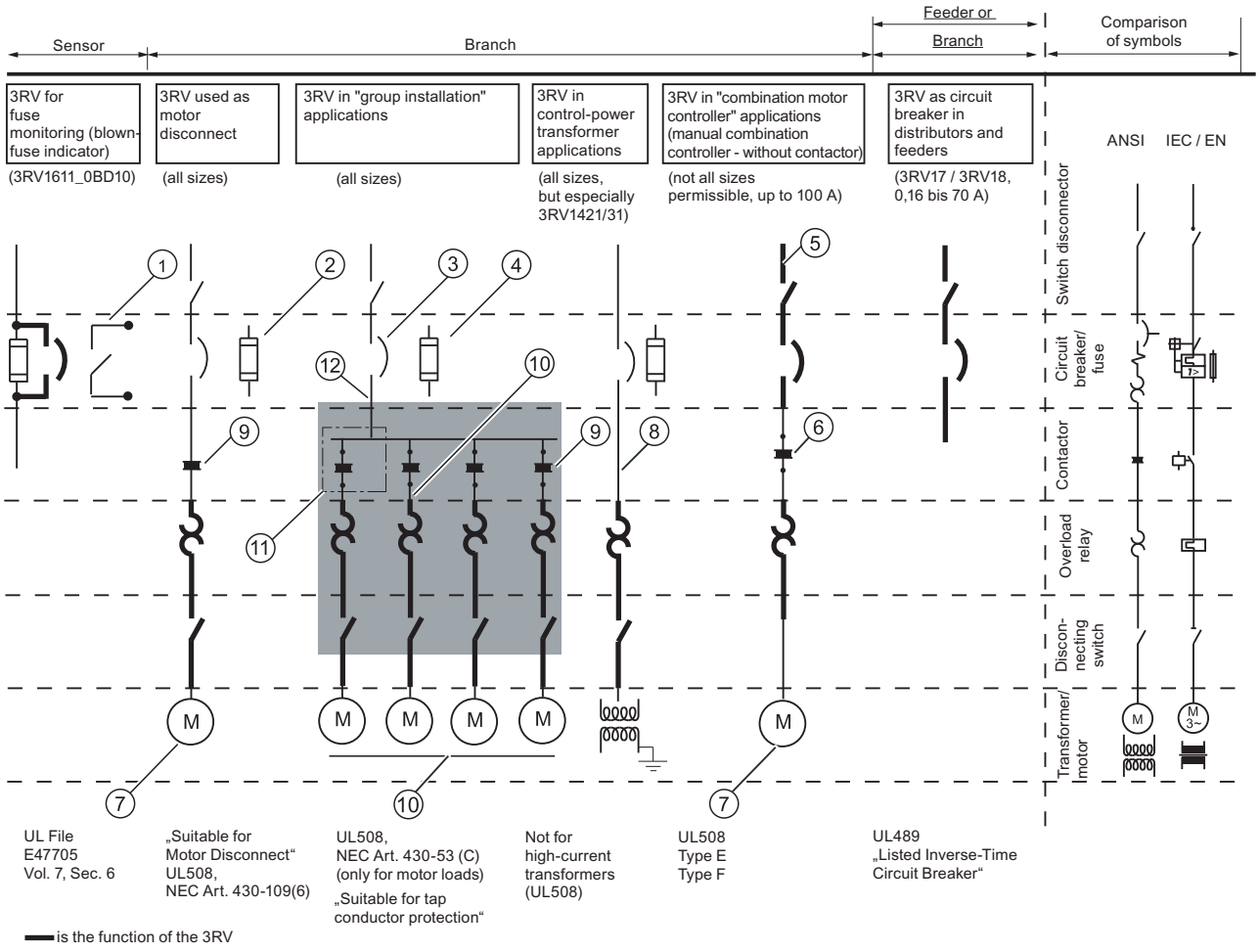
If you do not, however, want to do without the very practical type 3RV10 motor starter protector, you can revert to the rules for group installation.

All Siemens type 3RV10 (including size 00) and type 3RV101 motor starter protectors are UL-listed for group installation. Several devices can be protected by one circuit breaker or fuse. The nameplates are marked with the maximum permissible circuit breaker and fuse. The permissible protective devices are very large. In many cases, the existing main disconnecting means or the feeder circuit protection can be used to protect the group installation anyway.

The motor starter protectors can be fitted in series with or without magnetic controllers, and do not have to be fitted with larger terminal blocks. In such cases, the Group short-circuit protective element (circuit breaker or fused disconnect) already has the large spacing on the line side.
The cable sizes to be used and the largest protective element are described under "Tap-Conductor Protection". **NEC 2008 Art. 430.53**

6.3.10 Example of combination motor controllers with SIRIUS 3RV motor starter protectors

Overview of the numerous applications of the Siemens type 3RV motor starter protector



① The auxiliary switch 3RV1901-1E or -1A should be ordered separately

② Fuse or circuit breaker

③ Current = 250 % of largest FLC + Σ of all motors

④ Current = 175 % of largest FLC + Σ of all motors

⑤ Large terminal spacing (distances through air and over surfaces):

⑥ Magnetic controller optional for Manual Combination Controller

⑦ 125% power capacity of the motor's full load

⑧ 125% power capacity of the load

⑨ Magnetic controller is optional

⑩ Small terminal spacing (distances through air and over surfaces):

⑪ Suitable, for tap conductor protection in group application

⑫ Tap rule applicable

6.3.11 Wye-delta magnetic controller combination arrangement

Startup procedure

UL 508A Art. 33.5

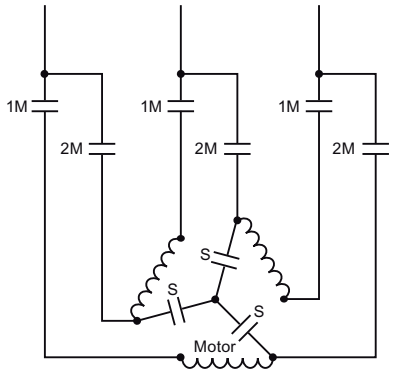
Wye-delta starting of motors is a very popular way of reducing the start-up current. UL 508A describes 2 arrangements, with and without current interrupts for switching from wye to delta: "open-circuit" and "closed-circuit transition".

With "closed-circuit transition" the motor remains connected to the supply system via an extra magnetic controller – resistance combination (not designed for full-load amps) during the switch from wye to delta.

The most common application is the "open-circuit transition". "Closed-circuit transition", which is used when current peaks, which may arise with large motors when switching from wye to delta, are not permitted. Nowadays, it is more cost-effective to use a soft-starter (e.g. type 3RW3 or 3RW4) rather than this combination. Only "open-transition" will be discussed here.

6.3.11.1 Magnetic controller sizing

OPEN-CIRCUIT TRANSITION



CONTACTOR SEQUENCE				
CONTAC-TOR	START		TRANSI-TION	RUN
1M		X	X	X
2M				X
S	X			

Table 33.2
Contactor sizing for wye-delta controller
Table 33.2 effective April 25, 2003

Contactor designation	Required contactor ampere rating	
	"make" current, LRA	"break" current, FLA
1M	0.33 multiplied by motor LRA	0.577 multiplied by motor FLA
2M	0.577 multiplied by motor LRA	0.577 multiplied by motor FLA
1S	No current	0.33 multiplied by motor LRA
2S	a	a
[a] Rating of contactor shall be determined based on the impedance provided		

According to this table, the power supply, delta and wye magnetic controllers should be sized such that the values specified above are below the values tested in **UL 508**. The corresponding magnetic controllers for power ratings of 5-300 hp at 230, 460 and 575 V are given in the Annex under Devices.

Siemens solution

Siemens supplies ready wired wye-delta combinations (without overload relay) for up to 95 A of motor current. Furthermore, the individual Siemens devices that you can fit yourself are detailed in a table.

A couple of technical notes:

- The start-up current in wye is 1/3 of the start-up current in delta
- Phase current divided by power supply and delta magnetic controller is 0.577 of the rated motor current.
- The wye magnetic controller is 0.33 of the rated motor current.

New: The "1S" wye magnetic controller does not have to be taken into account when establishing the short-circuit current rating. **UL 508A, Art. SB4.2.1**

6.3.11.2 Interlock between wye-delta contactor combinations

Overview

Either a mechanical **or** an electrical form of interlocking is specified under **UL 508A Art. 33.4** and **33.5**.

1. New – **UL 508A, Art. 66.8.1 in "Industrial machinery" applications**: Reversing motor controllers and wye-delta switches shall be provided with both mechanical and electrical interlocking means.
2. **NFPA 79 Art. 9.3.4.2** Mechanical and electrical interlocking is only specified if the motor can run in the reverse direction of rotation (for example, reversing motor controllers, not wye-delta combinations; only where these are mechanically interlocked do they also need to be electrically interlocked).

Interlocking

UL do **not** generally specify generally the use of mechanical interlocking. It is, however, standard practice, and most customers expect mechanical interlocking to be used between these two magnetic controllers.

If interlocking is used, please note

- 3RT101 to 3RT104 only use the same frame sizes with interlocks that can be mounted at the top or attached at the side (for all sizes).
- 3RT104 can now be used with 3RT105.
- 3RT105 to 3RT107 can also be used.

6.3.12 Drives with reversible direction of rotation (reversing motor controllers)

UL 508A § 33.4 "Reversing Motor Controller"

Here a separate magnetic controller shall be used for each direction of rotation.

Both magnetic controllers shall be interlocked in a suitable manner to ensure they cannot be activated simultaneously.

This can be achieved by one of the following methods.

1. Electrical interlocking via control circuitry
2. Mechanical interlocking

6.3.13 Soft starter

SIRIUS soft-starter 3RW

Siemens supplies three ranges of soft-starters: 3RW30/31, 3RW40 and 3RW44.
All three ranges are UL-listed according to **UL 508**.

SIRIUS 3RW30/31

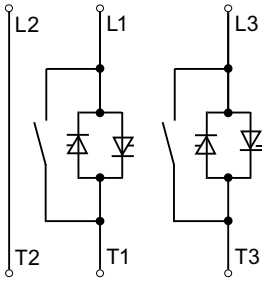
The SIRIUS 3RW30/31 soft-starter is available in various versions:

- Standard version for three-phase motors with fixed speed in frame sizes S00, S0, S2 and S3
- Version for three-phase motors with fixed speed in 22.5 mm enclosure
- Special version 3RW31 for Dahlander motors, only in frame size S0
- Version for soft starting single-phase motors in frame sizes S0, S2 and S3.

3RW30/31 soft-starters are not fitted with an internal overload relay. The motor shall be protected using an external overload relay (**UL 508**).

SIRIUS 3RW30/31 for three-phase motors

These are soft-starters rated up to 60 hp at 460 V and a surrounding air temperature of 50 °C for standard applications in three-phase networks. Very small frame sizes, low power losses and easy start-up are just 3 of the numerous advantages of this soft-starter. The special feature of the 3RW31 components is that they allow two start-up ramps to be set up differently from each other (Dahlander motors).



SIRIUS 3RW30

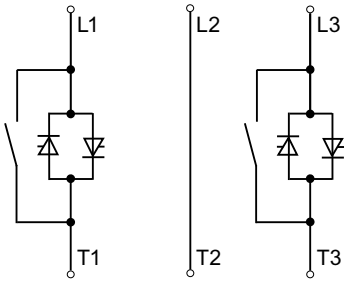
SIRIUS 3RW30 for single-phase motors

This is the additional version for standard applications in single-phase networks. At the time of starting, the motor's making current is reduced and the motor torque is effectively cut by its voltage ramp function. This preserves the load and the supplying network.

SIRIUS 3RW40 for three-phase motors

These are soft-starters rated up to 300 hp at 460 V and a surrounding air temperature of 50 °C for standard applications in three-phase networks. Very small frame sizes, low power losses and easy start-up are just 3 of the numerous advantages of the SIRIUS 3RW40 soft-starter.

The 3RW40 is equipped with an internal UL-listed overcurrent relay (according to **UL 508** and **UL 1998**). This removes the need for additional overload protection.



SIRIUS 3RW40

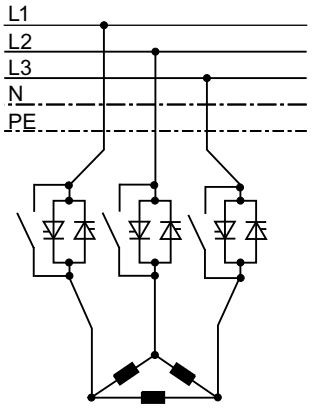
SIRIUS 3RW44 for high-feature applications

The SIRIUS 3RW44 electronic soft-starter offers not just soft starting up and ramping down but also numerous features for more demanding requirements. At a surrounding air temperature of 50 °C, the performance range is up to 950 hp at 460 V in the standard connection and up to 1700 hp at 460 V in the inside-delta connection.

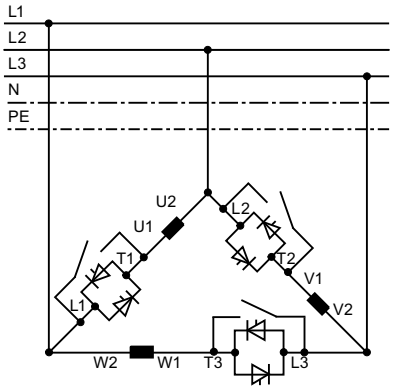
The SIRIUS 3RW44 soft-starters have a compact design, which saves space and makes them easy to install in industrial control panels. When it comes to achieving optimized motor startup/stop, the innovative SIRIUS 3RW44 soft-starters are an attractive alternative to frequency converters, not least because they offer significant savings. The new torque control and adjustable current limiter ensure that High - Feature soft-starters can be used for almost any conceivable application. They guarantee safe avoidance of sudden torque changes and current peaks during motor starts/stops. This means that savings can be made when sizing industrial control panels and maintaining machinery. With the SIRIUS 3RW44 soft-starter, savings can be made with respect to frame size and outlay, both for In-Line or inside-delta connection. Combinations of different start, operating or ramping down possibilities ensure optimum adjustment to the application requirements.

The starter can be operated and started up using the user-friendly keypad with a menu-assisted, multiple line, graphic display and background lighting. Optimized motor startup/ramp down can be configured quickly, easily and safely in a preselected language by making just a few settings. 4-key operation and plain text displays for each menu item ensure clear configuration and operation at all times.

The 3RW44 is equipped with an internal UL-listed overload relay (according to **UL 508** and **UL 1998**). This removes the need for additional overload protection.



3RW44



3RW44 – internal arrangement

6.3.14 Frequency converters or variable speed drives

In general, these devices are treated and sized in the same way as "Motor Controllers".

As far as these semiconductor switching devices are concerned, it is very important to take account of the information in the relevant UL report on the branch circuit protective device which may/shall be used.

Here too, attention should be paid to the tables for sizing the Motor Controllers.

6.3.15 Branch circuit protection for "non-motor" loads

UL 508A § 31.5 ... 31.8

The general requirements are detailed below. Please check **UL 508A** for exceptions, and make any adjustments that may be necessary.

6.3.15.1 Heater load

UL 508A § 31.6

In general, the following applies in terms of sizing.

- Not less than 125% of the heater load rated current
- Not greater than 60 A rated current
- Wiring shall be based on the current of the branch circuit protection.

6.3.15.2 General appliance protection (appliance load)

UL 508A § 31.7

- Single appliance, non-motor-operated:
  - According to the technical documentation for the appliance
  - Not more than 20 A for appliances rated higher than 13.3 A where the appliance documentation contains no relevant specific details
  - 150% for appliances rated higher than 13.3 A where the appliance documentation contains no relevant specific details.
    Exception:
    An appliance provided with a power supply cord is not obliged to comply with this requirement as the receptacle used for connection is itself protected.
- Single motor-operated appliance
  - According to the technical documentation for the appliance
  - Or the requirements relating to combination motor controllers
  - Or the requirements relating to receptacles

6.3.16 Determining the "full-load ampacity" of transformers, heater loads and capacitor loads

UL 508A Art. 50.6

If transformers (rating in VA), heater loads (rating in W) or capacitor loads (rating in VAR) are used, the full-load amps are calculated as follows:

Single-phase: Current [A] = (rating in VA, W or VAR)／(rated voltage [V])

Three-phase: Current [A] = (rating in VA, W or VAR)／√3 × (rated voltage [V])

6.4 Device selection according to technical data

6.4.1 Overview of devices in power circuits and their functions

Siemens devices in the power circuit

This table lists the most important Siemens devices in the power circuit. It shows the function for which a device may be used in the power circuit:

- In the feeder circuits or branch circuits
- Upstream or downstream of the branch circuit protection

The UL CCN (Classification Control Number) determines the application for which a device may be used. The UL file number specifies the file in which the device is listed/recognized. It shall be specified when submitting an industrial control panel to UL.

Siemens Family	CCN UL file	CSA file	Branch				Feeder	
			Short-circuit protection BCPD	Overload protection	Motor switching function (motor control)	Motor disconnect	Main disconnecting means	Feeder protection
3WL5	DIVQ (UL 489) E10848		X				X	X
3WL5	WJAZ (UL 489) E236091		X				X	
3VL	DIVQ (UL 489) E10484	LR12730	X		X	X	X	X
3RV17 [1)]	DIVQ (UL 489) E235044	LR12730	X			X		
3RV S00,S0,S2, S3	NLRV (UL 508) E47705	LR12730		X	X	X		
3RV S0 3RV1928-1H Type E	NKJH (UL 508) E156943	LR12730	X	X	X[2)]	X		

1) These are circuit breakers from the SIRIUS product family in frame sizes S0 and S3 approved as thermal-magnetic (TM) circuit breakers according to UL 489.

2) Only manual control possible without contactor

Siemens Family	CCN UL file	CSA file	Branch				Feeder	
			Short-circuit protection BCPD	Overload protection	Motor switching function (motor control)	Motor disconnect	Main disconnecting means	Feeder protection
RV1928-1H 3RT 1.2 Type F	NKJH **(UL 508)** E156943	LR12730	X	X	X	X		
3RV S2 Type E	NKJH **(UL 508)** E156943	LR12730	X	X	X	X		
3RV S3 3RT1945 Type F	NKJH **(UL 508)** E156943	LR12730	X	X	X	X		
3RT	NLDX **(UL 508)** E31519	LR12730			X			
3RF	NMFT **(UL 508)** E143112	LR12730			X			
3RU	NKCR **(UL 508)** E44653	LR12730		X				
3RB	NKCR **(UL 508)** E6635	LR12730		X				
3RW	NMFT **(UL 508)** E143112	LR12730		X [3)]	X			
3RA	NLDX **(UL 508)** E31519	LR12730		X	X			
3LD2	NLRV **(UL 508)** E47705	LR12730				X		
3KA53 3KA57	NLRV **(UL 508)** E47705	LR12730				X		

[3)] 3RW40 and 3RW44 only

6.4.2 Overview of devices in control circuits and their functions

Devices in the control circuit and their functions

Siemens family	CCN UL File	CCN CSA	Short-circuit protection	Overload protection	Switching	Time switching	Monitoring	Accessories
5SY4, 5SY6, 5SY7, 5SY8, 5SP4, 5SX2, 5ST30, 5SX9	QVNU2 **(UL 1077)** E116386	QVNU8 *CSA C22.2 No. 235*	X X -	X X -				- - X
5SJ4 ... HG	DIVQ **(UL 489)** E243414	DIVQ7 *CSA C22.2 No. 5-02*	X	X				
7LF44, 7LF53	WGZR2 **(UL 917)** E301698	WGZR8 *CSA C22.2 No. 14* and *177*				X		
7KT58	XHNR2 **(UL 863)** E300537	XHNR8 *CSA C22.2 No. 6* and *55*					X	
5TE6804	RTRT2 **(UL 498)** E258598	RTRT8 *CSA C22.2 No. 182.3M*						X
5TE1	NLRV **(UL 508)** E302554				X			
5TT57	NLDX **(UL 508)** E303328				X			
3NC	JFHR2 **(UL 248-13)** E167357	JFHR8 *CSA C22.2 No. 248.13-00*	X	X				
3NE	JFHR2 **(UL 248-13)** E167357	JFHR8 *CSA C22.2 No. 248.13-00*	X	X				
3NC10, 3NC14, 3NC22	IZLT2 **(UL 512)** E220063		X	X				
3NW ... 0HG	**JDDZ (UL 248-4)** E258218							X
3NW7 5x3-0HG	IZLT **(UL 512)** E171267	IZLT7 *CSA C22.2 No. 39-M*						X
3NH	IZLT **(UL 512)** E171267	IZLT8 *CSA C22.2 No. 39-M*						X

6.4.3 Devices for combination motor controllers

6.4.3.1 Tables for selecting across-the-line magnetic controllers

SIRIUS Frame Sizes	Maximum Current		Maximum Horsepower Ratings					
	Inductive AC3 Amperage	Resistive AC1 Amperage	Single Phase		Three Phase hp Ratings			
			115 V [hp]	230 V [hp]	200 V [hp]	230 V [hp]	460 V [hp]	575 V [hp]
3RT1015	7	18	0.25	0.75	1.5	2	3	5
3RT1016	9	22	0.33	1	2	3	5	7.5
3RT1017	12	22	0.5	2	3	3	7.5	10
3RT1023	9	40	0.33	1	2	3	5	7.5
3RT1024	12	40	0.5	2	3	3	7.5	10
3RT1025	17	40	0.5	2	5	5	10	15
3RT1026	25	40	1	3	7.5	7.5	15	20
3RT1033	28	40	2	5	7.5	10	20	25
3RT1034	32	50	2	5	10	10	25	30
3RT1035	40	60	3	7.5	10	15	30	40
3RT1036	50	60	3	10	15	15	40	50
3RT1044	65	100	5	15	20	25	50	60
3RT1045	80	120	7.5	15	25	30	60	75
3RT1046	95	120	10		30	30	75	100
3RT1054	115	160	-	25	40	50	100	125
3RT1055	150	185	-	30	50	60	125	150
3RT1056	185	215	-	30	60	75	150	200
3RT1064	225	275	-	-	60	75	150	200
3RT1065	265	330	-	-	75	100	200	250
3RT1066	300	330	-	-	100	125	250	300
3RT1075	400	430	-	-	125	150	300	400
3RT1076	500	610	-	-	150	200	400	500
3TF68	630	700	-	-	200	250	500	650
3TF69	820	910	-	-	290	300	700	860

6.4.3.2 Selection criteria for wye-delta contactor combination arrangement

Procedure

1. The smallest size of the Main (=1M) and Delta (=2M) contactor is calculated from the full load current (FLC) according to the hp-values from the standards. The portion of the 1M and 2M current shall not be less than FLC * 0,577.
2. The smallest size of the Wye (=1S) contactor is calculated from the full load current (FLC) acc. to the hp-values from the standards. The portion of the 1S current shall not be less than FLC * 0,333.
3. All selected contactors shall be checked for their Locked Rotor Current (LRC). The LRC shall be taken acc. to the hp-value from the standard. The portion for the contactors (1M, 2M, 1S) shall be calculated with the same factors as the FLC-portions are calculated, see above.
   All selected contactors (1M, 2M, 1S) shall have an LRC value not less than the calculated one.

