ציוד מתח גבוה

תחנת טרנספורמציה

DISTRIBUTION STATION

https://electrical-engineering-portal.com/respr/Medium-Voltage-Technical-Guide-2017.pdf

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פרקי למידה

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7. מנתקי עומס
8. מנתקי הארקה

Gas Insulated Transformer

The Gas Insulated Transformer (GIT) uses SF_6 gas for insulation anc
underground substations. GIT development and manufacturing at T

GIT

DB422128_EN.eps

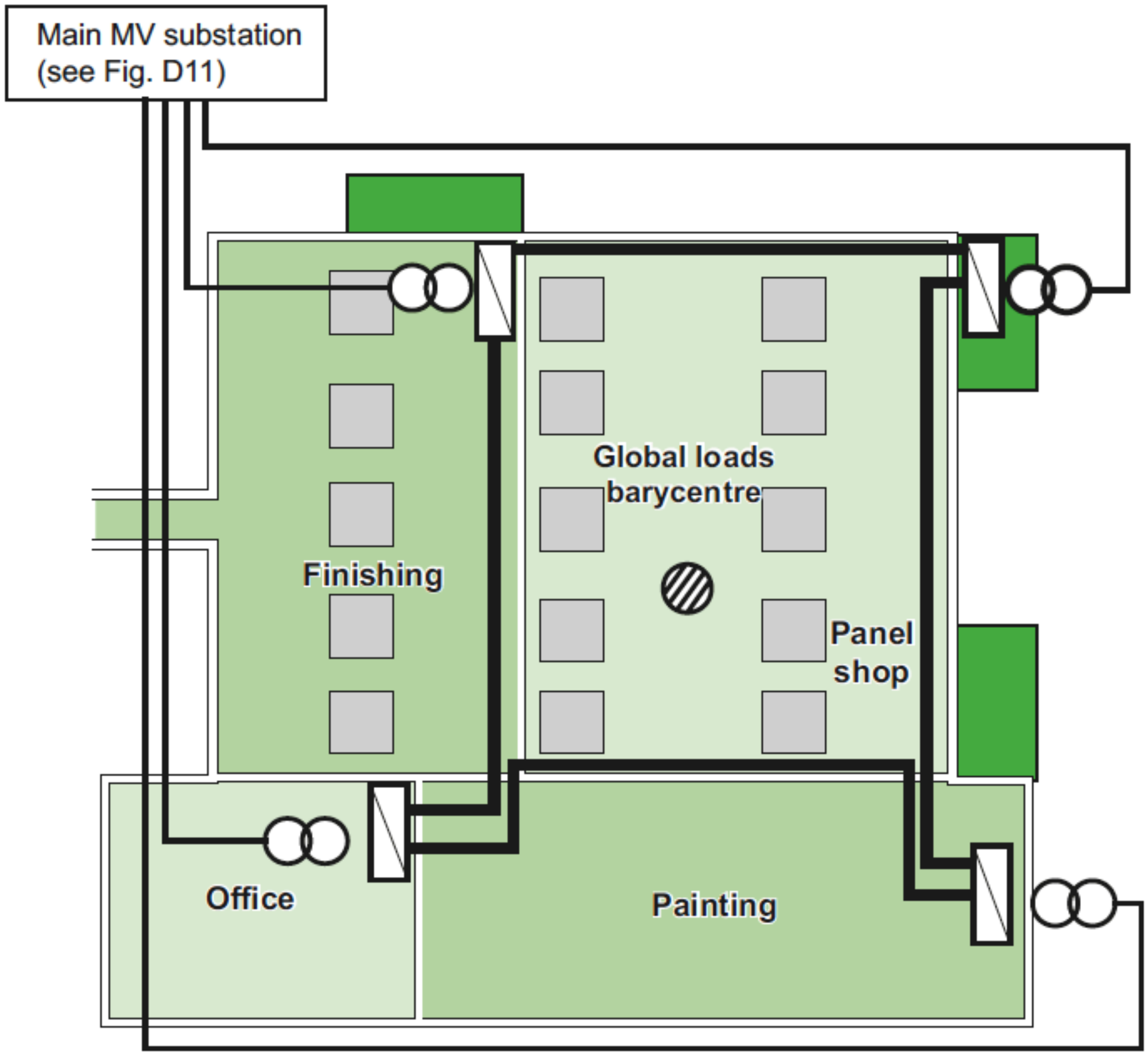


Fig. D13 The position of the global load barycentre guides the positioning of power sources

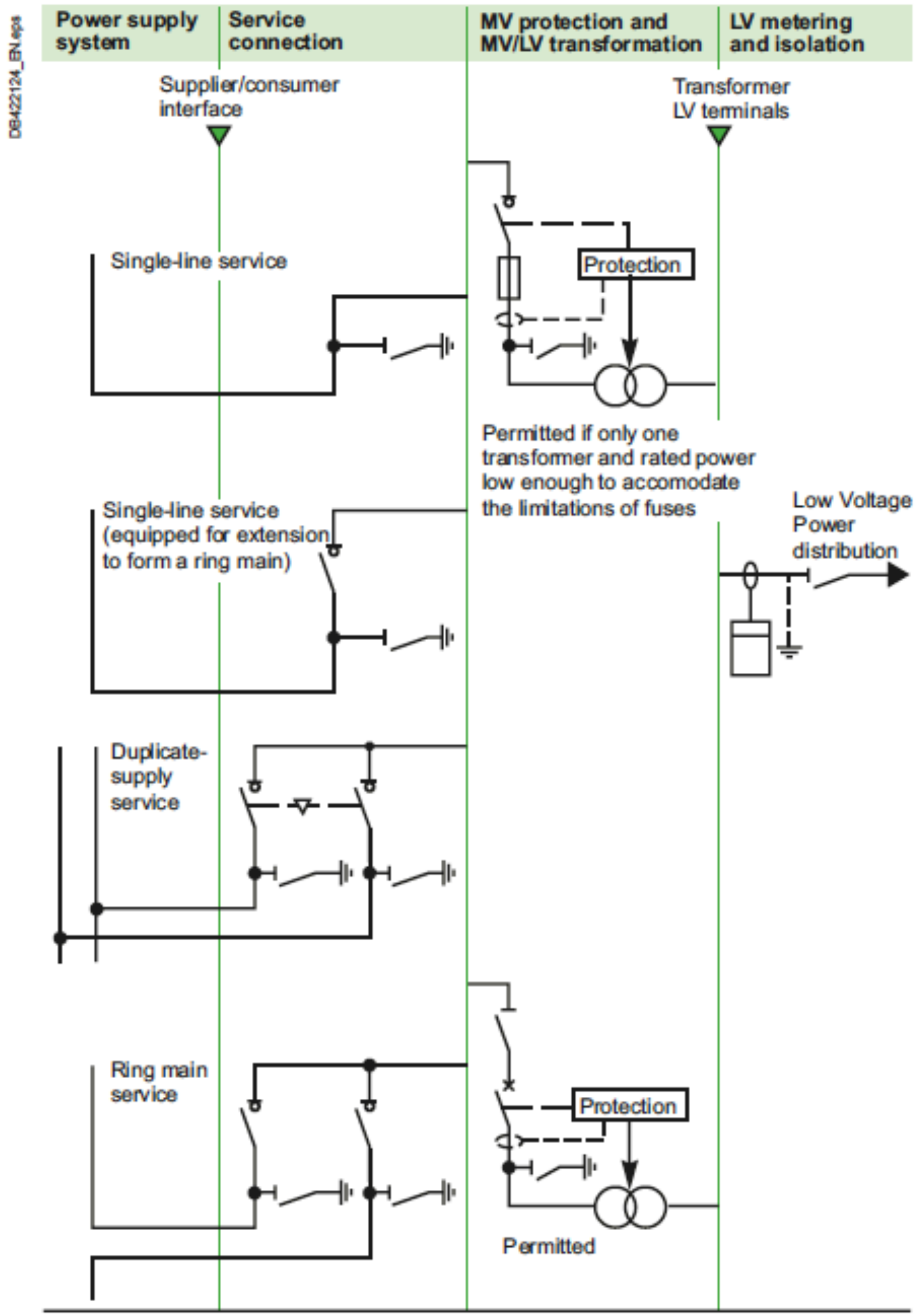
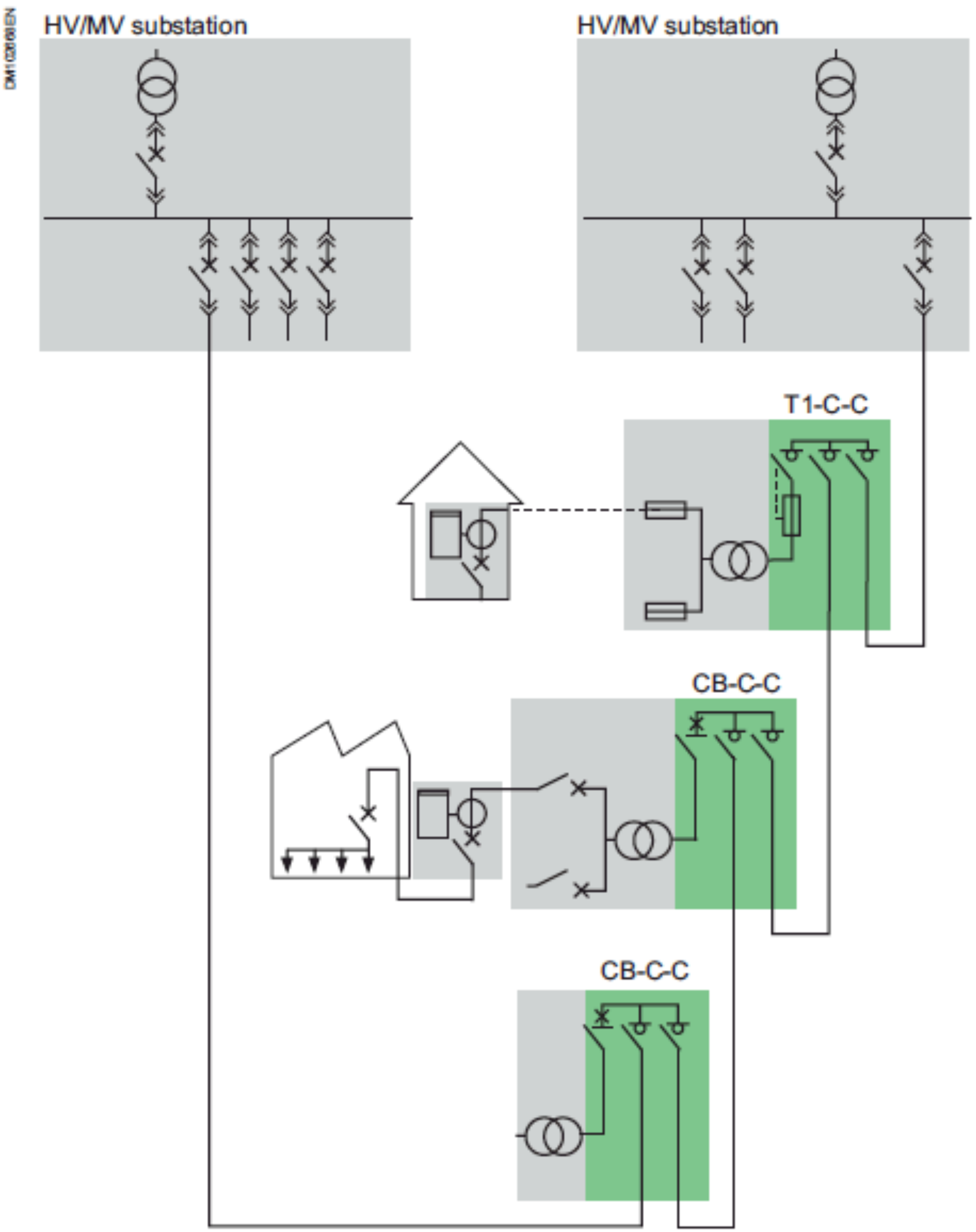


