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Modern Trends in Manufacturing of Medium Voltage Switchgear

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***Abstract*- Switchgear is regarded as crucial equipment in networks that distribute electric power for protection. This is because it's essential to keep an eye on the Switchgear's performance and condition and to carry out the necessary corrective maintenance on any equipment that might be causing issues. A single incident could harm numerous customers, and operational staff would be seriously risked. Before employing outages to shut down the system, many factors must be considered because they may increase maintenance costs and impair the users' access to electricity. Therefore, accurate switchgear status evaluation interpretation is essential for the early detection of potential failures. The production of MV switchgear is discussed in this study.**

***Index Terms*—Power system protection, MV switchgear, Protective relays busbar.**

I. INTRODUCTION

A group of electrical components enclosed in a framework made mostly of metal is known as medium voltage switchgear. This centralized system's switches, transformers, fuses, and circuit breakers come in several varieties. Better protection, control, and segregation of electrical equipment from one another are achieved through the usage of electrical panels. Electrical Switchgear is frequently used in medium- to large-sized commercial or industrial facilities and in power transmission and distribution networks. We shall describe the many types of medium voltage electrical panels in this post and discuss the pertinent standards [1].

Consider how these networks connect to the main grid via a specific MV substation to see why design flexibility is crucial. Circuit breakers, Switches, Contactors, Current-Limiting Fuses, Disconnections and Earthling Switches, Current Transformers, Voltage Transformers, etc., are some of the embedded components in the substation, which mostly consists of MV switchgear. Each Switchgear and switchgear piece must meet all applicable national, regional, and international standards, including IEC 62271-200 [2-4]. Before any integration, the components must be qualified following their standards. An operating procedure connected to the interlocks and any tools governs the accessibility to these components and how they are connected. This accessibility is separate from the availability of services.

Thus, a diversity of networks, operating modes, and other issues are faced by panel manufacturers. These depend on consumer and end-user behaviour and national, even regional, laws. The proper equipment, operating procedures, and maintenance must meet these criteria, including the LSC standards.

Some switchgear fundamentals must be taken into account before making these decisions. They may be gas-insulated Switchgear, shielded solid insulation switchgear, or air-insulated Switchgear (AIS) (Air Insulated Switchgear). The choice impacts the distribution plan's adaptability, which also affects the accessibility of the compartment [5].

Among the three, AIS provides the broadest range of possible component combinations. As a result, it provides the highest design architecture freedom, which is a significant benefit. Additionally, all compartments can be easily monitored to support any critical installation's predictive maintenance program for asset performance management.

II. KEY FEATURES

The following characteristics apply to small, type-tested Switchgear intended for interior installation in accordance with IEC 62271-1, 62271-200, and 62271-100 standards:

1. For the VTs, there are five separate metal-clad constructions.
2. A test for internal arc faults is used to confirm personal safety.
3. panel widths: 650 mm and 1000 mm.
4. Arc pressure in all compartments is to be released upward by Switchgear.
5. All replaceable parts must be uniform and able to be switched out.
6. Depending on the situation, vacuum circuit breakers might be truck- or cassette-style.

A. SAFTEY FEATURES

1. All electrical and mechanical operations occur when the enclosure doors are closed.
2. Increased operating safety thanks to a full mechanical interlocking system used in serial production.
3. Independent working metallic shutters automatically protect the isolating contacts when the unit is withdrawn.
4. Earthling switches with fail-safes.
5. The speedy exchange of withdrawable units brings on a high level of availability.
6. Vacuum Circuit Breaker rack-in and rack-out with closed doors offer complete personnel safety.

B. DURABILITY

1. Panels employ a minimal amount of insulant volumes and are air-insulated.
2. Technical and financial aspects make ideal assembly possible.
3. Spare parts are readily available since standard insulators, instrument transformers, and other components are used. Typical copper sections and switching equipment

C. HIGH-QUALITY REQUIREMENTS

1. Modern manufacturing processes that ensure precise dimensional correctness employ a high-precision laser cutting system.
2. Internal double-sheet steel walls between panels that are arc resistant.
3. Optional busbar partitioning from panel to panel.
4. The front door and side panels have electrostatic powder coating.
5. In compliance with the EN ISO 9001 quality management system.

D. QUALITY MANAGEMENT

An integrated quality system meticulously designed for all areas is used to manufacture MV switchgear. It is important to guarantee that the panels are flawlessly constructed and adhere to all applicable standards at every stage of the manufacturing process.

