

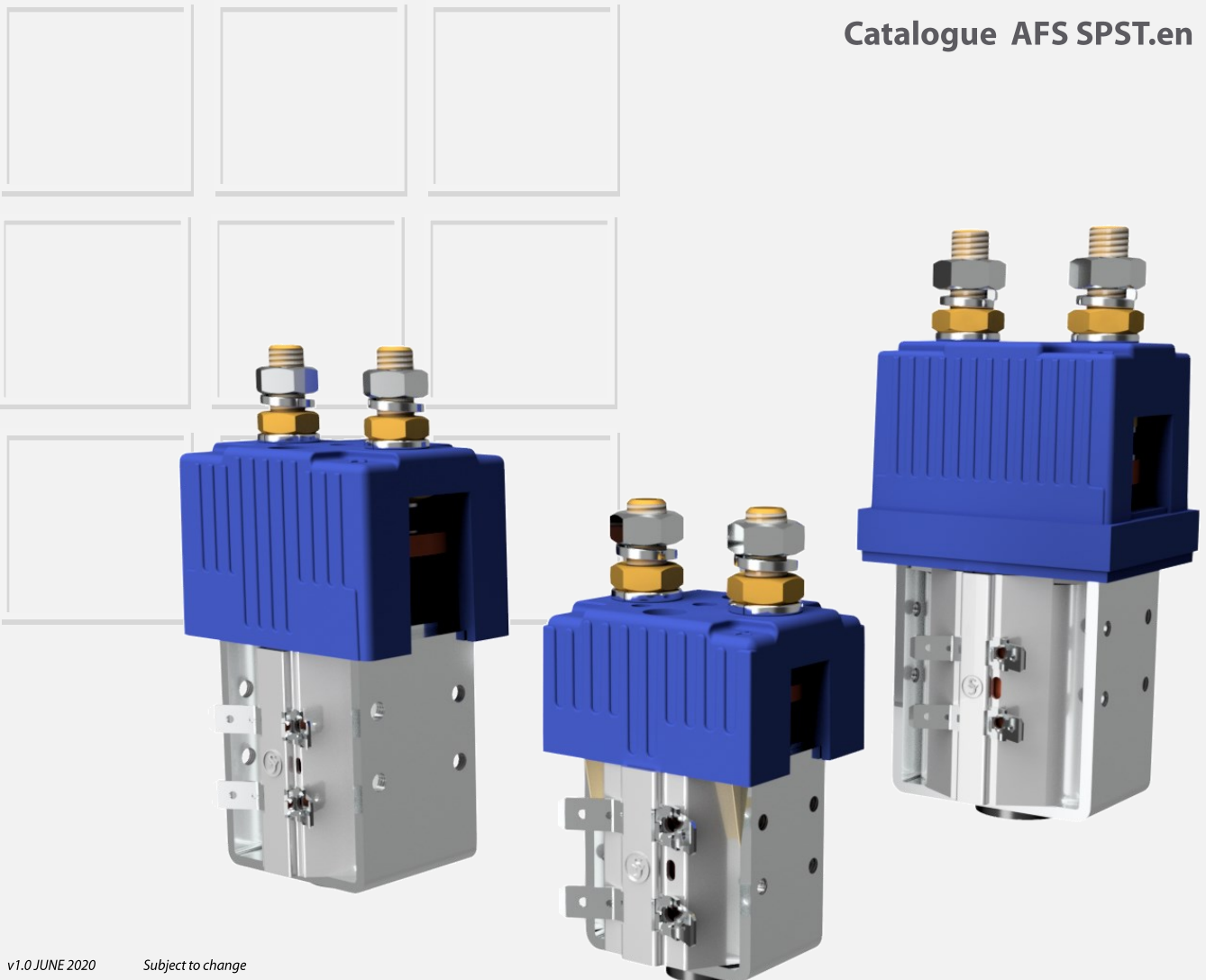
3

Contactors

**AFS SPST Series
AFS19, AFS819 & AFS799**

**Single Pole DC NO contactors for
Industrial truck, AGV, EV, UPS, New
energy & Fixed industrial applications**

Catalogue [AFS SPST.en](#)



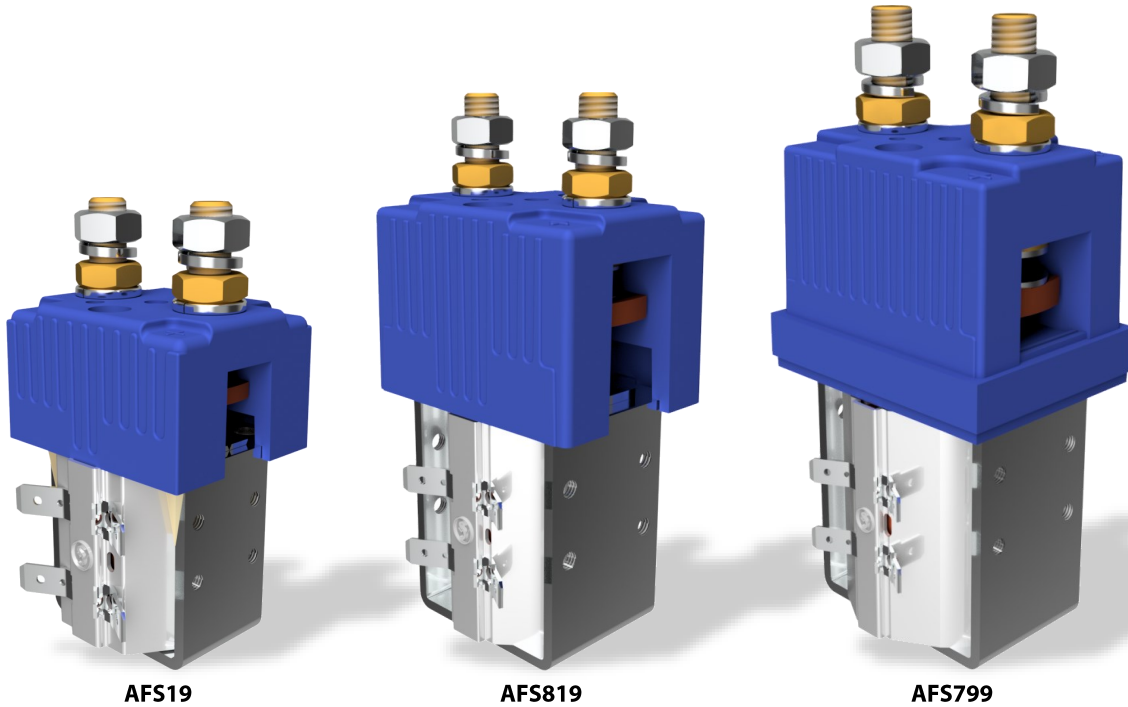
DC contactors for battery voltages AFS SPST Series

Our SPST range of AFS contactors are an economical solution for switching low voltage direct current loads. Developed to suit the requirements of direct on-load and off-load switching, the AFS range is suitable for switching straight resistive or reactive loads.

Operated by a DC control voltage up to 130Vdc, or 230Vac using a mounted rectifier board, to switch high current loads up to 80V—higher voltages can be disconnected and insulated. Permanent magnetic blowout devices can be included to rapidly extend and extinguish the arc when operated under load. This ensures a long service life with respect to electrical endurance. An optional DPST

NO/NC changeover auxiliary switch may be fitted to provide a switch status during operation or directly control class 2 or Limited voltage/current circuits.