Fig. D8 MV connection with LV metering

Screenshot



Example of ring made up of compact units.

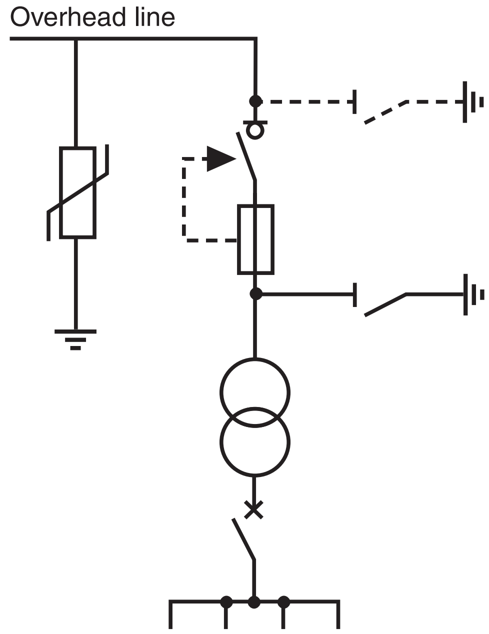


***Fig. B11** : Single-line service*

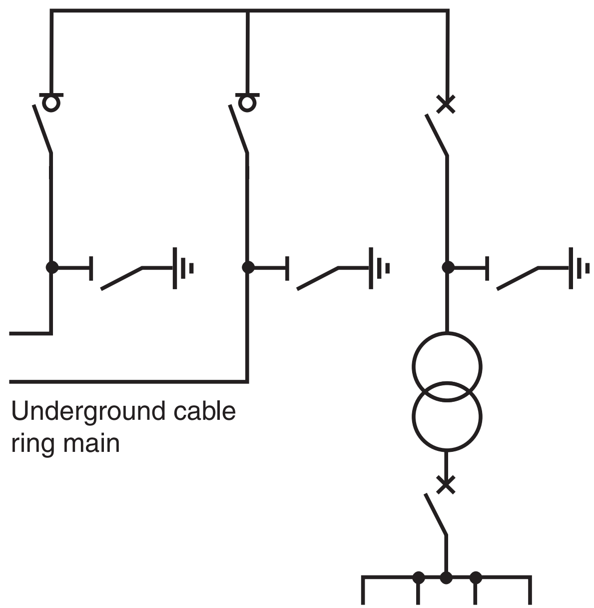


***Fig. B12** : Ring-main service*

תכונות מספיק זרם-מנתקים

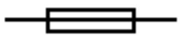
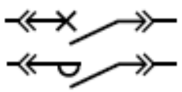
Specific device characteristics

The functions provided by various interrupting devices and their main constraints are presented in the table below.

Device	Isolation	Current switching conditions		Main constraints
		Normal	Fault	
Disconnector	yes	no	no	Longitudinal input/output isolation Earthing switch: short-circuit making capacity
Switch	no	yes	no	Making and breaking of normal load current Short-circuit making capacity With a fuse: short-circuit breaking capacity in fuse no-blow zone
Contactor	no yes, if withdrawable	yes	no	Rated making and breaking capacities Maximum making and breaking capacities Duty and endurance characteristics
Circuit breaker	no yes, if withdrawable	yes	yes	Short-circuit breaking capacity Short-circuit making capacity
Fuse	no	no	yes	Minimum short-circuit breaking capacity Maximum short-circuit breaking capacity

Switchgear functions

The following table describes the different switching and protecting functions met in MV networks and their associated schema.

Designation and symbol	Function	Current switching	
		Operating current	Fault current
Disconnector 	Isolates		
Earthing switch 	Connects to the earth		(short-circuit making capacity)
Load break switch 	Switches loads	•	
Disconnecting switch 	Switches Isolates	•	
Circuit-breaker 	Switches Protects	•	•
Contactor 	Switches loads	•	
Withdrawable contactor 	Switches Isolates if withdrawn	•	
Fuse 	Protects Does not isolate		• (once)
Withdrawable devices 	See associated function	See associated function	See associated function

• = yes

Sr No	Switchgear Equipment	Function
1.	Fuse	To Protect circuit against over current and short circuit currents.
2.	Circuit breaker	To make or break the circuit manually or remotely under normal condition and automatically under fault condition.
3.	Isolator	To disconnect the part of the system for maintenance from live circuit under no current condition.
4.	Earthing Switch	To discharge the voltage on the line (due to charges of line capacitance to earth) after disconnecting line from live section.
5.	Light using arrester	To divert high voltage surge towards the earth, due to lighting stroke or switching surges.
6.	Current transformer	To stepping down the magnitude of current for measurement, protection and control.
7.	Potential transformer	To stepping down the magnitude of line voltage for measurement, protection and control.
8.	Relay	To disconnect the abnormally operating part so as to prevent the subsequent faults e.g. Overload protection of a machine protects the machine and prevent insulation failure.

Power transformers

General

Service conditions

Temperature rise limits

Transformer efficiency

Voltage drop

Parallel operation

Three-phase common transformer vector groups

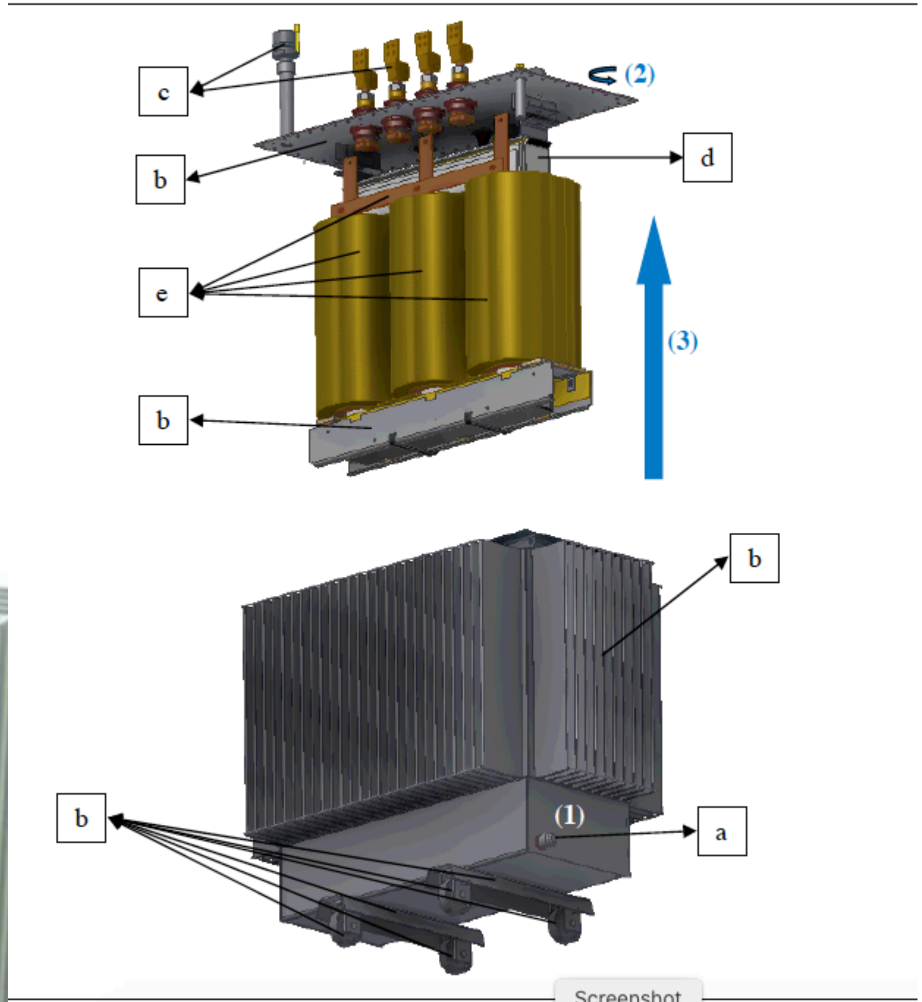
Technologies

Air-breathing conservator-type tank
at atmospheric pressure

Page B27

Oil-immersed

Dry type


c
(2)
b
d
e
(3)
b
b
b
(1)
a

Resiglas

Dry Cast Resin Transformer

Up to 5.5 MVA - 36kV

Distribution Transformer

Range of power and voltages

Resiglas transformers work in power range of 63 kVA to 5.500 KVA in the following types of voltage:

- maximum UV system voltage 7.2 kV; 12 kV; 17,5 kV; 24 kV; 36 kV
- maximum LV system voltage 1.1 kV; 3.3 kV; 7.2 kV.

