3TL Vacuum Contactors

Medium-Voltage Equipment
Selection and Ordering Data

Catalog HG 11.21 · 2008

Answers for energy.

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3TL vacuum contactors – The Untiring

3TL vacuum contactors are three-pole contactors with electromagnetic operating mechanism for medium-voltage switchgear. They are load breaking devices with a limited short-circuit making and breaking capacity for applications with high switching rates of up to 1 million electrical operating cycles or 3 million mechanical operating cycles.

3TL6 vacuum contactor – The Compact

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As the operating mechanism is located at the rear, 3TL6 vacuum contactors have a very compact design. This arrangement also enables front access to the main conductor terminals as well as very variable installation options.

In 3TL7 (bottom right figure) / 3TL8 (top right figure) contactors, the low-voltage and medium-voltage components are not arranged one behind the other (3TL6), but one above the other. This provides a slim design which can easily be mounted on the different switchgear and frame structures.

3TL7/3TL8 vacuum contactors – The Slim

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Switching medium

The vacuum switching technology, proven and fully developed for more than 30 years, serves as arc-quenching principle by using vacuum interrupters.

Construction

3TL vacuum contactors consist of a medium-voltage and a low-voltage part. Together with the main conductor terminals, the vacuum interrupters constitute the medium-voltage part. All components required to operate the vacuum interrupter, such as the operating mechanism, closing latch and control unit make up the low-voltage part. These components can be arranged either one behind the other (3TL6) or one above the other (3TL7 and 3TL8).

Application examples

The vacuum contactors are suitable for operational switching of alternating current consumers in indoor switchgear, and can be used, e.g., for the following switching duties:

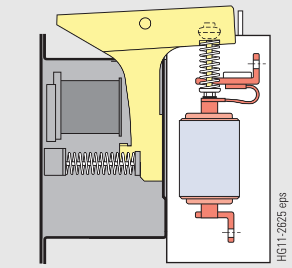
- Motor starting
- Plugging or reversing the direction of rotation of motors
- Switching of transformers
- Switching of reactors
- Switching of resistive consumers such as electrical furnaces
- Switching of capacitors.

With these duties, the contactors are used in conveying and elevator systems, pumping stations, air conditioning systems as well as in systems for reactive power compensation, and can therefore be found in almost every industrial sector.

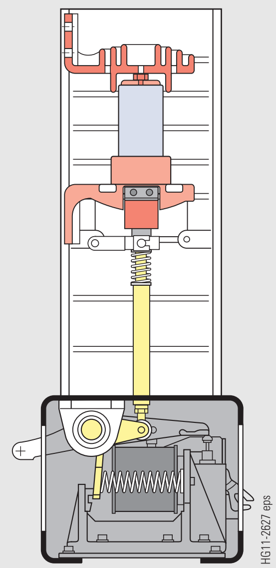
In contactor-type reversing starter combinations (reversing duty), only one contactor is required for each direction of rotation if HV HRC fuses are used for short-circuit protection.

Design

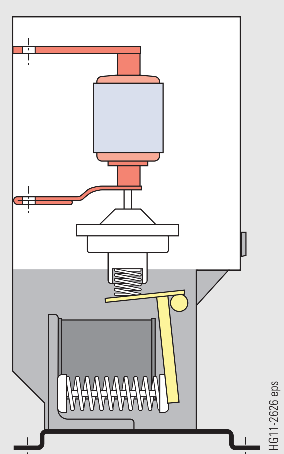
3TL vacuum contactors are designed as an open construction, degree of protection IP00 according to IEC 60529 and DIN EN 60529.