Note:

- The various current values of the magnetic controllers can be found in our catalogues or UL-files.
- For mechanical interlocking between delta and wye magnetic controllers - see page 163
- If the actual used motor has different LRC values, please use the values from the motor
- The UL508A § 33.4 rules this topic. But the terms for FLA and FLC are not clearly differentiated but as relevant table for the motor currents Tab. 50.1 from UL508A is used as reference.
  Therefore we used the FLC and LRC acc. the Standards in the following tables

230 V Wye-Delta Starter Combination - Example-selection of diverse combinations

Standard values acc. to UL508A			Selection criteria for contactors 1M (=Main) and 2M (=Delta)			Selection criteria for the contactor 1S (=Wye)		
Motor Power hp	Acc. to UL 508A Tab. 50.1 FLC[1]	Acc. to UL 508A Tab. 50.3 LRC[1, 2]	Portion of FLC for 1M & 2M 0.577xFLC	Portion of LRC for 1M & 2M 0.577xLRC	Smallest 1M & 2M acc. to its thermal current	Portion of FLC for 1S 0.333xFLC	Portion of LRC for 1S 0.333xLRC	Smallest 1S acc. to its thermal current
5	15.2	92	8.8	53.1	3RT1016	5.1	30.6	3RT1015
7.5	22	127	12.7	73.3	3RT1025	7.3	42.3	3RT1016
10	28	162	16.2	93.5	3RT1025	9.3	53.9	3RT1016
15	42	232	24.2	133.9	3RT1033	14.0	77.3	3RT1025
20	54	290	31.2	167.3	3RT1035	18.0	96.6	3RT1026
25	68	365	39.2	210.6	3RT1035	22.6	121.5	3RT1033
30	80	435	46.2	251.0	3RT1044	26.6	144.9	3RT1033
40	104	580	60.0	334.7	3RT1044	34.6	193.1	3RT1035
50	130	725	75.0	418.3	3RT1045	43.3	241.4	3RT1044
60	154	870	88.9	502.0	3RT1054	51.3	289.7	3RT1044
75	192	1085	110.8	626.0	3RT1054	63.9	361.3	3RT1044
100	248	1450	143.1	836.7	3RT1055	82.6	482.9	3RT1054
125	312	1850	180.0	1067.5	3RT1056	103.9	616.1	3RT1054
150	360	2170	207.7	1252.1	3RT1065	119.9	722.6	3RT1054
200	480	2900	277.0	1673.3	3RT1066	159.8	965.7	3RT1056
250	604	3650	348.5	2106.1	3RT1075	201.1	1215.5	3RT1065

FLC (Full-Load-Current) Rated current according to standard

LRC (Locked-Rotor Current) Locked rotor current according to the standard

1 Check the current value according to the motors' data sheets.

2 this value applies for motor with the designations B, C, D

The motor overload protection (Bi-Metal) has to be selected according to the name plate of the motor used.

The relevant Branch Circuit Protection Device shall be selected according to the application, e.g. UL508A.

460 V Wye-Delta Starter Combination - Example-selection of diverse combinations

Standard values acc. to UL508A			Selection criteria for the contactors 1M (=Main) and 2M (=Delta)			Selection criteria for the contactor 1S (=Wye)		
Motor Power hp	Acc. to UL 508A Tab. 50.1 FLC[1]	Acc. to UL 508A Tab. 50.3 LRC[1, 2]	Portion of FLC for 1M & 2M 0.577xFLC	Portion of LRC for 1M & 2M 0.577xLRC	Smallest 1M & 2M acc. to its thermal-current	Portion of FLC for 1S 0.333xFLC	Portion of LRC for 1S 0.333xLRC	Smallest 1S acc. to its thermal current
5	8	46	4.4	26.5	3RT1015	2.5	15.3	3RT1015
7.5	11	64	6.3	36.6	3RT1016	3.7	21.1	3RT1015
10	14	81	8.1	46.7	3RT1017	4.7	27.0	3RT1015
15	21	116	12.1	66.9	3RT1025	7.0	38.6	3RT1016
20	27	145	15.6	83.7	3RT1026	9.0	48.3	3RT1017
25	34	183	19.6	105.6	3RT1026	11.3	60.9	3RT1025
30	40	218	23.1	125.8	3RT1033	13.3	72.6	3RT1025
40	52	290	30.0	167.3	3RT1034	17.3	96.6	3RT1026
50	65	363	37.5	209.5	3RT1035	21.6	120.9	3RT1033
60	77	435	44.4	251.0	3RT1036	25.6	144.9	3RT1033
75	96	543	55.4	313.3	3RT1044	32.0	180.8	3RT1034
100	124	725	71.5	418.3	3RT1045	41.3	241.4	3RT1036
125	156	908	90.0	523.9	3RT1046	51.9	302.4	3RT1036 3RT1044
150	180	1085	103.9	626.0	3RT1054	59.9	361.3	3RT1044
200	240	1450	138.5	836.7	3RT1055	79.9	482.9	3RT1046
250	302	1825	174.3	1053.0	3RT1056	100.6	607.7	3RT1054
300	361	2200	208.3	1269.4	3RT1065	120.2	732.6	3RT1054 3RT1055
350	414	2550	238.9	1471.4	3RT1065 3RT1066	137.9	849.2	3RT1055
400	477	2900	275.2	1673.3	3RT1066	158.8	965.7	3RT1056
450	515	3250	297.2	1875.3	3RT1066 3RT1075	171.5	1082.3	3RT1056
500	590	3625	340.4	2091.625	3RT1075	196.5	1207.125	3RT1065

FLC (Full-Load-Current) Rated current according to standard

LRC (Locked-Rotor Current) Locked rotor current according to the standard

1) Check the current value according to the motors' data sheets.

2 this value applies for motor with the designations B, C, D

The motor overload protection (Bi-Metal) has to be selected according to the name plate of the motor used.

The relevant Branch Circuit Protection Device shall be selected according to the application, e.g. UL508A.

575 V Wye-Delta Starter Combination - Example-selection of diverse combinations

Standard values acc. to UL508A			Selection criteria for the contactors 1M (=Main) and 2M (=Delta)			Selection criteria for the contactor 1S (=Wye)		
Motor Power hp	Acc. to UL 508A Tab. 50.1 FLC[1]	Acc. to UL 508A Tab. 50.3 LRC[1, 2]	Portion of FLC for 1M & 2M 0.577xFLC	Portion of LRC for 1M & 2M 0.577xLRC	Smallest 1M & 2M acc. to its thermal current	Portion of FLC for 1S 0.333xFLC	Portion of LRC for 1S 0.333xLRC	Smallest 1S acc. to its thermal current
5	6	37	3.5	21.2	3RT1015	2.0	12.3	3RT1015
7.5	9	51	5.2	29.3	3RT1015	3.0	16.9	3RT1015
10	11	65	6.3	37.4	3RT1017	3.7	21.6	3RT1015
15	17	93	9.8	53.7	3RT1017	5.7	31.0	3RT1015
20	22	116	12.7	66.9	3RT1025	7.3	38.6	3RT1017
25	27	146	15.6	84.2	3RT1025	9.0	48.6	3RT1017
30	32	174	18.5	100.4	3RT1026	10.7	57.9	3RT1017
40	41	232	23.7	133.9	3RT1033	13.7	77.3	3RT1025
50	52	290	30.0	167.3	3RT1034	17.3	96.6	3RT1026
60	62	348	35.8	200.8	3RT1035	20.6	115.9	3RT1026
75	77	434	44.4	250.4	3RT1036	25.6	144.5	3RT1033
100	99	580	57.1	334.7	3RT1044	33.0	193.1	3RT1035
125	125	726	72.1	418.9	3RT1045	41.6	241.8	3RT1036
150	144	868	83.1	500.8	3RT1046	48.0	289.0	3RT1036
200	192	1160	110.8	669.3	3RT1054	63.9	386.3	3RT1045
250	242	1460	139.6	842.4	3RT1055 3RT1056	80.6	486.2	3RT1046
300	289	1760	166.8	1015.5	3RT1056	96.2	586.1	3RT1046
350	336	2040	193.9	1177.1	3RT1065	111.9	679.3	3RT1054
400	382	2320	220.4	1338.6	3RT1065	127.2	772.6	3RT1055
450	412	2600	237.7	1500.2	3RT1065	137.2	865.8	3RT1055
500	472	2900	272.3	1673.3	3RT1066	157.2	965.7	3RT1056

FLC (Full-Load-Current) Rated current according to standard

LRC (Locked-Rotor Current) Locked rotor current according to the standard

1 Check the current value according to the motors' data sheets.

2 this value applies for motor with the designations B, C, D

The motor overload protection (Bi-Metal) has to be selected according to the name plate of the motor used.

The relevant Branch Circuit Protection Device shall be selected according to the application, e.g. UL508A.

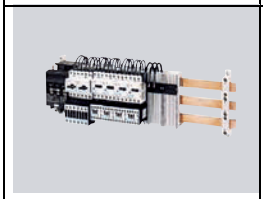
6.5 Device selection

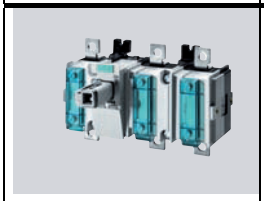
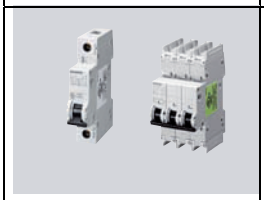
6.5.1 Overview

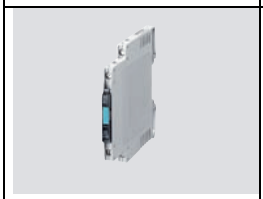
Our Portfolio for Industrial Control Panels

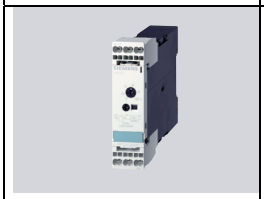
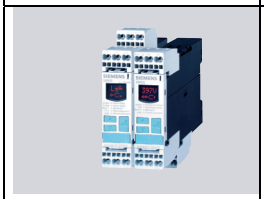
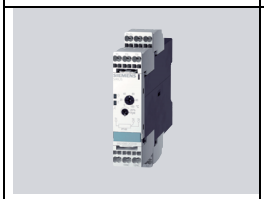
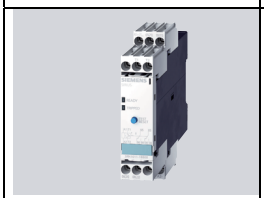
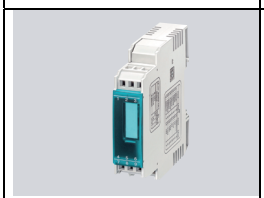
Right from the product development stage, we take not only IEC guidelines, but also UL standards, into account. This has resulted in a wide-ranging portfolio of UL-certified low-voltage switchgear, controlgear and circuit protection technology. Whether in the form of SENTRON circuit breakers, SIRIUS industrial control equipment (from motor starter protectors and starters through to magnetic controllers and overload relays), SENTRON disconnect switches or SIRIUS detecting and control devices, busbar systems, terminals, miniature circuit breakers, fuses or SIRIUS transformers and filters, our low-voltage switchgear and controlgear gives you peace of mind with regard to UL, enabling you to manufacture industrial control panels quickly and easily in accordance with UL standards.

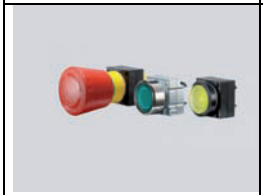
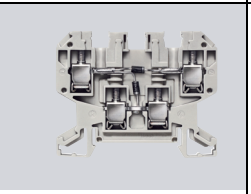
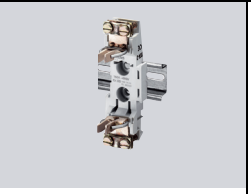
	Product	Order No. body	UL standard	Explanation
	**SENTRON air circuit breakers** (ACB)	3WL5	**UL 489**	The SENTRON 3WL air circuit breakers are particularly flexible. With only three sizes, they cover a power range from 250 A to 5,000 A. This makes them uncomplicated and universally applicable. All models feature the same design, operation and mechanical accessories. Result: Unique planning reliability and global applicability – with a single circuit breaker range!
	**SENTRON molded-case circuit breakers** (MCCB)	3VL	**UL 489**	Covering the range from 20 A to 1,600 A, the SENTRON 3VL molded-case circuit breakers ensure optimum safety. As main disconnecting means or as branch circuit protector, they protect systems, motors and generators against short circuit and overload. Their versatile Industrial Control Panel installation options as well as their space-saving design are major advantages.
	**SIRIUS circuit breakers** **SIRIUS motor starter protectors/ manual motor controllers**	3RV17, 3RV18 3RV	**UL 489** **UL 508**	The 3RV17/18 are compact circuit breakers. They protect against short circuit and guarantee safe disconnection from the power supply in case of maintenance or conversion works. The 3RV with the approval as manual motor controllers protect motors against overload. They are also suitable for disconnection and manual switching of motors.

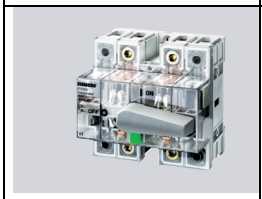
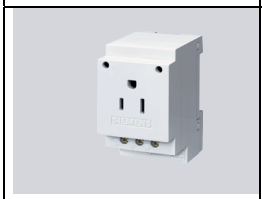
	Product	Order No. body	UL standard	Explanation
	**SIRIUS contactors/ magnetic motor controllers**	3RT, 3RH	**UL 508**	SIRIUS contactors for motor switching as well as contactor relays for the control and auxiliary circuit are particularly rugged and feature a high switching contact reliability. They cover the power range from 3 kW to 250 kW with 400 V for AC or DC actuation and can be connected with minimum time and cost expenditures. Their long service life even under extreme application conditions is a convincing advantage.
	**SIRIUS thermal overload relays** **SIRIUS solid-state overload relays**	3RU 3RB	**UL 508** **UL 508**	The overload relays of the SIRIUS range, which are available as thermal and solid-state versions, assume the current-dependent overload protection of consumers in the power circuit and other switching and protection devices in the respective load feeder. With minimum variance, they ensure integrated motor protection in numerous applications.
	**SIRIUS soft-starters**	3RW	**UL 508**	SIRIUS 3RW soft starters offer a complete portfolio which covers all standard and high-feature applications of soft motor start-up and ramp-down. Their soft start-up and ramp-down behavior facilitates jerk-free motions to protect the motors' mechanics. The soft starter range can be flexibly adjusted to the various conditions on site and thus allows for the easy and efficient realization of optimum machine concepts.
	**SIRIUS fuseless load feeders**	3RA	**UL 508**	SIRIUS 3RA fuseless load feeders are assembled from 3RV self-protected combination motor controllers (type E) and 3RT contactors. Thanks to their integrated prewiring, the fuseless load feeders can be rapidly and easily mounted. They are the optimum solution particularly for distributed and wide-spread system structures.
	**Busbar system/fast bus**	8US1	**UL 508**	The 8US busbar system (fast bus system) is ideal for applications in Industrial Control Panels, motor control centers and power distribution systems. The adapters, which are amongst others available for SIRIUS and SENTRON circuit breakers as well as SENTRON disconnect switches, facilitate numerous assemblies.
	**SENTRON manual motor disconnect**	3LD2	**UL 508**	The particularly compact 3LD2 manual motor disconnect units are employed for the switching of power and auxiliary circuits as well as for three-phase motors and other consumers for maintenance and repair cases. Amongst others, they facilitate the cable bending radius specified by UL.

	Product	Order No. body	UL standard	Explanation
	**SENTRON disconnect switches** **SENTRON disconnect switches with fuses** (manual motor controllers)	3KA 3KL	**UL 508** **UL 508**	SENTRON disconnect switches in three-pole design assume the tasks “disconnecting” and “switching under load” for the stated rated current and guarantee safety disconnection in all low-voltage networks. They are thus predestined for use as EMERGENCY-STOP, repair or load transfer switch. (According to UL, only applicable with SITOR fuses – special-purpose fuse.)
	**SIRIUS transformers** **SIRIUS power supplies**	4AJ, 4AM, 4AP, 4AW 4AT, 4BT, 4AP, 4AU, 4BU 4AV	**UL 506** **UL 1561** **UL 1012**	SIRIUS transformers offer optimum protection through high permissible ambient temperatures up to 40 °C or 55 °C (104 °F or 131 °F), high short-time rating with control transformers, fuseless design and their “safety inside” standard in accordance with IEC 61558. They are employed for the voltage and power supply of systems, controls and series products (medical engineering, machine tool construction, robots and compressors).Safety inside SIRIUS power supplies are safe, rugged, compact and comply with the latest standards.
	**SIDAC reactors** **SIDAC filters**	4EM, 4ET, 4EP, 4EU 4EV 4EF11 4EF15	**UL 1561** **UL 506** **UL 508** **UL 1283**	SIDAC reactors and filters can be used as options for variable speed drives in all sectors and applications. They improve the line quality and efficiency of systems by reducing harmonics, increase the reliability of applications and thus enhance the availability of installations and systems. The portfolio comprises line, commutation, smoothing, output and filter reactors as well as radio interference suppression, dv/dt and sinewave filters.
	**Miniature circuit breakers** (MCBs)	5SJ4 ... HG	**UL 489**	The 5SJ4 ....HG miniature circuit breakers of the BETA low-voltage circuit protection portfolio can be used as "branch protector" for protection tasks in branches, distribution boards, Industrial Control Panels and controls in accordance with UL 508A. Furthermore, they are also approved for circuit protection in heating, air-conditioning and ventilation systems.
	**Miniature circuit breakers** (MCBs)	5SY4, 5SY6, 5SY7, 5SY8, 5SP4, 5SX2, 5ST30, 5SX9	**UL 1077**	Within the scope of the UL 1077 standard, we offer a series of miniature circuit breakers for various residential and functional building as well as industrial applications.

	Product	Order No. body	UL standard	Explanation
	**SIRIUS motor starters**	3RK	**UL 508**	Whether central or distributed assembly in the industrial control panel or in high degree of protection in the field – SIRIUS motor starters are always an optimum and easy solution. The motor starters of the ET 200S system are, for example, suitable for central assembly in the control panel or for distributed solutions directly in the field. The distributed I/O system SIMATIC ET 200pro is ideal for complete solutions in particularly high degree of protection thanks to its modular design. We also offer motor starters with standardized connection technology for our distributed system solution ECOFAST® to facilitate a fast and efficient realization of distributed automation solutions.
	**SIMOCODE pro motor management and control devices**	3UF7	**UL 508**	SIMOCODE pro is a flexible and modular motor management system for motors with constant speeds in the low-voltage range. It optimizes the connection between control technology and motor starter, improves the system availability and simultaneously facilitates considerable savings in terms of system construction, commissioning, operation and maintenance.
	**SIRIUS coupling relays**	3TX70, 3RS18	**UL 508**	The very narrow SIRIUS 3TX70 coupling relays allow for particularly space-saving assemblies in the control panel and offer a large range of input and output coupling links.
	**SIRIUS plug-in relays**	LZX	**UL 508**	SIRIUS LZX plug-in relays are available both as complete units and as individual modules for self-assembly or spare parts requirements. They are employed as coupling relays for coupling between the inputs and outputs of electronic controls, for contact multiplication, for switching of small loads and as measuring transducer.
	**SIRIUS power relays**	3TG10	**UL 508**	With a width of only 36 mm, the compact SIRIUS 3TG10 power relays / small contactors are particularly suitable for applications in minimum space, e. g. for air-conditioning units, heatings, pumps, fans – as well as generally for simple electric controls. Thanks to their hum-free operation, they are also ideally suited for application in household appliances or power distributions in office and residential buildings.

	Product	Order No. body	UL standard	Explanation
	**SIRIUS solid-state switching devices**	3RF2	**UL 508**	SIRIUS solid-state switching devices are optimized for the frequent switching of resistive loads and motors. They do not feature any mechanically moved parts and therefore facilitate noise-free, wear-free and almost unlimited switching. Their compact design allows for space-saving assemblies in the control panel.
	**SIRIUS timing relays**	3RP15, 3RP20	**UL 508**	The electronic SIRIUS 3RP timing relays are employed for all time-delayed switching operations in control, start-up, protection and regulation circuits. They ensure a high functionality as well as a high repeat accuracy of the set operating time.
	**SIRIUS monitoring relays**	3UG4	**UL 508**	The electronic SIRIUS 3UG4 monitoring relays facilitate the maximum protection of non-stationary machines and systems – particularly in unstable networks. Line and voltage faults can be detected and rectified early before leading to more substantial damage.
	**SIRIUS temperature monitoring relays**	3RS10, 3RS11	**UL 508**	The SIRIUS 3RS10/3RS11 temperature monitoring relays, which are available as analog and digital versions, offer precise and reliable measurement of temperatures in solid, liquid and gaseous media.
	**SIRIUS thermistor motor protection**	3RN1	**UL 508**	SIRIUS 3RN1 thermistor motor protection devices offer a safe and reliable temperature-dependent overload protection of three-phase motors.
	**SIRIUS interface converters**	3RS17	**UL 508**	SIRIUS 3RS17 interface converters assume the coupling function for analog signals, both on the input and the output side. They are indispensable for the processing of analog values with electronic controls.
	**SIRIUS position switches**	3SE5	**UL 508**	SIRIUS 3SE5 standard position switches with and without tumbler convert the mechanical positions of moved machine parts to electronic signals. They are available with a multitude of different drive variants.

	Product	Order No. body	UL standard	Explanation
	**SIRIUS magnetically operated switches**	3SE6	**UL 508**	SIRIUS 3SE6 magnetically operated switches are designed for attachment to mobile protective devices. Evaluation is realized via a safety relay or connection to a bus system. The touch-free, magnetically operated 3SE6 safety switches are characterized by their closed design and high degree of protection IP67.
	**SIRIUS cable-operated switches**	3SE7	**UL 508**	SIRIUS cable-operated switches are employed for monitoring applications or as EMERGENCY-STOP device in particularly hazardous system components.
	**SIRIUS pushbutton units and indicator lights**	3SB	**UL 508**	SIRIUS pushbuttons and indicator lights are characterized by maximum functionality, their modern and flat design as well as particular ease of mounting.
	**SIRIUS signaling columns**	8WD4	**UL 508**	SIRIUS 8WD4 signaling columns are employed for checking complex machine functions or in automated processes and serve as visual or acoustic warning device.
	**ALPHA 8HP molded-plastic distribution systems**	8HP	**UL 50**	The ALPHA 8HP molded-plastic distribution system is suitable for the assembly of small low-voltage distribution boards, control panels and power distribution boards.
	**ALPHA Fix terminal blocks**	8WA, 8WH	**UL 1059 (completely or partially)**	A complete range of terminal blocks is available in all conventional connection technologies for the safe connection of wires, conductors and lines.
	**LV HRC fuse bases**	3NH3, 3NH4	**UL 512 (only downstream the branch protection)**	In combination with SITOR fuse links, the LV HRC fuse bases of the BETA low-voltage circuit protection portfolio ensure the reliable protection of power semiconductors.

	Product	Order No. body	UL standard	Explanation
	**Cylindric fuse holders and Class CC fuse holders** **Class CC fuse links**	3NW7 0xx/3NW7 1xx, 3NW7 5x3-0HG 3NW1 xxx-0HG, 3NW2 xxx-0HG, 3NW3 xxx-0HG	**UL 512** **UL 284-4**	Our range of cylindric fuses is particularly characterized by a high switching capacity, high current limiting and minimized design.
	**SITOR Semiconductor fuses**	3NE, 3NC 3NC1 0, 3NC1 4, 3NC2 2	**UL 248-13 UL 512**	The particularly compact and flexible SITOR fuses for semiconductor protection are suitable for a multitude of industrial applications.
	**Switch disconnectors**	5TE1	**UL 508**	The 5TE1 switch disconnectors from 100 A to 200 A in 3- and 4-pole design can be employed as motor disconnect switch, repair switch, outgoing isolator and emergency disconnectors unit.
	**Receptacles** Receptacles	5TE6 804	**UL 498**	The 5TE receptacles are for example employed for the connection of plug-in communication devices in communication distribution boards or in switchboards for maintenance purposes.
	**Insta contactors**	5TT5 7	**UL 508**	Insta 5TT5 7 contactors are ideally suited for the switching of heatings, lightings and motors.
	**Time switches**	7LF4 4, 7LF5 3	**UL 917**	The 7LF digital and mechanical time switches of the latest generation offer numerous functions and ease of handling. The digital timing of process sequences ensures profitable power savings.

