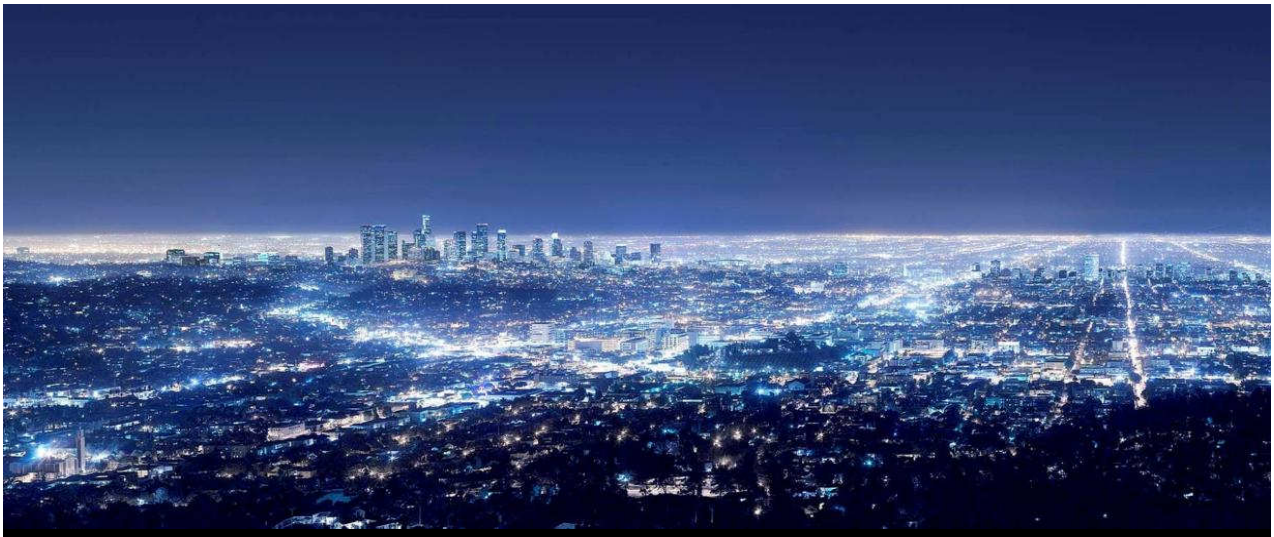

Iyer, Low Voltage Systems, Accelerate learning on low voltage switchboard, 19th Feb 09

Low voltage switchboard design Safe and reliable

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Content

- Introduction
- Design concept
  - Internal separation
  - IP degree of protection for enclosure.
  - Ventilation and temperature rise requirement.
- Summary
- Q&A

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Introduction

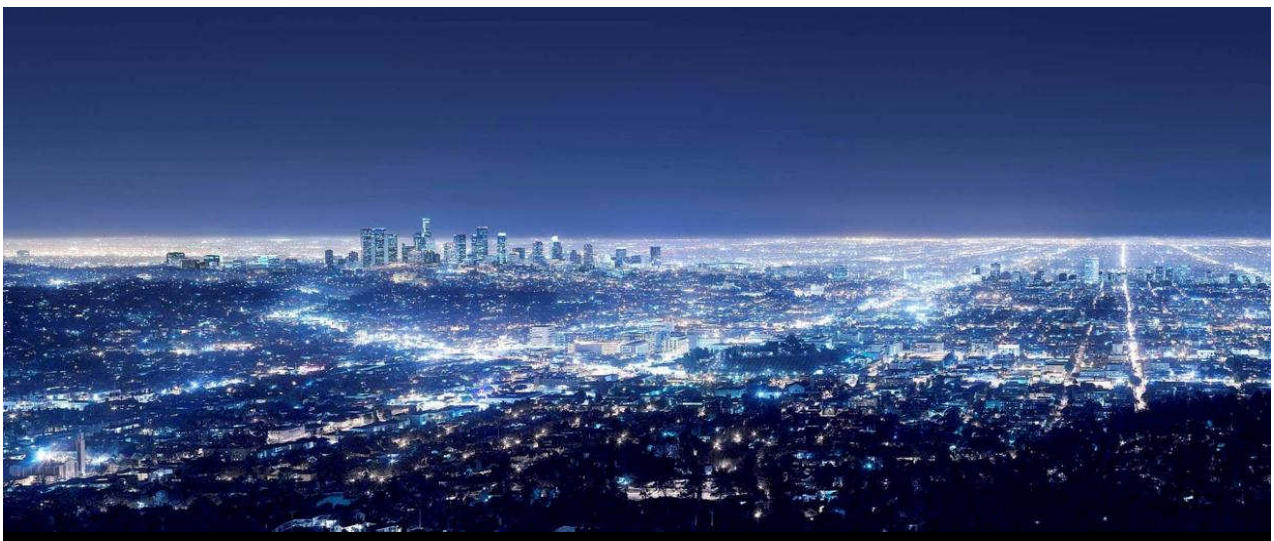
- Poorly designed switchboard may lead to the following problems:
  - Over heating.
  - Dust and dew accumulation
  - Frequent maintenance.
  - Difficult in maintenance
  - Danger to operating person
  - Frequent down time
  - Difficulty in fault finding / rectification
  - Failure or Fire

Introduction

- Key Aspects of LV switchboard design:
  - Suitability of switchgear for the environmental conditions
  - Internal separation
  - Ventilation and temperature rise requirement
  - Protection against mechanical influence or IP degree of protection for enclosure.
  - Busbar sizing for rated as well as short time current
  - Fault level and Mechanical withstand strength
  - Measures for protection against electric shock
  - Selectivity and discrimination study
  - Safety of switchgear under conditions of internal arc.
- For today's session, we are able to touch on only the first three items.

Introduction

- Few Key Aspects of LV switchboard design are taken up in this session
  - Internal separation
  - IP degree of protection for enclosure.
  - Ventilation and temperature rise requirement



Iyer, LVS, 19th Feb 09

Internal Separation

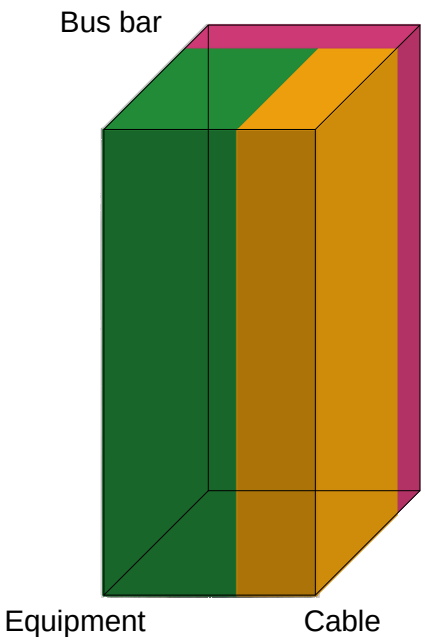
Internal separation
Objective

Internal separation of switchgear assemblies forms an important aspect of switchgear design for its safe and reliable operations.

- Access to functional unit for extension and maintenance.
- Protection against direct contact .
- Safety for the personnel and the plant.