This compact and rugged range of contactors are well suited to mobile applications including battery, motor and auxiliary functions in Industrial trucks, EV, AGV and Marine. Fixed installations including power distribution, UPS, telecoms, test equipment, on demand charging. Also smaller mobile plant including welding sets, generators, solar power and compressors.



AFS19

AFS819

AFS799

Features AFS SPST Series

- Single Pole Single Throw
- Normally Open contacts
- Compact and rugged
- Three available sizes
- Double break contacts for high reliability
- Galvanically isolated contacts for safely switching high power loads
- Easily serviceable with spares kits available
- Various mounting and bracket options available
- Various coil configurations to suit all coil duty expectations
- Customisable through a series of options

Approvals AFS SPST Series

Our standard SPST range of AFS contactors has CE approval and conforms to the following standards:

- EN 1175-1
- EN 60947-1
- EN 60947-4-1

Variants of AFS SPST contactors are available as UL recognized components for US and Canada, according to UL file E203761.

- CSA C22.2 No. 60947-113
- UL 583
- UL 60947-1
- CSA C22.2 No. 60947-4-1-14
- UL 1801
- UL 60947-4-1



Note: Only contactors marked with the recognized component mark should be considered UL compliant

Ordering Code AFS SPST Series

The ordering code illustrated provides a couple of options to help you quickly select a contactor for your needs or to help you understand an AFS product you may already have.

There are over 1000 unique AFS variants. The letters at the end of the code denote the variant to distinguish similar contactors apart.

At Schaltbau Machine Electrics we are able to manufacture AFS SPST

contactors to specifically suit any additional requirements you have.

When ordering an AFS SPST contactor please consider the many options illustrated on pages 8-11 and speak to our sales team.

Should you require a bespoke solution, our engineering team can supply customised designs. In this case, however, minimum order quantities apply.

Contactor configuration

AFS	Standard configuration
AFT	Textured fine point tips
AFW	Wrapped & varnished coil
AFE	Metal clad enclosed (EE)
AFX	Special packaging requirement

Series

19	100 A SPST NO
819	150 A SPST NO
799	250 A SPST NO

Contactor Tip Size

L	Standard tips
	Large tips

AFS19 L A / 24 XX

Variant

A	Unique identifier
...	
ZZ	
Coil voltage	
6	6V min.
...	
130	130Vdc max. / 240Vac max.
Auxiliary / Latching	
	No auxiliary
A	DPST NO/NC changeover auxiliary
AM	Magnetic latching

Terminology AFS SPST Series

Term	Abbreviation	Explanation
Single Pole Single Throw	SPST	For a SPST contactor, one control coil is used to connect one input and one output.
Double Pole Single Throw	DPST	For a DPST auxiliary switch, two inputs and two outputs are switched by means of one mechanical connection to a contactor.
Magnetic Latching	AM	Magnetic latching contactors require a 0.3s pulse U_{sn} to pull-in, will maintain connection with no control voltage and then require a 0.3s pulse U_{sn} in reverse to pull-out. These contactors are stable in both states without power but are not recommended on dynamic application subjected to shock and vibrations. An auxiliary switch is recommended to confirm contactor status on startup.
Continuous Operation	CO	A 100% duty cycle where the coil is energised continuously. CO contactors have lower power coils and lighter return springs to limit temperature rise at the coil.
Intermittent Operation	IO	Up to 50% duty cycle where the coil is energised for no longer than 20 continuous minutes. IO contactors have higher power coils with heavier return springs offering superior switching when compared with CO contactors.
Prolonged Operation	PO	Up to 70% duty cycle where the coil is energised for no longer than 60 continuous minutes. PO contactors have medium power coils offering a middle ground offering between IO and CO contactors.
Enclosed	EN / ENC	When included in a contactor's description, an enclosed top cover is used on a contactor to contain any possible plasma arcing. See page 10 for more information.
Blow-Out	BO	When included in a contactor's description, blow-out magnets are used in a contactor to stretch and throw any possible plasma arcing away from the centre of the contactor. See page 10 for more information.
Suppression	SU / SUP	When included in a contactor's description, a suppression device is used on the coil of a contactor to transient loads when the contactor is dropped-out. See page 10 for more information.
Bracket	BK / BKT	When included in a contactor's description, a bracket is mounted on the contactor for ease of installation. See page 12 for more information.

Specifications AFS SPST Series

AFS SPST Series			AFS19	AFS819	AFS799
Voltage					
Type of voltage			DC & AC (w/o BO)		
Switching configuration / Contactor type ⁽¹⁾			1x SPST NO / Type A		
Nominal voltage	U_n		48 V ⁽¹⁾ / 60 V ^(11/12) / 80 V ⁽⁴⁾		
Nominal operating voltage	U_e		48 V ⁽¹⁾ / 60 V ^(11/12) / 80 V ⁽⁴⁾		
Rated insulation voltage ⁽³⁾	U_i	$U_e = 48V / U_e = 80V$	80 V / 150 V		
Rated impulse withstand voltage ⁽³⁾	U_{imp}	$U_e = 48V / U_e = 80V$	0.8 kV / 1.5 kV		
Pollution degree / Overvoltage category ⁽³⁾			PD3 / OV2		
Dielectric strength			1.0 kV ⁽¹⁾ / 1.5 kV ⁽³⁾		
Current					
Conventional free air thermal current	I_{th}	Used contacts, <8h duration	100 A	150 A	250 A
Load wire stranded for I_{th}			25 mm ²	50 mm ²	95 mm ²
Free air thermal current (UL contactors)	I_{th}	UL file E203761	100 A	200 A	350 A
Load wire stranded for I_{th} (UL contactors)		UL file E203761	95 mm ²		
Short time overload capacity		1.5 x I_{th} , used contacts	8 mins 30 secs	13 mins 30 secs	19 mins
Short time overload capacity		2 x I_{th} , used contacts	2 mins 2 secs	2 mins 50 secs	4 mins 15 secs
Short time overload capacity		3 x I_{th} , used contacts	29 secs	45 secs	50 secs
Utilisation category		$U_e = 48V / U_e = 80V$	Category 1 ⁽¹⁾ / DC-1 ⁽³⁾		
Rated short-time withstand current	I_{cw}	$U_e = 48V, \tau \leq 1ms$	800 A	1.5 kA	2.0 kA
Rated short-circuit making capacity	I_{cm}	$U_e = 48V, \tau \leq 1ms$	600 A	1.0 kA	1.6 kA
Rated short-circuit breaking capacity	I_{cn}	$U_e = 48V / U_e = 80V, \tau \leq 1ms$	300 A / 200 A	500 A / 300 A	1.3 kA / 900 A
Rated Breaking capacity		$U_e = 48V (\tau = 15ms) (1) / U_e = 80V (\tau \leq 1ms) (3)$	600 A / 150 A	900 A / 225 A	1.5 kA / 375 A
Coil					
Nominal coil voltage	U_{sn}		6 to 130 V DC (230 V AC optional)		
Coil pull-in voltage tolerance	$U_{s,pull-in}$	$T_a = 20^\circ C$	60% (IO) / 63% (PO) / 66% (CO) to 110% U_{sn}		
Coil pull-in voltage tolerance ^(1/4)	$U_{s,pull-in}$	$T_a = 40^\circ C$	70% (IO & PO) / 85% (CO) to 110% U_{sn}		
Coil drop-out voltage	$U_{s,drop-out}$	$T_a = 20^\circ C$	<40% U_{sn} (15% typ.)		
Coil power dissipation at 20°C		IO / CO	18 / 11 W	33 / 14 W	39 / 16 W
Physical					
Main contact material			AgSnO ₂ EMB10 90/10 (Silver/Tin oxide)		
Main contact terminal size / Recommended torque			M8 / 7 Nm	M10 / 10 Nm	
Coil terminals (standard)		configuration 1	6.3 mm blade terminals		
Degree of protection ⁽¹⁰⁾			IP00		
Vibration ⁽⁷⁾			5g (10 Hz to 500 Hz)		
Shock ⁽⁹⁾			100g (6 ms, half sinus)		
Bump ⁽⁹⁾			20g (10 ms, half sinus)		
Mechanical endurance		life cycles	> 1 x 10 ⁶ (CO) / > 3 x 10 ⁶ (PO & IO)		
Electrical endurance		$U=U_e, I=I_{th}, \tau \leq 1ms, cycle = 6/min$	> 100,000 cycles		
Packaged weight		typ.	430 g	680 g	1280 g
Environment					
Operating ambient temperature ^(1/8)			-25 °C to +40 °C (up to 60°C upon request)		
Storage temperature ^(5/6)			-40 °C to +85 °C		
Relative humidity ⁽²⁾		yearly average, no condensation	30% to 95%		

