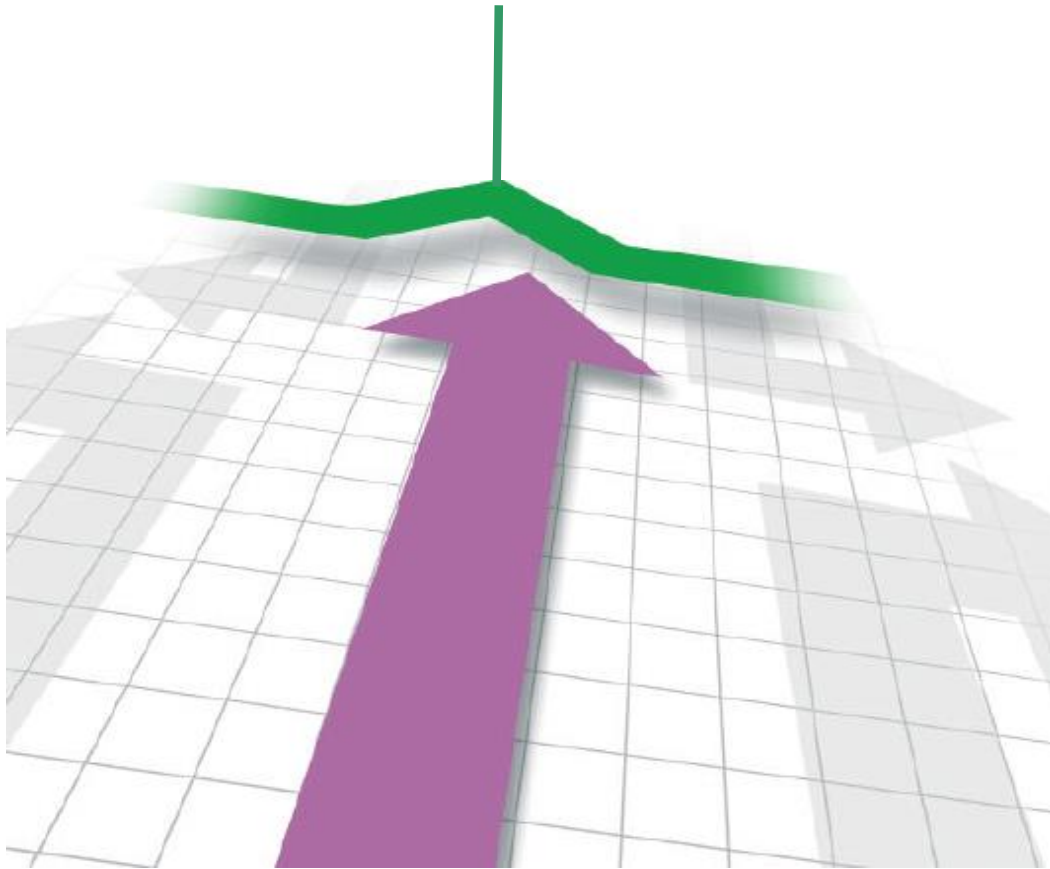


LV Switchgears Overview

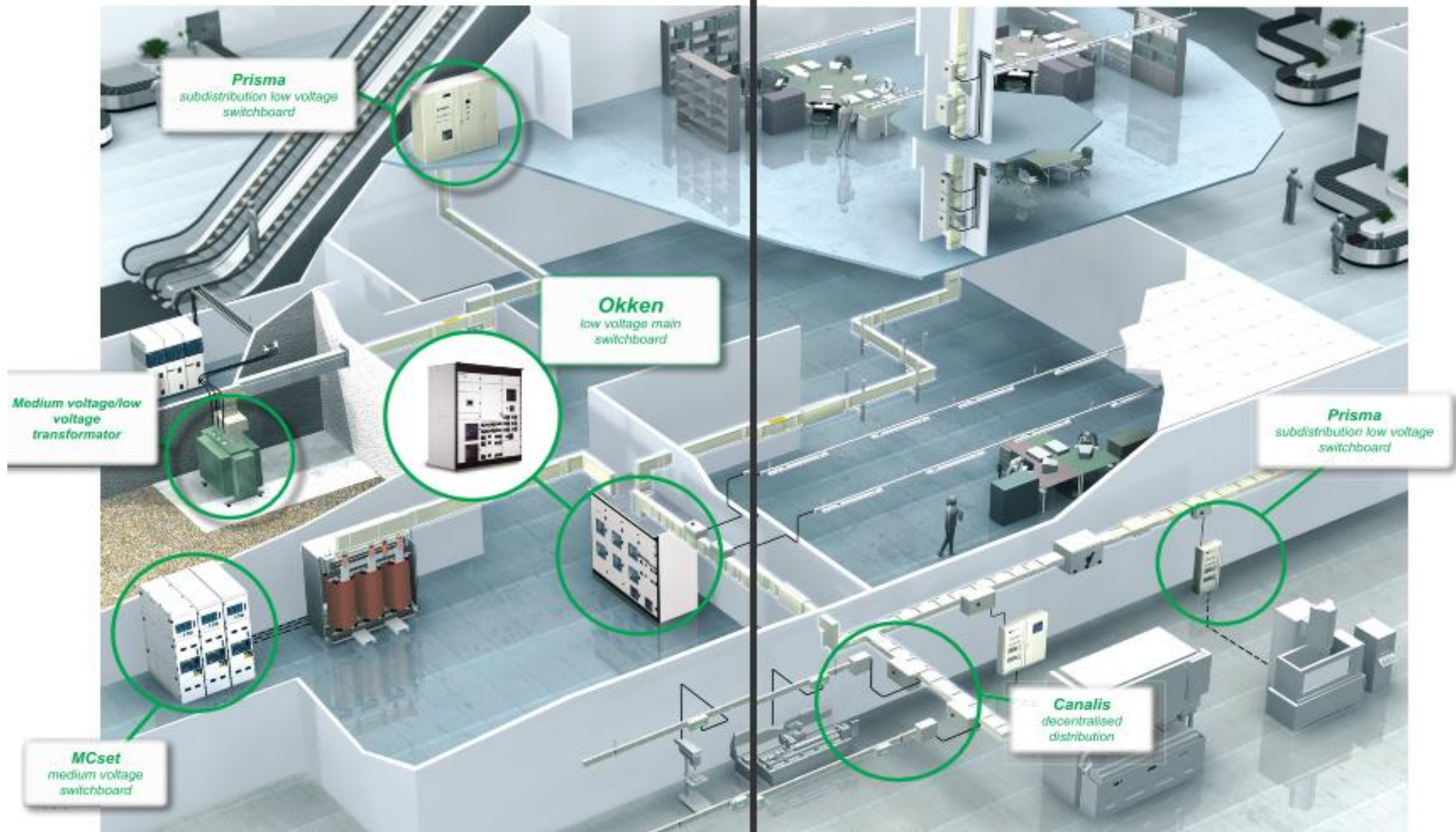


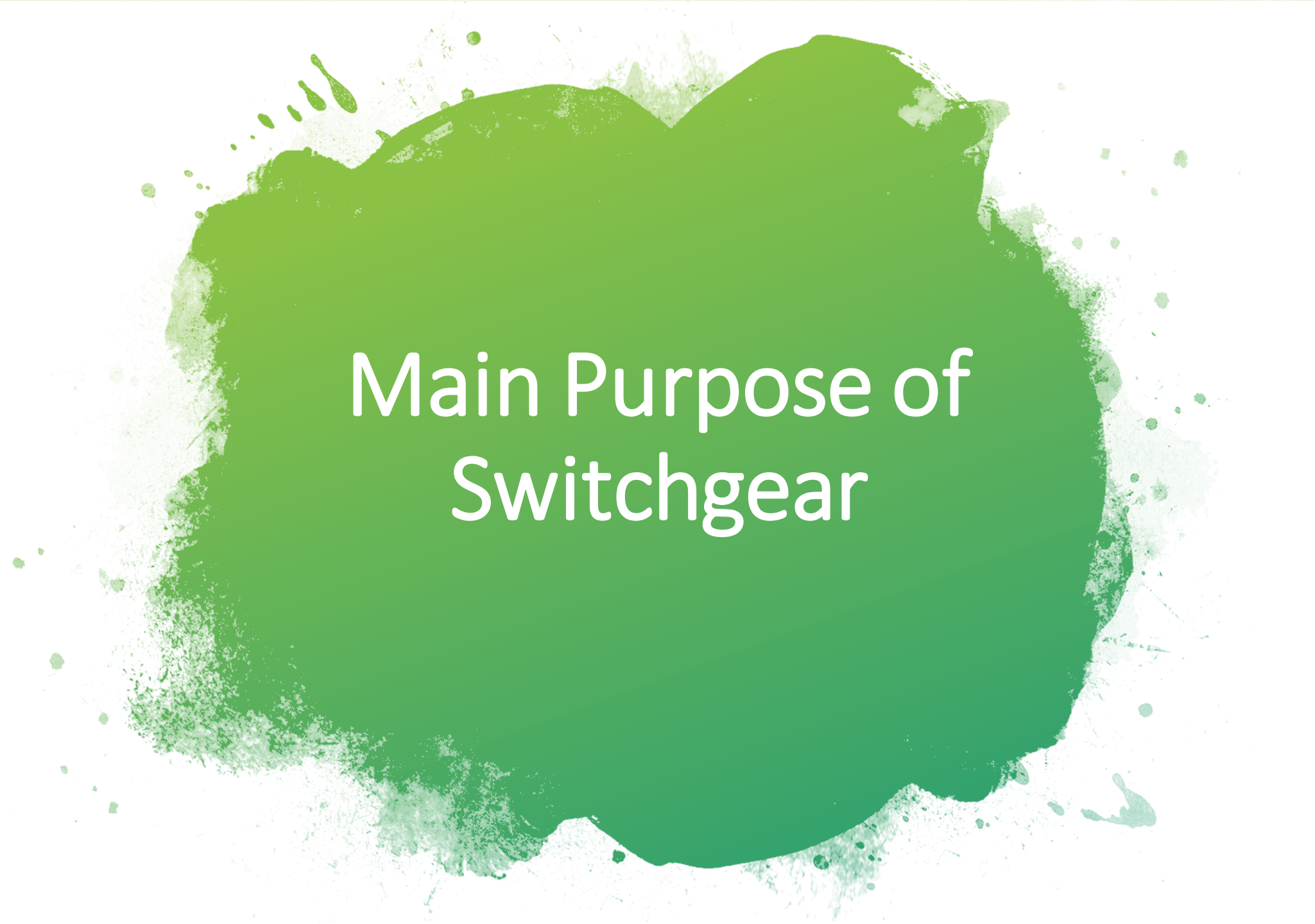
By
Ahmed Besheer
Senior Electrical Design Engineer
at Schneider Electric

Schneider Electric Graduation Projects Sponsorship



- 1 Main Purpose of Switchgear**
- 2 Types of LV switchgears according to installation method.**
- 3 Free Stand LV switchgear construction**
- 4 Accessibility of Free stand switchgear**
- 5 Ingress Protection (IP)**
- 6 Forms of separation**
- 7 Internal Arc criteria**
- 8 Overview about devices used in LV switchgears**





Main Purpose of Switchgear

- **Switchgear is a general term covering a wide range of equipment concerned with 3 basic notions:**

- **Isolation**

- ✓ cutting off the supply or a discrete section of the installation by separating the installation or section from every source of electrical energy for safety reasons (e.g. when work on conductors is required)

- switch, isolator

- **Control**

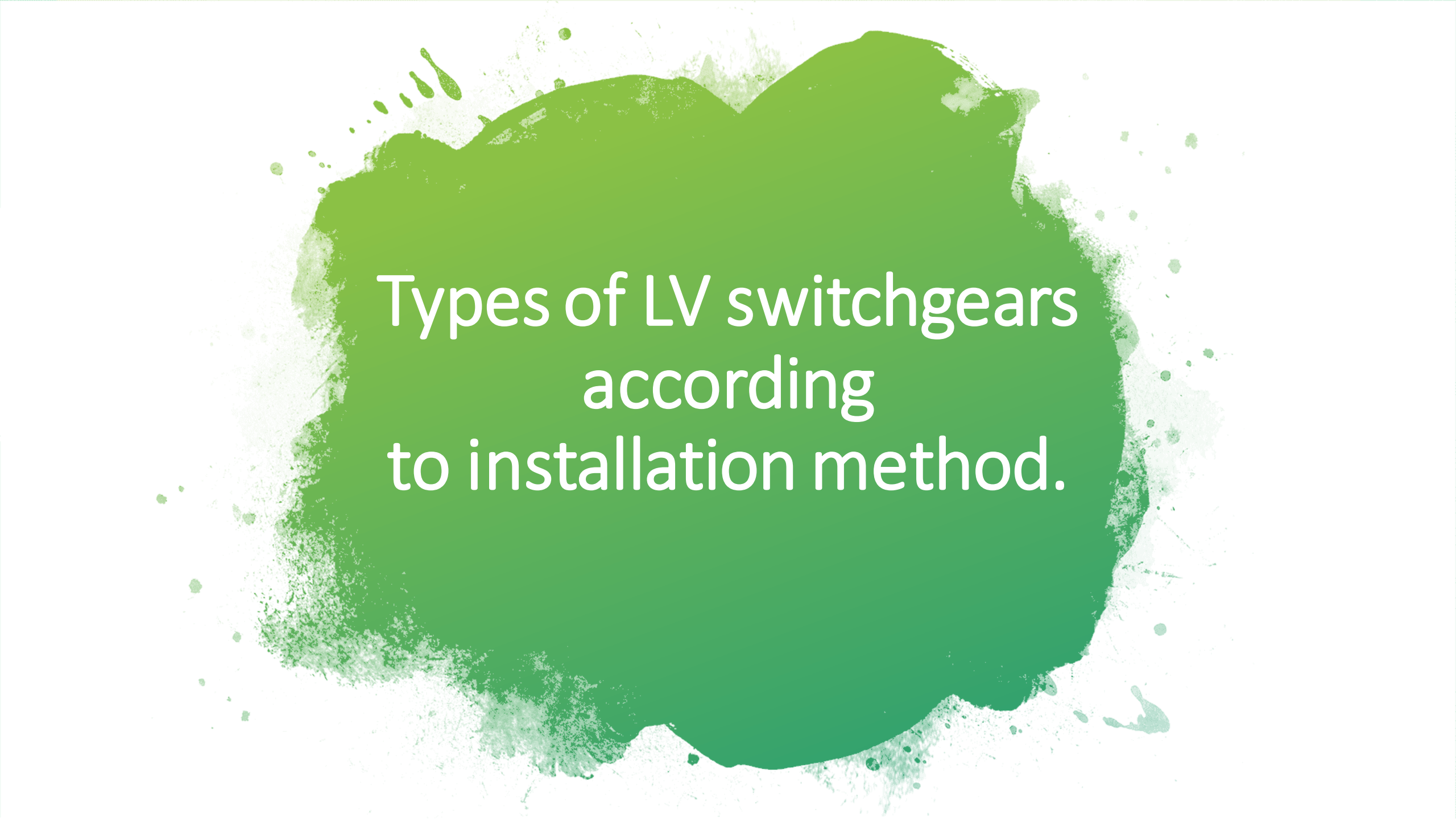
- ✓ switching on or off during normal operating conditions, for the purpose of operation and maintenance

- contactor, switch, emergency switching

- **Protection**

- ✓ protecting cables, equipment and people against abnormal conditions such as overload, short-circuit and earth fault, by interrupting the fault currents and thereby isolating the fault

- circuit breaker, switch fuse



Types of LV switchgears
according
to installation method.

