GUIDE

Contactors and contactor relays

AF09 up to AF2850

ABB is a pioneering technology leader in electrification products, robotics & motion and industrial automation, serving customers in utilities, industry , transport and infrastructure globally.

Continuing a history of innovation spanning more than 130 years, ABB today is writing the future of industrial digitalization with two clear value propositions: bringing electricity from any power plant to any plug and automating industries from natural resources to finished products.

Foreword

ABB offers a wide range of contactors, and we realize that with all the standards, rules, listings and codes, the what, when, where, why and how of contactors can get complicated. The following information is provided to aid in the proper use of ABB contactors and all their capabilities.

This guide is written with the aim of being a general guide for people working with contactors applications, but also for those who are simply interested in learning more about the products, standards, and applications. All these are relevant for European applications (based on IEC) and North American applications (UL / CSA).

The guide is neither a complete technical guide nor a manual for all types of ABB's contactor solution. It is a complement to the catalog, data sheets and brochures available for our products and will provide a general overview of what to consider when working with contactors.

More information on Contactor as well as other ABB products are available at:

https://new.abb.com/low-voltage/products/motor-protection

All the information provided in this guide is only general and each individual application must be handled as a specific case. Be sure to always follow all national and local installation regulations/codes for your specific application.

Safety and warnings

	This symbol in conjunction with the signal word "DANGER" indicates an imminent electrical hazard. Failure to observe the related safety note may cause personnel injury or death or equipment damages.
	This symbol in conjunction with the signal word "WARNING" indicates a potentially dangerous situation. Failure to observe the related safety note may cause personnel injury or death or equipment damages.
	This symbol indicates a safety note: "ATTENTION! Hazardous voltage!" Installation by a certified service engineer only."
	This symbol in conjunction with the signal word "NOTE" indicates operator tips, particularly useful or important information for the use of the product. This symbol and wording do not indicate a dangerous situation.
	This symbol indicates a compulsory action: "Reading the instruction manual/booklet before starting work or before operating equipment or machinery.
	Recycle.
	Do not dispose with ordinary trash.

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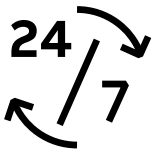
AF contactor range

The simplest way to get the control and performance of the customers need. The contactor range of the ABB offers exceptional reliability and performance in a brilliant space-saving design. Use it for motor starting applications up to 750 A 400 V AC-3, or for power switching up to 2850A 690V AC-1.

Optimized logistics

Cut your costs

With its contactor and motor protection range, ABB has managed to reduce the number of contactor coils to just four. The total number of product variants has been reduced by up to 90%. This simplifies customers' logistics while cutting storage and administration costs.



Continuous operation

Secure uptime

Prevent stoppages caused by voltage fluctuations. The AF contactor ensures distinct operation in unstable networks and signifies a major advance in motor control and power switching. Voltage sags, dips, or surges pose no threat. The AF contactor secures your uptime.

Speed up your projects

Simplify design

Use the same part number in Europe, Asia and North America, as one contactor coil now handles 100 V – 250 V AC / DC, 50 / 60 Hz. By reducing contactor coil energy consumption by up to 80%, panels can be built smaller and transformers more compact.

1 Standards and approvals

All ABB low voltage devices are developed and manufactured according to the rules set out by the IEC (International Electrotechnical Commission). The IEC issues publications that act as a basis for the world market. The applicable standard is the IEC / EN 60947 series for Europe and UL 60947 for North America. All devices are built according to this standard, and in most countries they are not subject to any other tests besides the manufacturer's responsibility. In some countries, the law requires additional certification.

1.1 European Directives for contactors

The guarantee of the free movement of goods within the European Community means that any regulatory differences between member states have been eliminated. The European directives set up common rules that are included in the legislation of each state, and contradictory regulations are abolished.

- **Low Voltage Directive 2014/35/EU**
  Concerns electrical equipment from 50 to 1000 V AC and from 75 to 1500 V DC.
- **Machinery Directive 2006/42/EC**
  Safety specifications of machines and equipment on complete machines
- **Electromagnetic Compatibility Directive 2014/30/EC**
  Applies to all devices able to create electromagnetic disturbance.
- **RoHS Directive 2011/65/EU inc. 2015/863/EU**
  Restriction of the use of Certain Hazardous Substances in Electronic and Electrical Equipment
- **WEEE Directive 2012/19/EU**
  Directive of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (Waste Electrical and Electronic Equipment Directive)

1.2 CE Marking

When a product is verified according to its applicable EN standard, the product is presumed to fulfill all applicable directives, e.g. the " Low Voltage Directive 2014/35/EU", and it is allowed to apply the CE marking on the product.
For contactors, the CE marking does not cover the "Machinery Directive, Directive 2006/42/EC", which rather concerns the machine and requires a special verification of the installation. The AF contactors is an electrical device. It is instead covered by the low voltage directive.

The CE marking is not a quality label - it is proof of conformity to the European Directives concerning the product. This is a self-declaration from the manufacturer.

1.3 Standards in North America

Specifications for North America and Canadian markets are quite similar, but differ significantly from IEC standards and European specifications.

- **USA** - UL Underwriters Laboratories Inc.
- **Canada** - CSA Canadian Standards Association

There are different types of UL certification, including UL listed and UL component recognition. The UL Listing means that UL has tested representative samples of the product and determined that it meets UL's requirements. UL's component recognition service, however, only covers the evaluation of components or materials intended for use in a complete product or system.

- **Listed Product**

A product that has been produced under UL's listing and follow-up service program in accordance with the terms of UL's service agreement and that bears the UL listing mark as the manufacturer's declaration that the product complies with UL's requirements.

- **Recognized Component**

A part or subassembly covered under UL's recognition service and intended for factory installation in listed (or other) products. Recognized components are incomplete in certain construction features or restricted in performance capabilities and are not intended for separate installation in the field - they are intended for use as components of incomplete equipment submitted for investigation by UL. Final acceptance of the component in the complete equipment is dependent upon its installation and use in accordance with all applicable use conditions and ratings noted in the component report issued by UL, in the guide information and in the individual client's Recognized Component information page.

The combined UL signs for the USA and Canada are recognized by the authorities of both countries.

ABB contactors that have UL certification are UL listed. Most ABB contactors can also be cULus-listed, meaning that they are UL listed to US and Canadian safety standards. All the requirements of both UL and CSA are covered by cULus, so the product is then suitable for use in the US and in Canada.

1.4 CCC (China Compulsory Certification)

Since the contactor's standard is listed according to the CCC regulation in China, it is mandatory to have the product approved and labeled with a CCC mark to be allowed to be sold on the Chinese market. The Chinese GB14048.2 and GB14048.4 standard is based on the IEC standard IEC 60947-2 and IEC 60947-4-1.

1.5 Other local approvals based on IEC standards

In addition to IEC and UL standards, many countries have their own local certifications. Some examples of the major ones besides the already mentioned CSA and CCC are listed below:

- **EAC** – The **Eurasian Conformity** mark for Russia, etc.
- **RCM** – The **Regulatory Compliance Mark** for Australian and New Zealand
- **NOM** – The **Norma Oficial Mexicana**
- **KC** – The **Korea Certification** mark

1.6 Marine approvals

For contactors used onboard ships, maritime insurance companies sometimes require different marine certificates of approvals. Some examples include: DNV GL (Det Norske Veritas together with Germanischer Lloyd), BV (Bureau Veritas), LR (Lloyds Register EMEA) which are based on the IEC standard, or from ABS (the American Bureau of Shipping) which is based on UL standards or on some other independent certification organization. Typically, marine approvals have special requirements regarding shock, vibrations, and humidity.

1.7 Applied standards

The following standards are used or partly used for ABB´s contactors.

		Title
International	IEC 60947-1	Low-voltage switchgear and controlgear - Part 1: General rules
	IEC 60947-4-1	Low-voltage switchgear and controlgear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motorstarters
	IEC 60947-5-1	Low-voltage switchgear and controlgear - Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices
	IEC 60947-5-4	Low-voltage switchgear and controlgear – Part 5-4: Control circuit devices and switching elements. Method of assessing the performance of low-energy contacts. Special tests
	IEC 60947- 6-1	Low-voltage switchgear and controlgear – Part 6: Multiple function equipment – Section 1: Automatic transfer switching equipment
	IEC 60204-1	Electrical equipment of industrial machines – Part 1: General requirements
	IEC 60715	Dimensions of low-voltage switchgear and control-gear. Standardized mounting on rails for mechanical support of electrical devices in switchgear and controlgear installations
European standards	EN 50 005	Low-voltage switchgear and controlgear for industrial use – Terminal marking and distinctive number: General rules (Annex L of IEC 60947-1)
	EN 50 011	Low-voltage switchgear and controlgear for industrial use – Terminal marking, distinctive number and distinctive letter for particular contactor relays (Annex M of IEC 60947-5-1)
	EN 60947-1	Low-voltage switchgear and controlgear - Part 1: General rules
	EN 60947-4-1	Low-voltage switchgear and controlgear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motorstarters
	EN 60947-5-1	Low-voltage switchgear and controlgear - Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices
	EN 60947-5-4	Control circuit devices and switching elements. Method of assessing the performance of low-energy contacts. Special tests
	EN 60947- 6-1	Low-voltage switchgear and controlgear – Part 6: Multiple function equipment – Section 1: Automatic transfer switching equipment
	EN 60204-1	Electrical equipment of industrial machines – Part 1: General requirements.
	EN 60 715	Dimensions of low-voltage switchgear and control-gear. Standardized mounting on rails for mechanical support of electrical devices in switchgear and controlgear installations
Standards for North America	UL 60947-4-1 (formerly UL 508)	Low-voltage switchgear and controlgear - Part 4-1: Contactors and Motor-Starters - Electromechanical contactors and motorstarters
	UL 60947-4-1A	2nd Ed. - Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor Starters – Electromechanical Contactors and Motor-Starters
	UL 60947-5-1	Low-Voltage Switchgear and Controlgear - Part 5-1: Control Circuit Devices and Switching Elements - Electromechanical Control Circuit Devices
Standards for Canada	CSA C22.2 No.60947-1 (formerly CSA C22.2 No.14)	Low-voltage switchgear and controlgear - Part 1: General rules
	CSA C22.2 No.60947-4-1 (formerly CSA C22.2 No.14)	Low-voltage switchgear and controlgear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motorstarters
Standards for China	GB/T14048.1	Low-voltage switchgear and controlgear - Part 1: General rules
	GB/T14048.4	Low-voltage switchgear and controlgear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motorstarters
	GB/T14048.5	Low-voltage switchgear and controlgear - Part 5-1: Control circuit devices and switching element - Electromechanical control circuit devices

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National Standards

European countries' national standards reproduce the corresponding EN... standards. Codification is created by the addition of a prefix to EN numbering. For instance:

- France NF EN...
- Germany DIN EN...
- Great Britain BS EN...
- Italy CEI EN...
- Sweden SS EN...

2 General product overview

2.1 Basic function

Contactors are electromagnetically operated switches. The functional principle can be described as follows: when control power flows through the magnet coil of a contactor, the resulting magnetic field attracts the mechanical contact carrier. By interruption of the coil control circuit, the mechanical contact carrier returns to the starting position.

ABB contactors are provided in either three or four power pole configurations with a variety of accessories, including auxiliary contacts, easy connecting links (between products), interlocks, and bus bars. Contactors are primarily used for controlling single and three-phase motors and switching power circuits.

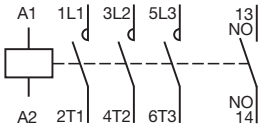
The ABB contactors belong to the class of air-break contactors. If coil power is removed, an arc is created as the contacts open. Air-break contactors extinguish the arc by separating the contacts by a sufficient distance.

Contactors are approved according to IEC / EN 60947-4-1, IEC / EN 60947-5-1., and Contactor relays are approved according to IEC / EN 60947-5-1. The basic function is realized with the following sub functions:

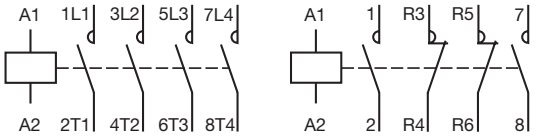
Contactors together with CA4, CAT4 or CAL4 accessories:
- mechanically contact elements
- mirror contacts

Contactors relays together with CA4 or CAL4 accessories:
- mechanically contact elements

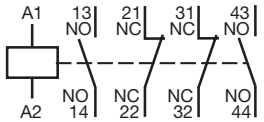
Below some examples:



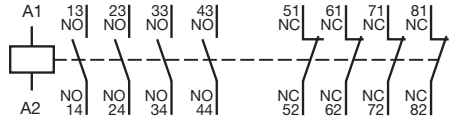
01 3-pole contactor



02 4-pole contactor 4N.O. or 2 NO + 2N.C



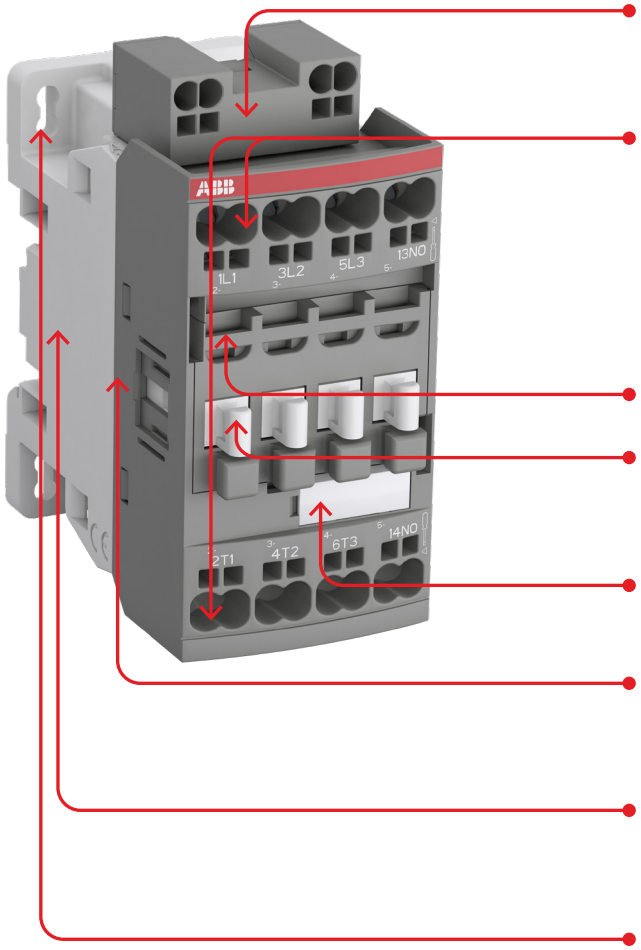
03 4-pole contactor relay (e.g. NF..22E)



04 8-pole contactor relay (e.g. NF..44E)

Note: More details about mechanically linked contacts and mirror contacts look in to chapter: 2.1.6 Mechanically linked contacts or mirror contacts

2.1.1 Structure of AF09 up to AF96



Coil terminals block
Can be pre-wired prior to installation and easily rotated from top (standard) to bottom.

Main pole terminals
Allow the connection of up to two conductors with different cross-sections for the main.

AF09 up to AF38 are available as screw terminals or push-in spring terminals.
AF40 up to AF96 are available as screw terminals.

Contacts for front-mounted coil terminal

Contact carrier
Linked to the coil positioning open or close, and leads the front-mounted accessories.

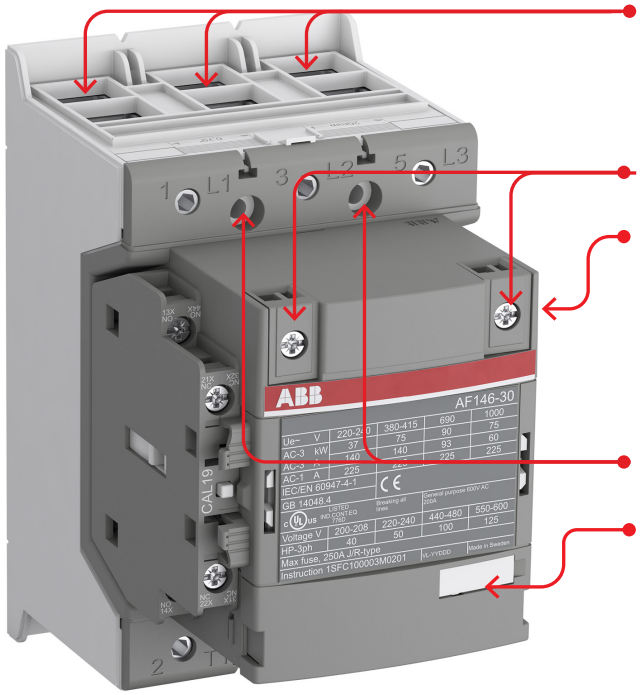
Function markers
Included as standard and available as an accessory.

Contact carrier for side
Linked to the coil positioning open or close, and leads the side-mounted accessories.

DIN mounting
Allows mounting of the device on DIN rails 35 x 7.5 mm, 35 x 15 mm or 75 mm.

Mounting hole pattern

2.1.2 Structure of AF116 up to AF146



Power terminals
Main terminals of AF116 … AF146 contactors are at the back of the contactors to facilitate your bus bar connections. AF116 up to AF145 are available as screw terminals or with screw.

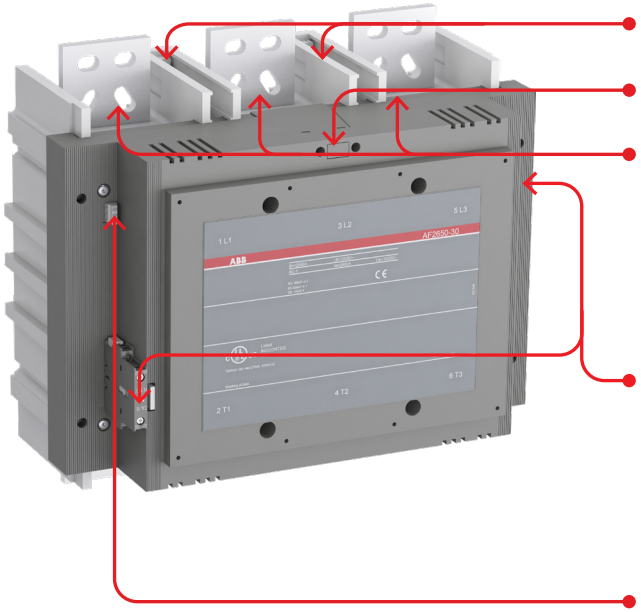
Coil control terminals

2 side mounted auxiliary contact blocks
AF116 … AF2850 contactors can take up to 2 side mounted auxiliary contact blocks without adding to its width. Coil connection terminals, mechanical and electrical interlocks and electronic timers are easily connected through the snap-to-connect function.

Mounting hole pattern

Function markers included as standard (available as an accessory)

2.1.3 Structure of the AF146-B and AF190 up to AF2650



Mounting hole pattern

Coil control terminals

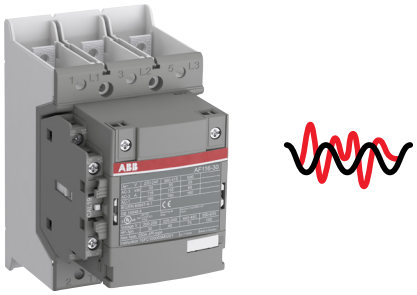
Power terminals
Main terminals of AF116 ... AF2850 contactors are at the contactors' back to facilitate bus bar connections. It also allows easy contact inspection and maintenance from AF400 and above. AF146-B and AF190 up to A2850 are available as screw connection with connection rails.

2 side mounted auxiliary contact blocks
AF116 ... AF2850 contactors can take up to 2 side mounted auxiliary contact blocks without adding to its width. Coil connection terminals, mechanical and electrical interlocks and electronic timers are easily connected through the snap-to-connect function.

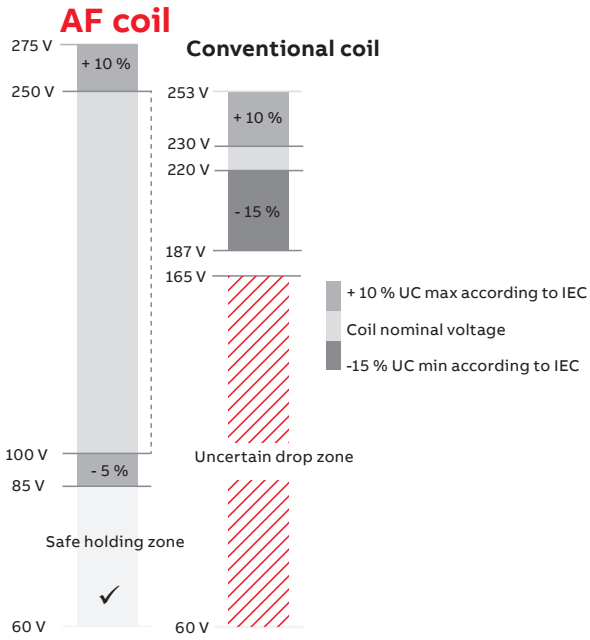
Built-in PLC interface
For control with 24 V DC ≥ 10 mA PLC output. The built-in PLC interface operates the 100 up to 250 V AC / DC or 250 up to 500 V AC / DC AF contactor coil. Available for AF contactors from 55 kW - 400 V / 75 hp up to 560 kW - 400 V /900 hp 480 V and up to 2850 A AC-1 / General use. Dedicated coil code from AF116 up to AF370 and standard feature from AF400 up to AF2850.

2.1.4 AF technology

Reliable in all networks
The electronic system within the AF contactor continuously monitors the current and voltage applied to the coil. The contactor is safely operated in an always optimized condition and hum-free.

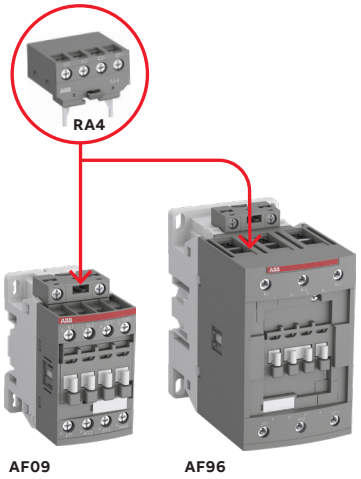


Wide control voltage range
With conventional contactor technology, different contactors are needed for different network voltages. Thanks to the wide operating range of the AF contactor, it can operate equally well in Europe as in Asia or North America. The core coil of the AF contactor range covers 100-250 V AC / DC, 50 / 60 Hz.

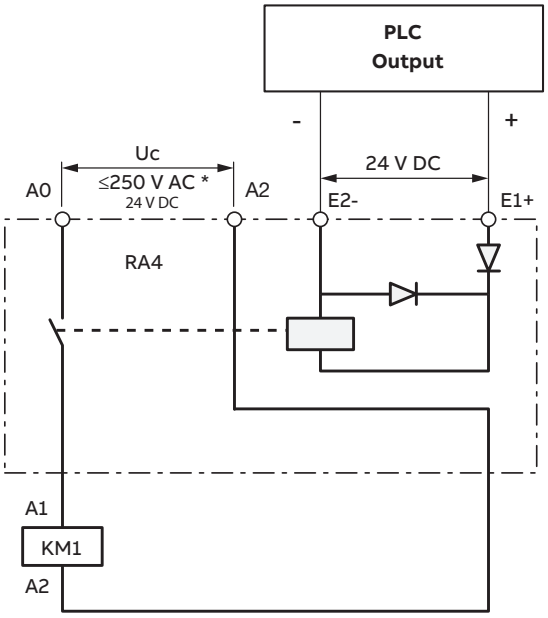


AF contactor <100 A coil interface for PLC

Coil interfaces are offered to operate all contactor with very low PLC output signals. They allow a galvanic isolation between the PLC circuit and the contactor coil circuit.



For control with 24 V DC ≥ 20 mA PLC output. RA4 interface relay can be used for rated control circuit voltages Uc 24 ... 250 V 50/60 Hz and 24 V DC with the standard AF contactors up to 45 kW - 400 V / 60 hp - 480 V and with NF contactor relays.



AF contactor >100 A general operating

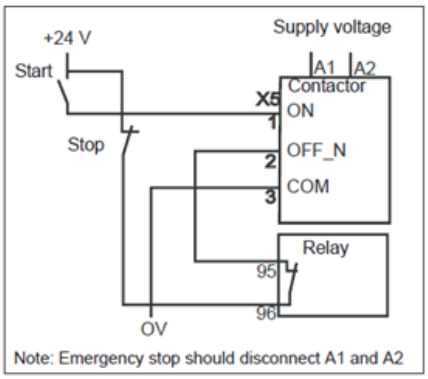
AF-Contactors >100 A are fitted with an electronic coil interface. For a given coil, this interface allows the contactor to accept a very wide voltage range. The contactor can also be controlled by separate logic control signals from for instance a PLC. The selection of the control method is done with switch S1. Control by switching voltage on A1 and A2 requires the switch in position B while control with logic signals requires the switch in position A.

Control by switching voltage on A1 and A2 (switch S1 in position B default factory setting)

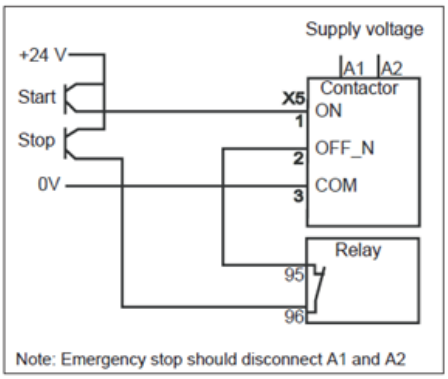
The operation of AF contactors is the same as with conventional contactors, by applying and removing voltage on A1 and A2.

