CEEAMA™
Consulting Electrical Engineers Association of Maharashtra

CEEAMA LiveWire

E-NEWSLETTER

Published by Consulting Electrical Engineers Association of Maharashtra

Topic for August 2025

INDOOR SUBSTATIONS

"Inside: This month's hot topic and smart reads..
Do solve the quiz at the end..!!

Electrical Consultants Newsletter
Volume No. 4 Issue #52
August2025

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Mr. Subhash L. Bahulekar
Chief Editor - CEEAMA LIVEWIRE

From the Editors Desk,

HAPPY MONSOON TO ALL!!

HAPPY INDEPENDENCE DAY

The month of August which mostly coincides with the happiest Indian calendar month of Shravan also has yet another national celebration that we proudly remember viz. 15th August. This year we celebrated 79th glorifying year!

Shravan month triggers a romantic, devotional and pious mood in the air. No wonder, the most popular Indian classical Raaga, Malhar, literally means the same (mal+har) and is dedicated to the rainy season!

CEEAMA keeps organising fun-filled programs for members combined with knowledge. Our Ex. President Narendra Duvedi hosted meet and networking get-together on 10th August which was also gratefully sponsored by M/S. Greycell Energy LLP in Pune.

Last 3 months' LiveWire has been featuring Substations; starting with GIS substation, then Outdoor Switchyards and now Indoor Substation in this edition! The purpose is clear! Safety starts with Substations. Its basic knowledge and the serious safety concerns must be educated to all practising electrical engineers. I would like to express my gratefulness to all contributors! Encouraging you guys to continue and more to join this "Gyan-yagya"!

In this editorial, I would like to pay our heartfelt condolences to the bereaved family members and near & dear ones of our Ex-LFM, Mr. Prabhuappa Revappa Banale on his sad demise on 3rd August 2025.

Om Shanti!

Wish you yet another month of safety and happiness!

Subhash L. Bahulekar
Chief Editor – CEEAMA

From the President's desk:

Dear Friends,

Firstly, deep condolences to the bereaved family members as well as friends and acquaintances of our Ex-LFM, Mr. Prabhuappa Revappa Banale on his sad demise on 3rd August 2025. We lost a friend and mentor to some of our LFMs, leaving behind memories and the golden words of advice.

This week we focus on Indoor Substations. Apart from the internet and Artificial Intelligence impact on almost all equipment in the substation, the latest in the indoor substation arena is the question of how to replace the SF6 gas.

SF_6 (sulphur hexafluoride) is a very effective insulating and arc-quenching medium, but also an extremely potent greenhouse gas (about 23,500 times more harmful than CO_2 as per some reports). Vacuum Interruption coupled with Clean Air / Solid Insulation is an alternative and has been experimented upto 40.5kV applications abroad. A popular "green gas for grid" or G3 technology is deployed by a major manufacturer which uses Fluoronitriles and CO2 in addition to Nitrogen. This mixture reportedly has more than 99% lower Global Warming Potential (GWP) than SF_6. The Fluoronitrile molecules absorb arc energy and prevent breakdown (similar to SF_6), while CO_2 and O_2 act as buffer gases, supporting insulation and pressure stability.

Friends, CEEAMA is changing. The website will be revamped and some additional features will be planned. Please feel free to write to admin@ceeama.org regarding your suggestions and ideas for the revamp. We will discuss and implement your ideas after the Governing Council consensus.

What a whirlwind of geo-politics since the last month with strained Indo-US relationship and the US tariff war! Indian manufacturers of transformers, switchgear and cables cater to the US market. If their exports decline due to tariffs, their domestic sales focus may increase, which may benefit Indian projects by improving local supply availability. Indian suppliers may shift focus from the US to Middle East, Africa, ASEAN, and Europe, while catering to growing domestic demand. Technology localisation may increase and the US and global OEMs may enter joint ventures with Indian firms to manufacture in India, bypassing tariffs and ensuring competitive supply. Let us all wait and watch what unfolds here over the next few days, weeks, months.

August 2025 has plenty to look at for in Indian festivals - Raksha Bandhan on August 9th, Independence Day and Parsi New Year (Navroz) on August 15th, Krishna Janmashtami on August 16th, and Ganesh Chaturthi on August 27th for the most important festive dates. Paryushana Parva begins August 21st which is the most important festival for the Jain community, while Onam (harvest festival in Kerala) begins on August 26th.

Have great festive days in August, but don't forget to be safe!

Jai Hind and …
Ganapati Bappa Moraya !! Mangal Murti Moraya !!