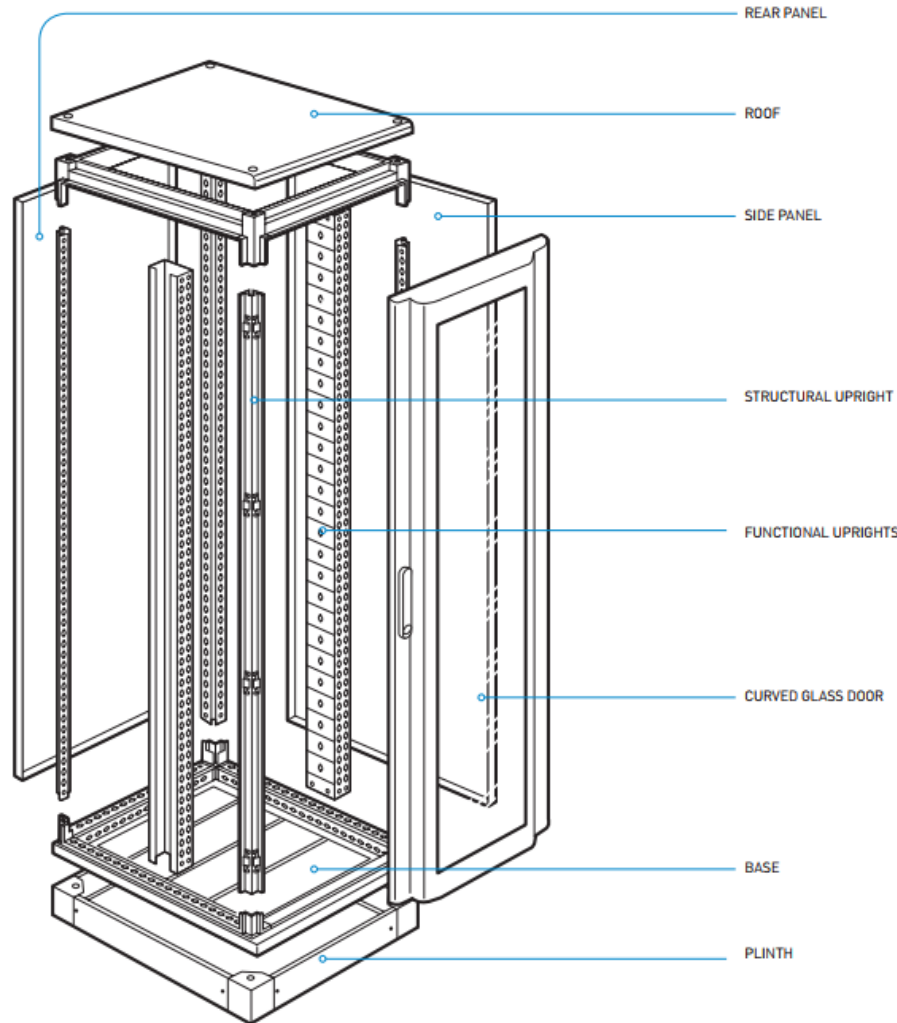
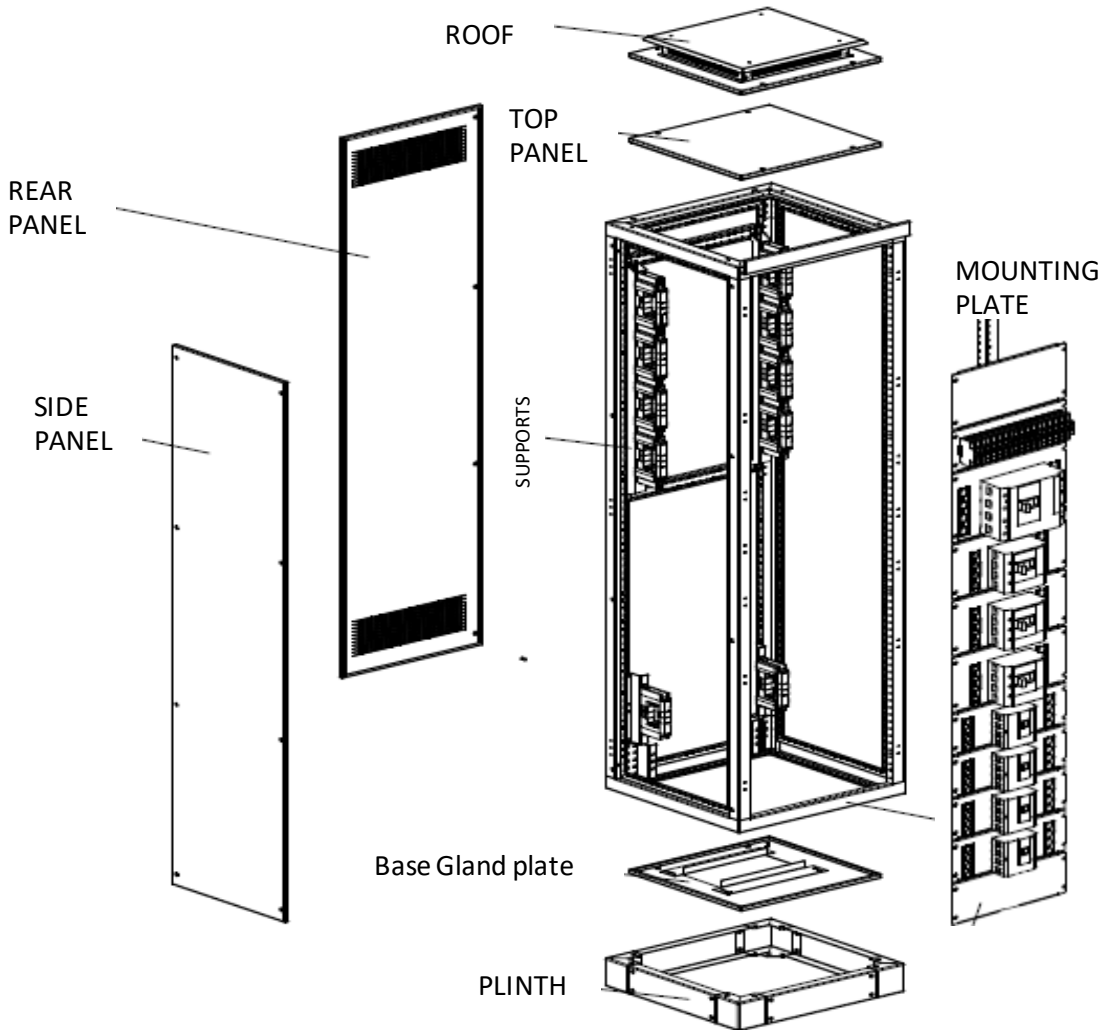
1. Flush Wall Mounted.
2. Surface Wall mounted.
3. Free Stand.

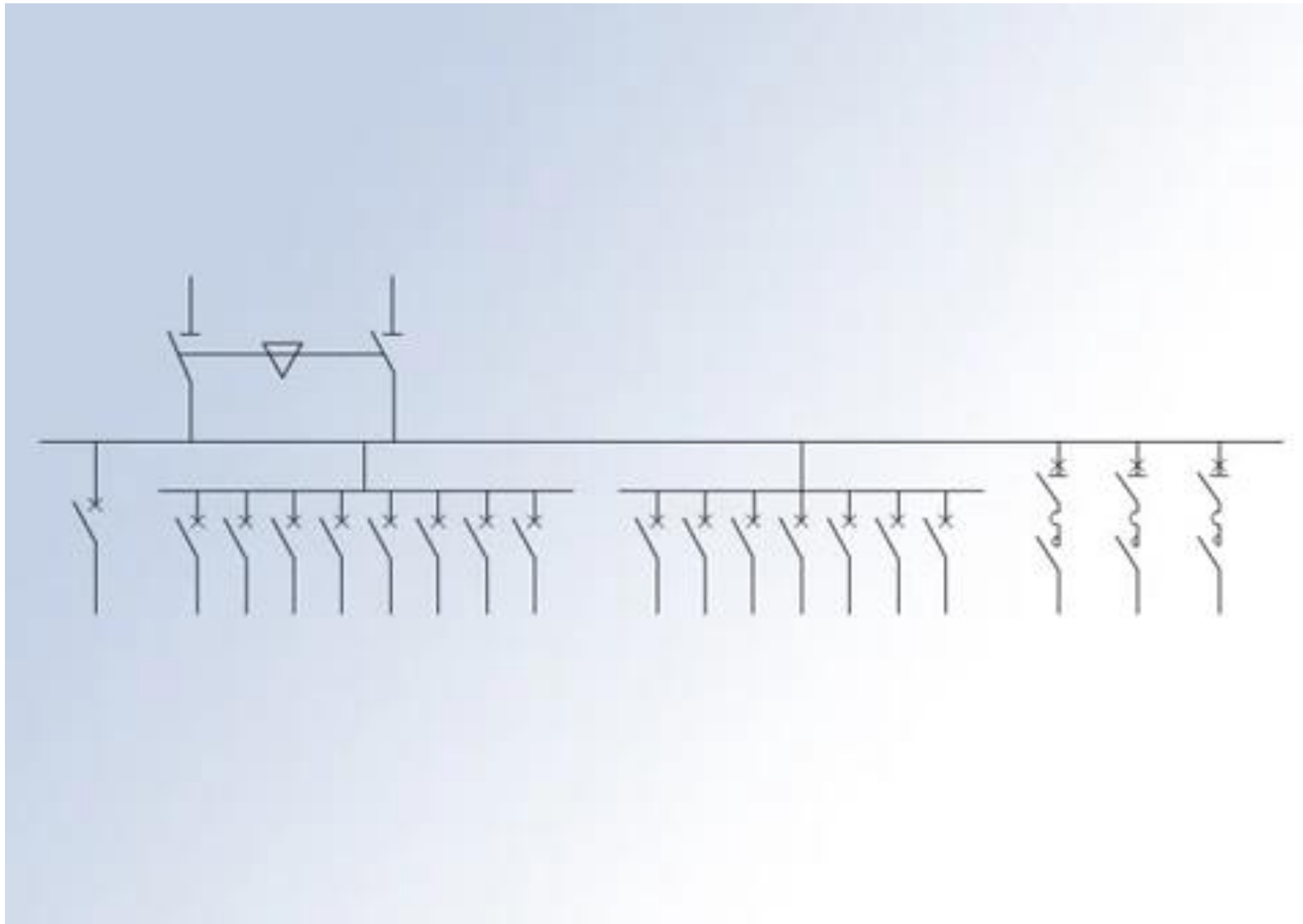




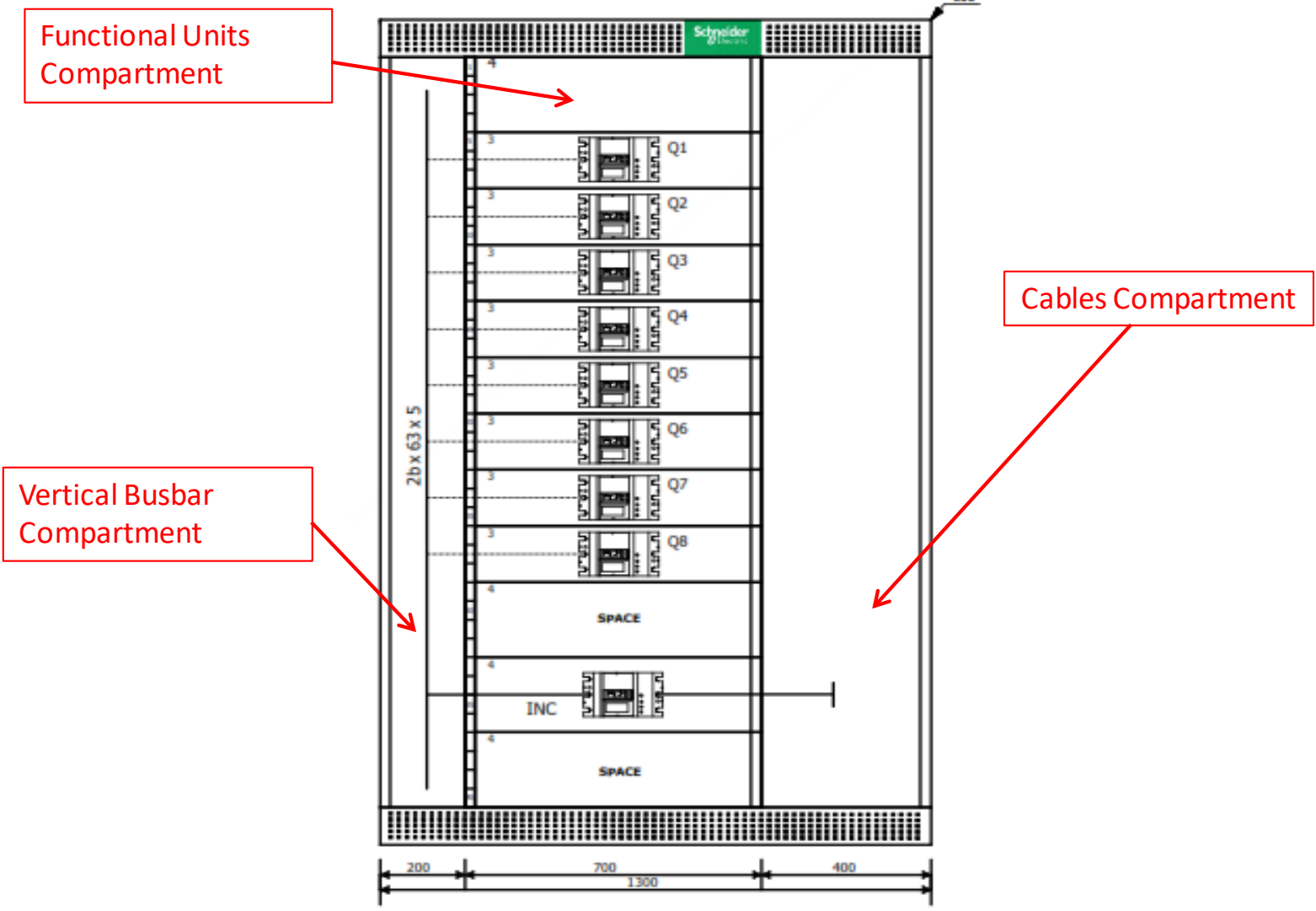
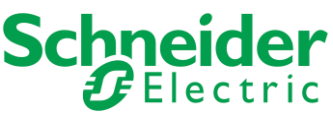
Free Stand LV switchgear construction