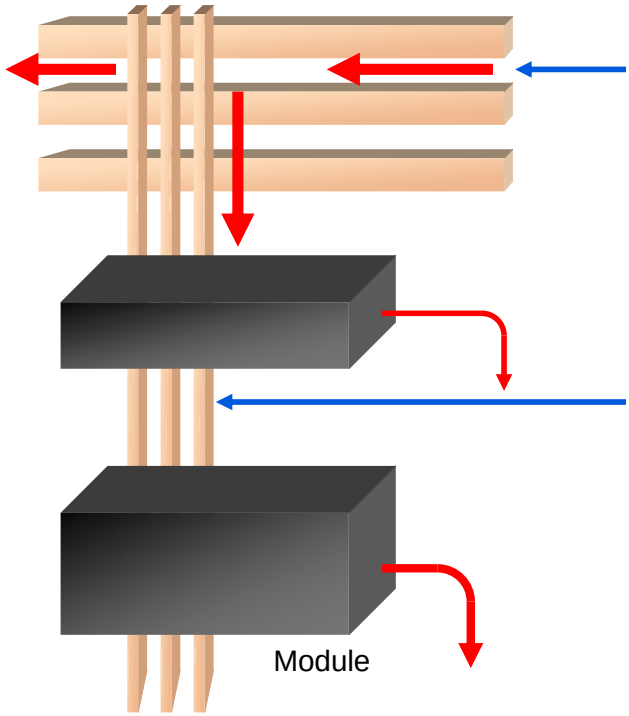
- **Sub-divided into Form 1 to Form 4**

Internal Separation



Assemblies are divided by means of partitions or barriers –metallic or non metallic to form the cubicle compartment.

Internal separation



- Busbar system in a typical cubicle
- Main bus bar running horizontal through the cubicles
- Distribution bus bar Vertical in the cubicle
- Energy distribution to the different modules

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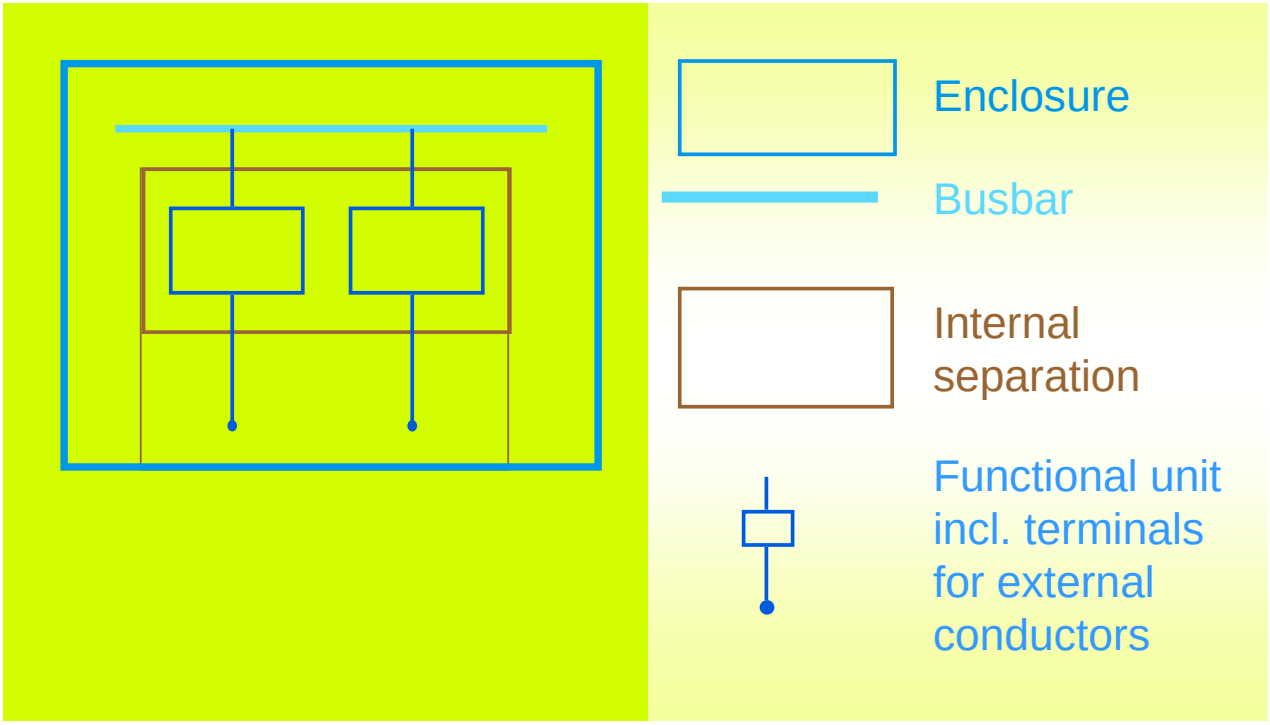
Internal separation according to IEC 60439-1



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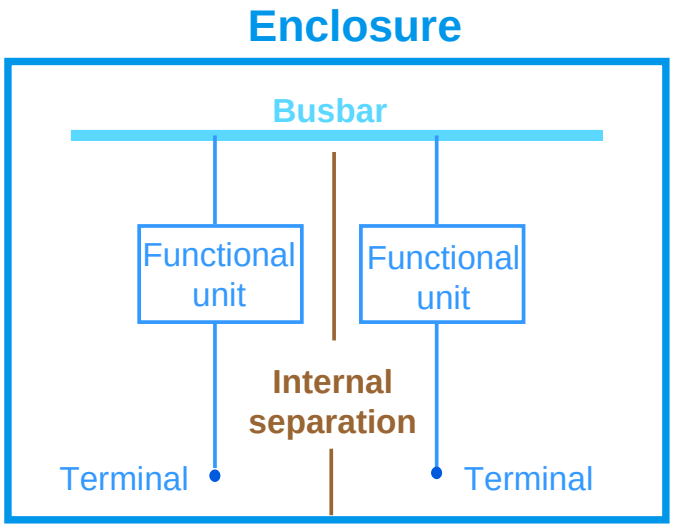
Internal separation according to IEC 60439-1: Know the Various Parts



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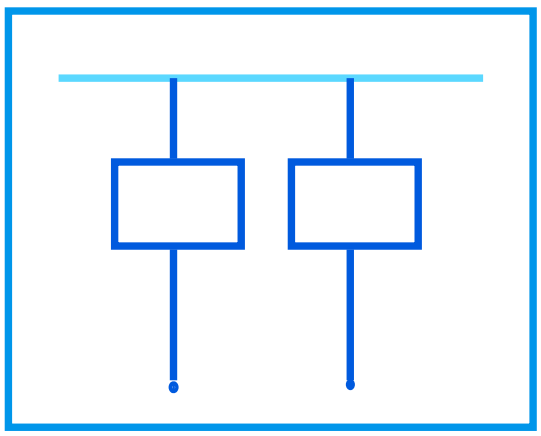
Internal separation: form 1



- FORM 1
  - Internal Separation:No internal separation
  - Protection of persons :No protection of persons when doors are open.
  - Protection of equipment: No internal protection.