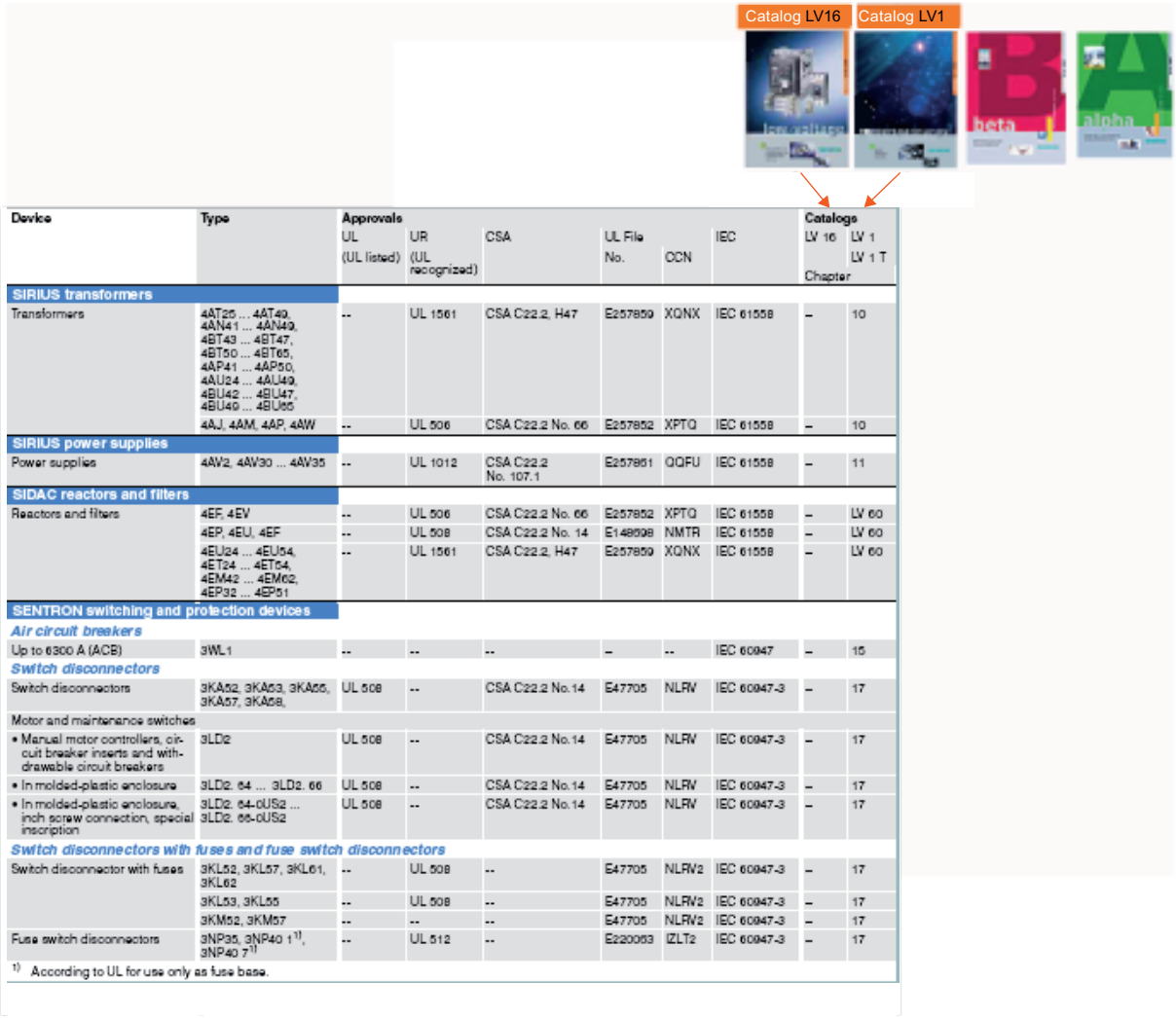
	Product	Order No. body	UL standard	Explanation
	**Time and pulse counters**	7KT5 8	**UL 863**	Time and pulse counters are employed for the reliable detection of production and service times. They facilitate an accurate planning and monitoring of production sequences, maintenance cycles and warranty periods.
	**SENTRON PAC3200 power monitoring device**	7KM	**UL 61010-1**	The innovative SENTRON PAC3200 power monitoring device, which can be connected to a wide variety of loads, enables you to record electrical characteristics and energy precisely. Measurement results can be evaluated centrally using Power Management Software such as SIMATIC WinCC powerrate or SIMATIC PCS 7 powerrate.

6.5.2 Overview of device approval

Product/standards/UL file/CCN reference table

Chapter 1 of our LV16 catalog titled "Controls and Components for Applications According to UL" contains a summary of the available products/product groups with details of the relevant UL standard that has been met.

Details of the UL file number and the relevant CCN (Category Code Number) are also provided.



Device	Type	Approvals UL (UL listed)	UR (UL recognized)	CSA	UL File No.	CCN	IEC	Catalogs LV 16 Chapter	LV 1 LV 1 T
SIRIUS transformers									
Transformers	4AT25 ... 4AT49, 4AN41 ... 4AN49, 4BT43 ... 4BT47, 4BT50 ... 4BT65, 4AP41 ... 4AP50, 4AU24 ... 4AU49, 4BU42 ... 4BU47, 4BU49 ... 4BU55	--	UL 1561	CSA C22.2, H47	E257859	XQNX	IEC 61558	–	10
	4AJ, 4AM, 4AP, 4AW	--	UL 506	CSA C22.2 No. 66	E257852	XPTQ	IEC 61558	–	10
SIRIUS power supplies									
Power supplies	4AV2, 4AV30 ... 4AV35	--	UL 1012	CSA C22.2 No. 107.1	E257851	QQFU	IEC 61558	–	11
SIDAC reactors and filters									
Reactors and filters	4EF, 4EV	--	UL 506	CSA C22.2 No. 66	E257852	XPTQ	IEC 61558	–	LV 60
	4EP, 4EU, 4EF	--	UL 508	CSA C22.2 No. 14	E148698	NMTR	IEC 61558	–	LV 60
	4EU24 ... 4EU54, 4ET24 ... 4ET54, 4EM42 ... 4EM62, 4EP32 ... 4EP51	--	UL 1561	CSA C22.2, H47	E257859	XQNX	IEC 61558	–	LV 60
SENTRON switching and protection devices									
Air circuit breakers									
Up to 6300 A (ACB)	3WL1	--	--	--	–	--	IEC 60947	–	15
Switch disconnectors									
Switch disconnectors	3KA52, 3KA53, 3KA55, 3KA57, 3KA58,	UL 508	--	CSA C22.2 No.14	E47705	NLRV	IEC 60947-3	–	17
Motor and maintenance switches									
• Manual motor controllers, circuit breaker inserts and withdrawable circuit breakers	3LD2	UL 508	--	CSA C22.2 No.14	E47705	NLRV	IEC 60947-3	–	17
• In molded-plastic enclosure	3LD2. 64 ... 3LD2. 66	UL 508	--	CSA C22.2 No.14	E47705	NLRV	IEC 60947-3	–	17
• In molded-plastic enclosure, inch screw connection, special inscription	3LD2. 64-0US2 ... 3LD2. 66-0US2	UL 508	--	CSA C22.2 No.14	E47705	NLRV	IEC 60947-3	–	17
Switch disconnectors with fuses and fuse switch disconnectors									
Switch disconnector with fuses	3KL52, 3KL57, 3KL61, 3KL62	--	UL 508	--	E47705	NLRV2	IEC 60947-3	–	17
	3KL53, 3KL55	--	UL 508	--	E47705	NLRV2	IEC 60947-3	–	17
	3KM52, 3KM57	--	--	--	E47705	NLRV2	IEC 60947-3	–	17
Fuse switch disconnectors	3NP35, 3NP40 1[1], 3NP40 7[1]	--	UL 512	--	E220063	IZLT2	IEC 60947-3	–	17

[1] According to UL for use only as fuse base.

Tips:

This reference table also refers to other relevant catalogs and their corresponding chapters:

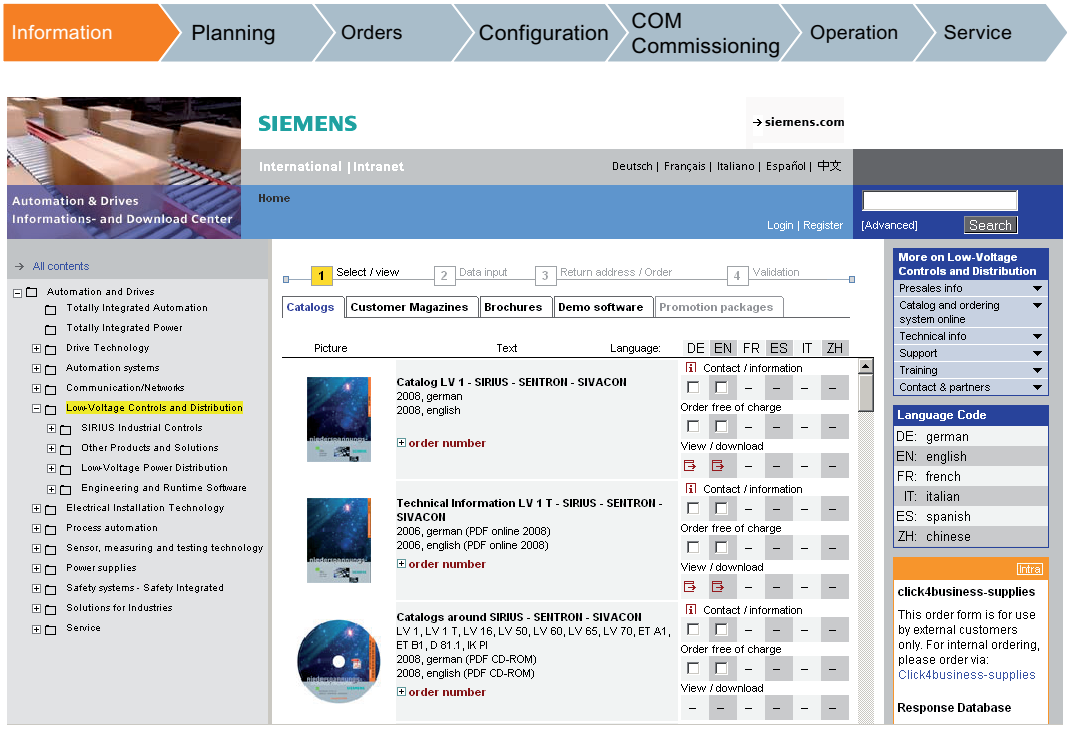
Overview of relevant catalogs:

- Catalog LV16 "Controls and Components for Applications According to UL" with the following UL-approved portfolio:
  - SIRIUS 3RV17 and 3RV18 Circuit Breaker according to **UL 489**
  - SENTRON components for 8US distribution systems according to **UL 508A**
  - SENTRON 3WL5 air circuit breakers/non-automatic air circuit breakers according to **UL 489**
  - SENTRON 3VL molded-case circuit breakers according to **UL 489**
  - ALPHA devices according to the UL standard
  - BETA devices according to the UL standard
- Catalog LV1
  "low-voltage CONTROLS AND DISTRIBUTION – SIRIUS SENTRON SIVACON"
  with additional UL-approved low-voltage controls and distribution
- Catalog ET A1 "ALPHA Distribution Boards and Terminal Blocks"
  and ET B1 "BETA Modular Installation Devices"
  with UL-approved products for electrical installation

6.5.3 Where to find more information on the Internet

Catalogs and information

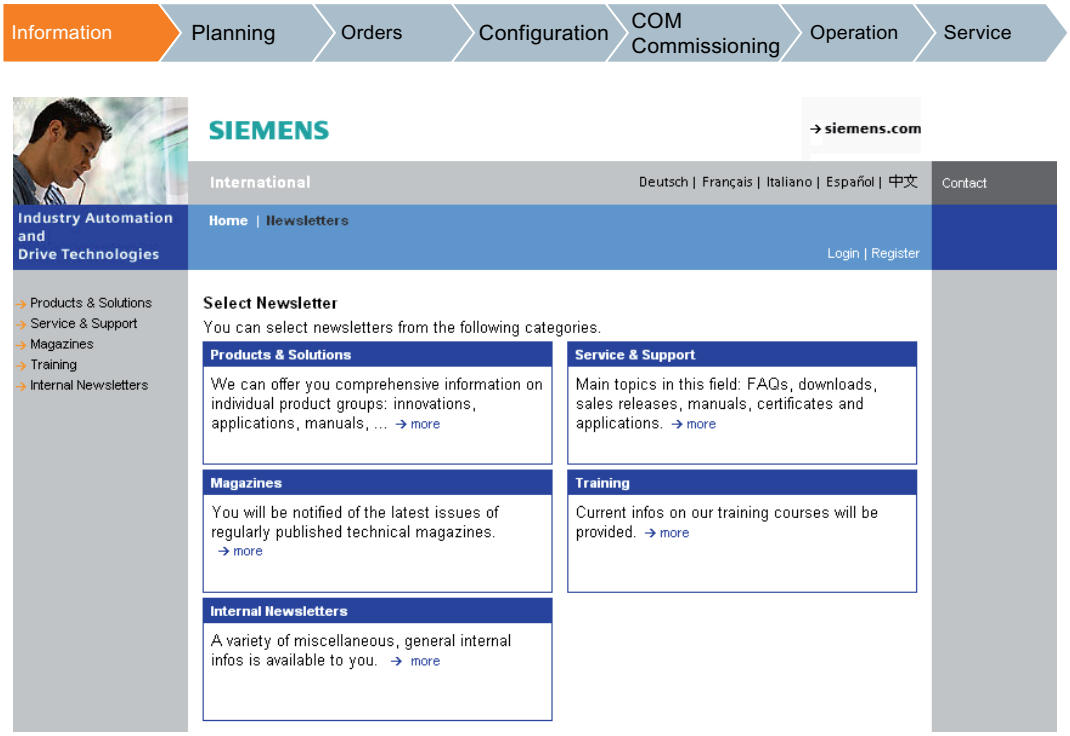
(www.siemens.com/lowvoltage/catalogs)



The Siemens Information and Download Center contains all the current catalogs, customer magazines, brochures, demonstration software and promotion packages ready for you to download. Alternatively, you can order them if you prefer.

Newsletters

(www.siemens.com/lowvoltage/newsletter)

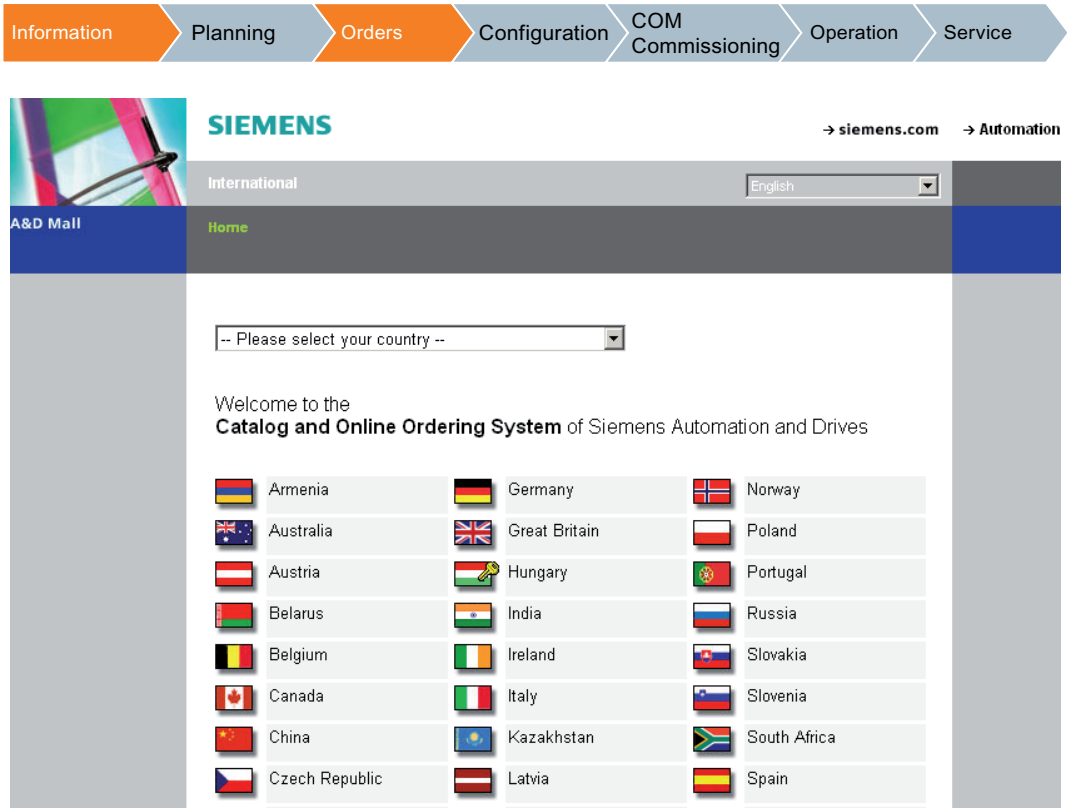


Always up to date: Our regular newsletter gives you the latest information on industrial controls and low-voltage power distribution.

To receive it, all you need to do is register.

E-business

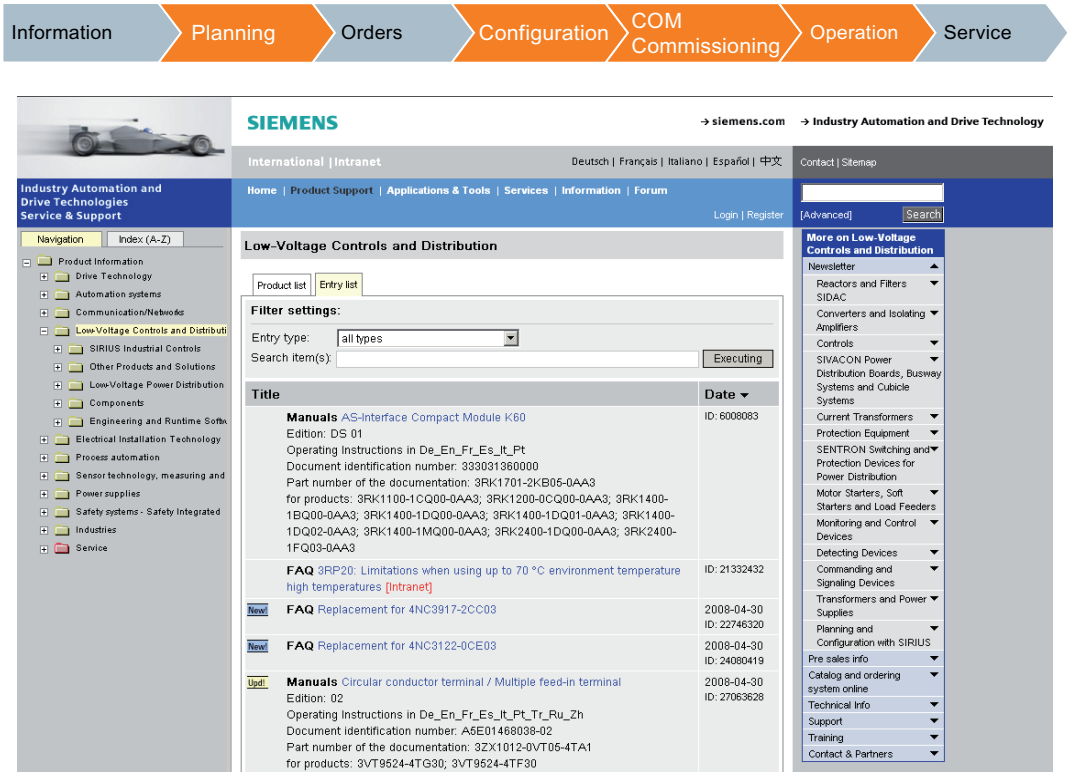
(www.siemens.com/lowvoltage/mall)



24/7-access to a comprehensive information and ordering platform for products and systems of the low-voltage controls and distribution portfolio? Comprehensive information on our complete portfolio? Product selection, order tracking, service, support and training information? All this can be conveniently found at our A&D Mall.

Online support

(www.siemens.com/lowvoltage/support)



Detailed technical information on our product portfolio and systems from low-voltage controls and distribution, product support and further services and support, based on helpful tools, are available on our Siemens Industry Automation and Drives Technologies Service & Support Internet platform.

Tip:

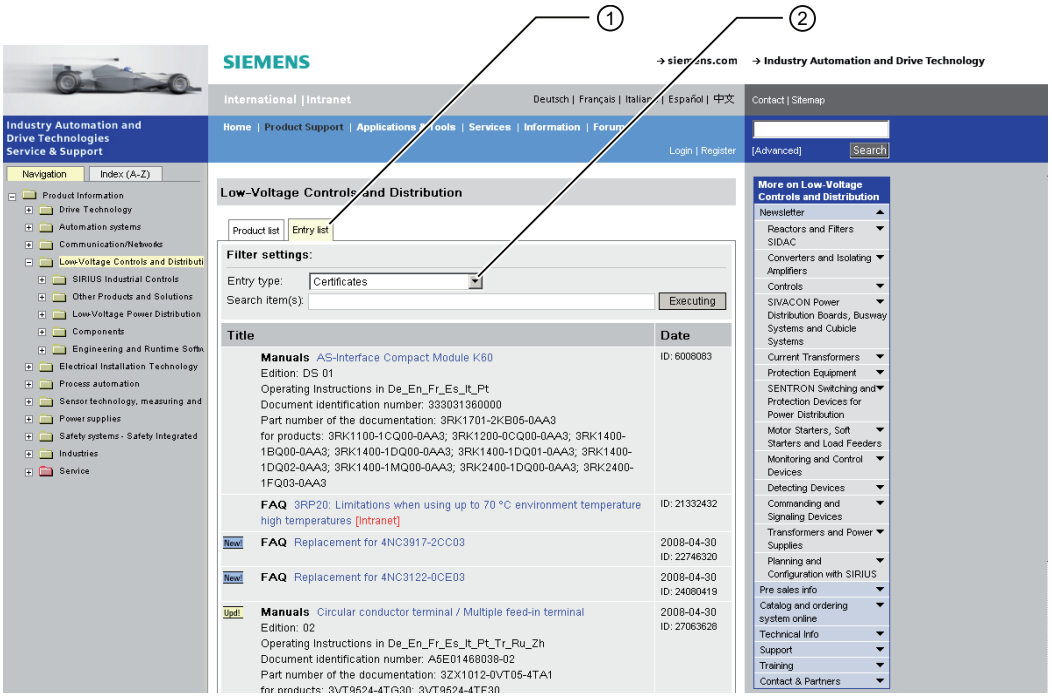
The platform lets you download UL files/reports and technical data sheets for our products.