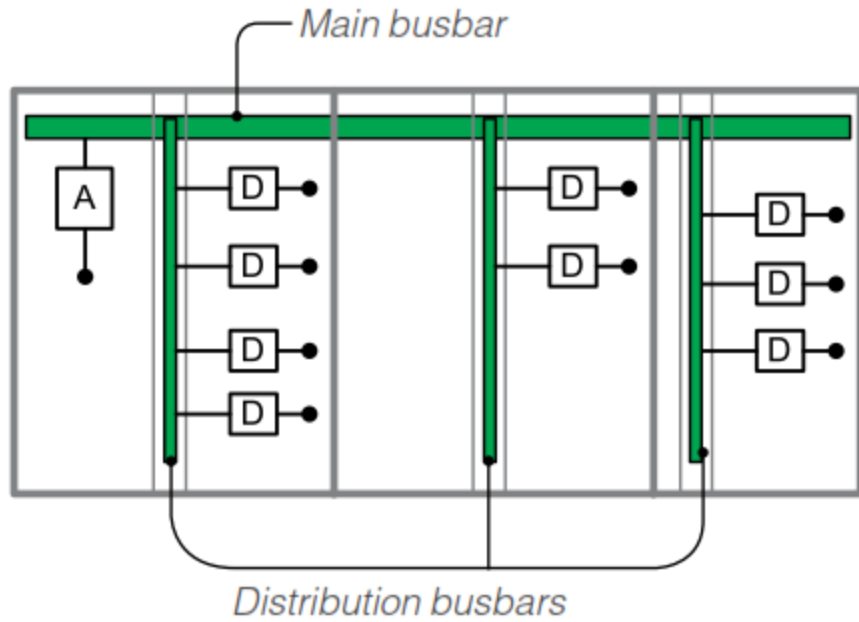
Body Construction





Main Compartments





Vertical Busbar
Compartment

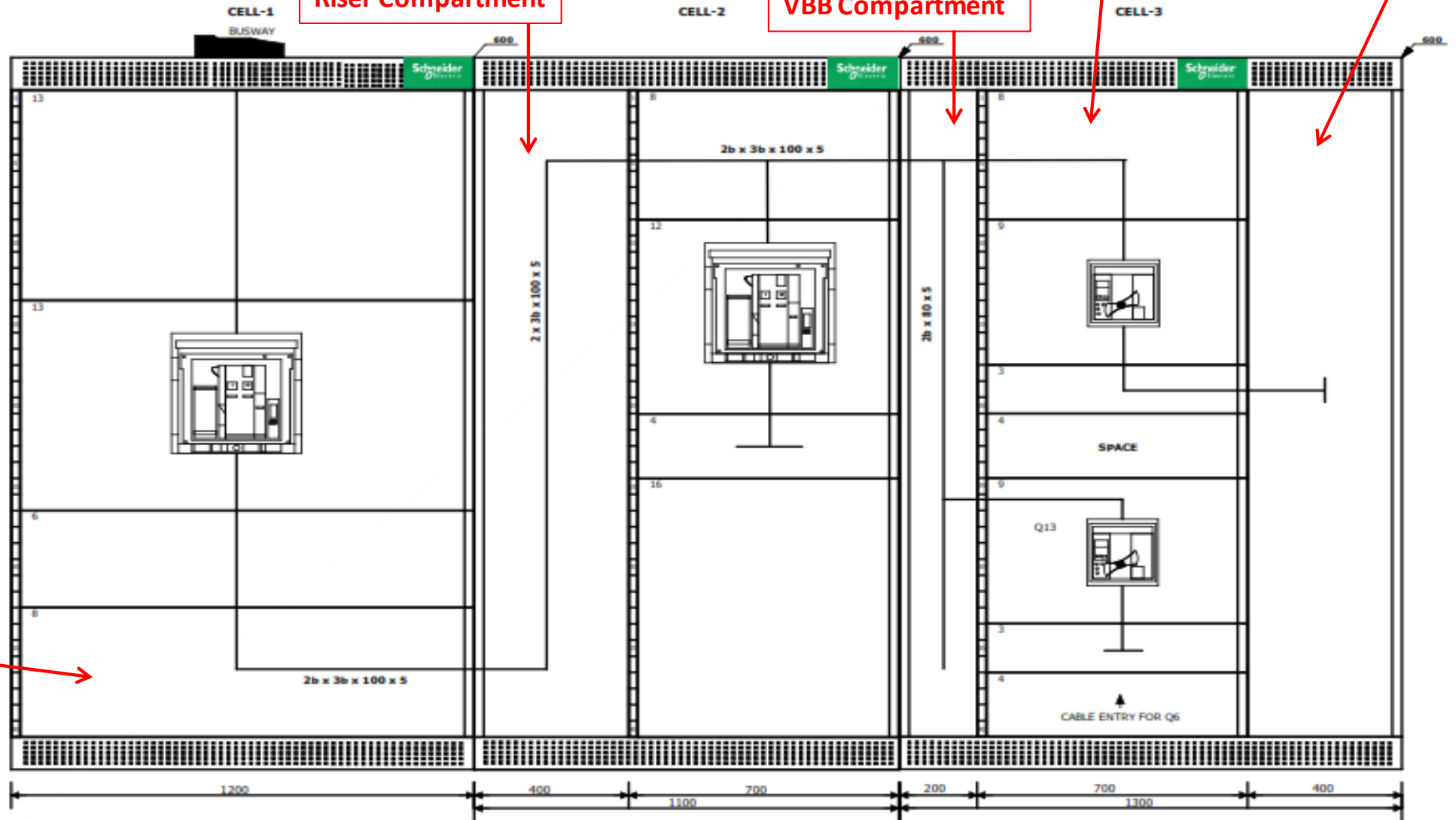
Cables Compartment



Functional Units
Compartment

Riser Compartment

VBB Compartment

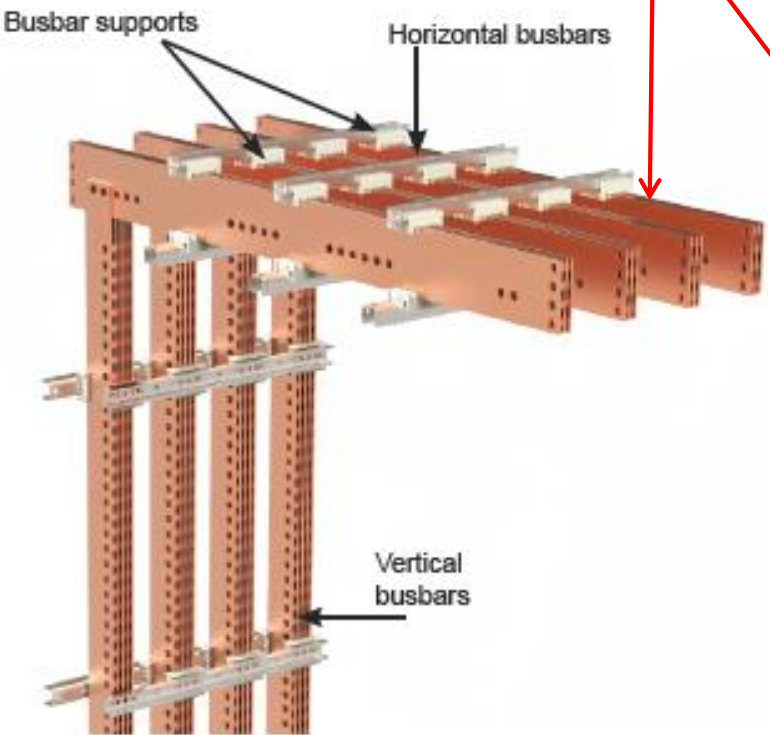


HBB Compartment

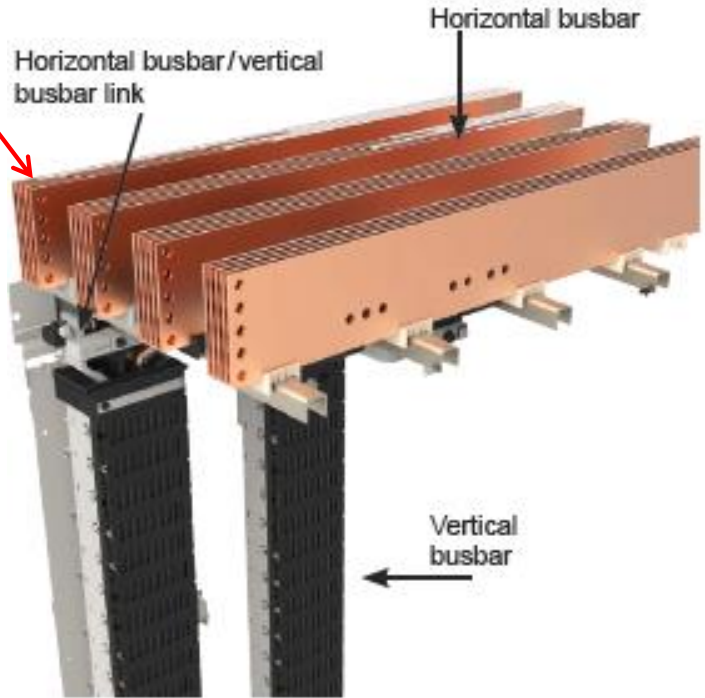
BUSBARS TYPES



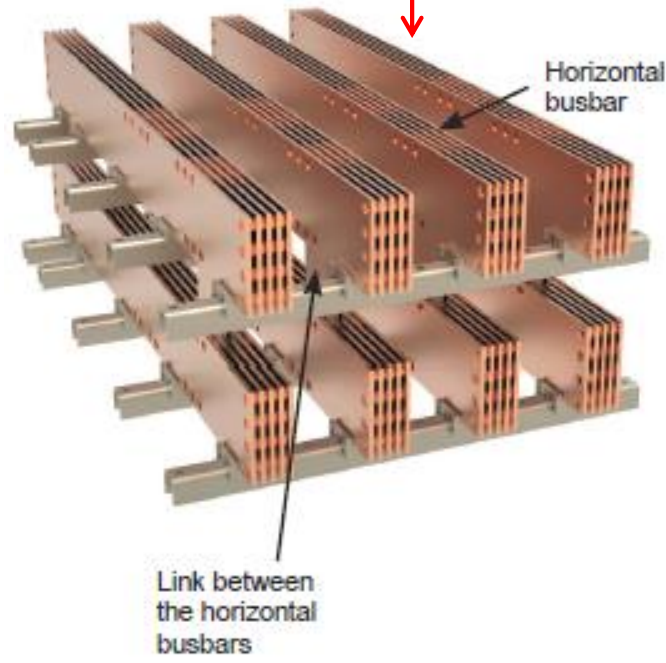
Single Horizontal Busbar

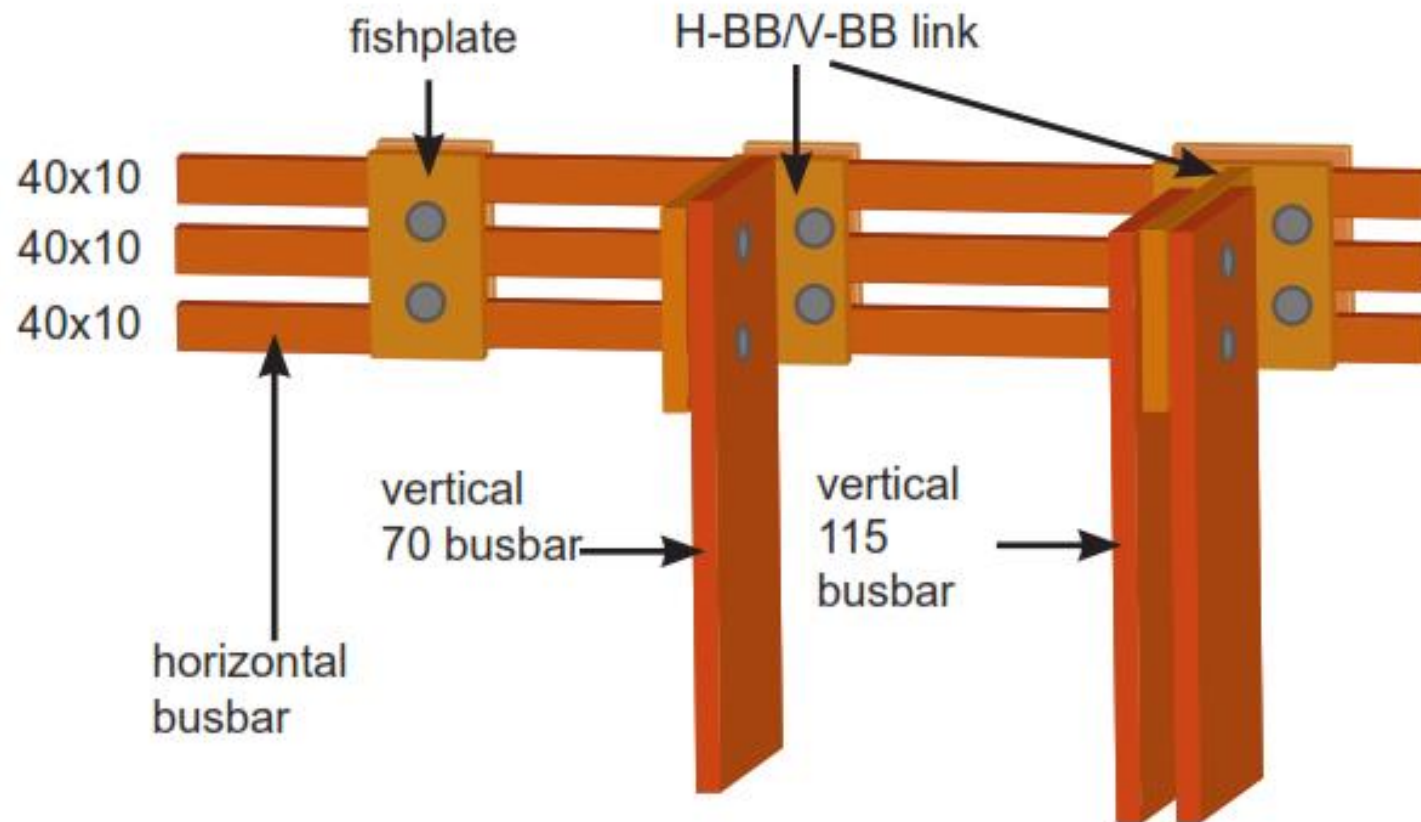


Copper Bars

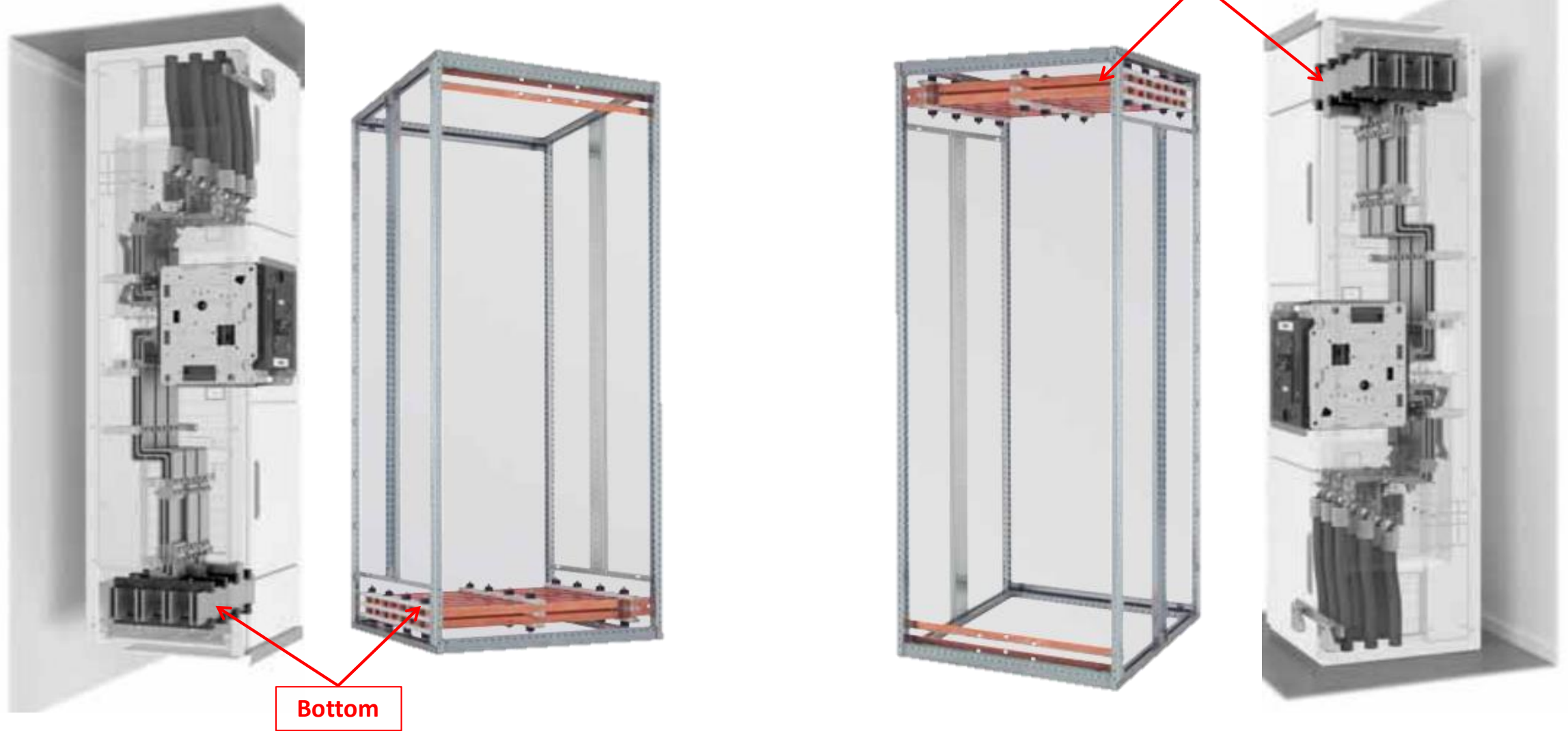


Double Horizontal Busbar

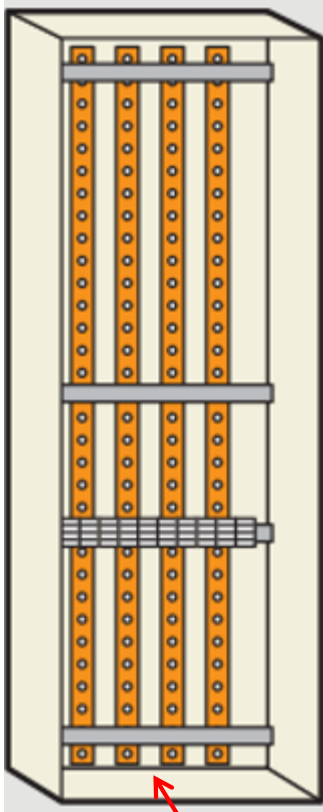




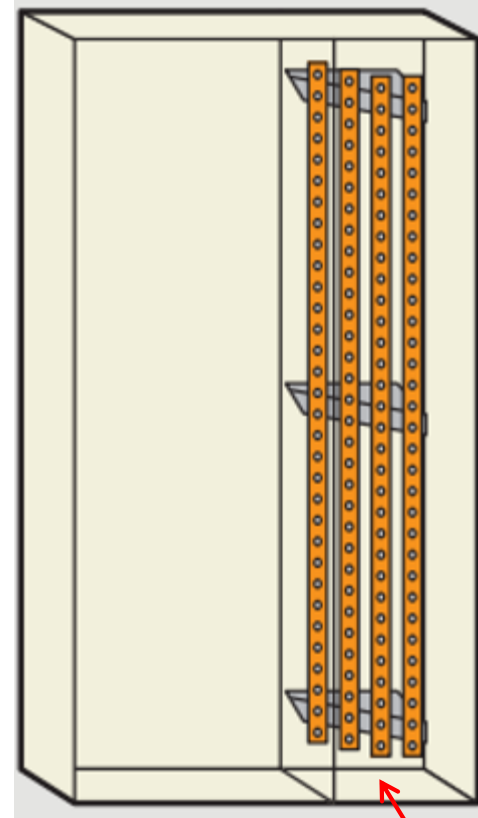
Horizontal Busbar Locations



Vertical Busbar Locations



REAR to Functional Units



Side to Functional Units

Functional Units Types:

1- Fixed



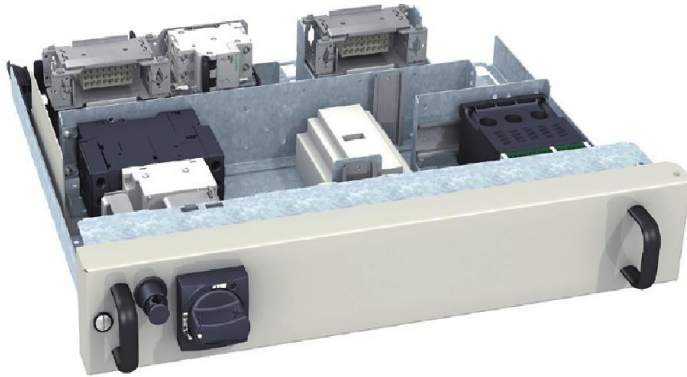
2- Plug-in



BLOKSET D-TYPE