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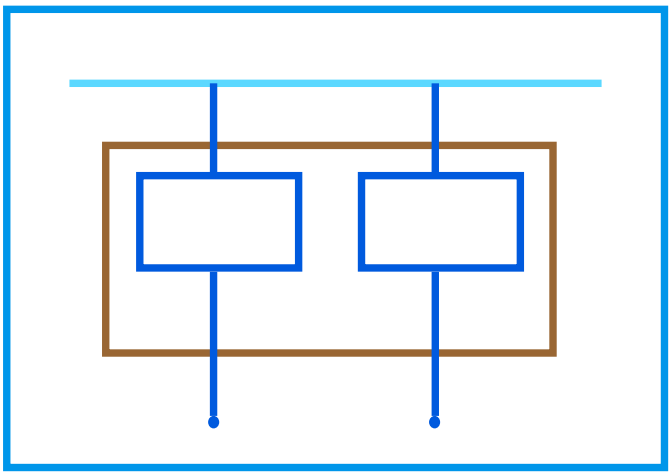
Internal separation: form 2
Form 2a



Form 2a Terminals not separated from busbars

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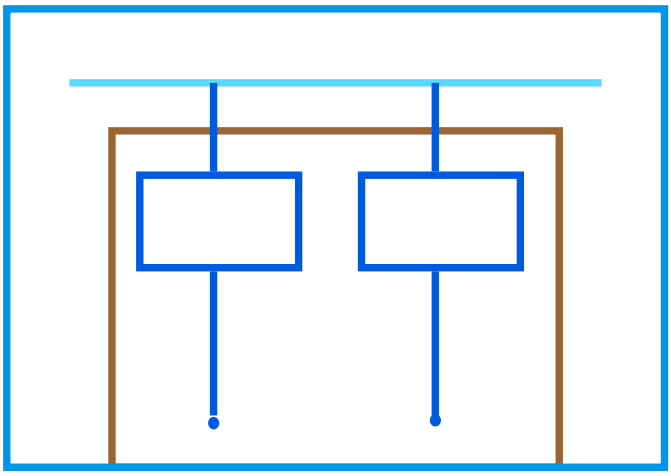
Internal separation: form 2
Form 2b



Form 2b Terminals separated from busbars

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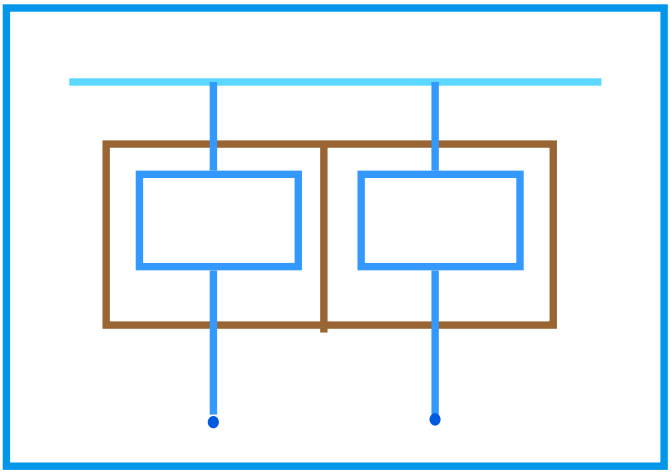
Internal separation :
Form 2

- Form 2a: Separation of busbars from the functional units.
- Terminals not separated from busbars.

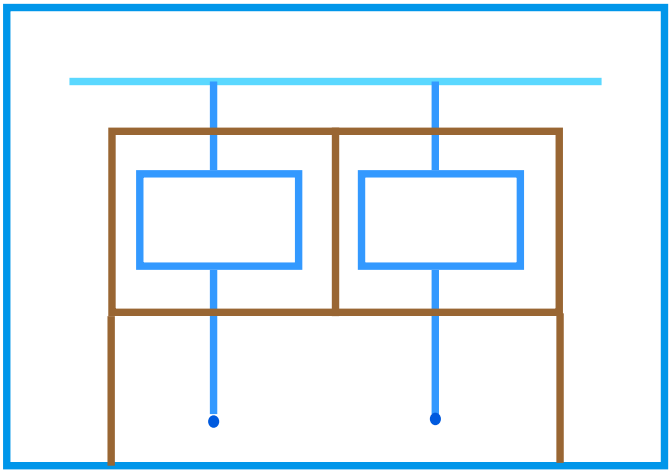
  - Form 2b: Separation of busbars from the functional units.
  - Terminals separated from busbars.
  - Protection of persons:Persons are protected against touch of busbars.during work on the functional units in Forms 2b.
  - Protection of Equipment: Protection against ingress of foreign objects between functional units into the busbar compartment.

Internal separation: Form 3
Form 3a



Form 3a Terminals not separated from busbars

Internal separation: Form 3
Form 3b



Form 3b Terminals separated from busbars

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Internal separation:
Form 3

Form 3 - Internal Separation

- Separation of busbars from all functional units.
- Separation of all functional units from one another.
- Separation of terminals from the functional units.
- No separation of terminals from each other.

  Form 3a:
  - Terminals not separated from busbars.

  Form 3b:
  - Terminals separated from busbars

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Internal separation:
Form 3

Protection of Persons

When working on the functional unit ,

- Persons are protected against touch of busbars.
- Persons are protected against touch of neighbouring functional unit.
- Additional protection during work on the terminals for external conductors in form 3b.

Protection of equipment

- Protection against ingress of foreign objects
- between functional units into the busbar compartment.
- From one functional units into the neighbouring functional units.
- Between functional units and common terminal compartment.

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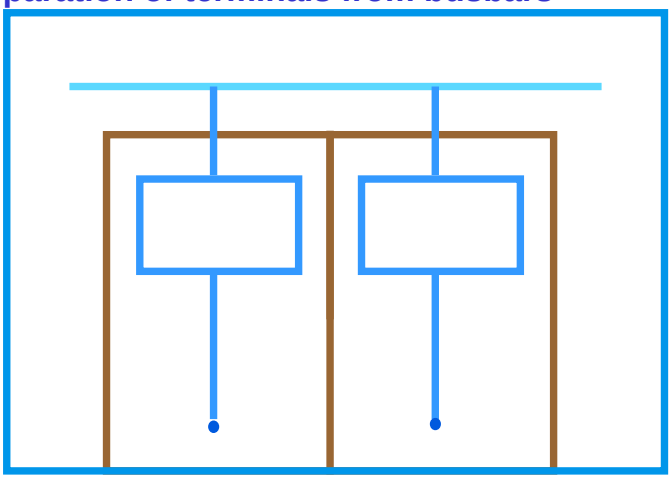
Internal separation: Form 4
Form 4a

- **Separation of busbars from the functional units**
- **Separation of functional units from one another**
- **Separation of terminals from busbars**



Form 4a Terminals in same compartment as associated functional unit

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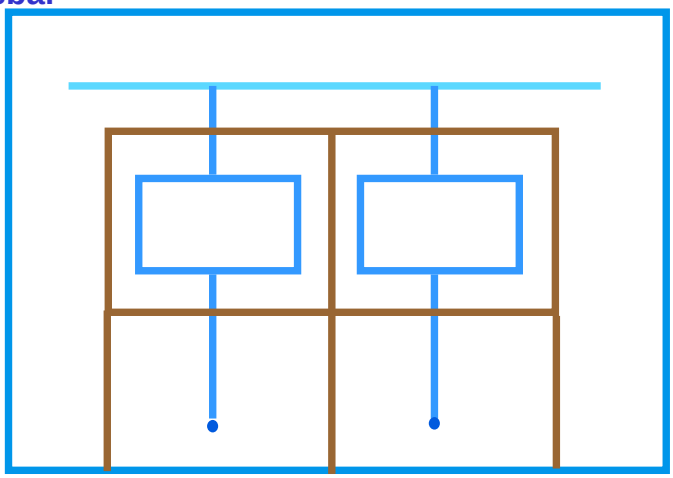
Internal separation: Form 4
Form 4b

- **Separation of busbars from the functional units**
- **Separation of functional units from one another**
- **Separation of terminals from functional units and Busbar**



Form 4b Terminals not in same compartment as associated functional unit

Internal separation:
Form 4

Form 4 - Internal Separation

- Separation of main busbars functional units.
- Separation of all functional units from one another.
- Separation of terminals for external conductors from the main busbars.