Rated characteristics of a transformer

- Rated power
- Frequency
- Rated primary and secondary voltages
- Insulation techniques:
  - dry type transformers + liquid filled transformer (askarel banned)
- Off-circuit top selector switch:
  - generally allows a choice of a ± 2.5% and 5% level around the rated voltage of the highest voltage winding (the transformer must be de- energized before the switch is operated).
- Type of protection (Fuse or CB)
- Winding configurations:
  - are indicated in schematic form by standard symbols
    D = delta   Y = star   Z = zigzag (interconnected-star) eliminates H3

Technology: cast resin

- Trihal (Schneider range)
  - types of manufacturing, as a rule:
    - power from 160 to 2500 kVA for MV/LV
    - power > 2500 kVA up to 10 MVA for MV/MV
    - 50 or 60 Hz 3-pole transformers for indoor installation
    - natural cooling in air, AN or AF type
    - optional protection by PTC or PT100 RTDs in each LV winding
- Low voltage
  - generally aluminium or copper strip insulated by class F in-between layer, cast unmoulded (impregnated) in a synthetic resin of the alkyd type or equivalent
- Medium voltage
  - not incorporated with LV and made of flat wire with class F insulating material
  - the winding is then cast and vacuum moulded in a fireproofed epoxy coating system.

Necessary conditions for parallel operation

- Same power for both transformers (recommended); otherwise the ratio between the two transformers must not be greater than 1,4.
- Same frequency
- All parallel-mounted units must be supplied by the same network
- Secondary cabling must have equal lengths and cross-sections
- Short-circuit voltages are equal or differ by less than 10 %
- No more than 0.4 % between secondary voltages
- The winding configurations (star, delta, zigzag) of the different transformers have the same phase shift between primary and secondary voltages: DY11n + DY11n

Choice of 20kV/0.41kV MV/LV transformers (1)

- Liquid filled transformer

	50	100	160	250	400	630	800	1000	1250	1600	2000	2500
237 V												
In (A)	122	244	390	609	974	1535	1949	2436				
Isc (kA)	3.04	6.06	9.67	15.04	23.88	37.20	31.64	39.29				
Usc (%)	4	4	4	4	4	4	6	6				
copper losses (kW)	1.350	2.150	2.350	3.25	4.6	6.5	10.7	13				
410 V												
In (A)	70	141	225	352	563	887	1127	1408	1760	2253	2816	3520
Isc (kA)	1.76	3.50	5.59	8.69	13.81	21.50	18.29	22.71	28.16	35.65	44.01	54.16
Usc (%)	4	4	4	4	4	4	6	6	6	6	6	6
copper losses (kW)	1.35	2.15	2.35	3.25	4.6	6.5	10.7	13	16	20	25.5	32

Isc for different types of transformers Psc = 500 MVA

Isc : short circuit fault current in Amps
Usc : short circuit impedance voltage on the transformer in %

Choice of 20kV/0.41kV MV/LV transformers (2)

- Dry type transformer (cast-resin transformer)

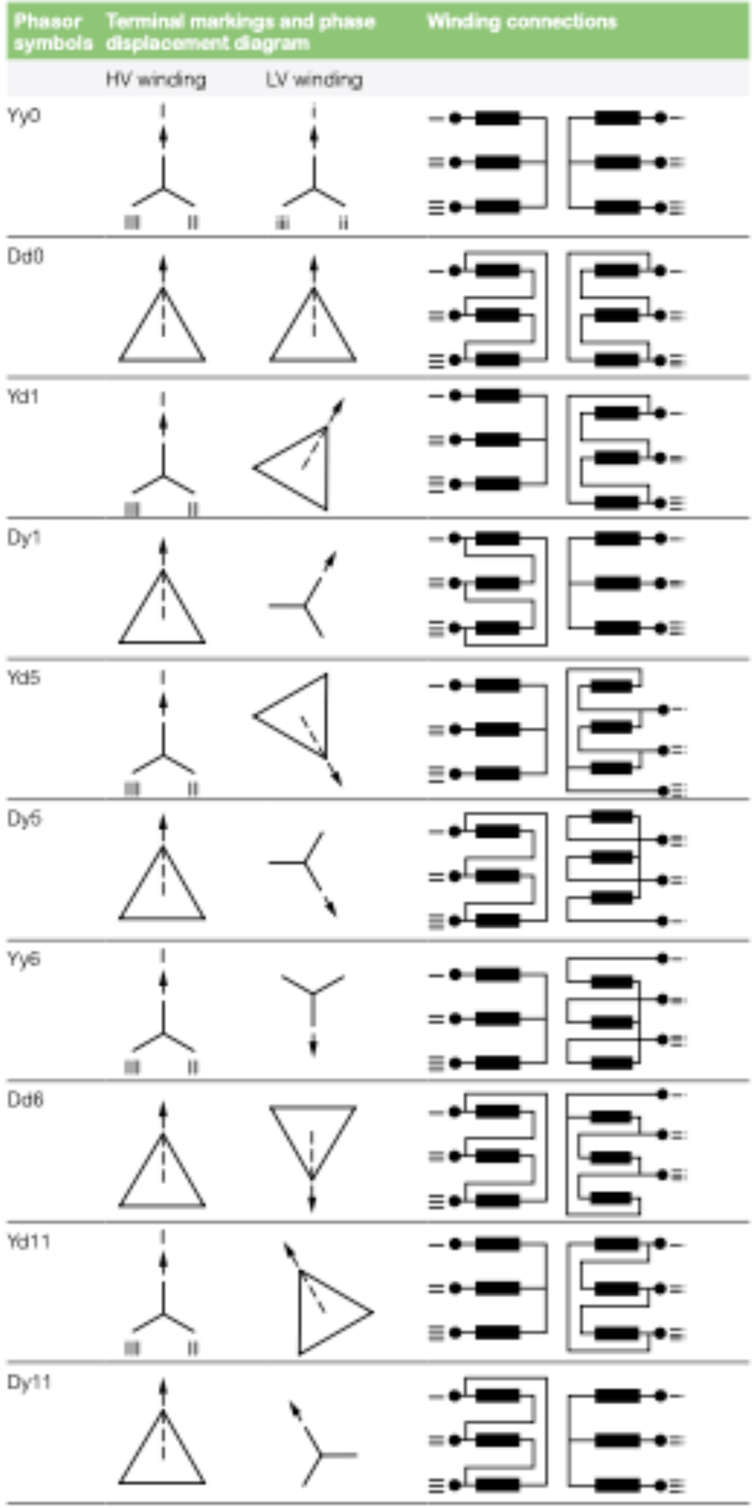
	100	160	250	315	400	500	630	800	1000	1250	1600	2000	2500
237 V													
In (A)	244	390	609	767	974	1218	1535	1949	2436				
Isc (kA)	4.05	6.46	10.07	12.66	16.03	19.97	25.05	31.64	39.29				
Usc (%)	6	6	6	6	6	6	6	6	6				
copper losses (kW)	2.05	2.7	3.38	4.6	5.5	6.5	7.8	9.4	11				
410 V													
In (A)	141	225	352	444	563	704	887	1127	1408	1760	2353	2816	3520
Isc (kA)	2.34	3.74	5.82	7.32	9.26	11.54	14.48	18.29	22.71	28.16	35.65	44.01	54.16
Usc (%)	6	6	6	6	6	6	6	6	6	6	6	6	6
copper losses (kW)	2.05	2.7	3.8	4.6	5.5	6.5	7.8	9.4	11	13.1	16	20	23

dry type transformer.

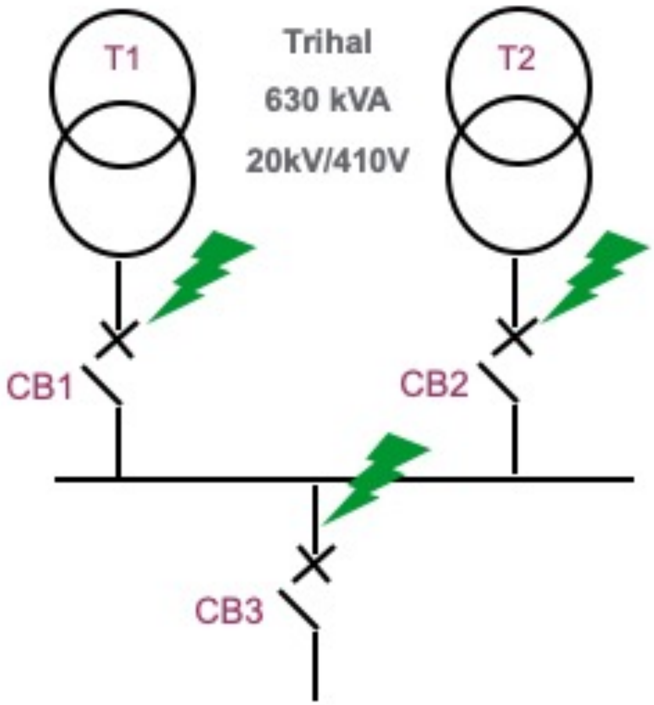
Isc : short circuit fault current in Amps
Usc : short circuit impedance voltage on the transformer in %

Power transformers

Three-phase common transformer vector groups



The case of several transformers in parallel feeding a busbar



Do Exercise

- What is the maximum short-circuit value for each transformer ?