3- Withdrawable



BLOKSET MW2-TYPE



Drawer positions

Drawers operation is very simple. Using the indexing pushbutton, the operator can simply move the drawer in the draw-in, test, draw-out positions. Each position are mechanically marked with a mechanical indicator on the drawer sides.



Draw-in

- The functional unit is operational.
- Power and auxiliaries are connected.



Test

- The functional unit is not operational.
- Only auxiliaries are connected.
- Padlocking is possible to keep the drawer in this position.
- Allows the functional unit testing.
- Allows maintenance on the process.



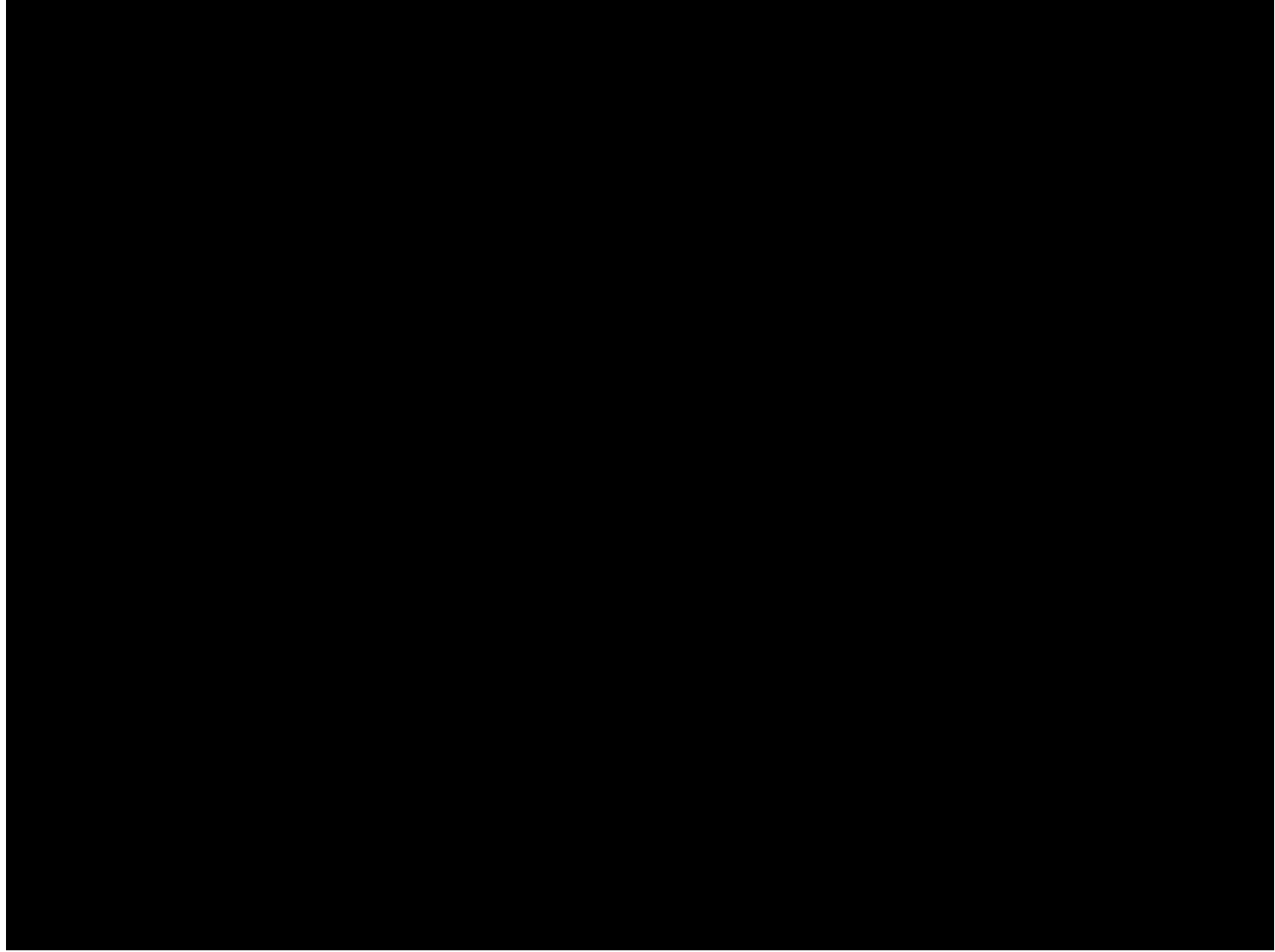
Draw out

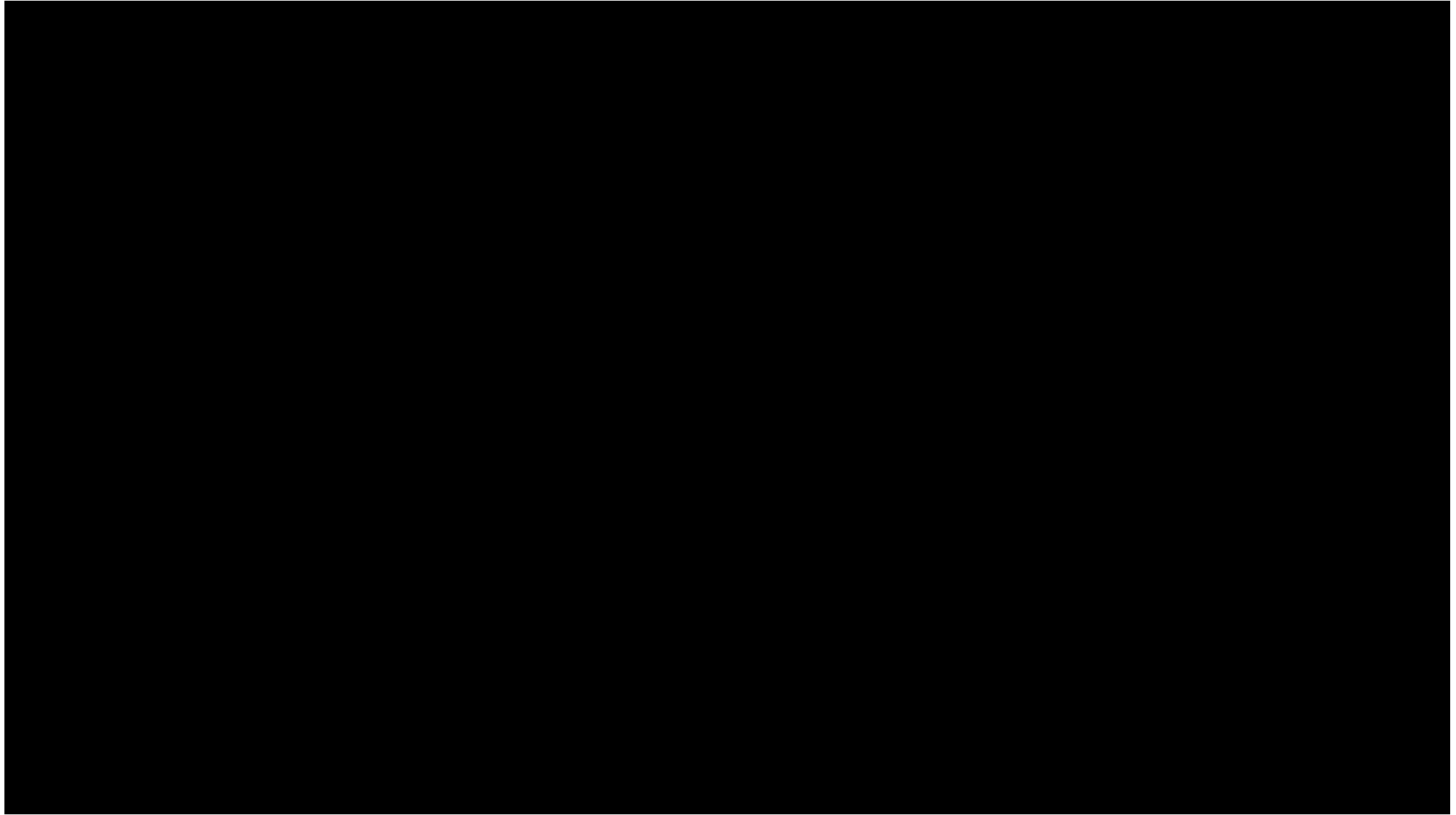
- The functional unit is not operational.
- Power and auxiliaries are disconnected.
- Padlocking is possible to keep the drawer in this position.
- Allows maintenance on the process.