Control with logic control signals (switch S1 in position A)

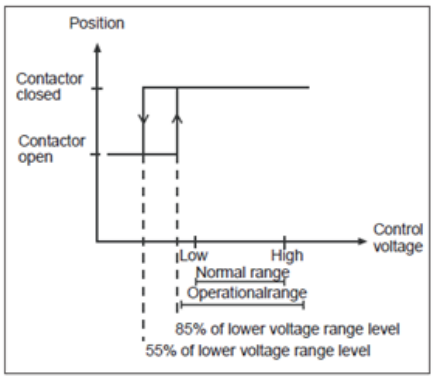
The use of the logic control signals also requires a steady voltage on terminals A1 and A2 within the operational limits. The minimum pulse length for opening and closing is 7 ms. The function of the logic control signals will no longer be guaranteed when the logic on A1 and A2 is removed. The logic control signals operate with 24 V DC and consist of two control signals (ON and OFF_N) and a common reference (COM). To close the contactor, it is sufficient to have a control pulse at ON and to open its removal of voltage from OFF_N.

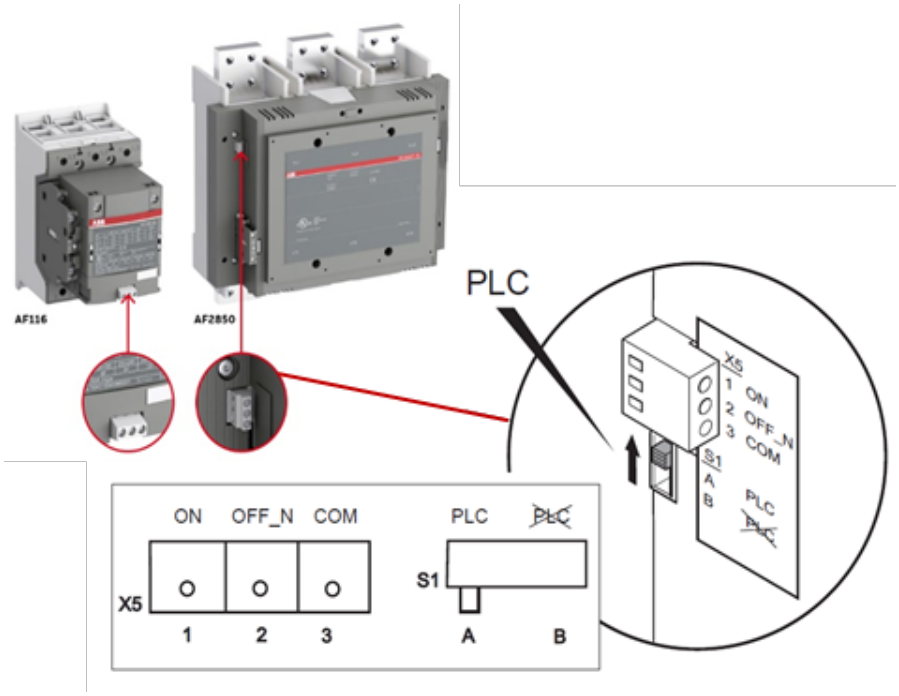


When used with switches the wiring can be done according to diagram above.

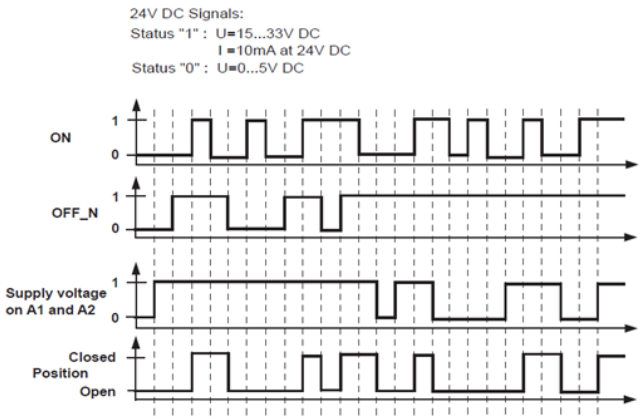


When used with transistor outputs the wiring can be done according to diagram above.





For control with 24 V DC ≥ 10 mA PLC output. The built-in PLC interface operates the 100 ... 250 V AC / DC or 250 ... 500 V AC / DC AF contactor coil. Available for AF contactors from 55 kW - 400 V / 75 hp up to 560 kW - 400 V / 900 hp 480 V and up to 2850 A AC-1 / General use. Dedicated coil code from AF116 up to AF370 and standard feature from AF400 up to AF2850.



The functions are described with the following diagram. "1" means 24 V DC between the control signal and COM, "0" means no voltage between the control signal and COM. The function is made so that ON and OFF_N can be connected in parallel for a common ON/OFF signal. In addition to these signals, the function limits for the supply voltage are still valid (closing at 77% and opening at 55%), which is indicated in the diagram by high and low voltage.

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2.1.5 Protective separation

“Protective separation” or "Safe isolation" of circuits is ensured when a single failure does not result in a voltage from one circuit to another. Errors to be considered are e.g. a bent solder pin, a bent or dissolved conductive part, a broken winding wire, the breakage of a partition within a device or a failed screw.

Protective separation between circuits within equipment is achieved by complying with the basic requirements set out in the regulation IEC / EN 60947-1, Annex N.
The main basic requirements are:

- Double or reinforced insulation
- Protective shield
- Combination of double or reinforced insulation and protective shielding

During the entire expected lifetime, the insulation must be resistant to aging. No safe separation will be required for circuits without safety extra-low voltage or without functional extra-low voltage.

The term protective separation is often closely linked in conjunction with functional extra-low voltage and protective extra-low voltage. The protective separation should reliably prevent the passage of a dangerous voltage to a safe separate voltage (i.e. to a safety extra-low voltage, which is connected or applied in the same device). In case the different voltages are operated on the current paths of a contactor, a "safe separation" must exist!

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2.1.6 Mechanically linked contacts or mirror contacts

Mechanically linked contacts according to IEC / EN 60947-5-1 Annex L

Definitions of mechanically linked elements acc. to IEC 60947-5-1, Annex L. Combination of "n" Make auxiliary contact element(s) and "m" Break auxiliary contact element(s) are designed in such a way that they cannot be in the closed position simultaneously. One control circuit device may have more than one group of mechanically linked contact elements.
All ABB contactor relays (with at least one NC contact) have been tested in accordance with IEC 60947-5-1 and have had positively driven contact elements in the basic unit or in the basic unit in conjunction with auxiliary switches since the product was introduced.

Mirror contacts according to the IEC / EN 60947-4-1 Annex F
Definitions of mirror contact acc. to IEC 60947-4-1, Annex F 2.1. Normally closed auxiliary contact (N.C.) which cannot be in the closed position simultaneously with the normally open (N.O.) main contact.

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2.1.7 Electromagnetic compatibility

The definition for the AF... contactors that comply with IEC / EN 60947-1 and IEC / EN 60947-4-1 standards, are:

Environment A: "Mainly relates to low-voltage non-public or industrial networks/locations/installations (EN 50082-2 article 4) including highly disturbing sources".

Environment B: "Mainly relates to low-voltage public networks (EN 50082-1 article 5) such as residential, commercial and light industrial locations/installations. Highly disturbing sources such as arc welders are not covered by this environment".

Notice for AF09…AF2650 contactors:
- AF09 … AF38 contactors and NF contactor relays (produced since week 08-2013), AF40 ... AF96 contactors have been Designed for environment B.
- AF09 … AF38-..-..-12 contactors and NF..E-12 contactor relays (48...130 V 50/60 Hz-DC), AF116 ... AF2650 contactors: these products have been designed for environment A. The use of this product in environment B may cause unwanted electromagnetic disturbances in which case the user may be required to take adequate mitigation measures.

Note: for 48...130 V 50/60 Hz-DC in environment B, AF09Z … AF38Z-..-..-22 contactor or NFZ..E-22 contactor relays can be selected.

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2.1.8 SEMI F47 compliance

SEMI F47-0706 defines the voltage sag immunity required for semiconductor processing, metrology, and automated test equipment, and on subsystems and components which are used in the construction of semiconductor processing equipment, including but not limited to:
- Power supplies
- Generators
- Robots and factory interface
- Chillers, pumps, blowers
- AC operated contactors and contactor relays

2.2 Terms and ratings

Circuits	**Auxiliary circuit** All the conductive parts of a contactor designed to be inserted in a different circuit from the main circuit and the contactor control circuits. **Control circuit** All the conductive parts of a contactor (other than the main circuit and the auxiliary circuit) used to control the contactor's closing operation or opening operation or both **Main circuit** All the conductive parts of a contactor designed to be inserted in the circuit that it controls
Coil operating range	Expressed as a multiple of the rated control circuit voltage U_c for the lower and upper limits.
Cycle time	This is the sum of the current flow time and the no-current time for the given cycle. **Electrical durability** Number of on-load operating cycles that the contactor is able to carry out. It depends on the operational current, the operational voltage, and the utilization category. **Mechanical durability** Number of no-current operating cycles that a contactor is able to carry out
Endurance / durability	**Electrical endurance** The number of on-load operating cycles (i.e. with the current on the main contacts) a contactor can achieve, varies depending on the utilization category. **Mechanical endurance** The number of off-loading operating cycles (i.e. without current on the main contacts) a contactor can achieve.
Load factor	Ratio of the on-load operating time to the total cycle time x 100 (%).
Inching	Energizing a motor once or repeatedly for short periods to obtain small movements of the driven mechanism.
Intermittent duty	Duty in which the main contacts of a contactor remain closed for periods of time insufficient to allow the contactor to reach thermal equilibrium, the current-carrying periods being separated by off-load periods of sufficient duration to restore equality of temperature with the cooling medium.
Rated breaking capacity; Rated making capacity	Value of RMS current a contactor can break or make at a fixed voltage value, within the conditions specified by the standards, depending on the utilization category.
Rated control circuit voltage U_c	Control voltage value for which the control circuit of the unit is sized.
Rated insulation voltage U_i	Voltage value which designates the unit and to which dielectric tests, clearance, and creepage distances are referred.
Rated impulse withstand voltage U_{imp}	The highest peak value of an impulse voltage of prescribed form 1.2/50, which does not cause breakdown under specified test conditions.
Rated operating current I_e	Current value stated by the manufacturer and considering the rated operating voltage Ue, the rated frequency, the rated duty, the utilization category, the electrical contact life and the type of protective enclosure.
Rated operating voltage U_e	Voltage value to which utilization characteristics of the contactor are referred, i.e. phase to phase voltage in 3 phase circuits.
Conventional thermal current I_{th}	Value of current the contactor can withstand with poles in closed position, in free air for an eight-hour duty, without the temperature rise of its various parts exceeding the limits specified by the standards.
Making and breaking current	Current at contactor closing or at contactor opening.
Resistance to shocks	Requirements applicable for instance to vehicles, crane operation or switchgear slide-in module systems. At the quoted permissible «g» values, contactors must not undergo a change in switching state and overload relays must not trip.
Resistance to vibration	Requirements applicable to all the vehicles, vessels and other similar transport systems. At the quoted amplitude and vibration frequency values, the unit must be capable to achieve the required duty.
Times	**Closing time** Time between energization of the coil until the moment the contacts of the first current path to be closed actually close. **Opening time** Time between de-energization of the coil until the moment when the contacts of the last current path to be opened are open. **Minimal operation time** Shortest control duration to ensure complete closing or opening of a contactor. **Short time current permissible** Value of current which the contactor can withstand in closed position for a short time period and within specified conditions. **Time constant** Ratio of inductance to the resistance: L/R = mH/Ohm = ms. **Cycle duration** Total time of the on-load + off-load period.

2.3 Product range

2.3.1 Contactor for motor control and power switching AF

ABB range of AF contactors is the industry benchmark. The integrated electronically controlled coil offers multiple benefits over conventional alternatives, and together with ABB's wide product range provides optimal configuration every time

AF contactors are available as **3-pole contactors** from 9 A up to 1060 A AC-3 or up to 2850 A AC-1, with AC / DC wide operational voltage range coils.

AF contactors are also available as **4-pole contactors** from 25 A up to 525 A AC-1, with AC operational voltage coils, DC operational voltage range coils or AC / DC wide operational voltage range coils.




AC / DC control supply				Type	AF09	AF12	AF16	AF26	AF30	AF38	AF40	AF52	AF65	AF80	AF96
IEC	AC-3	Rated operational power θ ≤ 60 °C for AF09 ... AF370 θ ≤ 55 °C for AF400 ... AF2650	220 - 230 - 240 V	kW	2.2	3	4	6.5	9	11	11	15	18.5	22	25
			380 - 400 V	kW	4	5.5	7.5	11	15	18.5	18.5	22	30	37	45
			415 V	kW	4	5.5	9	11	15	18.5	22	30	37	45	55
			440 V	kW	4	5.5	9	15	18.5	22	22	30	37	45	55
			500 V	kW	5.5	7.5	9	15	18.5	22	22	30	37	45	55
			690 V	kW	5.5	7.5	9	15	18.5	22	22	30	37	45	55
			1000 V	kW	—	—	—	—	—	—	—	—	—	35	40
		Rated operational current	380 - 400 V	A	9	12	18	26	32	38	40	53	65	80	96
	AC-1	Rated operational current	θ ≤ 40 °C, 690 V	A	25	28	30	45	50	50	70	100	105	125	130

UL / CSA	1-phase motor rating		120 V	hp	0.75	1	1.5	2	2	2	3	3	5	7.5	7.5
			240 V	hp	1.5	2	3	3	5	5	7.5	10	15	15	20
	3-phase motor rating		200 - 208 V	hp	2	3	5	7.5	10	10	10	15	20	25	30
			220 - 240 V	hp	2	3	5	7.5	10	10	15	20	25	30	30
			440 - 480 V	hp	5	7.5	10	15	20	25	30	40	50	60	60
			550 - 600 V	hp	7.5	10	15	20	25	30	40	50	60	75	75
	General use rating		600 V	A	25	28	30	45	50	50	60	80	90	105	115
NEMA	NEMA Size				00	0	—	1	—	—	2	—	—	3	—




AC / DC control supply				Type	AF116	AF140	AF146	AF190	AF205	AF265	AF305	AF370	AF400	AF460
IEC	AC-3	Rated operational power θ ≤ 60 °C for AF09 ... AF370 θ ≤ 55 °C for AF400 ... AF2650	220 - 230 - 240 V	kW	30	37	45	55	55	75	90	110	110	132
			380 - 400 V	kW	55	75	75	90	110	132	160	200	200	250
			415 V	kW	55	75	75	90	110	132	160	200	220	250
			440 V	kW	75	90	90	110	132	160	160	200	220	250
			500 V	kW	75	90	90	110	132	160	200	250	250	315
			690 V	kW	55	75	90	132	160	200	250	315	315	355
			1000 V	kW	—	—	75	110	132	160	185	200	220	280
		Rated operational current	380 - 400 V	A	116	140	146	190	205	265	305	370	400	460
	AC-1	Rated operational current	θ ≤ 40 °C, 690 V	A	160	200	225	275	350	400	500	600	600	700
UL / CSA	1-phase motor rating		120 V	hp	—	—	—	—	—	—	—	—	—	—
			240 V	hp	—	—	—	—	—	—	—	—	—	—
	3-phase motor rating		200 - 208 V	hp	30	40	40	50	60	75	100	125	125	150
			220 - 240 V	hp	40	50	50	60	75	100	125	150	150	200
			440 - 480 V	hp	75	100	100	125	150	200	250	300	350	400
			550 - 600 V	hp	100	125	125	150	200	250	300	350	400	500
	General use rating		600 V	A	160	200	200	250	300	350	400	520	550	650
NEMA	NEMA Size				—	4	—	—	—	5	—	—	—	6


AC / DC control supply				Type	AF580	AF750	AF1250	AF1350	AF1650	AF2050	AF2650	AF2850
IEC	AC-3	Rated operational power θ ≤ 60 °C for AF09 ... AF370 θ ≤ 55 °C for AF400 ... AF2650	220 - 230 - 240 V	kW	160	220	—	257	315	—	—	—
			380 - 400 V	kW	315	400	—	475	560	—	—	—
			415 V	kW	355	425	—	500	630	—	—	—
			440 V	kW	355	450	—	560	710	—	—	—
			500 V	kW	400	520	—	560	710	—	—	—
			690 V	kW	500	600	—	800	1000	—	—	—
			1000 V	kW	355	400	—	—	—	—	—	—
		Rated operational current	380 - 400 V	A	580	750	—	860	1060	—	—	—
	AC-1	Rated operational current	θ ≤ 40 °C, 690 V	A	800	1050	1260	1350	1650	2050	2650	2850
UL / CSA	1-phase motor rating		120 V	hp	—	—	—	—	—	—	—	—
			240 V	hp	—	—	—	—	—	—	—	—
	3-phase motor rating		200 - 208 V	hp	200	250	—	—	—	—	—	—
			220 - 240 V	hp	250	300	—	400	450	—	—	—
			440 - 480 V	hp	500	600	—	800	900	—	—	—
			550 - 600 V	hp	600	700	—	1000	1150	—	—	—
	General use rating		600 V	A	750	900	1210	1350	1650	2100	2700	2850
NEMA	NEMA Size				—	7	—	—	8	—	—	—




IEC	AC-1 rated operational current	θ ≤ 40 °C, 690 V	A	25	30	45	55	70	100	125
UL/CSA	General use rating	600 V	A	25	30	45	55	60	80	105
AC / DC Control supply			Type	AF09	AF16	AF26	AF38	AF40	AF52	AF80
AC Control supply			Type	AF09	AF16	AF26	AF38	AF40	AF52	AF80
DC Control supply			Type	AF09	AF16	AF26	AF38	AF40	AF52	AF80
IEC	AC-1 rated operational current 690 V	θ ≤ 40 °C	A	25	30	45	55	70	100	125
		θ ≤ 60 °C (1)	A	25	30	40	45	60	80	105
		θ ≤ 70 °C	A	22	26	32	37	50	70	90
	With conductor cross sectional area		mm^2	4	6	10	16	35	35	50
	Rated operational voltage U_e max.		V	690	690	690	690	690	690	690

(1) θ ≤ 55 °C for EK550, EK1000 contactors



IEC	AC-1 rated operational current	θ ≤ 40 °C, 690 V	A	160	200	275	350	400	500	525
UL/CSA	General use rating	600 V	A	160	175	230	250	300	350	420
AC / DC Control supply			Type	AF116	AF140	AF190	AF205	AF265	AF305	AF370
AC Control supply			Type	AF116	AF140	AF190	AF205	AF265	AF305	AF370
DC Control supply			Type	AF116	AF140	AF190	AF205	AF265	AF305	AF370
IEC	AC-1 Rated operational current 690 V	θ ≤ 40 °C	A	160	200	275	350	400	500	525
		θ ≤ 60 °C (1)	A	145	175	250	300	350	400	425
		θ ≤ 70 °C	A	130	160	200	240	290	325	350
	With conductor cross sectional area		mm^2	70	95	150	240	240	300	2 x 185
	Rated operational voltage U_e max.		V	690	690	1000	1000	1000	1000	1000

(1) θ ≤ 55 °C for EK550, EK1000 contactors

More information about ABB contactors is easily accessible in ABB´s Download Center (https:/library.abb.com) All Categories > Products > Low Voltage Products and Systems > Control Product > Contactors

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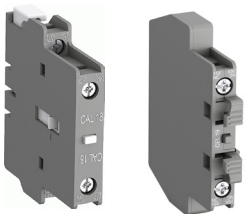
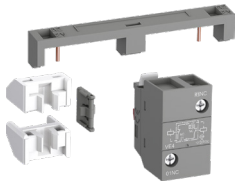
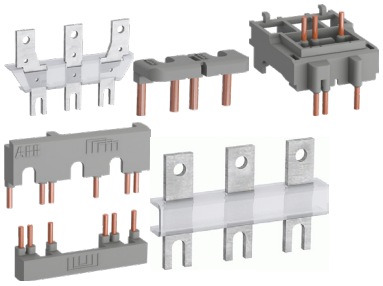
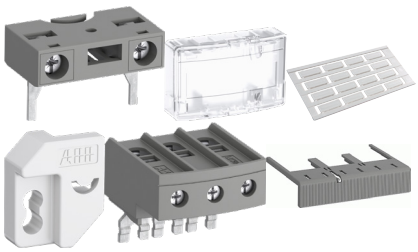
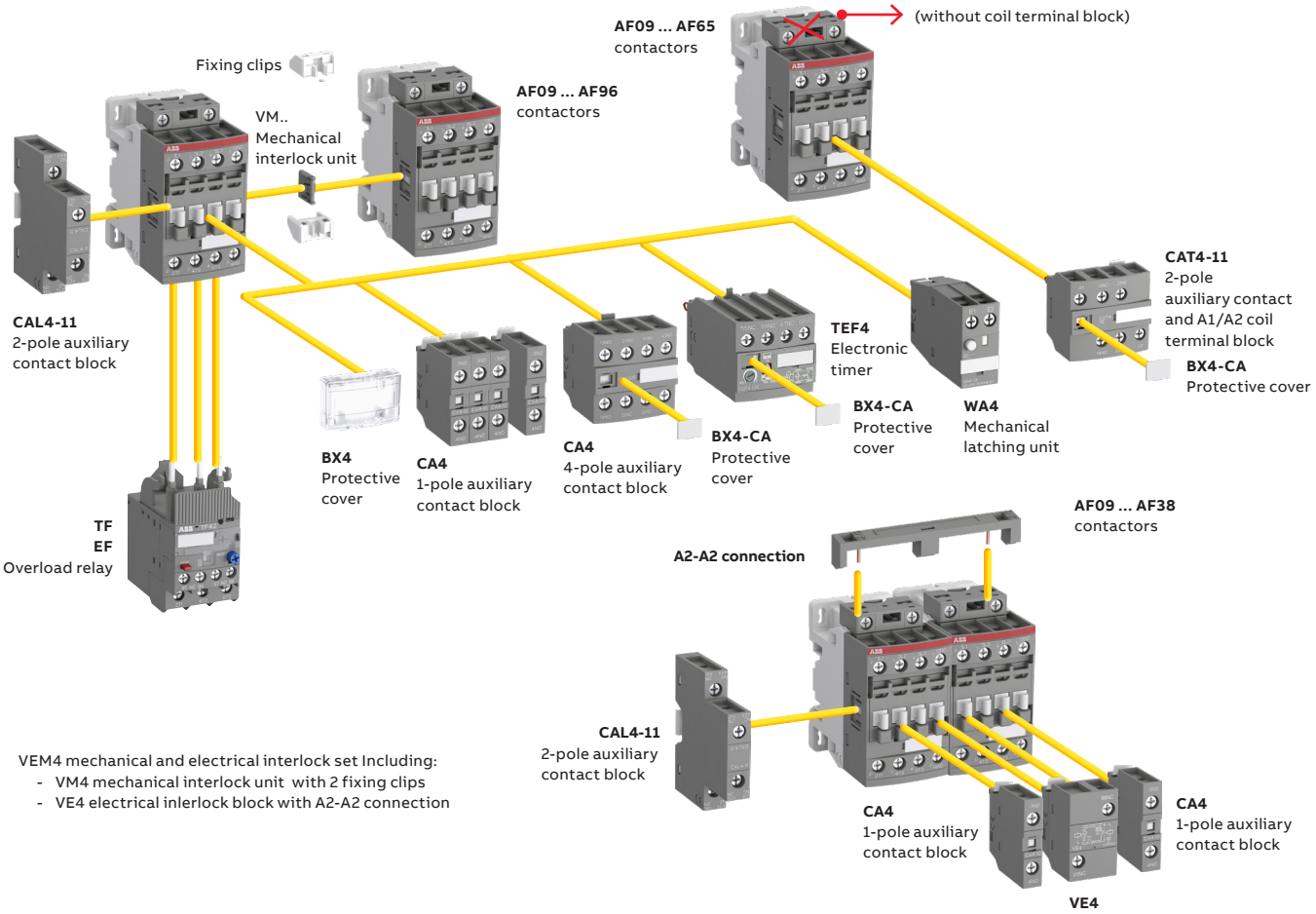
2.3.2 Accessories

Since contactors combine the functions of multiple components, they are offered with many of the same types of accessories. Thus, the contactors can be extended with auxiliary contacts, which can be connected either on the side or - especially space-saving - on the front. Also, an electronic timer is available, and mechanical and electrical interlock sets complement the product range. Compact starter combinations can be easily and quickly built with the aid of separately available direct adapters.