Mr. Chidambar Joshi
Hon. President
CEEAMA

From the Secretary's desk:

It is a privilege to address the esteemed CEEAMA members through the Live Wire, a monthly E-Newsletter, a platform where knowledge is shared with the Consulting Electrical Engineers, Contractors, and other stakeholders, under the common mission of safeguarding lives and achieving safety by following innovative & safe design, installation and maintenance practices.

Since India is developing at a faster pace, creating huge opportunities for the manufacturers, consultants, and contractors, the role of electrical safety becomes more critical than ever.

At the Consulting Electrical Engineers Association, our commitment is to empower our members by sharing knowledge, participating in commenting on various drafts of Indian Standards widely circulated for seeking the comments from all the stakeholders, and various government policies related to safety, sustainability and reliability.

An explosion and fire at a pharmaceutical plant in Telangana resulted in the deaths of 46 people on 30th June 2025. A further 33 people were injured after the blast at the Sigachi Industries Limited factory. It caused a fire and a subsequent building collapse while over 140 people were working inside.

Such accidents can certainly be prevented by Designing safe installations, use of IS/IEC marked material, carrying out electrical installations as per CEA Safety Regulations, NEC, NBC and related installation standards, and last but not the least adopting Periodic inspections and maintenance practices. Taking timely corrective actions whenever any abnormality is observed in the plants or installations, will also help in minimising risk of accidents.

So let us continue to collaborate, share knowledge, and lead the society to a safer place to live in, making electrically Surakshit Bharat!

Wishing all the members a very happy 79th Independence day!

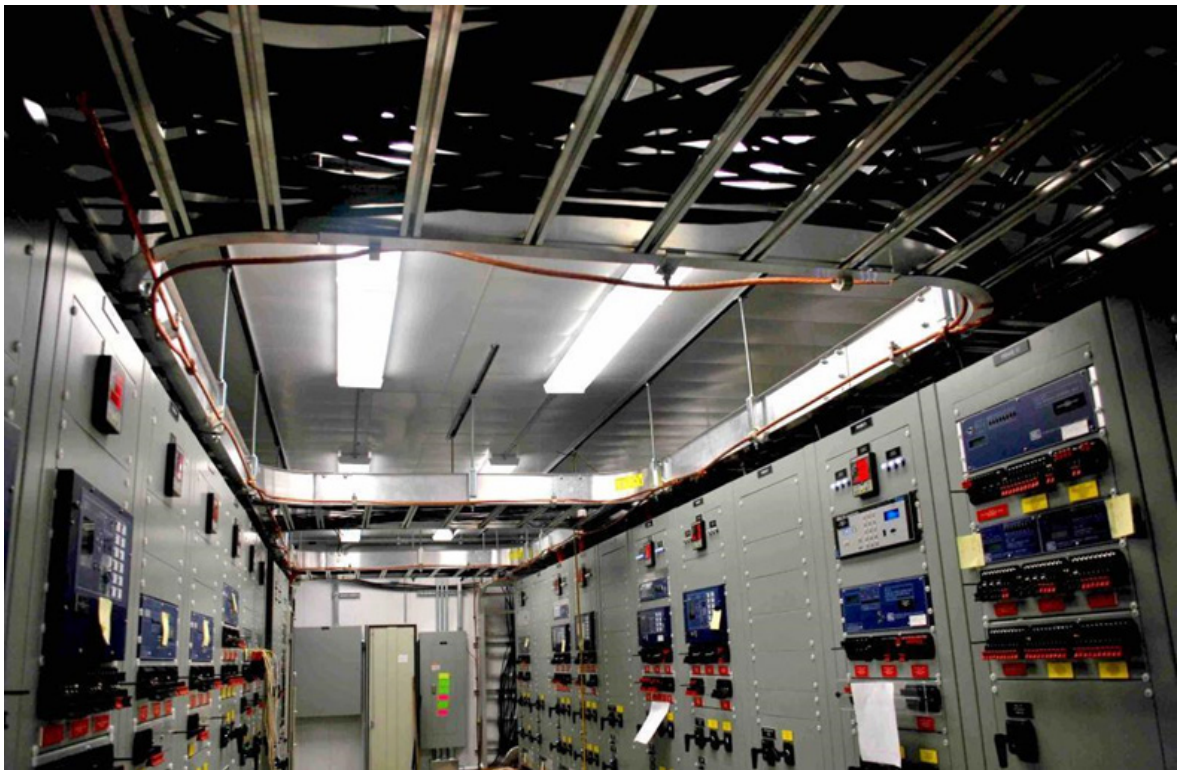
Best Regards,

Mr. Ulhas Vajre

Hon. Secretary

CEEAMA

INDOOR SUBSTATION



INTRODUCTION TO INDOOR SUBSTATION

DEFINITION

A substation in which the apparatus is equipped inside the substation building is called an indoor substation.