Withdrawn

- The drawer can be fully extracted.
- Allows quick replacement.
- Allows switchboard live change.
- Padlocking is possible on the fixed part.







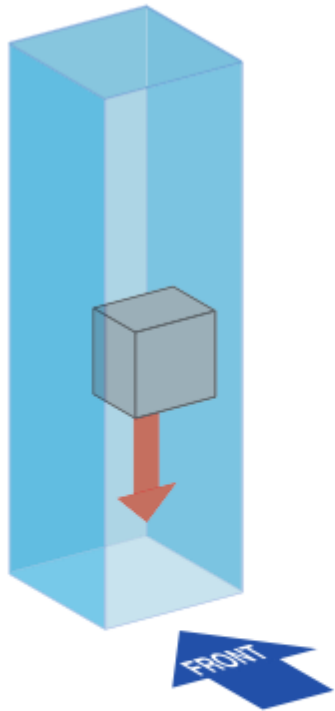
Life Is On



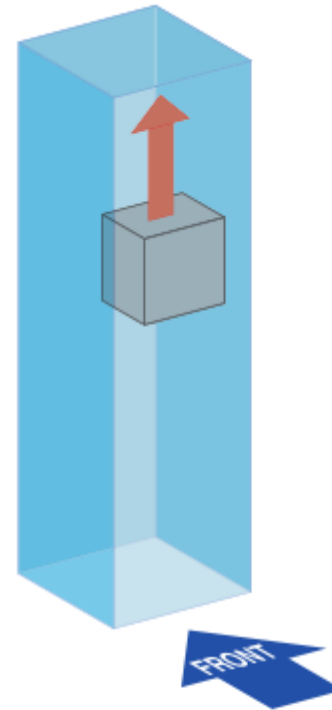
A large, irregular green watercolor splash with white text centered inside.

Accessibility of Free Stand Switchgear

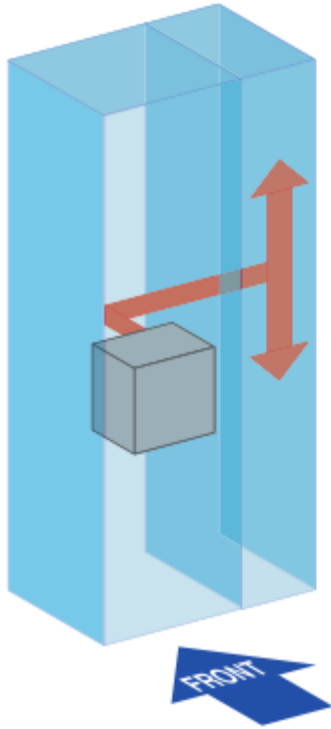
Feeder “connection/Entry” Types



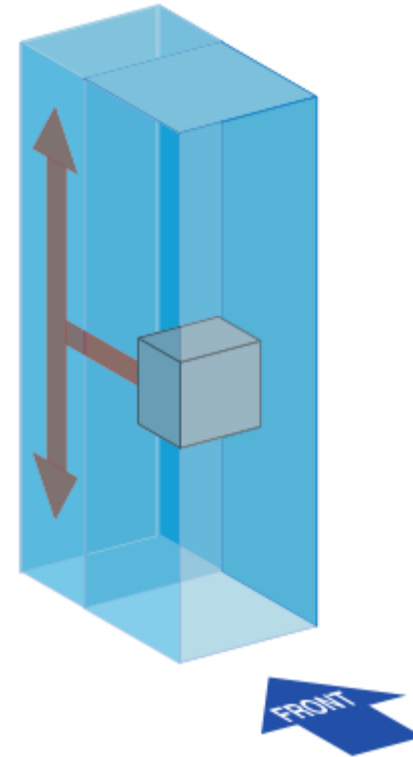
BDC: bottom direct connection



TDC: top direct connection



SC: side connection



RC: rear connection

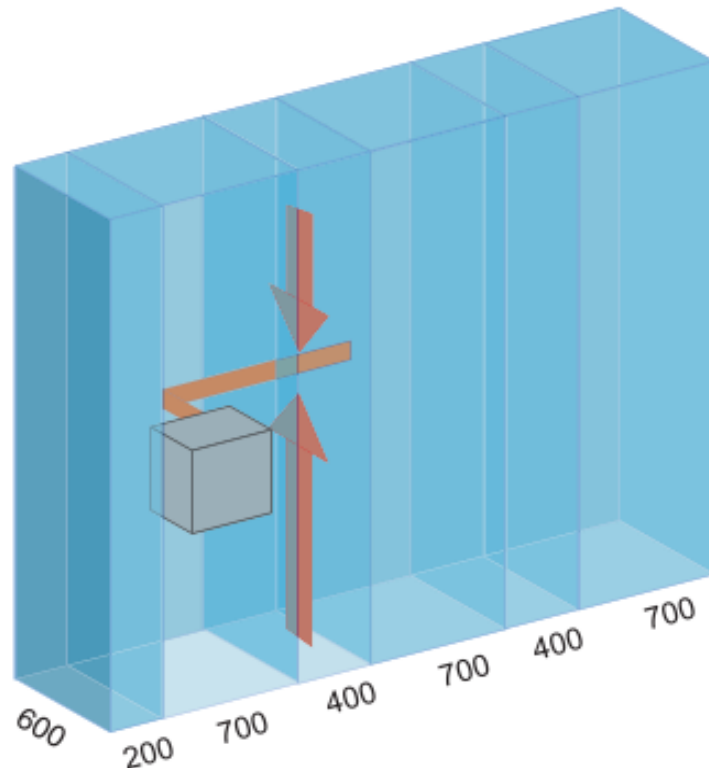


Life Is On



Front Accessibility of Cables

Columns for side connection (SC)



- A** device cubicle
- C** cable compartment
- V** vertical busbar compartment

In case of a side connection switchboard, the depth is unique allthrough its length: 600 mm.

To the right of the device cubicle, compartments (width 200, 400 or 700 mm) are added in order to give way for the cables and device connections, according to the size and the quantity of cables to be connected.

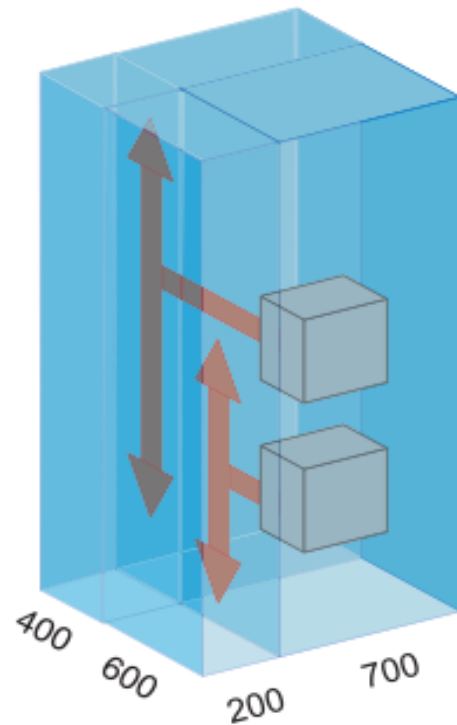
Due to the position of the horizontal busbar, device connection can be made indifferently from the top or from the bottom of the switchboard.

SC columns panorama (switchboard depth: 600 mm)

column width 900/1100 mm			column width 900 mm		
A C 600 700 200/400			V A C 600 200 700 200/400		

Rear Accessibility of Cables

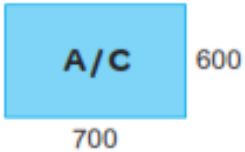
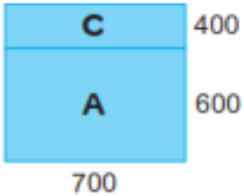
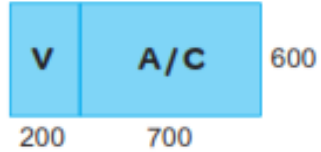
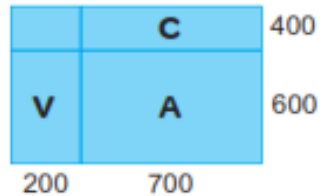
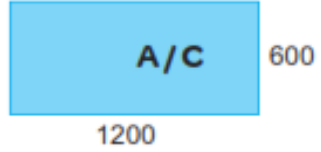
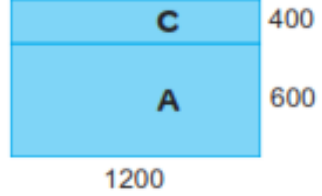
Columns for rear connection (RC)



- A** device cubicle
- C** cable compartment
- V** vertical busbar compartment

For rear connection (RC), a solution depth 600 mm is possible for small I_n (≤ 630 A).
An additional compartment depth 400 mm is added for $I_n > 630$ A.

RC columns panorama

	switchboard depth 600 mm	switchboard depth 1000 mm
device cubicle width 700 mm		
device cubicle width 900 mm		
device cubicle width 1200 mm		

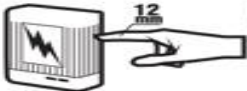
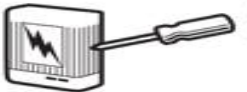
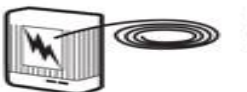
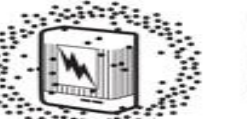


Ingress Protection (IP)

Ingress Protection or “Degree / index” of protection:

The European standard EN 60529 dated October 1991, IEC publication 529 (2nd edition - November 1989), defines a coding system (IP code) for indicating the degree of protection provided by electrical equipment enclosures against the ingress of solid foreign objects or water.

IP (Ingress Protection) Ratings Guide

SOLIDS		WATER	
1	 Protected against a solid object greater than 50 mm such as a hand.	1	 Protected against vertically falling drops of water. Limited ingress permitted.
2	 Protected against a solid object greater than 12.5 mm such as a finger.	2	 Protected against vertically falling drops of water with enclosure tilted up to 15 degrees from the vertical. Limited ingress permitted.
3	 Protected against a solid object greater than 2.5 mm such as a screwdriver.	3	 Protected against sprays of water up to 60 degrees from the vertical. Limited ingress permitted for three minutes.
4	 Protected against a solid object greater than 1 mm such as a wire.	4	 Protected against water splashed from all directions. Limited ingress permitted.
5	 Dust Protected. Limited ingress of dust permitted. Will not interfere with operation of the equipment. Two to eight hours.	5	 Protected against jets of water. Limited ingress permitted.
6	 Dust tight. No ingress of dust. Two to eight hours.	6	 Water from heavy seas or water projected in powerful jets shall not enter the enclosure in harmful quantities.
Rating Example: IP65 INGRESS PROTECTION		7	 Protection against the effects of immersion in water between 15 cm and 1 m for 30 minutes.
		8	 Protection against the effects of immersion in water under pressure for long periods.

الرقم الأول من اليسار	تعريف درجة الرقم الأول	الرقم الثاني من اليسار	تعريف درجة الرقم الثاني
0	لا توجد حماية	0	لا توجد حماية
1	حماية من الأجسام الصلبة الأكبر من 50 ملم (مثل حماية ضد تعرض اليد للامسة الأجزاء الكهربائية)	1	حماية ضد سقوط قطرات الماء عموديا (التكثيف على سبيل المثال)
2	حماية من الأجسام الصلبة الأكبر من 12 ملم (مثل أصابع اليد)	2	حماية ضد الرش مباشرة من الماء تصل إلى 15 درجة عموديا.
3	حماية من الأجسام الصلبة الأكبر من 2.5 ملم (مثل الأدوات والاسلاك)	3	حماية ضد الرش مباشرة من الماء تصل إلى 60 درجة عموديا.
4	حماية من الأجسام الصلبة الأكبر من 1 ملم (مثل الأدوات والاسلاك الصغيرة)	4	حماية ضد رش المياه من جميع الاتجاهات - دخول محدود مسموح به
5	حماية محدودة لدخول الغبار - لا تشمل الترسبات القوية للغبار	5	محمي ضد تدفق المياه تحت ضغط قليل من كل الاتجاهات - دخول محدود مسموح به
6	حماية كاملة ضد دخول الغبار	6	محمي ضد تدفق المياه تحت ضغط عالي من كل الاتجاهات - دخول محدود مسموح به
		7	حماية ضد آثار غمر الجهاز بالماء بين 15 سم ومتر واحد
		8	حماية ضد آثار غمر الجهاز بالماء تحت الضغط لفتترات طويلة

IP degree selection

- Selection of IP degree must be according to actual operating conditions based on the locations in which switchgears & panel boards are installed.

- For Example:

IP54 degree of protection - according to IEC standard 60529

is the answer when a distribution and motor control switchboard's operating environment is dusty and contains damp, in some industrial and tertiary sites.

- Correct selection of IP degree will highly optimize switchgears dimensions & cost.

Example showing the effect of (IP) on deration values of C.Bs:

T°amb (°C)	IP ≤ 42				IP 54			
	35	40	45	50	35	40	45	50
NT06	630	630	630	630	630	630	630	630
NT08	800	800	800	800	800	800	800	800
NT10	1000	950	900	900	900	900	850	850
NT12	1250	1250	1200	1150	1150	1100	1050	1000
NT16	1400	1350	1300	1250	1250	1200	1150	1100



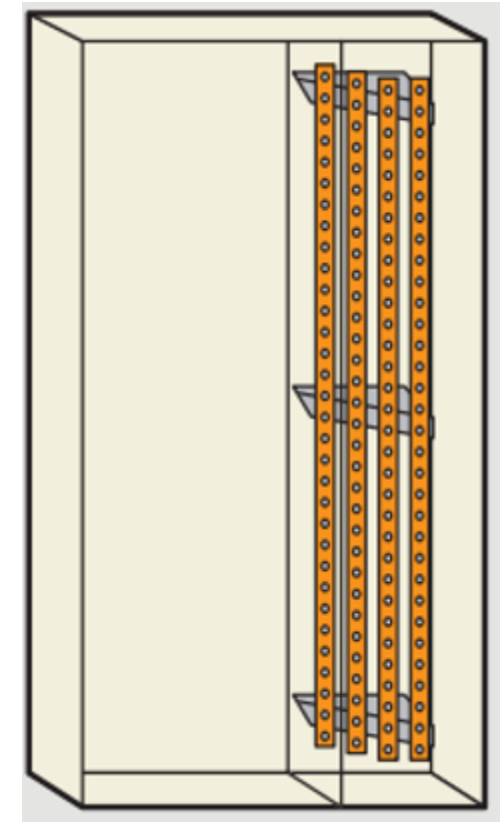
Example showing the effect of (IP) on deration values of Busbars:

IP ≤ 42 - VBB

Section /ph <i>Cross-section /ph</i>	Température ambiante extérieure (°C) <i>Outside ambient temperature (°C)</i>			
	35	40	45	50
1b x 80 x 6	1050	1000	950	900

IP54 - VBB

Section /ph <i>Cross-section /ph</i>	Température ambiante extérieure (°C) <i>Outside ambient temperature (°C)</i>			
	35	40	45	50
1b x 80 x 6	800	770	730	690

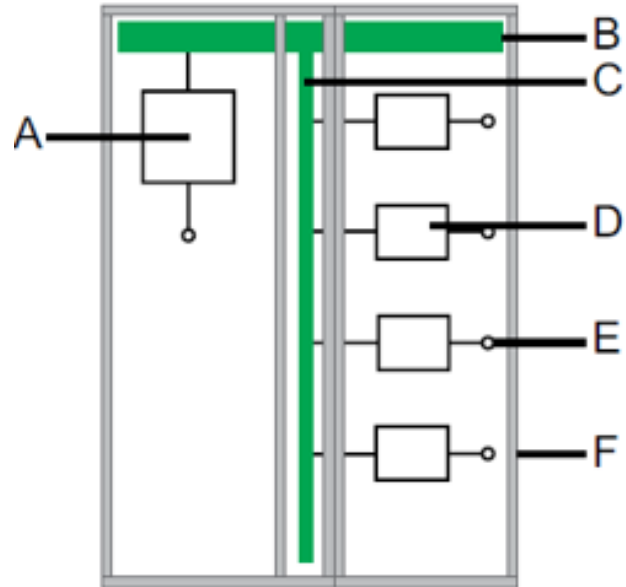




Forms of separation

Form 1

No separation inside the switchboard.