Auxiliary contact blocks for AF09 ... AF96 NF	Auxiliary contact blocks **CA4, CC4, CAT4, CAL** Auxiliary contact blocks with push-in spring terminals **CA4..K, CAL4..K** Auxiliary contact blocks for demanding industrial environments **CE5**	
Auxiliary contact blocks for AF116 ... AF2850	**CAL19**: AF116...AF370 **CAL18**: AF400...AF2850 **CEL19**: AF116...AF370 **CEL18**: AF400...AF2850	
Electronic timers	Electronic timers **TEF4** Electronic timers with spring terminals **TEF4-S**	
Interlocks	Mechanical interlock units **VM** Mechanical and electrical interlock sets **VEM4**, **VEM4K**	
Impulse contact blocks	Impulse contact block **CB5**	
Interface relays	Interface relays **RA4**	
Mechanical latching units	Mechanical latching unit **WA4**	
Connections	Terminal enlargements **LW** Terminal extension **LX** Connection sockets **LL** Terminal connecting strips and shorting bars **LY, LP, LH, LF, LG** Connection accessories for starting solutions **BEA** Connection sets for reversing contactors **BER, BEM** Connection sets for star-delta starter **BEY, BED** Phase-to-phase connection **BEP, BES**	
Other accessories	Additional coil terminal blocks **LDC4, LDC4K** Protective covers **BX4** Function markers **BA** Mounting piece **BP** Additional terminal blocks **LD38** Terminal shrouds **LT**	

Note: for condition of use, please refer to contactor and contactor relay accessory fitting details

Main accessory fitting details for AF09 ... AF96 3-pole contactors



VEM4 mechanical and electrical interlock set Including:
- VM4 mechanical interlock unit with 2 fixing clips
- VE4 electrical inlerlock block with A2-A2 connection

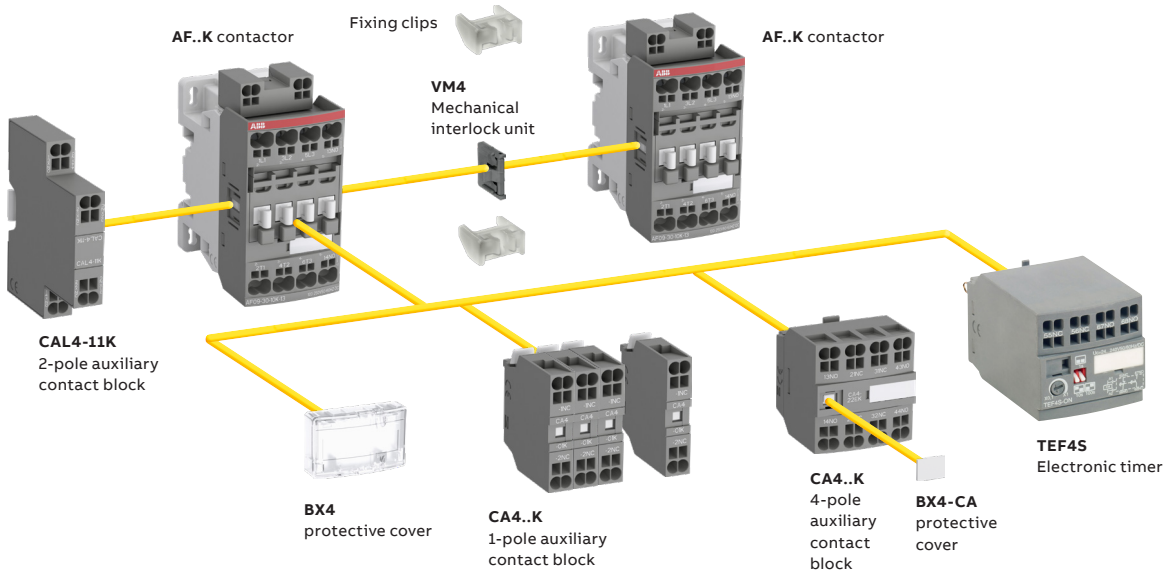
Main accessory fitting details

Many configurations of accessories are possible depending on whether they are front-mounted or side-mounted.

Contactor types	Main poles	Built-in auxiliary contacts	Front-mounted accessories							Side-mounted accessories	
			Auxiliary contact blocks			Electronic timer	Mechanical latching unit	Electrical and mechanical interlock set (between 2 contactors)		Auxiliary contact blocks	
										2-pole CAL4-11	
			1-pole CA4	2-pole CAT4-11	4-pole CA4	TEF4	WA4 (2)	VEM4		Left side	Right side
AF09(Z) ... AF38(Z) (1)											
AF09 ... AF16	3 0	0 1	4 max.	or 1	or 1	or 1	or 1	–	+	1	–
AF09 ... AF16	3 0	1 0	2 max.	or 1	–	or 1	or 1	–	+	1	+ 1
AF26 ... AF38	3 0	0 0	3 max.	–	–	–	–	+ 1 (3)	+	1	or 1
AF09Z ... AF38Z 24 V DC designed for PLC - coil 30 (1)											
AF09Z ... AF16Z	3 0	0 1	4 max.	–	or 1	or 1	–	– (3)	or	1	+ 1
AF09Z ... AF16Z	3 0	1 0	2 max.	–	–	or 1	–	– (3)	+	1	or 1
AF26Z ... AF38Z	3 0	0 0	–	–	–	1	–	–	+	1	+ 1
AF40 ... AF96											
AF40 ... AF65	3 0	0 0	4 max.	or 1	or 1	or 1	or 1	–	+	1	+ 1
AF80, AF96	3 0	0 0	4 max.	–	or 1	or 1	or 1	–	+	1	+ 1

(1) Including add-on and built-in contacts : 4 N.C. auxiliary contacts max on positions 1, 2, 3, 4 and 3 N.C. auxiliary contacts max. on positions 1 ±30°, 5.
(2) Use WA4 for AF09...AF65 and WA4-96 for AF80, AF96.
Accept 1-pole CA4 auxiliary contacts (1 block on each side of the mechanical latch) in respect to the total number of built-in or additional N.C. auxiliary contacts.
For WA4 accessory use with contactor coil 30, please consult your ABB local sales organization.
(3) VEM4 not suitable for AF..Z contactors with DC control voltages 12...20 V DC (coil 20) and 24 V DC (coil 30). Use VM4 side-mounted mechanical interlock unit.

Main accessory fitting details for AF09..K ... AF38..K 3-pole contactors – with push-in spring terminals



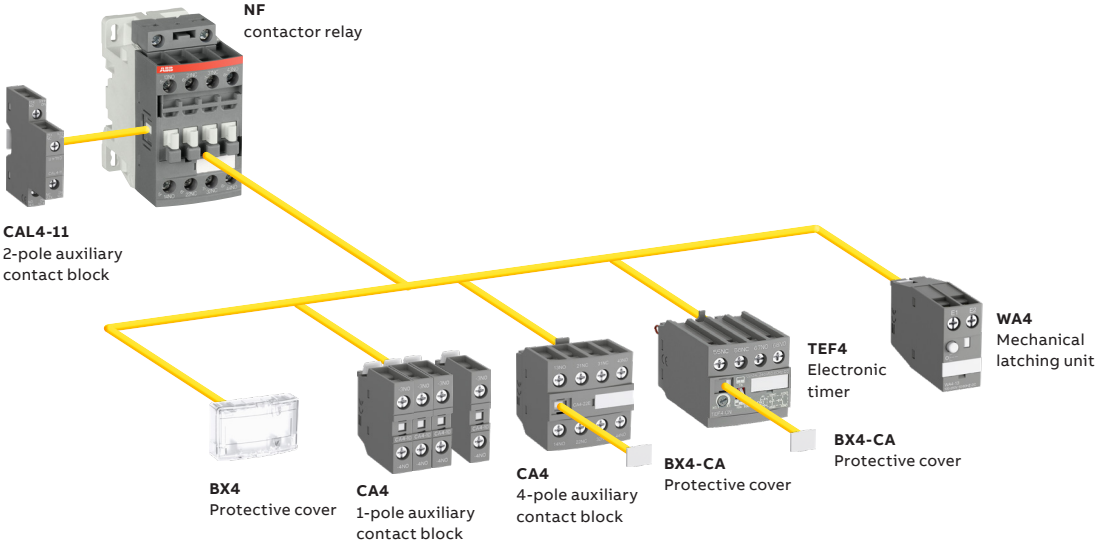
Main accessory fitting details

Many configurations of accessories are possible depending on whether they are front-mounted or side-mounted.

Contactor types	Main poles	Built-in auxiliary contacts		Front-mounted accessories					Side-mounted accessories	
				Auxiliary contact blocks		Electronic timer	Mechanical interlock unit (between 2 contactors)		Auxiliary contact blocks	
									Left side	Right side
				1-pole CA4..K	4-pole CA4..K	TEF4S	VM4		2-pole CAL4-11K	
AF09(Z)..K ... AF38(Z)..K (1)										
AF09..K ... AF16..K	3 0	0	1	4 max.	or 1	or 1	–	+	1	–
AF09..K ... AF16..K	3 0	1	0	2 max.	–	or 1	–	+	1	+ 1
AF26..K ... AF38..K	3 0	0	0	4 max.	or 1	or 1	+ 1	+	1	or 1
AF09Z..K ... AF38Z..K 24 V DC designed for PLC - coil 30 (1)										
AF09Z..K ... AF16Z..K	3 0	0	1	4 max.	or 1	or 1	+ 1	or	1	+ 1
AF09Z..K ... AF16Z..K	3 0	1	0	2 max.	–	or 1	+ 1	+	1	or 1
AF26Z..K ... AF38Z..K	3 0	0	0			1	–	+	1	+ 1

(1) Including add-on and built-in contacts: 4 N.C. auxiliary contacts max. on positions 1, 2, 3, 4 and 3 N.C. auxiliary contacts max. on positions 1 ±30°, 5

Main accessory fitting details for NF 4-pole contactor relays



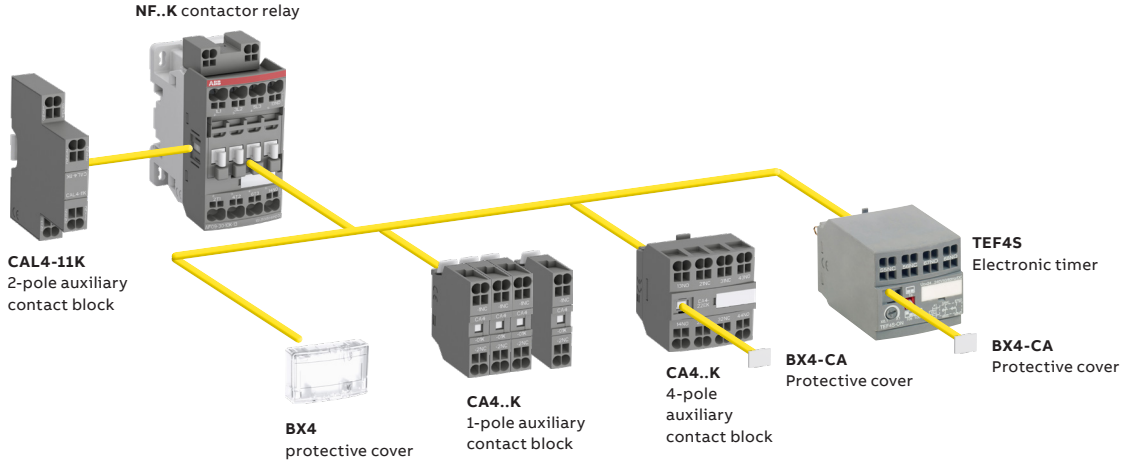
Main accessory fitting details

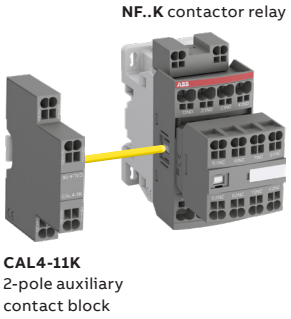
Many configurations of accessories are possible depending on whether they are front-mounted or side-mounted.

Contactor relay types	Main poles			Front-mounted accessories					Side-mounted accessories		
				Auxiliary contact blocks		Electronic timer	Mechanical latching unit		Auxiliary contact blocks 2-pole CAL4-11		
				1-pole CA4	4-pole CA4	TEF4	WA4 (3)		Left side		Right side
NF(Z)											
NF	2 2	E (1)		4 max.	or 1	or 1	or 1	+	1		–
	3 1	E (1)		2 max.	–	or 1	or 1	+	1		+ 1
	4 0	E (2)									
NFZ 24 V DC designed for PLC - coil 30											
NFZ	2 2	E (1)		4 max.	or 1	or 1	–	or	1		+ 1
	3 1	E (1)		2 max.	–	or 1	–	+	1		–
	4 0	E (2)		–	–	1	–	+	1		+ 1

(1) Including add-on contacts: 3 N.C. auxiliary contacts max. on positions 1, 2, 3, 4 and 2 N.C. max. on positions 1 ±30°, 5.
(2) Including add-on contacts: 4 N.C. auxiliary contacts max. on positions 1, 2, 3, 4 and 3 N.C. max. on positions 1 ±30°, 5.
(3) Accept 1-pole CA4 auxiliary contacts (1 block on each side of the mechanical latch) in respect to the total number of additional N.C. auxiliary contacts.
For WA4, accessory use with contactor relays coil 30, please consult your ABB local sales organization.

Main accessory fitting details for NF..K 4-pole contactor relays – with push-in terminals





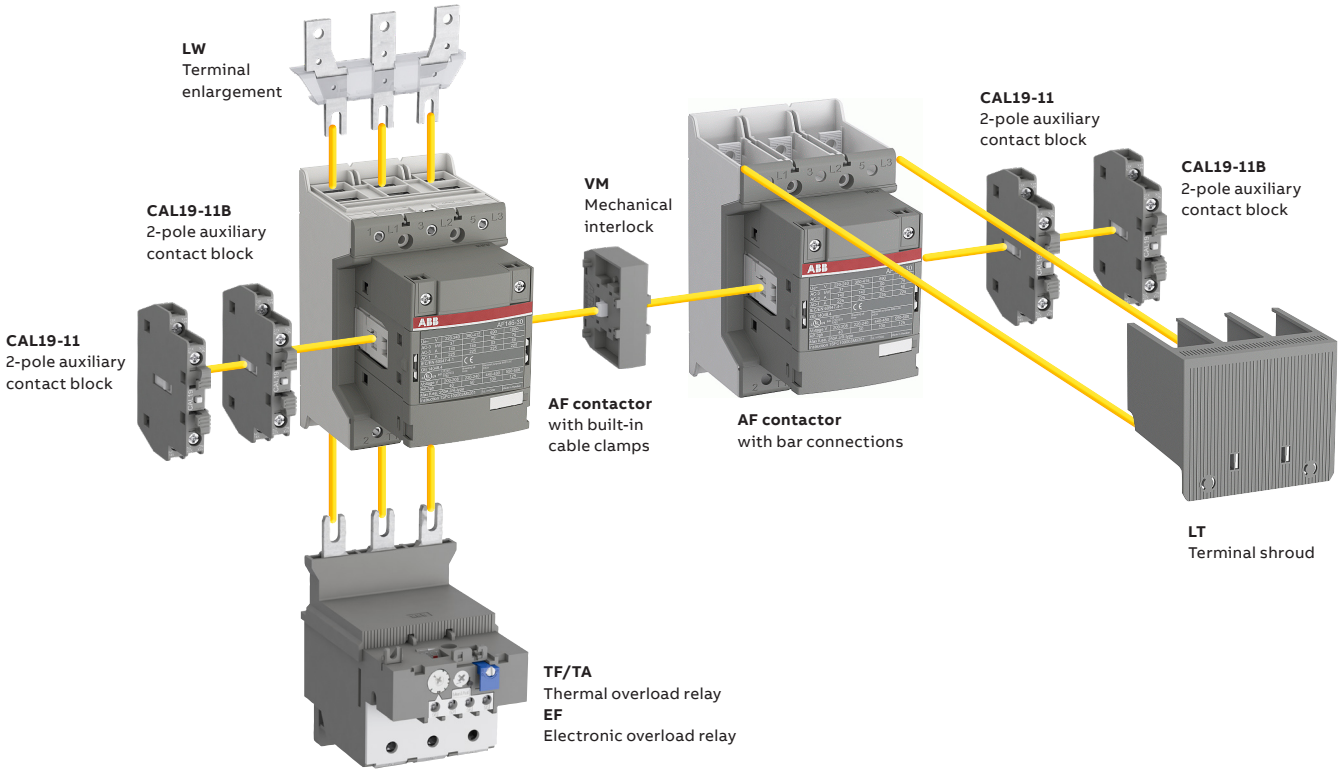
Main accessory fitting details

Many configurations of accessories are possible depending on whether they are front-mounted or side-mounted.

Contactor relay types	Main poles		Front-mounted accessories					Side-mounted accessories	
			Auxiliary contact blocks		Electronic timer			Auxiliary contact blocks 2-pole CAL4-11K	
			1-pole CA4..K	4-pole CA4..K	TEF4S			Left side	Right side
NF(Z)									
NF	2 2	EK (1)	4 max.	or 1	or 1		+	1	-
	3 1	EK (1)	2 max.	-	or 1		+	1	+ 1
	4 0	EK (2)							
NF	4 4	EK	-	-	-	-	+	1	-
	5 3	EK							
	6 2	EK							
	7 1	EK							
	8 0	EK							
NFZ 24 V DC designed for PLC - coil 30									
NFZ	2 2	EK (1)	4 max.	or 1	or 1		or	1	+ 1
	3 1	EK (1)	2 max.	-	or 1		+	1	
	4 0	EK (2)			1		+	1	+ 1
NFZ	4 4	EK	-	-	-			-	-
	5 3	EK							
	6 2	EK							
	7 1	EK							
	8 0	EK							

(1) Including add-on contacts: 3 N.C. max. on positions 1, 2, 3, 4 and 2 N.C. max. on positions 1 ±30°, 5
(2) Including add-on contacts: 4 N.C. max. on positions 1, 2, 3, 4 and 3 N.C. max. on positions 1 ±30°, 5

Main accessory fitting details for AF116 ... AF370 3-pole contactors



Main accessory fitting details

Contactor types	Main poles	Available auxiliary contacts	Side-mounted accessories Auxiliary contact blocks		Mechanical interlock units (between two contactors)
			CAL19-11 (3)	CAL19-11B	
AF116 ... AF370	3 0	0 0	2 x CAL19-11	+ 2 x CAL19-11B	–
AF116 ... AF370	3 0	0 0	2 x CAL19-11 (1)	+ 2 x CAL19-11B (1)	+ VM... (2)

(1) Total number of auxiliary contact blocks for the two contactors.
(2) Interlock type, according to the contactor ratings (see the accessories section).
(3) The CEL19 auxiliary contact blocks can replace the CAL19-11 and CAL19-11B. However, no auxiliary contact block can be mounted outside the CEL19.

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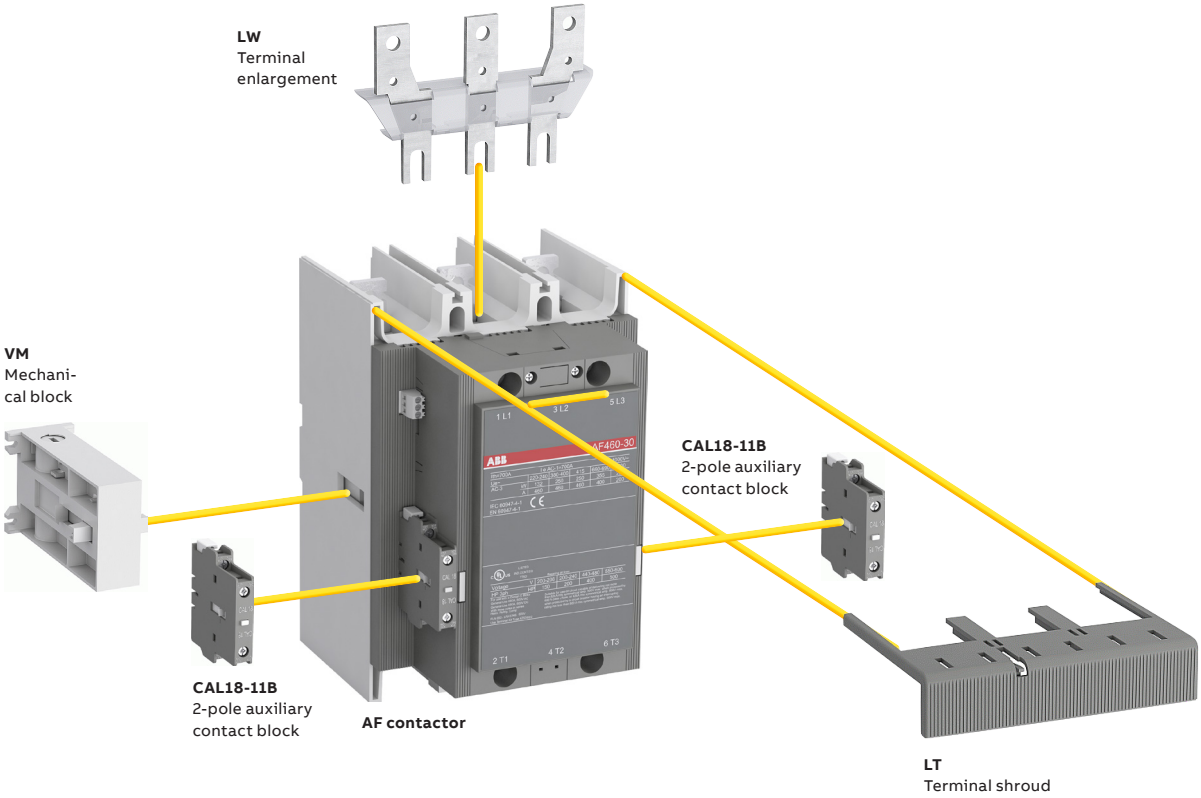
Main accessory fitting details for AF400 ... AF2850 3-pole contactors

Main accessories (other accessories available)



Main accessory fitting details

Contactor types	Main poles	Available auxiliary contacts	Side-mounted accessories Auxiliary contact blocks		Mechanical interlock units (between two contactors)
			CAL18-11	CAL18-11B (3)	
Contactors + auxiliary contact blocks					
AF400 ... AF2850	3 0	1 1	1 x CAL18-11	+ 2 x CAL18-11B	–
Contactors with mechanical interlocking + auxiliary contact blocks					
AF400 ... AF2850	3 0	1 1	2 x CAL18-11 (1)	+ 4 x CAL18-11B (1)	+ VM...H (2)

(1) Total number of auxiliary contact blocks for the two contactors.
(2) Interlock type, according to the contactor ratings (see the accessories section).
(3) The CEL18-.. auxiliary contact blocks can replace the CAL18-11 and CAL18-11B. However, no auxiliary contact block can be mounted outside the CEL18-..

—

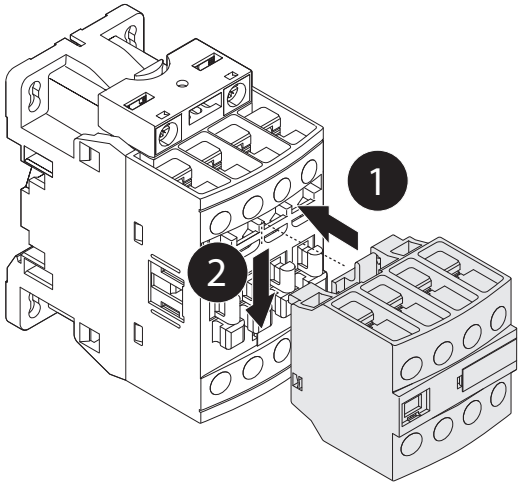
Mounting instructions for accessories for AF09 ... AF96

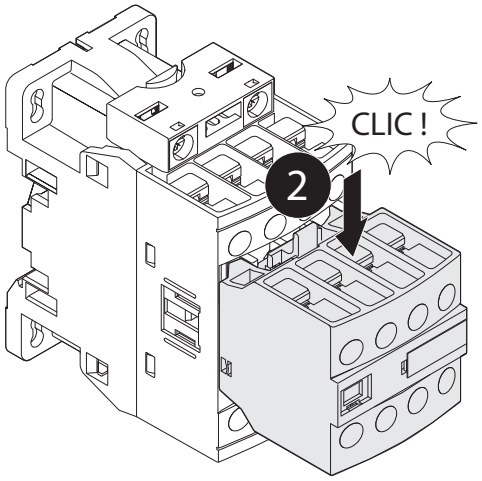
—

Auxiliary contacts

The auxiliary contact blocks are used for the operation of auxiliary circuits for standard industrial environments. Auxiliary contacts are available in various versions as normally open contacts or normally closed contacts. From the designation of the auxiliary contact, it can be seen whether it acts as an NC or NO contact. Types of auxiliary contact blocks for front mounting:

- 1 or 4-pole block, with instantaneous N.O., N.C. contacts [CA4, CA4-K]
- 1-pole block, with N.O. leading contact or N.C. lagging contact [CC4]
- 2-pole block, with instantaneous N.O. + N.C. contacts and A1 / A2 coil terminal connection on front face [CAT4]
- 1-pole block, instantaneous with N.O. contact or N.C. contact, available in 2 IP degrees
  - with built-in microswitch IP40, degree of protection (IP20 on terminals) [CE5-D]
  - with built-in microswitch IP67, degree of protection (IP20 on terminals) [CE5-W]

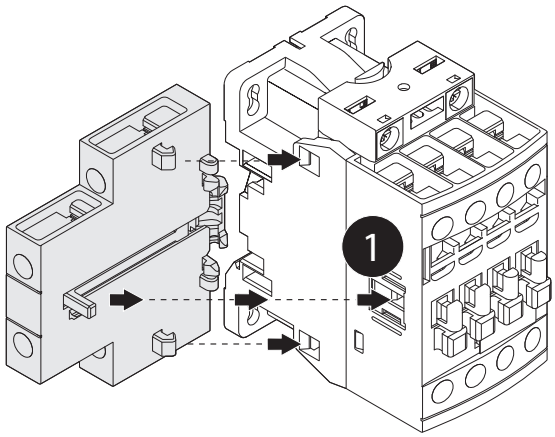


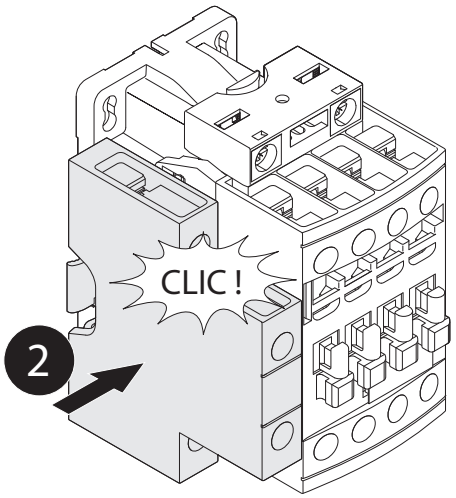


Select the 4-pole auxiliary contact blocks CA4-..E, CA4-..M, CA4-..U or CA4-..N type, according to the contactor or contactor relay type for compliance with the standard requirements

Types of auxiliary contact blocks for side mounting:

- 2-pole block, with instantaneous N.O. + N.C. contacts [CAL4, CAL4-K, CAL18]
- 1-pole block, with built-in microswitch IP67 degree of protection (IP20 on terminals). Instantaneous N.O. or N.C. contact [CEL]



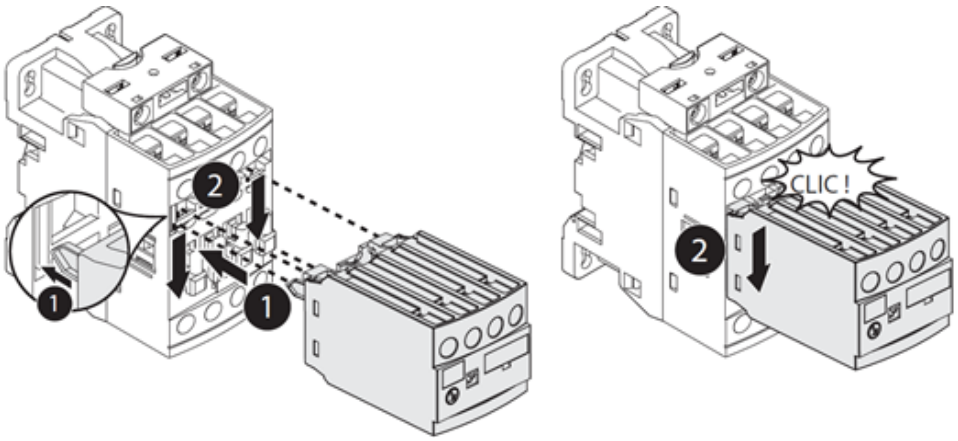


For clipping onto the right- and/or left-hand side of the contactors. The auxiliary contact blocks are equipped with screw-type connecting terminals delivered open, protected against accidental direct contact and bear the corresponding function marking.