1. EN 1175-1

4. EN 60947-4-1

7. EN 60068-2-6

10. IEC 60529

2. EN 50125-1

5. EN 60068-2-1

8. EN 60068-2-14

11. UL 60947-4-1

3. EN 60947-1

6. EN 60068-2-2

9. EN 60068-2-27

12. CSA C22.2 No. 60947-4-1-14

AFS19 Single pole NO contactor 100 A DC

AFS19 Series contactors are designed for continuous thermal currents of 100 A DC and short duration currents up to 300 A DC for battery voltages up to 80 V.

The AFS19 is a single pole NO contactor suitable for use as a main or auxiliary contactor.

The contactors are fitted with DC coils featuring an extra wide coil

tolerance as required for traction batteries of industrial trucks and other battery-powered vehicles.

Refer to data sheet on page 4 for detailed specifications.

Please note, data provided should only be used as a guide. Data may need de-rating depending on the application. The engineering team are able to offer support where required.

Dimensions and Circuit Diagram AFS19

Below are the relevant dimensions and circuit diagram for a standard AFS19 contactor. An auxiliary switch is shown for illustration purposes. More detailed information about the optional auxiliary switch refer to page 8.

For different coil options refer to page 9.

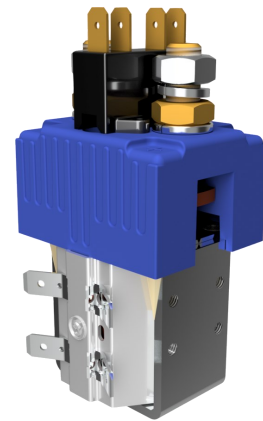
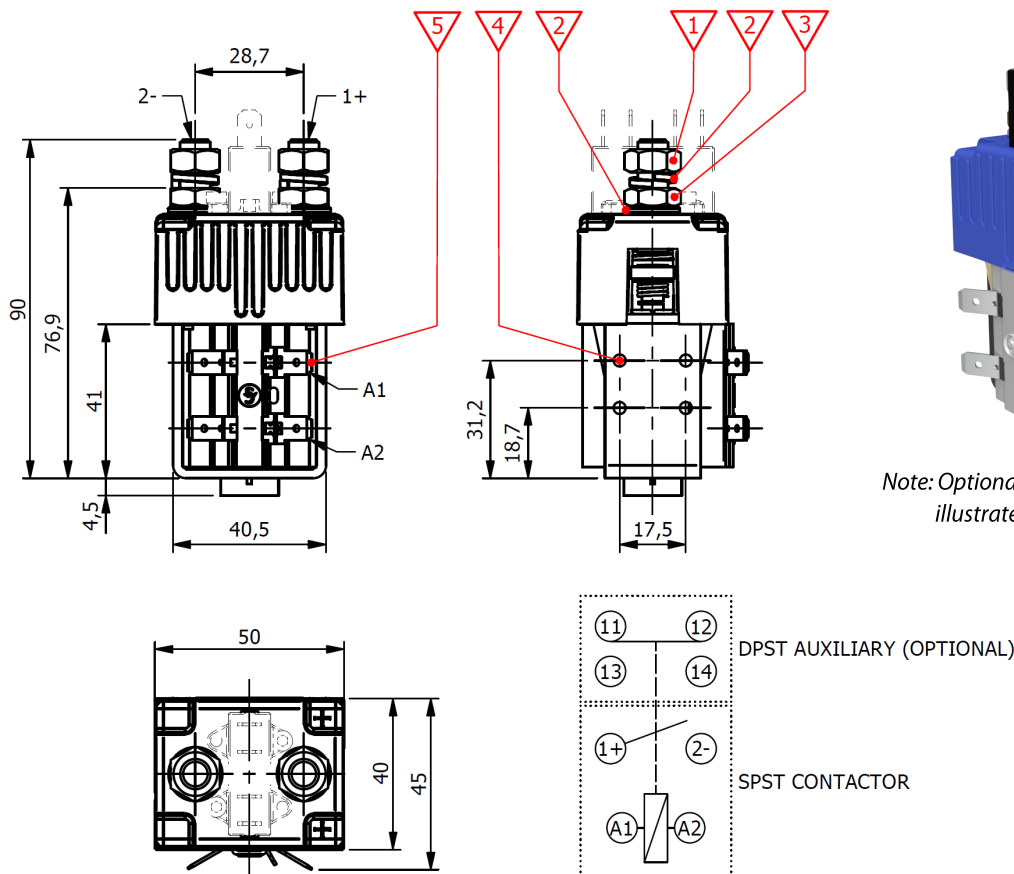
For different contactor options such as coil suppression, auxiliary

contacts, enclosed top covers, magnetic blowouts, large and/or textured tips and steel shrouds please refer to page 10.

For mounting solutions refer to page 11.

For mounting instructions including minimum distances refer to page 12.

Different mounting hole patterns are available upon request.



Note: Optional auxiliary switch shown to illustrate installation position

1 MAIN CONTACT CONNECTION
M8 STEEL CLEAR ZINC PLATED NUT
MAX. TORQUE: 7 Nm

2 M8 SPLIT WASHER

3 M8 CZ101 BRASS NUT
MAX. TORQUE: 3 Nm

4 CONTACTOR MOUNTING
4x M4x0.7 x 2.5 DEEP
MAX. TORQUE: 2 Nm

5 COIL/SOLENOID CONNECTION
2x 6.3x0.8 mm BLADE TERMINALS

AFS819 Single pole NO contactor 150 A DC

AFS819 Series contactors are designed for continuous thermal currents of 150 A DC and short duration currents of up to 450 A DC for battery voltages up to 80 V.

The AFS819 is a single pole NO contactor suitable for use as a main or auxiliary contactor.

The contactors are fitted with DC coils featuring an extra wide coil

tolerance as required for traction batteries of industrial trucks and other battery-powered vehicles.

Refer to data sheet on page 4 for detailed specifications.

Please note, data provided should only be used as a guide. Data may need de-rating depending on the application. The engineering team are able to offer support where required.

Dimensions and Circuit Diagram AFS819

Below are the relevant dimensions and circuit diagram for a standard AFS819 contactor. An auxiliary switch is shown for illustration purposes. More detailed information about the optional auxiliary switch refer to page 8.

For different coil options refer to page 9.