Searching for UL certificates

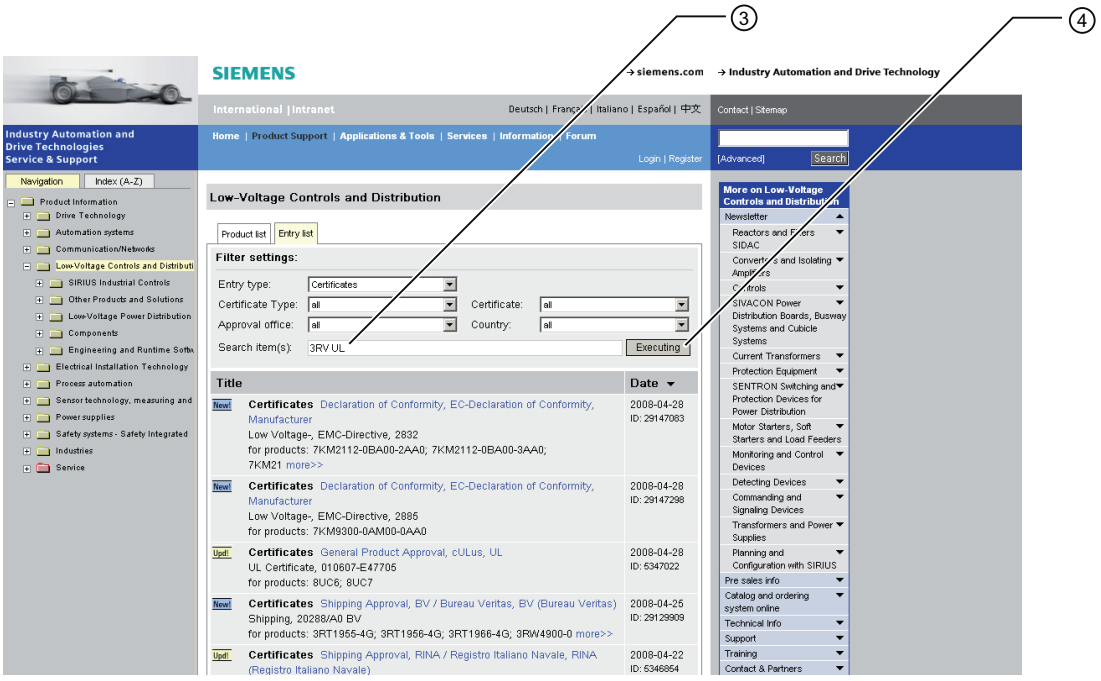
The following screenshots explain how to locate the relevant documents for our products on our Siemens Internet sites.

I. Example: 3RV

a) Click the entry list ① and
select "Certificates" under entry type ②.

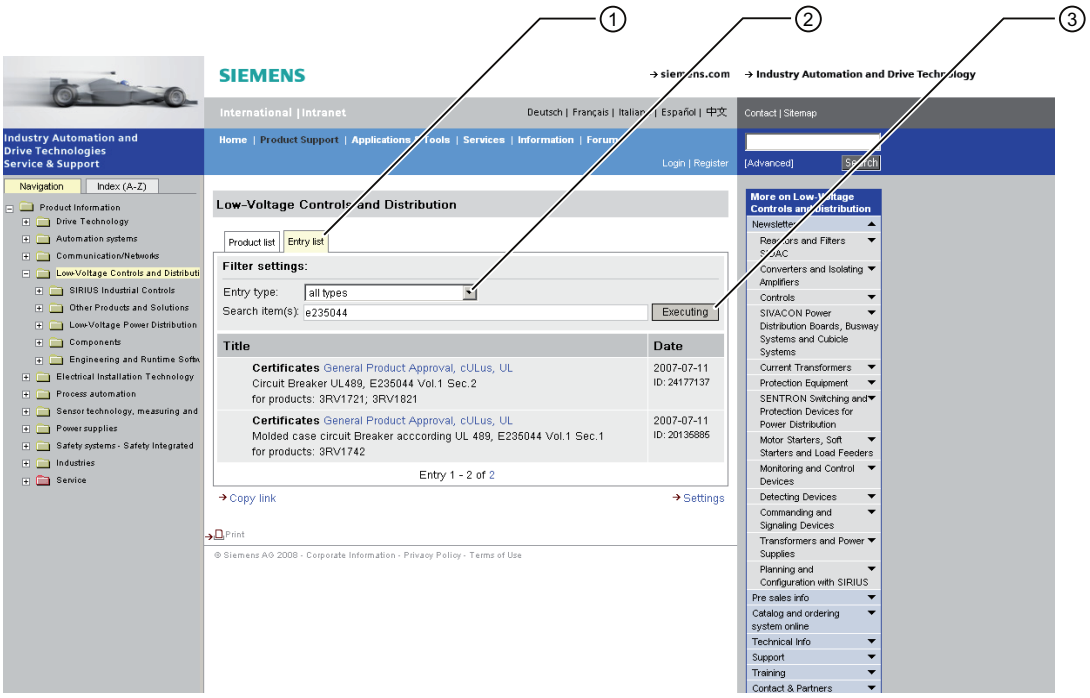


b) Enter "3RV UL" as the search item ③ before finally clicking the Executing button ④.



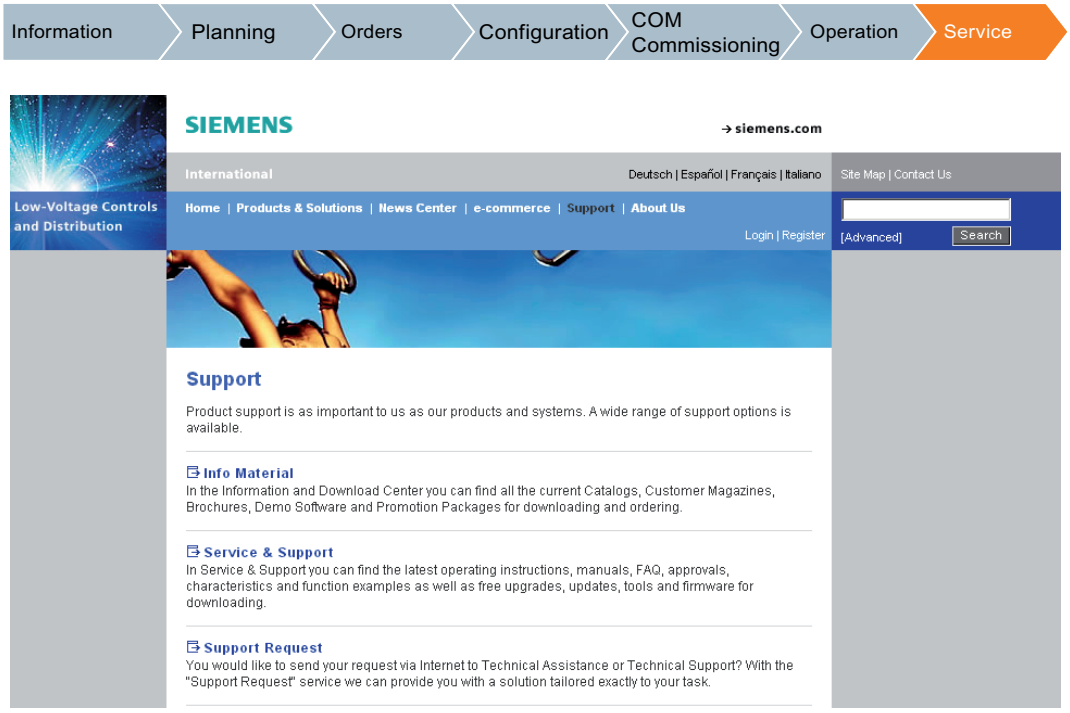
II. Searching for a known "file number"

a) Click the entry list ① and enter the file number ②, before finally clicking the Executing button ③.



Technical assistance

(www.siemens.com/lowvoltage/technical-assistance)



Are you looking for the right product to suit your application? Do you have technical questions, require spare parts or need a regional expert on site? Our experienced team of engineers and technicians as well as UL experts will be pleased to assist you:

In person from Monday to Friday	8:00 to 17:00 (CET)
Telephone:	+49(911)-895-5900
Fax:	+49(911)-895-5907
E-mail:	technical-assistance@siemens.com

Go **online** to access the Siemens Industry Automation and Drives Technologies Internet platform.

This facility offers a FAQ database where you can look for information and solutions for your application around the clock. Alternatively, you can send your question direct to a specialist support adviser via the Support Request feature.

Training

(www.siemens.com/sitrain-cd)

Our training centers at numerous sites worldwide offer individual training programs covering all fields of automation and industrial solutions. Moreover, with the help of our online courses and various learning software, you can acquire new know-how to be even more time- and cost-efficient.

Alternatively, you can contact us direct:

Information telephone line:	01805/23 56 11
Fax:	01805/23 56 12

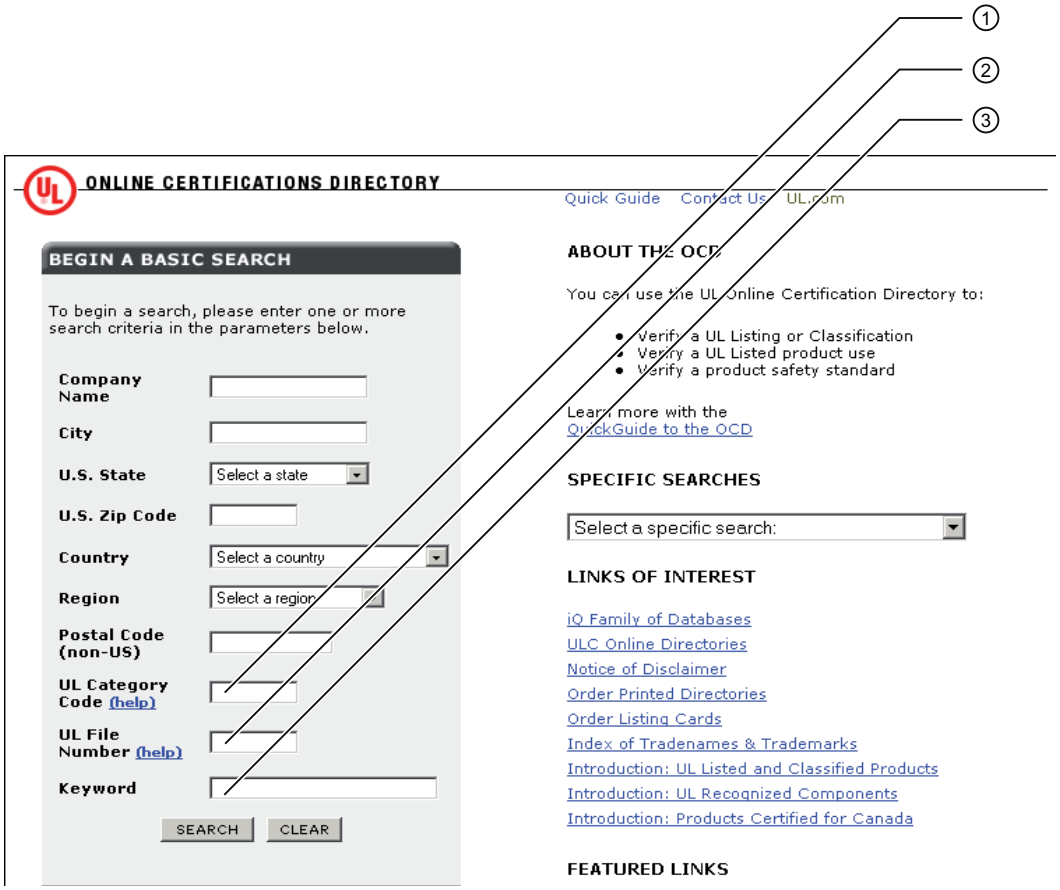
UL websites

(http://www.ul.com/database)

This UL website offers a variety of search options. Each option can be used individually or in combination with other options. These are the three most popular search options.

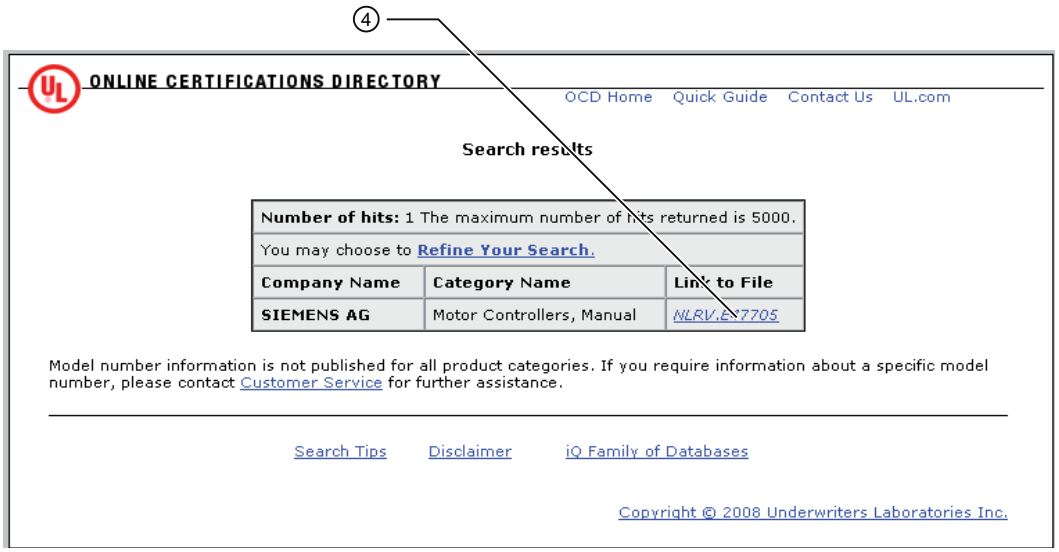
1. UL Category Code: known CCN code, such as **DIVQ**
2. UL File Number: known file number, such as **E156943**
3. Keyword: product designation, order number for device or product group, such as **3RV**

Click "SEARCH" after entering the data for the search function.

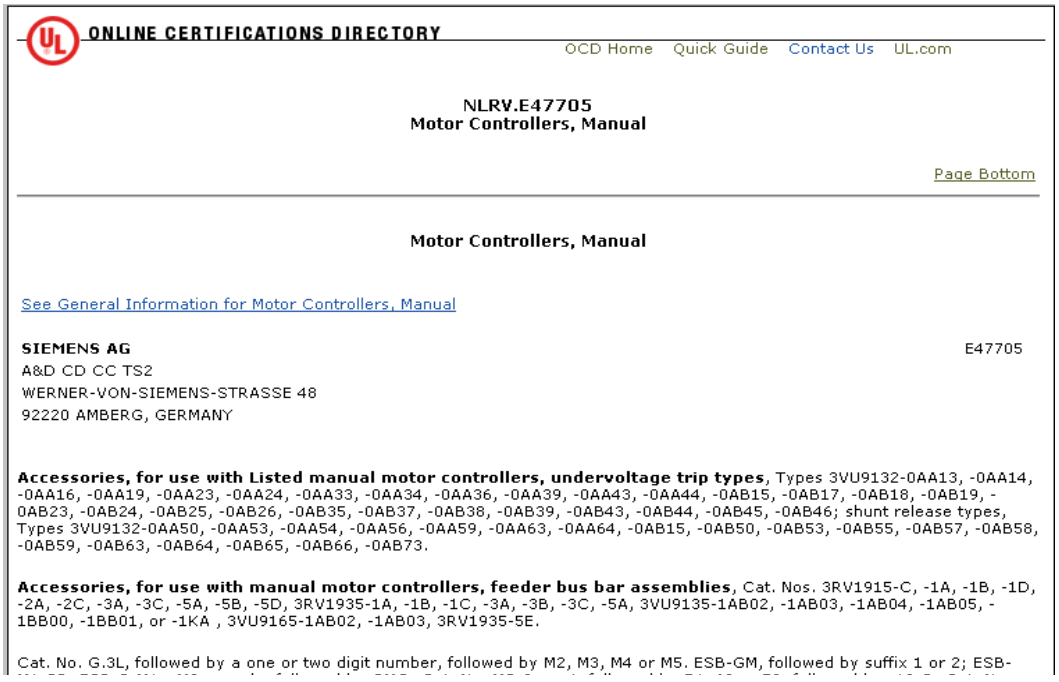


The following screenshot shows the search results when "3RV" is entered in the "Keyword" field. The results provide both the CCN code and the file number.

④ This is the CCN file number: **NLRV.E47705**



Clicking on the result ("NLRV.E47705") generates the following overview. This shows the products (order numbers) and accessory parts belonging to this "Listing".



Color coding

7

Below is a description of color coding according to **UL 508A**.

7.1 Color coding of the grounding conductor (PE) and the grounded conductor (N)

Ground connection (Bonding Conductor) UL 508A Art. 17.4

Insulated grounding conductors shall be green, with or without one or more yellow stripes.

Only grounding conductors shall be color coded in this way.

Comments:

There are indications elsewhere in the UL standards and the **NEC** that the yellow element shall not cover more than 50% of the conductor. This would make the green and yellow conductor acceptable according to the IEC.

Exception 1:

Conductors sized 4 AWG or larger with different color coding shall be permanently identified at each termination point by green insulating tape.

Exception 2:

Integral leads of UL-approved devices are not required to meet this requirement.

Exception 3:

Commercially available insulated conductor types/versions that are not manufactured in this color, such as SIS cables, may be used, but shall again be permanently identified at each termination point by green insulating tape.

Grounded conductor, UL 508A Art. 17.4

Insulated grounded conductors shall be identified by white or gray insulation. Alternatively, any color other than green may be used, but in this case three white stripes will be required along the entire length.

Exception 1:

Conductors sized 4 AWG or larger with different color coding shall be permanently identified at each termination point by white insulating tape.

Exception 2:

Integral leads of UL-approved devices are not required to meet this requirement.

Exception 3:

Commercially available insulated conductor types/versions that are not manufactured in this color, such as SIS cables, may be used, but shall again be permanently identified at each termination point by white insulating tape.

7.2 Color coding of conductors in the power circuit

UL 508A, Art. 66.5.3

1. All ungrounded conductors
   ⇒ black
2. All grounded conductors (N) from power circuits
   ⇒ white
   ⇒ gray
   ⇒ 3 white, continuous stripes on any color other than green, blue, orange, yellow

Exception

Conductors sized 4 AWG or larger with different color coding shall be permanently identified at each termination point by white insulating tape.

7.3 Color coding of conductors in the control circuit

UL 508A, Art. 66.9.1

Color coding for conductors

Color	Conductor	Remark
Green with or without one or more yellow stripes	Grounding conductor May only be energized in an emergency (not a PEN conductor)	Green/yellow is permitted in accordance with IEC 60204-1.
Black	All ungrounded control circuit conductors operating at the supply voltage	
Red	All ungrounded AC control circuit cables operating at a voltage less than the supply voltage	
Blue (dark blue)	Ungrounded DC control circuit cables	
Yellow **or orange**	Ungrounded control circuit cables which are energized when the main disconnect is in the "off" position.	In IEC 60204-1, orange is used for this purpose.
White or gray or three white stripes on conductors, but NOT on green, blue, orange or yellow	Grounded AC current-carrying control circuit conductor regardless of voltage	
White with blue stripes	Grounded DC current-carrying conductor	In IEC 60204-1,light blue is used for this purpose.
White with orange or yellow stripes	Grounded AC current-carrying conductor that remains energized when main disconnect switch is in the "off" position.	

Exceptions

Leads on tested components, multiconductor cable, leads used to connect electronic devices, and conductor sizes 20 - 30 AWG are not required to comply with this requirement.

7.4 Color coding for control and signaling devices

General information on START/STOP buttons – UL 508A 66.12

START – Start operators shall be located above or to the left of the associated stop buttons.

An Industrial Control Panel provided with operator controls shall also be provided with an emergency stop button.

The emergency stop button shall have an actuator that is a mushroom or palm type, and of the self-latching type.

The emergency stop button shall be red with a yellow background.

Color coding

NFPA 79 Art. 10

There are no **UL 508A** definitions for color coding control and signaling devices. If US-specific color coding is however required, reference shall be made to **NFPA 79**. The following table is taken from **NFPA 79**.

Color coding for devices according to NFPA 79

Color	Device function	Typical function	Example
Red	Pushbutton	Emergency stop, stop, off	Emergency stop pushbuttons, Off pushbuttons for one or more motors
	Indicator light	**Danger or alarm**, unusual situations; immediate actions shall be taken.	
	Illuminated pushbutton		Motor overload protection trips due to overload (the color RED for the emergency stop button shall not be dependent on an indicator light).
Amber	Pushbutton	Intervention in abnormal condition. Warning	Return machine to a safe condition. Bypasses other functions which were previously selected.
	Indicator light	Abnormal/critical condition, imminent change in condition.	Automatic cycle or motor running; some values (pressure, temperature) are approaching a specified limit. Ground fault display. Overload that is permitted for a certain period.
	Illuminated pushbutton	Caution, start of process to prevent a dangerous situation from arising.	Certain values (pressure, temperature) are approaching the specified values. Pressing the pushbutton bypasses functions which were previously set.
Green	Pushbutton	ON, START	General or machine start. Start of a cycle or a sequence; start of one or more motors; start of auxiliary sequences; excitation of a control circuit.
	Indicator light	Machine is ready for operation, safe condition. Safe operation	Message reporting a safe condition or approval for subsequent processes. The machine is ready for operation, all conditions are normal, or the cycle is complete and the machine can be restarted.
	Illuminated pushbutton	Machine or machine part is ready for operation.	ON or START permission, when illuminated, starting of one or more motors for auxiliary functions.
Black	Pushbutton	No special function assigned.	May be used for all functions except for the the sole function of OFF or STOP.
White or **trans-parent**	Pushbutton	Functions not mentioned above.	Control of functions that are not linked to the operating cycle.
	Indicator light	Message reporting normal conditions.	Normal pressure, temperature
	Illuminated pushbutton	Message reporting that an electric circuit has been activated, motion.	Excitation of auxiliary functions or electric circuits that are not linked to the operating cycle.
Blue or **gray**	Pushbutton	Functions that have not been dealt with by the colors listed above.	"Reset" for overload relay
	Indicator light	Functions that have not been dealt with by the colors listed above.	"Reset" for overload relay
	Illuminated pushbutton	Functions that have not been dealt with by the colors listed above.	"Reset" for overload relay

Remarks

The following colors are often used for simple machines:

- On, start: Green or black pushbutton with flat head
- Off, stop: Red mushroom pushbutton with raised button
- Stationary machine: Green indicator light
- Machine running: Red indicator light

Emergency stop: The customer generally prefers 40 mm Push-Pull, illuminated and self-locking mushroom pushbuttons. Siemens offers a complete range of pushbuttons and indicator lights, with installation diameters of between 16 mm and 22 mm, Siemens type 3SB.

Annex A - Tables

A

A.1 Device selection tables for combination motor controllers

The tables in Annex A.1 are based on combination tests. The results of these tests are listed in the UL reports for the relevant devices (e.g. magnetic controller, soft-starter) requiring protection ("High Capacity Short Circuit Rating" or "HIC").
If you need combinations which are not included in these tables, there are two ways to determine the values for the missing combinations.

1. Put together the combination using the configuration rules in **UL 508A** (see Chapter 6.2 and Chapter 6.3). The SCCR values required for this can be found in the tables in annexes A.2 - A.6.
2. It is possible that additional tested combinations have become available since this guide went to print. Information regarding this is available from Technical Assistance. Please see Chapter 6.5 for further information.

Note

The typical switching diagrams featured below use IEC graphical symbols.

Note

The details contained in the tables are provided for rough guidance only.

Please take the sizing requirements defined by the relevant standards into account (e.g. UL 508A, NFPA 79) when configuring combination motor controllers.