The standards of the ISO 9001:2015 quality assurance model have been verified as fully met by the medium voltage quality system [6]. The quality checks include a graphic assessment and the temperature rise test examination.

III. IEC CLASSIFICATIONS

A. REVISED DIELECTRIC REQUIREMENTS

The test must always be performed in the correct switchgear panel [7, 8]. The variable placement may harm the switching capacity. To test the responsibilities, T10, T30, and T60 are required. Additionally, the breakers are subjected.

In Fig. 1, **A** shows the C.B, the Feeder compartment, and **B** shows, the secondary compartment.

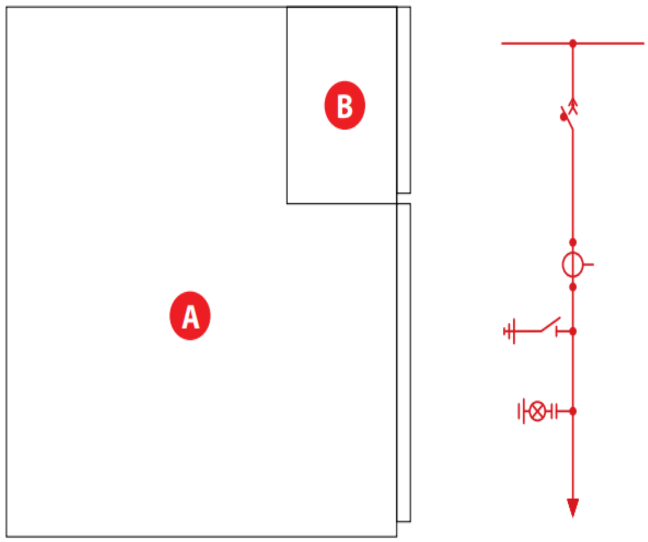

Figure 1: Secondary compartment.

Fig. 2, **A** shows the C.B., Feeder compartment. **B** shows the Busbar compartment, and **C** offers the Auxiliary compartment.

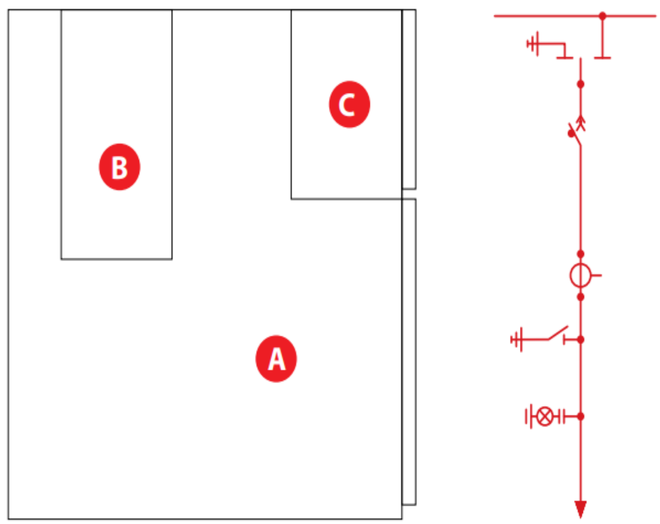

Figure 2: Busbar connections with the compartment.

In Fig. 3, **A** shows the C.B, Feeder compartment. **B** shows the Busbar compartment, and **C** shows the Auxiliary compartment.

B. INTERNAL ARC CLASSIFICATION

1. Arc faults occur, causing considerable damage to the equipment and posing a serious risk of injury to nearby employees.
2. Arc temperatures of up to 20,000°C, or four times the sun's surface temperature.

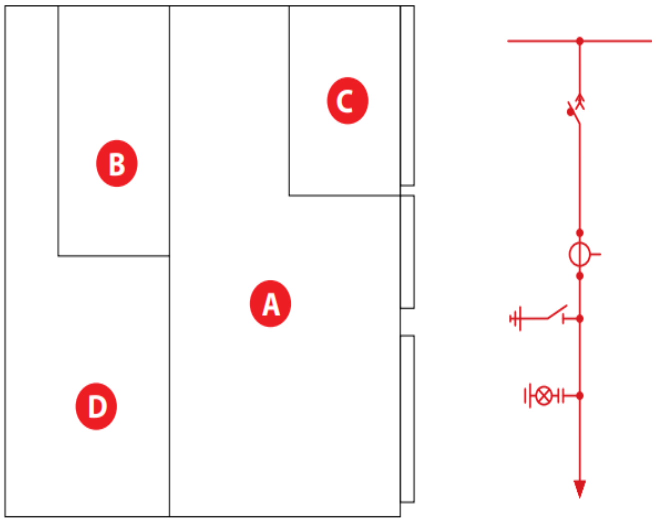

Figure 3: Th impairment and the segregation of the busbar.