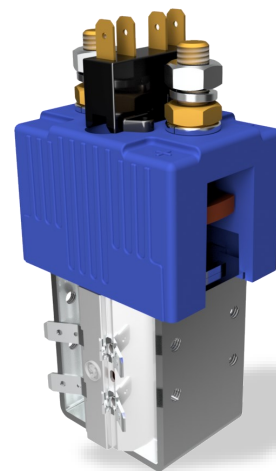
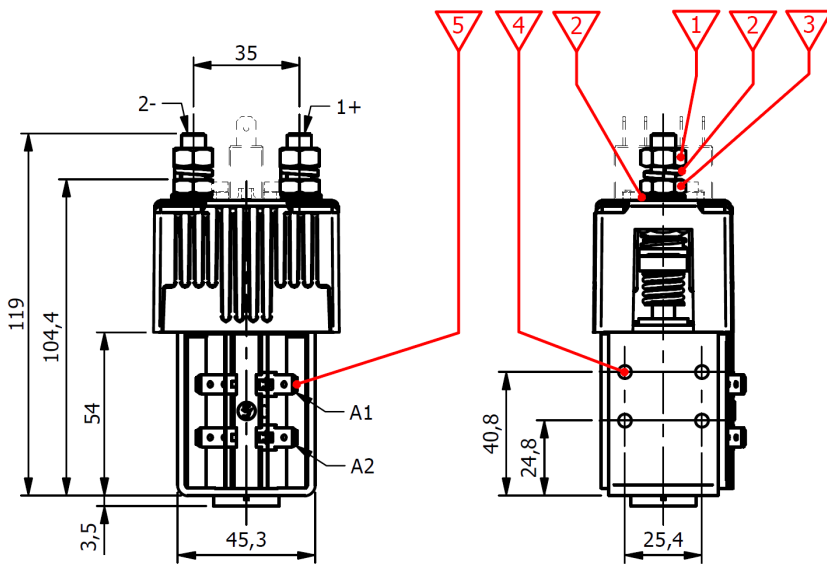
For different contactor options such as coil suppression, auxiliary

contacts, enclosed top covers, magnetic blowouts, large and/or textured tips and steel shrouds please refer to page 10.

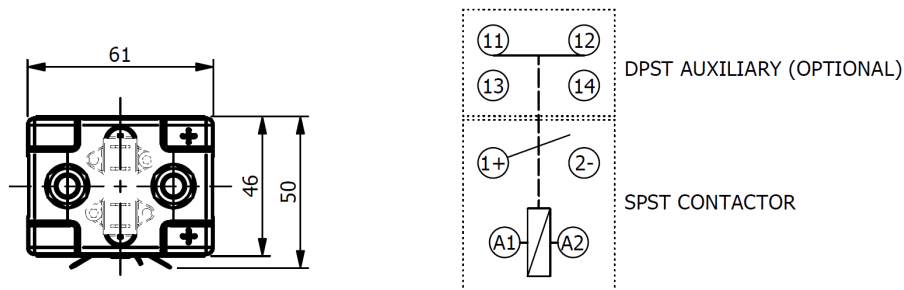
For mounting solutions refer to page 11.

For mounting instructions including minimum distances refer to page 12.

Different mounting hole patterns are available upon request.



Note: Optional auxiliary switch shown to illustrate installation position



1 MAIN CONTACT CONNECTION
M8 STEEL CLEAR ZINC PLATED NUT
MAX. TORQUE: 7 Nm

2 M8 SPLIT WASHER

3 M8 CZ101 BRASS NUT
MAX. TORQUE: 3 Nm

4 CONTACTOR MOUNTING
4x M5x0.8 x 2.5 DEEP
MAX. TORQUE: 3 Nm

5 COIL/SOLENOID CONNECTION
2x 6.3x0.8 mm BLADE TERMINALS

AFS799 Single pole NO contactor 250 A DC

AFS799 Series contactors are designed for continuous thermal currents of 250 A DC and short duration currents of up to 750A for battery voltages of up to 80 V.

The AFS799 is a single pole NO contactor suitable for use as a main or auxiliary contactor.

The contactors are fitted with DC coils featuring an extra wide coil

tolerance as required for traction batteries of industrial trucks and other battery-powered vehicles.

Refer to data sheet on page 4 for detailed specifications.

Please note, data provided should only be used as a guide. Data may need de-rating depending on the application. The engineering team are able to offer support where required.

Dimensions and Circuit Diagram AFS799

Below are the relevant dimensions and circuit diagram for a standard AFS799 contactor. An auxiliary switch is shown for illustration purposes. More detailed information about the optional auxiliary switch refer to page 8.

For different coil options refer to page 9.

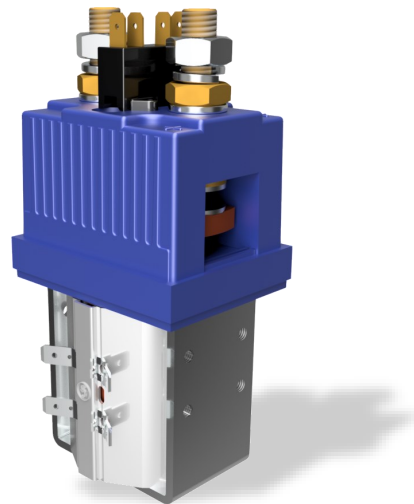
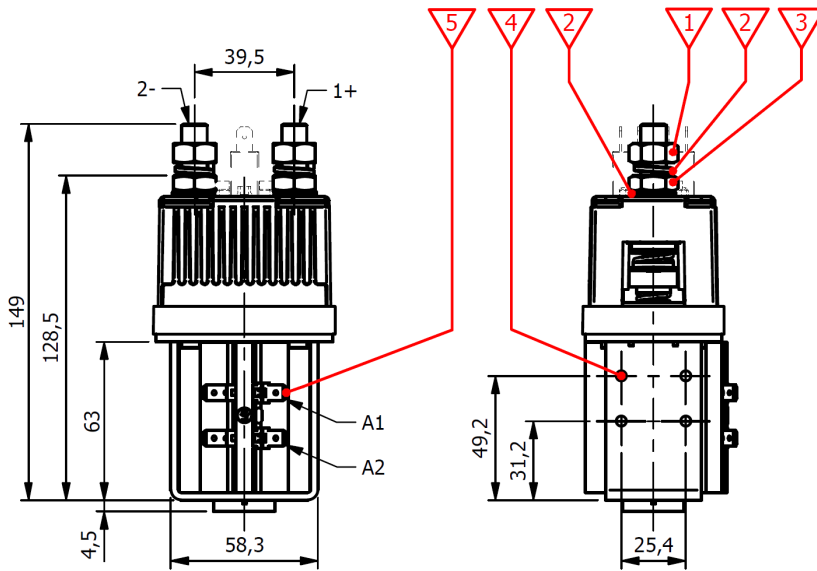
For different contactor options such as coil suppression, auxiliary

contacts, enclosed top covers, magnetic blowouts, large and/or textured tips and steel shrouds please refer to page 10.

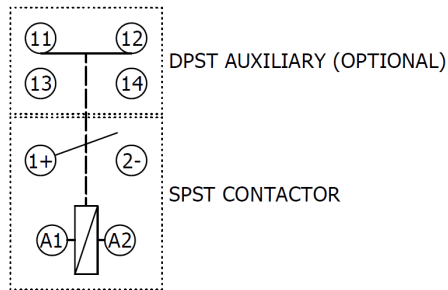
For mounting solutions refer to page 11.

For mounting instructions including minimum distances refer to page 12.

Different mounting hole patterns are available upon request.