—

Electronic timers TEF4

This front-mounted electronic timers are used for realizing timing function and are available in ON-delay and OFF-delay versions. A mechanical indicator allows us to show the state of the contactor. TEF4 electronic timers are supplied by a direct plug-in parallel connection to the coil suppress terminals. A1 - A2 of the contactor or contactor relay. A varistor is integrated on the timer to offer built-in protection against surges in the contactor coil.



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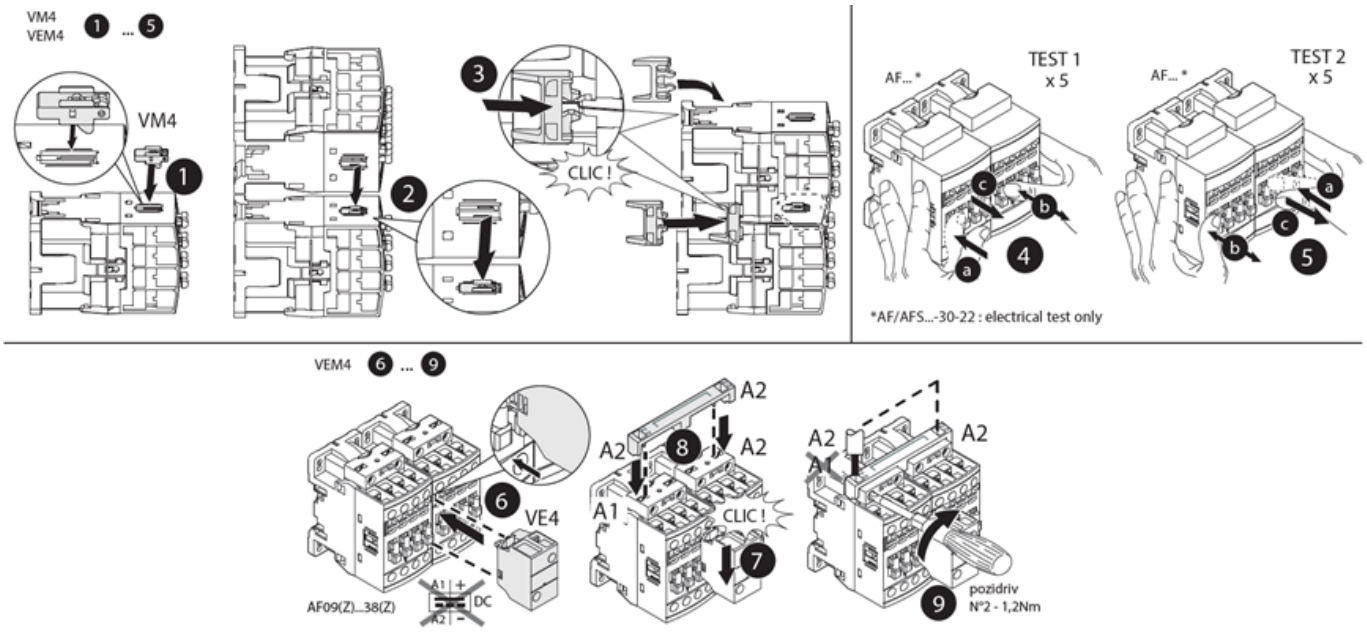
Interlock units

Mechanical interlock units VM4 and VM96-4

The VM mechanical interlock units are designed for the interlocking of two AF contactors. When mounted between two contactors, the VM mechanical interlock unit prevents one of the contactors from closing as long as the other contactor is closed. The mechanical interlock units VM4 and VM96-4 include 2 fixing clips (BB4).

Mechanical and electrical interlock sets VEM4

VEM4 mechanical and electrical interlock set for the interlocking of two AF contactors. VEM4 set includes a mechanical interlock unit VM4 with 2 fixing clips (BB4) and a VE4 electrical interlock block with A2-A2 connection. Fixing the electrical interlock block to the contactor front face connects the 2 built-in N.C. interlocking contacts with the two coils. VE4 block must be used with the A2-A2 connection to correspond to the the electrical connection diagram.



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Impulse contact block CB5

Impulse contact blocks are designed for use in enclosures, in association with an adjustable mechanical pushbutton. Two types are available:

- CB5-10: N.O. contact with a black actuator ("ON" function)
- CB5-01: N.C. contact with a light grey actuator ("OFF" function).

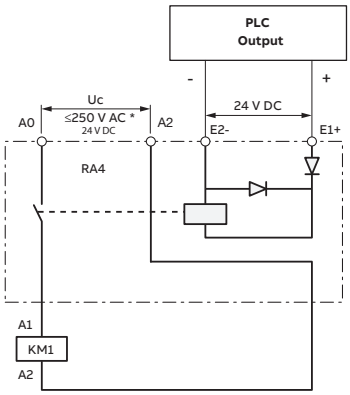
These blocks are equipped with 2 connecting leads 0.5 mm² with end, approximately 18 cm long. Mounting: clipped onto the front face of the contactors, like the front mounting auxiliary contacts (chapter 2.3.2.4).

—

Interface relay RA4

RA4 interface relay is designed to receive 24 V DC signals delivered by PLC's or other sources with a low output power and to restore them with sufficient power to operate the coils of the relevant AF09 ... AF96 contactors or the NF contactor relays. RA4 interface relay is made up of a miniature electromechanical relay equipped with an N.O. contact and with a low consumption 24 V DC coil.

The interface relay coil is controlled by the PLC while the N.O. contact ensures switching of the power contactor.



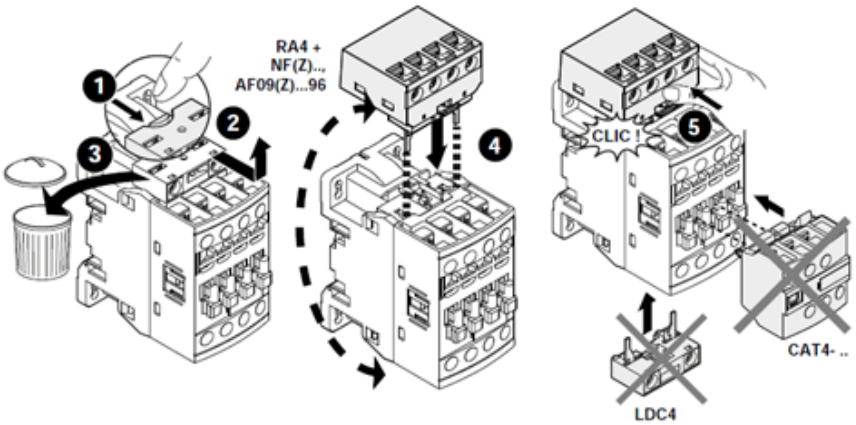
Coil switching gives rise to overvoltages that have adverse effects on the electronic devices, insulators and, more generally, on component lifetime. The RA4 is protected from surge thanks to the built-in surge protection of AF09 ... AF96. Furthermore, the RA4 is protected against relay pole reversal by a diode inserted between the E1 and E2 input terminals.

Connection

The E1+ and E2– input terminals must be connected, according to their polarity, to the PLC output. The RA4 is equipped with two terminal pads for connection to the A1 and A2 terminals of the contactor coil. This coil is supplied between the A0 and A2 terminals of the RA4.

Mounting

Remove the coil terminal block from the contactor and clip the interface relay without any screwing operation.



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Mechanical latching WM4

The WA4 mechanical latching unit for AF09 ... AF96 contactors and NF contactor relays ensures that the contactor or contactor relay remains switched on even if there is a lack of a voltage failure. Standard contactors can be easily converted to compact latched contactors. The WA4 block contains a mechanical latching device with electromagnetic impulse unlatching (AC or DC) or manual unlatching.

Operation

After closing, the contactor continues to be held in the closed position by the latching mechanism should the supply voltage fail at the contactor coil terminals.
Contactor opening can be controlled:

- electrically by an impulse (AC or DC) on the WA4 block coil (the coil is not designed to be permanently energized)
- manually by pressing the pushbutton on the front face of the WA4 block

Mounting

The WA4 block is clipped onto the front face of the 1-stack contactor where it takes up two slots in the central position. The two other slots may accept CA4 single-pole auxiliary contacts (1 block on each side of the mechanical latch).
Additional CAL4 can be fitted on the side of the contactor with respect to the total number of built-in or additional N.O. and N.C. auxiliary contacts as described in the accessory fitting details part of each contactor type.

Connecting links with manual motor starters BEA

The BEA insulated 3-pole connecting links are used to connect AF09 ... AF65 contactors with the MS116 or MS132 or MS165 manual motor starters. The BEA insulated 3-pole connecting links ensure the electrical and mechanical connection between the contactor and the associated manual motor starter. BPR65-4 35 mm rail hooks used with BEA65-4 connecting link, allow direct mounting on 2 rails 35 mm of MS165 manual motor starters with AF40 ... AF65 contactors (for AF<100A BEA bus links are used for connection between contactor and breaker).

Connection sets for reversing contactors BER and BEM

The BER and BEM connection sets are used to connect the main poles of two 3-pole contactors mounted side by side. The BER connection sets are made up of 1 upstream and 1 downstream connection. The BEM connection sets are made up of 3 upstream and 3 downstream connections. BER and BEM connection sets are insulated and made of solid copper bars.

Phase to phase connections BEP and BES

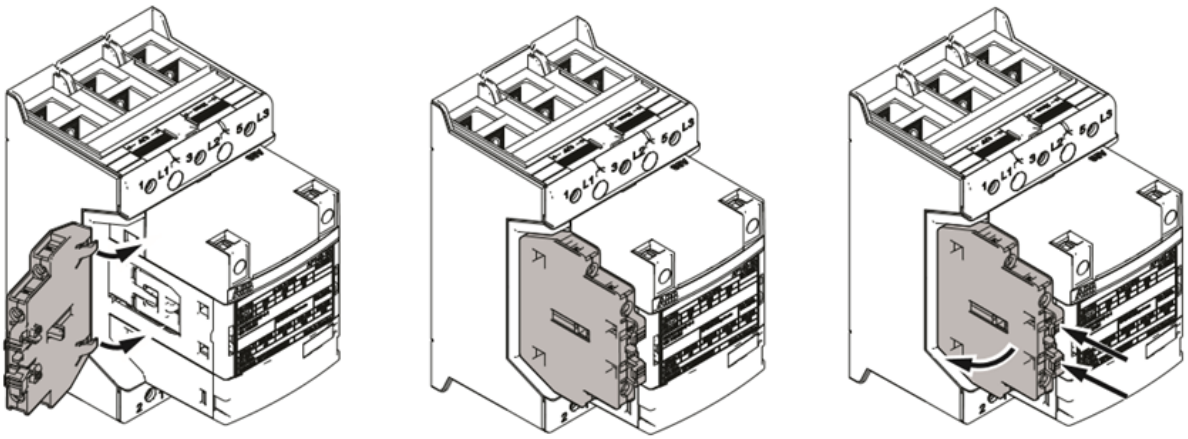
The BEP and BES connection sets are used to connect phase-to-phase the main poles of two contactors mounted side by side. 4-pole contactors will then operate as source reversing contactors. The BEP connection sets are made up of 1 upstream or downstream connections. The BES connection sets are made up of 3 upstream or downstream connections. BEP and BES connection sets are insulated and made of solid copper bars.

—

Mounting instructions for accessories for AF116 ... AF370

Types of auxiliary contact blocks for side mounting:

- 2-pole block, with instantaneous N.O. + N.C. contacts [CEL19-11]
- 1-pole block, with instantaneous N.O. [CEL19-10] or N.C. [CEL19-01] contacts



For clipping onto the right- and/or left-hand side of the contactors. The auxiliary contact blocks are equipped with screw-type connecting terminals delivered open, protected against accidental direct contact and bear the corresponding function marking.

—

Mechanical interlock units VM19

The VM mechanical interlock units are designed for the interlocking of two AF contactors. When mounted between two contactors, the VM mechanical interlock unit prevents one of the contactors from closing as long as the other contactor is closed.

—

Mechanical interlock units for two contactors mounted side by side

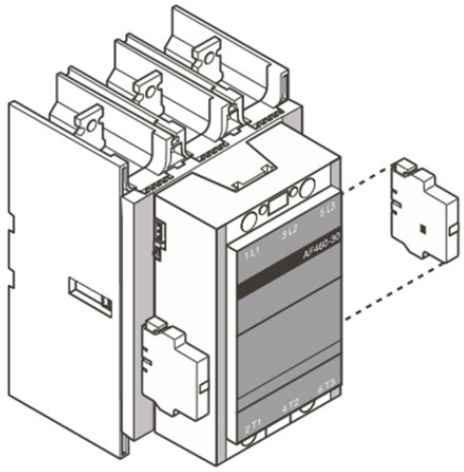
AF116 ... AF146 AF190, AF205 AF265 ... AF370	VM19
AF116 ... AF146 and AF190, AF205	VM140/190
AF190, AF205 and AF265 ... AF370	VM205/265
AF265 ... AF370 and AF400 ... AF460	VM370/400

—

Mounting instructions for accessories for AF400 ... AF2850

Types of auxiliary contact blocks for side mounting:

- 2-pole block, with instantaneous N.O. + N.C. contacts [CAL18-11]



For clipping onto the right- and/or left-hand side of the contactors. The auxiliary contact blocks are equipped with screw-type connecting terminals delivered open, protected against accidental direct contact and bear the corresponding function marking.

—

Mechanical interlock units VM...

The VM mechanical interlock units are designed for the interlocking of two AF contactors. When mounted between two contactors, the VM mechanical interlock unit prevents one of the contactors from closing as long as the other contactor is closed.

—

Mechanical interlock units VM...	
Mechanical interlock units for two contactors mounted side by side	
AF265 ... AF370 and AF400 ... AF460	VM370/400
AF400 ... AF1250	VM750H (PN.. mounting plate to be ordered separately)
AF1350 ... AF2650	VM1650H (Plate included)
Mechanical interlock units for two contactors mounted one above the other	
AF400 ... AF1250	VM750V (Additional plate, not supplied)

—

Connections for AF116 ... 2850

Terminal enlargements LW
Enlargement pieces designed to increase the width of the contactor terminal pads to allow larger connections to be mounted.

Terminal extension LX
Extension pieces designed to extend the main terminals of contactors for combined mounting of contactors and connection sets.

Connection sockets LL
Connection socket can be used to replace built-in cable clamps in AF116 ... AF146.

Connection module LD146
The connection module can be fixed on AF116 ... AF146 delivered with bar terminals.

Terminal connecting strips and shorting bars LY, LP, LH, LF, and LG
Parallel and series connection of 3-pole contactors:
- To obtain a star point (3 parallel-connected poles)
- To connect poles in parallel and thus increase the AC load passing through the flow path made up of the parallel-connected poles: LP, LY, LH, LF, LG. The relevant cable cross-sectional area may limit the maximum permissible current.
- To connect poles in series and thus increase the DC voltage controlled by the poles: LP, LY (only LY16-4 and LY38-4 secable strips).

3 Load types

ABB contactors are not only limited to one application, as they can be used for controlling differed types of loads, such as motors, heaters, lights and so on. The table below shows the main ratings for ABB contactors.

Alternating current main ratings	Direct current main ratings
AC-1: Non-inductive or slightly inductive loads, resistance furnace	DC-1: Non-inductive or slightly inductive loads, resistance furnaces
AC-3: Squirrel-cage motors: starting, switching off motors during running, reversing	DC-3: Shunt motors: starting, plugging, inching, dynamic breaking of DC motors
AC-3e: Squirrel-cage motors with higher locked rotor current: starting, switching off motors during running, reversing	DC-5, Series motors: starting, plugging, inching, dynamic breaking of DC motors
AC-5a: Electric discharge lamps (ballast)	DC-12: Control of resistive loads and static loads with opto-coupler isolation
AC-5b: Incandescent lamps	DC-13: Control of DC electromagnets
	DC-PV3: Carrying full current and switching ON and OFF PV circuit(s) at low current
AC-6a: Transformers	
AC-6b: Capacitor bank switching	
AC-15: Control of electromagnetic loads (>72 VA)	
AC-14: Control of weak electromagnetic loads (≤ 72 VA)	

Table 10: Load types

3.1 General use and heaters

The harmonized utilization category AC-1 covers general and resistive type loads. This includes non-inductive or slightly inductive loads, as well as resistance furnaces and heaters. Additional ratings, such as “Resistance Air Heat-ing” and “CSA Electrical Heating Control”, which require additional electrical cycling, can be performed to further validate control devices for use in heating applications. However, the general use of the AC-1 rating is sufficient for most heating applications.

3.2 Motors

Due to their high inrush peaks, locked rotor currents, and high potential for overheating, motor loads represent one of the most demanding load types. The figures below show an overview of an across-the-line motor start. Starting current is a characteristic of the motor. Starting time is a function of load torque, inertia, and motor torque and is influenced by the motor technology. As the starting current ratio (6-10 x Ie) is higher than the rated operational current Ie, an excessively long starting or breaking period can cause an overload (temperature rise) in the motor. This can create electromechanical stresses or damage the motor’s insulation if it is not properly protected.

There are many different manufacturers on the market, selling at various prices. Not all motors have the same performance and quality as ABB motors. High efficiency enables significant savings in energy costs during the motors normal endurance. In the standard for rotating electrical machines, IEC 60034-30, four different efficiency classes have been defined. The classes are called IE1, IE2, IE3 and IE4, where motors belonging to IE4 are the most efficient ones. See the graph below. A low level of noise is something else that is of interest today, as well as the ability to withstand demanding environments. There are also other parameters that differ. The design of the rotor affects the starting current and torque and there can be very significant variation between different manufacturers for the same power rating.

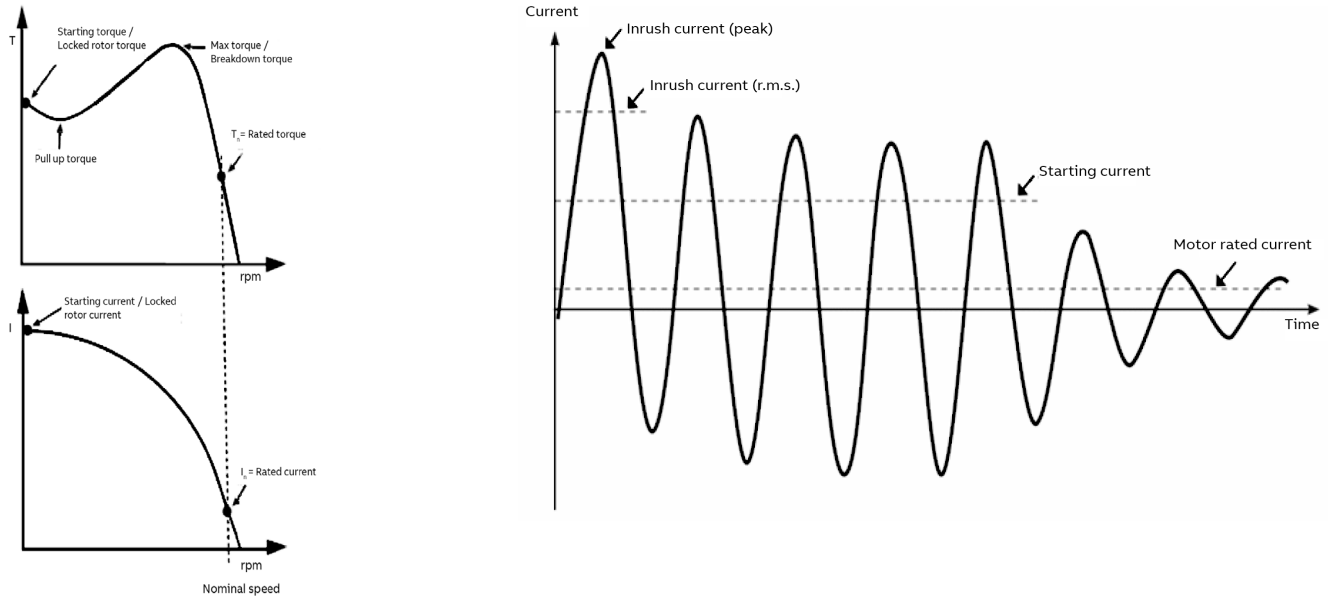


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Figure 12: Different diagrams with the different currents at the start of a motor

—

3.2.1 About motors

Modern electrical motors are available in many different forms, such as single-phase motors, three-phase motors, brake motors, synchronous motors, asynchronous motors, special customized motors, two-speed motors, three-speed motors, and so on, all with their own performance and characteristics. For each type of motor, there are many different mounting arrangements, for example, foot mounting, flange mounting or combined foot and flange mounting.

The cooling method can also differ a great deal, from the simplest motor with free self-circulation of air to a more complex motor with totally enclosed air-water cooling with an interchangeable cassette type of cooler.

To ensure a long life for the motor, it is important to select it with the correct degree of protection when operating under heavy-duty conditions in a severe environment.

The letters IP (International Protection) state the degree of protection followed by two digits, the first of which indicates the degree of protection against contact and penetration of solid objects, whereas the second states the motors degree of protection against water.

The end of the motor is defined in the IEC standard as follows:
- The D-end is normally the drive end of the motor
- The N-end is normally the non-drive end of the motor

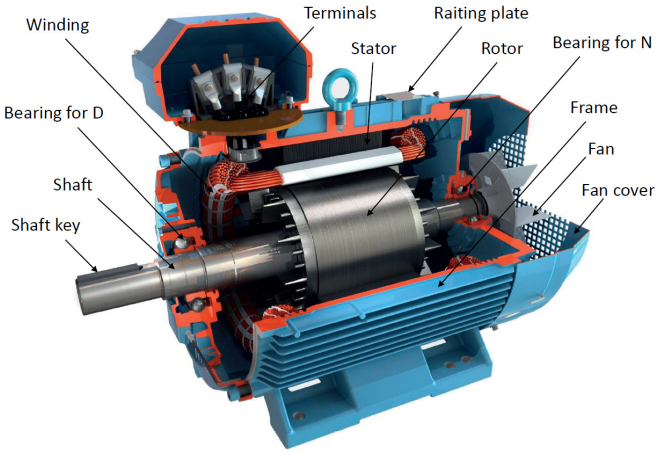

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Figure 13: Interior view of a motor with all components

3.2.2 Squirrel cage motors

The squirrel cage motor is the most common type on the market. It is relatively cheap and maintenance costs are usually low. There are many different manufacturers represented on the market, selling at various prices. Not all motors have the same performance and quality as motors from ABB.

The starting current of motors is a characteristic of the motor. The starting time is a function of load torque, inertia, and motor torque and is influenced by the motor technology. As the starting current (6-8 x Ie) is always much higher than the rated operational current: an excessively long starting or braking period will cause an overload (temperature rise) in the motor. This could cause electromechanical stresses or damage the motor's isolation.

The lifetime of an electrical engine is linked to the temperature stress. As a rough guide, the lifetime of the winding isolation reduces by half each time the temperature exceeds 10°C. Even slight temperature increases can decrease the lifetime of an electrical engine significantly.

3.2.3 International motor efficiency standards and regulations

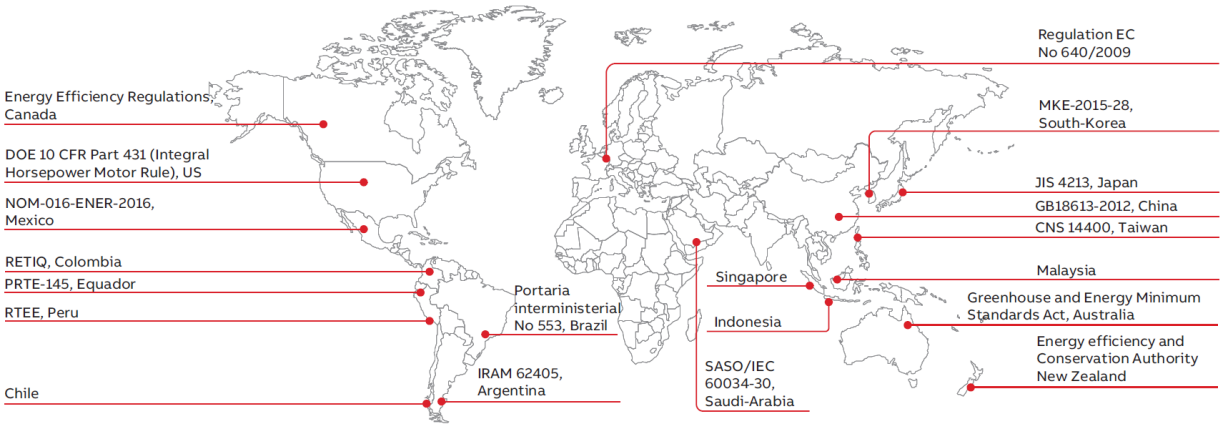

Figure 14: International motor efficiency standards and regulations

Since the validation of IEC 60034-30:2008 and its refined version IEC 60034-30-1:2014, a worldwide energy efficiency classification system has existed for low voltage three-phase asynchronous motors. These international standards have been created to enable and increase harmonization in efficiency regulations around the world and to also cover motors for explosive atmospheres.