PURPOSE

Such type of substation is mainly used for the voltage up to 11000 volts, but when the surrounding air is contaminated by impurities such as metal corroding gases and fumes, conductive dust, etc., their voltage can be raised up to 33000 volts to 66000 Volts.

APPLICATIONS

- ✓ Industrial Plants
- ✓ Commercial Buildings
- ✓ Urban Areas

TYPES OF INDOOR SUBSTATIONS

- ✓ Distribution Substation
- ✓ Industrial Substation
- ✓ Switching Substation
- ✓ Frequency Changer Substation

✓ Power Factor Correction Substation

MAJOR EQUIPMENT USED

POWER TRANSFORMER

- **Function**: Voltage step-up or step-down.
- **Standard Ratings:**

✓ Primary Voltage: 6.9 kV to 69 kV
✓ Secondary Voltage: 2.4 kV to 34.5 kV
✓ Capacity: 500 kVA to 20,000 kVA

- **Type**: Dry-type or oil-immersed (dry-type preferred for indoor)

CIRCUIT BREAKERS

- **Function:** Interrupt fault currents and isolate equipment.
- **Standard Ratings:**
  - ✓ Voltage: Up to 38 kV (medium voltage)
  - ✓ Current: 630 A to 4000 A
  - ✓ Interrupting Capacity: Up to 50 kA
- **Types**: SF6, Vacuum, Air.

ISOLATORS

Function: Isolate equipment for maintenance.

Ratings:
✓ Voltage: 11 kV to 400 kV
✓ Current: 400 A to 1600 A

BUSBARS

Function: Conduct electricity within the substation.

Material: Copper or Aluminum

Ratings:

- ✓ Voltage: 11 kV to 400 kV
- ✓ Current: Up to 5000 A

CURRENT TRANSFORMER & VOLTAGE TRANSFORMER (CTs & VTs)

Function: Step down voltage for metering and protection.

Ratings:

- ✓ Voltage: 11 kV to 400 kV
- ✓ Accuracy Class: 0.2, 0.5

PROTECTION RELAYS

Function: Detect faults and trigger breakers.

Types: Overcurrent, Differential, Distance, Earth fault

Technology: Electromechanical or digital (numerical)

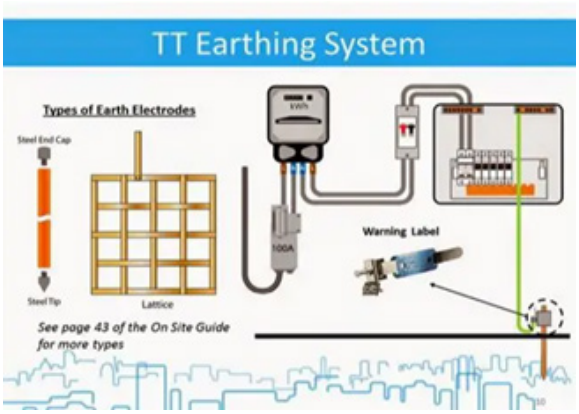
CONTROL PANELS

SCADA integration, monitoring, and control.

Function: Interface for monitoring and controlling substation equipment.

Includes: SCADA systems, relay panels, annunciators

EARTHING SYSTEM



Safety against fault currents.

Function: Ensure safety by grounding fault currents.

Components: Earth mats, rods, conductors

AUXILIARY EQUIPMENT

BATTERY BANKS AND CHARGERS

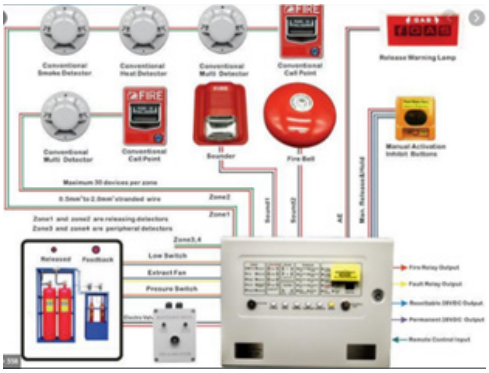
Purpose: Provide backup DC power for control, protection, and communication systems.

Ratings:

✓ Voltage: 24V, 48V, 110V, or 220V DC

✓ Capacity: Depends on load and backup duration (typically 100–500 Ah)

FIRE PROTECTION SYSTEM



Purpose: Detect and extinguish fires automatically.