T1 =

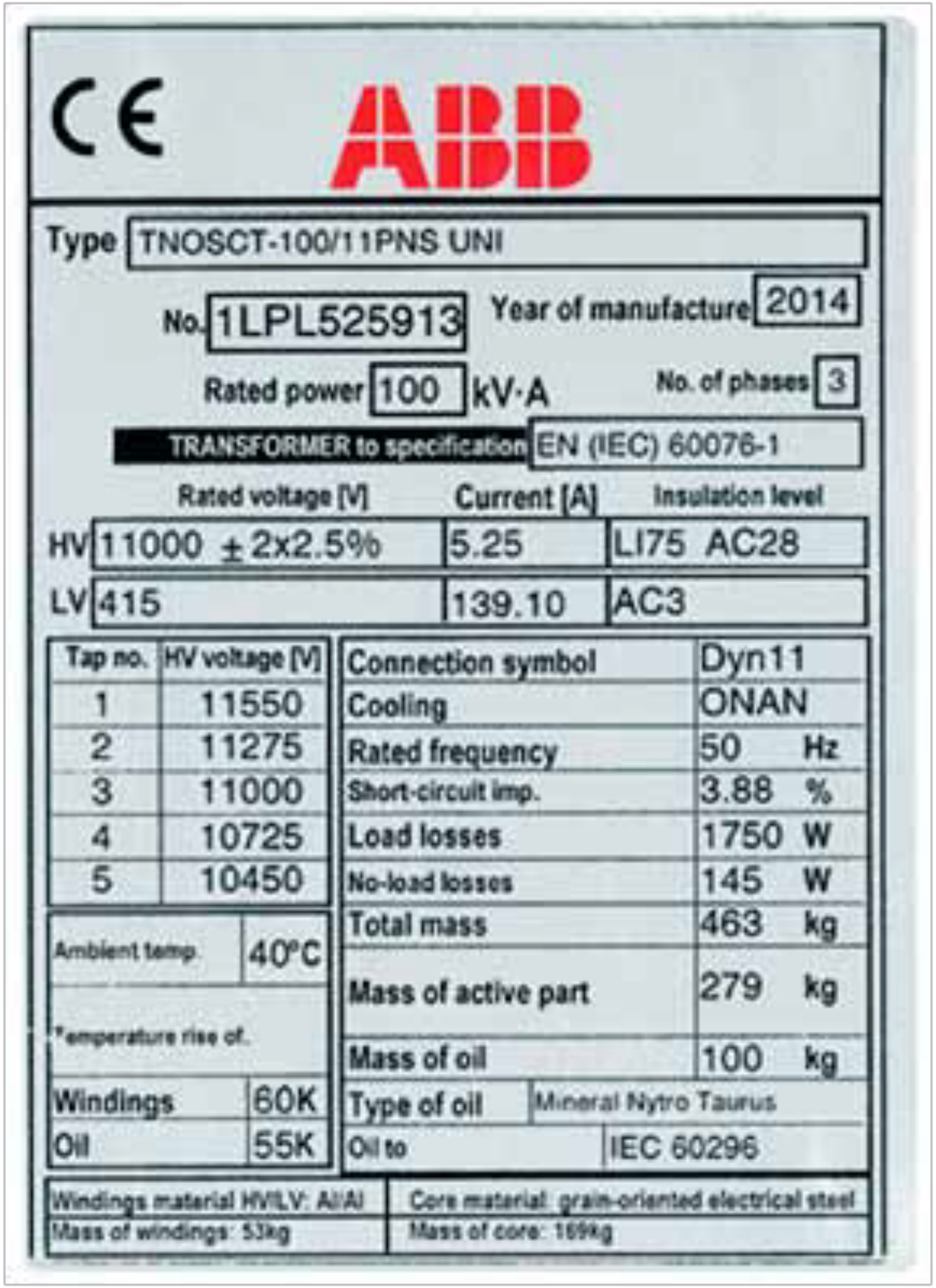
T2 =

- What is the minimum breaking capacity for each circuit-breaker ?

CB1 =

CB2 =

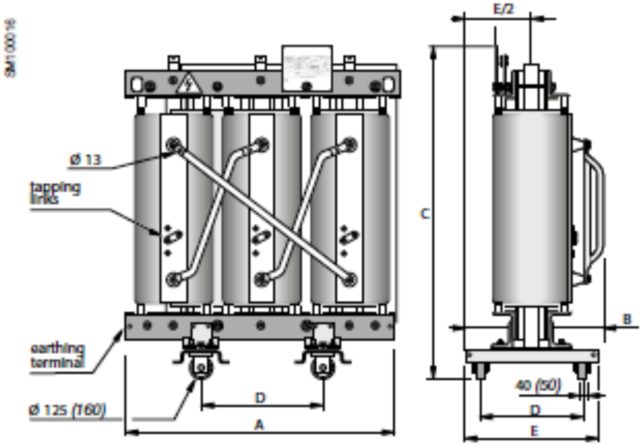
CB3 =



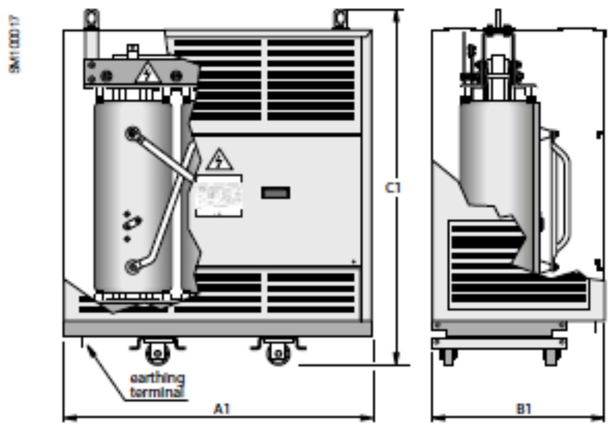
CE
ABB
Type TNOSCT-100/11PNS UNI
No. 1LPL525913
Year of manufacture 2014
Rated power 100 kV·A
No. of phases 3
TRANSFORMER to specification EN (IEC) 60076-1
Rated voltage [V]
Current [A]
Insulation level
HV 11000 ± 2x2.5% 5.25 LI75 AC28
LV 415 139.10 AC3
Tap no.
HV voltage [V]
1 11550
2 11275
3 11000
4 10725
5 10450
Connection symbol Dyn11
Cooling ONAN
Rated frequency 50 Hz
Short-circuit imp. 3.88 %
Load losses 1750 W
No-load losses 145 W
Total mass 463 kg
Mass of active part 279 kg
Mass of oil 100 kg
Type of oil Mineral Nytro Taurus
Oil to IEC 60296
Ambient temp. 40°C
emperature rise of.
Windings 60K
Oil 55K
Windings material HV/LV: Al/Al
Mass of windings: 53kg
Core material: grain-oriented electrical steel
Mass of core: 169kg

Dimensions* and weights

Without enclosure (IP00)



With IP31 metal enclosure



Rated power (kVA)		100	160	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150
Without enclosure IP00															
Dimensions (mm)	-A	1030	1110	1250	1270	1320	1420	1430	1530	1580	1590	1790	1880	1940	2090
	-B	520	520	520	670	670	670	670	670	820	820	820	1070	1070	1070
	-C	1260	1280	1390	1470	1620	1550	1550	1720	1860	1960	1940	2130	2170	2430
	-D	645	645	645	795	795	795	795	795	945	945	945	1230	1230	1230
	-E	650	650	670	800	800	800	800	800	950	950	950	1230	1230	1270
Total weight (kg)		660	820	1100	1300	1560	1800	1820	2440	2800	2940	3520	4300	5080	6400
With IP31 metal enclosure															
Dimensions (mm)	-A1	1650	1650	1510	1800	1900	1800	1800	1900	2150	2150	2020	2100	2240	2390
	-B1	950	950	770	1020	1100	1020	1020	1100	1170	1170	950	1230	1230	1270
	-C1	1750	1750	1690	2050	2300	2050	2050	2300	2480	2480	2240	2430	2570	2830
Weight enclosure (kg)		180	180	200	210	240	210	210	240	320	320	400	400	400	400
Total weight (kg)		840	1000	1300	1510	1800	2010	2030	2680	3120	3260	3920	4700	5480	6800

* see page 10 all available Trihal technical range

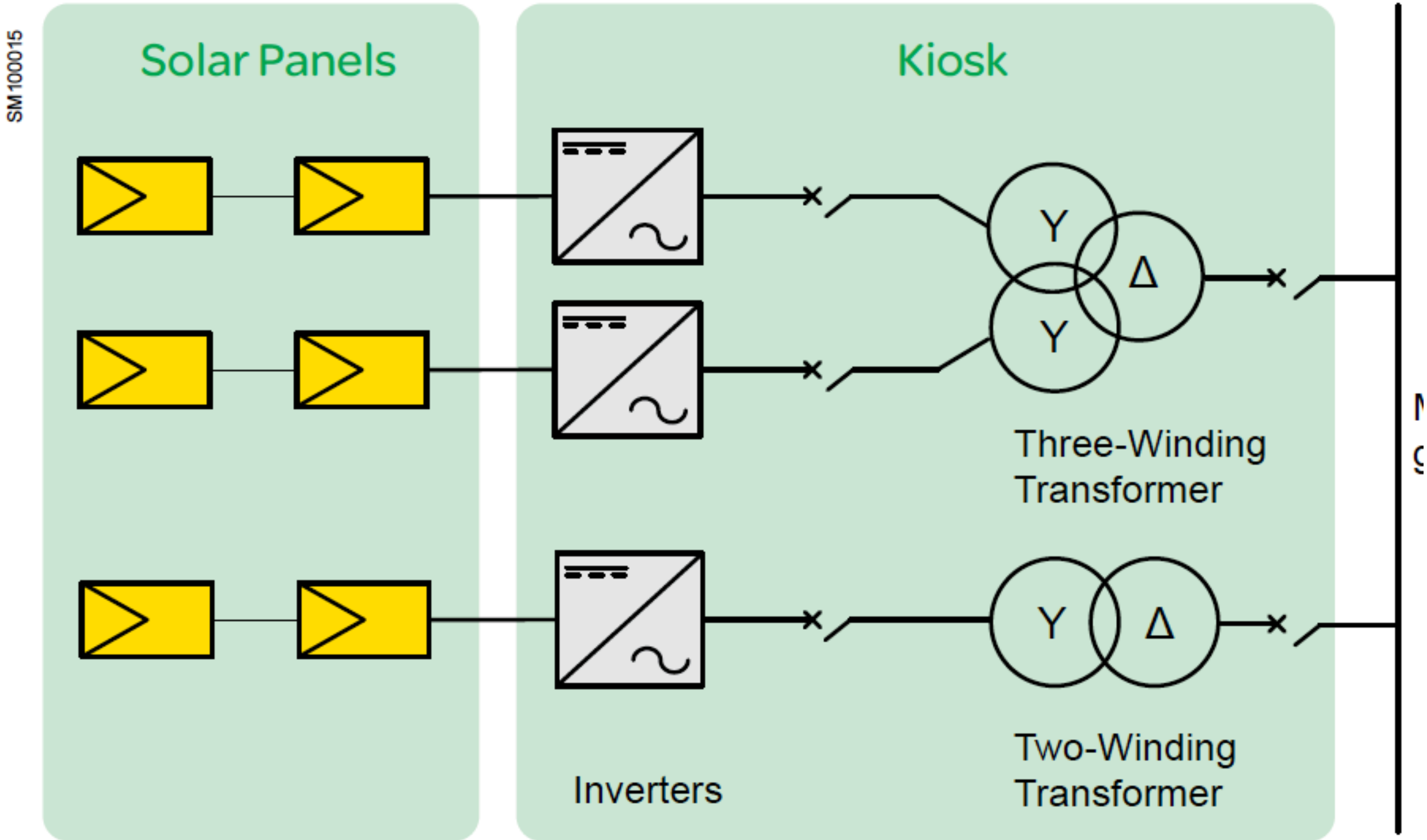
Transformers for grid-connected photovoltaic systems