Note: Optional auxiliary switch shown to illustrate installation position



1 MAIN CONTACT CONNECTION
M10 STEEL CLEAR ZINC PLATED NUT
MAX. TORQUE: 10 Nm

2 M10 SPLIT WASHER

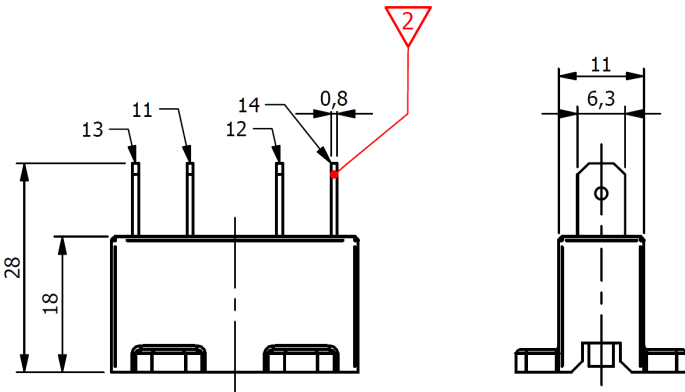
3 M10 CZ101 BRASS NUT
MAX. TORQUE: 4 Nm

4 CONTACTOR MOUNTING
4x M5x0.8 x 2.5 DEEP
MAX. TORQUE: 3 Nm

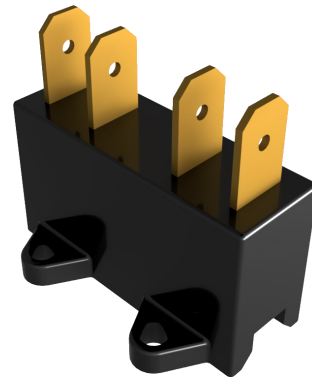
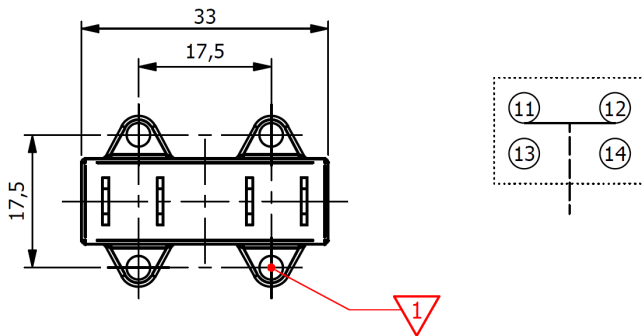
5 COIL/SOLENOID CONNECTION
2x 6.3x0.8 mm BLADE TERMINALS

Auxiliary Contact (Optional) AFS SPST Series

If you need to check the switch status of an AFS SPST contactor, an auxiliary contact can be supplied.



- 1** M3 CLEARANCE HOLE
MAX. TORQUE: 0.3 Nm
- 2** SWITCH CONNECTIONS
4x 6.3x0.8mm BLADE TERMINALS
- 3** AUXILIARY SWITCHING CAPACITY
AT 24 V DC: 5A
AT 48 V DC: 2A



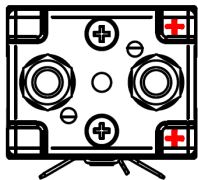
Contactor Configurations AFS SPST Series

AFS SPST can be built to eight contactor configurations which determine the orientation of the top cover and any brackets.

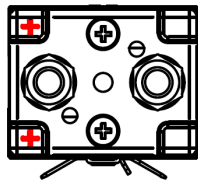
The top cover orientation is especially important when blowout magnets are used as incorrect polarity upon installation can result in the contactor becoming damaged by the plasma arc.

The bracket options illustrated can be used in conjunction with the top-hat, 'L' shaped or integrated brackets shown on page 11.

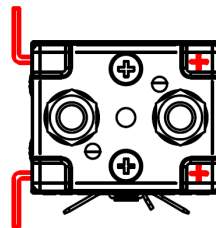
By providing the correct configuration from the image below to our sales team ensures that the product is built exactly to your needs.



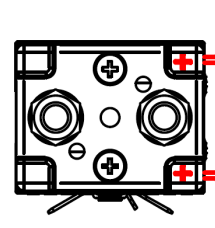
Configuration 1:



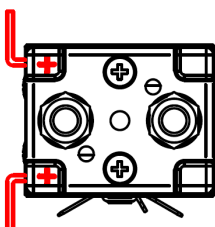
Configuration 2:



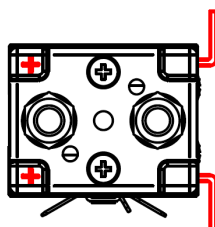
Configuration 3:



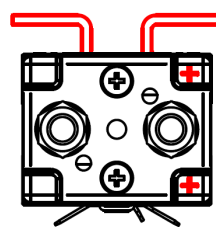
Configuration 4:



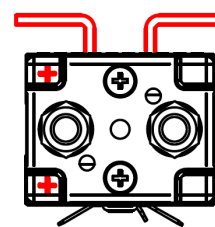
Configuration 5:



Configuration 6:



Configuration 7:



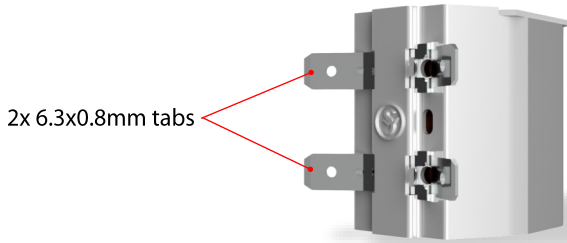
Configuration 8:

Coil Options AFS SPST Series

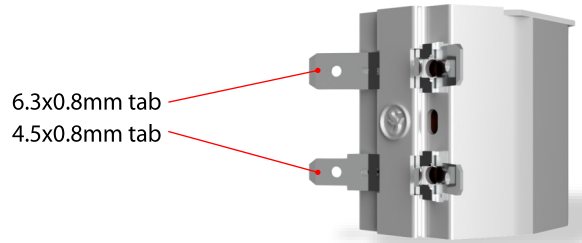
Our standard AFS contactors come with two 6.3x0.8mm tabs for the coil connection (see configuration 1 below) but we are able to offer many other options to suit your application. Should you require a configuration illustrated below, speak to a member of our Sales team.

Different tabs sizes between A1 and A2 can prevent accidental wrong polarity connection when coil suppression is employed, coils with no suppression are not polarity sensitive. For coil suppression options please refer to page 10.

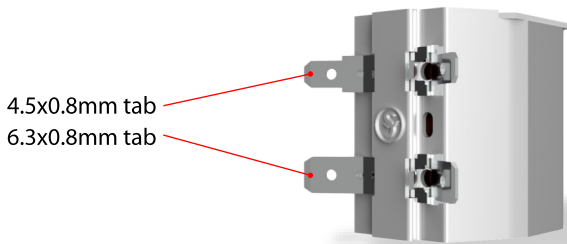
Coil Configuration 1:



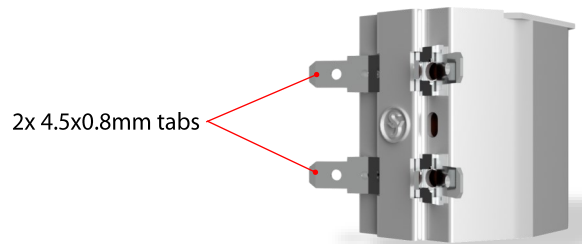
Coil Configuration 2:



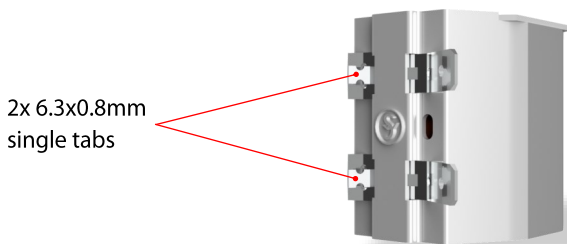
Coil Configuration 3:



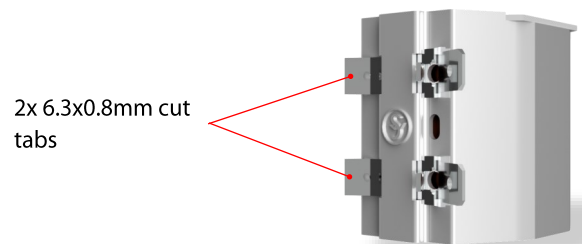
Coil Configuration 4:



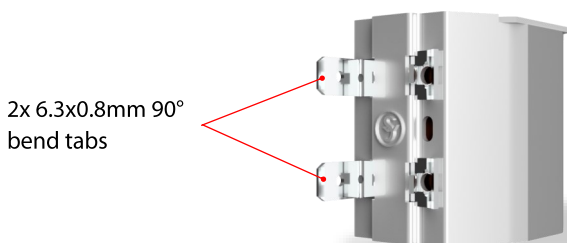
Coil Configuration 5:



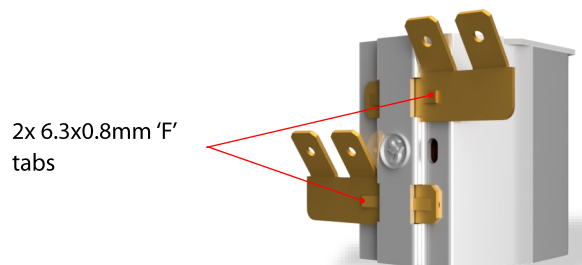
Coil Configuration 6:



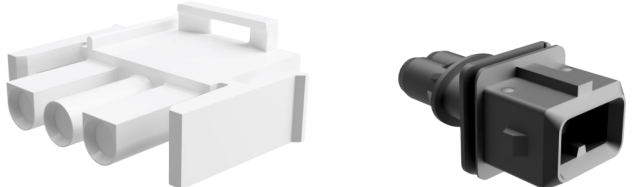
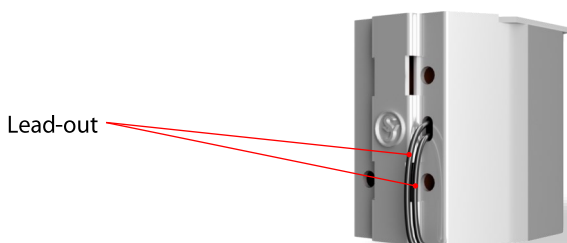
Coil Configuration 7:



Coil Configuration 8:



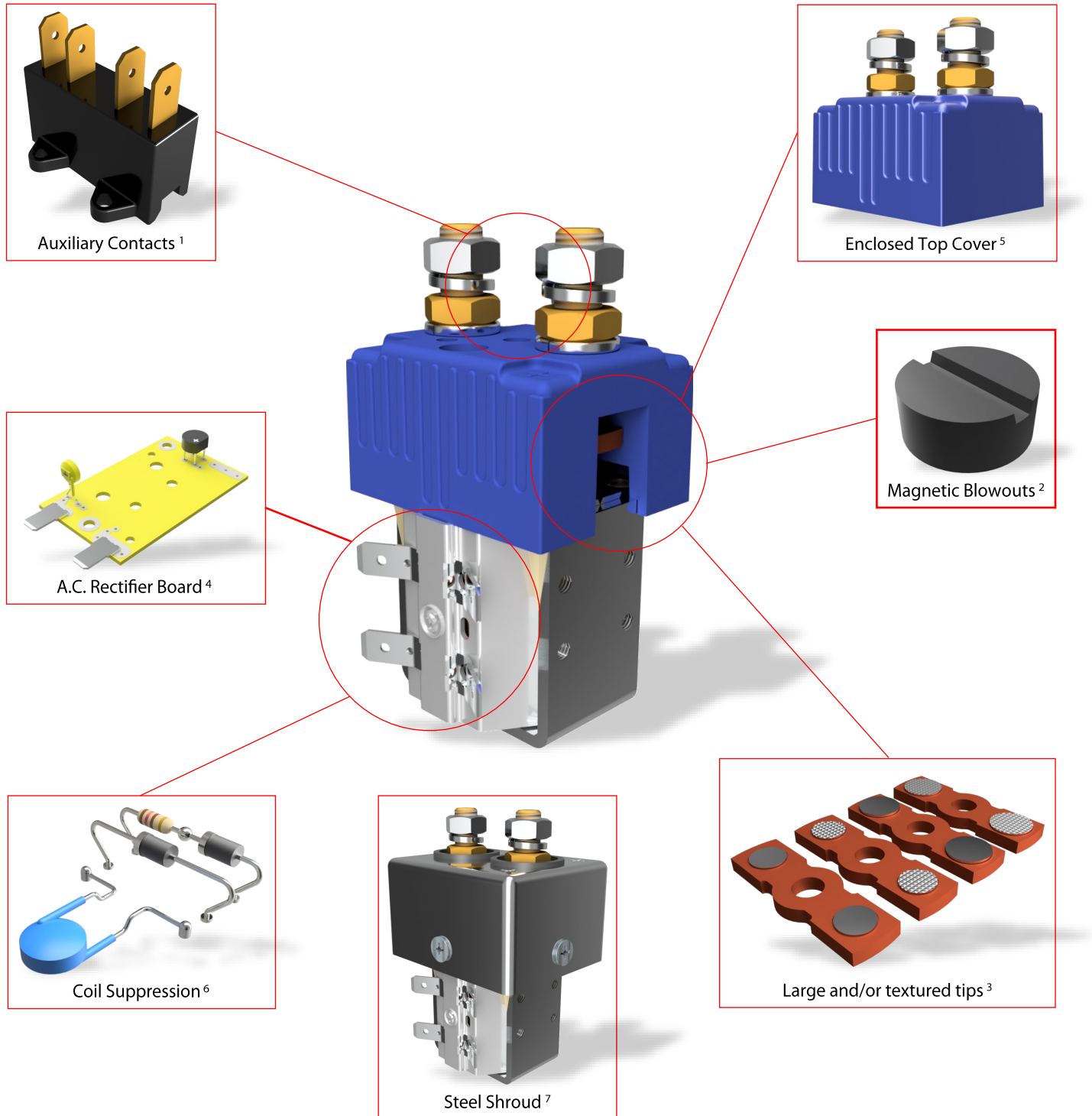
Coil Configuration 9:



Connectors can be terminated onto coil leads where requested.

Contactor Options AFS SPST Series

Below are a list of options available for the AFS range of contactors. Speak to our Sales team if you require any of these options.