A = Incoming device

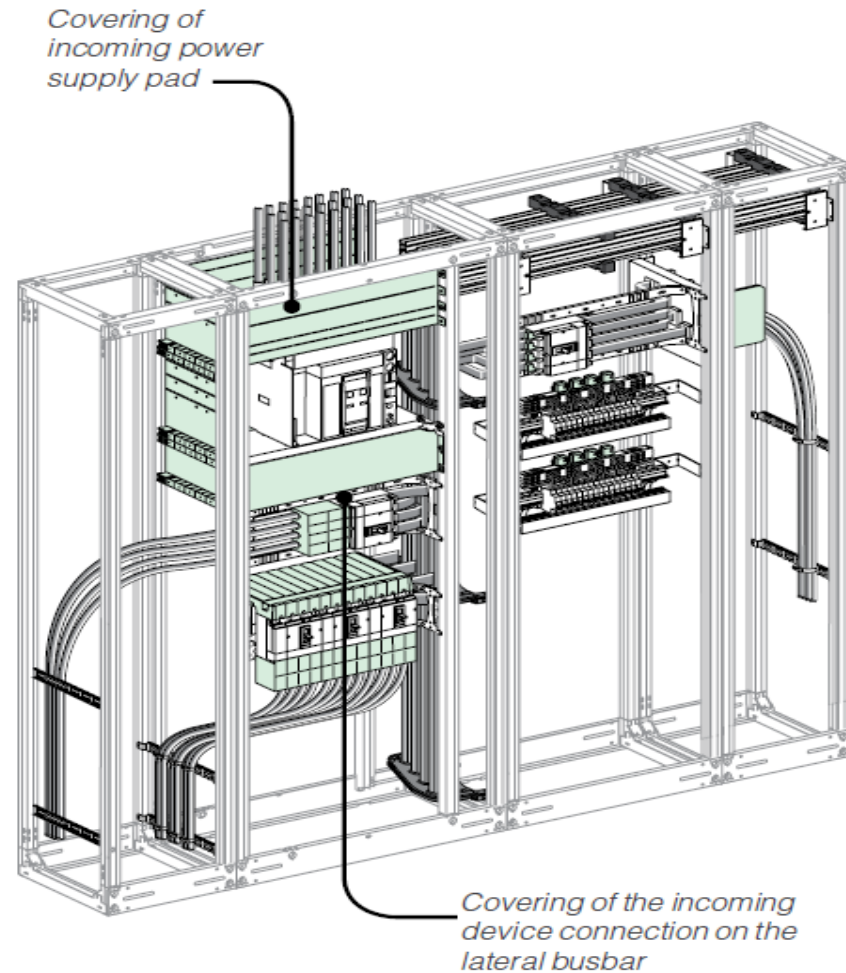
B = Main busbar

C = Distribution busbar

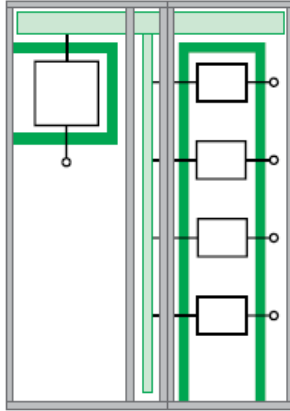
D = Outgoing device

E = Terminals for external conductors

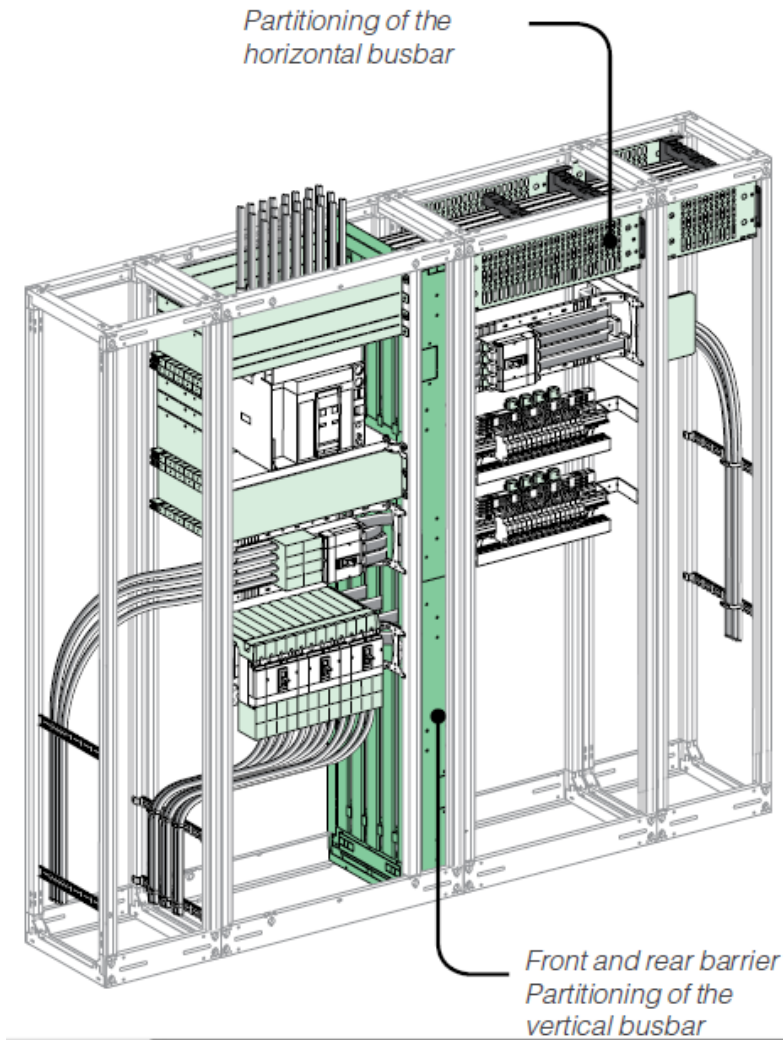
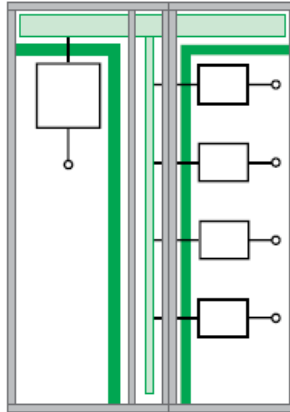
F = Enclosure IP2X minimum



Form 2a: terminals for external conductors are not separated from the busbars.



Form 2b: terminals for external conductors are separated from the busbars.



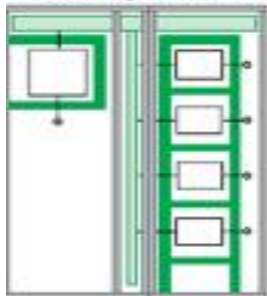
Form 3

Form 2 + Separation inside the switchboard of all functional units:

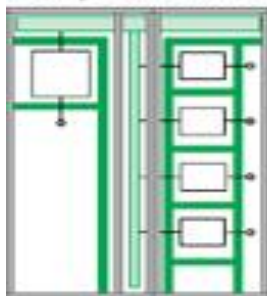
- protection of persons against contact with live parts upstream of outgoing devices,
- limitation of the risk of faults between each of the functional units (propagation of electric arcs).

There are two variants of form 3:

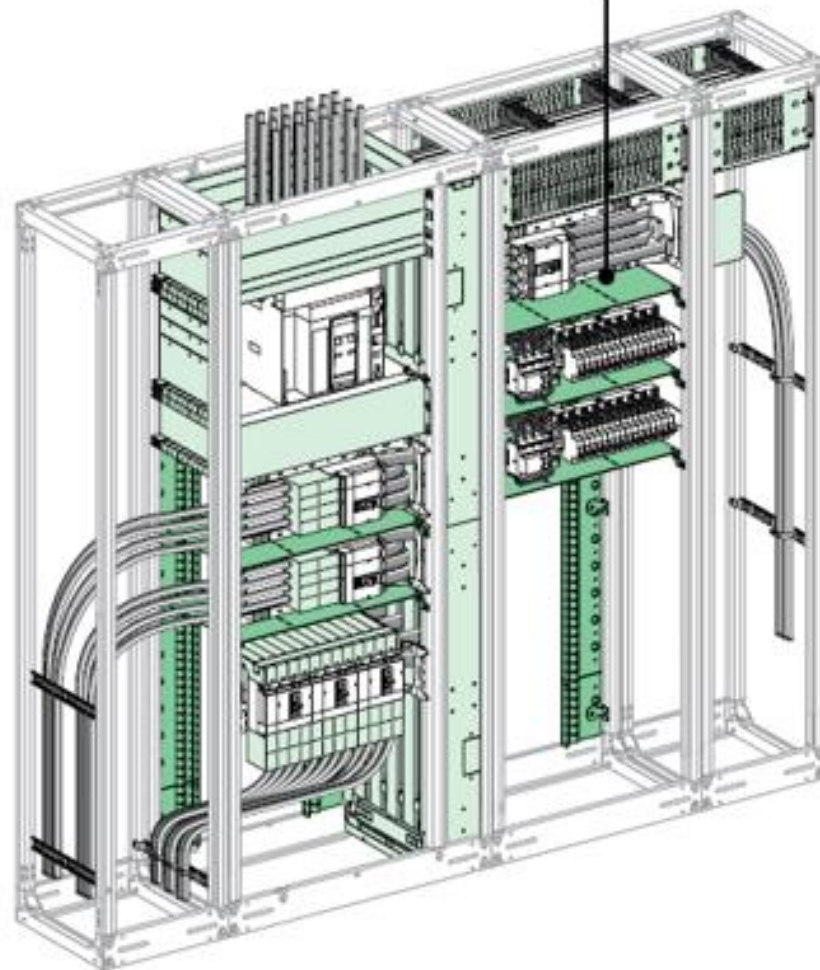
Form 3a: terminals for external conductors are not separated from the busbars.



Form 3b: terminals for external conductors are separated from the busbars.



Partitioning of Functional Units



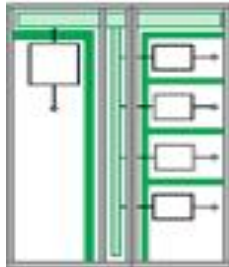
Form 4

Form 3 + Separation inside the switchboard of terminals for external conductors that are an integral part of each functional unit:

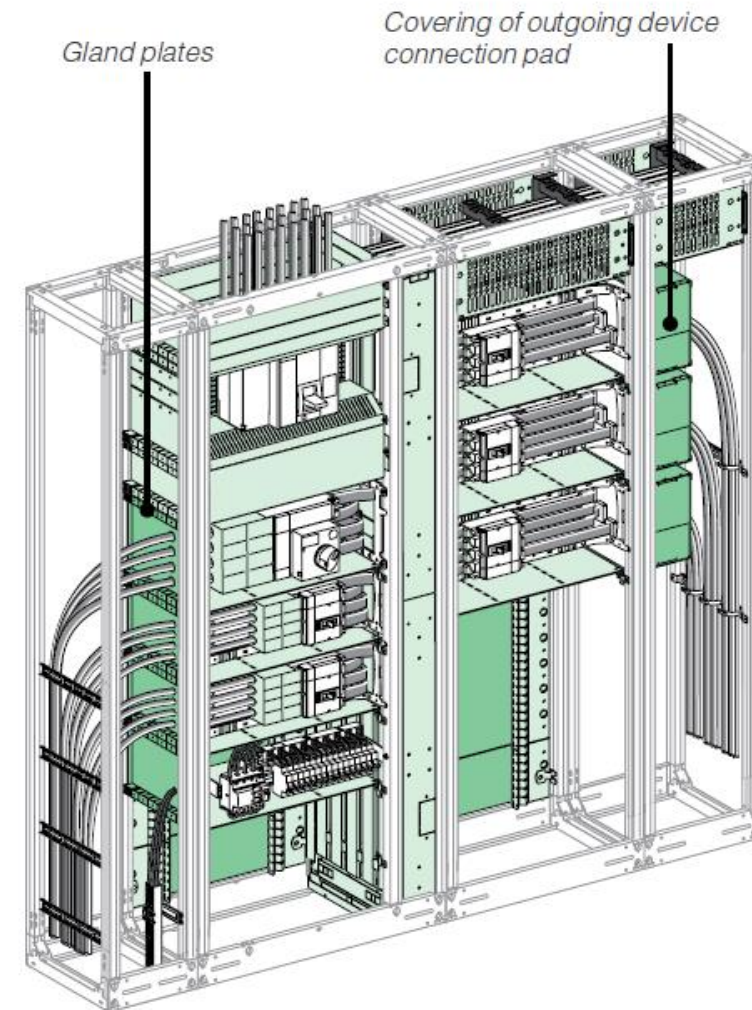
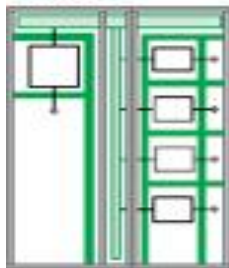
- protection of persons against contact with live parts upstream of outgoing devices,
- limitation of the risk of faults between each of the functional units (propagation of electric arcs).

There are two variants of form 4:

Form 4a: terminals for external conductors are in the same cubicle as the functional unit with which they are associated.