3TL6 vacuum contactor

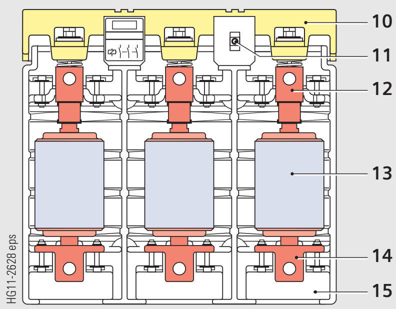


3TL7 vacuum contactor

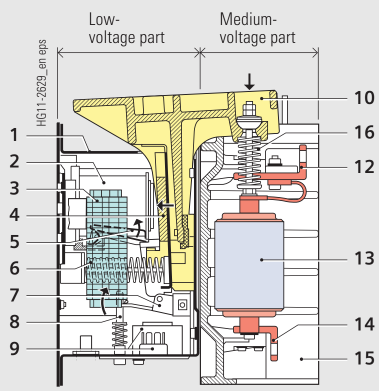


3TL8 vacuum contactor

Construction and mode of operation



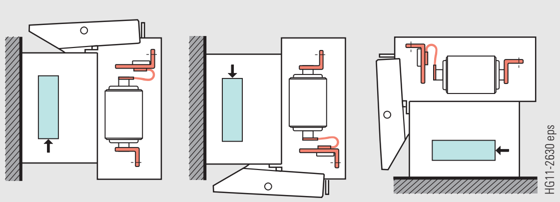
Construction of the 3TL6 vacuum contactor
(front view)



Construction of the 3TL6 vacuum contactor in "OPEN" position
Side view from the left (section).
The arrows show the moving direction for "CLOSE"

Legend

1 Operating mechanism box
2 Magnet system (magnet coil) with rectifier and economy resistor
3 Terminal strip
4 Magnet armature
5 Mechanical closing lock-out
6 Opening spring
7 Latch
8 Tripping bolt
9 Latch release solenoid with rectifier and varistor module
10 Integral rocker
11 Position indicator O - I
12 Upper main conductor terminal
13 Vacuum interrupter
14 Lower main conductor terminal
15 Molded-plastic housing
16 Contact pressure spring



Wall mounting
Vertical arrangement

Vertical arrangement
(turned by 180°)

Floor mounting
Horizontal arrangement

The arrow shows the arrangement of the terminal strip

3TL6 vacuum contactor

Mode of operation

The atmospheric pressure exerts a force on the metal bellows of the vacuum interrupter. Without the influence of the operating mechanism, this would close the contact gap. The opening springs (6) keep the moving interrupter contact in open position via the integral rocker (10). To close the vacuum contactor, the compressive force of the opening springs (6) is overcome by the magnet system (2). The magnet armature (4) is attracted, thus moving the integral rocker (10), which releases the moving interrupter contact from the open position. The atmospheric pressure closes the contacts. The integral rocker (10) compresses the contact pressure springs (16), thus generating the necessary contact force. When the magnetic excitation is de-energized, the opening springs (6) open the contact gap via the integral rocker (10) and the moving interrupter contact. The DC magnet system operates as an economy circuit, proving a high mechanical endurance and a low pickup and holding power.

Mechanical closing latch

The latch (7) holds the vacuum contactor in closed position even without excitation of the magnet system. When the magnet system is energized, the integral rocker is latched mechanically in the "CLOSED" position through a lever and roller system. The vacuum contactor is released electrically by means of a latch release solenoid (9) or mechanically by the tripping bolt (8).

Mechanical closing lock-out

The mechanical closing lock-out (5) prevents unintentional closing of the vacuum contactor, e.g. due to vibrations or while racking the withdrawable part. During operational switching, the closing lock-out is inactive.

Installation position

3TL6 vacuum contactors can be installed in different positions. Besides wall mounting (vertical arrangement), they can also be mounted on the floor (horizontal arrangement).

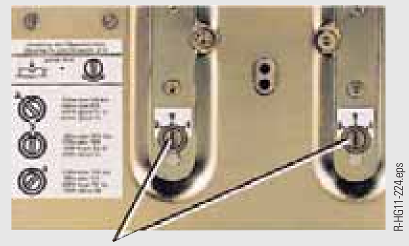
3TL6 vacuum contactor (continuation)

Adjustment to the site altitude

At the factory, the vacuum contactor is adjusted to a site altitude of – 200 m to + 1250 m above sea level. For other site altitudes, the contactor must be adapted to the corresponding site altitude range by means of adjusters located on the rear side of the device (see figure on the right).

Blocking element to interlock two contactors

To interlock two contactors mutually for reversing duty, a mechanically operating blocking element is available on request (for 3TL61 only). The blocking element is fixed between the two contactors, blocking the movement of the operating rocker of the two contactors alternatively. This excludes a phase short-circuit that could occur when the two directions of rotation are activated simultaneously as a result of mechanical impact and electrical maloperation.