The fine print notes below apply to all tables in Annex A.
The circled numbers (e.g. ③) refer directly the explanations in Chapter 6.2.2 "Possible combination motor controllers ("Construction Types").
Fine print notes which were not provided in full in Chapter 6.2 have been identified with an "x" (e.g. x3).

X1	Conversion factor for hp to kW: 1 kW = 1.34 hp
X2	Standard value for motor full load current (Full load current = FLC). This value provides the basis for sizing industrial control equipment.
X3	Typical rated current for motors. These values are provided for rough guidance only. Please take actual values from the relevant technical data sheet for the motor being used. This value shall only be used for the purpose of configuring the bi-metal (motor overload protection).
X4	Maximum permissible short-circuit current rating for which this combination can be used. These values have been determined using what are known as "HIC = High Interrupting Current" tests and confirmed by UL by means of the relevant UL report. You can obtain these values from us by referring to the relevant UL reports for the magnetic controllers.
X5	Cable cross sections for wiring in the Industrial Control Panels. These values apply to copper and a wire end temperature of 75 °C. Other cross sections may be required outside the Industrial Control Panel under certain circumstances. For examples, please refer to such documents as the **NEC** or **NFPA 79**.

The following figures refer to the general description in Chapter 6.2 and the corresponding devices in the tables and the associated pictographs.

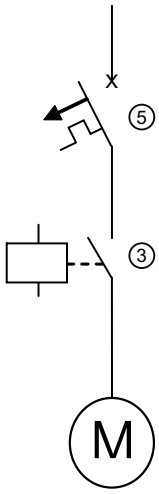
①	Disconnecting function in the form of an additional device for a "Manual / Magnetic Motor Controller" (construction type "C").
③	Motor control function in the form of an additional device for each "... magnetic ... Motor Controller".
④	Motor overload protection. The bi-relays were selected according to the values in the column for typical rated currents for motors (see fine print note X3). An SF of 1 was assumed for the motors. Under certain circumstances, other bi-relays should be selected for motors with an SF of 1.15 or higher.
⑤	Self Protected Manual Motor Control: Every 3RV with this additional feature is approved for complete branch circuit and motor protection. The 3RV was selected according to the typical rated currents for the motors (motor nameplate). As far as possible, the adjustable overload range was set to the average setting range and for motors with a SF of 1.0. Please remember to always test the actual setting range in real applications specifically on the basis of the motors' set values.
⑤1	The add-on terminal referred to here is needed for a number of 3RVs to ensure compliance with the distances through air and over surfaces specified by UL.

Note

All details given refer to 3-phase motors.

A.1.1 240 VAC "corner grounded delta"

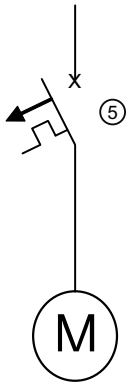
Table A- 1 240 V – Type F

240 V corner grounded Delta - Self-Protected Manual / Magnetic Motor Control - "Construction Type F"								
	Rated motor output [hp]	Standard motor current (according to the standard) FLC [A]	Typical motor amps FLA [A]	Motor starter protector (Self Protected)	Type E terminal block	Magnetic controller (Motor Control)	SCCR [kA]	Internal wire cross section for Cu (75 °C) [AWG]
	X1 *)	X2 *)	X3 *)	(5) *)	(5.1) *)	(3) *)	X4 *)	X5 *)
	0.5	2.2	1.7	3RV1021-1BA..	3RV1928-1H	3RT1023	65	14
	0.75	3.2	2.34	3RV1021-1CA..	3RV1928-1H	3RT1023	65	14
	1	4.2	3.1	3RV1021-1DA..	3RV1928-1H	3RT1023	65	14
	1.5	6.0	4.3	3RV1021-1FA..	3RV1928-1H	3RT1023	65	14
	2	6.8	5.8	3RV1021-1GA..	3RV1928-1H	3RT1023	65	14
	3	9.6	8.3	3RV1021-1JA..	3RV1928-1H	3RT1023	65	14
	5	15.2	13.2	3RV1021-4AA..	3RV1928-1H	3RT1025	65	12
	7.5	22.0	19.4	3RV1021-4BA..	3RV1928-1H	3RT1026	65	10
	10	28.0	25.2	3RV1031-4EA..	--- a)	3RT1033	65	10
	15	42.0	38.2	3RV1031-4FA..	--- a)	3RT1035	65	8
	20	54	50.6	3RV1041-4JA..	--- a)	3RT1044	65	6
	25	68	62.6	3RV1041-4KA..	3RT1946-4GA07	3RT1044	65	4
	30	80	72.8	3RV1041-4KA..	3RT1946-4GA07	3RT1045	65	4
	40	104	94.5	3RV1041-4MA..	3RT1946-4GA07	3RT1046	65	2

a) No add-on terminal is required for this type.

*) For information, see Device selection tables for combination motor controllers (Page 207)

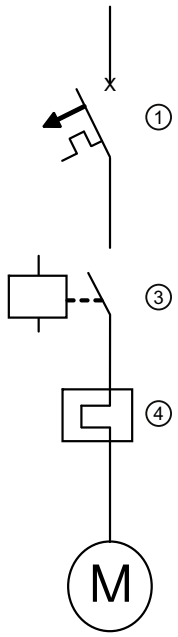
Table A- 2 240 V – Type E

240 V corner grounded Delta - Self-Protected Manual Motor Control - "Construction Type E"							
	Rated motor output [hp]	Standard motor current (according to the standard) FLC [A]	Typical motor amps FLA [A]	Motor starter protector (Self Protected)	Type E terminal block	SCCR [kA]	Internal wire cross section for Cu (75 °C) [AWG]
	X1 *)	X2 *)	X3 *)	(5) *)	(5.1) *)	X4 *)	X5 *)
	0.5	2.2	1.7	3RV1021-1BA..	3RV1928-1H	65	14
	0.75	3.2	2.34	3RV1021-1CA..	3RV1928-1H	65	14
	1	4.2	3.1	3RV1021-1DA..	3RV1928-1H	65	14
	1.5	6.0	4.3	3RV1021-1FA..	3RV1928-1H	65	14
	2	6.8	5.8	3RV1021-1GA..	3RV1928-1H	65	14
	3	9.6	8.3	3RV1021-1JA..	3RV1928-1H	65	14
	5	15.2	13.2	3RV1021-4AA..	3RV1928-1H	65	12
	7.5	22.0	19.4	3RV1021-4BA..	3RV1928-1H	65	10
	10	28.0	25.2	3RV1031-4EA..	--- a)	65	10
	15	28.0	38.2	3RV1031-4FA..	--- a)	65	8
	20	54	50.6	3RV1041-4JA..	--- a)	65	6
	25	68	62.6	3RV1041-4KA..	3RT1946-4GA07	65	4
	30	80	72.8	3RV1041-4KA..	3RT1946-4GA07	65	4
	40	104	94.5	3RV1041-4MA..	3RT1946-4GA07	65	2

a) 3RV103 already has large distances through air and over surfaces.

*) For information, see Device selection tables for combination motor controllers (Page 207)

Table A- 3 240 V – Magnetic Motor Control

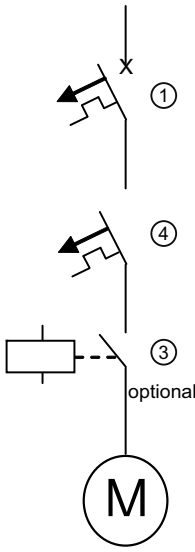
240 V corner grounded Delta - Magnetic Motor Control - "Construction Type C"								
	Rated motor output [hp]	Standard motor current (according to the standard) FLC [A]	Typical motor amps FLA [A]	MCCB	Magnetic controller (Motor Control)	Overload (Overload Relay)	SCCR [kA]	Internal wire cross section for Cu (75 °C) [AWG]
	X1 *)	X2 *)	X3 *)	(1) *)	(3) *)	(4) *) b')	X4 *)	X5 *)
	0.5	2.2	1.7	3RV1721-1ED10 xx)	3RT1023	3RB2906-2BG1	50 xx)	14
	0.75	3.2	2.34	3RV1721-1GD10 xx)	3RT1023	3RB2906-2BG1	50 xx)	14
	1	4.2	3.1	3RV1721-1HD10 xx)	3RT1023	3RB2906-2DG1	50 xx)	14
	1.5	6.0	4.3	3RV1721-4KD10 xx)	3RT1023	3RB2906-2DG1	50 xx)	14
	2	6.8	5.8	3RV1721-4AD10 xx)	3RT1023	3RB2906-2DG1	50 xx)	14
	3	9.6	8.3	3RV1721-4BD10 xx)	3RT1023	3RB2906-2DG1	50 xx)	14
	5	15.2	13.2	3RV1721-4CD10 xx)	3RT1025	3RB2906-2DG1	50 xx)	12
	7.5	22.0	19.4	3RV1742-5HD10	3RT1026	3RB2906-2DG1	65	10
	10	28.0	25.2	3RV1742-5JD10	3RT1033	3RB2906-2JG1	65	10
	15	42.0	38.2	3RV1742-5LD10	3RT1035	3RB2906-2JG1	65	8
	20	54	50.6	3RV1742-5PD10	3RT1044	3RB2906-2JG1	65	6
	25	68	62.6	3VL1191-1KM30-….	3RT1044	3RB2906-2JG1	65	4
	30	80	72.8	3VL1112-1KM30-….	3RT1045	3RB2906-2JG1	65	4

b) Can only be used with the 3RB22 or 3RB23 evaluation modules and 3RB29 87-2 connecting cables

*) For information, see Device selection tables for combination motor controllers (Page 207)

xx) Alternatively, 3RV1742-… can also be used here. This allows 65 kA SCCR to be reached.

Table A- 4 240 V – Manual/Magnetic Motor Control

240 V corner grounded Delta - Manual / Magnetic Motor Control - "Construction Type C"								
	Rated motor output [hp]	Standard motor current (according to the standard) FLC [A]	Typical motor amps FLA [A]	MCCB	Magnetic controller **) (Motor Control)	Overload (Overload Relay) xxx)	SCCR [kA]	Internal wire cross section for Cu (75 °C) [AWG]
	X1 *)	X2 *)	X3 *)	(1) *)	(3) *)	(4) *)	X4 *)	X5 *)
	0.5	2.2	1.7	3RV1721 -1ED10	3RT1013	3RV1011- 1BA..	50	14
	0.75	3.2	2.34	3RV1721 -1GD10	3RT1013	3RV1011- 1CA..	50	14
	1	4.2	3.1	3RV1721 -1HD10	3RT1013	3RV1011- 1EA..	50	14
	1.5	6.0	4.3	3RV1721 -1JD10	3RT1013	3RV1011- 1FA..	50	14
	2	6.8	5.8	3RV1721 -1KD10	3RT1013	3RV1011- 1GA..	50	14
	3	9.6	8.3	3RV1721 -4AD10	3RT1013	3RV1011- 1JA..	50	14
	5	15.2	13.2	3RV1721 -4CD10	3RT1025	3RV1021- 4AA..	50	12
	7.5	22.0	19.4	3RV1742 -5FD10	3RT1026	3RV1021- 4CA..	65	10
	10	28.0	25.2	3RV1742 -5JD10	3RT1033	3RV1031- 4EA..	65	10
	15	42.0	38.2	3RV1742 -5PD10	3RT1035	3RV1031- 4FA..	65	8
	20	54	50.6	3RV1742 -5PD10	3RT1044	3RV1041- 4JA..	65	6
	25	68	62.6	3VL1110 -1KN30- ….	3RT1044	3RV1041- 4KA..	65	4
	30	80	72.8	3VL1120 -1KN30- ….	3RT1045	3RV1041- 4LA..	65	4

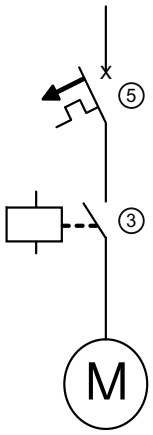
*) For information, see Device selection tables for combination motor controllers (Page 207)

**) No magnetic controller is required for this version of the motor starter.

xxx) This 3RV (4) is approved both as a Manual Motor Controller and as motor overload protection.
If a magnetic controller is used, it will be a Manual/Magnetic Motor Controller.
If no magnetic controller is used, it will be a Manual Motor Controller.

A.1.2 480/277 VAC, "solidly grounded wye"

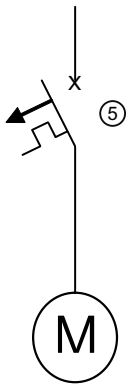
Table A- 5 480/277 V – Type F

480 / 277 V solidly grounded Wye - Self-Protected Manual / Magnetic Motor Control "Construction Type F"								
	Motor rated output [hp]	Standard motor current (according to the standard) FLC [A]	Typical motor amps FLA [A]	Motor starter protector (Self Protected)	Type E terminal block	Magnetic controller (Motor Control)	SCCR [kA]	Internal wire cross section for Cu (75 °C) [AWG]
	X1 *)	X2 *)	X3 *)	(5) *)	(5.1) *)	(3) *)	X4 *)	X5 *)
	0.5	1.1	0.67	3RV1021-0HA..	3RV1928-1H	3RT1023	65	14
	0.75	1.6	0.93	3RV1021-0JA..	3RV1928-1H	3RT1023	65	14
	1	2.1	1.2	3RV1021-0KA..	3RV1928-1H	3RT1023	65	14
	1.5	3	1.7	3RV1021-1BA..	3RV1928-1H	3RT1023	65	14
	2	3.4	2.3	3RV1021-1CA..	3RV1928-1H	3RT1023	65	14
	3	4.8	3.3	3RV1021-1EA..	3RV1928-1H	3RT1023	65	14
	5	7.6	5.3	3RV1021-1GA..	3RV1928-1H	3RT1023	65	14
	7.5	11	7.7	3RV1021-1HA..	3RV1928-1H	3RT1024	65	14
	10	14	10.1	3RV1021-1JA..	3RV1928-1H	3RT1025	65	14
	15	21	15.2	3RV1021-4AA..	3RV1928-1H	3RT1026	65	10
	20	27	20.2	3RV1031-4DA..	--- a)	3RT1033	65	10
	25	34	25	3RV1031-4EH..	--- a)	3RT1034	65	8
	30	40	29.2	3RV1031-4EA..	--- a)	3RT1035	65	8
	40	52	39.2	3RV1041-4FA..	3RT1946-4GA07	3RT1036	65	6
	50	65	48.4	3RV1031-4DA..	3RT1946-4GA07	3RT1044	65	6
	60	77	57.2	3RV1041-4JA..	3RT1946-4GA07	3RT1045	65	4
	75	96	71.2	3RV1041-4KA..	3RT1946-4GA07	3RT1046	65	3

a) No add-on terminal is required for this type.

*) For information, see Device selection tables for combination motor controllers (Page 207)

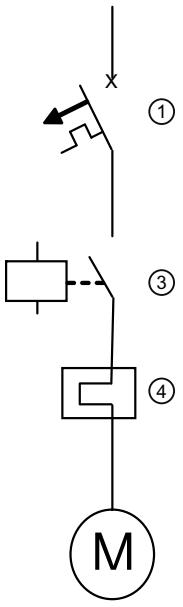
Table A- 6 480/277 V – Type E

480 / 277V solidly grounded Wye - Self-Protected Manual Motor Control - "Construction Type E"							
	Rated motor output [hp]	Standard motor current (according to the standard) FLC [A]	Typical motor amps FLA [A]	Motor starter protector (Self Protected)	Type E terminal block	SCCR [kA]	Internal wire cross section for Cu (75 °C) [AWG]
	X1 *)	X2 *)	X3 *)	(5) *)	(5.1) *)	X4 *)	X5 *)
	0.5	1.1	0.67	3RV1021-0HA..	3RV1928-1H	65	14
	0.75	1.6	0.93	3RV1021-0JA..	3RV1928-1H	65	14
	1	2.1	1.2	3RV1021-0KA..	3RV1928-1H	65	14
	1.5	3	1.7	3RV1021-1BA..	3RV1928-1H	65	14
	2	3.4	2.3	3RV1021-1CA..	3RV1928-1H	65	14
	3	4.8	3.3	3RV1021-1EA..	3RV1928-1H	65	14
	5	7.6	5.3	3RV1021-1GA..	3RV1928-1H	65	14
	7.5	11	7.7	3RV1021-1HA..	3RV1928-1H	65	14
	10	14	10.1	3RV1021-1JA..	3RV1928-1H	65	14
	15	21	15.2	3RV1021-4AA..	3RV1928-1H	65	10
	20	27	20.2	3RV1031-4DA..	--- a)	65	10
	25	34	25	3RV1031-4EA..	--- a)	65	8
	30	40	29.2	3RV1031-4EA..	--- a)	65	8
	40	52	39.2	3RV1041-4FA..	3RT1946-4GA07	65	6
	50	65	48.4	3RV1041-4FA..	3RT1946-4GA07	65	6
	60	77	57.2	3RV1041-4JA..	3RT1946-4GA07	65	4
	75	96	71.2	3RV1041-4KA..	3RT1946-4GA07	65	3
	100	124	91.85	3RV1041-4LA..	3RT1946-4GA07	65	1

a) No add-on terminal is required for this type.

*) For information, see Device selection tables for combination motor controllers (Page 207)

Table A- 7 480/277 V – Magnetic Motor Control

480 / 277V solidly grounded Wye - Magnetic Motor Control - "Construction Type C"								
	Rated motor output [hp]	Standard motor current (according to the standard) FLC [A]	Typical motor amps FLA [A]	MCCB	Magnetic controller (Motor Control)	Overload (Overload Relay)	SCCR [kA]	Internal wire cross section for Cu (75 °C) [AWG]
	X1 *)	X2 *)	X3 *)	(1) *)	(3) *)	(4) *)	X4 *)	X5 *)
	0.5	1.10	0.67	3RV1721-1BD10	3RT1023	3RB2906-2BG1b)	50	14
	0.75	1.60	0.93	3RV1721-1DD10	3RT1023	3RB2906-2BG1b)	50	14
	1	2.10	1.2	3RV1721-1ED10	3RT1023	3RB2906-2BG1b)	50	14
	1.5	3.00	1.7	3RV1721-1FD10	3RT1023	3RB2906-2BG1b)	50	14
	2	3.40	2.3	3RV1721-1GD10	3RT1023	3RB2906-2BG1b)	50	14
	3	4.80	3.3	3RV1721-1HD10	3RT1023	3RB2906-2JG1b)	50	14
	5	7.60	5.3	3RV1721-4AD10	3RT1023	3RB2906-2JG1b)	50	14
	7.5	11.00	7.7	3RV1721-4BD10	3RT1024	3RB2906-2JG1b)	50	14
	10	14.00	10.1	3RV1721-4CD10	3RT1025	3RB2906-2JG1b)	50	14
	15	21.00	15.2	3RV1742-5FD10	3RT1026	3RB2906-2JG1b)	65	10
	20	27.00	20.2	3RV1742-5HD10	3RT1033	3RB2906-2JG1b)	65	10
	25	34.00	25	3RV1742-5JD10	3RT1034	3RB2906-2JG1b)	65	8
	30	40.00	29.2	3RV1742-5LD10	3RT1035	3RB2906-2JG1b)	65	8
	40	52.00	39.2	3RV1742-5PD10	3RT1036	3RB2906-2JG1b)	65	6
	50	65.00	48.4	3VL3110-2KN30-….	3RT1044	3RB2906-2JG1b)	65	6

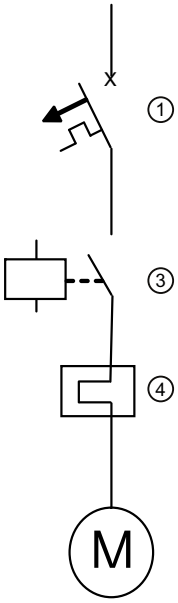
b) Can only be used with the 3RB22 or 3RB23 evaluation modules and 3RB29 87-2 connecting cables.

c) The standard values are currently the only values for branches with this level of power (hp).

*) For information, see Device selection tables for combination motor controllers (Page 207)

Table continued on next page

Continued from previous page

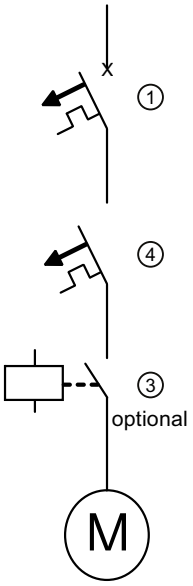
480 / 277V solidly grounded Wye - Magnetic Motor Control - "Construction Type C"								
	Rated motor output [hp]	Standard motor current (according to the standard) FLC [A]	Typical motor amps FLA [A]	MCCB	Magnetic controller (Motor Control)	Overload (Overload Relay)	SCCR [kA]	Internal wire cross section for Cu (75 °C) [AWG]
	X1 *)	X2 *)	X3 *)	(1) *)	(3) *)	(4) *)	X4 *)	X5 *)
	60	77.00	57.2	3VL3115-2KN30-….	3RT1045	3RB2906-2JG1b)	65	4
	75	96.00	71.2	3VL3115-2KN30-….	3RT1046	3RB2906-2JG1b)	65	3
	100	124.00	91.9	3VL3120-1KN30-….	3RT1054	3RB2906-2JG1b)	10c)	1
	125	156.00	115.6	3VL3125-1KN30-….	3RT1055	3RB2956-2T.2b)	10c)	2/0
	150	180.00	133.3	3VL4125-1KN30-….	3RT1056	3RB2956-2T.2b)	10c)	3/0
	200	240.00	177.8	3VL4135-1KN30-….	3RT1.65	3RB2956-2T.2b)	10c)	250 kcmil
	250	302.00	223.7	3VL4140-1KN30-….	3RT1.66	3RB2966-2WH2b)	18c)	350 kcmil
	300	361.00	267.4	3VL4550-1KN30-….	3RT1.75	3RB2966-2WH2b)	18c)	500 kcmil
	350	414.00	306.7	3VL4560-1KN30-….	3RT1.76	3RB2966-2WH2b)	18c)	600 kcmil
	400	477.00	353.3	3VL6160-1KN30-….	3RT1.76	3RB2966-2WH2b)	18c)	800 kcmil
	450	515.00	381.5	3VL6170-1KN30-….	3TF68	3RB2966-2WH2b)	30c)	900 kcmil
	500	590.00	437.0	3VL6180-1KN30-….	3TF68	3RB2966-2WH2b)	30c)	1250 kcmil

b) Can only be used with the 3RB22 or 3RB23 evaluation modules and 3RB29 87-2 connecting cables.

c) The standard values are currently the only values for branches with this level of power (hp).