Form 4a:
- Terminals in the same compartment as the functional unit.

Form 4b:
- Terminals not in the same compartment as associated functional unit.
- Terminals of different functional units segregated from one another.

Internal separation:
Form 4

Protection of Persons

When working on functional unit

- Persons are protected against touch of busbars in form 4a and 4b.
- Persons are protected against touch of neighbouring functional unit.

Additionally

- Protection during work on the terminals for external conductors in form 4b.
- Protection to terminals of the neighbouring functional units.

Protection of equipment

Protection against ingress of foreign objects

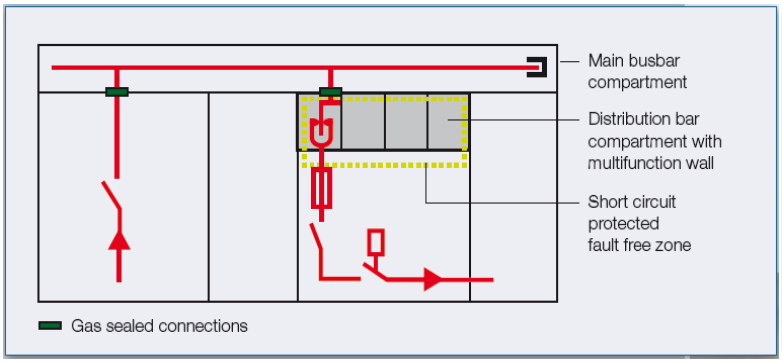
- Between functional units into the busbar compartment.
- From functional units into the neighbouring functional units.
- Between functional units and common terminal compartment.
- Protection to terminals of the neighbouring functional units.

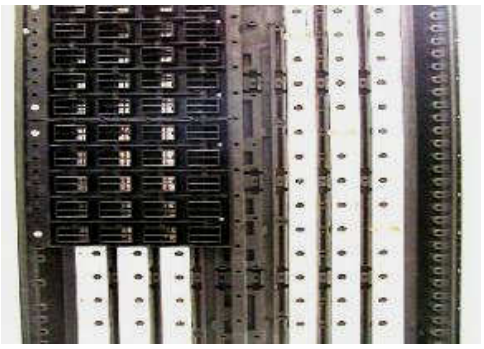
Internal Separation:
Forms in MNS Design



- Special measures in MNS going beyond IEC regulations.
- All separations fulfill the requirements of the degree of protection IP20.
- MNS is only available with higher protection than form 1.
- Use of multifunction wall

Internal Separation:
Forms in MNS Design

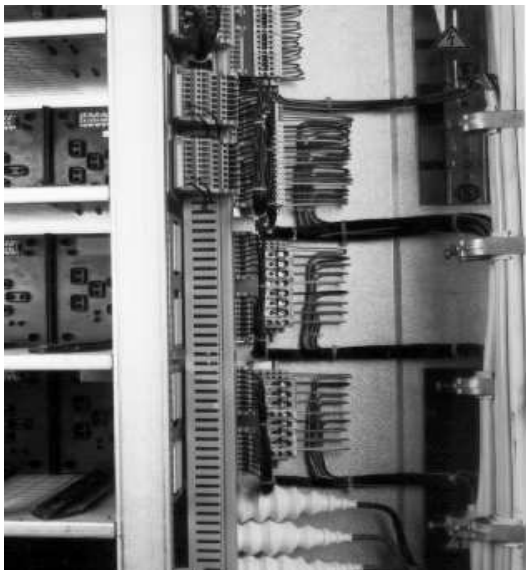




Multi-function wall
Form 2b through 4b

- If internal separation is required, MNS offers additional safety by the use of the Multifunction Wall (MFW).
- The MFW is a separate compartment for the distribution bars.
- It provides a “gas sealed” connection between the main busbars and the distribution bars.

Internal Separation –
Forms in MNS Design



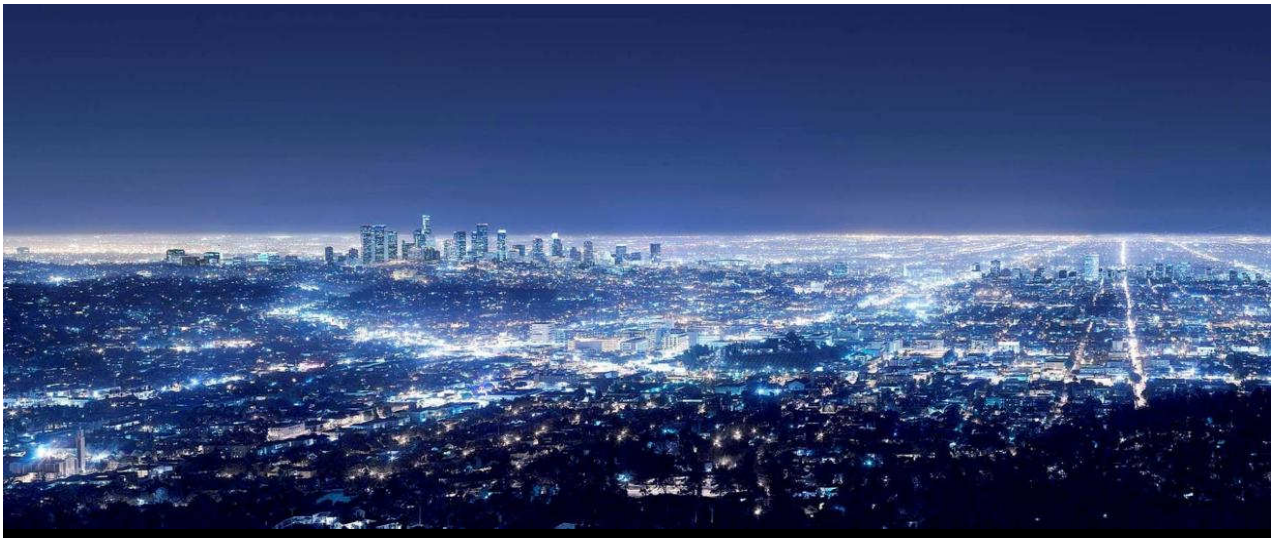
Cable and wiring connections in a switchgear cubicle with withdrawable modules

Form 3b and 4b

- For switchboards with outgoing modules.
- At MNS withdrawable modules each phase at the terminals for external conductors is isolated.