PM102296

Transformer in PV box

Minera PV Transformers for photovoltaic systems
• Three-Winding
• Oil-immersed
• Voltages up to 36 kV
• Three phase 500, 1000,1250 kVA *
• Standard or low losses
• Indoor or outdoor
• Sealed or conservator type

* other power ratings available upon customer's request



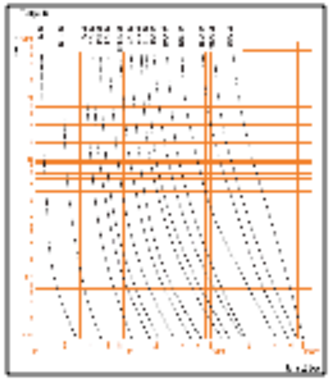
Typical diagram for Photovoltaic systems

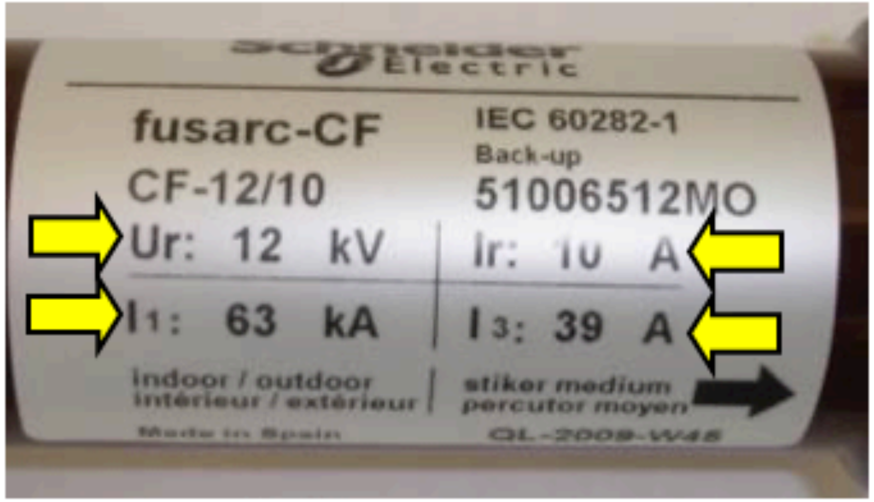
Thermal relays with sensors

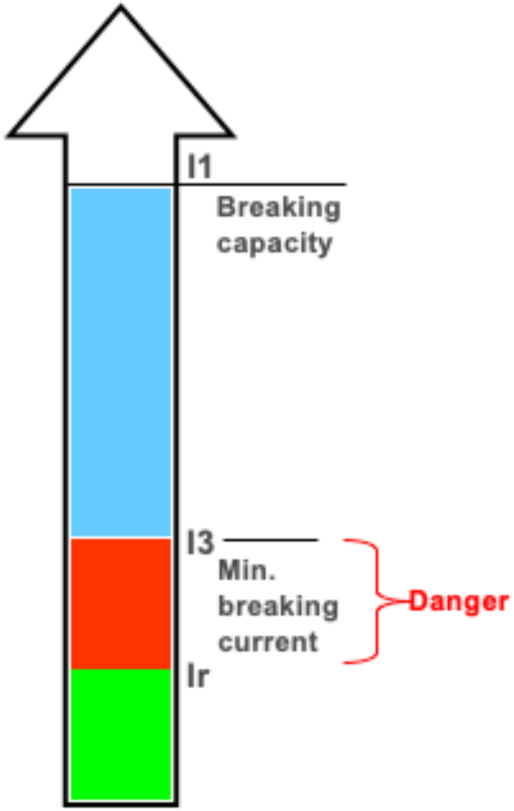
The use of protective relaying controlled by PTC sensors (posistors) is a modern way of protecting windings in cast resin transformers against overheating. These sensors are usually placed inside LV windings, which are at most risk of overheating. Sensor resistance is changed discretely after exceeding the response temperature. TZAM and TZM type windings are protected by posistors with a response temperature of 140°C (alarm) and 155°C (transformer switch-off). Each transformer is equipped with a set of sensors connected in series, lead to a common terminal strip. The set of relays controlled by PTC sensors with RTT14 system is a part of standard equipment. Other

Fuse

- The fuse is a device that interrupts current by melting the fuse element







Fuse components

1. Fuse element
2. Star core
3. Insulating tube
4. Arc-quenching powder
5. Insulating end-cap
6. Striker

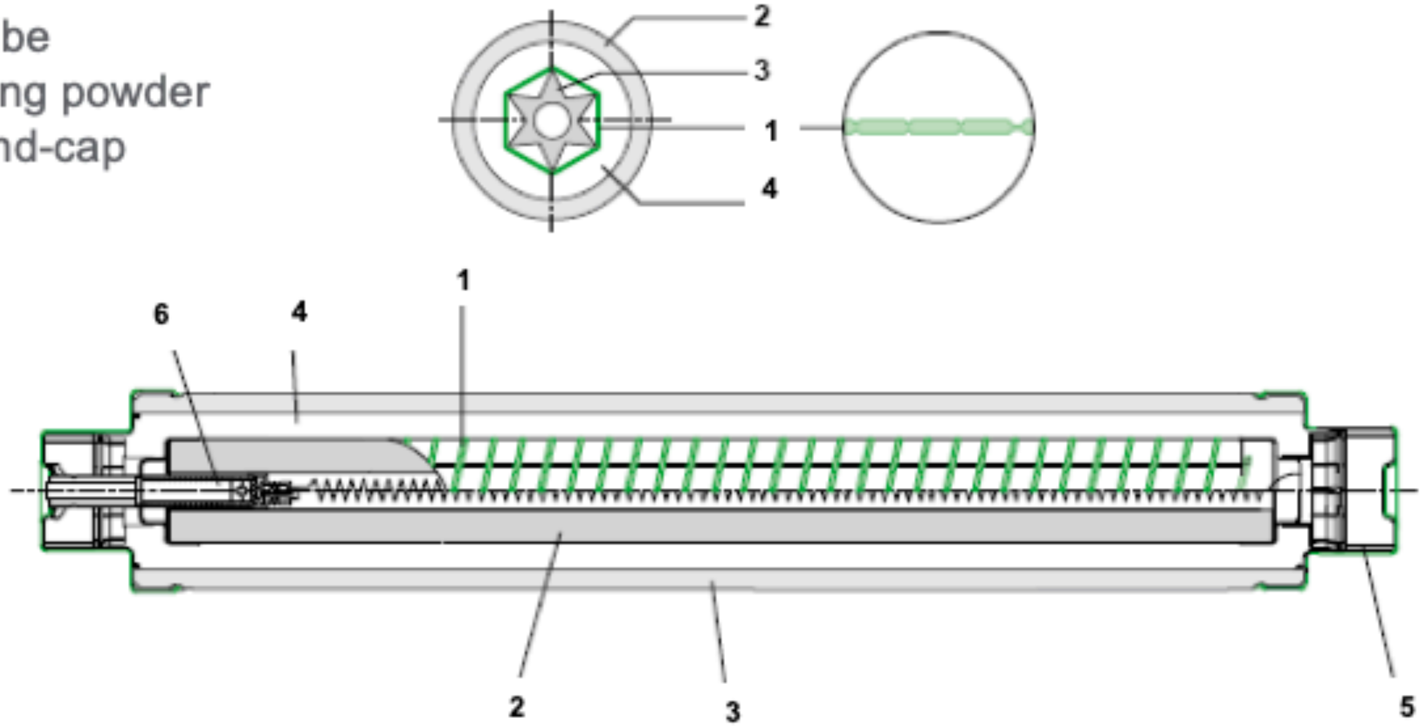
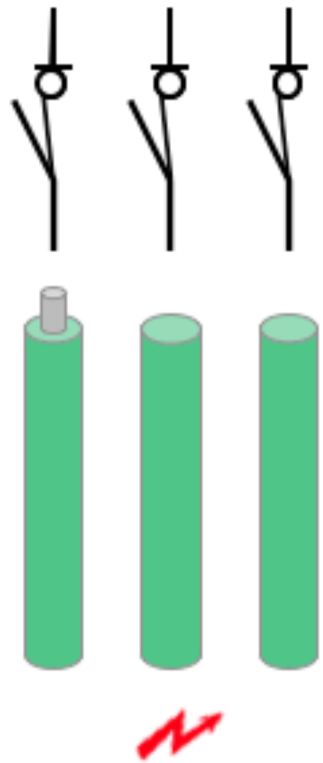


Table3. *Comparison of the SF6 And Vacuum Switching Technologies In Relation To Switching Applications*

Criteria	SF6 Circuit Breaker	Vacuum Circuit Breaker
Switching of Short circuit current with High DC component	Well suited	Well suited
Switching of Short circuit current with High RRV	Well suited under certain conditions (RRV>1-2 kV per Milli seconds	Very well suited
Switching of transformers	Well suited.	Well suited
Switching of reactors	Well suited	Well suited. Steps to be taken when current <600A. to avoid over voltage due to current chopping
Switching of capacitors	Well suited. Re-strike free	Well suited. Re-strike free
Switching of capacitors back to back	Suited. In some cases current limiting reactors required to limit inrush current	Suited. In some cases current limiting reactors required to limit inrush current
Switching of arc furnace	Suitable for limited operation	Well suited. Steps to be taken to limit over voltage.

Switch-fuse combination unit

- Three fuses with strikers
- A three-phase switch
  - is not a protection device on its own
  - can be tripped by any of the three strikers



Drawbacks of fuses

- Only work once
- Fragile
- Sensitive to the environment
- Dissipate a lot of energy as heat
  (cost of Joule losses)
- Sensitive to ageing (approximate service life: 10 years)
- Have a danger zone (Ir < I < I3)
- Possible single-pole breaking
- Application limited to small transformers
- One rating per application (large stock of spare parts)

Advantages of fuses

- Fast interruption
  - for high short-circuit values

    (but high short-circuit currents are very rare and are generally preceded by low fault currents)

- Current-limiting capacity
  - capability to limit short-circuit current

Characteristics of MV fuses

- **In** = Rated current
- **I3** = Minimum breaking current
- **I1** = Current <= network short-circuit current
- **Un** = Rated voltage
- **Type** = Fusarc, Solefuse…
- **With or without striker**
- **Standard**
- **Frequency**
- **Indoor / Outdoor**

Example

Indoor	Un = 7.2 kV
In = 250 A	IEC = 282.1
I3 = 2200 A	DIN = 43625

There are three main types of electric circuit opening and closing devices which are used in medium voltage networks.