Adjusters (on the rear side of the device) to set the site altitude

Setting ranges above sea level:
1. + 1250 m to + 2500 m
2. – 200 m to + 1250 m
3. – 1250 m to + 200 m

3TL7 vacuum contactor

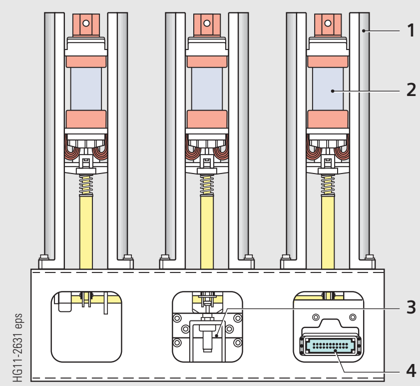
Construction

3TL7 vacuum contactors have two slim pole shells above the operating mechanism. The vacuum interrupters (2) are fixed between two pole half-shells (1). This design enables easy and universal installation on the different switchgear and frame structures. The low-voltage part contains the magnetic drive, auxiliary contactor and auxiliary contacts.

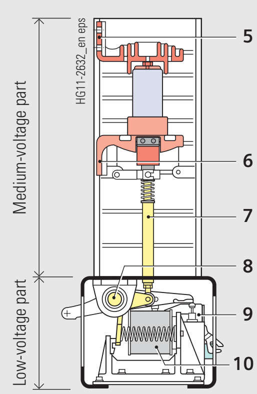
Mode of operation

The magnetic drive of the 3TL7 vacuum contactor opens and closes the contacts of the vacuum interrupters. Due to the use of a special double coil, the magnetic drive is designed for the closing and holding process.

To implement a mechanical interlocking between the withdrawable part of the switchgear and the vacuum contactor, there is a lug available on the operating shaft which transfers the signalling commands.

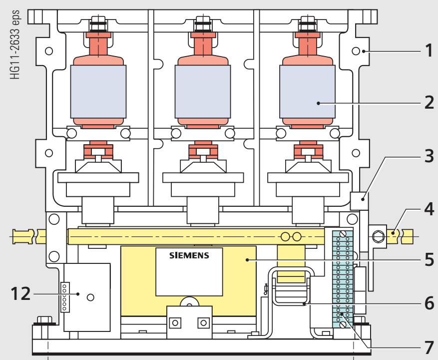


Construction of the 3TL7 vacuum contactor (front view)

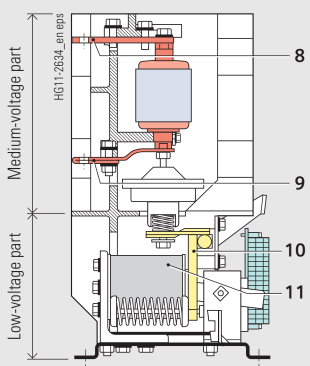


Legend
1 Pole half-shell
2 Vacuum interrupter
3 Mechanism section
4 Auxiliary plug connector
5 Upper main conductor terminal
6 Lower main conductor terminal
7 Mechanical connection between medium-voltage and low-voltage part
8 Operating shaft
9 Auxiliary contact block
10 Magnet system (magnet coil)

3TL7, side view from the left (section)



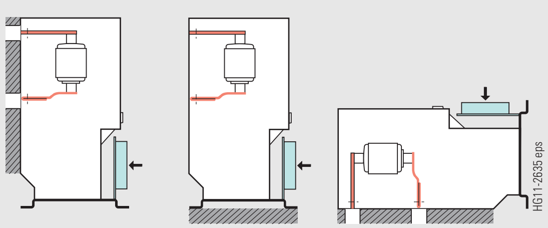
Construction of the 3TL8 vacuum contactor
(front view)



3TL8, side view from the left
(section)

Legend

1 Molded-plastic housing
2 Vacuum interrupter
3 Position indicator O - I
4 Operating shaft (short or long version)
5 Drive lever
6 Mechanical closing latch with rectifier module for AC operation
7 Terminal strip
8 Upper main conductor terminal
9 Lower main conductor terminal
10 Mechanical connection between medium-voltage and low-voltage part
11 Magnet system (magnet coil)
12 Electronic module (electronic economy circuit) with connection terminals



Wall mounting
Vertical arrangement

Floor mounting
Vertical arrangement

Horizontal arrangement

The arrow shows the arrangement of the terminal strip

3TL8 vacuum contactor

Mode of operation

3TL8 vacuum contactors open and close the contacts of the vacuum interrupters (2). Due to the use of the electronic economy circuit (12), the magnet system (11) is to a large extent independent of the voltage type and level.