IEC 60034-30-1:2014 defines International Efficiency (IE) classes for single-speed, three-phase, 50 Hz and 60 Hz induction motors. The efficiency levels defined in IEC 60034-30-1 are based on the test method specified in IEC 60034-2-1:2014. Both standards are part of an effort to unify motor testing procedures with CSA390-10 and IEEE 112 standards as well as efficiency and product labeling (IE) requirements to enable motor purchasers worldwide to easily recognize premium efficiency products.

To promote transparency in the market, IEC 60034-30-1 states that both the efficiency class and efficiency value must be shown on the motor rating plate and in product documentation. The documentation must clearly indicate the efficiency testing method used as different methods can produce differing results.

Minimum energy performance standards

While the IEC as an international standardization organization sets guidelines for motor testing and efficiency classes, the organization does not regulate efficiency levels in countries. The biggest drivers for mandatory Minimum Energy Performance Standard (MEPS) levels for electric motors are global climate change, government targets to curb CO2 emissions and rising electricity demand, especially in developing countries. The whole value chain, from manufacturer to end user, must be aware of the legislation in order to meet local re¬quirements, to save energy and reduce the carbon footprint.

Harmonized global standards and the increasing adoption of MEPS around the world are good news for all of us. However, it is important to remember that harmonization is an ongoing process. Even though MEPS are already in effect in several regions and countries, they are evolving and differ in terms of scope and requirements. At the same time, more countries are planning to adopt their own MEPS regulations. A view of existing and future MEPS regulations worldwide can be seen on the world map above.

—

IEC 60034-30-1:2014

This standard defines four International Efficiency (IE) classes for single speed electric motors that are rated according to IEC 60034-1 or IEC 60079-0 (explosive atmospheres) and designed for operation on sinusoidal voltage.

- IE4 = Super premium efficiency
- IE3 = Premium efficiency
- IE2 = High efficiency
- IE1 = Standard efficiency

IEC 60034-30-1 covers the power range from 0,12 kW up to 1000 kW. Most of the different technical constructions of electric motors are covered as long as they are rated for direct online operation.
The coverage of the standard includes:

- Single-speed electric motors (single and three-phase), 50 and 60 Hz
- 2, 4, 6 and 8 poles
- Rated output PN from 0.12 kW to 1000 kW
- Rated voltage UN above 50 V AC up to 1 kV
- Motors capable of continuous operation at their rated power with a temperature rise within the specified insulation temperature class
- Motors, marked with any ambient temperature within the range of -20 °C to +60 °C
- Motors, marked with an altitude up to 4000 m above sea level

By comparing IEC 60034-30-1 to CSA C390-10:2015 and “10CFR431 Subpart B – Electric motors”, it can be seen that the efficiency limits and tables are well aligned, and their major difference is in the scope of the output power where CSA and 10CFR431 have a maximum power of 500 hp. There are also some minor differences in the scope of excluded motors.

—

The following motors are excluded from IEC 60034-30-1:

- Single-speed motors with 10 or more poles or multi-speed motors
- Motors completely integrated into a machine (for example pump, fan or compressor) that cannot be tested separately from the machine
- Brake motors, when the brake cannot be dismantled or separately fed

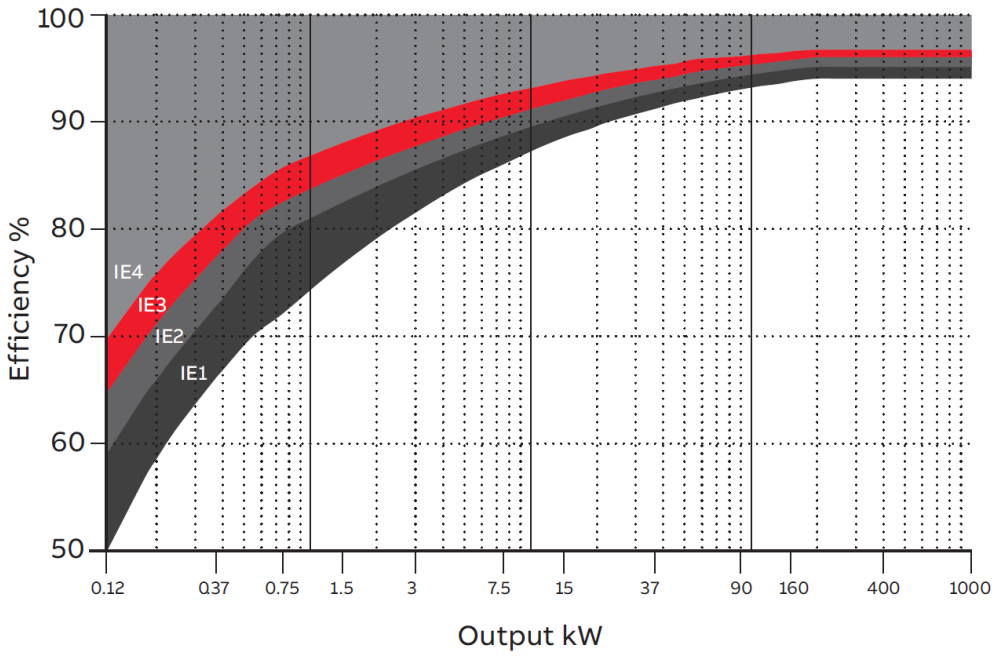

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Figure 15: Overview of the nominal efficiency limits defined in IEC 60034-30-1. Note: A detailed overview of the nomnal efficiency limits defined in IEC 60034-30-1 you will find in chapter: 9. Appendix

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ABB and efficiency standards

ABB determines efficiency values according to IEC 60034-2-1 using the low uncertainty method (i.e. summation of losses), with additional load losses determined by the method of residual loss.
It is good to mention and emphasize that the IEC 60034-2-1 test method, which is known as an indirect method, is technically equivalent to the test methods in the standards CSA 390-10 and IEEE 112 Method B leading to the equivalent losses and thus efficiency values.

As the world market leader, ABB offers the largest range of LV motors available. It has long advocated the need for efficiency in motors, and high-efficiency products have formed the core of its portfolio for many years. The core of ABB's process performance range is based on a full range of IE2 and IE3 motors, with many available from stock. We also supply IE4 motors for additional energy savings.

—

Motors to NEMA Premium

NEMA Premium® Motors program for the North American market must comply with the EISA 2007 energy efficiency standards. Since December 2010, the engines must meet the NEMA Premium Efficient standard. These requirements are similar to the IE3 requirement. The technical requirements for motors for the North American market are described in NEMA MG-1.

—

What distinguishes an IE3/IE4 motor from motors with lower efficiency?

The IE3 motors are able to reach higher efficiency thanks to innovative designs and the use of better conducting material. The design, giving higher efficiency will ultimately show a lower-rated motor current for any given kW rating. However, during the starting phase of the motor, there may be an increase of inrush and starting current. The increased inrush and starting current can in some cases affect the selection of the starter components as well as the short-circuit protection device.

If a motor is directly connected to the line the current will be drawn very high in the start-up, which is mostly reactive. The line in the following figure it shows a typical starting RMS current curve for an IE3 motor in a direct online connection.
In general, the motor draws current in three steps:

- Shortly after starting, during the first 20 ms to 30 ms: I_{peak} a high peak current (inrush)
- Between inrush and 0,5 s to 10 s (depending on rated power and inertia), a steady-state current I_d. This current remains constant as long as the rotor just starts revolving; its duration depends on the motor load and design
- After 0.5 s to 10 s: the rotor accelerates and reaches its final speed. The current stabilizes to reach the motor's rated current I_n at full load

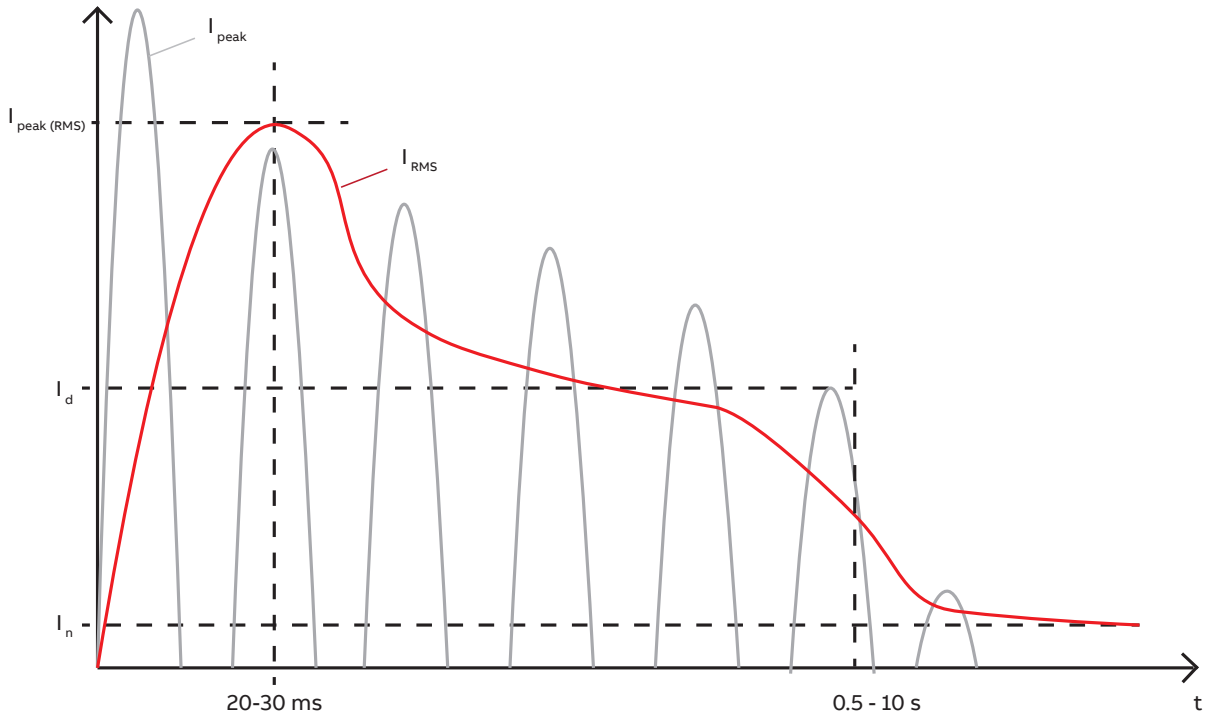

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Figure 16: Diagram with the current at the start of a IE3 motor

To be able to offer the best possible starter solutions, ABB performed many tests on different motors, to learn what are the relevant data when starting these motors, taking also into consideration the findings of ABB's own motor manufacturing. The tests and analyzes clearly show that Premium Efficiency motors (IE3 motors) in general will draw a higher starting current than IE1 and IE2 motors. The estimation is a 15 % higher starting current compared to IE2 motors.

Once the IE3 motor reaches the full speed, the rated motor current is lower for the same load conditions, because of the higher efficiency and the wanted energy saving.

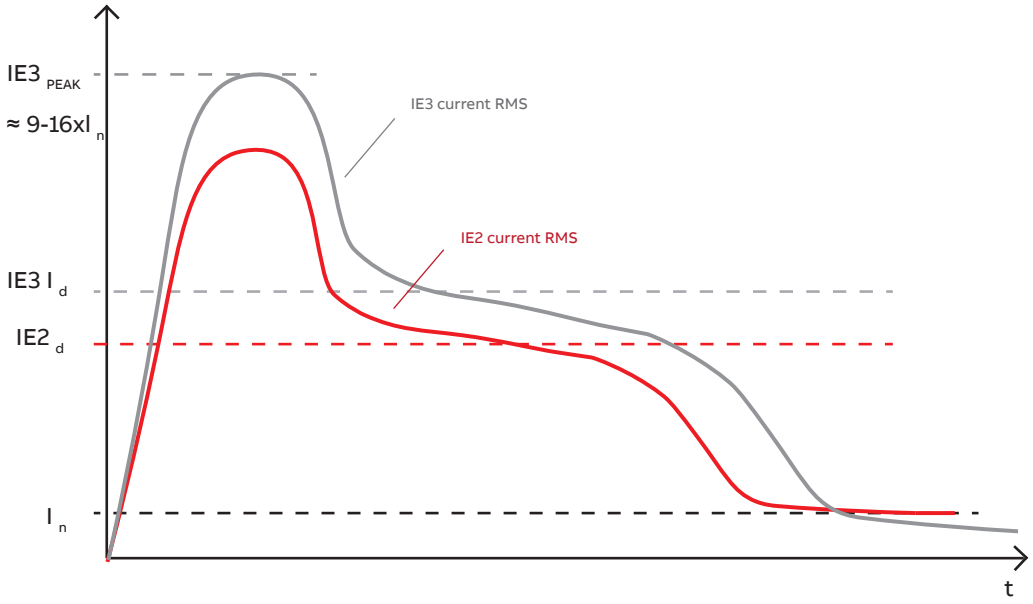


Figure 17: Diagram with the different of the current by an IE3/IE2 motor

3.2.4 Rating plate of a motor

The rating plate details on a motor provide the user information relating to the construction and performance characteristics. On the rating plate, it is necessary to indicate the IE code and nominal efficiency of the motor at full load 100 %, 3/4 load 75 % and 1/2 load 50 %, as required by IEC 60034-30-1.
Here an example of a rating plate:

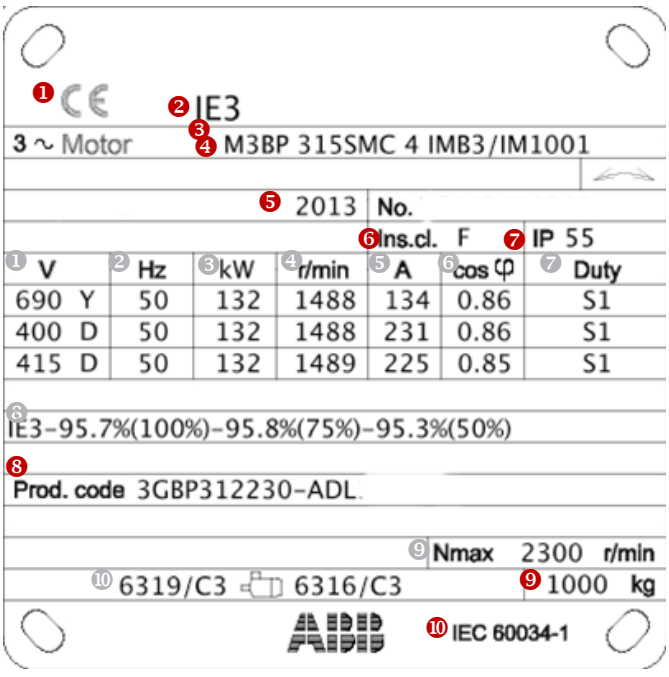


Figure 18: Rating plate of a ABB motor

Basic information

1. Certification label
2. Efficiency Code – IE
3. Number of phases
4. ABB motor type
5. Manufacturing date
6. Insulation class
7. Degree of protection
8. Product code
9. Motor weight
10. IEC Standard

In-/output information

1. Rated operating voltage
2. Frequency
3. Motor rated power
4. Full load speed
5. Rated operating current
6. Power factor
7. Service factor
8. Partial load efficiencies
9. Rotation speed
10. Drive end bearing type and amount of grease (where applicable) and non-drive end bearing type and amount of grease (where applicable)

3.2.5 Voltage

Three-phase single speed motors can normally be connected for two different voltage levels. The three stator windings are connected in star (Y) or delta (D). If the rating plate on a squirrel cage motor indicates voltages for both the star and delta connection, it is possible to use the motor for both 230 V AC, and 400 V AC as an example.

The winding is delta connected at 230 V AC and if the main voltage is 400 V AC the star connection is used.
When changing the main voltage, it is important to remember that for the same power rating the rated motor current will change depending on the voltage level. The method for connecting the motor to the terminal blocks for star or delta connection is shown in the picture below.

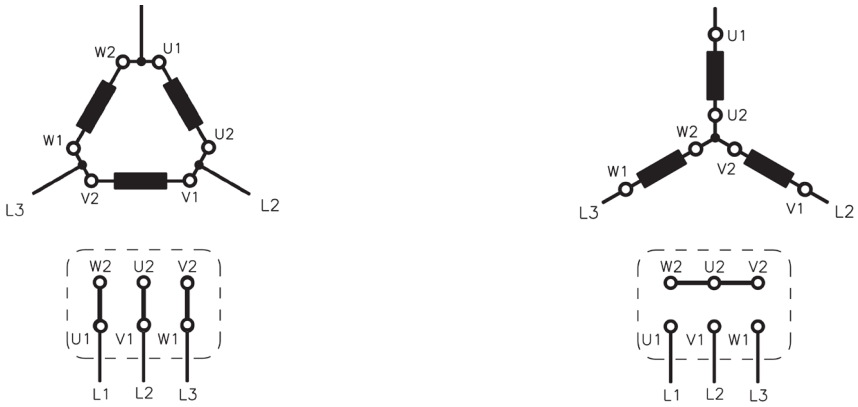


Figure 19: Voltage connection at the motor

3.2.6 Current

The rated current of the motor, which can be found on the motor nameplate, is the current used by the motor when fully loaded and while up at full speed. An unloaded motor will use far less current and an overloaded motor will use more current. During direct on-line start, the current used by the motor is far higher than the rated current though.

Usually between 6 to 8 times the rated current (for IE2 motors), but it can be more than 10 times the rated current. This can be clearly seen in a speed-current diagram for the motor. As the motor accelerates, the current will drop and when reaching the rated speed, the current will have dropped to the rated current.

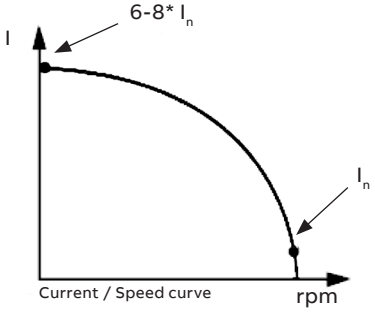


Figure 20: Diagram of the current vs. speed

The required increase in efficiency of the IE3 motors is usually achieved by lower-rated currents of the motors. In the small power ranges, the required increase in efficiency is greater, so that the deviation of the rated current is greater there. The higher the power, the lower the deviation of the rated currents compared to IE1 / IE2 motors.

Increasing starting current conditions
The starting current conditions (ratio of starting current to rated current, steady state, stalled rotor) increase with increasing IE class.

Amplitude of inrush current
The amplitude of inrush current from IE1 to IE2 and IE3 / IE4 depends on the following factors in the respective application:
- Structure of the motor
- Network conditions (in particular the size of the short-circuit power of the transformer and thus the voltage stability)
- Length and routing of motor cables
- Switch-on phase position in the respective phase

3.2.7 Power factor

A motor always consumes active power, which it converts into mechanical action. Reactive power is also required for the magnetization of the motor, but it doesn´t perform any action. In the diagram below the active and reactive power is represented by P and Q, which together give the apparent power S.

The ratio between the active power P (kW) and the apparent power S (kVA) is known as the power factor and is often designated as the cos **φ**. A normal value is between 0.7 and 0.9. When running, where the lower value is for small or low loaded motors and the higher for large ones.

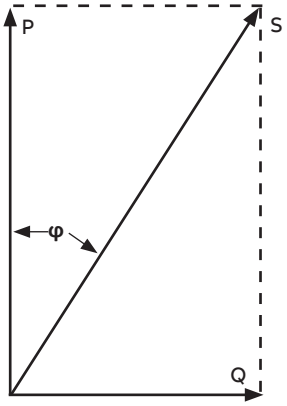


Figure 21: Diagram indicating P, Q, S and cos φ

3.2.8 Torque

The starting torque for a motor differs significantly depending on the size of the motor. A small motor, e.g. ≤ 30 kW, normally has a value of between 1.5 and 2.5 times the rated torque, and for a medium-size motor, for example up to 250 kW, a typical value is between 2 to 3 times the rated torque. Very large motors tend to have a very low starting torque, sometimes even lower than the rated torque. It is not possible to start such a motor fully loaded, not even through direct online starting.

T_n = Rated torque (Nm)
P_r = Rated motor power (kW)
n_r = Rated motor speed (rpm)

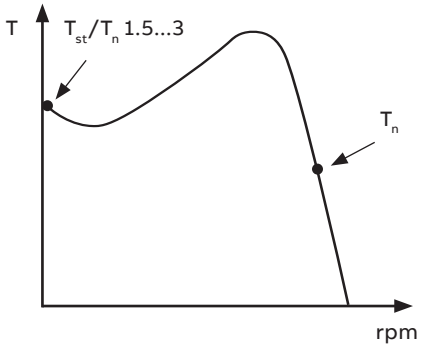


Figure 22: Diagram of torque vs. speed

Different load conditions
All motors are used for starting and running different applications. These different applications will result in different load conditions for the motor. This is a direct braking force on the motor shaft. To be able to accelerate, the motor must be stronger than the load. The accelerating torque is the difference between the available motor torque and the load torque. Many starting methods will reduce the torque of the motor and thereby reducing the accelerating torque which will give a longer starting time. Accelerating torque = available motor torque – braking load torque. The load curve can have different characteristics depending on the application. Some of the common load types can be seen below.

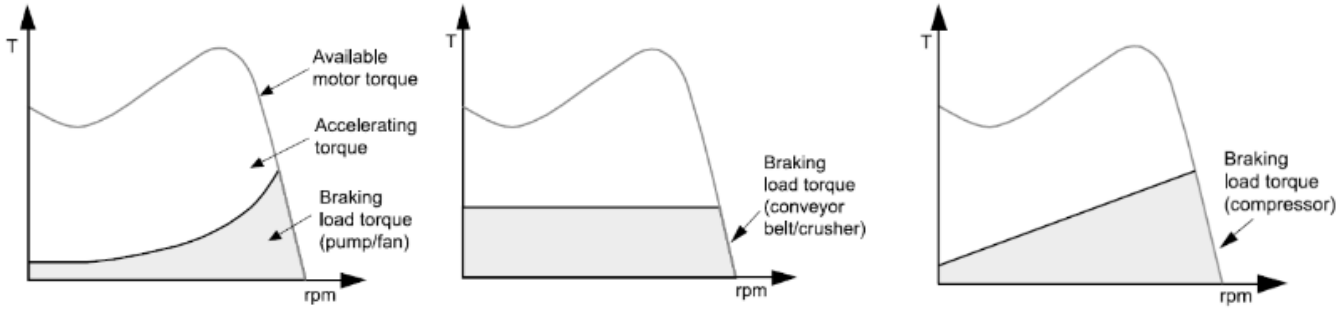


Figure 23: Diagram of the torque vs. speed by different load conditions

Many applications are usually started unloaded, and the load is applied first when the motor has reached the rated speed. This will reduce the load torque to about 10 to 50% of the load torque of a loaded start.

Contactors are well suited for both the control motors, including high-efficiency types. Since the tests for IEC utilization category AC-3 and UL/CSA “AC Motor” have yet to be fully harmonized, contactors carry both ratings to ensure international acceptability.

For additional information regarding IE3 high-efficiency motors for Europe, please click the “Info on IE3 Motors” link in the Selected Optimized Coordination (SOC) selection tool (http://applications.it.abb.com/SOC/page/selection.aspx).

3.3 Hermetic refrigerant compressor motors

A hermetic refrigerant compressor motor is a combination of a compressor and a motor, both of which are enclosed in the same housing, with no external shaft or shaft seals, with the motor operating in refrigerant. These motors are commonly used in air-conditioning and refrigeration equipment. Two harmonized utilization categories exist for these types of loads: AC-8a and AC-8b. AC-8b is an additional test accompanying AC-8a and is referred to as a “recycle rating”, which covers applications where overload releases are automatically reset. For control can be used as the AF contactors.

3.4 DC switching applications

DC-1, DC-3, DC-5, DC-PV3 applications according to IEC 60947-4-1
The circuit switching on DC is more difficult than on AC, as alternating current goes to zero according to the frequency of the supply source while DC current has a continuous value.

3.4.1 General

The arc switching on DC is more difficult than on AC, due to no zero-crossing.

- It is essential to determine the current, the voltage and the L/R time constant of the controlled load
- For information, typical time constant values are quoted hereafter: non-inductive loads such as resistance furnaces (L/R ≈ 1 ms), inductive loads such as shunt motors (L/R ≈ 2 ms) or series motors (L/R ≈ 7.5 ms)
- The addition of a resistor in parallel with an inductive winding helps in the elimination of the arcs

—

3.4.2 Time constant and utilization categories

In DC applications, the nature of load to switch (resistor, inductance or a combination) is characterized by the ratio of the inductance to the resistance (L (inductance of operated circuit) / R (resistance of operated circuit) = mH/Ω = ms). This ratio L/R is called the time constant of the circuit.

DC current utilization categories are defined according to IEC 60947-4-1:

- DC-1 non-inductive or slightly inductive loads, resistance furnaces ($L/R \leq 1$ ms)
- DC-3 shunt motors: starting, plugging, inching, dynamic breaking of DC motors ($L/R \leq 2$ ms)
- DC-5 series motors: starting, plugging, inching, dynamic breaking of DC motors ($L/R \leq 7.5$ ms)

The higher the time constant value is, the more difficult it is to break the arc. The addition of a resistor in parallel with an inductive winding helps in the elimination of the arcs, by reducing the time constant.

—

3.4.3 Operational voltage

- The higher the operating voltage value is, the more difficult it is to break the arc
- The use of main poles connected in series will allow to increase the value of switched voltage

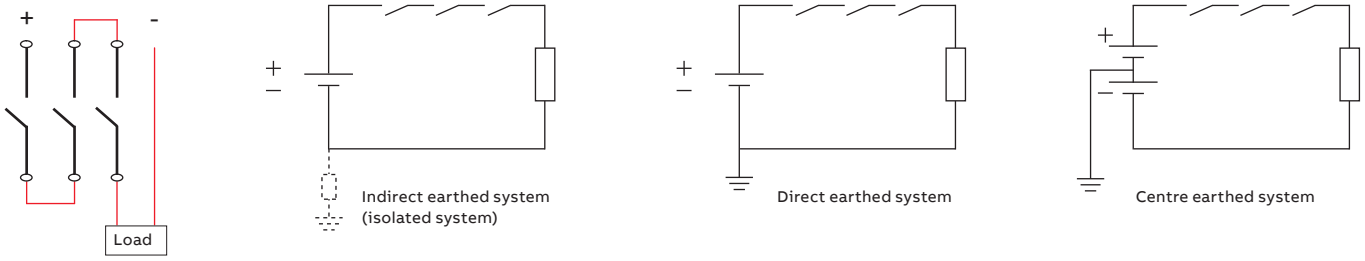
However, the maximum switched voltage must be within the maximum operational voltage of the contactor. All the poles required for breaking must be connected in series between the load and the source polarity not linked to the earth (or chassis) (see recommended connection diagrams).