Internal Separation:
Decision

- Choice of form is closely related to the following.
  - Level of safety
  - Frequency of maintenance
  - Downtime
  - Temperature rise



Iyer, LVS, 19th Feb 09

Degree of Protection (IP)

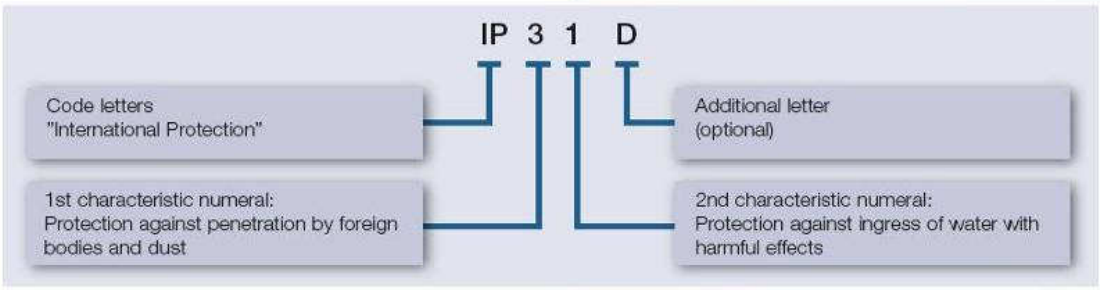
IP – Degree of Protection

Definitions

Degrees of protection provided by enclosures of electrical equipment in accordance with IEC 60529:

1. Protection of persons against access to hazardous parts inside the enclosure;
2. Protection of the equipment inside the enclosure against ingress of solid foreign objects;
3. Protection of the equipment inside the enclosure against harmful effects due to the ingress of water.

Designation for the degrees of protection:



Remark

Where a characteristic numeral is not required to be specified, it shall be replaced by the letter "X" ("XX" if both numerals are omitted).

IP – Degree of Protection

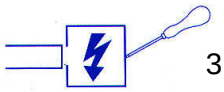
- IP is the definition of the Degree of Protection against contact with **live** parts and ingress of solid foreign bodies and liquid.
- Degree of protection a criteria for Type Test.
- Subject to agreement between the manufacturer and user.
- The IP-code consists of a two-digit number and optional letters.
- The IP-degree refers to the enclosure in normal service: all doors closed.
- First Numeral indicates –
- Protection of persons against access to harmful parts
- Protection of equipment against ingress of foreign bodies.
- The second numeral indicates-
- Protection of the equipment inside the enclosure against harmful effects due to the ingress of water.

Description of the IP code (1)

- First characteristic numeral defines
  - the protection of persons against access to hazardous part inside the enclosure
  - the protection of the equipment inside the enclosure against ingress of solid foreign objects

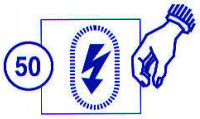


0 = no protection



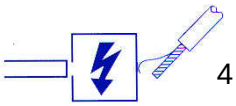
3 = tool

Solid foreign objects ∅ ≥ 2,5 mm



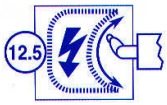
1 = back of the hand

Solid foreign objects ∅ ≥ 50 mm



4 = wire

Solid foreign objects ∅ ≥ 1 mm



2 = finger

Solid foreign objects ∅ ≥ 12,5 mm



5 = Dust protected

Ingress of dust is not totally prevented, but no impact to safety or function

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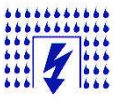
Description of the IP code (2)

- second characteristic numeral defines
  - the protection of the equipment inside the enclosure against harmful effects due to the ingress of water



- 0 = no protection



1 = vertically falling water drops



2 = vertically falling water drops when the enclosure is tilted up to 15°



3 = spraying water
...at an angle of 60° on either side of the vertical ...



4 = splashing water
...from any direction ...

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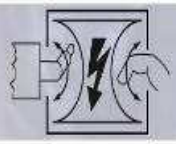
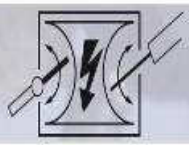
Description of the IP code :
Additional letter

Additional Letter (Optional)		Protection against access to hazardous parts with:
A		Back of the hand ≥ 50 mm diameter
B		Finger / Tool ≥ 12.5 mm diameter, 80 mm length
C		Tool / Wire ≥ 2.5 mm diameter, 100 mm length
D		Tool / Wire ≥ 1.0 mm diameter, 100 mm length

IP – Degree of Protection in MNS Switchboard

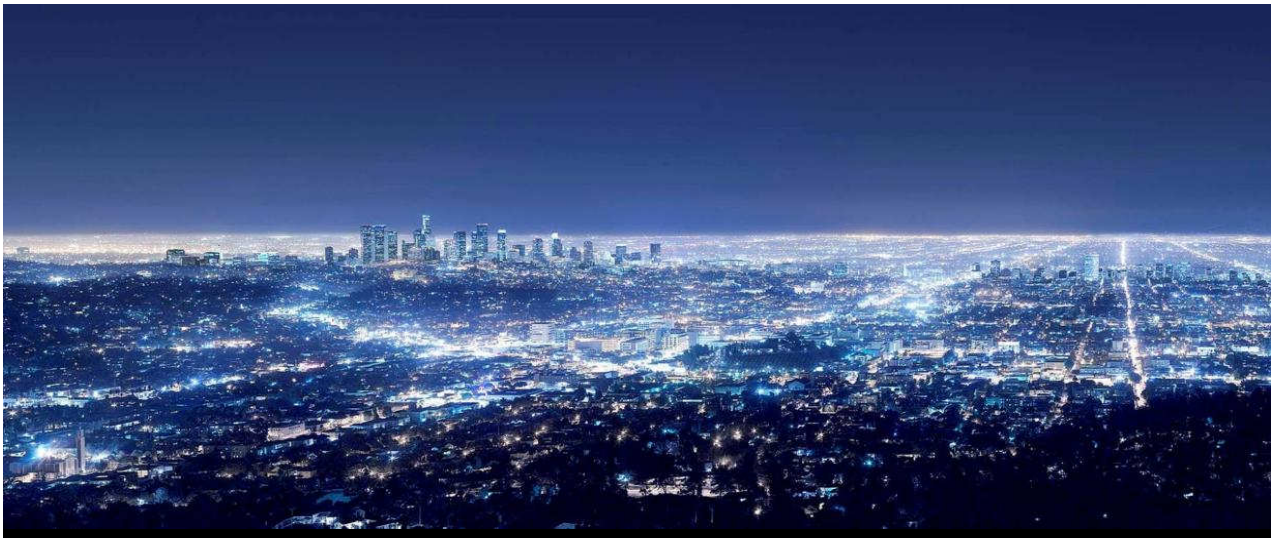
MNS – Available standard degrees of protection

As MNS is designed for indoor applications, no IP degrees covering water jetting and total water immersion are foreseen.

Ventilated		Non-ventilated
Ventilation grids in: Doors, covers and roof plate		Sealed; no ventilation openings
IP30	IP40	
IP31	IP41	
IP32	IP42	
		IP54
Maximum heat dissipation (by air convection)	→	Low heat dissipation (heat emission via enclosure only)

IP – Degree of Protection
Decision

- Major influence on the attainable heat dissipation from the individual switchgear cubicle.



Iyer, LVS, 19th Feb 09

Ventilation and Temperature rise

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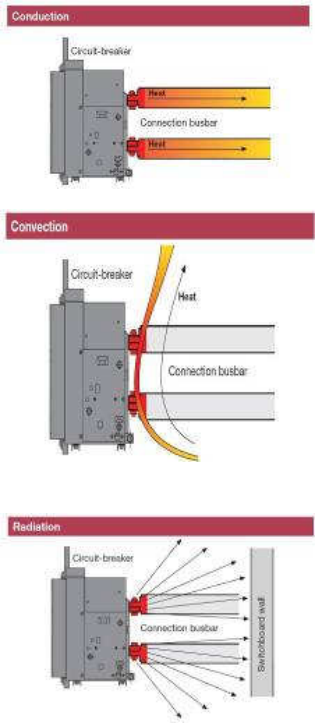
Ventilation and Temperature Rise Considerations

Source of temperature rise in switchgear cubicles.