Mechanical closing latch

The mechanical closing latch (6) holds the vacuum contactor in closed position even without excitation of the magnet system (11). The latching module of the mechanical closing latch (6) is accommodated in the mechanism section.
When the magnet system (11) is energized, the vacuum interrupter (2) is latched mechanically in "CLOSED" position through a lever and roller system. The vacuum contactor is released electrically by means of a latch release solenoid or mechanically by a tripping bolt (customer control required). The command duration for the latch release coil must range between 100 ms and 1 s. De-energizing must be provided externally.

Installation position

3TL8 vacuum contactors can be installed in different positions. Besides wall mounting (vertical arrangement), they can also be mounted on the floor (vertical or horizontal arrangement).

Utilization categories

In IEC 60470, power contactors are divided into different utilization categories. According to these categories, 3TL vacuum contactors are dimensioned for different electrical consumers and operating conditions. The opposite table shows typical applications in accordance with the respective utilization categories.

Utilization category	Typical applications
AC-1	Non-inductive or slightly inductive loads, resistance furnaces
AC-2	Slip-ring motors: Starting, switching off
AC-3	Squirrel-cage motors: Starting, switching off during running
AC-4	Squirrel-cage motors: Starting, plugging [1], reversing [1], inching [2]

1) By plugging is understood stopping or reversing the motor rapidly by reversing motor primary connections while the motor is running

2) By inching is understood energizing a motor once or repeatedly for short periods to obtain small movements of the driven mechanism

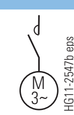
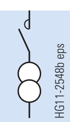
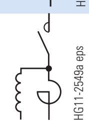
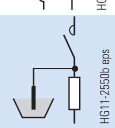
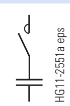
Application

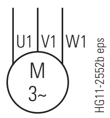
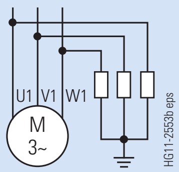
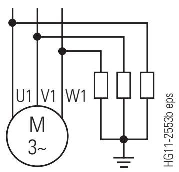
3TL vacuum contactors are 3-pole contactors with electromagnetic operating mechanism for medium-voltage switchgear. They are load breaking devices with a limited short-circuit making and breaking capacity for applications with high switching rates (> 10000 operating cycles).

Vacuum contactors are suitable for operational switching of alternating-current consumers in indoor switchgear, and can be used e.g. for the following switching duties:

- Switching of three-phase motors in AC-3 or AC-4 operation
- Switching of transformers
- Switching of reactors
- Switching of resistive consumers
- Switching of capacitors.

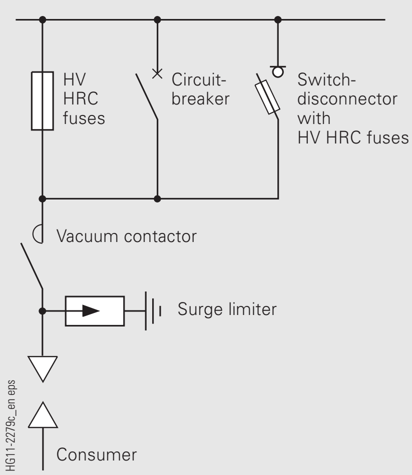
In contactor-type reversing starter combinations (reversing duty), only one contactor is required for each direction of rotation if HV HRC fuses are used for short-circuit protection.