Types: Smoke detectors, heat sensors, gas-based suppression (e.g., FM-200)

CABLE TRENCHES & RACEWAYS

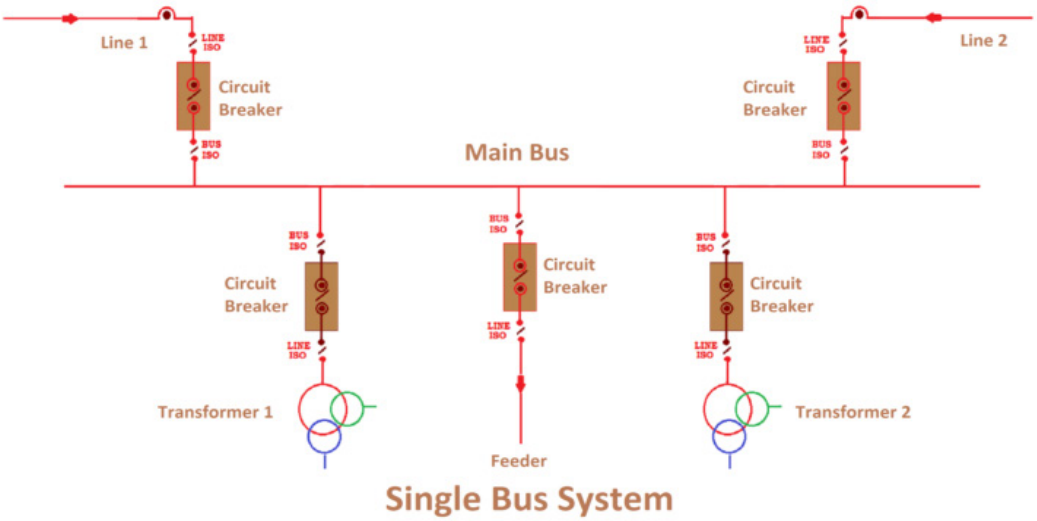
Cable trenches and raceways are essential for organizing, protecting, and routing electrical cables within an indoor substation.

They ensure safe and efficient cable management while maintaining accessibility for maintenance and upgrades.

TYPICAL LAYOUT DESIGNS

SINGLE BUSBAR SYSTEM

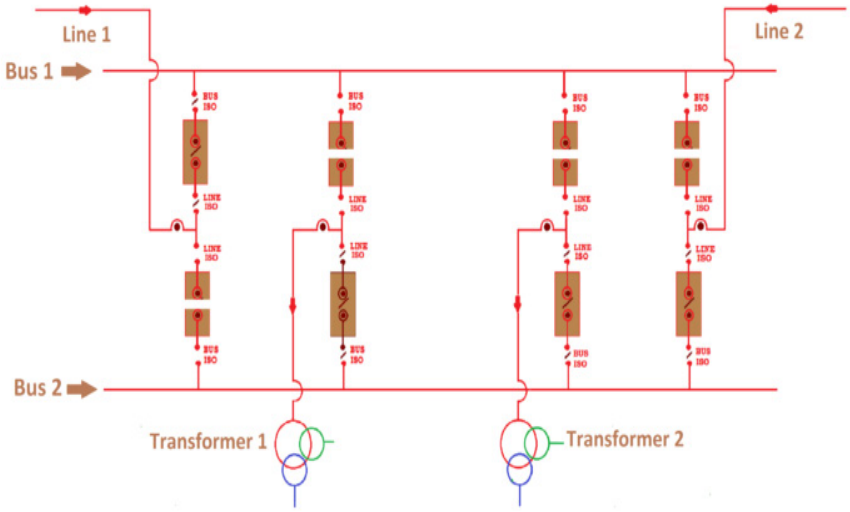
The arrangement of such type of system is very simple and easy. The system has only one bus bar along with the switch.