—

3.4.4 Connection diagrams

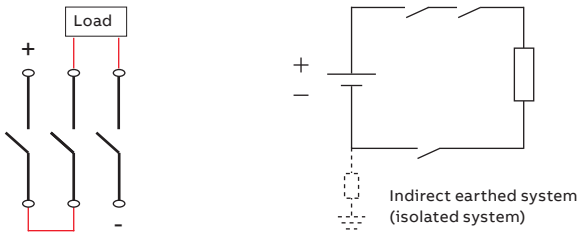
Recommended connection

In the example below, the three poles are connected in series without the load in between. This connection is recommended in systems according to the following configurations.



Alternative connection (not possible for GA75, GAE75)

The load could be placed in between the contacts in an indirect earthed system. If not connected according to the configuration below, a fault to earth could result in one or two contacts breaking the full load for which the contactor is not approved.



Note: The above relates to power circuit switching. The SCPD (Short Circuit Protection Device) must comply with the applicable protection rules.

3.5 Lamps and lighting loads

Two lamp-specific utilization categories exist AC-5a for electric discharge (fluorescent) lamps, and AC-5b for incandescent lamps, both of which have been fully harmonized. The AF contactors are suitable for the manual control of lamp loads. The table below shows a correlation between these ratings and a variety of commercially available lamps.

Lamp type	Ballast AC-5a	Tungsten AC-5b
Compact fluorescent lamps	X	
Fluorescent lamps with electronic ballast[1)]	X	
Halogen electric light bulbs		X
Halogen metal vapor lamps	X	
High-pressure discharge lamps	X	
Incandescent (filament) light bulbs		X
LEDs	X	
Mercury vapor high-pressure lamps	X	
Mixed lamps		X
Sodium vapor high-pressure lamps	X	

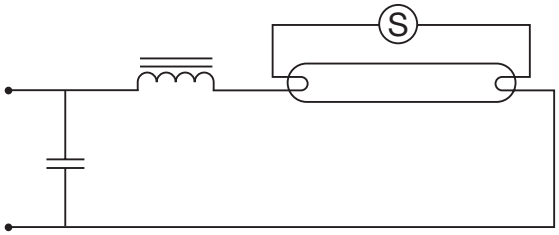
Table 11: Lamps and lighting loads

3.5.1 Lighting circuits

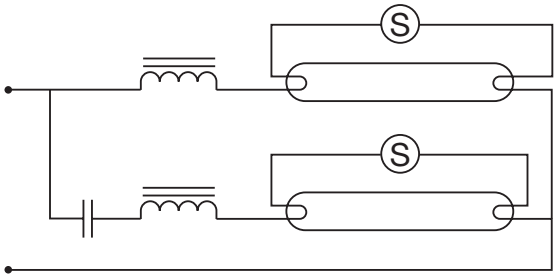
In a given circuit, the number and power rating of lamps are defined and cannot result in overload. Only short-circuit protection has to be provided. gG fuses or modular circuit-breakers will be chosen for this purpose. The lamps have very specific technical data, according to their construction type.

- Incandescent lamps have a very high current on closing: more than 15 times nominal current. They do not introduce a large phase displacement between current and voltage.
- Fluorescent tubes are equipped with a ballast whose purpose is two-fold: contribute to ignition and limit current to nominal value once a steady state is reached. This ballast is a reactor that consider-bly lowers the power factor. It may or may not be compensated.

Individual compensation
(parallel compensation)



Serial compensation in dual mounting



3.6 Capacitors

AC-6b utilization category according to IEC 60947-4-1

In Low Voltage industrial installations, capacitors are mainly used for reactive energy correction (raising the power factor). When these capacitors are energized, overcurrents of high amplitude and high frequencies (3 to 15 kHz) occur during the transient period (1 to 2 ms).

The amplitude of these current peaks, also known as "inrush current peaks", depends on the following factors:

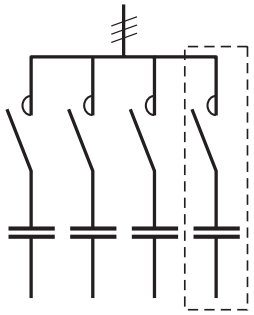
- The network inductances
- The transformer power and short-circuit voltage
- The type of power factor correction

—

3.6.1 Types of power factor correction

There are 2 types of power factor correction: fixed or automatic.

- **Fixed power factor correction**
  Fixed power factor correction consists of inserting, in parallel on the network, a capacitor bank whose total power is provided by the assembly of capacitors of identical or different ratings. The bank is energized by a contactor that simultaneously supplies all the capacitors (a single step). The inrush current peak, in the case of fixed correction, can reach 30 times the nominal current of the capacitor bank.
- **Automatic power factor correction**
  An automatic power factor correction system, on the other hand, consists of several capacitor banks of identical or different ratings (several steps), energized separately according to the value of the power factor to be corrected.



—
Multi-step capacitor bank scheme Use the UA... or UA..RA contactor ranges.

An electronic device automatically determines the power of the steps to be energized and activates the relevant contactors. The inrush current peak, in the case of automatic correction, depends on the power of the steps already on duty and can reach 100 times the nominal current of the step to be energized.

—

3.6.2 Steady state condition data

The presence of harmonics and the network's voltage tolerance lead to a current, estimated to be 1.3 times the nominal current In of the capacitor, permanently circulating in the circuit. Taking into account the manufacturing tolerances, the exact power of a capacitor can reach 1.15 times its nominal power.

Standard IEC 60831-1 Edition 2002 specifies that the capacitor must, therefore, have a maximum thermal current IT of:
IT = 1.3 x 1.15 x In = 1.5 x In

The Consequences for the contactors: to avoid malfunctions (welding of main poles, abnormal temperature rise, etc.), contactors for capacitor bank switching must be sized to withstand:
- A permanent current that can reach 1.5 times the nominal current of the capacitor bank
- The short but high peak current on pole closing (maximum permissible peak current Î)

—

3.7 Overview of load types for contactors

Switching type		Applicable device for the application
Motor	AC-3: Squirrel-cage motors	AF09 ... AF1650 3-phase contactors are mainly used for controlling motors from 4 up to 560 kW.
Resistive loads	AC-1: General use	AF09 ... AF2850 3-phase contactors are also used for controlling power circuits from 25 up to 2850 A. AF09 ... AF370 4-pole contactors are mainly used for controlling non-inductive or slightly inductive loads (i.e. resistance furnaces...) and generally for controlling power circuits from 25 up to 525 A.
Direct current (DC)	DC-1, L/R ≤ 1 ms DC-3, L/R ≤ 2 ms DC-5, L/R ≤ 7.5 ms	AF09 ... AF2850 3-pole or AF09 ... AF370 4-pole contactors with either 1- pole breaking or breaking with poles connected in series. Special contactors designed for DC breaking with permanent magnets fitted on the main poles for use with the 3 poles connected in series and considered as 1-pole devices: GA75 and GAE75 contactors: the 3 poles are connected in series via two supplied and fitted insulated connections, for current up to 100 A DC-1. GAF145 ... GAF2050 contactors: the 3 poles must be connected in series by the user according to conductor cross-sectional area (refer to main pole technical data) or by using LP connection bars to be ordered separately, for current up to 100 A DC-1. GF875...GF1050 contector for 1500 VDC switching, DC-1, and DC-PV3 (although not DC-3). GF has no permanent magnet installed, so it is bi-directional.
Capacitor	AC-6b: Capacitor bank	Contactor versions according to the value of the inrush current peak and the power of the capacitor banks: UA..RA contactors for capacitor switching (UA16..RA to UA110..RA) with insertion of damping resistors for 12.5 up to 80 kvar. The insertion of damping resistors protects the contactor and the capacitor from the highest inrush currents. UA contactors for capacitor switching (UA16 to UA110) for 12.5 up to 75 kvar. Maximum permissible peak current Î ≤ 100 times the nominal rms current of the switched capacitor.
Lighting circuit	AC-5a / AC-5b	AF09 ... AF2650 3-pole or AF09 ... AF370 4-pole contactors are also used for controlling a light load.
Auxiliary and control Circuits	AC-15/ AC-14/ DC-12 / DC-13	NF22 ... NF80 4-pole and 8-pole contactor relays CA4, CC4, CAT4, CAL Auxiliary contact blocks

4 Selection criteria

4.1 Sizing contactor for motor applications

Contactors should be sized based on the rated current (for UL full-load current (FLC)) of the motor. The rated operational current Ie of the contactor represents the maximum current rating of the device. Contactors should be selected so that the motor current rating falls between these ranges.

4.2 Selected Optimized Coordination (SOC)

As a help to select the right ABB product for the application, the “Selected Optimized Coordination” (SOC) web tool will be very useful. In order to guarantee the best performance and the longest lifetime, devices involved in the applications mentioned above (short-circuit protection devices, contactors, overload relays, softstarters ...) need to be coordinated.

The coordination among devices cannot be determined directly: tests in power laboratories have to be carried out to qualify the coordination type at low fault and high fault currents, according to IEC or UL standards. ABB coordination tables are the results of such tests and represent the ABB offerings in terms of motor starting and protection, selectivity, backup, and switch-disconnector protection.

In SOC, all available ABB coordination tables are stored and easily accessible. The following chapter is a guide to the main tasks and user interactions.

SOC is available on www.abb.com/lowvoltage (in the "Support “menu select "Online Product Selection Tools “, then select “Coordination Tables”) or click on the following permanent link: http://applications.it.abb.com/SOC

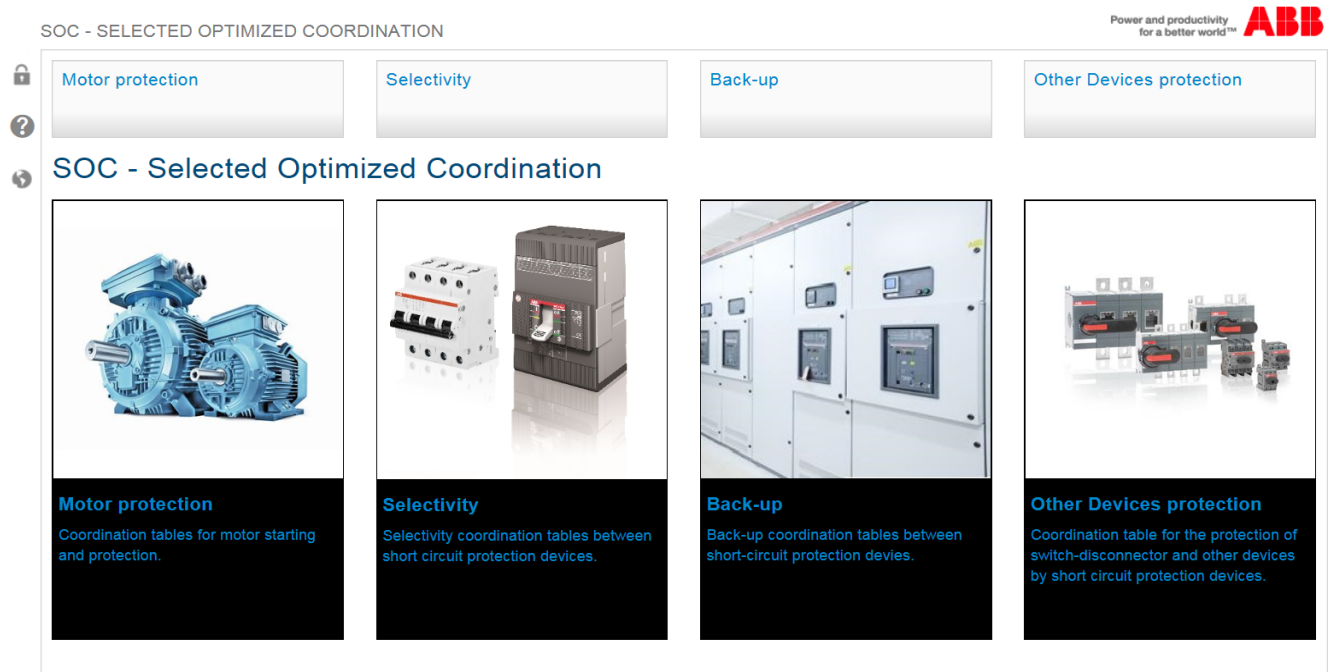


Figure 26: Screenshot from SOC

Under the interface “Motor protection” the following filters are available:
- type of protection device
- rated voltage
- short-circuit current
- starter type
- coordination type
- overload relay
- motor rated power

Example: if you are looking for products for motor protection, where a manual motor starter is used as short-circuit protection device, in a plant where the rated voltage is 400 V AC and the IE3 Motor Rated Power is 2.2 kW:

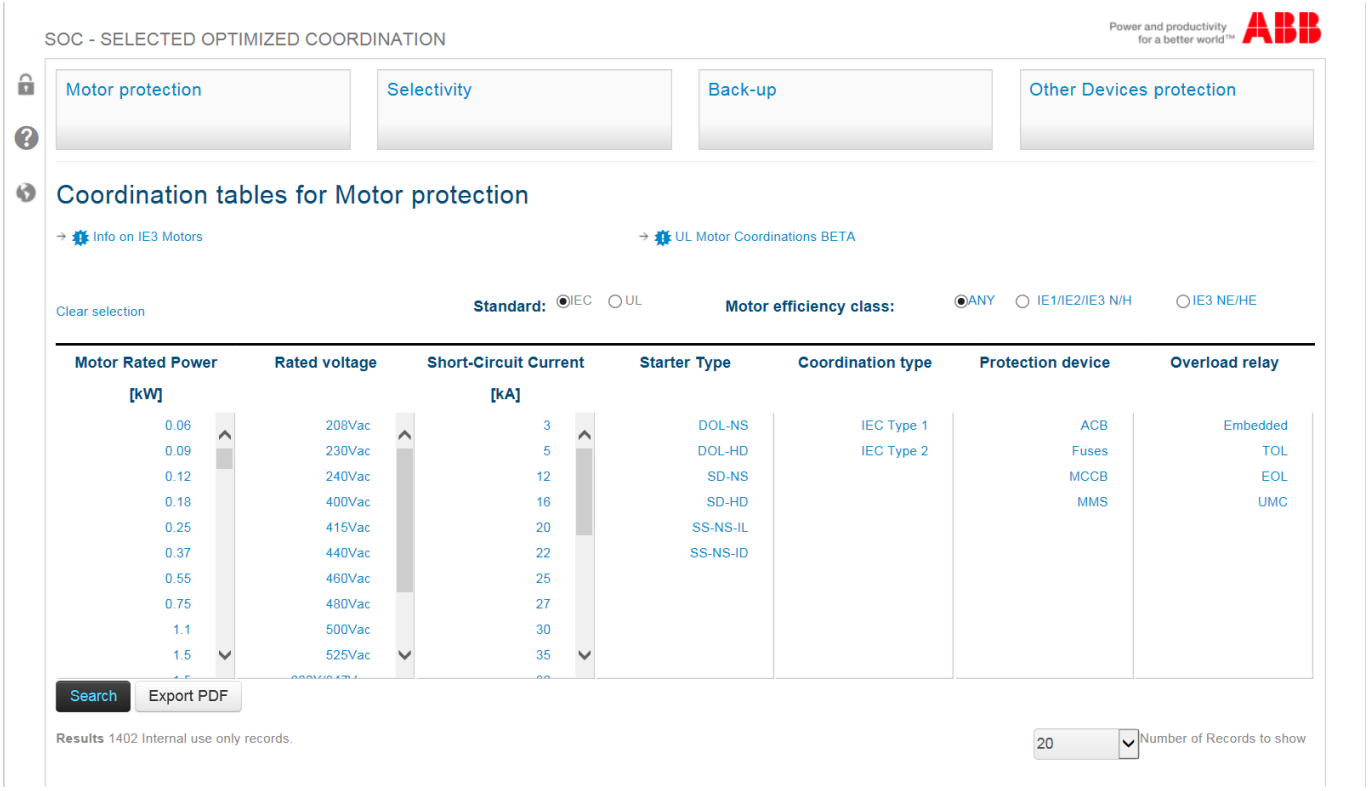


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Figure 27: Screenshot from an example on SOC

SOC is showing the right protection device for the selected application depend on the Coordination type. Click on >> to see the complete table.

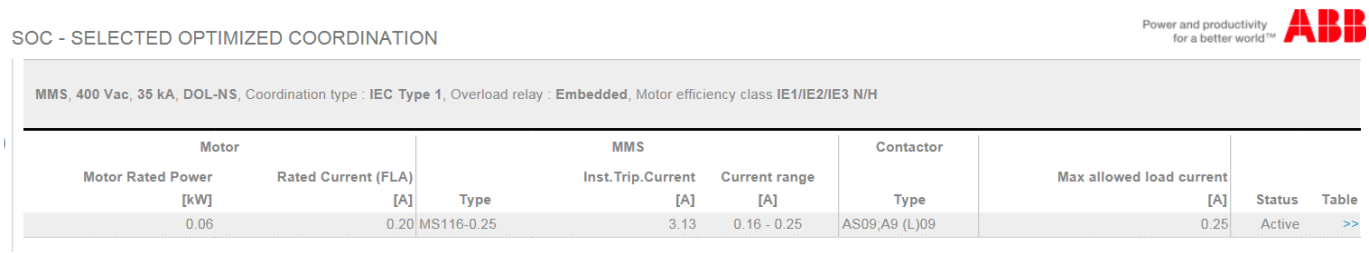

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Figure 28: Screenshot from an example on SOC

5 Installation and de-installation

Contactors are suitable for use in many climates. They are intended for use in enclosed environments in which no severe operating conditions (such as dust, caustic vapors or hazardous gases) prevail. When installed in dusty and damp areas, suitable enclosures must be provided.

5.1 Temperature

Temperature rise limits of parts of contactors
ABB is testing the contactors according to Standard IEC 60947-1 table 2 and 3. The heating of the contactor is a result not only of the surrounding ambient temperature but also of the connected load, which must be added to the surrounding temperature. The temperature of the contactor can be influenced by ventilation and cooling so that the temperature can be reduced by heat removal. If no sufficient heat removal exists, as the material heats up a steady increase in the resistance of the contact results. The increased resistance of the contact and also of the installation contactor increases the temperature. This table indicates the maximum temperature rise of the contactor. Here you will find some examples for the temperature rise.

Terminal material	Temperature-rise limits [a,c] in kelvin [K]
Bare copper	60
Bare brass	65
Tin plated copper or brass	65
Silver-plated or nickel-plated copper or brass	70
Other metals	b

The use in service of connected conductors significantly smaller than those listed in Tables 9 and 10 could result in higher terminals and internal part temperatures and such conductors should not be used without the manufacturer's consent, since higher temperatures could lead to equipment failure.

b Temperature-rise limits to be based on service experience or life tests but not to exceed 65 K.
c Different values may be prescribed by product standards for different test conditions and for devices of small dimensions, but not exceeding the values of this table by more than 10 K.

Table 4: Table 2 from the IEC 60947-1 Temperature-rise limits of terminals

Accessible parts		Temperature-rise limits[a] in kelvin [K]
Manual operating means:	Metallic Non-metallic	15 20
Parts intended to be touched but not hand-held:	Metallic Non-metallic	30 40
Parts which need not be touched during normal operation b:	Exteriors of enclosures adjacent to cable entries: Metallic Non-metallic Exterior of enclosures for resistors Air issuing from ventilation openings of enclosures for resistors	 40 50 200b 200b

Different values may be prescribed by product standards for different test conditions and for devices of small dimensions but not exceeding by more than 10 K the values of this table.

b The equipment shall be protected against contact with combustible materials or accidental contact with personnel. The limit of 200 K may be exceeded if so stated by the manufacturer. Guarding and location to prevent danger is the responsibility of the installer. The manufacturer will provide appropriate information, in accordance with section 5.3.

Table 5: Table 3 from the IEC 60947-1 Temperature-rise limits of accessible parts

—

5.2 Recommendation in use in applications

—

5.2.1 Ambient air temperature

The contactors are intended at ambient air temperature (Ambient air temperature is the temperature near the device) inside the following temperature range:

For AF09 … AF96:
- Close to Contactor without Thermal O/L Relay -40 ... +70 °C
- Close to Contactor Fitted with Thermal O/L Relay -25 ... +60 °C

For AF116 … AF2860:
- Close to Contactor without Thermal O/L Relay -40 ... +70 °C
- Close to Contactor Fitted with Thermal O/L Relay -25 ... +50 °C

—

5.2.2 Climatic withstand

The AF contactors are tested according to the Standard IEC 60947-1 Annex Q, and reached the category B: Environment subject to temperature and humidity (temperature test range −25 °C to +70 °C) = MC1+CC2+SC1, means:
- MC1: no vibration and,
- CC2: −25 °C to +70 °C (second range: dry heat test at +70 °C / damp heat test at +55 °C / cold test at −25 °C) and,
- SC1: no salt mist

—

5.2.3 Shock and vibration stress

The AF contactors are tested with regard to their shock resistance to sinusoidal and rectangular shock

—

5.3 Recommendation for storage

General cautions at products arrival in storage areas
- Check contactors, thermal and electronic overload relays on receipt,
- Cover packages of the equipment with a waterproof sheet.

—

5.3.1 Ambient air temperature and humidity

Equipment is intended to be stored at ambient air temperature (*) inside the following temperature range:
- Close to Contactor for Storage -60 ... +80 °C

The relative humidity of the air must not exceed 50 % at a temperature of +40°C. Higher relative humidity is permitted at lower temperatures (e.g. 90 % at +20 °C); for higher temperature lower relative humidity is permitted (e.g. 20% at 70°C).
Equipment is intended to be stored inside a stable temperature environment:
- Quick or low temperature variation can create condensation inside the products and damage them. (e.g.: PCB soldering and connection)
- Fast changes of temperature must be avoided: in case equipment are subjected to fast changes of temperature, it is mandatory to check that there is no presence of condensation on the contactors, thermal and electronic overload relays before putting into service.

(*) Ambient air temperature is the temperature near the device.

—

5.3.2 Precipitations and wind

Equipment have to be stored in a covered room or warehouse as it is important to protect it from rain, hail, snow, wind and the combined action of precipitations and wind.
Additional protection could be considered to cover the packages of the equipment with a waterproof sheet on upper, lower and lateral surfaces of the packages themselves in regards with room or warehouse environments.

—

5.3.3 Air pressure

The upper limit for air pressure inside the storage areas must not exceed the 107% of the air pressure at sea level.
Electronic overload relays: Maximum storage altitude is 2000m. Air pressure must not be less than 800kPa or 80% of the pressure at sea level.

—

5.3.4 Solar radiation

Equipment have to be stored in a covered room or warehouse as it is important to protect it from direct solar radiation: exposure to solar radiation causes peak of temperature that can damage plastic materials and grease. If air's temperature is often near to the lower limit allowed (-40°C) it is mandatory to keep the equipment in a covered room because the radiation from the contactors, thermal and electronic overload relays to the sky can further reduce the temperature in many parts, accelerating the aging phenomena.

—

5.3.5 Dust, sand and smoke

Dust, sand and smoke cause damages and rapid wear of products; these effects are increased by high wind speed. Dust and sand concentration and the presence of large particles are raised with higher wind speed. The presence of dust and sand is influenced by several factors as terrain, wind, temperature, humidity and precipitations: a combination of these factors concur to damage products (places more subjected to these phenomena are deserts or seaside). It is mandatory to cover the packages of the equipment with a sealed waterproof sheet.
Particularly critical are enclosed locations as mills, cement mills, sawmill and similar places where sedimentation arises throughout the manufacturing process. Critical places are also locations where dust storms occur or around a vehicle in motion on dusty roads. It is strictly recommended to avoid the storage in these plants or places.

—

5.3.6 Salt mist

The atmosphere over the sea and in coastal areas is largely saline consisting of salt in the form of solid particles or of minute drops of saline solution, also containing various other constituents. The constituent parts of a saline atmosphere are approximately equal to those found in the sea. If the equipment has to be stored in coastal areas, it is recommended to cover the packages of the equipment with a sealed waterproof sheet.

—

5.3.7 Vibration and shock

Vibration and shock references are valid under the condition that contactors, thermal and electronic overload relays are stored inside their original packages without any damages to it. Maximum values allowed for stationary sinusoidal vibrations are:

- displacement amplitude 0,3 mm for frequency range 2 Hz…9 Hz;
- acceleration amplitude 1 m/s2 for frequency range 9 Hz…200 Hz;

Occasionally non-stationary vibration, including shock, are allowed if the shock response spectrum is type I (ref. IEC 60721-3-1) and peak acceleration is less than 40 m/s2.

—

5.3.8 Seismic phenomena

The vibration nature of the ground motion (both horizontal and vertical) can be magnified in foundation mounted products: for any given ground motion the magnification depends on the characteristic frequencies of vibration of the system (soil, foundation and product) and on the mechanism of damping. In seismic regions the equipment must be stored in a soil suitable to reduce magnitude of vibrations. Storage area and storage support systems must not be vibrations amplitude magnifying ones.

- if during storage period, the equipment is subjected to a moderate earthquake (persisting for 15s to 30s and Richter magnitude degree up to 3), no actions are required
- if during storage period, the equipment is subjected to a medium earthquake (persisting for more than 30s or Richter magnitude degree from 4 up to 6), it is mandatory to check every functionality
- if during storage period, the equipment is subjected to a strong earthquake (persisting for more than 60s or Richter magnitude degree higher than 6), it is strictly recommended not put in service the apparatus.