- Current flow in electrical equipment generates heat loss heating itself and neighboring parts. These are
  - Main current paths of the electrical equipment .
  - Active power consumption of auxiliary devices .
  - Enclosure parts due to eddy currents.
- Operativeness of the equipments depends on its operating temperature.
- The temperature inside the switchgear cubicle compared to the surrounding air must not exceed 55 ℃ on average, and 60℃ at maximum under the roof plate of the cubicle.
- This must be ensured by means **Temperature rise tests** or suitable measures like calculations.

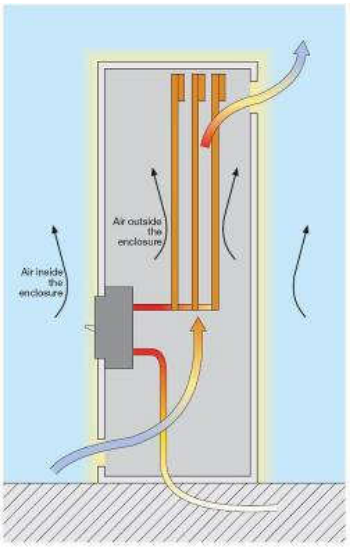
Ventilation and Temperature Rise Considerations



Dissipation of heat loss

- Heat conductance
- Heat convection
- Heat Radiation

Ventilation and Temperature Rise Considerations



Dissipation of heat loss

- Inside the cubicle heat transmission is by convection.
- Inside to the outside of the cubicle heat transmission is by radiation as well as internal and external convection.
- The heat sources must be properly distributed, and good ventilation must be ensured.

Ventilation and Temperature Rise Considerations

Standards and tests

- IEC 60439-1 clause 7.3 table 2 specify temperature rise limits for mean ambient temperature less than or equal to 35 deg C .
- Temperature rise limits for built in components – as per product standard
- Terminals for external conductors – 70 ^{0}K.
- Busbar temperature rise is limited
  1. by mechanical strength of conducting material.
  2. Possible effect on adjacent equipment.
  3. Permissible temperature limit of the insulating materials in contact with the conductor.
  4. Effect of the temperature of the conductor on the apparatus connected to it.
- Accessible external enclosure and covers- 30 ^{0}K
- Insulating surface - 40 ^{0}K

Ventilation and Temperature Rise Considerations

Standards and tests

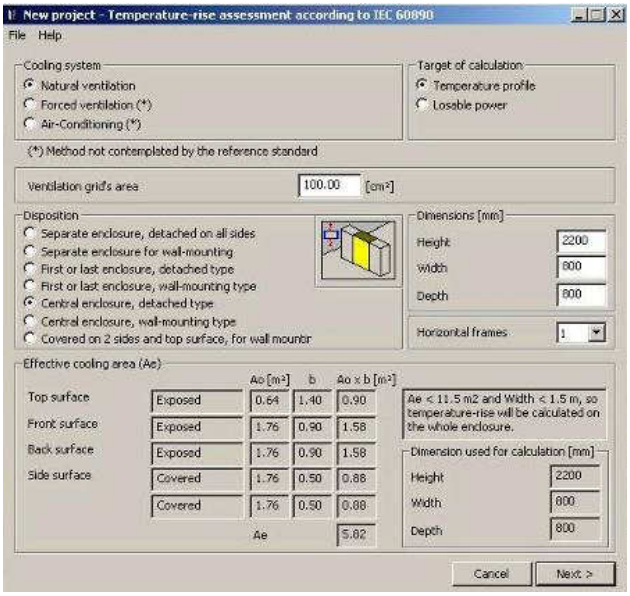
- Calculation as extrapolation as per IEC 60890 when temperature rise test not feasible for PTTA.
- Conditions for applications
- Approximately even distribution of power losses inside the enclosure.
- Air circulation not impeded by equipment arrangement .
- The equipment is designed for a current upto 3150A.
- Arrangement of conductors are such that eddy current losses are negligible.
- The cross section of air outlet is 1.1 times the cross section of air inlet openings.
- There are no more than three horizontal partitions in the PTTA or section of it.
- IEC 60890 gives calculation procedures and factors to be used .

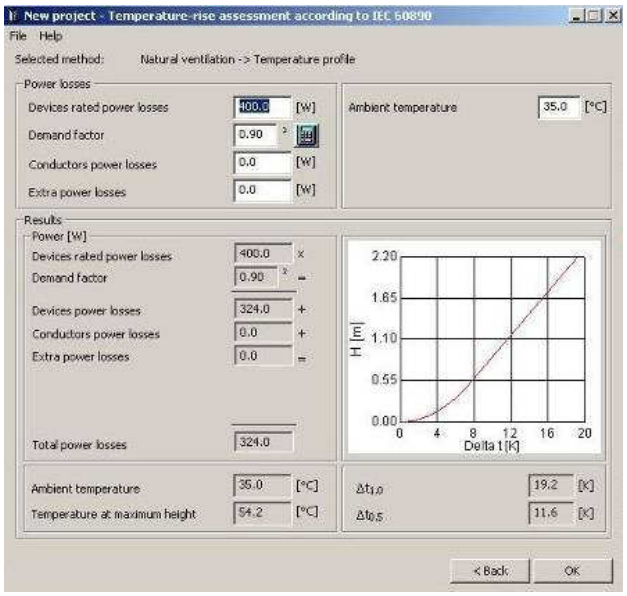
Ventilation and Temperature Rise Considerations

Standards and tests

- The following data are needed to calculate the temperature-rise of the air inside an enclosure:
- Geometric dimensions (height / width / depth);
- Effective power loss of equipment, busbars, cables and connections;
- Type of installation of the enclosure (exposed, covered etc....);
- Presence and dimensions of ventilation openings;
- Number of internal horizontal partitions.
- Calculation method is given in IEC 60890 .ABB OTC software can be used if above data are available.

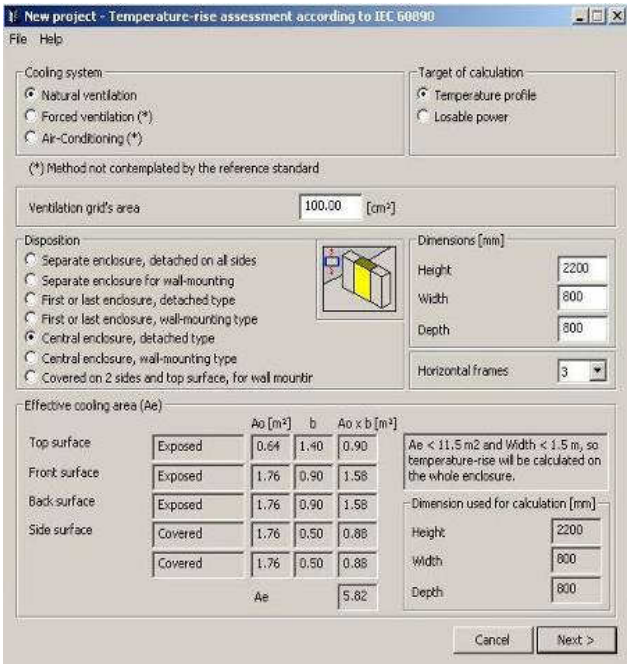
Ventilation and Temperature Rise Considerations- IEC 60890