*) For information, see Device selection tables for combination motor controllers (Page 207)

Table A- 8 480/277 V – Manual / Magnetic Motor Control

480 / 277V solidly grounded Wye - Manual / Magnetic Motor Control - "Construction Type C"								
	Rated motor output [hp]	Standard motor current (according to the standard) FLC [A]	Typical motor amps FLA [A]	MCCB	Magnetic controller **) ((Motor Control))	Overload (Overload Relay)	SCCR [kA]	Internal wire cross section for Cu (75 °C) [AWG]
	X1 *)	X2 *)	X3 *)	(1) *)	(3) *)	(4) *)	X4 *)	X5 *)
	0.5	1.1	0.67	3RV1721-1BD10	3RT1023	3RV1011-0HA..	50	14
	0.75	1.6	0.93	3RV1721-1DD10	3RT1023	3RV1011-0JA..	50	14
	1	2.1	1.2	3RV1721-1ED10	3RT1023	3RV1011-1AA..	50	14
	1.5	3	1.7	3RV1721-1FD10	3RT1023	3RV1011-1BA..	50	14
	2	3.4	2.3	3RV1721-1GD10	3RT1023	3RV1011-1CA..	50	14
	3	4.8	3.3	3RV1721-1HD10	3RT1023	3RV1011-1EA..	65	14
	5	7.6	5.3	3RV1721-4AD10	3RT1023	3RV1011-1GA..	65	14
	7.5	11	7.7	3RV1721-4BD10	3RT1024	3RV1011-1JA..	65	14
	10	14	10.1	3RV1721-4CD10	3RT1025	3RV1011-1KA..	65	14
	15	21	15.2	3RV1742-5FD10	3RT1026	3RV1021-4AA..	65	10
	20	27	20.2	3RV1742-5HD10	3RT1033	3RV1021-4CA..	65	10
	25	34	25	3RV1742-5JD10	3RT1034	3RV1031-4EA..	65	8
	30	40	29.2	3RV1742-5LD10	3RT1035	3RV1031-4EA..	65	8
	40	52	39.2	3RV1742-5PD10	3RT1036	3RV1031-4GA..	65	6
	50	65	48.4	3VL3110-2KN30-….	3RT1044	3RV1031-4HA..	65	6
	60	77	57.2	3VL3115-2KN30-….	3RT1045	3RV1041-4JA..	65	4
	75	96	71.2	3VL3115-2KN30-….	3RT1046	3RV1041-4KA..	65	3

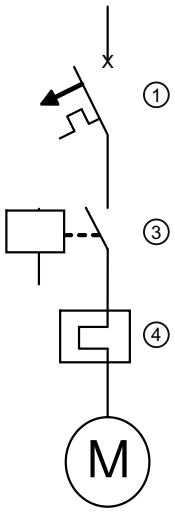
*) For information, see Device selection tables for combination motor controllers (Page 207)

**) No magnetic controller is required for this version of the motor starter.

This 3RV ④ is approved both as a Manual Motor Controller and as motor overload protection.
If a magnetic controller is used, it will be a Manual/Magnetic Motor Controller.
If NO magnetic controller is used, it will be a Manual Motor Controller.

A.1.3 480 VAC "corner grounded delta"

Table A- 9 480 V – Magnetic Motor Control

480V corner grounded Delta - Magnetic Motor Control - "Construction Type C"								
	Rated motor output [hp]	Standard motor current (according to the standard) FLC [A]	Typical motor amps FLA [A]	MCCB	Magnetic controller (Motor Control)	Overload (Overload Relay)	SCCR [kA]	Internal wire cross section for Cu (75 °C) [AWG]
	X1 *)	X2 *)	X3 *)	(1) *)	(3) *)	(4) *) a)	X4 *)	X5 *)
	7.5	11	7.7	3VL1102-2KM30-....	3RT1024	3RB2906-2DG1	65	14
	10	14	10.1	3VL1102-2KM30-....	3RT1025	3RB2906-2DG1	65	14
	15	21	15.2	3VL1125-2KM30-....	3RT1026	3RB2906-2DG1	65	10
	20	27	20.2	3VL1106-2KM30-...	3RT1033	3RB2906-2DG1	65	10
	25	34	25	3VL1106-2KM30-….	3RT1034	3RB2906-2DG1	65	8
	30	40	29.2	3VL1108-2KM30-….	3RT1035	3RB2906-2JG1	65	8
	40	52	39.2	3VL1110-2KM30-….	3RT1036	3RB2906-2JG1	65	6
	50	65	48.4	3VL1112-2KM30-….	3RT1044	3RB2906-2JG1	65	6
	60	77	57.2	3VL1150-2KM30-….	3RT1045	3RB2906-2JG1	65	4
	75	96	71.2	3VL1150-2KM30-….	3RT1046	3RB2906-2JG1	65	3

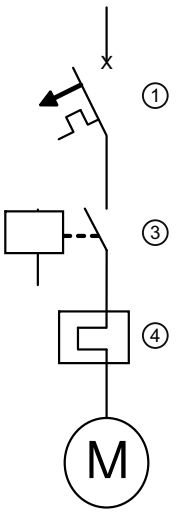
a) Can only be used with the 3RB23 evaluation module and 3RB29 87 -2 connecting cables

b) The standard values are currently the only values for branches with this level of power (hp).

*) For information, see Device selection tables for combination motor controllers (Page 207)

Table continued on next page

Continued from previous page

480V corner grounded Delta - Magnetic Motor Control - "Construction Type C"								
	Rated motor output [hp]	Standard motor current (according to the standard) FLC [A]	Typical motor amps FLA [A]	MCCB	Magnetic controller (Motor Control)	Overload (Overload Relay)	SCCR [kA]	Internal wire cross section for Cu (75 °C) [AWG]
	X1 *)	X2 *)	X3 *)	(1) *)	(3) *)	(4) *) a)	X4 *)	X5 *)
	100	124	91.9	3VL3117-1KN30-….	3RT1054	3RB2906-2JG1	10b)	1
	125	156	115.6	3VL3122-1KN30-….	3RT1055	3RB2956-2T.2	10b)	2/0
	150	180	133.3	3VL4125-1KN30-….	3RT1056	3RB2956-2T.2	10b)	3/0
	200	240	177.8	3VL4135-1KN30-….	3RT1.65	3RB2956-2T.2	10b)	250 kcmil
	250	302	223.7	3VL4140-1KN30-….	3RT1.66	3RB2966-2WH2	18b)	350 kcmil
	300	361	267.4	3VL4550-1KN30-….	3RT1.75	3RB2966-2WH2	18b)	500 kcmil
	350	414	306.7	3VL4560-1KN30-….	3RT1.76	3RB2966-2WH2	18b)	600 kcmil
	400	477	353.3	3VL6170-1KN30-….	3RT1.76	3RB2966-2WH2	18b)	800 kcmil
	450	515	381.5	3VL6180-1KN30-….	3TF68	3RB2966-2WH2	30b)	900 kcmil
	500	590	437.0	3VL7180-1KN30-….	3TF68	3RB2966-2WH2	30b)	1250 kcmil

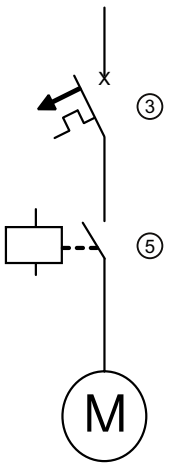
a) Can only be used with the 3RB23 evaluation module and 3RB29 87 -2 connecting cables

b) The standard values are currently the only values for branches with this level of power (hp).

*) For information, see Device selection tables for combination motor controllers (Page 207)

A.1.4 600/347 VAC "solidly grounded wye"

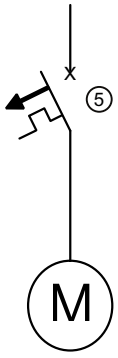
Table A- 10 600/347 V – Type F

600 / 347 V solidly grounded Wye - Self-Protected Manual / Magnetic Motor Control "Construction Type F"								
	Motor rated output [hp]	Standard motor current (according to the standard) FLC [A]	Typical motor amps FLA [A]	Motor starter protector (Self Protected)	Type E terminal block	Magnetic controller (Motor Control)	SCCR [kA]	Internal wire cross section for Cu (75 °C) [AWG]
	X1 *)	X2 *)	X3 *)	(5) *)	(5.1) *)	(3) *)	X4 *)	X5 *)
	0.5	0.9	0.6	3RV1021-0HA..	3RV1928-1H	3RT1023	25	14
	0.75	1.3	0.9	3RV1021-0KA..	3RV1928-1H	3RT1023	25	14
	1	1.7	1.1	3RV1021-1AA..	3RV1928-1H	3RT1023	25	14
	1.5	2.4	1.6	3RV1021-1BA..	3RV1928-1H	3RT1023	25	14
	2	2.7	1.8	3RV1021-1CA..	3RV1928-1H	3RT1023	25	14
	3	3.9	2.6	3RV1021-1DA..	3RV1928-1H	3RT1023	25	14
	5	6.1	4.1	3RV1021-1FA..	3RV1928-1H	3RT1023	25	14
	7.5	9.0	6.0	3RV1021-1GA..	3RV1928-1H	3RT1023	25	14
	10	11.0	7.3	3RV1021-1JA..	3RV1928-1H	3RT1024	25	14
	15	17.0	12.9	3RV1021-4AA..	3RV1928-1H	3RT1025	25	12
	20	22.0	16.7	3RV1021-4BA..	3RV1928-1H	3RT1026	25	10
	25	27.0	20.5	3RV1031-4DA..	--- a)	3RT1033	25	10
	30	32.0	24.2	3RV1031-4EA..	--- a)	3RT1034	25	8
	40	41.0	31.1	3RV1031-4FA..	--- a)	3RT1035	25	8
	50	52.0	39.4	3RV1031-4HG..	--- a)	3RT1036	25	6
	60	62.0	47.0	3RV1041-4JA..	3RT1946-4GA07	3RT1044	30	6
	75	77.0	58.3	3RV1041-4KA..	3RT1946-4GA07	3RT1045	30	4
	100	99.0	75.0	3RV1041-4LA..	3RT1946-4GA07	3RT1046	30	3

a) No add-on terminal is required for this type.

*) For information, see Device selection tables for combination motor controllers (Page 207)

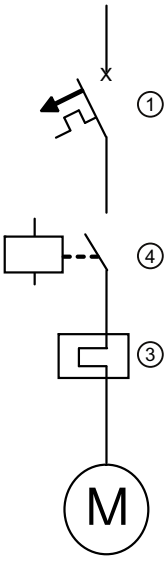
Table A- 11 600/347 V – Type E

600 / 347 V solidly grounded Wye - Self Protected Manual Motor Control - "Construction Type E "							
	Motor rated output [hp]	Standard motor current (according to the standard) FLC [A]	Typical motor amps FLA [A]	Motor starter protector (Self Protected)	Type E terminal block	SCCR [kA]	Internal wire cross section for Cu (75 °C) [AWG]
	X1 *)	X2 *)	X3 *)	(5) *)	(5.1) *)	X4 *)	X5 *)
	0.5	0.9	0.6	3RV1021-0HA..	3RV1928-1H	30	14
	0.75	1.3	0.9	3RV1021-0KA..	3RV1928-1H	30	14
	1	1.7	1.1	3RV1021-1AA..	3RV1928-1H	30	14
	1.5	2.4	1.6	3RV1021-1BA..	3RV1928-1H	30	14
	2	2.7	1.8	3RV1021-1CA..	3RV1928-1H	30	14
	3	3.9	2.6	3RV1021-1DA..	3RV1928-1H	30	14
	5	6.1	4.1	3RV1021-1FA..	3RV1928-1H	30	14
	7.5	9.0	6.0	3RV1021-1GA..	3RV1928-1H	30	14
	10	11.0	7.3	3RV1021-1JA..	3RV1928-1H	30	14
	15	17.0	12.9	3RV1021-4AA..	3RV1928-1H	30	12
	20	22.0	16.7	3RV1021-4BA..	3RV1928-1H	30	10
	25	27.0	20.5	3RV1031-4DA..	--- a)	25	10
	30	32.0	24.2	3RV1031-4EA..	--- a)	25	8
	40	41.0	31.1	3RV1031-4FA..	--- a)	25	8
	50	52.0	39.4	3RV1031-4HG..	--- a)	25	6
	60	62.0	47.0	3RV1041-4JA..	3RT1946-4GA07	30	6
	75	77.0	58.3	3RV1041-4KA..	3RT1946-4GA07	30	4
	100	99.0	75.0	3RV1041-4LA..	3RT1946-4GA07	30	3
	125	125.0	94.7	3RV1041-4MA..	3RT1946-4GA07	30	1

a) No add-on terminal is required for this type.

*) For information, see Device selection tables for combination motor controllers (Page 207)

Table A- 12 600/347 V – Type C

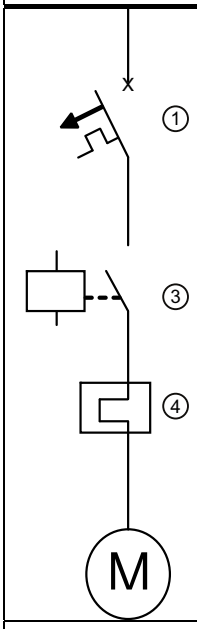
600 / 347 V solidly grounded Wye - Magnetic Motor Control - "Construction Type C"								
	Motor rated output [hp]	Standard motor current (according to the standard) FLC [A]	Typical motor amps FLA [A]	MCCB	Magnetic controller (Motor Control)	Overload (Overload Relay)	SCCR [kA]	Internal wire cross section for Cu (75 °C) [AWG]
	X1 *)	X2 *)	X3 *)	(1) *)	(3) *)	(4) *)	X4 *)	X5 *)
	0.5	0.9	0.6	3RV1721-1BD10	3RT1023	3RV1021-0HA..	25	14
	0.75	1.3	0.9	3RV1721-1CD10	3RT1023	3RV1021-0JA..	25	14
	1	1.7	1.1	3RV1721-1DD10	3RT1023	3RV1021-0KA..	25	14
	1.5	2.4	1.6	3RV1721-1ED10	3RT1023	3RV1021-1BA..	25	14
	2	2.7	1.8	3RV1721-1FD10	3RT1023	3RV1021-1DA..	25	14
	3	3.9	2.6	3RV1721-1HD10	3RT1023	3RV1021-1FA..	25	14
	5	6.1	4.1	3RV1742-5AD10	3RT1023	3RV1021-1HA..	25	14
	7.5	9.0	6.0	3RV1742-5BD10	3RT1023	3RV1021-4HA..	25	14
	10	11.0	7.3	3RV1742-5CD10	3RT1024	3RV1021-4AA..	25	14
	15	17.0	12.9	3RV1742-5FD10	3RT1025	3RV1031-4BA..	25	12
	20	22.0	16.7	3VL2105-3KN30-….	3RT1026	3RV1031-4EA..	25	10
	25	27.0	20.5	3VL2105-3KN30-….	3RT1033	3RV1031-4DA..	25	10
	30	32.0	24.2	3VL2106-3KN30-….	3RT1034	3RV1031-4EA..	25	8
	40	41.0	31.1	3VL2191-3KN30-….	3RT1035	3RV1031-4GA..	25	8
	50	52.0	39.4	3VL2191-3KN30-….	3RT1036	3RV1031-4HA..	25	6
	60	62.0	47.0	3VL2110-3KN30-….	3RT1044	3RV1041-4JA..	25	6
	75	77.0	58.3	3VL3115-3KN30-….	3RT1045	3RV1041-4JA..	25	4
	100	99.0	75.0	3VL3117-3KN30-….	3RT1046	3RV1041-4LA..	25	3

*) For information, see Device selection tables for combination motor controllers (Page 207)

**) No magnetic controller is required for this version of the motor starter.
This 3RV (4) is approved both as a Manual Motor Controller and as motor overload protection.
If a magnetic controller is used, it will be a Magnetic Motor Controller.
If no magnetic controller is used, it will be a Manual Motor Controller.

A.1.5 600 VAC "corner grounded delta"

Table A- 13 600 V – Magnetic Motor Control

600 V corner grounded Delta - Magnetic Motor Control - "Construction Type C"								
	Rated motor output [hp]	Standard motor current (according to the standard) FLC [A]	Typical motor amps FLA [A]	MCCB	Magnetic controller (Motor Control)	Overload (overload relay)	SCCR [kA]	Internal wire cross section for Cu (75 °C) [AWG]
	X1 *)	X2 *)	X3 *)	(1) *)	(3) *)	(4) *) a)	X4 *)	X5 *)
	20	22.0	16.7	3VL2107-3KN30-….	3RT1026	3RB2906-2DG1	25	10
	25	27.0	20.5	3VL2106-3KN30-….	3RT1033	3RB2906-2JG1	25	10
	30	32.0	24.2	3VL2106-3KN30-….	3RT1034	3RB2906-2JG1	25	8
	40	41.0	31.1	3VL2191-3KN30-….	3RT1035	3RB2906-2JG1	25	8
	50	52.0	39.4	3VL2112-3KN30-….	3RT1036	3RB2906-2JG1	25	6
	60	62.0	47.0	3VL3117-3KN30-….	3RT1044	3RB2906-2JG1	25	6
	75	77.0	58.3	3VL3120-3KN30-….	3RT1045	3RB2906-2JG1	25	4
	100	99.0	75.0	3VL3125-3KN30-….	3RT1046	3RB2906-2JG1	25	3

a) Can only be used with the 3RB22 or 3RB23 evaluation modules and 3RB29 87-2 connecting cables.

*) For information, see Device selection tables for combination motor controllers (Page 207)

A.2 Short circuit ratings for Siemens 3RT contactors (extracts)

Note

The valid UL reports for your specific application always overrule the tables given here.

A.2.1 3RT101 contactors (extracts)

Table A- 14

Magnetic controller	Fuse class K5, RK5, RK1, J	Circuit breaker		Short-circuit current rating	Voltage
		Bkr TM 1	Bkr I 2		
	[A]	[A]	[A]	[kA]	[V]
3RT101	Max. 60	Max. 50	Max. 25	5	600
3RT131	Max. 60	Max. 50	Max. 25	5	600
3RT151	Max. 60	Max. 50	Max. 25	5	600
3RT161	Max. 70	-	-	5	600
3RT171	Max. 60	Max. 50	Max. 25	5	600

[1] Note: Circuit breaker (Inverse Time) according to **UL 489** with thermal and magnetic trip unit (overcurrent and short circuit)

[2] Note: Circuit breaker for starter combinations according to **UL 489** (short-circuit trip unit only, adjustable), see report E31519 for details.

Protection from high short-circuit currents

480 V, 65 kA when using a 3RV101 to a maximum of 8 A (UL-listed motor starter protector, made by Siemens)

Type 2 coordination according to UL 60947-4-1

This is equivalent to the IEC type of coordination "2".
Short-circuit current ratings with fuse protection for magnetic controller/overload relay combination, according to
UL 60947-4-1, for type "2" coordination.

Table A- 15

Magnetic controller	Overload relay	Fuse class J	Voltage with high short-circuit current rating	High short-circuit current rating acc. to UL 60947-4-1	Standard short-circuit current rating acc. to UL 60947-4-1 at 600 V
		[A]	[V]	[kA]	[kA]
3RT1015	3RU1116-0F	1	600	100	1
3RT1015	3RU1116-0G	1	600	100	1
3RT1015	3RU1116-0H	1	600	100	1
3RT1015	3RU1116-0J	2	600	100	1
3RT1015	3RU1116-0K	2	600	100	1
3RT1015	3RU1116-1A	2	600	100	1
3RT1015	3RU1116-1B	3	600	100	1
3RT1015	3RU1116-1C	3	600	100	5
3RT1015	3RU1116-1D	6	600	100	5
3RT1015	3RU1116-1E	6	600	100	5
3RT1015	3RU1116-1F	8	600	100	5
3RT1015	3RU1116-1G	10	600	100	5
3RT1015	3RU1116-1H	15	600	100	5
3RT1016	3RU1116-1H	15	600	100	5
3RT1016	3RU1116-1J	15	600	100	5

A.2.2 3RT102 contactors (extracts)

Table A- 16

Magnetic controller	Fuse class K5, RK5, RK1, J	Circuit breaker		Short-circuit current rating	Voltage
		Bkr TM [1]	Bkr I [2]		
	[A]	[A]	[A]	[kA]	[V]
3RT1023	Max. 70	Max. 60	Max. 10	5	600
3RT1024	Max. 70	Max. 60	Max. 10	5	600
3RT1025/3RT1325	Max. 70	Max. 60	Max. 30	5	600
3RT1026	Max. 100	Max. 100	Max. 40	5	600
3RT1326/3RT1526	Max. 100	Max. 100	Max. 40	5	600
3RT1626	Max. 80	-	-	5	600
3RT1627	Max. 125	-	-	5	600

[1] Note: Circuit breaker (Inverse Time) according to **UL 489** with thermal and magnetic trip unit (overcurrent and short circuit)

[2] Note: Circuit breaker for starter combinations according to **UL 489** (short-circuit trip unit only, adjustable). Where required, select the corresponding type according to the UL report.

Protection from high short-circuit currents

Table A- 17

Magnetic controller	Fuse		Circuit breaker TM	3RV 102 Size S0[3]	Short-circuit current rating	Voltage
	Class RK5; K5, RK1	Class J				
	[A]	[A]	[A]	[A]	[kA]	[V]
3RT1023	40	80	-	-	100	600
	-	-	30	8	25	600
	-	-	30	8	65	480
3RT1024	40	80	-	-	100	600
	-	-	40	10	25	600
	-	-	40	10	65	480
3RT1025	40	80	-	-	100	600
	-	-	50	12.5	25	600
	-	-	50	16	65	480
3RT1026	-	100	-	-	100	600
	-	-	70	12.5	25	600
	-	-	70	22	65	480

[3] Note: Siemens 3RV102 (size S0) UL-Listed Combination Motor Controller Type described in **UL File E156943**

Type 2 coordination according to UL 60947

Short-circuit current ratings with fuse protection for magnetic controller/overload relay combination, according to **UL 60947-4-1**, for type "2" coordination.

Table A- 18

Magnetic controller	Overload relay	Fuse class LPJ	Voltage with high short-circuit current rating	High short-circuit current rating acc. to UL 60947-4-1	Standard short-circuit current rating acc. to UL 60947-4-1 at 600 V
		[A]	[V]	[kA]	[kA]
3RT1024	3RU1126-1K	20	600	100	5
3RT1025	3RU1126-4A	25	600	100	5
3RT1025	3RU1126-4B	30	600	100	5
3RT1026	3RU1126-4C	40	480	100	5
3RT1026	3RU1126-4C	40	600	65	5
3RT1026	3RU1126-4D	30	600	100	5
3RT1026	3RU1126-4D	50	480	100	5
3RT1026	3RU1126-4D	50	600	65	5

A.2.3 3RT103 contactors (extracts)

Table A- 19

Magnetic controller	Fuse class K5, RK5, RK1, J	Circuit breaker		Short-circuit current rating	Voltage
		Bkr TM 1	Bkr I [2]		
	[A]	[A]	[A]	[kA]	[V]
3RT1033	Max. 125	Max. 125	Max. 10	5	600
3RT1034	Max. 125	Max. 125	Max. 10	5	600
3RT1035/3RT1535	Max. 150	Max. 150	Max. 50	5	600
3RT1036/3RT1336	Max. 200	Max. 200	Max. 100	5	600
3RT1636	Max. 125	-	-	10	600

[1] Note: Circuit breaker (Inverse Time) according to **UL 489** with thermal and magnetic trip unit (overcurrent and short circuit)

[2] Note: Circuit breaker for starter combinations according to **UL 489** (short-circuit trip unit only, adjustable). Where required, select the corresponding type according to the UL report.