Single Bus System

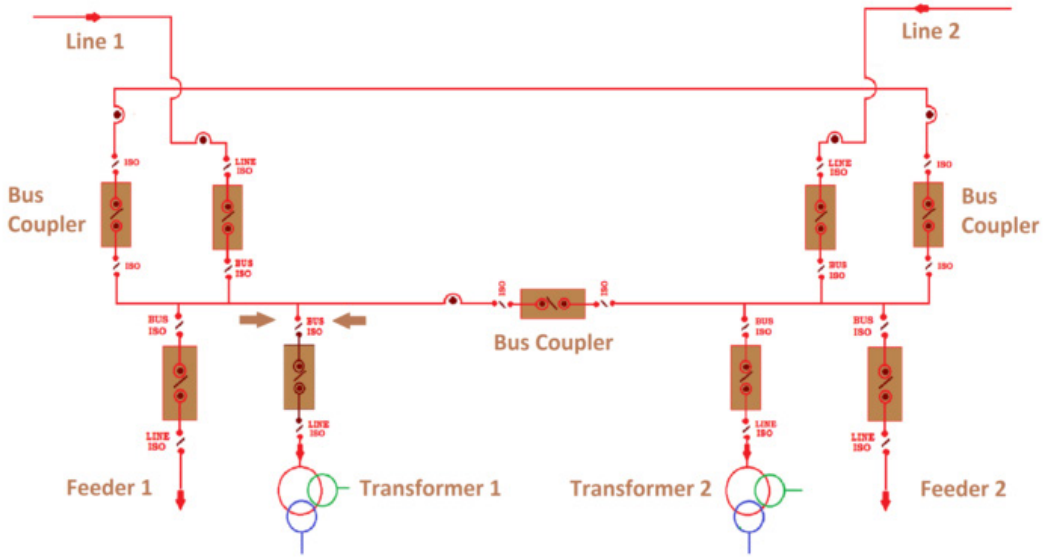
DOUBLE BUSBAR SYSTEM

This type of arrangement requires two bus bar and two circuit breakers. It does not require any additional equipment like bus coupler and switch.



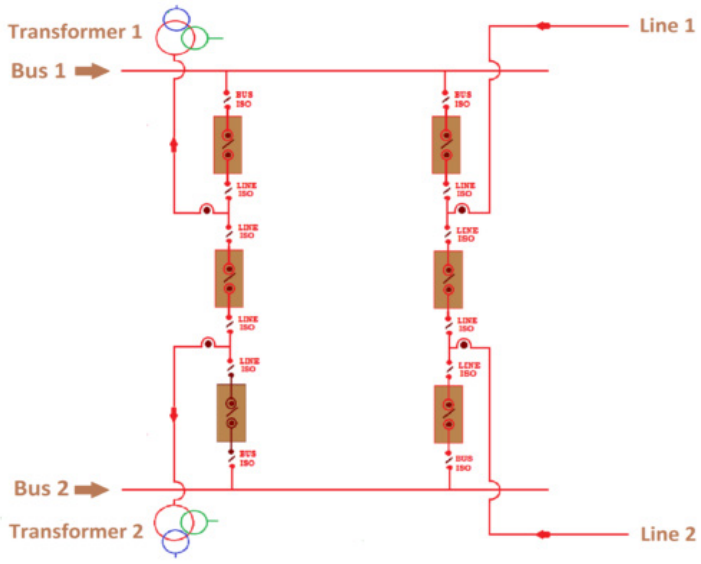
RING MAIN UNIT (RMU) LAYOUT

In such type of arrangement, the end of the bus bar is connected back to the starting point of the bus to form a ring.