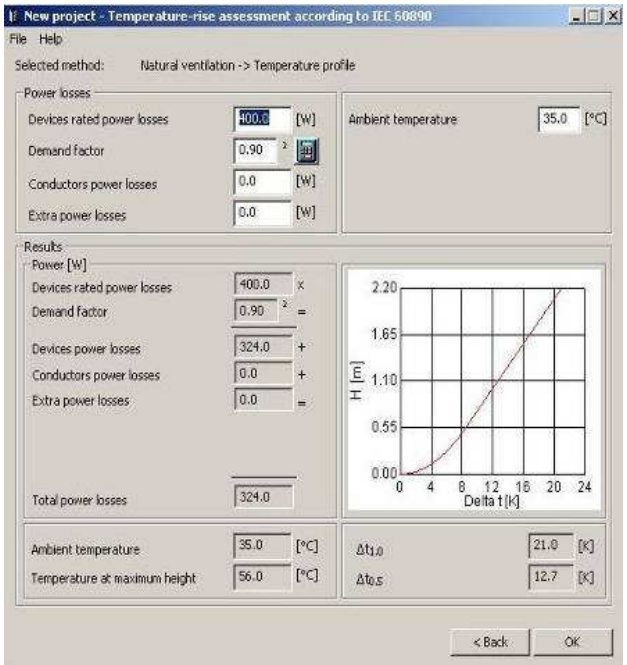




Effect of Temperature rise with one partition

Ventilation and Temperature Rise Considerations-IEC 60890



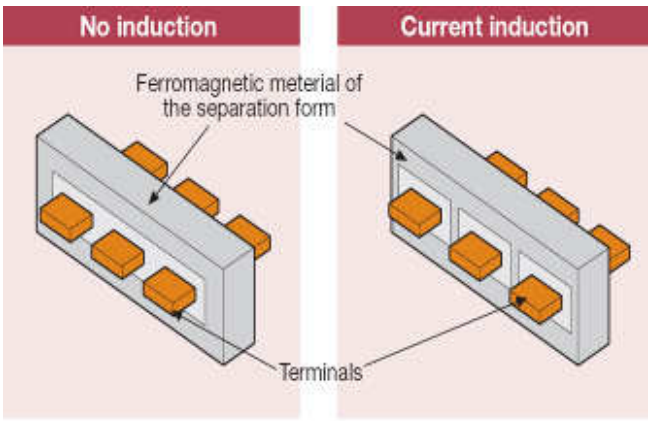


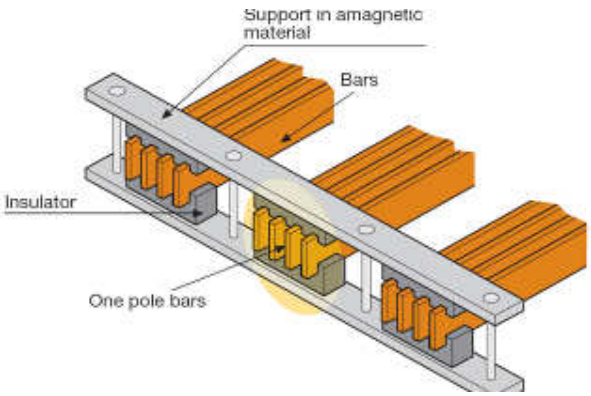
Effect of Temperature rise with three partition

Ventilation and Temperature Rise Considerations

- **Standards and tests**
- MNS switchgear systems are type-tested switchgear and controlgear assemblies according IEC 60439-1.
- Test results to IEC 439-1 Par. 8.2.1 from neutral testing laboratories are available and confirmed by ABB test certificates.

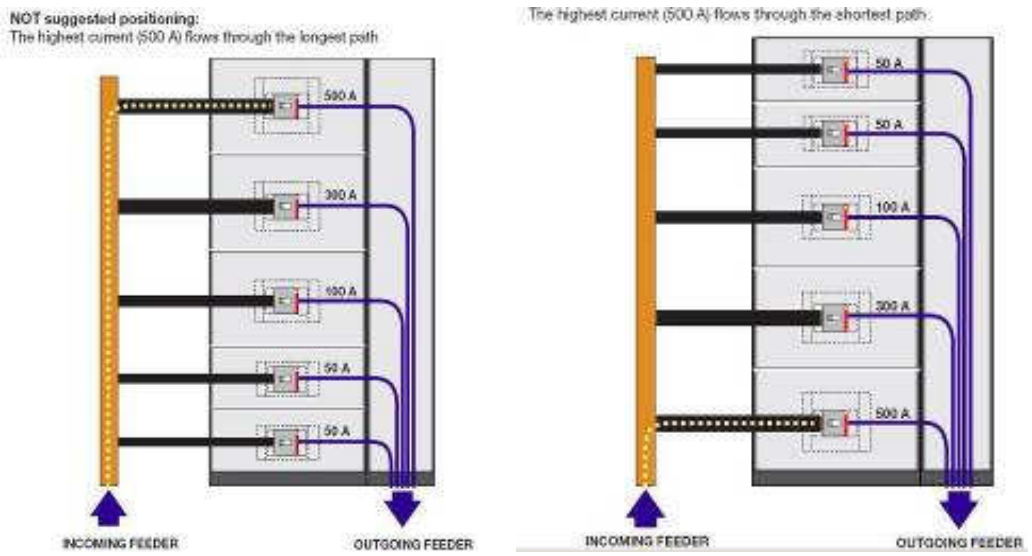
Ventilation and Temperature Rise Considerations
Prescriptions for improving Heat Dissipation





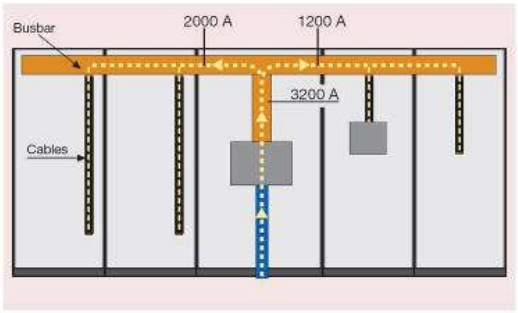
- Avoid Ferromagnetic ring embracing all 3 conductors of 3 phase system.

Ventilation and Temperature Rise Considerations
Prescription for Improving Heat Dissipation

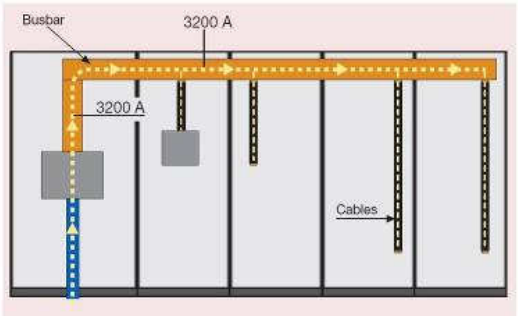


- Keep paths of highest current as short as possible.