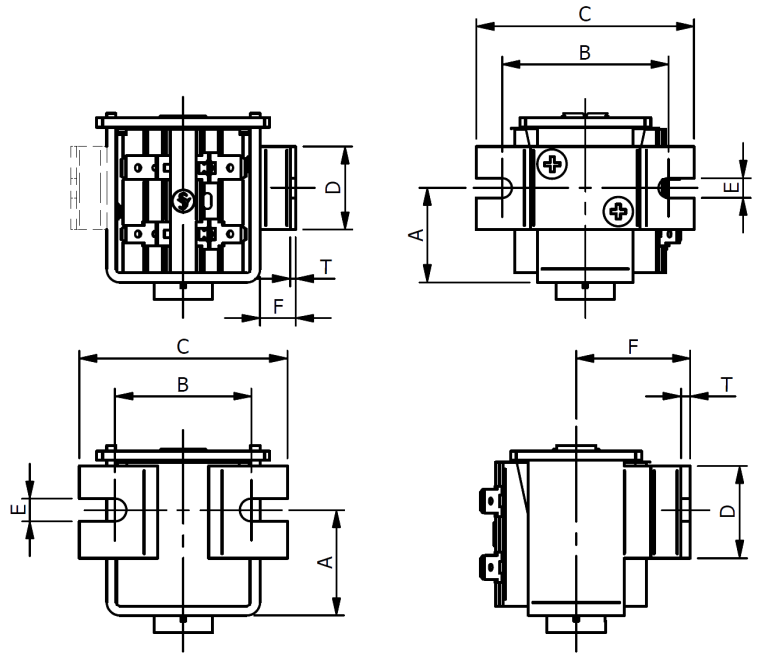
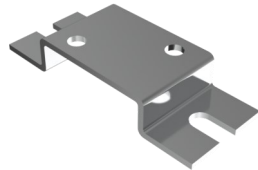


1. Auxiliary contacts can provide a switch status for the contactor. See page 8 for details.
2. Magnetic blowouts are recommended for inductive uni-directional loads, voltages 48V and above and for improved electrical endurance in demanding applications.
3. Contact tips can be enlarged and/or textured. Large tips improve endurance whilst textured tips break through contamination build up.
4. An A.C. rectifier board can be supplied to allow solenoid control coils to be driven from AC supplies for simplified fixed installation.
5. Enclosed top covers contain the plasma arc during switching and allows the clearance distance around the top cover to be reduced.
6. Suppression is optional to reduce high voltage transients on drop out. Flyback diodes offer the highest suppression but slower drop out time. Adding a series resistor recovers some drop out time, but allows a higher transient spike. Varistors provide a direct short circuit in the event of higher than expected coil supply voltages, taking out the supply fuse.
7. A steel shroud can be supplied for hazardous environments as an optional extra as required for type EE trucks.

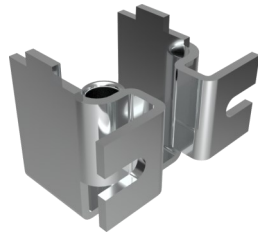
Bracket Options AFS SPST Series

Our SPST AFS contactors can be supplied with a range of different mounting options as illustrated below. Some of which can be ordered separately. Brackets to hold multiple contactors are also available. Speak to our Sales team for more information.

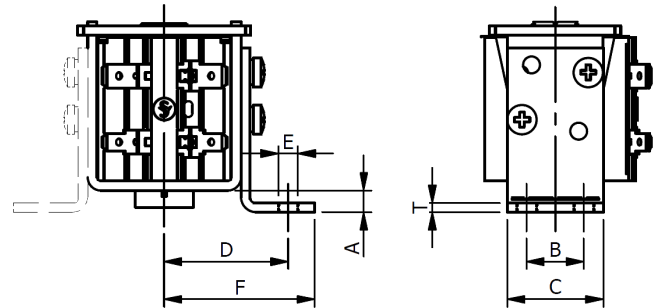
Top Hat Bracket:



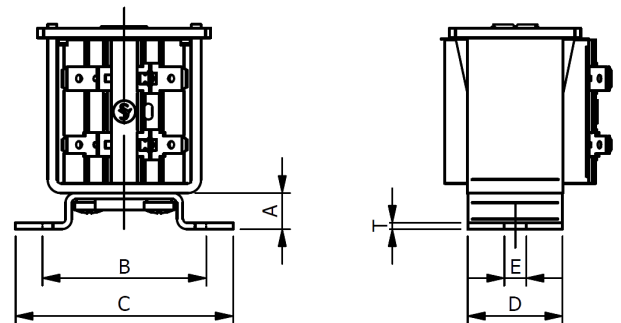
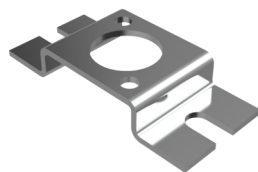
Integrated Bracket:
Note: Only available for AFS19



'L' Shaped Bracket:



Base Mount Bracket:
Note: Only available for AFS19

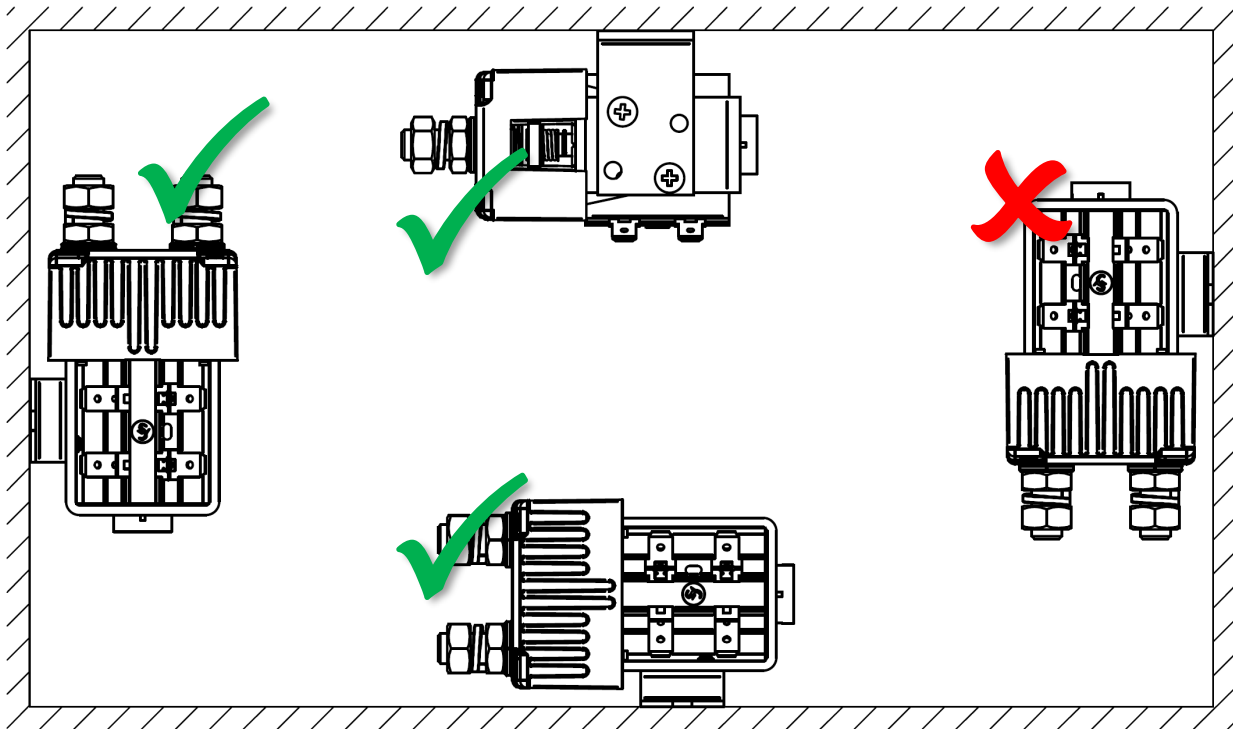


	Top Hat Bracket			Integrated Bracket			'L' Shaped Bracket			Base Mount Bracket		
	AFS19	AFS819	AFS799	AFS19	AFS819	AFS799	AFS19	AFS819	AFS799	AFS19	AFS819	AFS799
A	25,0	32,8	40,2	27,9	-	-	5,8	10,3	9,3	9,5	-	-
B	44,0	61,1	75,1	36,0	-	-	15,1	22,5	22,5	43,3	-	-
C	57,5	80,0	101,0	55,0	-	-	25,4	38,0	38,0	57,5	-	-
D	22,0	31,7	32,0	24,3	-	-	32,8	35,7	42,2	25,0	-	-
E	5,2	6,5	7,0	6,0	-	-	5,2	6,0	6,0	5,8	-	-
F	9,5	14,6	18,5	30,2	-	-	39,8	42,7	49,2	-	-	-
T	1,5	2,0	2,0	2,5	-	-	2,5	3,0	3,0	1,6	-	-

Mounting Instructions AFS SPST Series

AFS contactors can be mounted vertically or horizontally but should never be mounted upside down. Always observe minimum distances when installing against grounded components. The image below assumes enclosed top covers are used.