C. *MV SWITCHGEAR BREAKDOWN*

In Fig. 4, 1 shows Pressure flaps, 2 shows the low voltage compartment, 3 shows the Shutters, 4 shows the VCB contacts, 5 shows the relays, 6 shows the VCB door, 7 shows the Vacuum circuit breaker, 8 shows the VT compartment, 9 shows the Earth switch, 10 shows the VT Busbar, 11 shows the Rear door, 12 shows the bus bar, 13 shows the spout bushing, 14 shows the Current Transformers, 15 shows the Power cable compartment and the 16 represents the truck.

IV. PHYSICAL LAYOUT OF SUBSTATIONS

When selecting any arrangement plan, the consumer should be aware of the following primary criteria: System simplicity., Versatile equipment maintenance is simple, Reducing the amount of downtime during maintenance, and Provision of extension in the future as demand increases [9]—and choosing a bus bar arrangement design that maximizes the system's return on investment.

The single bus bar is a simple and space-efficient option for your power supply. All circuits in this configuration are directly coupled to one main bus, as shown in Fig. 5. The advantages are simple circuits, cost-effectiveness, and required bus bar. The disadvantages are Low flexibility and difficulty in maintenance [10].

A. *SINGLE BUS CONNECTED WITH BUS COUPLER*

Turning on the sectional or bus coupler breaker allows all loads to be fed, even if one or more sources are disconnected from the system [11]. By electrifying the other segment of the bus bar, the half load of the substation can be fed if one section of the bus bar system is undergoing maintenance, as shown in Fig. 6. The advantages are It is cost-effective, a Moderately simple circuit and more reliable.

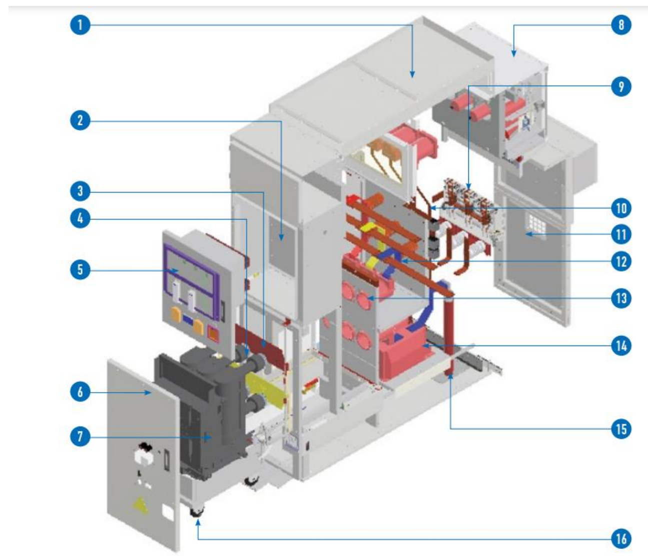

Figure 4: Product Breakdown.