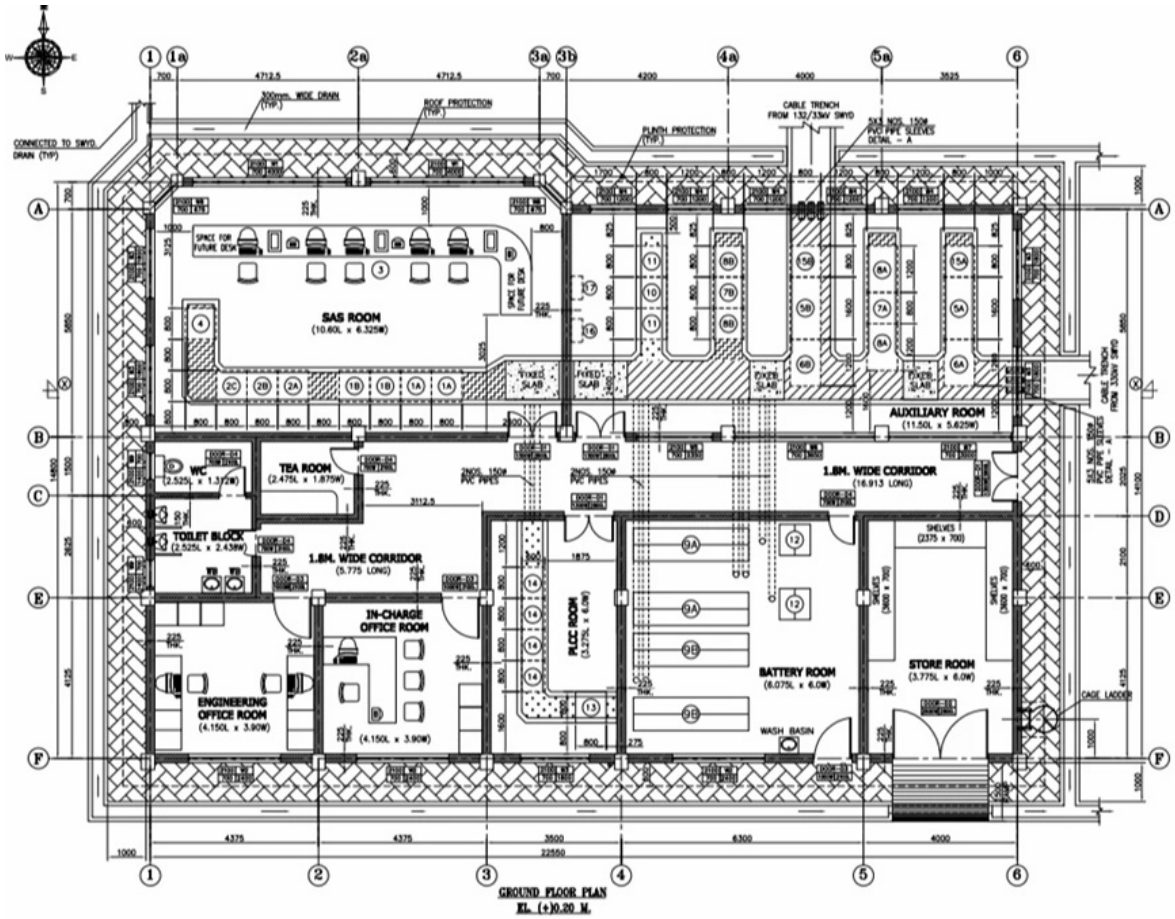


BREAKER & HALF SCHEME

In this arrangement, three circuit breakers are required for two circuits. Each circuit of the bus bar uses the one and a half circuit breaker. Such a type of arrangement is preferred in large stations where power handled per circuit is large.



GENERAL ARRANGEMENT DRAWING



SAFETY AND STANDARDS

CODES & STANDARDS

IEEE 979-2012 – Guide for Substation Fire Protection

This guide provides design and equipment recommendations to mitigate fire risks in substations. It includes:

- ✓ Fire detection and suppression systems
- ✓ Material selection for fire resistance
- ✓ Layout considerations to prevent fire spread

IEEE 80 – Guide for Safety in AC Substation Grounding Covers grounding system design to ensure personnel safety and equipment protection

IEEE 525 – Guide for Design and Installation of Cable Systems in Substations Offers best practices for cable routing, insulation, and fire protection in cable trenches

IEC 61936-1 – Power installations exceeding 1 kV AC This IEC standard outlines general requirements for electrical installations, including substations, with emphasis on safety, accessibility, and environmental protection.

IEC 62271 Series – High-voltage switchgear and control gear Includes standards for indoor switchgear used in substations, covering insulation, testing, and operational safety.

FIRE SAFETY MEASURES

- ✓ **Detection Systems:** Smoke, heat, and flame detectors integrated with SCADA or alarm systems.
- ✓ **Suppression Systems:** Use of clean agents (e.g., FM-200), CO_2, or water mist systems depending on equipment sensitivity.
- ✓ **Compartmentalization:** Fire-rated walls and doors to isolate critical equipment.
- ✓ **Emergency Access:** Clearly marked and unobstructed escape routes.
- ✓ **Material Selection:** Use of fire-retardant cables, panels, and insulation materials.
- ✓ **Maintenance Protocols:** Regular inspection and testing of fire protection systems.

CLEARANCE AND ACCESSIBILITY NORMS

Working Clearance:

- 0.75–1.2 meters around switchgear for safe operation and maintenance.

Height Clearance:

- Minimum 2 meters headroom in access areas.

Accessibility:

- All equipment should be reachable without obstruction.
- Emergency exits must be accessible within 10 seconds of walking distance.

Signage and Lighting:

- Adequate lighting for visibility.
- Safety signs for high-voltage areas and fire exits.