Circuit-breakers

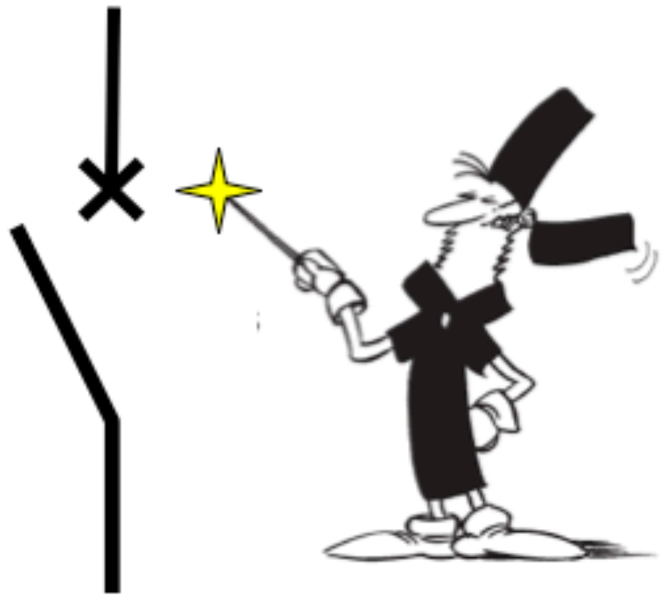
Switch-disconnectors

case of a fault to guarantee selective t

Circuit breaker

- The circuit breaker is a device capable of making, withstanding and interrupting currents under normal and abnormal conditions (up to short-circuit current)

- It is defined by its:
  - voltage (Ur)
  - rated current (Ir)
  - breaking capacity (Isc)



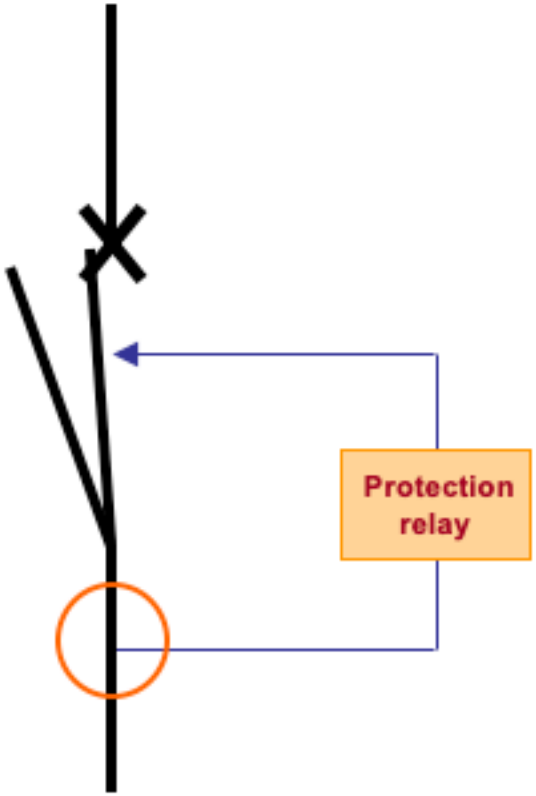
Circuit breaker protection chain

- To create a protection chain, the circuit breaker must be connected to:
  - current sensors (CTs)
  - a protection relay

3 – The circuit breaker trips and breaks the fault current

2 – The protection device analyzes the fault current and transmits a tripping order

1 – The current sensor (CT) detects the fault current and transmits the information to the protection device



circuit breaker

Sepam

current sensor

Circuit breaker protection: a flexible solution

- Circuit breaker's capability to break all currents below its breaking capacity
- No difficulty withstanding inrush currents and other overloads
- Multiple choice of protection relays
- No complex coordination calculations
- Capable of accommodating intelligent network management
- Possibility of remote reclosing after a fault (remote control)

Rated operating sequence (cf. § 4.104 IEC 62271-100)

See ANSI/IEEE C37.09 for America.

Rated switching sequence according to IEC, O - t - CO - t' - CO.

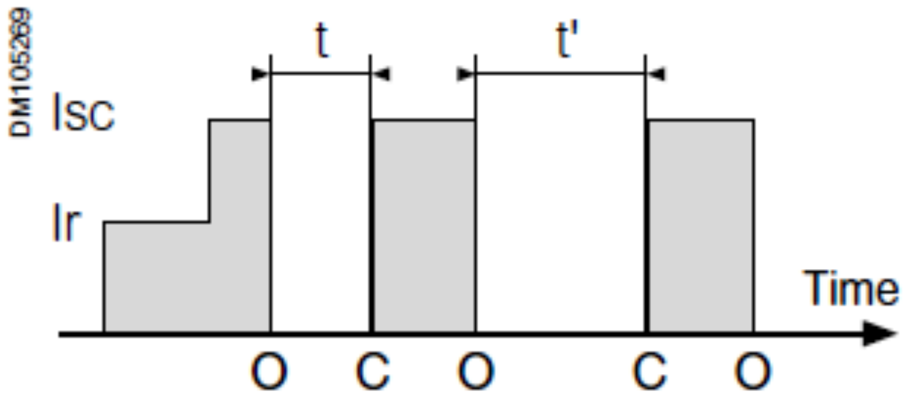
(cf. opposite diagram)

O	Represents opening operation
CO	Represents closing operation followed immediately by an opening operation

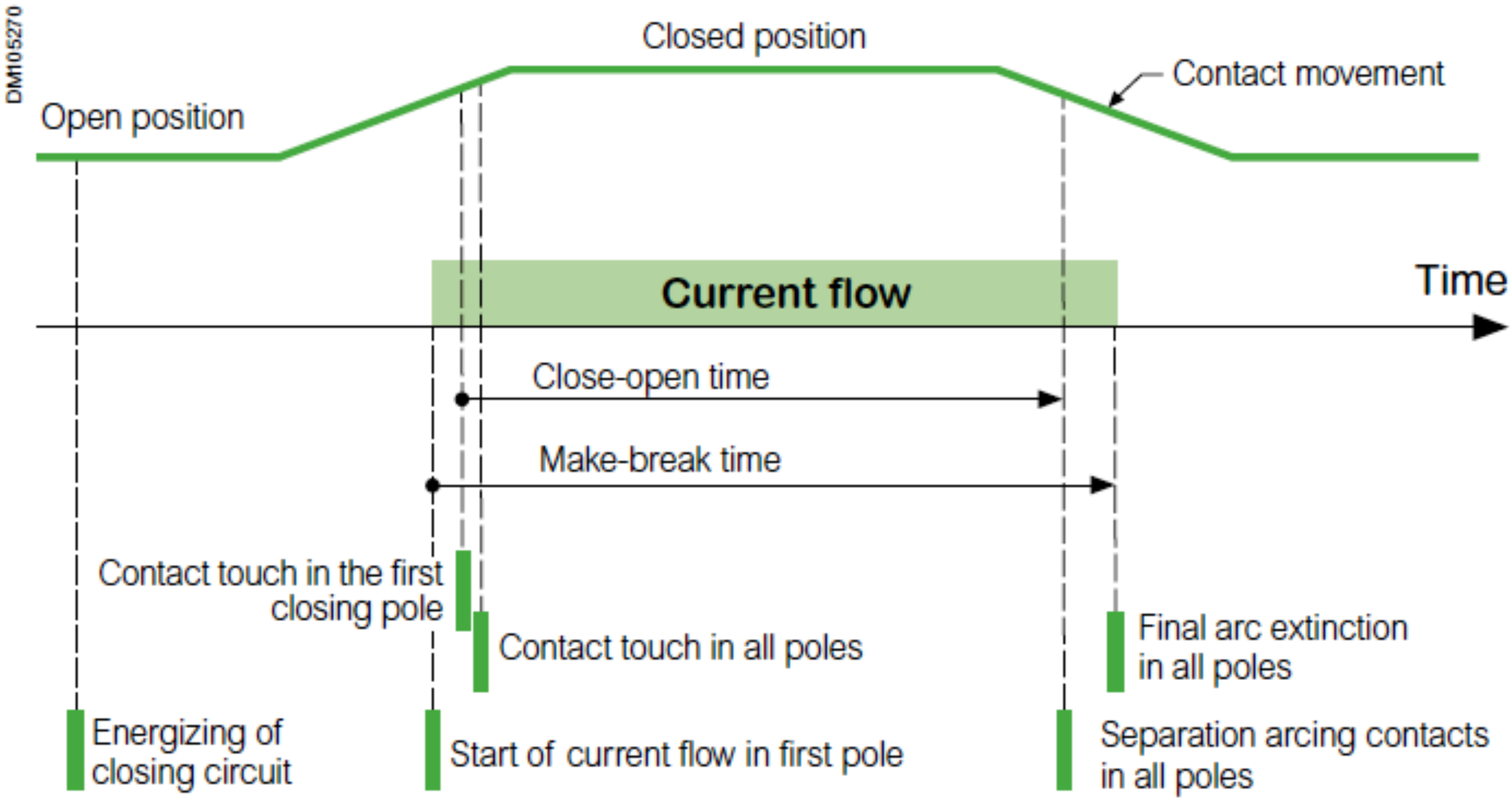
Three rated operating sequences exist:

- slow: O - 3 min - CO - 3 min - CO
- fast 1: O - 0.3 s - CO - 3 min - CO
- fast 2: O - 0.3 s - CO - 15 s - CO

N.B.: other sequences can be requested.