—

5.3.9 Flora and fauna

In geographical areas with warm damp climates, fauna and flora, especially insects and microorganisms, such as mould and bacteria, will find favorable conditions of life. Humid or wet rooms in buildings or rooms for processes producing humidity are suitable living spaces for rodents, insects and micro-organisms. The range of temperature in which moulds may grow is from 0°C to 40°C, while the most favorable temperatures for many cultures is between 22°C and 28°C. If the surfaces of products carry layers of organic substances (e.g. grease, oil, dust) or deposits of animal or vegetable origin, such surfaces are ideal for the growth of moulds and bacteria. It is important to avoid deposits from fauna, especially from insects, rodents, birds like:

- presence of the animals themselves
- building of nests or settlements
- feed stocks

- metabolic products and enzymes on the packages of the equipment.

It is also important to avoid deposits from all kinds of flora like on packages of the equipment:

- detached parts of plants (leaves, blossom, seeds, fruits, etc.)
- growth layers of cultures of moulds or bacteria and effects of their metabolic products.

—

5.3.10 Fire exposure

In case of possible fire exposure, the equipment must be stored following these indications:

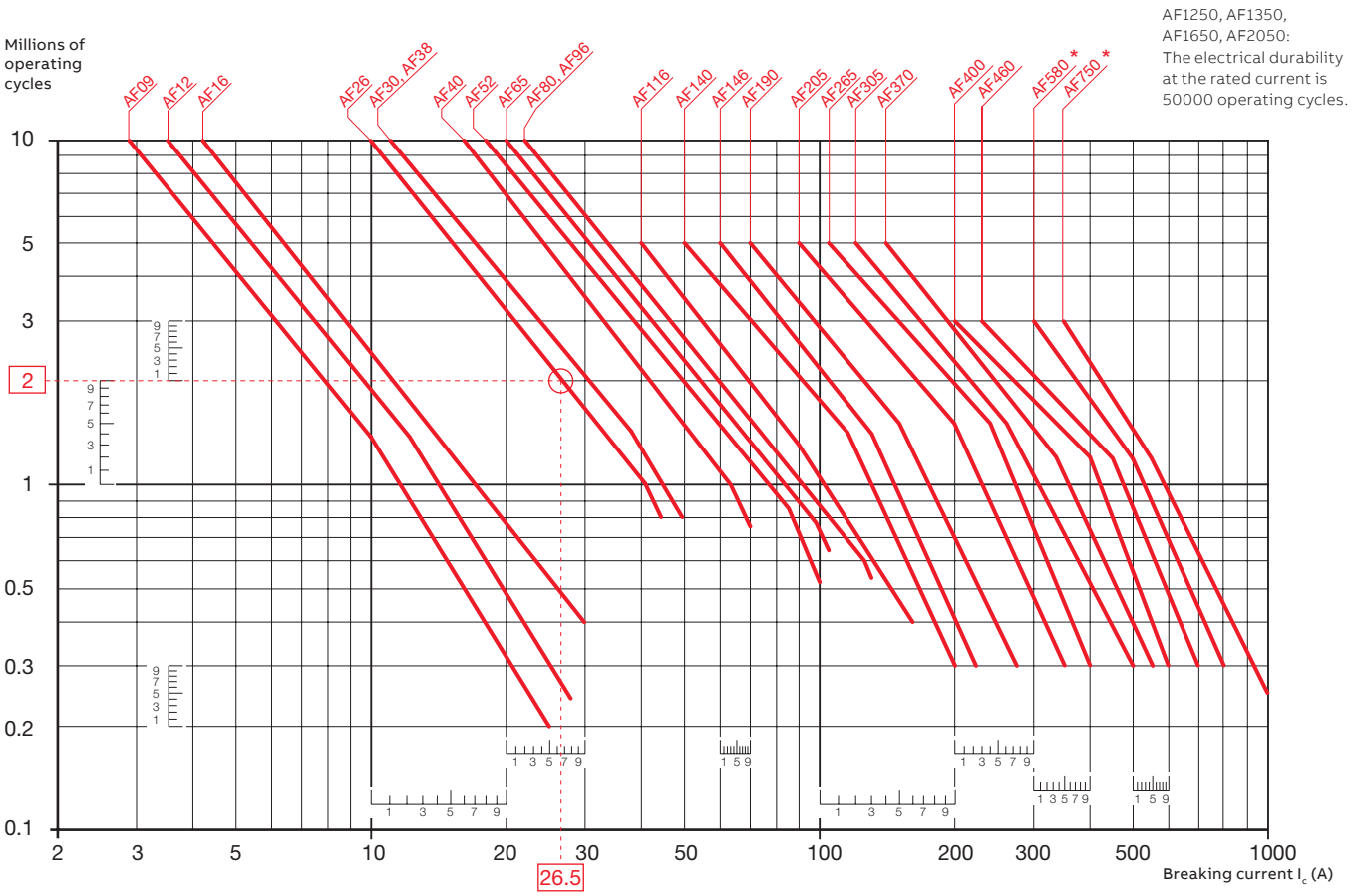
- no presence of fire sources in the room
- absence of every kind of fuel in the room
- absence of combusting gases in the room
- at least one meter of distance from surfaces with external temperature over 70°C

—

5.4 Electrical durability

Electrical durability for AC-1 utilization category - $U_e \leq 690$ V for AF09 ... AF2050

Switching non-inductive or slightly inductive loads. The breaking current Ic for AC-1 is equal to the rated operational current of the load. Ambient temperature and maximum electrical switching frequency: see "Technical data".



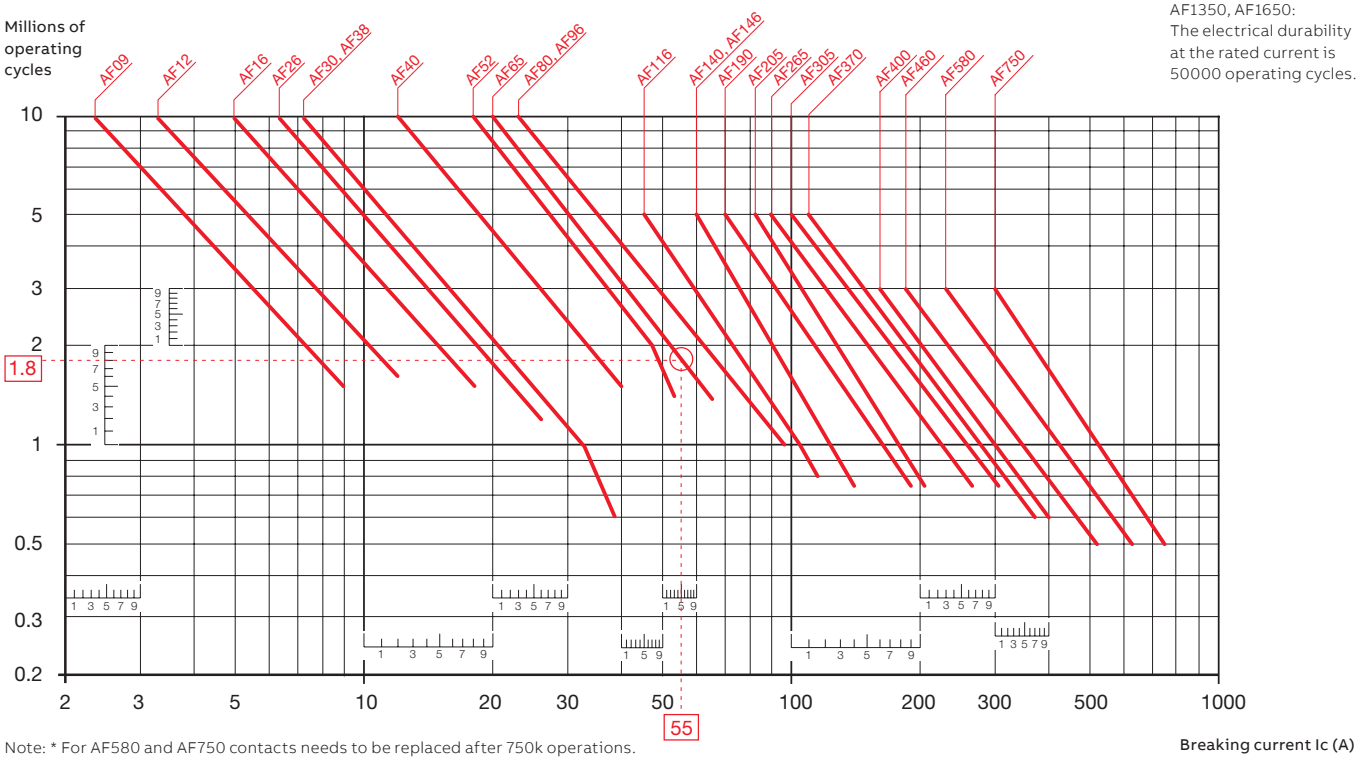
Note: * For AF580 and AF750 contacts needs to be replaced after 750k operations.

Example:

I_c / AC-1 = 26.5 A – Electrical durability required = 2 millions operating cycles. Using the AC-1 curves above select the AF26 contactor at the intersection " " (26.5 A / 2 million operating cycles).

Electrical durability for AC-3 utilization category - Ue $\leq$ 440 V for AF09 ... AF1650

Switching cage motors: starting and switching off running motors. The breaking current I_c for AC-3 is equal to the rated operational current I_e (I_e = motor full load current). Ambient temperature and maximum electrical switching frequency: see "Technical data"



AF1350, AF1650: The electrical durability at the rated current is 50000 operating cycles.

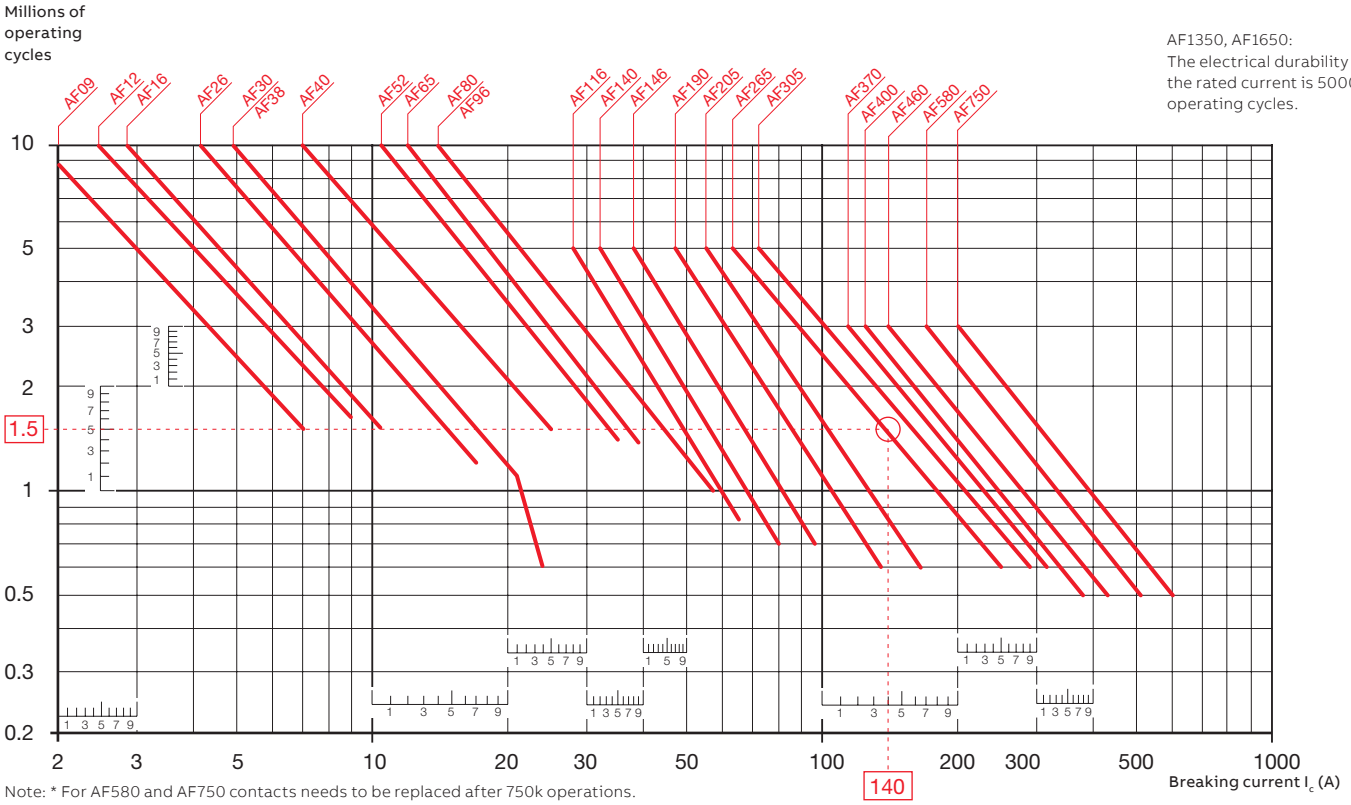
Note: * For AF580 and AF750 contacts needs to be replaced after 750k operations.

Example:

Motor power 30 kW for AC-3 - Ue = 400 V and Ie = 55 A utilization – Electrical durability required = 1.8 million operating cycles. For AC-3: Ic = Ie. Select the AF65 contactor at intersection " " (55 A / 1.8 million operating cycles) on the curves (AC-3 - $U_e \leq 440$ V).

Electrical durability for AC-3 utilization category - 440 V < Ue ≤ 690 V. for AF09 ... AF1650

Switching cage motors: starting and switching off running motors. The breaking current I_c for AC-3 is equal to the rated operational current I_e (I_e = motor full load current). Ambient temperature and maximum electrical switching frequency: see "Technical data".



AF1350, AF1650: The electrical durability at the rated current is 50000 operating cycles.

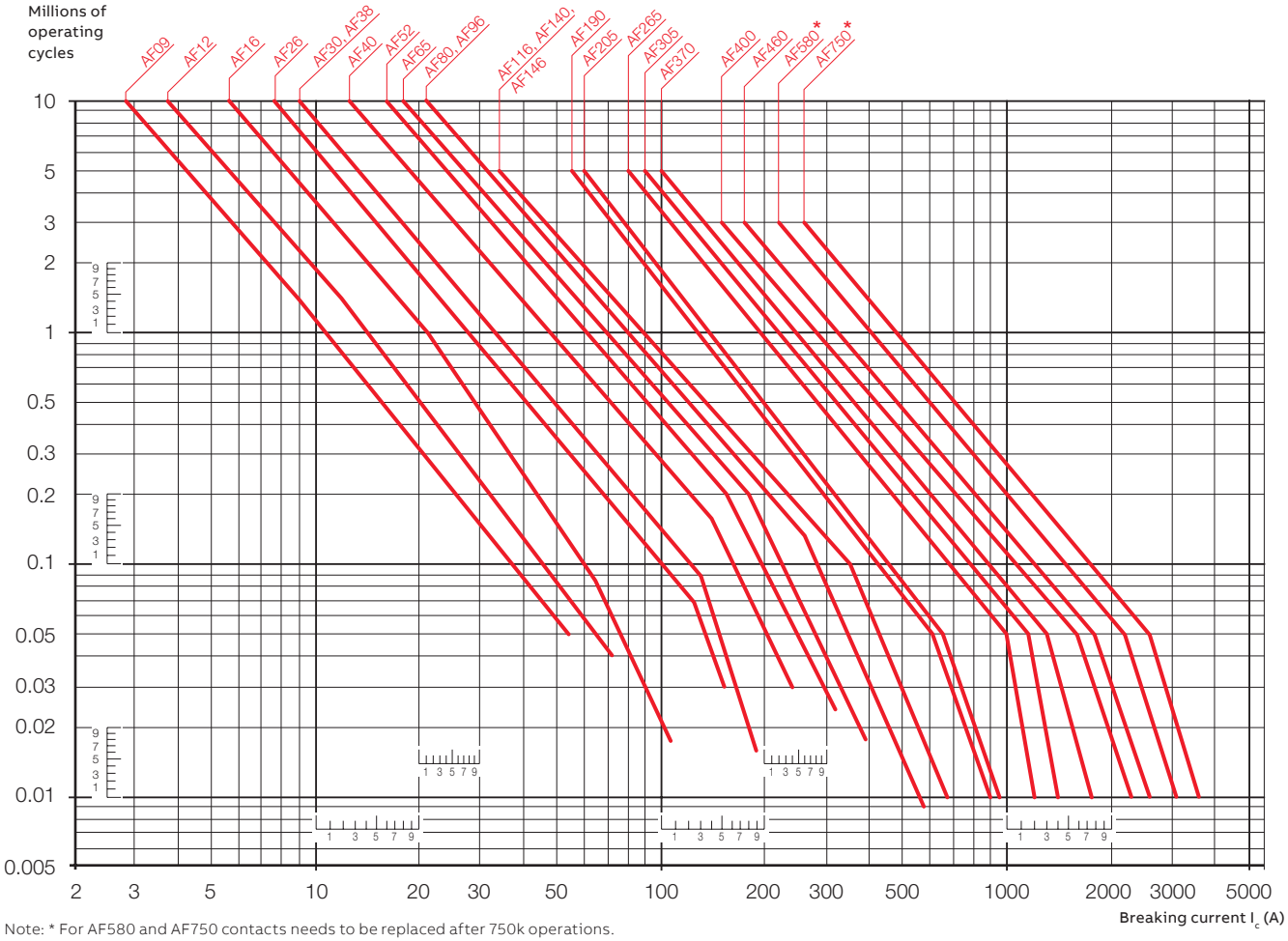
Note: * For AF580 and AF750 contacts needs to be replaced after 750k operations.

Example:

Motor power 132 kW for AC-3 - U_e = 660 V and Ie = 140 A utilization – Electrical durability required = 1.5 million operating cycles. For AC-3: $I_c = I_e$. Select the AF265 contactor at intersection " " (140 A / 1.5 million operating cycles) on the curves (AC-3 - 440 V < $U_e \leq 690$ V).

Electrical durability for AC-2 or AC-4 utilization category - $U_e \leq 440$ V by an Ambient temperature ≤ 60 °C for AF09 ... AF370, ≤ 55 °C for AF400 ... AF1650

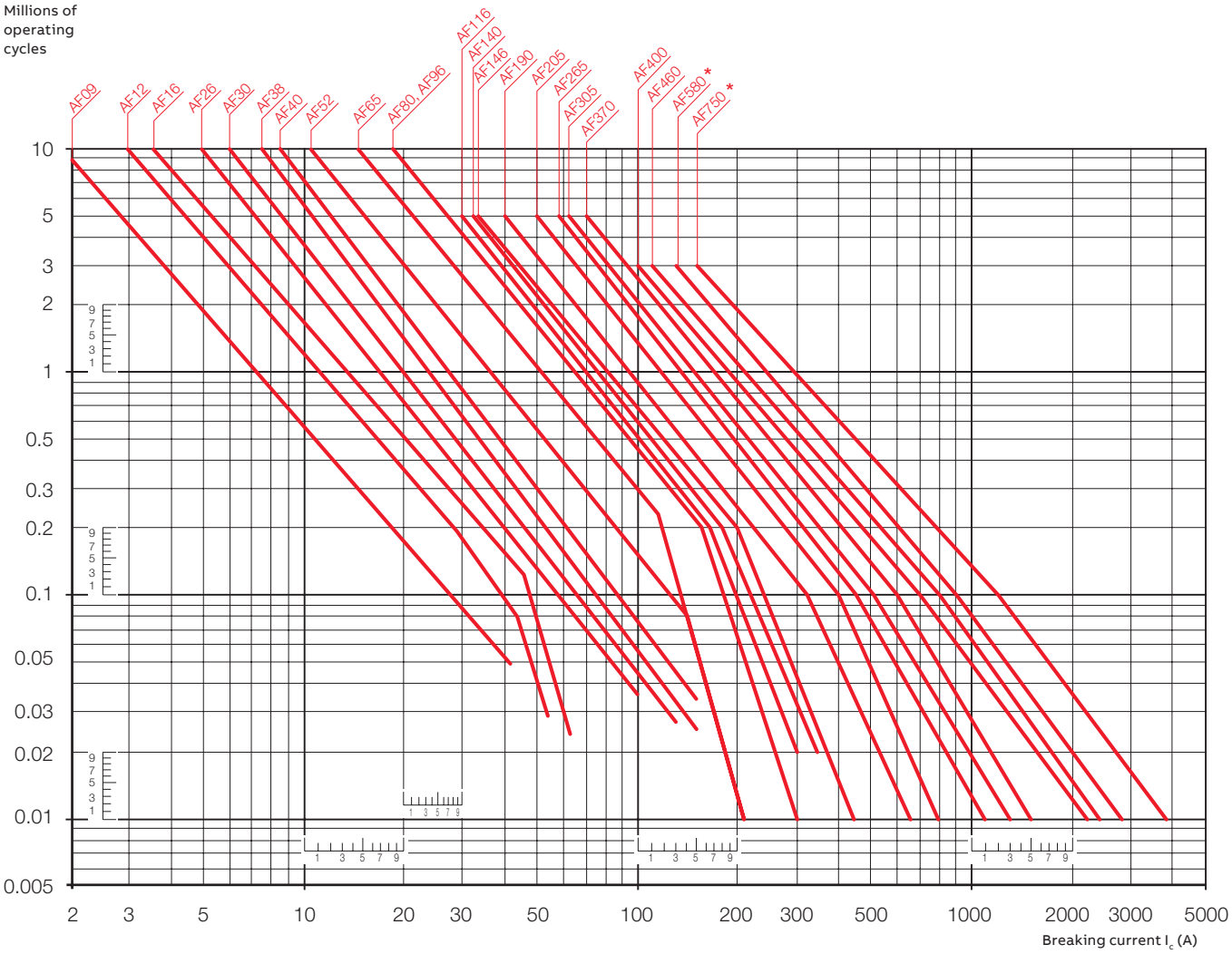
Switching cage motors: starting, reverse operation and step-by-step operation. The breaking current I_c is equal to 2.5 x I_e for AC-2 and 6 x I_e for AC-4, keeping in mind that I_e is the motor-rated operational current (I_e = motor full-load current). Maximum electrical switching frequency: see "Technical data"



Note: * For AF580 and AF750 contacts needs to be replaced after 750k operations.

Electrical durability for AC-2 or AC-4 utilization category - 440 V < U_e ≤ 690 V for AF09 ... AF750 by an ambient temperature ≤ 60 °C for AF09 ... AF370, ≤ 55 °C for AF400 ... AF750

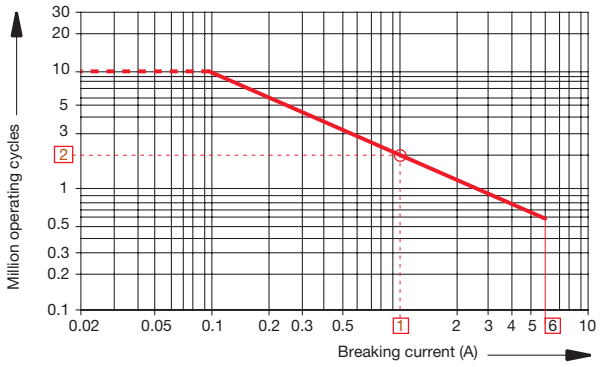
Switching cage motors: starting, reverse operation and step-by-step operation. The breaking current I_c is equal to 2.5 x Ie for AC-2 and 6 x I_e for AC-4, keeping in mind that I_e is the motor-rated operational current (I_e = motor full load current). Maximum electrical switching frequency: see "Technical data".



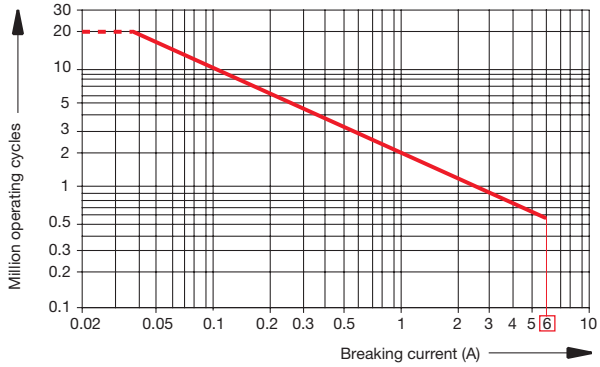
Electrical durability for AC-15 utilization category for AF09 ... AF96 contactor and NF contactor relays
AC-15 utilization category according to
IEC 60947-5-1 / EN 60947-5-1:
- making current: 10 x I_e with cos **φ** = 0.7 and U_e
- breaking current: I_e with cos φ = 0.4 and U_e.

These curves represent the electrical durability of the built-in or add-on auxiliary contacts in relation to the breaking current. The curves have been drawn for resistive and inductive loads up to 690 V, 40...60 Hz. AF09 ... AF96 contactor built-in auxiliary contacts
1-pole and 4-pole CA4, 2-pole CAT4,
1-pole CC4,
2-pole CAL4 add-on auxiliary contacts.

Example:
Breaking current = 1 A
On the opposite curve at the intersection "O" 1 A the corresponding value for the electrical durability is approximately 2 million operating cycles.

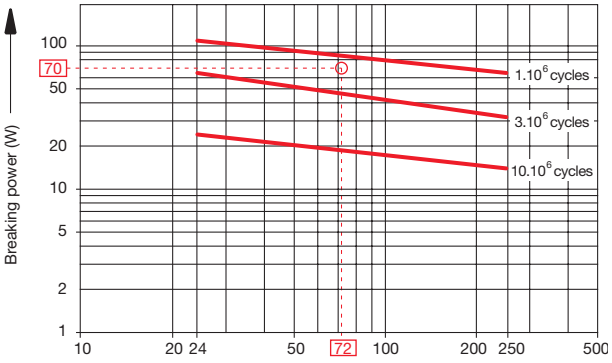


NF contactor relays.
(For add-on auxiliary contacts see curve above).