Contributed By

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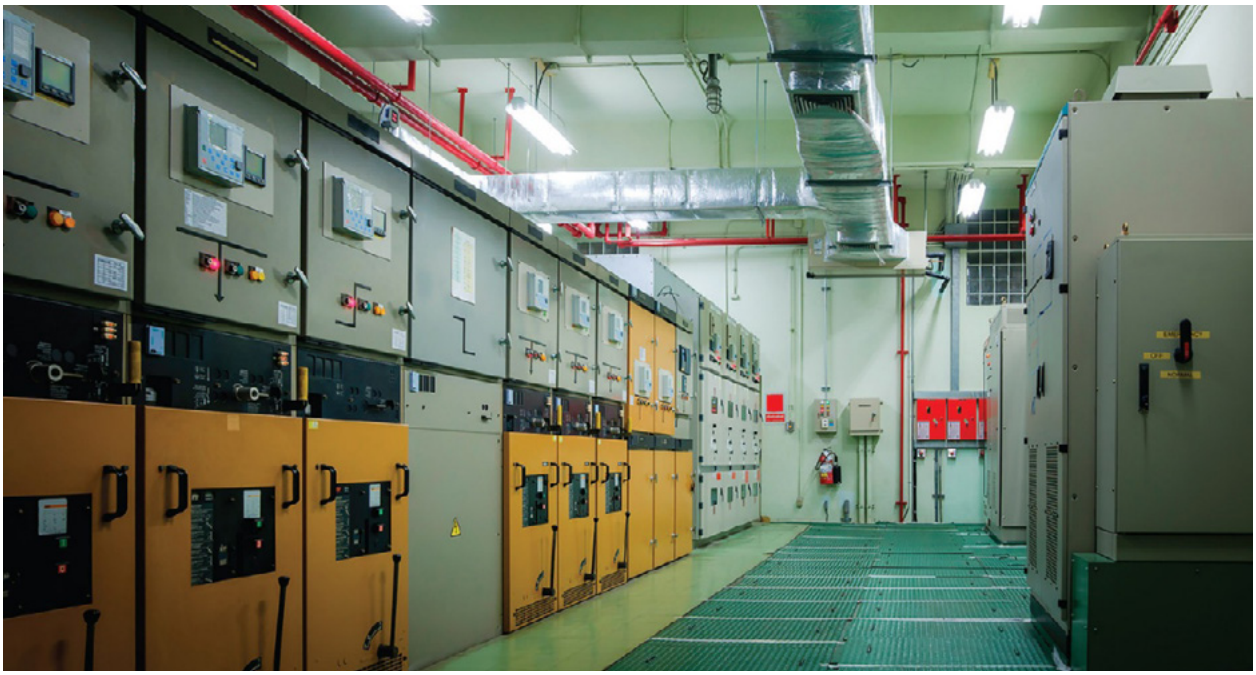
L&T Technology Services

INDOOR SUBSTATIONS

DESIGN, OPERATION AND TECHNICAL ADVANCEMENTS



1.0 Introduction

With growing electrification and the shift to urban environments, indoor substations have become critical infrastructure in modern power systems. Unlike outdoor substations, these are housed within buildings or enclosures, offering notable advantages for reliability, safety, and land-use efficiency - especially in urban or industrial settings.

2.0 Fundamental Concepts

2.1 What is an Indoor Substation?

An indoor substation is a facility where all major equipment such as transformers, switchgear, and control panels are installed inside a building. They are used for voltages up to 11kV but can be extended up to 33kV or even 66kV in cases where environmental protection is needed, such as areas with corrosive gases or conductive dust.

2.2 Applications include:

- Urban distribution networks
- High-rise buildings, hospitals, commercial complexes
- Industrial areas with challenging environmental conditions

3.0 Components of Indoor Substations

3.1 Major Equipment

- **Transformers:** Step down (or up) voltage levels for distribution; key for adapting high voltage to usable levels. OLTC RTCC, Marshalling panel and other auxiliaries are housed inside along with LV Switchboards.
- **DG Set:** Although part of Indoor substation, DG set is provided with separate room, or with Acoustic canopy if considered outdoor type. Control Panel, and ATS panels are provided indoor along with LV Switchboards.
- **Switchgear & Protection Devices:** Includes circuit breakers, relays, isolators, and fuses,

contained within metal-clad or gas-insulated enclosures for safety and reliability. These include HT Switchboards, LV PCC/MCC, MLDB, PDBs, LDBs, etc.

- **Busbars:** Main conductors to interconnect various substation elements, typically copper or aluminum especially applicable for GIS.
- **Capacitor Banks:** For power factor correction and voltage regulation.
- **Control & Metering Panels:** For monitoring, control, and data logging.
- **Auxiliaries:** Batteries, fire-fighting equipment, HVAC, and lighting.
- **Pressurization System:** In case the indoor substation is inside or in the vicinity of any hazardous area, the entire substation is provided with pressurization system to maintain positive pressure to avoid ingress of peripheral harmful hazard laden air.

4.0 Design and Construction

4.1 Indoor substations are:

- ✓ **Integrity Built Type:** On-site construction with concrete/brick compartments housing each element.
- ✓ **Composite Built-Up Type:** Prefabricated metal enclosures or cabinets that are assembled on site.
- ✓ **Unit Type/Containerized Substations:** Pre-assembled modules transported and installed as ready-to-go units, reducing onsite work and speeding up commissioning.