For mounting solutions refer to page 11.



For Enclosed Top Covers

Minimum Distances AFS SPST Series

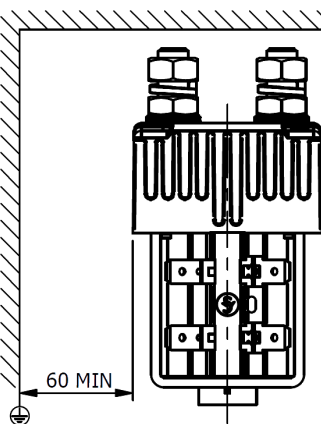
Special care and attention should be taken to observe minimum distances when installing AFS contactors and other components. The illustrations below provide minimum distances around an AFS contactor for grounded components.

For open top covers, when contactors switch under load arc plasma is ejected outside of the contactor top cover. The distance ejected increases with the use of blowout magnets or inductive loads. Ensure

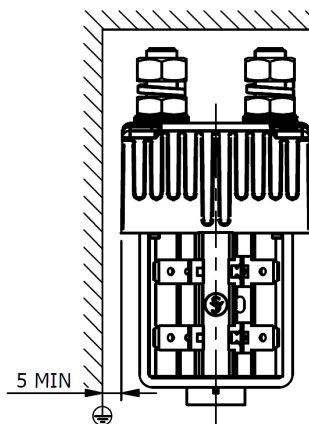
recommended clearances are observed.

In assemblies where load switching is not expected, consider application fault conditions.

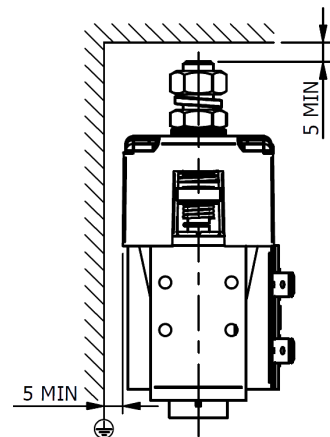
For contactors mounted against a surface, including horizontally mounted contactors, always consider the minimum distance to ground or use an enclosed top cover.



For Open Top Covers



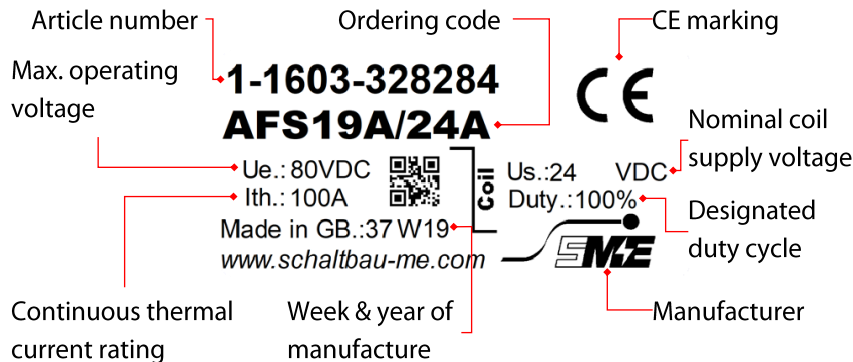
For Enclosed Top Covers



For Open/Enclosed Top Covers

Labelling Information AFS SPST Series

Every AFS SPST contactor is delivered with a product label attached to the top cover and a usage leaflet included with the package.



GB Important Usage Advice

When used in industrial trucks this contactor meets the requirements for switching capacity according to EN 1175-1:1998 + A1:2010, chapter 5.5, category 1 (50 operations with $I=6 \times I_{th}$, $U=U_e$, $L/R=15\text{ms}$) only for contact voltages $\leq 48\text{V}$. For voltages up to 80 V, utilization category DC1 of EN 60947-4-1:2010 applies.

Usage advice leaflet provided in 22 different languages

Maintenance and Safety Instructions AFS SPST Series

Maintenance:

- AFS series contactors are basically maintenance free.
- Make regular in-depth visual inspections once or twice a year.
- Lightly remove dust to ensure continued reliable service.
- Should you require any spare parts speak to our Sales team.



Defective contactors or parts (e.g. top covers, auxiliaries) must be replaced immediately

Safety Instructions:

- Only qualified competent persons should install AFS contactors, ensuring isolation of all supplies before doing so.
- The device must be used according to the intended purpose as specified in the technical documentation. You are obliged to observe all specifications depending on operating temperature, degree of pollution etc. that are relevant to your application.
- Without further safety measures the AFS Series contactors are not suited for use in potentially explosive atmospheres.
- In case of malfunction of the device or uncertainties stop using it any longer and contact the manufacturer instantly.
- Tampering with the device can seriously affect the safety of people and equipment. This is not permitted and leads to an exclusion of liability and warranty.
- Coil suppression for reducing surges when the coil is switched off is optimally attuned to the contactor's switching behaviour. The existing opening characteristic must not be negatively influenced by parallel connection with an external diode.
- Contactors running permanently may heat up. So make sure that the contactor has sufficiently cooled down before you start any inspection or maintenance work.
- When installing AFS contactors with magnetic blowout make sure to do it in such a way that no magnetisable parts can be attracted by the permanent magnets that are also capable of destroying all data of swipe cards.
- Strong electromagnetic induction caused when switching off can influence other components installed near the contactor.
- Improper handling of the contactor, e.g. when hitting the floor with some impact, can result in breakage, visible cracks and deformation.

Schaltbau Machine Electrics

For detailed information on our products and services visit our website or give us a call!

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with compliments:



Schaltbau Machine Electrics manufactures in accordance with the EU's RoHS directive



Certified to ISO 14001 since 2010. For the most recent certificate visit our website.



Certified to ISO 9001 since 1996. For the most recent certificate visit our website.

Electrical Components and Systems for Railway Engineering and Industrial Applications

Connectors

- Connectors manufactured to industry standards
- Connectors to suit the special requirements of communications engineering (MIL connectors)
- Charging connectors for battery-powered machines and systems
- Connectors for railway engineering, including UIC connectors
- Special connectors to suit customer requirements

Snap-action switches

- Snap-action switches with positive opening operation
- Snap-action switches with self-cleaning contacts
- Enabling switches
- Special switches to suit customer requirements

Contactors

- Single and multi-pole DC contactors
- High-voltage AC/DC contactors
- Contactors for battery powered vehicles and power supplies
- Contactors for railway applications
- Terminal bolts and fuse holders
- DC emergency disconnect switches
- Special contactors to suit customer requirements

Electrics for rolling stock

- Equipment for driver's cab
- Equipment for passenger use
- High-voltage switchgear
- High-voltage heaters
- High-voltage roof equipment
- Equipment for electric brakes
- Design and engineering of train electrics to customer requirements