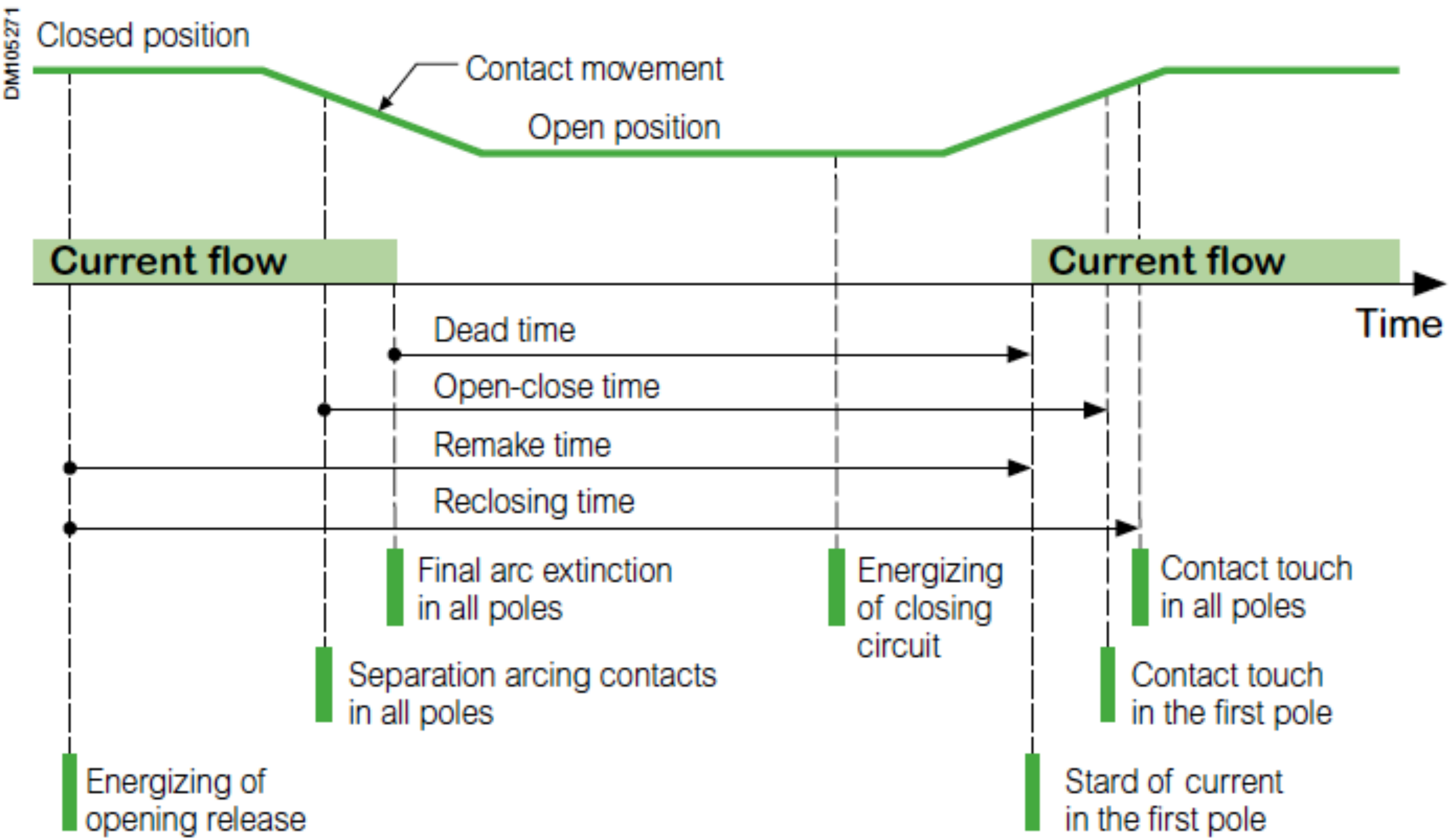


Close/Open cycle



Automatic reclosing cycle

Assumption: C order as soon as the circuit breaker is open,
(with time delay to achieve 0.3 s or 15 s or 3 min).



סיכום מפסיקי זרם

מסרט ב youtube

Different selection criteria

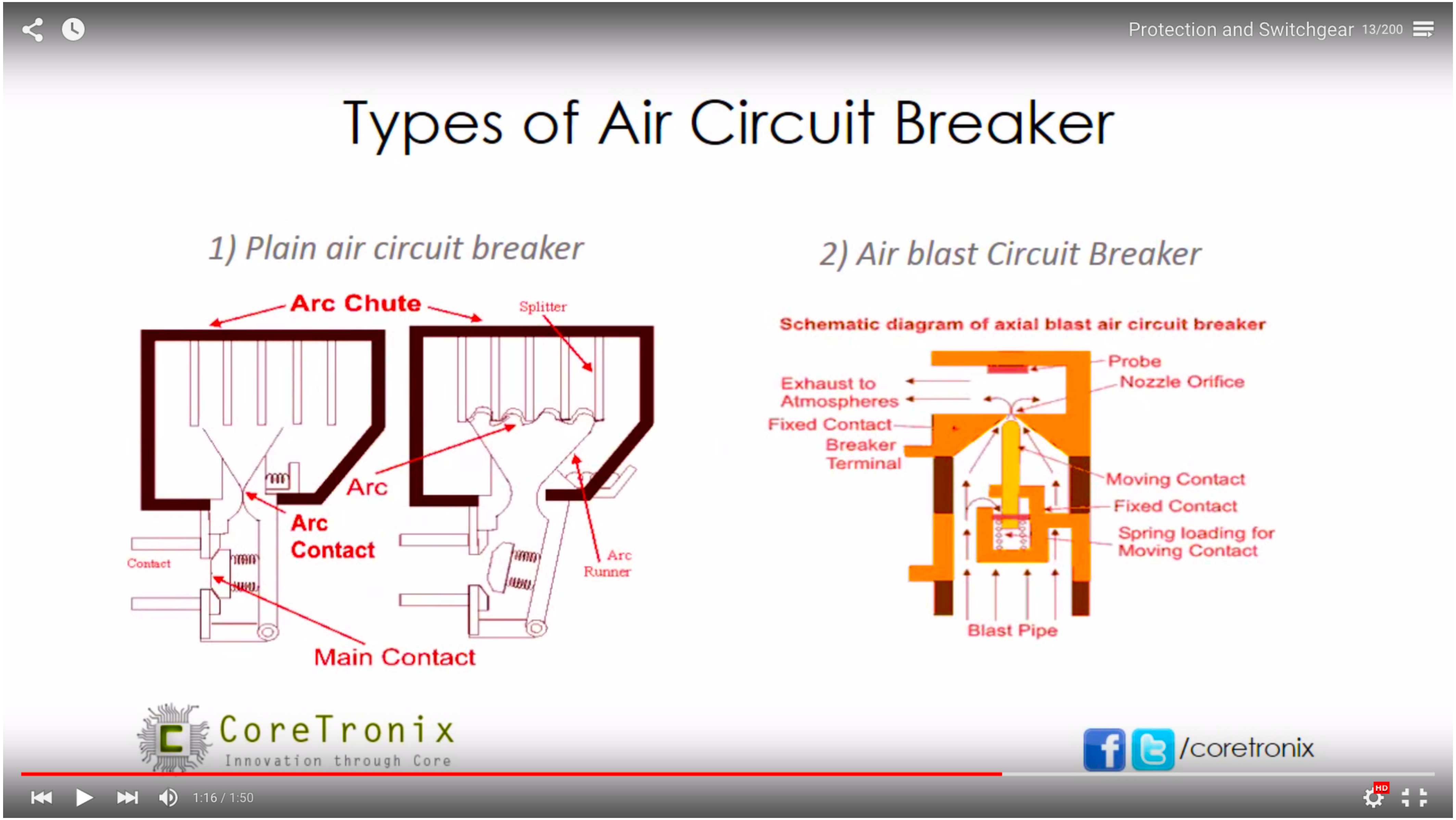
- All the characteristics for choosing a circuit breaker
  - Upstream Scc = upstream short-circuit power
  - U bb = voltage on busbars
  - I bb = current on busbars
  - Isc bb = short-circuit current on busbars
  - Ie = rated operating current
  - Ith = rated thermal current
  - Fixed or withdrawable
  - Standard

Electrical Circuit Breaker

- Definition of Circuit Breaker

  Electrical Circuit Breaker is a switching device which can be operated manually as well as automatically for controlling and protection of electrical power system respectively. As the modern power system deals with huge currents, the special attention should be given during designing of circuit breaker to safe interruption of arc produced during the operation of circuit breaker. This was the basic definition of circuit breaker.

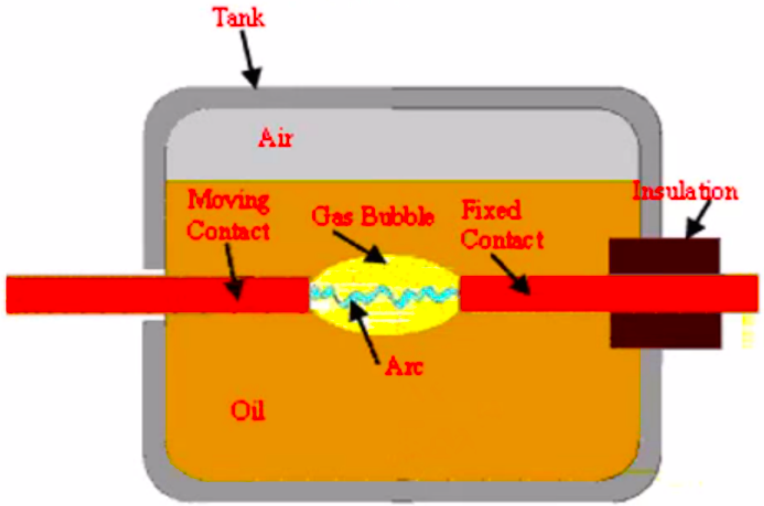
- Types of Circuit Breaker
  1) Oil Circuit Breaker
  2) Air Circuit Breaker
  3) SF6 Circuit Breaker
  4) Vacuum Circuit Breaker



Protection and Switchgear 13/200
Types of Air Circuit Breaker
1) Plain air circuit breaker
Arc Chute
Splitter
Arc
Arc Contact
Contact
Arc Runner
Main Contact
2) Air blast Circuit Breaker
Schematic diagram of axial blast air circuit breaker
Probe
Nozzle Orifice
Exhaust to Atmospheres
Fixed Contact
Breaker Terminal
Moving Contact
Fixed Contact
Spring loading for Moving Contact
Blast Pipe
CoreTronix
Innovation through Core
/coretronix
1:16 / 1:50