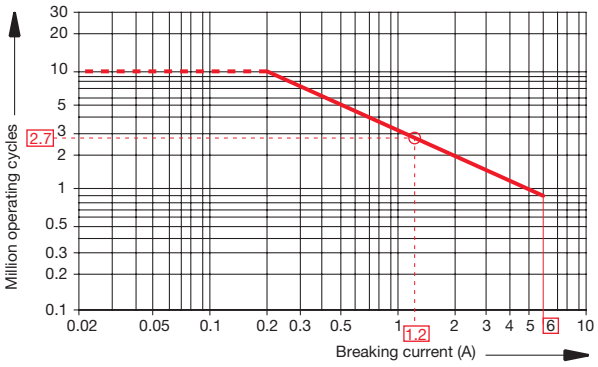


Electrical durability for DC-13 utilization category for AF09 ... AF96
DC-13 utilization category according to IEC 60947-5-1 / EN 60947-5-1: making and breaking current I_e and U_e.
- AF09 ... AF96 contactor built-in auxiliary contacts 1-pole and 4-pole CA4, 2-pole CAT4,
- 1-pole CC4,
- 2-pole CAL4 add-on auxiliary contacts.

Example:
Breaking current = 1 A
On the opposite curve at the intersection "O" 1 A the corresponding value for the electrical durability is approximately 2 million operating cycles.



Electrical durability for AC-15 utilization category for AF116 ... AF2850
AC-15 utilization category according to IEC 60947-5-1 / EN 60947-5-1:
Making current: 10 x I_e with cos φ = 0.7 and U_e
Breaking current: I_e with cos φ = 0.4 and U_e.
These curve represent the electrical durability of the add-on auxiliary contacts, in relation to the breaking current.
The curves have been drawn for resistive and inductive loads up to 690 V, 40...60 Hz.



AF116 ... AF2850 contactors auxiliary contacts
2-pole CAL18 and CAL19 add-on auxiliary contacts

Example:
Breaking current = 1.2 A
On the opposite curve at intersection "O" 1.2 A the corresponding value for the electrical durability is approximately 2.7 million operating cycles

5.5 Pollution degree

The pollution degree refers to the environmental conditions for which the equipment is intended. The micro-environment determines the effects on the insulation; it includes all factors influencing the insulation, such as climatic and electromagnetic conditions, generation of pollution, etc. For equipment fitted inside an enclosure and intended for store (inside of it), the pollution degree of the environment is that one applicable to the enclosure. According to IEC 60947, in general conditions or unless otherwise stated by the relevant product standards, pollution degree of industrial applications can be assumed as “Pollution degree 3” (Conductive pollution occurs, or dry, non-conductive pollution occurs which becomes conductive due to condensation).

5.6 Modality of storage

- Keep contactors, thermal and electronic overload relays in their original packages
- Position the package of contactors, thermal and electronic overload relays on a horizontal surface, not in direct contact with the floor, but on a suitable support surface.

5.7 Putting into service

Before putting the equipment into service, it is mandatory to follow all prescriptions included in installation and maintenance documentation supplied in the contactors, thermal and electronic overload relays package or on manufacturer's website.

6 Installation and commissioning

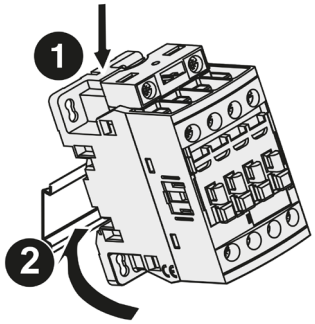
When mounting the contactors, observe the following instructions:
- The product must install in housing if there is a risk of contamination, heavy dust or an aggressive atmosphere.
- Dust deposits must be extracted.
- If foreign objects (e.g. drill chips) can get onto the devices, they must be removed by the mounting the contactors are covered.

6.1 Mounting

Contactors can be mounted as follows:
- Fixed on a 35 mm top hat rail according to IEC/ EN 60715 (35 x 15 or 35 x 7.5 mm)
- Screw fixing on wall/panel.

6.1.1 Mounting and dismantling on a DIN rail

The contactors size AF09 up to AF96 can be mounted on DIN rails according to DIN EN 60715 (35 x 15 or 35 x 7.5 mm).



Mounting
Place the device on the upper edge of the 35 mm DIN rail and push it downwards (1), until it snaps onto the lower edges of the DIN rail (2).

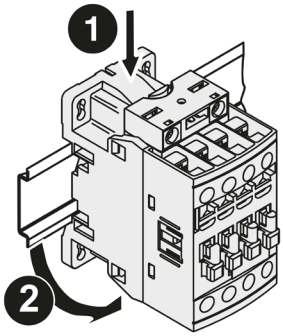


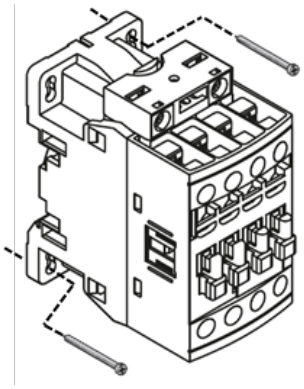
Figure 29: Dismantling of a contactor on 35 mm DIN rail mounting

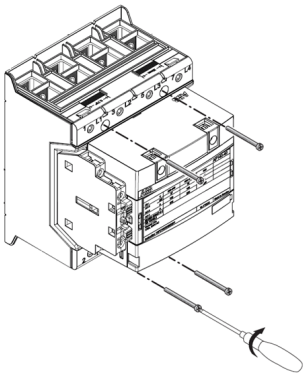
Dismantling
To dismantling, push the device downwards against the pull pf the mounting spring (1) and remove the device with a swivel motion (2).

—

6.1.2 Mounting and dismantling with screw fixing on wall/panel

The contactors size AF09 up to AF96 can be also mounted with screws on one mounting plate or on a wall. The contactors size AF116 up to AF2850 can only be mounted with screws on one mounting plate or on a wall. Screw the contactor diagonally in the holes provided with screws washers and spring washers.





Contactor Type	Screws	Max tightening torque
AF09... AF38	2x M4	1.2 Nm
AF40... AF96	2 x M6	1.5 Nm
AF116... AF146	4x M4	1.5 Nm
AF190... AF460	4x M5	2.9 Nm
AF580... AF1250	4x M6	3.5 Nm
AF1350... AF2850	4x M8	10 – 15 Nm

These tightening torque values are only given as an indication. Whatever the cases, end users must proceed to further tests to validate the fixing solution in regards to the characteristics of screws and washers used with the material of the plate.

Range	AF(S)09..38(Z) (K)(S), NF(Z) (K)(S)	AF(S)40...65	AF(S)80, AF96
Screw type	M4	M4 or M6	M6
Washer plate	according to ISO 7089 ext diam = 9mm	according to ISO 7089 ext diam = 9 mm (for M4) or ext diam =12 mm (for M6)	according to ISO 7089 ext diam =12 mm (for M6)
Torque values	1.2 N.m	1.2 N.m (for M4) – 1.5 N.m (for M6)	1.5 N.m

The number and the position of screws, the screwdriver type are indicated in the respective catalog of each range.

—

6.1.3 Minimum distances

There are no deratings necessary up to an ambient temperature of 70°C for all contactors, even with a side to side mounting.

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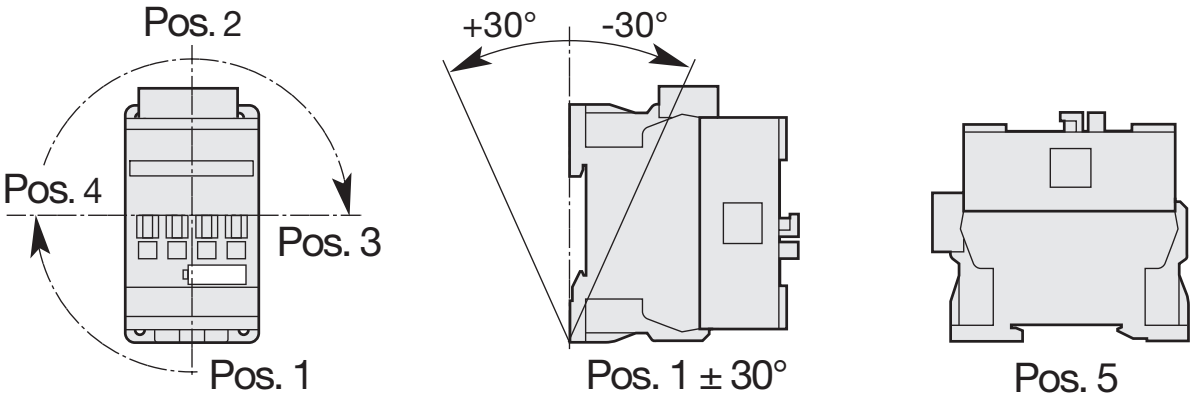
6.1.4 Mounting position

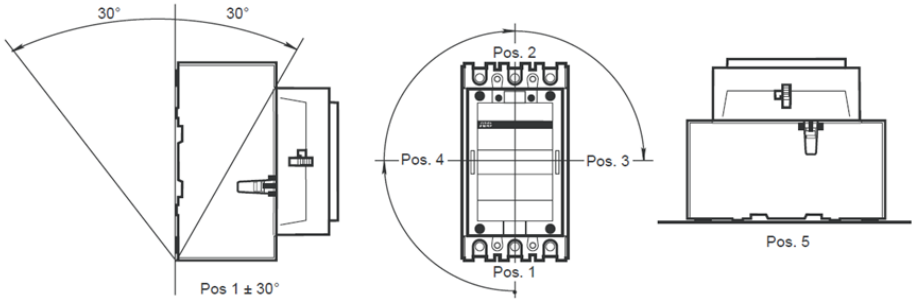
Mounting positions 1 until 5 are permitted for all AF contactors.

AF09 ... AF96:



Max. N.C. built-in and add-on N.C. auxiliary contacts: see accessory fitting details for a contactor AF09 ... AF96 and an NF contactor relay.

AF 116 ... AF2850:

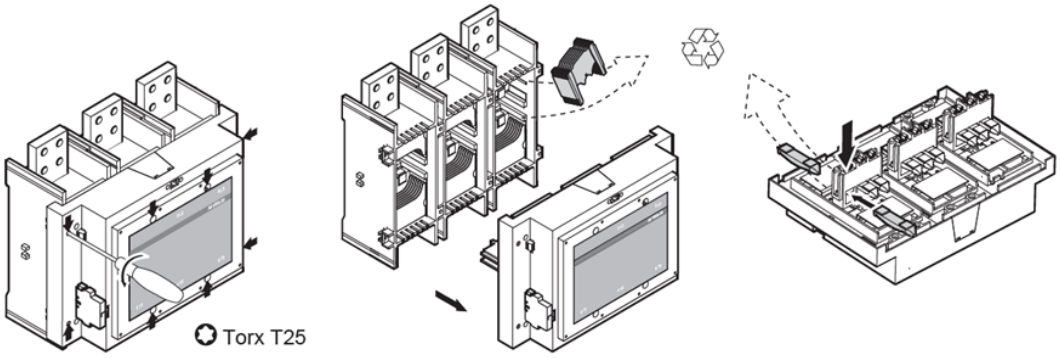


6.2 Changing main contacts, arc chutes, and coils

For the contactors AF116 ... AF2850 is it possible to change the main contacts, arc chutes and coils. The following chapters show the replacement of these spare parts.

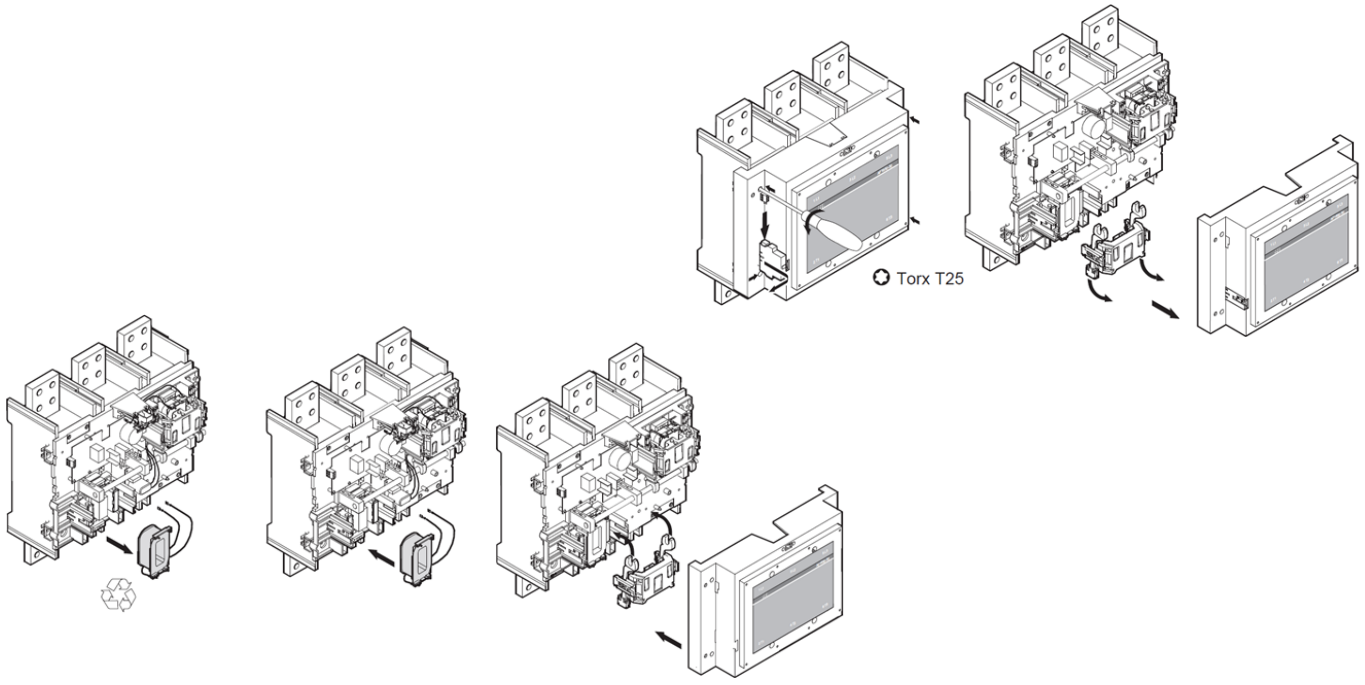
6.2.1 Changing the main contact sets

- Loosen the screws of the removable front frame with a Torx T25 screwdriver and remove carefully the front frame from the contactor off.
- Replace the arcing chamber with the new.
- Move the contacts out of the contact carrier and push the new contacts into the contact carrier.
- Push the front frame of the contactor back onto the rear contactor half until the retaining clips engage.
- Screw the contactor halves (1.1 - 1.3 Nm) with a screwdriver.



6.2.2 Changing the coils

- Loosen the screws of the removable front frame with a Torx T25 screwdriver and remove carefully the front frame from the contactor off.
- Remove the contact piece of the movable contact pieces from the rear half of the contactor.
- Remove the coil from the rear half of the contactor and insert the new coil.
- Hook the contact piece of the movable contact pieces into the rear half of the contactor
- Push the front frame of the contactor back onto the rear contactor half until the retaining clips engage.
- Screw the contactor halves (1.1 - 1.3 Nm) with a screwdriver.



6.3 Connection

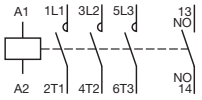
The AF contactors can be supplied either from the bottom or from the top (for non-UL applications).

6.3.1 Connection types

The contactors are available in the main circuit with the following connection types:
- AF09 up to AF38: screw terminals or push-in spring terminals
- AF40 up to AF96: screw terminals
- AF116 up to AF146: screw terminals or with screw connection with connection rails
- AF190 up to A2850: screw connection with connection rails

The contactors are in the auxiliary circuit/control circuit with the following connection types available:
- AF09 up to AF38 push-in spring terminals
- AF09 up to AF2850: screw terminals

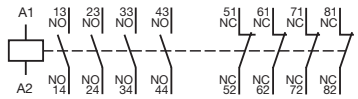
Push-in spring terminals allows an easily connect conductors directly. The special contact spring allows easy insertion and guarantees a high level of contact quality.



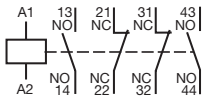
Terminal Name	Function / Designations
L1 ,L2 ,L3	Input main circuit – to the grid
T1, T2, T3	Output main circuit - to the load
A1, A2	Coil control circuit
13, 14	Auxiliary circuit – Normally open
21, 22	Auxiliary circuit – Normally close

Auxiliary contacts have a two-digit designation:
- First digit: successive number of auxiliary contacts
- Second digit: function of the auxiliary contact e.g 1-2 for openers or 3-4 for closers

4-pole contactor relays are used for switching auxiliary and control circuits, so also here are used the digits as for the Auxiliary contacts, here two examples:



Terminal Name	Function / Designations
A1, A2	Coil control circuit
13, 14	Auxiliary circuit – Normally open
23, 24	Auxiliary circuit – Normally open
33, 34	Auxiliary circuit – Normally open
43, 44	Auxiliary circuit – Normally open



Terminal Name	Function / Designations
A1, A2	Coil control circuit
13, 14	Auxiliary circuit – Normally open
23, 24	Auxiliary circuit – Normally close
33, 34	Auxiliary circuit – Normally close
43, 44	Auxiliary circuit – Normally open

6.3.2 Terminal designations

6.3.3 Terminal designations - connection cross sections for screw connection technology

The following tables show the permissible conductor cross-sections for main connections and auxiliary conductor connections of all AF sizes.

Terminal designation AF09... AF38

								
	AF09(Z)... AF16(Z) 3 & 4-pole	M3.5 1.2 Nm	ø 5.5	Pozidriv No. 2	2 x 0.75... 6	2 x 0.75...2.5 1 x 0.75...4	10	<9.6
	AF26(Z)... AF38(Z) 3-pole	M4 2.5 Nm	ø 6.5		2 x 1.5...10	2 x 1.5...4 1 x 1.5...10	10	<12.5
	AF26(Z)... AF38(Z) 4-pole	M4.5 2.5 Nm	ø 5.5		2 x 1.5... 16	2 x 1.5... 16	12	-
	AF09(Z)... 16(Z)-30-10 AF09(Z)... 16(Z)-30-01	M3.5 1.2 Nm	ø 5.5		2 x 0.75... 2.5	2 x 0.75... 1.5 1 x 0.75...2.5	10	<9.6
	NF(Z)... AF09(Z)... 38(Z)-30-22 AF26(Z)... 38(Z)-30-11							<8
	AF09(Z)... AF38(Z) NF(Z)...	M3.5 1.2 Nm	ø 5.5		2 x 0.75... 2.5	2 x 0.75... 1.5 1 x 0.75...2.5	10	<8

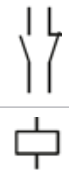
Terminal designation AF40... AF96

								
	AF40...65 3-pole	M6 4 Nm	ø 6.5	Pozidriv No. 2	2 x 4... 35	2 x 4... 35	16	-
	AF80...96 3-pole	M8 6 Nm	-	Hexagon 4 mm	2 x 6... 50	2 x 6... 50	17	-
	AF40...96-30-11 AF40...96-30-22	M3.5 1.2 Nm	ø 5.5	Pozidriv No. 2	2 x 0.75... 2.5	2 x 0.75... 1.5 1 x 0.75...2.5	10	<8
	AF40...65 3-pole AF80...96 3-pole	M3.5 1.2 Nm	ø 5.5		2 x 0.75... 2.5	2 x 0.75... 1.5 1 x 0.75...2.5	10	<8

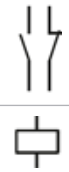
Terminal designation AF116... AF146

				mm	*Flexible mm²	*Stranded mm²	mm²	mm	mm	mm
	AF116... AF146		M8 8 Nm	4	1 x 10... 70 2 x 10... 70	1 x 10... 95 2 x 10.. .95	not allowed	20	-	-
			M6 9 Nm	5	-	-	-	-	20 5.5	22
	* Only use wires of the same dimension when you connect 2 wires to each terminal.									
					mm²	mm²	mm²	mm²	mm	mm
	AF116... AF146	M3.5 1 Nm	ø 5.5	Pozidriv No. 2	2 x 1... 4 1 x 1... 4	2 x 0.75... 2.5 1 x 0.75... 2.5	2 x 0.75... 2.5 1 x 0.75... 2.5	2 x 0.75... 2.5 1 x 0.75... 2.5	9	<8

Terminal designation AF190... AF370

				mm	*Flexible mm²					
	AF190, AF205		M8 18 Nm	24 8	24					
	AF265... AF370		M10 28 Nm	32 10	32					
					mm²	mm²	mm²	mm²	mm	mm
	AF190... AF370	M3.5 1 Nm	ø 5.5	Pozidriv No. 2	2 x 1... 4 1 x 1... 4	2 x 0.75... 2.5 1 x 0.75... 2.5	2 x 0.75... 2.5 1 x 0.75... 2.5	2 x 0.75... 2.5 1 x 0.75... 2.5	9	<8

Terminal designation AF400... AF1250

				mm	*Flexible mm²					
	AF400, AF460		M10 35 Nm	47	45					
	AF580... AF1250		M12 45 Nm	52	50					
					mm²	mm²	mm²	mm²	mm	mm
	AF400... AF1250	M3.5 1 Nm	ø 5.5	Pozidriv No. 2	2 x 1... 2.5 1 x 1... 2.5	2 x 1... 2.5 1 x 1... 2.5	???	???	???	<8

—

Terminal designation AF400... AF1250

				mm						
	AF1350... AF2850		M12 45 Nm	100						
					mm²	mm²	mm²	mm²	mm	mm
	AF1350... AF2850	M3.5 1 Nm	ø 5	Pozidriv No. 2	2 x 1... 2.5 1 x 1... 2.5	2 x 0.75... 2.5 1 x 0.75... 2.5	???	???	???	<8

Connection cross sections for push-in spring terminals technology

The following tables show the permissible conductor cross-sections for main connections and auxiliary conductor connections of the AF09-K up to AF38-K contactors:

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Connection cross sections for push-in spring terminals technology

			mm mm	mm²	mm²	mm²	mm²	mm²	mm²	mm²	mm	
				Push-in			**Spring**					
	AF09 ... 16(Z)-..K	ø 3 x 0,5		2 x 1... 6 1 x 1... 6	2 x 1... 4 1 x 1... 4	2 x 1... 2.5 1 x 1... 4	2 x 1... 6 1 x 1... 6	2 x 0.5... 4 1 x 0.5... 4	2 x 0.5... 4 1 x 0.5... 4	2 x 0.5... 4.5 1 x 0.5... 4		12
	AF26 ... 38(Z)-..K			2 x 1... 10 1 x 1... 10	2 x 1... 6 1 x 1... 6	2 x 1... 6 1 x 1... 6	2 x 1... 10 1 x 1... 10	2 x 1... 6 1 x 1... 6	2 x 1...6 1 x 1... 6	2 x 1... 6		14
	AF09 ... 38(Z)-..K, NF(Z)..., CA(L)4..K, VEM4K, LDC4K			2 x 1... 2.5 1 x 1... 2.5	2 x 1... 2.5 1 x 1... 2.5	2 x 1... 1.5 1 x 1... 1.5	2 x 1... 2.5 1 x 1... 2.5	2 x 0.5... 2.5 1 x 0.5... 2.5	2 x 0.5... 2.5 1 x 0.5... 2.5	2 x 1... 1.5 1 x 1... 1.5		10

*only possible with Spring technology

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6.4 Installation instructions

Installation instructions for Contactors can be accessed through the ABB Download Center https://library.abb.com. All Categories > Products > Low Voltage Products and Systems > Control Product > Contactors

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6.5 2D drawings and 3D models

2D and 3D drawings for Contactors and accessories can be accessed through the "ABB 3D portal (http://abb-control-products.partcommunity.com/portal/portal/abb-control-products)

7 Glossary

AC	Alternating current
Active power	The power consumed by the motor which is converted into mechanical action
Ambient temperature	Ambient temperature is the temperature of water, air or surrounding medium where the equipment is used or stored
DC	Direct current
Delta connection	The connection type of a motor where the windings are connected in a delta
Efficiency	The ratio between mechanical output and electrical input. The percentage given indicates how effective the motor is at converting electrical energy to mechanical energy
Frequency	The number of periodic cycles per unit of time
FLA	Full load amps (sometimes also FLC= Full load current), rated current at rated load and rated voltage. This is the amount of current (amps) the motor will draw from the electrical system when producing its rated output horsepower
I_e	The tripping characteristic of the instantaneous short-circuit releases is based on the rated operational current Ie, which, in the case of the manual motor starter, is the same as the upper value of the setting range.
IE3	Premium-efficiency class for single-speed motors according to IEC 60034-30
IE4	Super Premium-efficiency class for single-speed motors according to IEC 60034-30 version 2014
IEC	International Electrotechnical Commission, which is part of the International Standard Organization
Inertia	A measure of a body's resistance to change in velocity whether the body is moving at a constant speed or is at rest. The velocity can be rotational or linear
Inrush peak	A short, high-current transient occurring during the first milliseconds when the motor is started
LED	Light-emitting diode
Load torque	The braking torque on the motor shaft caused by the load. If the braking torque is equal or nearly equal to the rated motor torque it can be defined as high load torque
MEPS	Minimum Energy Performance Standard: local regulation specifying the minimum required energy performance for energy-using products. In Europe the EU MEPS for direct on-line motors is IE3
MMS	Manual motor starter
N-end	The end that is normally the non-drive end of an electrical motor
NEMA	The National Electrical Manufacturers Association (USA)
Network	Several nodes connected to each other with some type of communication medium. A network can be of single link type or multiple link type
Noise	Unwanted disturbances in a communication medium that tend to obscure the data content
Operational voltage	The voltage that is fed to the motor, usually 3-phase
Overload relay	A device used to avoid overheating of the motor. Can be of electronic or thermal type
PLC	Programmable Logic Controller
Power factor	Power factor (PF) is the ratio of working power, measured in kilowatts (kW), to apparent power, measured in kilovolt amperes (kVA).
Rated current	The rated current is the current drawn by a fully-loaded motor at its specified nominal speed
Reactive power	The power consumed by the motor which is used for the magnetization of the motor
RMS	Root Mean Square: the RMS value of an AC supply is the steady DC equivalent, which would convert electrical energy to thermal energy at the same rate in a given resistance

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You can find the address of your local sales organization on the ABB homepage

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