Typical application, switching of consumers	Symbols	Application examples
Medium-voltage three-phase motors		Conveyor and elevator systems, compressors, ventilation and heating
Transformers		Ring-main units, industrial system distributions
Reactors		Industrial system distributions, DC-link reactors, reactive power compensation systems
Resistive consumers		Heating resistors, electric furnaces
Capacitors		Reactive power compensation systems, capacitor banks

Circuit diagram	Mode of operation
	Switching of accelerated motors
	Occasional switching of just accelerated motors in case of fault [1]
	Frequent switching in AC-4 operation [1]

Circuit examples for surge protection of three-phase motors with a starting current ≤ 600 A

1) With surge limiter



Switching devices in combination with a vacuum contactor

Switching of motors

3TL vacuum contactors are especially suitable for frequent operation of motors. As the chopping currents of the contactors are ≤ 5 A, no unpermissibly high overvoltages are produced when accelerated motors are switched during normal operation. However, when high-voltage motors with starting currents of ≤ 600 A are stopped during start-up, switching overvoltages may arise. The magnitude of these overvoltages can be reduced to harmless values by means of special surge limiters. 3EF surge limiters can be arranged in parallel to the cable sealing ends, preferably in the cable compartment. The surge limiters consist of non-linear resistors (metal-oxide varistors SIOV) and a series-connected spark gap. During installation it must be observed that the surge limiter is flexibly mounted on one side for mechanical reasons.

Switching of transformers

When inductive currents are interrupted, current chopping can produce overvoltages at the contact gap. Such overvoltages can be controlled with a protective circuit composed of 3EF surge limiters.

Switching of capacitors

3TL vacuum contactors can interrupt capacitive currents up to 250 A up to the rated voltage of 12 kV without restrikes, and thus without overvoltages.

Surge protection via limiters

Overvoltages can arise as a consequence of multiple restrikes or by virtual current chopping, e.g. when motors are switched in braked condition or during start-up. Motors with a starting current ≤ 600 A are endangered. Safe protection against overvoltages is ensured by surge limiters; circuit examples are shown above.

Short-circuit protection

3TL vacuum contactors are not designed to switch short-circuit currents. It is therefore absolutely essential to provide short-circuit protection. The best protection is provided by HV HRC fuses, but circuit-breakers can also be used under the preconditions described above.

Short-circuit protection via HV HRC fuses

At high short-circuit currents, HV HRC fuses have a current-limiting effect, i.e. the fuse limits the short-circuit current to the let-through current. When selecting the fuses, the type of consumer must be observed, e.g. motor, transformer, capacitors.

The diagram shows an example for the coordination of a HV HRC fuse with an overcurrent-time protection.

Co-ordinating the components of the motor circuit:

- The time-current characteristic must be located on the right of the motor starting current (point A).
- The rated current of the HV HRC fuse-link must exceed the normal current of the motor.
- The current corresponding to the intersection B of the HV HRC fuse-link characteristic and the characteristic of the overcurrent-time protection must be higher than the minimum breaking current of the HV HRC fuse-link.
- If this is not feasible, it must be ensured that overload currents that are smaller than the minimum breaking current of the HV HRC fuse-link are interrupted by the switching device via the striker. This prevents thermal overloading of the HV HRC fuse-link, which would otherwise be destroyed.
- The selected HV HRC fuse link limits the sustained symmetrical short-circuit current I_k to the let-through current I_D shown in the diagram for the current-limiting characteristics (I_D as a function of I_K for HV HRC fuse-links with different rated currents). The maximum permissible let-through current is $I_D = 50$ kA.

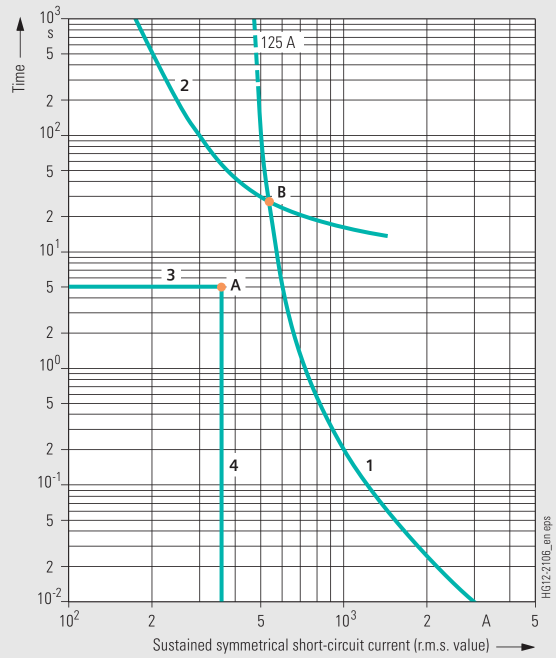
Requirements

- The let-through current I_D must not exceed 50 kA to 7.2 kV
- In case of low-voltage supply via a control transformer, short-circuit currents ranging above the limit switching capacity must be interrupted within 80 ms. This requirement does not apply if

– the mechanical latch is provided, or

– the opening times have been extended so much, that – in the a.m. range – the contactor can only open when the fuse has interrupted the current.