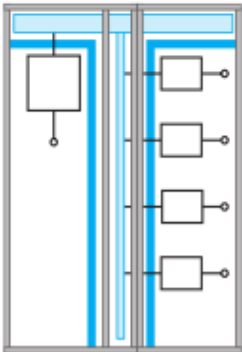
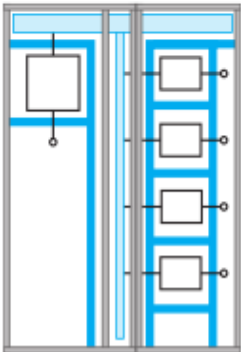
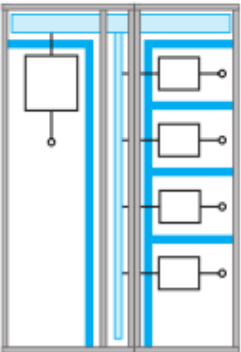
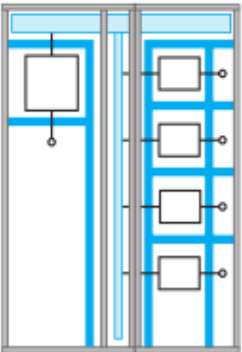


Form 4b: terminals for external conductors are not in the same cubicle as the functional unit with which they are associated, but in protected spaces or individual compartments that are separated and closed.



The left cubicle represents form 4a.
The right cubicle represents form 4b.

Commonly used Forms of separation:

Available forms	2b	3b	4a	4b
Busbars / fonctional units separation	■	■	■	■
Busbars / terminal blocks ⁽¹⁾ separation for external conductors	■	■	■	■
Separation between functional units	-	■	■	■
Separation between terminal blocks ⁽¹⁾ for external conductors	-	-	■	■
Terminal blocks separation for external conductors / functional units	-	-	-	■
(1) They are integral part of the functional unit.				

Form of separation Selection:

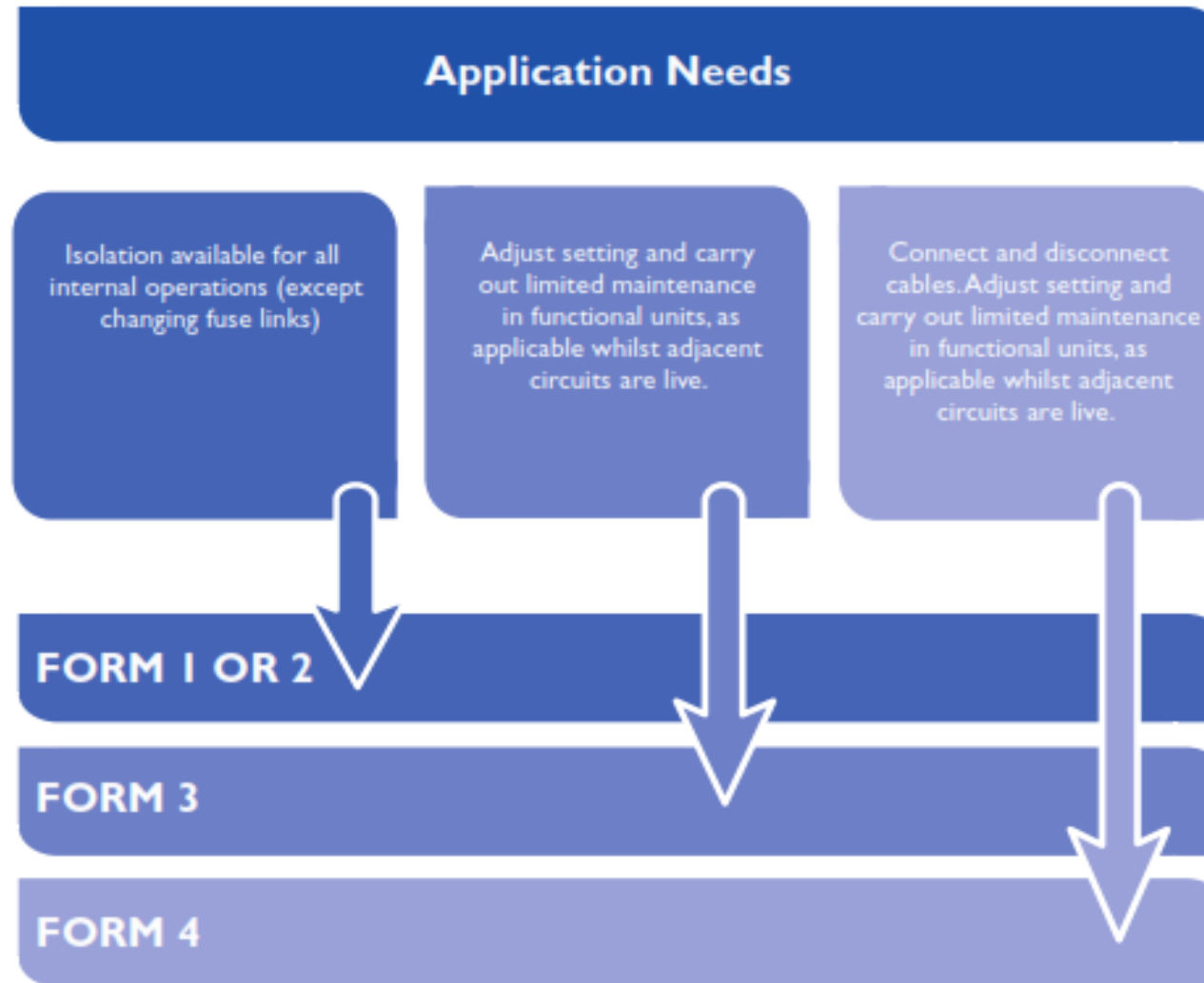
Specifying the most appropriate form of separation for an assembly is not an easy matter.

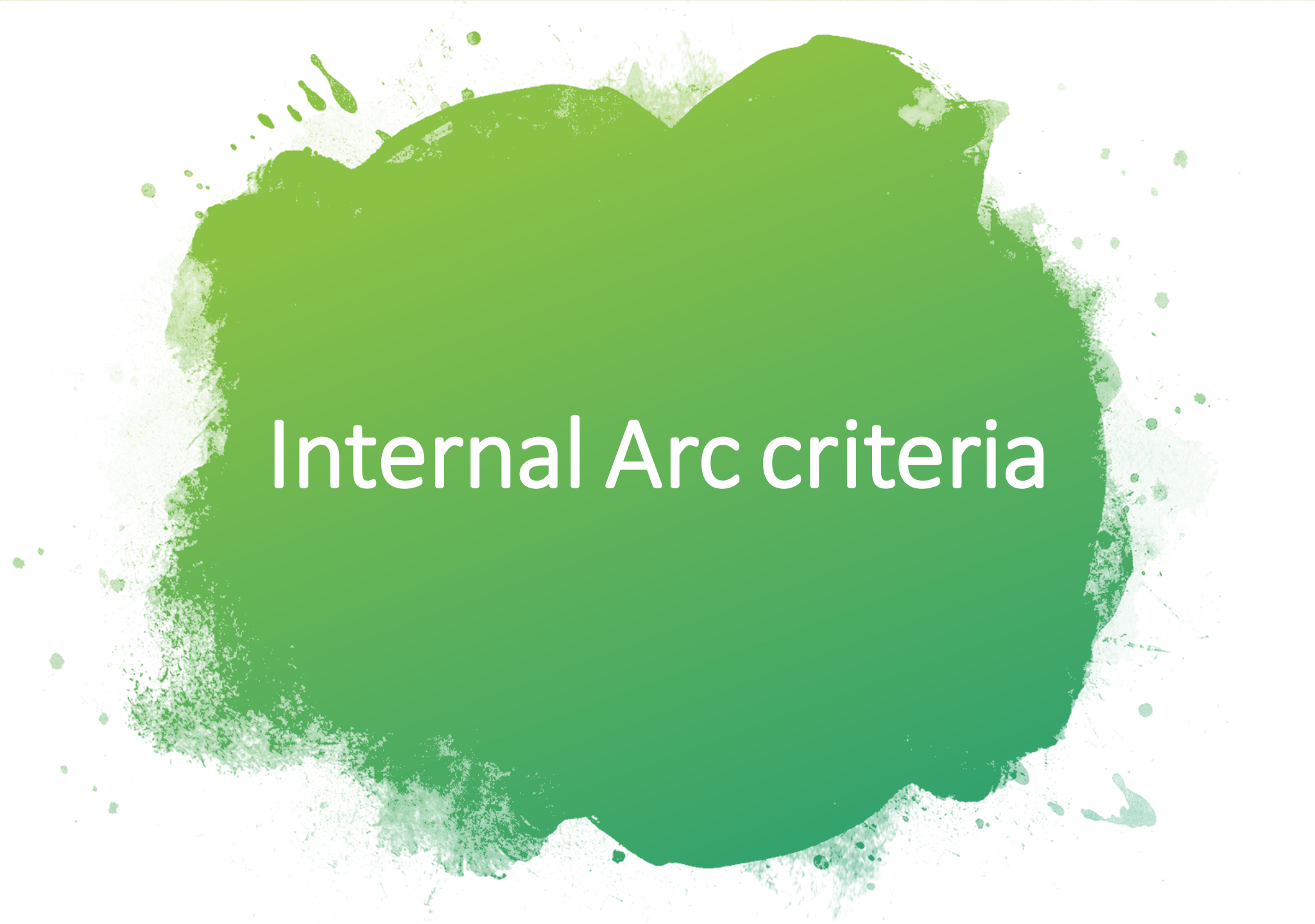
In specifying a form of separation the following should be considered:

- The consequences of isolating the assembly or part of it.
- Nature of task to be performed,
- Competence of person undertaking work whilst the remainder of the assembly is energized.
- In applications where an extremely high continuity of supply is required, there may be an advantage in being able to replace or add a functional unit while the busbars and adjacent circuits remain energized and in service.

For these applications:

An assembly with withdrawable or removable functional units should be specified.





Internal Arc criteria

Internal arc is composed of three main steps.

- 1- Air ionization making it conductive.
- 2- Explosion, creating a shock wave that can be lethal (= 4 kg of TNT)
- 3- Projections of molten metal particles (easily reaching a temperature of 3000°C).

Internal arc occurs mainly when:

the insulation between two live parts does not any more fulfill the technical requirements (reduced distance, reduced dielectric strength).

The main origins of this reduced insulation are usually:

1. faulty insulation or conductors overheating (insufficient section).
2. bad protection by the circuit breaker.
3. bad tightening of electrical connections.
4. oxidation of connections between conductors.
5. intrusion of animals in the switchboard (rat, snake, etc....).
6. forgotten tools (used during maintenance or installation).
7. presence of excessive moisture and/or dust in the switchboard.

Acceptance criteria of internal Arc according to IEC61641:

The switchboard must fulfill the following acceptance criteria to receive internal arc agreement:

1. The hinged doors and fixed panels must not open.
2. No parts should be projected.
3. No holes in the enclosure.
4. The cotton indicator should not ignite.
 - ✓ the operator is simulated by a “wall of cotton” ... The cotton quality is about 150g/m², which is 50% thinner than typical electrician clothes.
5. The protective ground circuit must remain operational (full ground continuity).

Acceptance criteria of internal Arc according to IEC61641:

The following criteria are checked after the internal Arc test:

Criterion 1: correctly secured doors, covers and such do not open.

Criterion 2: Any parts (of the assembly) which may cause a hazard do not fly off.

Criterion 3: Arcing does not cause holes to develop in the freely accessible external parts of the enclosure as a result of burning or other effects.

Criterion 4: The Cotton indicators arranged vertically do not ignite.

Criterion 5: The protective circuit for accessible parts of the enclosure is still effective.

Criterion 6: The assembly is capable of confining the arc to the defined area where it is ignited, and there is no propagation of the arc to other areas within the assembly.

Criterion 7: After clearing of the fault or after isolation or disassembly of the affected functional units in the defined area, emergency operation of the remaining assembly is possible. This is verified by a dielectric test with a value of 1.5 times the rated operational voltage during 1 minute.

Class. A: Personal protection is achieved when criteria 1 to 5 are fulfilled.

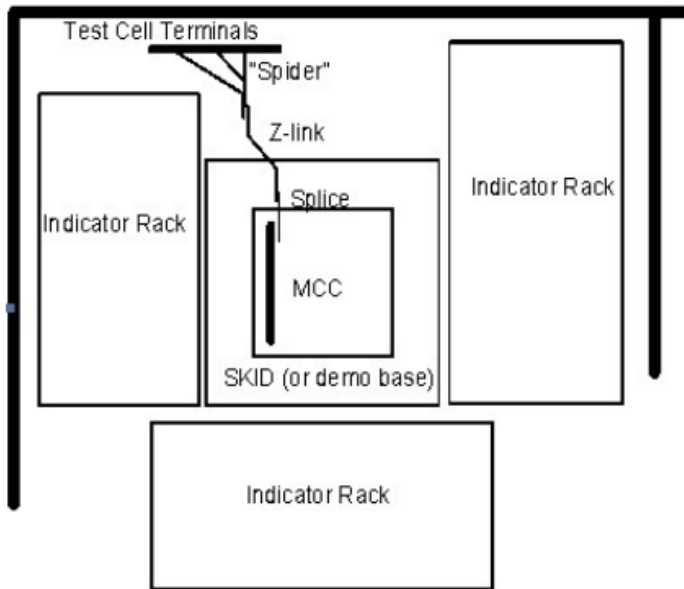
Class. B: Assembly protection is achieved when criteria 1 to 6 are fulfilled.

Class. C: The assembly is suitable for limited continued operation when criteria 1 to 7 are fulfilled.