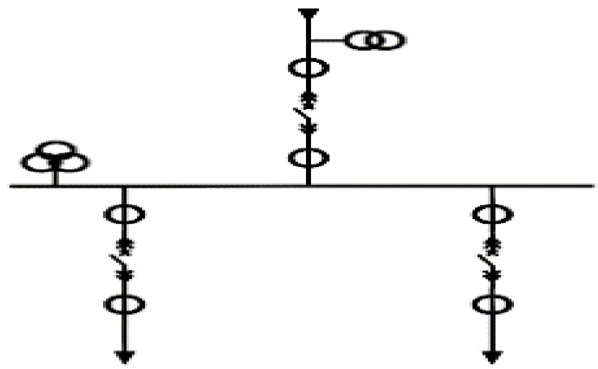

Figure 5: Signle bus-Single Breaker

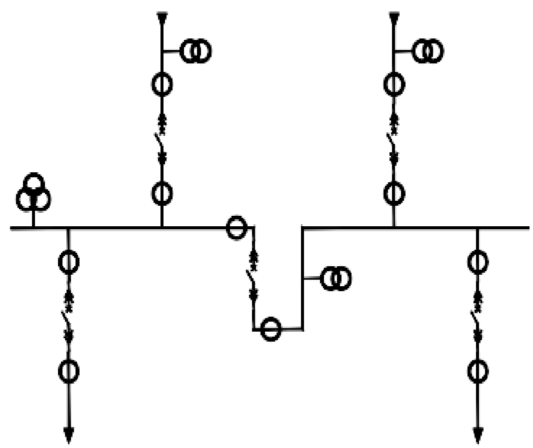

Figure 6: SB-BS connected with bus coupler.

V. TYPES OF MV SWITCHGEAR

A. INCOMER AND FEEDER

An installation's main distribution board often offers the feeder panel to distribute the power according to the customer's needs and for a variety of functions [9]. It is also employed for synchronizing with diesel generator sets that serve as backup supplies and connecting various sources of power [4]. Fig. 7 describes the single-line diagram of the incoming and outgoing feeder, and the panel's picture shows us the bus bar. Fig. 8, consists of the Upper bus bar.

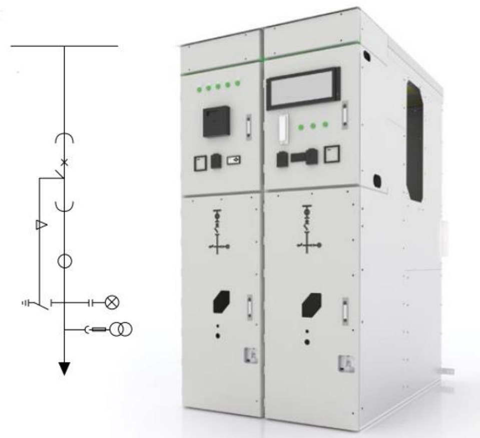

Figure 7: IF/OF SLD with Panel

B. BUS RISER

A bus riser is a cubicle intended to link horizontal bus bars between neighboring cubicles in a Switchgear run with incoming wires from below. When your incomings or outgoings are bus bars rather than cables, and they travel through an enclosed bus duct to their destination, this is what it entails. According to Fig. 9, it consists of an SLD of bus-riser.

Figure 8: Busbar compartment.

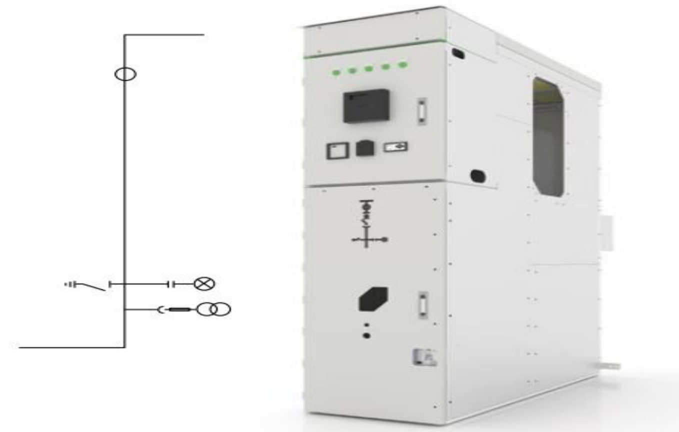

Figure 9: Bus Riser

1. Core Balance Current Transformers (CBCT)

Core Stability Current transformers (CBCTs), shown in Fig. 10, are used in power systems to protect against earth leakage. Due to their performance requirements, they differ from standard protective and metering current transformers.

In most cases, insulation monitoring is adequate to detect earth leakage but not to stop the power. In such situations, the operating crew will be able to take action to transfer the load to other feeders and swap out the faulty circuits for repairs. Circuits that send electricity to peat bogs, ore mines, and other similar loads are an exception to this rule since their protection systems are built to cut off the circuit in the case of an earth leak [12].

C. POWER SYSTEM PROTECTION

The safety system is in action, isolating the defective area [8, 9]. The protective system should operate quickly and selectively, isolating only the defective component in the least amount of time while causing the least amount of systemic disruption. A backup protection system that requires effective relay coordination should also exist in case the primary protection system malfunctions. A protective relay failing can cause severe equipment damage and protracted downtime.