- Due to the arising motor starting current, the instant when the motor starts represents the maximum stress for the HV HRC fuse. This stress must neither operate nor pre-damage the fuse.
- Other factors of influence on the stress of the HV HRC fuses are the starting time and the starting frequency of the motors.



Example for the coordination of an HV HRC fuse characteristic 125 A with a motor characteristic

1 Characteristic of HV HRC fuse 3GD11258-4D
2 Characteristic of the overcurrent-time protection
3 Motor starting time
4 Motor starting current

Short-circuit protection for "class E2 controllers" according to UL 347/CSA C22.2

For using 3TL6 and 3TL8 vacuum contactors as "class E2 controllers" for 7.2 kV, Siemens fuses of type 3GD1 150-4D (7.2 kV/250 A) or other fuses with a comparable current-time characteristic are specified for short-circuit protection. If two fuse-links are connected in parallel, the symmetrical short-circuit current determined has to be divided by two, and the associated let-through current for one fuse-link must be stated. This value must then be multiplied by two in order to obtain the total let-through current, which must not exceed the permissible value for the vacuum contactor. The parallel connection should ensure that the resistance values in the two branches are almost the same. When the fuses operate, the vacuum contactor must be switched off. A suitable device, actuated by the striker of the HV HRC fuse-link, should be provided.

Fuse monitoring

To prevent a three-phase load (e.g. a motor) from being supplied only by two phases when a fuse has operated, the fuse-bases can be equipped with a "fuse trip indicator". This device can be used either to energize a warning signal or to switch off the vacuum contactor.

Short-circuit protection by circuit-breakers

Consumers for which no suitable fuses are available can also be protected by circuit-breakers. Due to the longer break time of the circuit-breakers (max. permissible 120 ms), the symmetrical short-circuit current must not exceed the maximum permissible value (e.g. 20 kA at 7.2 kV for 3TL6 vacuum contactors). As a consequence of the longer opening time, the interrupters should be replaced immediately by new ones after carrying the maximum permissible symmetrical short-circuit current, as their service life has been considerably reduced.

Overload protection

For protecting high-voltage motors against overload, it is possible to use thermally delayed overcurrent relays with suitable current transformers.

Trip-free mechanism

All contacts of the vacuum contactors are trip-free. The "OPEN" command interrupts the "CLOSE" command, i.e. the instant of the "OPEN" command determines whether the contacts will close or not.

Standards

3TL vacuum contactors are designed in open construction, with degree of protection IP00 according to IEC 60529 and DIN EN 60529. They conform to the standards for high-voltage alternating current contactors above 1 kV and up to 12 kV:

- IEC 60470
- UL Standard 347
- CSA C22.2

As there are no standards available for 24 kV, 3TL7 vacuum contactors are designed according to
– IEC 60470, Edition 05.2000 / DIN EN 60470 Edition 01.2002
– DIN EN 62271-100 Edition 01.2004.

Tests

For the development and type testing of power switching devices, we have accredited testing laboratories at our disposal:

- Testing laboratories with a high electrical testing capacity
- Testing laboratories to prove the following features:
  - Mechanical operation
  - Reliability
  - Dielectric strength
  - Temperature-rise performance
  - Climatic resistance.

To obtain secure results, comprehensive test series are performed for the type tests defined in the standards.

If the customer requests further tests that should not be performed at internal Siemens laboratories, other accredited testing institutes are available as well.

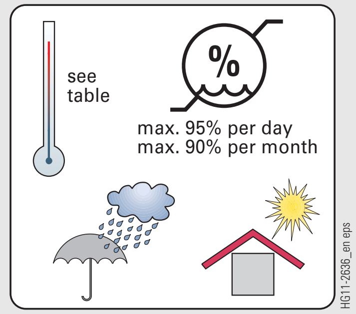
Ambient conditions

The vacuum contactors are designed for the normal operating conditions defined in the standards.