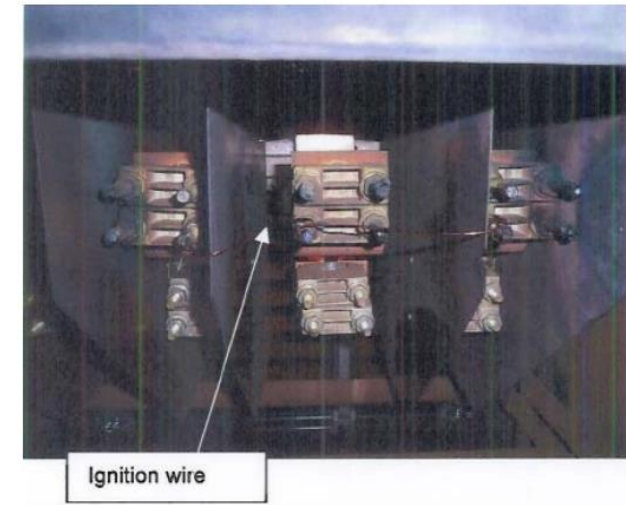
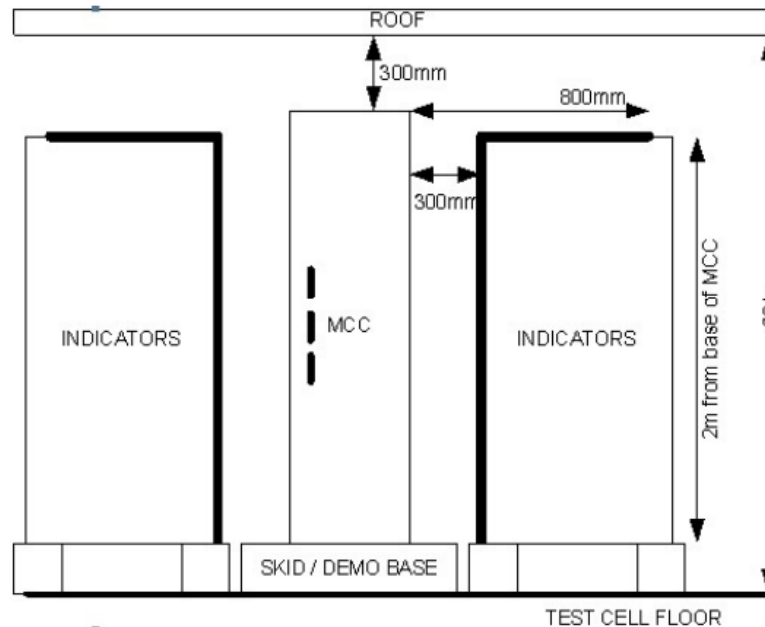
Internal Arc Tips:

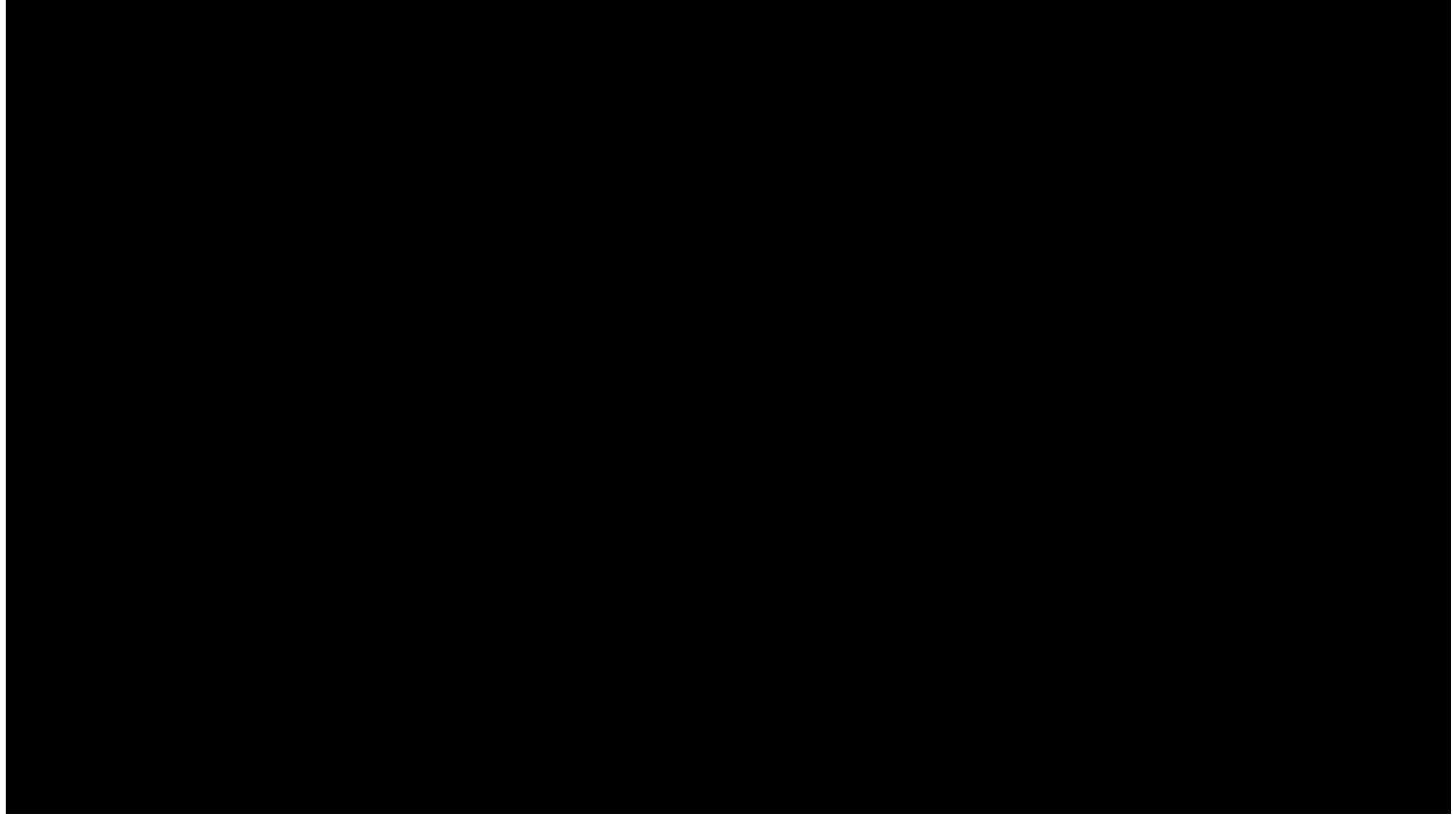
- ✓ Ignition-wire is used to produce internal Arc Fault during test.
- ✓ Hot Gases and pressure rise caused by an internal arc should be released in a way that will secure switchgear & personal.
- ✓ Manufacturer is responsible to apply needed mechanical design of switchgear to make it withstand internal Arc if requested by consultant.

Internal ARC Test Plan View



Internal ARC Test Front View







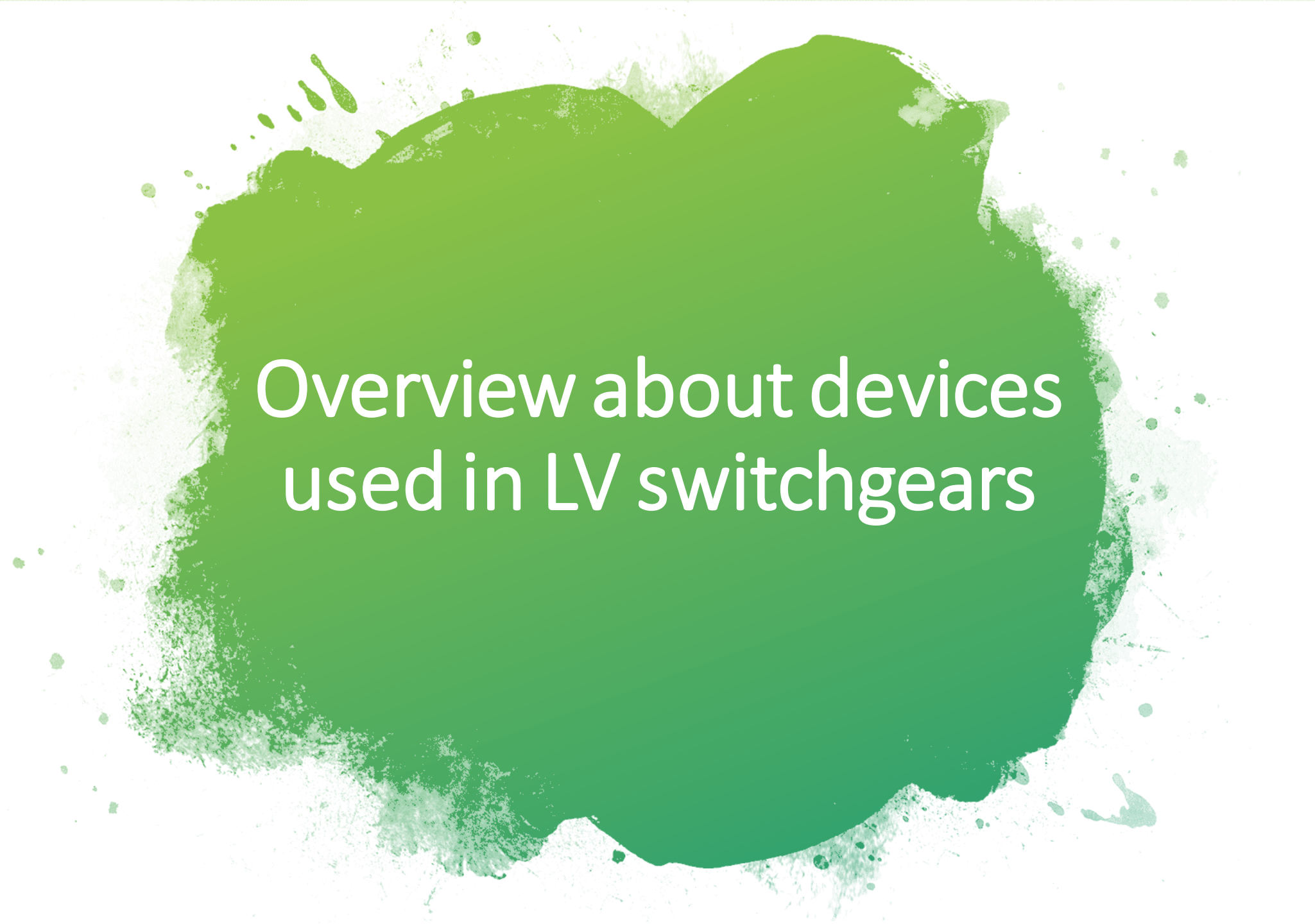


Self Study Question

The below terms are used in Internal Arc Specifications, state what is meant by each of them:

- ✓ A-FLR
- ✓ A-FL



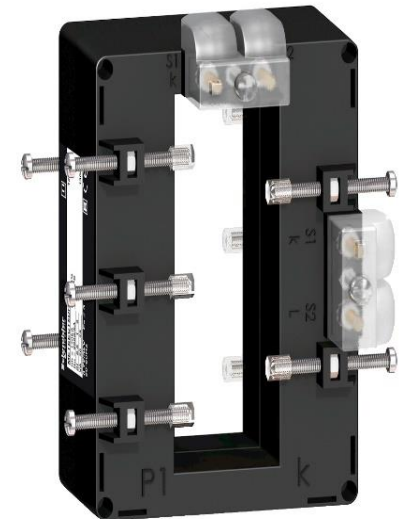
A large, irregular green watercolor splash with white text in the center. The splash has a textured, painterly appearance with various shades of green and some white highlights. The text is centered within the splash.

Overview about devices used in LV switchgears

Measurements Devices



Current transformers:



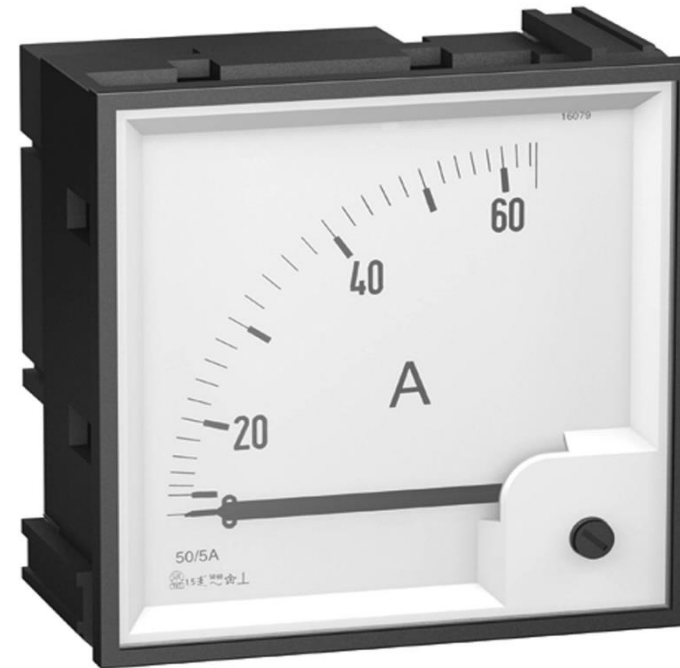
Voltage transformers:



Digital Power Meter:



Digital & Analog Ammeters



Digital & Analog Voltmeters



Digital & Analog Run Hour Meters



KWH Meters



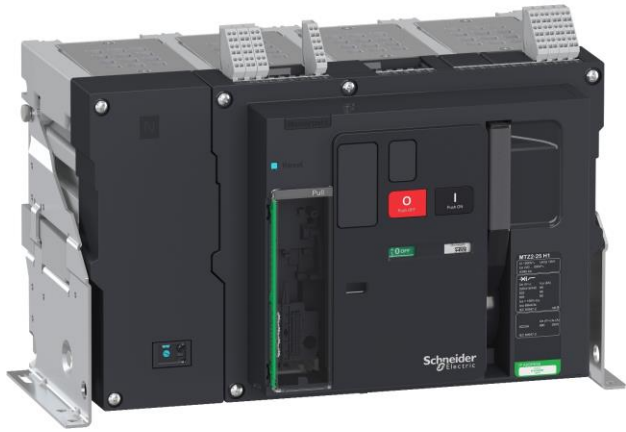
Frequency Meters



Protection Devices



Circuit Breakers & Fuses



ACB
NW / MTZ



MCCB
NS / NSX



MCB
Acti-9 IC60 or NG



Fuses
Acti-9

Protection Relays



SEPAM



**Over / Under voltage
Ph - seq / Ph - failure**



**Residual current protection relay
Vigirex**



TeSys T

Switch Disconnecter Devices



**Air
Switch disconnector
NW / MTZ**



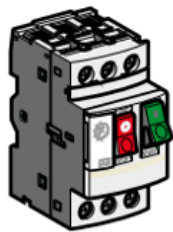
**Moulded Case
Switch disconnector
NSX**



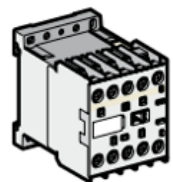
**Moulded Case
Switch disconnector
NS**

Motor Starters

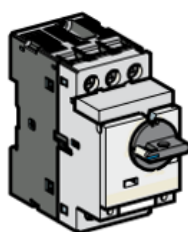
2 products



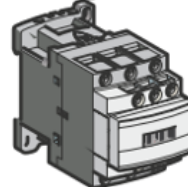
+



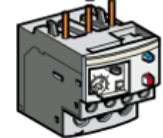
3 products



+



+



DOL & Star-Delta

2 Products = MCP + Contactor = GV*P + LC1D*

3 Products = MCP + Contactor + O.L = GV*L + LC1D* + LRD*



**Soft Starters
ATS48**



**Variable Speed Drives
ATV630**

General Indication & Control & other Components



Push Buttons
Harmony XB4



Emergency Stop P.B
Harmony XB4



Indication Lamps
Harmony XB5



Selector Switch
Harmony XB4



Timers
Zelio Time



**Control Relay
TeSys CAD**



**Control Relay
Zelio Relay**



**Heater
ClimaSys**



**Hygrostat
ClimaSys**



**Thermostat
ClimaSys**



**Ventilation Fan & Grid
ClimaSys**



**Control Terminal
Linerger**



**Capacitor Can
EasyCan**



**Ethernet switch
Modicon**



**PLC
Modicon**

Self Study Question

When to use?

- ✓ **Thermostat.**
- ✓ **Hygrostat.**
- ✓ **Heaters.**
- ✓ **Residual current Device “Vigirex”.**
 & why we need to use toroids with it?
 & How to select these Toroids?
- ✓ **Soft starters.**
- ✓ **Variable Speed Drives.**
- ✓ **DOL starters.**
- ✓ **Y-D starters.**





Thank You