Ventilation and Temperature Rise Considerations
Prescription for Improving Heat Dissipation



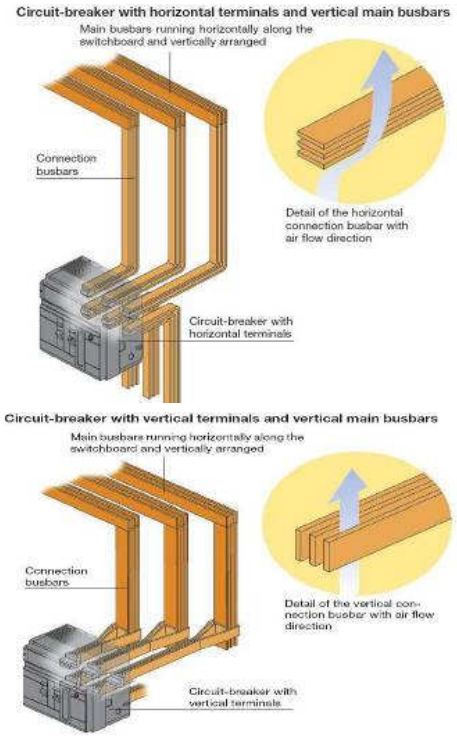
Advisable solution from a thermal point of view



Heavier solution from a thermal point of view

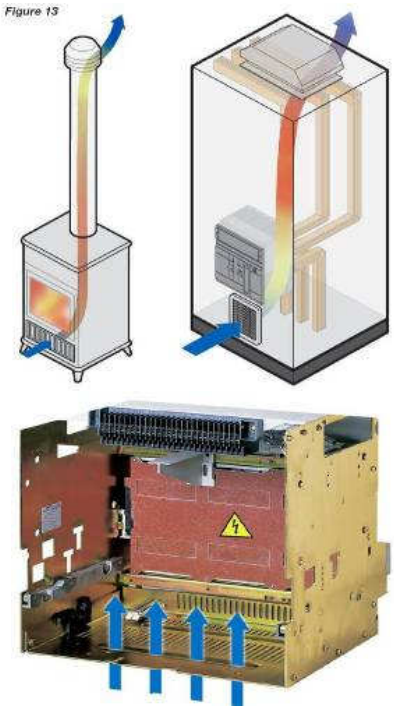
- Whenever possible install main incomers in the middle column.

Ventilation and Temperature Rise Considerations Prescription for Improving Heat Dissipation



- Terminal arrangement .When possible utilize the better heat convection in vertical terminals or busbars. Horizontal terminals impede air flow.
- Use of vertical terminals allow a better heat dissipation since they oppose a smaller cross section to the natural motion of air.

Ventilation and Temperature Rise Considerations Prescription for Improving Heat Dissipation



- Realize good circulation of air inside and maintain . Cross section of air outlets atleast 1.1 times the air inlet.
- Place ventilation outlet to achieve proper draught chimney effect.
- Position equipment inside the switchgear so as not to impede air flow.

Ventilation and Temperature Rise Considerations Prescription for Improving Heat Dissipation

Number of horizontal partitions n	Factor d
0	1
1	1.05
2	1.15
3	1.3

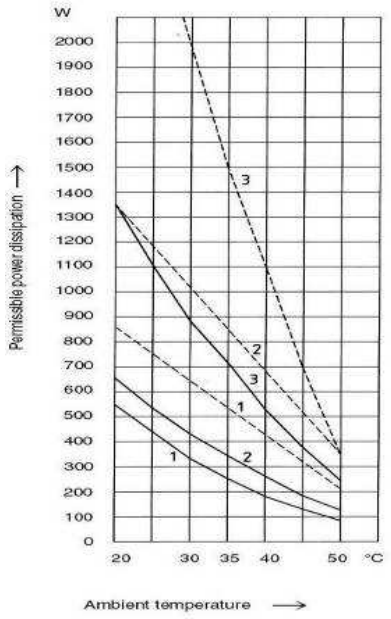
- Use appropriate internal separation.
- Horizontal partitions can cause air temperatures to rise upto 30%(3 partitions without ventilation openings)

- For enclosures without ventilation openings and effective cooling surface>1.25m^2

Number of horizontal partitions n	Factor d
0	1
1	1.05
2	1.10
3	1.15

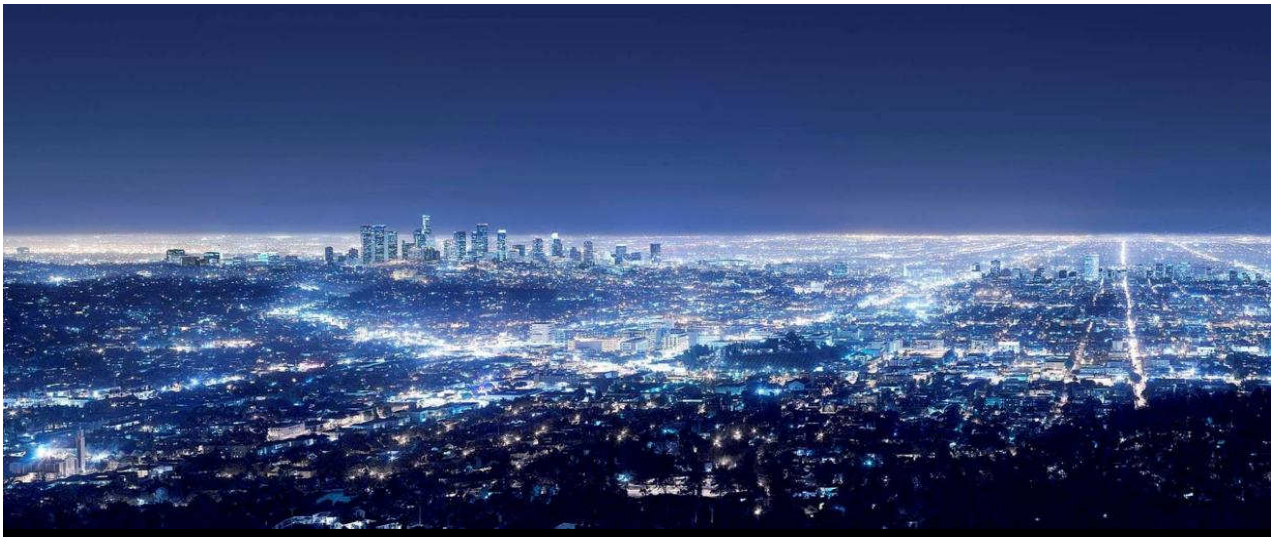
- For enclosures without ventilation openings and effective cooling surface>1.25m2

Ventilation and Temperature Rise Considerations Conclusion:Typical values for the maximum permissible effective power dissipation in an MNS switchgear cubicle.



- Figure shows interrelation between the degree of protection, the heat load of a switchgear cubicle and the influence of the ambient temperature.

- _____ degree of protection IP52 to IP54 ,----------degree of protection IP32 to IP42
- 1 = Withdrawable-part design,2 = Fixed-part design,3 = Switchgear cubicle with open-type circuit-breakers



Iyer, LVS, 19th Feb 09

Summary

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Summary

- Many more factors that contribute to make a good LV Switchboard. Here we have touched on three area:
  - Internal Separation
  - Index of Protection (IP)
  - Temperature rise and ventilation
- To improve the Safety and reliability, and balance with the cost of investment, the designer shall define the most suitable:
  - Form of Separation
  - IP and proper ventilation

  for the switchboard.

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