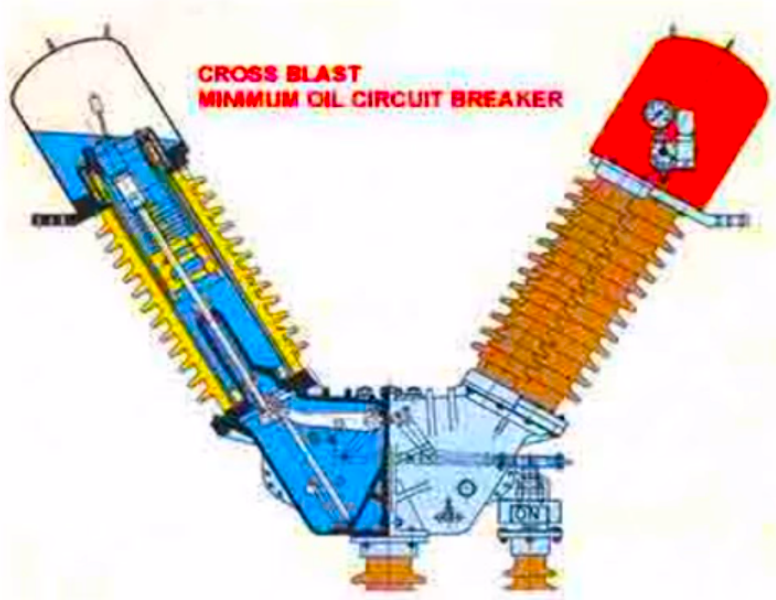
Types of oil circuit breakers

Bulk Oil Circuit Breaker or BOCB

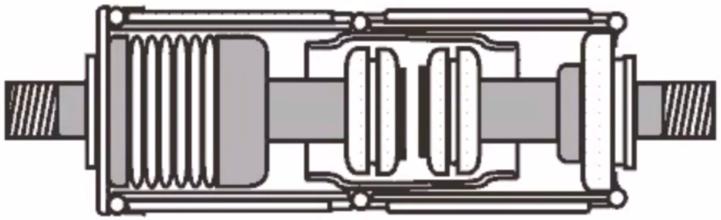


Conceptual view of Bulk Oil Circuit Breaker

Minimum Oil Circuit Breaker



Vacuum Circuit Breaker



Cross section of Vacuum Interrupter

SF6 Circuit Breaker

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Types and Operation of SF6 Circuit Breaker

Under Electrical Switchgear

This page is all about:

SF_6 Circuit Breaker

Disadvantages of SF_6 CB

Types of SF_6 Circuit Breaker

Working of SF_6 Circuit Breaker

https://www.electrical4u.com/types-and-operation-of-sf6-circuit-breaker/

Table2. *Comparison of the SF6 And Vacuum Technologies In Relation To Operational Aspects*

Criteria	SF6 Breaker	Vacuum Circuit Breaker
Summated current cumulative	10-50 times rated short circuit current	30-100 times rated short circuit current
Breaking current capacity of interrupter	5000-10000 times	10000-20000 times
Mechanical operating life	5000-20000 C-O operations	10000-30000 C-O operations
No operation before maintenance	5000-20000 C-O operations	10000-30000 C-O operations
Time interval between servicing Mechanism	5-10 years	5-10 years
Outlay for maintenance	Labour cost High, Material cost Low	Labour cost Low, Material cost High
Reliability	High	High
Dielectric withstand strength of the contact gap	High	Very high

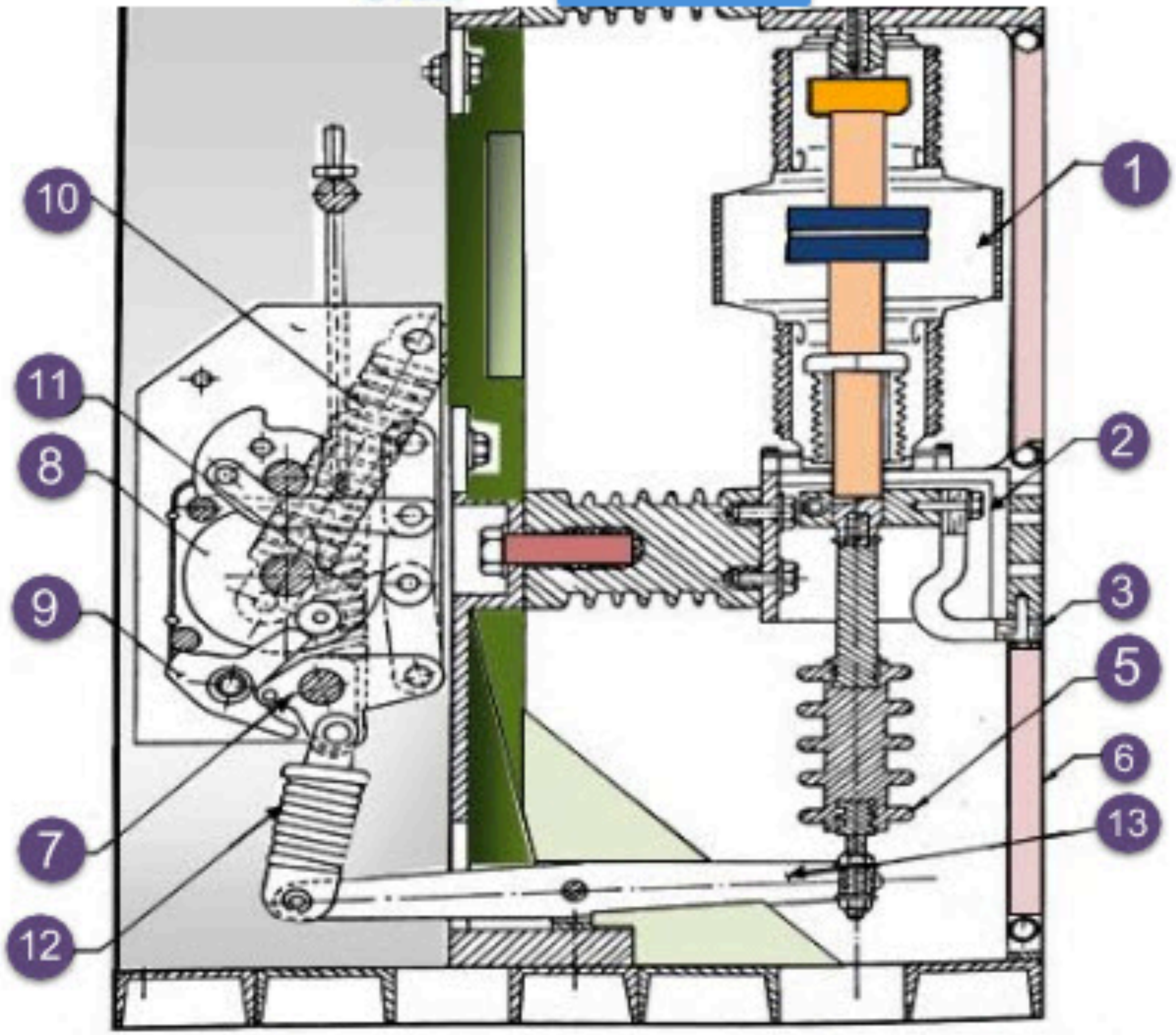
Here are a few #electrical characteristics of two medium voltage #circuit breakers which are used in the MCset range of cubicles.

A few characteristics of MV circuit breakers

	LF1	SF2
Rated voltage	7.2 & 12 kV	24 kV
Rated current	630/1250 A	630/1250/2500 A
Breaking capacity	31.5 kA	25 & 31.5 kA
Making capacity	80 kA	63 & 80 kA

LF1 circuit breaker

SF2 circuit breaker



1. Vacuum Interrupter
2. Terminals
3. Flexible connections
4. Support Insulators
5. Operating Rod
6. Tie bar
7. Common operating shift
8. Operating corn
9. Locking cam
10. Making spring
11. Breaking spring
12. Loading spring
13. Main Link

SF_6 or vacuum?

Choosing the right MV circuit-breaker

4.2 Inductive current transformers (CTs)

An important clarification must be made regarding the CTs relative to their construction shape and to the method of measurement. This refers particularly to ring CTs which are CTs to all effects and must be classified as such.

The CT can be of:

- wound type (as CTs inside medium voltage switchgear normally are), with the two terminal clamps of the primary circuit and the two terminal clamps of the secondary circuit taken outside.
  The primary circuit can, in this case, also have a number of turns different from 1;

- busbar bushing type where there is a piece of busbar (normally made of copper) already embedded in resin. In this

4.1 Inductive transformers

The main Standard references for the inductive type of CTs and VTs (with iron laminates) in medium voltage networks are:

- EN 60044-1 current transformers;
- EN 60044-2 voltage transformers.

The construction characteristics and definition of the precision classes are given in these Standards.
It must be considered that the precision class for instrument CTs and VTs and protection VT, is a function of the load connected to the secondary: precision is only guaranteed when the secondary load is higher than 25% of the rated performance of the transformer.
Considering the present low consumptions of the apparatus connected to the secondary, it is therefore essential for the performance of the VTs (both of measurement and of protection) as well as of the instrument CTs to be limited to guarantee that the transducer operates in the precision class for which it has been provided.

PE57466

MCset

Example 5

A very classic structure of withdrawable air-insulated switchgear (Schneider Electric MCset), with interlock accessible compartments for the connections (and CTs) and the main switching device.
The withdrawing function provides the independence of the main switching device compartment from the other HV compartments; then, the cables (and of course the busbar) can remain live when accessing the breaker.
The LSC classification applies, and category is LSC2B-PM as Schneider-Electric PIX range.

PE90700

SM6

Example 6

A typical secondary distribution switch-disconnector switchgear, with only one interlock accessible compartment for the connection (Schneider Electric SM6).
When accessing one compartment within the switchboard, all other functional units are kept in service. Category is LSC2.
Similar situation occurs with most of the Ring Main Units solutions.

PE57770

RM6

Example 7

An unusual functional unit, available in some ranges: the metering unit which provides VTs and CTs on the busbar of an assembly (here a Schneider Electric RM6).
This unit has only one compartment, accessible to possibly change the transformers, or their ratio. When accessing such a compartment, the busbar of the assembly shall be dead, then preventing any service continuity of the assembly. This functional unit is LSC1.

PE90845

Premset

Example 8

The new generation of MV Switchgear incorporates a wealth of innovations.
The Shielded Solid Insulation System (SSIS) drastically reduces the risk of internal arc faults, and makes it non sensitive to harsh environments.
A compact modular vacuum switchgear assembly (Schneider Electric PREMSET), with a wide choice of functions, designed to fit all applications.
This functional unit is LSC2A-PM.