Protection from high short-circuit currents

Table A- 20

Magnetic controller	Fuse		Circuit breaker TM	3RV 103 Size S2[3]	Short-circuit current rating	Voltage
	Class RK5; K5, RK1	Class J				
	[A]	[A]	[A]	[A]	[kA]	[V]
3RT1033	60	125	-	-	100	600
	-	-	60	25	25	600
	-	-	60	25	65	480
3RT1034	60	125	-	-	100	600
	-	-	60	32	25	600
	-	-	60	32	65	480
3RT1035	80	150	-	-	100	600
	-	-	80	40	25	600
	-	-	80	40	65	480
3RT1036	100	200	-	-	100	600
	-	-	125	50	25	600
	-	-	125	50	65	480

[3] Note: Siemens 3RV103 (size S2) UL-Listed Combination Motor Controller Type described in **UL File E156943**

Type 2 coordination according to UL 60947-4-1

Short-circuit current ratings with fuse protection for magnetic controller/overload relay combination, according to
UL 60947-4-1, for type "2" coordination

Table A- 21

Magnetic controller	Overload relay	Fuse class LPJ	Voltage with high short-circuit current rating	High short-circuit current rating acc. to UL 60947-4-1	Standard short-circuit current rating acc. to UL 60947-4-1 at 600 V
		[A]	[V]	[kA]	[kA]
3RT1033	3RU1136-4E	60	600	100	5
3RT1034	3RU1136-4F	60	600	100	5
3RT1035	3RU1136-4G	70	600	100	5

A.2.4 3RT104 contactors (extracts)

Table A- 22

Magnetic controller	Fuse		Circuit breaker		Short-circuit current rating	Voltage
	Class K5, RK5, RK1	Class J	Bkr TM [1]	Bkr I [2]		
	[A]	[A]	[A]	[A]	[kA]	[V]
3RT1044	250	225	Max. 250	Max. 50	5	600
3RT1045	300	300	Max. 300	Max. 100	10	600
3RT1046/3RT1446	350	400	Max. 400	Max. 150	10	600
3RT1647	250	250	-	-	10	600

[1] Note: Circuit breaker (Inverse Time) according to **UL 489** with thermal and magnetic trip unit (overcurrent and short circuit)

[2] Note: Circuit breaker for starter combinations according to **UL 489** (short-circuit trip unit only, adjustable). Where required, select the corresponding circuit breaker according to the UL report.

Protection from high short-circuit currents

Table A- 23

Magnetic controller	Fuse		Circuit breaker TM	3RV 104 Size S3[3]	Short-circuit current rating	Voltage
	Class RK5; K5, RK1	Class J				
	[A]	[A]	[A]	[A]	[kA]	[V]
3RT1044	-	200	-	-	100	600
	-	-	175	-	25	600
	-	-	-	63	30	600
	125	225	175	63	65	480
3RT1045	-	-	200	-	25	600
	-	-	-	75	30	600
	150	250	200	75	65	480
3RT1046	100	400	-	-	100	600
	-	-	250	-	25	600
	-	-	-	75	30	600
	200	350	250	100	65	480

[3] Note: Siemens 3RV102 (size S3) UL-Listed Combination Motor Controller Type described in **UL File E156943**

Type 2 coordination according to UL 60947-4-1

Short-circuit current ratings with fuse protection for magnetic controller/overload relay combination, according to
UL 60947-4-1, for type "2" coordination

Table A- 24

Magnetic controller	Overload relay	Fuse class LPJ	Voltage with high short-circuit current rating	High short-circuit current rating acc. to UL 60947-4-1	Standard short-circuit current rating acc. to UL 60947-4-1 at 600 V
		[A]	[V]	[kA]	[kA]
3RT1044	3RU1146-4J	90	600	100	5
3RT1044	3RU1146-4K	125	600	100	5
3RT1045	3RU1146-4L	175	600	100	10
3RT1046	3RU1146-4M	200	600	100	10

A.2.5 3RT105 contactors (extracts)

Table A- 25

Magnetic controller	Fuse	Circuit breaker		Short-circuit current rating	Voltage
		Bkr TM [1]	Bkr I [2]		
	[A]	[A]	[A]	[kA]	[V]
3RT1054	Max. 450	Max. 350	Max. 250	10	600
3RT1055	Max. 500	Max. 450	Max. 400	10	600
3RT1056	Max. 500	Max. 500	Max. 400	10	600

[1] Note: Circuit breaker (Inverse Time) according to **UL 489** with thermal and magnetic trip unit (overcurrent and short circuit)

[2] Note: Circuit breaker for starter combinations according to **UL 489** (short-circuit trip unit only, adjustable). Where required, select the corresponding circuit breaker according to the UL report.

Protection from high short-circuit currents

Table A- 26

Magnetic controller	Fuse class RK5			Circuit breaker (thermal-delayed)			Circuit breaker (instantaneous)		
	Size	Voltage	Short-circuit current rating	Size	Voltage	Short-circuit current rating	Size	Voltage	Short-circuit current rating
	[A]	[V]	[kA]	[A]	[V]	[kA]	[A]	[V]	[kA]
3RT1054	-	480	-	175	480	100	150	480	100
	-	600	-	175	600	25	150	600	25
3RT1055	-	480	-	200	480	100	200	480	100
	-	600	-	200	600	25	200	600	25
3RT1056	-	480	-	250	480	100	250	480	100
	-	600	-	250	600	25	250	600	25

A.2.6 3RT106 contactors (extracts)

Table A- 27

Magnetic controller	Fuse	Circuit breaker		Short-circuit current rating	Voltage
		Bkr TM [1]	Bkr I [2]		
	[A]	[A]	[A]	[kA]	[V]
3RT1064	Max. 700	Max. 500	Max. 400	10	600
3RT1065	Max. 800	Max. 700	Max. 400	18	600
3RT1066	Max. 800	Max. 800	Max. 400	18	600
3RT1264	Max. 600	Max. 500	Max. 400	10	600
3RT1265	Max. 700	Max. 700	Max. 400	18	600
3RT1266	Max. 800	Max. 800	Max. 400	18	600

[1] Note: Circuit breaker (Inverse Time) according to **UL 489** with thermal and magnetic trip unit (overcurrent and short circuit)

[2] Note: Circuit breaker for starter combinations according to **UL 489** (short-circuit trip unit only, adjustable). Where required, select the corresponding circuit breaker according to the UL report.

3RT106 with high short-circuit current ratings

Table A- 28

Magnetic controller	Fuse Class RK5, RK1, J	Short-circuit current rating	Voltage
	[A]	[kA]	[V]
3RT1066	Max. 400	100	600

A.2.7 3RT107 contactors (extracts)

Table A- 29

Magnetic controller	Fuse class L	Circuit breaker		Short-circuit current rating	Voltage
		Bkr TM [1]	Bkr I [2]		
	[A]	[A]	[A]	[kA]	[V]
3RT1075	Max. 1000	Max. 900	-	18	600
3RT1076	Max. 1200	Max. 900	-	30	600
3RT1275	Max. 1000	Max. 1000	Max. 600	18	600
3RT1276	Max. 1200	Max. 1200	Max. 600	30	600

[1] Note: Circuit breaker (Inverse Time) according to **UL 489** with thermal and magnetic trip unit (overcurrent and short circuit)

[2] Note: Circuit breaker for starter combinations according to **UL 489** (short-circuit trip unit only, adjustable)

3RT107 with high short-circuit current ratings

Table A- 30

Magnetic controller	Fuse	Short-circuit current rating	Voltage
	[A]	[kA]	[V]
3RT1076	Max. 600 (Class J, RK1; RK5)	100	600
3RT1076	Max. 400 (Class L)	100	600

A.3 Semiconductor relay

A.3.1 3RF20/21 semiconductor relays (extracts)

Protection from high short-circuit currents

Table A- 31

			Fuse	
3RF2	**Voltage [V]**	**Current [kA]**	**Max. size [A]**	**Class**
3RF2150	600	65	25	CC
3RF2150	600	65	35	J
3RF2190	600	10	45	J

A.3.2 3RF23/24 solid state controllers (extracts)

Table A- 32

			Fuse Class K5, RK5, RK1, J
3RF2	**Voltage [V]**	**Current [kA]**	**Max. size [A]**
3RF2403	600	5	Max. 10
3RF2405	600	5	Max. 10
3RF2410	600	5	Max. 20
3RF2412	600	5	Max. 30
3RF2416	600	5	Max. 30

A.4 Short circuit ratings for 3RW soft starters (extracts)

A.4.1 3RW30, 3RW40 and 3RW44 soft-starters (extracts) up to 75 hp at 460 - 480 V

3RW30 - Standard short-circuit current ratings

Table A- 33

3RW30	Max. fuse Class K5, RK5, RK1	Max. fuse Class J	Standard short-circuit current rating	Voltage
	[A]	[A]	[kA]	[V]
3RW3013		15	5	480
3RW3014		25	5	480
3RW3016		36	5	480
3RW3017		50	5	480
3RW3018		60	5	480
3RW3026	100	100	5	480
3RW3027	125	125	5	480
3RW3028	125	125	5	480
3RW3036	175	175	10	480
3RW3037	250	250	10	480
3RW3038	250	250	10	480
3RW3046		300	10	480
3RW3047		480	10	480

3RW30 - Protection from high short-circuit currents

Table A- 34

3RW30	Max. fuse Class K5, RK5, RK1	Max. fuse Class J	Standard short-circuit current rating	Voltage
	[A]	[A]	[kA]	[V]
3RW3013		15	42	480
3RW3014		25	42	480
3RW3016		25	42	480
3RW3017		25	42	480
3RW3018		25	42	480
3RW3026	60	100	42	480
3RW3027	60	125	42	480
3RW3028	60	125	42	480
3RW3036	100	175	30	480
3RW3037	100	200	30	480
3RW3038	100	200	30	480
3RW3046	110	200	42	480
3RW3047	110	200	42	480

3RW40 - Standard short-circuit current ratings

Table A- 35

3RW40	Max. fuse Class K5, RK5, RK1	Max. fuse Class J	Standard short-circuit current rating	Voltage
	[A]	[A]	[kA]	[V]
3RW4024	50	50	5	600
3RW4026	100	100	5	600
3RW4027	125	125	5	600
3RW4028	125	125	5	600
3RW4036	175	175	10	600
3RW4037	250	250	10	600
3RW4038	250	250	10	600
3RW4046	450[1)]	300	10	600
3RW4047	450[1)]	300	10	600
[1)] Special purpose fuse Type 3NE1333-2 manufactured by Siemens covered in File E1673257.				

3RW40 - Protection from high short-circuit currents

Table A- 36

3RW40	Max. fuse Class K5, RK5, RK1	Max. fuse Class J	Standard short-circuit current rating	Voltage
	[A]	[A]	[kA]	[V]
3RW4024	50	50	42	600
3RW4026	60	100	42	600
3RW4027	60	125	42	600
3RW4028	60	125	42	600
3RW4036	100	175	30	600
3RW4037	100	200	30	600
3RW4038	100	200	30	600
3RW4046	110	200	42	600
3RW4047	110	200	42	600

Table A- 37

	Max. fuse	Standard short-circuit current rating	Voltage
	[A]	[kA]	[V]
3RW405	450	10	600
3RW407	1200	30	600

3RW44 - Standard short-circuit current ratings

Table A- 38

3RW44	Max. fuse	Standard short-circuit current rating	Voltage
	[A]	[kA]	[V]
3RW442	300	10	600
3RW443	450	10	600
3RW444	1200	30	600

3RW44 5/6 - Standard short-circuit current ratings

Table A- 39

3RW44	Max. fuse Class L	Standard short-circuit current rating	Voltage
	[A]	[kA]	[V]
3RW4453	1600	42	600
3RW4454	2000	42	600
3RW4455	2000	42	600
3RW4456	2500	42	600
3RW4457	2500	42	600
3RW4458	2500	42	600
3RW4465	3000	85	600
3RW4466	3000	85	600

A.5 Short circuit ratings for 3RU overload relay (extracts)

A.5.1 3RU111 overload relay (extracts)

Table A- 40

3RU111.-xx.0 Suffix (xx)	Setting range		Short-circuit current rating	Fuse, max. class		Circuit breaker (thermal-delayed)
	From	To		K5, RK5, RK, CC	J	
	[A]	[A]	[kA]	[A]	[A]	[A]
0A	0.11	0.16	1	6	10	15
0B	0.14	0.2	1	6	10	15
0C	0.18	0.25	1	6	10	15
0D	0.22	0.32	1	6	10	15
0E	0.28	0.4	1	6	10	15
0F	0.35	0.5	1	6	10	15
0G	0.45	0.63	1	6	10	15
0H	0.55	0.8	1	6	10	15
0J	0.7	1	1	6	10	15
0K	0.9	1.25	1	6	10	15
1A	1.1	1.6	1	6	10	15
1B	1.4	2	1	10	15	15
1C	1.8	2.5	5	10	15	15
1D	2.2	3.2	5	15	25	15
1E	2.8	4	5	15	25	15
1F	3.5	5	5	20	25	20
1G	4.5	6.3	5	25	45	20
1H	5.5	8	5	30	50	30
1J	7	10	5	40	70	30
1K	9	12	5	45	70	50

Magnetic controller/overload relay combination (extracts)

Short-circuit current ratings with fuse protection for magnetic controller/overload relay combination, according to
UL 60947-4-1, for type "2" coordination.

Table A- 41

Magnetic controller	Overload relay	Fuse class LP	Voltage with high short-circuit current rating	High short-circuit current rating acc. to UL 60947-4-1	Standard short-circuit current rating acc. to UL 60947-4-1 at 600 V
		[A]	[V]	[kA]	[kA]
3RT1015	3RU1116-0F	1	600	100	1
3RT1015	3RU1116-0G	1	600	100	1
3RT1015	3RU1116-0H	1	600	100	1
3RT1015	3RU1116-0J	2	600	100	1
3RT1015	3RU1116-0K	2	600	100	1
3RT1015	3RU1116-1A	2	600	100	1
3RT1015	3RU1116-1B	3	600	100	1
3RT1015	3RU1116-1C	3	600	100	5
3RT1015	3RU1116-1D	6	600	100	5
3RT1015	3RU1116-1E	6	600	100	5
3RT1015	3RU1116-1F	8	600	100	5
3RT1015	3RU1116-1G	10	600	100	5
3RT1015	3RU1116-1H	15	600	100	5
3RT1016	3RU1116-1H	15	600	100	5
3RT1016	3RU1116-1J	15	600	100	5
3RT1016	3RU1116-1J	15	600	100	5

A.5.2 3RU112 overload relay (extracts)

Table A- 42

3RU112.-xx.0 Suffix (xx)	Setting range		Short-circuit current rating	Fuse, max. class		Circuit breaker (thermal-delayed)	Voltage
	From	To		K5, RK1, K5, CC	J		
	[A]	[A]	[kA]	[A]	[A]	[A]	[V]
0A	0.11	0.16	1	6	10	15	600
0B	0.14	0.2	1	6	10	15	600
0C	0.18	0.25	1	6	10	15	600
0D	0.22	032	1	6	10	15	600
0E	0.28	0.4	1	6	10	15	600
0F	0.35	0.5	1	6	10	15	600
0G	0.45	0.63	1	6	10	15	600
0H	0.55	0.8	1	6	10	15	600
0J	0.7	1	1	6	10	15	600
0K	0.9	1.25	1	6	10	15	600
1A	1.1	1.6	1	6	10	15	600
1B	1.4	2	1	6	10	15	600
1C	1.8	2.5	5	10	15	15	600
1D	2.2	3.2	5	15	25	15	600
1E	2.8	4	5	15	25	15	600
1F	3.5	5	5	20	35	20	600
1G	4.5	6.3	5	25	45	25	600
1H	5.5	8	5	30	50	30	600
1J	7	10	5	40	70	40	600
1K	9	12.5	5	50	90	50	600
4A	11	16	5	60	110	60	600
4B	14	20	5	80	150	80	600
4C	17	22	5	80	150	80	600
4D	20	25	5	100	175	100	600

Magnetic controller/overload relay combination

Short-circuit current ratings with fuse protection for magnetic controller/overload relay combination, according to
UL 60947-4-1, for type "2" coordination

Table A- 43

Magnetic controller	Overload relay	Fuse class LP	Voltage with high short-circuit current rating	High short-circuit current rating acc. to UL 60947-4-1	Standard short-circuit current rating acc. to UL 60947-4-1 at 600 V
		[A]	[V]	[kA]	[kA]
3RT1024	3RU1126-1K	20	600	100	5
3RT1025	3RU1126-4A	25	600	100	5
3RT1025	3RU1126-4B	30	600	100	5
3RT1026	3RU1126-4C	40	480	100	5
3RT1026	3RU1126-4C	40	600	65	5
3RT1026	3RU1126-4D	30	600	100	5
3RT1026	3RU1126-4D	50	480	100	5
3RT1026	3RU1126-4D	50	600	65	5

A.5.3 3RU113 overload relay (extracts)

Table A- 44

3RU113.-xx.0 Suffix (xx)	Setting range		Short-circuit current rating	Fuse, max. class		Circuit breaker (thermal-delayed)	Voltage
	From	To		K5, RK1, RK5, CC	J		
	[A]	[A]	[kA]	[A]	[A]	[A]	[V]
0A	0.11	0.16	1	6	10	15	600
0B	0.14	0.2	1	6	10	15	600
0C	0.18	0.25	1	6	10	15	600
0D	0.22	0.32	1	6	10	15	600
0E	0.28	0.4	1	6	10	15	600
0F	0.35	0.5	1	6	10	15	600
0G	0.45	0.63	1	6	10	15	600
0H	0.55	0.8	1	6	10	15	600
0J	0.7	1	1	6	10	15	600
0K	0.9	1.25	1	6	10	15	600
1A	1.1	1.6	1	6	10	15	600
1B	1.4	2	5	6	10	15	600
1C	1.8	2.5	5	10	15	15	600
1D	2.2	3.2	5	10	15	15	600
1E	2.8	4	5	15	25	15	600
1F	3.5	5	5	20	35	20	600
1G	4.5	6.3	5	25	45	25	600
1H	5.5	8	5	30	50	30	600
1J	7	10	5	40	50	40	600
1K	9	12.5	5	50	90	50	600
4A	11	16	5	60	110	60	600
4B	14	20	5	80	150	80	600
4D	18	25	5	100	175	100	600
4E	22	32	5	125	225	125	600
4F	28	40	5	150	250	150	600
4G	36	45	5	170	250	170	600
4H	40	50	5	200	350	200	600

Magnetic controller/overload relay combination

Short-circuit current ratings with fuse protection for magnetic controller/overload relay combination, according to
UL 60947-4-1, for type "2" coordination

Table A- 45

Magnetic controller	Overload relay	Fuse class J	Voltage with high short-circuit current rating	High short-circuit current rating acc. to UL 60947-4-1	Standard short-circuit current rating acc. to UL 60947-4-1 at 600 V
		[A]	[V]	[kA]	[kA]
3RT1033	3RU1136-4E	60	600	100	5
3RT1034	3RU1136-4F	60	600	100	5
3RT1035	3RU1136-4G	70	600	100	5

A.5.4 3RU114 overload relay (extracts)

Table A- 46

3RU114.-xx.0 Suffix (xx)	Setting range		Short-circuit current rating	Fuse, max. class		Circuit breaker (thermal-delayed)	Voltage
	From	To		K5, RK1, K5, CC	J		
	[A]	[A]	[kA]	[A]	[A]	[A]	[V]
4D	18	25	5	100	175	100	600
4E	22	32	5	125	225	125	600
4F	28	40	5	150	250	150	600
4H	36	50	5	200	350	200	600
4J	45	63	10	250	450	250	600
4K	57	75	10	300	500	300	600
4L	70	90	10	350	500	350	600
4M	80	100	10	350	500	400	600

Magnetic controller/overload relay combination

Short-circuit current ratings with fuse protection for magnetic controller/overload relay combination, according to
UL 60947-4-1, for type "2" coordination

Table A- 47

Magnetic controller	Overload relay	Fuse class LP	Voltage with high short-circuit current rating	High short-circuit current rating acc. to UL 60947-4-1	Standard short-circuit current rating acc. to UL 60947-4-1 at 600 V
		[A]	[V]	[kA]	[kA]
3RT1044	3RU1146-4J	90	600	100	5
3RT1044	3RU1146-4K	125	600	100	5
3RT1045	3RU1146-4L	175	600	100	10
3RT1046	3RU1146-4M	200	600	100	10

A.5.5 3RB20, 3RB21 electronic overload relay (standard applications) (extracts)

Setting ranges and short-circuit withstand rating

Table A- 48

Setting range	Fuse size, max.	Fuse Class	Short-circuit current rating	Voltage
[A]	[A]		[kA]	[V]
0.1 to 0.4	1.6	K5, RK1, RK5, J	5	600
0.32 to 1.25	5	K5, RK1, RK5, J	5	600
1 to 4	15	K5, RK1, RK5, J	5	600
3 to 12	45	K5, RK1, RK5, J	5	600
6 to 25	100	K5, RK1, RK5, J	5	600
12.5 to 50	200	K5, RK1, RK5, J	5	600
25 to 100	400	K5, RK1, RK5, J	5	600
50 to 200	601	L	10	600
55 to 250	700	L	30	600
160 to 630	1600	L	30	600

The short-circuit current ratings given here apply to the overload relay both on its own and when used in combination with a magnetic controller.

Maximum short-circuit withstand rating with fuse

Setting range	Fuse size, max.			Short-circuit current rating	Voltage
	Class K5, RK1, RK5	Class J	Class L		
[A]	[A]	[A]	[A]	[kA]	[V]
0.1 to 0.4	6	6	-	100	600
0.32 to 1.25	6	6	-	100	600
1 to 4	6	15	-	100	600
3 to 12	25	50	-	100	600
6 to 25	50	100	-	100	600
12.5 to 50	100	200	-	100	600
25 to 100	400	400	-	100	600
50 to 200	-	-	601	100	600
55 to 250	-	-	700	100	600
160 to 630	-	-	1600	100	600

The short-circuit current ratings given here apply to the overload relay both on its own and when used in combination with a magnetic controller.