Figure 10: Core Balance Current Transformers

a) Protection Systems Requirements

The shield system is a crucial component of the power system since it will function abnormally to stop failure or isolate faults and minimize their impact. The protective system must meet some fundamental characteristics, including reliability, selectivity, sensitivity, and speed of operation.

Switches are powered mechanisms that do not switch on or off unless instructed by an outside device. Relays and sensors signal the switching mechanism to function when an overcurrent or other abnormal or unacceptable situation is detected and control the operation of the MV circuit breakers, which act as brute-force switches [10].

These are divided into 2 main category:

- Tripping switches
  1) Automatic
  2) Lockout Relay
- Monitoring Relays
  1) DC Supervision Relay
  2) VT Fuse Supervision Relay
  3) Contacts Multiplication Relays

D. HIGH-SPEED EARTHING SWITCH

For safety, while doing maintenance and other tasks on the Switchgear, earthing switches connect the wires or busbar to the earth [3, 4]. It has a quick action mechanism that is operator independent, an interlocking feature, and insulators for voltage capacitive dividers. The switch complies with the relevant IEC standard and has a making capacity.

VI. TYPE TESTS AND APPLICATIONS

All the testing required by the international (IEC) Standards have been performed on MV switchgear. The results were also extended across the entire range because testing was conducted on switchgear components that were thought most susceptible to their impacts. The results were also extended across the entire range because testing was conducted on switchgear components that were thought most susceptible to their impacts. Before delivery, each piece of Switchgear is put through regular tests in the plant.

Electrical lines transport substantial energy through them and power at intermediate voltages to the primary distribution substations near the point of consumption. Large industrial and commercial consumers receive electricity directly from the principal distribution substations via the medium voltage network, or distribution centers within residential neighbourhoods receive electricity via the medium voltage network via primary feeders and from the distribution transformer to loads via cables see Fig. 11.

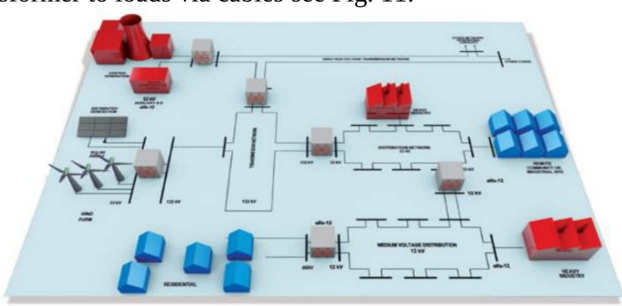

Figure 14: Power generation to transmission and distribution

Following are the applications of the medium voltage switchgear as shown in Fig. 12 to Fig. 15

Figure 15: Infrastructures and buildings

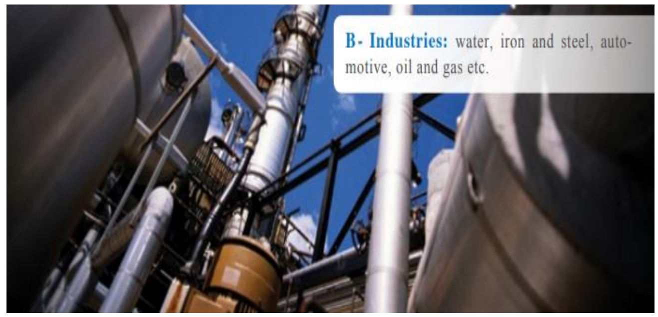

Figure 16: Industries

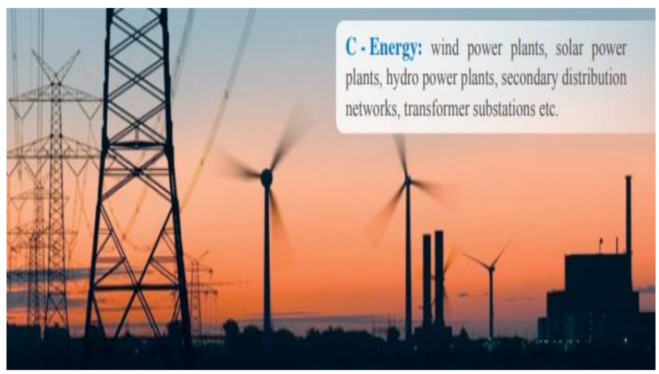

Figure 17: Energy

Figure 18: Special Application

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The authors declare they have no conflicts of interest to report regarding the present study.

CONFLICT OF INTEREST

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