Condensation can occasionally occur under the ambient conditions shown opposite. Vacuum contactors are suitable for use in the following climatic classes according to IEC 60721:

Climatic ambient conditions:	Class 3K4 1)
	Class 3K6 2)
	Class 3Z2
	Class 3Z5
Biological ambient conditions:	Class 3B1
Mechanical ambient conditions:	Class 3M2
Chemically-active substances:	Class 3C2 3)
Mechanically-active substances:	Class 3S2 4)

1) Low temperature limit: – 25 ° (– 5° for 3TL7)
2) Without icing and wind-driven precipitation
3) Without appearance of saline fog with simultaneous condensation
4) Restriction: Clean insulation parts



Temperature value	For vacuum contactor		
	3TL6	3TL7	3TL8
Maximum value	+ 80 °C	+ 55 °C	+ 65 °C
Maximum 24-hour mean value	+ 75 °C	+ 50 °C	+ 60 °C
Minimum value	– 25 °C	– 5 °C	– 25 °C

Dielectric strength

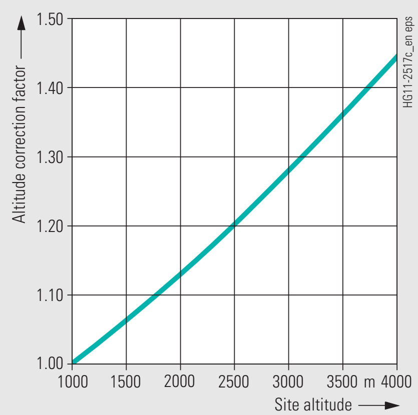
The dielectric strength of air insulation decreases with increasing altitude due to low air density. According to IEC 62271-1, the values of the rated lightning inpulse withstand voltage and the rated short-duration power-frequency withstand voltage specified in the chapter "Technical Data" apply to a site altitude of 1000 m above sea level. For an altitude above 1000 m, the insulation level must be corrected according to the opposite diagram.

The characteristic shown applies to both rated withstand voltages.

To select the devices, the following applies:

$U \geq U_0 \times K_a$

U Rated withstand voltage under reference atmosphere
U_0 Rated withstand voltage requested for the place of installation
K_a Altitude correction factor according to the opposite diagram



Example

For a requested rated lightning impulse withstand voltage of 60 kV at an altitude of 2500 m, an insulation level of 72 kV under reference atmosphere is required as a minimum:

72 kV ≥ 60 kV x 1.2

Contactor comparison

Contactor comparison

	3TL6	3TL7	3TL8
Rated voltage	7.2/12 kV	24 kV	7.2 kV
Rated normal current	400/450 A	800 A	400 A
Switching rate	1200/600 operating cycles/h	60 operating cycles/h	1200 operating cycles/h
Endurance – Contactor – Vacuum interrupter	Operating cycles Mech. endurance 3/1 mio. Mech. endurance 2/1 mio. Electr. endurance 1/0.5 mio.	Operating cycles Mech. endurance 1 mio. Mech. endurance 1 mio. Electr. endurance 0.5 mio.	Operating cycles Mech. endurance 1 mio. Mech. endurance 0.25 mio. Electr. endurance 0.25 mio.
Chopping current	< 5 A	< 5 A	≤ 0.6 A
Economy circuit	Via economy resistor	Via automatic coil changeover	Integrated in electronic module
Auxiliary contacts	Positively driven aux. contacts 8 NO, 7 NC	Positively driven aux. contacts 8 NO, 8 NC	Positively driven aux. contacts 4 NO, 4 NC
Operating mechanism	On the rear of the vacuum interrupters	Below the vacuum interrupters	Below the vacuum interrupters
Type of construction	Compact	Slim	Slim
Main conductor terminals	At the front of the vacuum interrupters	At the rear of the vacuum interrupters	At the rear of the vacuum interrupters
Auxiliary conductor terminals	Terminal strip with testing possibilities in built-in condition (optionally withdrawable terminal strip)	Wiring of auxiliary contacts to central plug connector	Direct tapping at the terminals (optionally, wiring of auxiliary contacts to central terminal strip)
Additional components	Mechanical closing latch 1), mechanical closing lock-out, extension or reduction of opening time	Reduction of opening time, more on request	Mechanical closing latch 1), long operating shaft for external non-force components, reduction of opening time

1) For operating voltages of the mechanical closing latch under 100 V, a stable power supply must be observed.