A.5.6 3RB22, 3RB23, 3RB29 electronic overload relays (high-feature) (extracts)

Table A- 49

Setting range	Fuse or circuit breaker, max.	Short-circuit current rating	Voltage
[A]	[A]	[kA]	[V]
0.3 to 3.0	10	100	600
2.4 to 25	100	100	600
10 to 100	400	100	600
25 to 150	600	100	600
20 to 200	601	100	600
150 to 300	800	100	600
160 to 567	1600	100	600
63 to 630	2000	100	600

A.6 Short circuit ratings for SIMOCODE 3UF7 (extracts)

Table A- 50

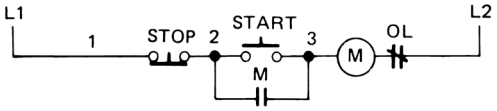
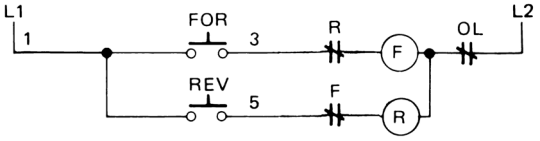
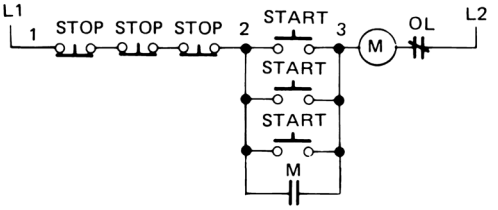
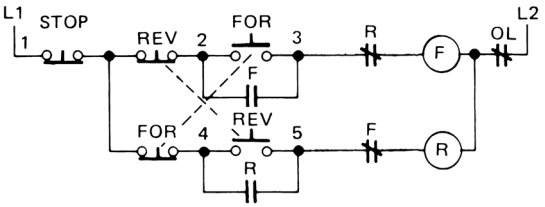
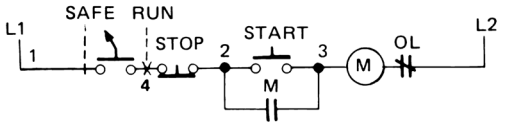
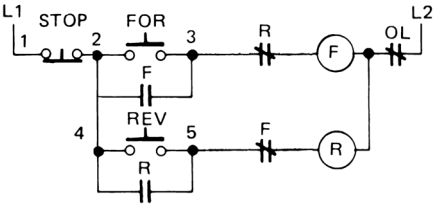
Setting range	Fuse or circuit breaker, max.	Short-circuit current rating	Voltage
[A]	[A]	[kA]	[V]
0.3 to 3.0	10	100	600
2.4 to 25	100	100	600
10 to 100	400	100	600
20 to 200	601	100	600
63 to 630	2000	100	600

Annex B

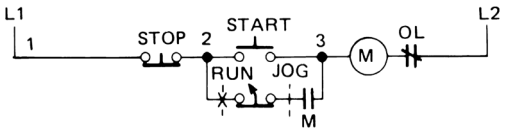
B

B.1 Typical circuit diagrams for motor control circuits

Two and three-wire open-loop control

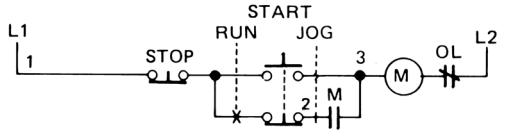
Three-wire open-loop control for motor control circuits with overload relay contact (OL) and holding contact (M). Pushbutton control with two command points 	Two-wire open-loop control for setup in forwards and reversing mode with pushbutton control based on two command points 
Three-wire open-loop control for motor control circuits with overload relay contact (OL) and holding contact (M). Pushbutton control with several dual command points 	Three-wire open-loop control for instantaneous reversing mode with pushbutton control based on two command points 
Three-wire open-loop control for motor control circuits with overload relay contact (OL) and holding contact (M) with toggle switch, two positions for off (Save) and operation (Run) 	Three-wire open-loop control for reversing mode after the stop with pushbutton control based on two command points 

Three-wire open-loop control for setup (Jog) or operation (Run) with start/stop pushbuttons and setup/run toggle switches

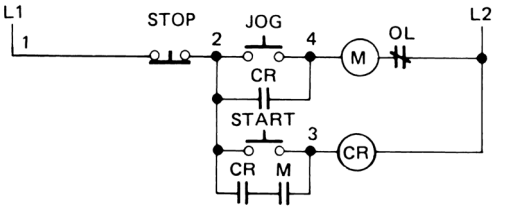


With special pushbutton/toggle switch:

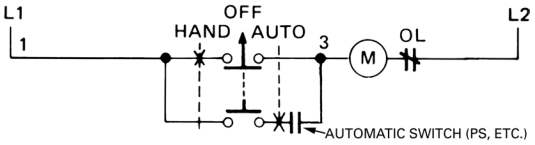
Open-loop control for setup (Jog) and operation (Run) for stop pushbutton and setup/run pushbutton/toggle switch. The contacts of the pushbutton/toggle switch are for the operation (Run) position (three-wire open-loop control). The rotating toggle switch and toggle-switch contact open between "2" and the "Stop" pushbutton. (Two-wire open-loop control)



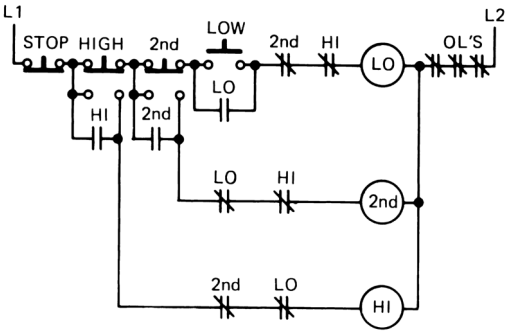
Three-wire open-loop control for motor control circuits with pushbuttons and relays (CR) for setup (Jog), start, stop



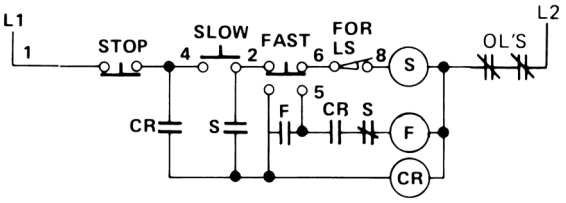
Two-wire open-loop control with manual-off-auto 3-position toggle switch (e.g. for automatic PLC controls)



Open-loop control for three-velocity circuit with selective electric circuit which ensures that the stop is always actuated before a lower velocity is selected.



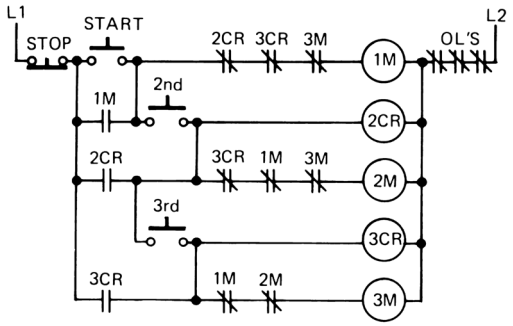
Three-wire open-loop control for two-velocity circuit with relays to ensure that the low velocity is always used for starting.



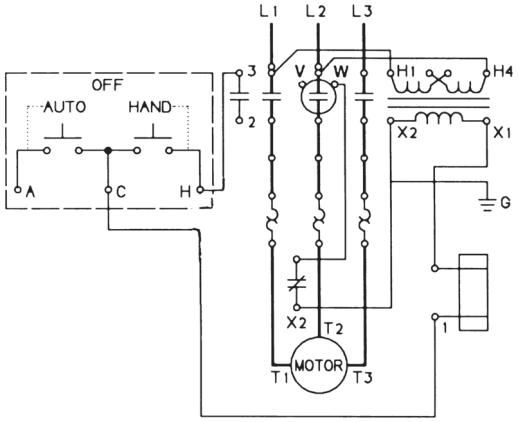
B.2 Typical circuit diagrams for speed control

Open-loop control for two and three velocities

Open-loop control for three-velocity circuit with relays to ensure that the low velocity is always used for starting.

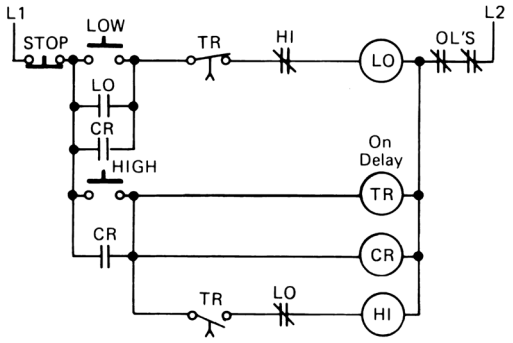


Size of 0 - 2½ with transformer and 3-position toggle switch

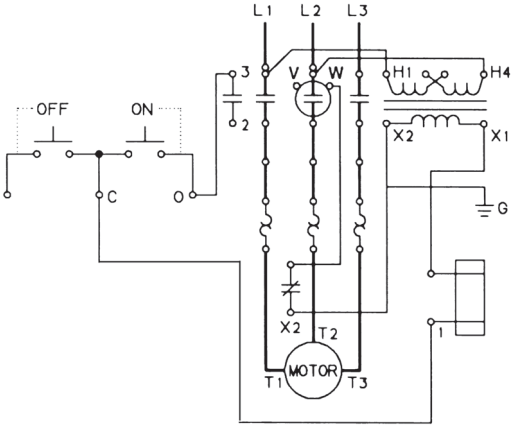


H1 transformer to L1 starter
H4 transformer to L2 starter
C from hand-off auto to X1 transformer
H from hand-off auto to 3 or V on starter
A to external contact, other side of external contact
to 3 or V transformer of user X2 on starter to X2 on transformer

Open-loop control for two-velocity circuit with time relays for automatic acceleration from Slow to Fast

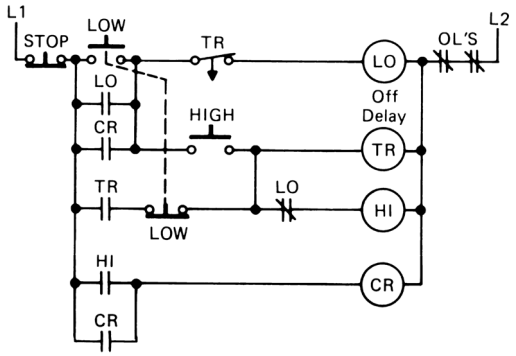


Size of 0 - 2½ with transformer and 2-position toggle switch

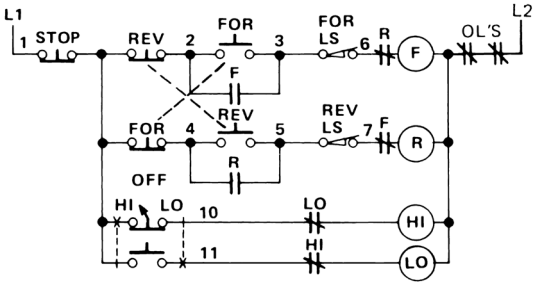


H1 transformer to L1 starter
H4 transformer to L2 starter
C from ON-OFF to X1 transformer
O from ON-OFF to 3 or V on starter
X2 on starter to X2 on transformer

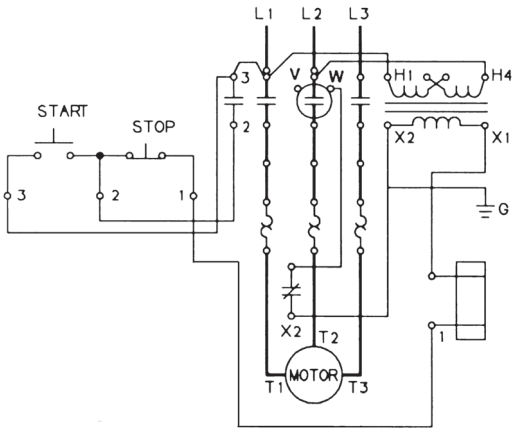
Open-loop control for two-velocity circuit with time relays for automatic reduction in velocity from Fast to Slow



Open-loop control for two-velocity circuit, reversing mode, with forwards and reversing, stop pushbutton and Fast-Slow-Off toggle switch



Size of 0 - 2½ with transformer and ON-OFF (START-STOP) pushbutton



H1 transformer to L1 starter
H4 transformer to L2 starter
1 from START-STOP to X1 transformer
2 from START-STOP to 2 on starter
3 from ON-OFF to 3 or V on starter
X2 on starter to X2 on transformer

B.3 Classification of control circuits according to IEC

Classification of control circuit - IEC

IEC 947-5-1 load classification for AC and DC control supply voltages

Table B- 1

AC control circuit Load category according to IEC 947-5-1	Close		Open	
	I/I_e	U/U_e	I/I_e	U/U_e
AC-12	1	1	1	1
AC-12	2	1	1	1
AC-12	6	1	1	1

I_e Operating current
U_e Operating voltage
I Close-open current
U Voltage before closing

The current at each voltage is determined by the manufacturer; it is not specified in the standard.

Table B- 2

DC control circuit Load category according to IEC 947-5-1	Close		Open	
	I/I_e	U/U_e	I/I_e	U/U_e
DC-12	1	1	1	1
DC-13	1	1	1	1
DC-14	10	1	1	1

I_e Operating current
U_e Operating voltage
I Close-open current
U Voltage before closing

Example of a typical IEC control circuit table for AC and DC [1]

Table B- 3

I_e/AC-12 [A]	Ue [V] AC	Ie/AC-15 [A]
10	24	6
	110	6
	220 / 230	6
	380 / 440	6

Table B- 4

Voltage [V]	I_e/DC-12 [A]	I_e/DC-13 [A]
24	6	3
60	5	1,5
110	2,5	0,7
230	1	0,3

[1] Example: A control contact, designed for AC-15 with a rating of 6 A at 230 V, can close at 230 V/60 A and open at 6 A.

I_e Operating current

U_e Operating voltage

I Close-open current

U Voltage before closing

B.4 Feedback form

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From	
Company: Name: Department: Function: Street: Location: Country: Telephone: E-mail:	Should you come across any printing errors when reading this publication, please notify us on this sheet. Suggestions for improvement are also welcome

Assessment of the UL manual

Very good ☐ Good ☐ Not so good ☐

Because:

Time savings resulting from use of the document:

None ☐ approx. 5% ☐ approx. 10% ☐ Other.....%

Suggestions:

Glossary

3-wire control

In motor starters, command device arrangement with latching contact.
Control circuit.

ANSI

American National Standards Institute.
ANSI is the most senior authority for regulations in the USA. Most regulations feature the ANSI standard (e.g. **NEC 2008, UL 508**).

AWG

American Wire Gauge.
International label for wire cross sections, e.g. AWG 16 = 1.3 mm^2 ≙ 0.201 $inch^2$ to 10 A.

Reference: **UL 508A T29.1; NEC 2008 Art. 310.17 (60 °C**)

Branch circuit

Branch electric circuit.
Reference: **NEC 2008 Art. 100; NEC 2008 Art. 210**.
Starting from the load, all products up to the first "overcurrent" branch circuit protective device.

Branch circuit protective device (BCPD)

A device for protecting the branch circuit (listed fuses, circuit breakers or miniature circuit breakers (listed according to UL 489 ≙ circuit breakers))

Reference: **NEC 2008 (Art. 240.6; NEC 2008 Art. 430.52)**

CANENA

(Consejo de Armonizacion de Normas Electrotecnicas de las Nacionas de las Americas).
Council for Harmonization of Electrotechnical Standardization of North America.
This is the standards association for NAFTA (currently of minor importance).

Circuit breaker (molded case)

Circuit breaker, generally UL-approved

Reference: **UL 489**

Class 2

Class 2 electric circuits and devices are devices tested and approved by UL for limited energy circuits.

Reference: **NEC 2008 Art. 725.2**

Clearances

Distances through air and over surfaces (see Feeder and Branch)

Combination motor controller

Starter with a disconnect switch (circuit breaker or disconnect switch)
A Combination motor controller includes the disconnecting, switching and overload functions for the motor branch circuit.

Reference: **UL 508, Art. 2.16**

Common control

Control circuit without control transformer, rated voltage at load and on command devices.

Reference: **UL 508A Art. 41**

Conduit

Pipes in which electric cables are laid. Made from metal or plastic, rigid or flexible (e.g. "liquid-tight", which is used in machine tools).

Reference: **NEC 2008 Art. 342 to NEC 2008 Art. 362**

Control circuit, class 1, direct

"Common control circuit" means that a control transformer is not used; the voltage corresponds to that of the motor and/or load.

Control transformer

A transformer is referred to as a "Control Transformer" if it **only** has control circuits connected on its secondary side.

CSA

Canadian Standards Association.
The CSA publishes standards and approves products in accordance with its own and other standards (IEC, EN, UL, etc.).

Daisy chaining

The laying of a wire in series from one terminal of a device to another.

Disconnect switch

A switch for disconnecting

Reference: **UL 98**

EEMAC

Electrical und Electronic Manufacturer Association of Canada.
EEMAC is the equivalent of NEMA in Canada.

ETL

Electrical Testing Laboratory.
ETL is a test body that approves devices in accordance with other regulations (UL, IEC, CSA, etc.).

External wiring

This is Field wiring laid by the electrician.

Factory wiring

Wiring that is only laid and connected in the manufacture of industrial control panels
(i.e. under supervision).

Reference: **UL 508A Art. 29.6 & 38**

Compare with "Internal wiring".

Factory wiring terminals

Terminals which are only connected up in the manufacture of industrial control panels
(i.e. under supervision).

Reference: **UL 508A Art. 29.6 & 38**

FCPD

Feeder-Circuit Protective Device.
A device for protecting the feeder circuit (listed fuses, circuit breakers or miniature circuit breakers (listed according to UL 489 ≙ circuit breakers))

Feeder circuit

Starting from the load, this refers to all products upstream of the first "overcurrent" branch circuit protective device.

Reference: **NEC 2008 Art. 240.2; NEC 2008 Art. 215; NEC 2008 220**

Field wiring

Wiring which is connected "in the field" by an electrician.

Reference: **UL 508A Art. 28.3 & 37**

Field wiring terminals

Terminals which are connected "in the field" by an electrician.

Reference: **UL 508A Art. 28.3 & 37**

FLA

Full-Load Amps
Rated motor current according the nameplate of the motor used.

FLC

Full-Load-Current
Rated motor current according to the tables in the UL508A or/and NEC.

Reference: **UL 508A Art. 50; NEC 2008 Art. 430.250**

FM

Factory Mutual Research.
The work of FM mainly involves testing components for non-electrical systems, such as boilers, water heaters, oil stoves, etc. For example, "SITOP" and "LOGO!" are approved by FM.

GFCI

Ground Fault Circuit Interrupter

GTCP

Group Tap-Circuit Protector.
Motor branch circuit protection

hp

Horse Power.
1 hp = 0.74570 kW
1 kW = 1.3410 hp

IEEE

Institute of Electrical and Electronics Engineers, Inc., .This body publishes electrical and electronic regulations.

Instantaneous trip circuit breaker

Circuit breaker with just one magnetic trip unit, may only be used to protect the motor, and only if overload protection is present.

Reference: **UL 489, NEC 2008 Art. 100; NEC 2008 Art 430.52 (C) (3)**

Internal wiring

Internal wiring for power circuits: laid by the industrial control panel builder.

Compare with: "Factory Wiring"

Inverse time circuit breaker

A circuit breaker with thermal or magnetic (instantaneous) trip unit.

Reference: **UL 489, NEC 2008 Art. 100; NEC 2008 Art. 430.52**

JIC

Joint Industrial Council.
Industrial control equipment for the automotive industry used to be standardized by this body. This body is no longer active but is often specified. NFPA 79 is the replacement regulation.

Kcmil (old term: MCM)

Kilo-circular-mil.
Wire size (cross-sectional area) specification. One mil is 1/1,000 inch. A wire of 1 cmil (circular mil) is a round wire with a cross-sectional area of 5.063 x 10^{-4} mm^2).

Knockouts

Knockout openings in enclosures for fitting cable conduits.

Reference: **NEC 2008** Index

KO

See Knockouts

Label service

UL program for certain products which are provided with a special label.

Listed

See "Listing, Listed"

Reference: **NEC 2008 Art. 100**

Listing, listed

A device that is tested by UL or another approval body and managed in a "list".

Reference: UL-Listed

Locked rotor current (LRC or LRA = locked rotor amps or MLRA = motor-locked-rotor amps)

A motor's starting current

Reference: **NEC 2008 Art. 430.251 (B)**

Main disconnecting means

A supply circuit disconnecting device, either in the form of a circuit breaker or a disconnect switch.

Reference: **NEC 2008 Art. 430.109**

MCP

Motor Circuit Protector, see "Instantaneous Trip Circuit Breaker"

Miniature circuit breaker (MCB)

Depending on its design, a miniature circuit breaker (MCB) can be used as a "Supplementary protector" in accordance with **UL 1077** or a "Branch protector" in accordance with **UL 489**.

Motor branch circuit

Reference: **NEC 2008 Art. 430.1**

Motor control circuit

A motor control circuit is a circuit which produces electrical signals for controlling machines/systems. Control circuits are normally limited to 15 A. Control circuits can be set up in a variety of ways.

- Directly connected upstream of the branch circuit protective device. Appropriate protection devices for feeder circuits should be used here such as circuit breakers according to **UL 489**.
- Directly connected downstream of the branch circuit protective device. Devices known as "Supplementary Protectors" can also be used here, such as miniature circuit breakers according to **UL 1077**.
- Via transformers or power supplies.

Reference: **NEC 2008 Art. 430** Sec.VI

Motor feeder

Motor supply cable

Reference: **NEC 2008 Art. 430.28 & 53 (D)**

MSP

Motor Starter Protector

An American name for a circuit breaker in accordance with IEC/EN 60947-2 which shall not be used in the USA as a "circuit breaker". An example is a 3RV (motor starter protector).
UL 508

NEC

Der National Electrical Code

The **NEC** is written by the NFPA (NFPA 70). The **NEC** is the installation regulation for the USA. All installations shall meet this code. The **NEC** is generally used by local inspectors (Authority Having Jurisdiction - AHJ). In many cases, local authorities have added extra conditions to it. The **NEC** is revised every 3 years. The version currently valid is from 2008.

NEMA

National Electrical Manufacturer Association.
The NEMA is an organization of manufacturers which publishes market data for its members and standardizes products, such as magnetic controllers and motor frame sizes.
NEMA size: (00.0) 1 to 9 are standardized sizes.

- ICS-1 Industrial Control and Systems – General regulations
- ICS-2 Industrial Control and Systems – Magnetic controllers and overload relays
- ICS-6 Industrial Control and Systems – Enclosures, industrial control panels

NFPA

National Fire Protection Association.
The NFPA publishes numerous regulations and guidelines, such as the "National Electrical Code" **NEC**, or the NFPA 79 "Electrical Standard for Industrial Machinery".

NFPA 79

The Electrical Standard for Industrial Machinery is mainly used in the automotive industry and is specified by manufacturers of machine tools. (2005 edition).

NRTL

National Recognized Testing Laboratory.
This is an approved (non-state) test body, e.g. UL, ETL, CSA, TUV Rheinland of North America. It is approved by the OSHA (Occupational Safety and Health Administration), a US state body.

OSHA

Occupational Safety and Health Administration.
The OSHA publishes guidelines for safety in plants and workplaces.

Overload relay

Device for motor overload protection

Reference: **UL 508**

Pilot duty rating

Rated values for contacts which switch solenoids; specified in e.g. A600/P600
(similar to e.g. IEC, AC-15, etc.)

Reference: **UL 508**

Power circuit

The power circuit can be connected directly or via transformers.
Electrical motors are generally considered to be "Power Circuits". Devices for a Power Circuit should be used here, such as circuit breakers according to **UL 489**.

Power transformer

A transformer is referred to as a "Power Transformer" if loads are connected to its secondary side.
Motors are almost always loads; solenoid valves, however, are seldom to be considered as loads.

Recognized

Components and devices which are not in general use but only when certain conditions are met.

Recognized component index

UL list in which all UL Recognized Components are recorded. Is also known as the "yellow book".

Reexamination service

Factory inspection by UL inspectors for UL-listed products

rms

Root mean square.
For example, Vrms (peak) = Vrms x √2

Self-protected combination starter

A device or group of devices which are approved in accordance with **UL 508** (type E) for controlling and protecting motors.

Reference: **UL 508**

Series rating

The UL-listed combination of two or more circuit breakers for the purpose of increasing the short-circuit current rating.

Reference: **UL 489**

Service entrance

The first termination point of the utility or after the main transformer of the building.

Reference: **NEC 2008 Art. 220**

Short-circuit interrupting rating

The short-circuit breaking capacity of circuit breakers and fuses.

Reference: **UL 489 & UL 248**

Short-circuit rating

Short-Circuit Current Rating (SCCR) or Short-Circuit Withstand Rating (SCWR).

Short-circuit current rating for which a device or system is approved, stated as the prospective short-circuit current in amps (root mean square value) in relation to the corresponding voltage.

Reference: **UL 508 & UL 508A**

Starter

Magnetic controller with overload relay

Reference: **UL 508**

Supplementary protector

Subordinate or auxiliary protective device; also used downstream of branch circuit protection.

Reference: **NEC 2008 Art. 430.72; UL 1077**

Terminal blocks

Reference: **UL 1059**

Thermal-magnetic circuit breaker

See inverse time circuit breaker

Reference: **UL 489**

Type E

See self-protected combination starter

Reference: **UL 508**

Type F

Starter combination, magnetic combination starter / controller

Reference: **UL 508**

UL

Underwriters Laboratories, Inc.
UL publish standards and approve products in accordance with their own and other standards, including IEC, EN, CSA.

UL standards

For explanations of individual standards, see Chapter 2.2.2

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