4.2 Safety Features

- ✓ Fire-resistant walls, CO^2/automatic fire extinguishers
- ✓ Ventilation and climate control
- ✓ Access control and surveillance for operator security
- ✓ Proper earthing and insulation

5.0 Comparison between Indoor and Outdoor Substations

Point	Indoor substation	Outdoor substation
Fault Location	Difficult	Easy as all equipment is within view
Future Expansion	Difficult	Easy
Time required for erection	More	Less
Amount of building material required	Large	Small
Capital cost and cost of switchgear installation	More	Less
Operation	Easy	Difficulty
Space required	Less	More

Description	Distance
At the rear of HV Switchboard	1500mm
At the front HV Switchboard	2000mm
At the side of various Switch boards and from wall	1000mm
At the front of various Switchboards	1500mm

Between front to front of two Switchboards. (Say DRAWOUT MCCs) facing each other.	2000 mm
At the rear of MV Switchboards requiring rear access	1000mm
Rear clearance in other cases	More than 750mm or less than 200mm.
Transformers with wall on one side	As per IS 10028
Transformers with walls on three sides	As per IS 10028
Clear height of busduct from finished floor level	2000mm
Clear space between Switchboard top and beam soffit	1000mm

Clearances of Various Equipment

6.0 Advantages of Indoor Substations

- ✓ **Enhanced safety:** Equipment is shielded from weather, dust, and vandalism, and reduces risk to personnel.
- ✓ **Space efficiency:** Ideal for limited or expensive urban land; equipment can be stacked or arranged compactly.
- ✓ **Operational reliability:** Protected from environmental extremes, leading to lower failure rates and reduced outages.
- ✓ **Reduced maintenance:** Lower exposure to pollution; less cleaning and longer lifespan for equipment.
- ✓ **Aesthetics & Noise Control:** Buildings minimize visual and acoustic impact, important in sensitive locations.

7.0 Disadvantages & Limitations

- ✓ Higher initial cost: Construction, fire protection, and climate controls increase capex.
- ✓ Limited scalability: Modifications and expansions are more complicated post-installation.
- ✓ Specialized ventilation and cooling required.
- ✓ Complex maintenance: Equipment is less accessible compared to outdoor substations, requiring skilled personnel.

8.0 Operation, Maintenance & Safety

- Routine Checks
- Monitoring for hotspots, sparking, and flashovers
- Regular inspection of transformers, circuit breakers, batteries, and relay calibration
- Ensuring HVAC, fire safety, and access controls function properly.
- Daily, monthly, and yearly maintenance schedules are essential.
- Safety Practices
- Physical security (limited access, surveillance)
- Clear labeling and instructions
- Emergency response systems and drills
- Grounding and insulation checks
- Fire suppression and evacuation plans.

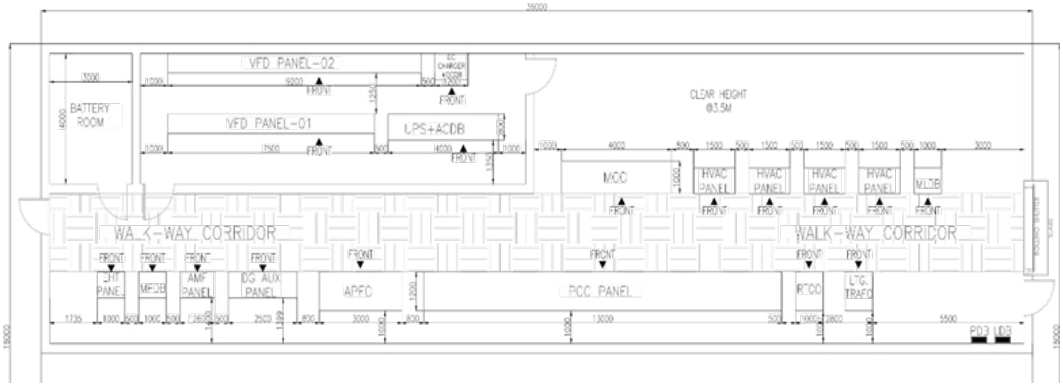
9.0 Technological Advancements

- ✓ **Prefabricated/Containerized Substations:** Reduce site work, enable rapid deployment, and provide maximum reliability.
- ✓ **Gas-Insulated Switchgear (GIS):** Enables extremely compact, low-maintenance installations ideal for dense urban areas. GIS uses SF6 gas for insulation, reducing space and improving reliability.
- ✓ **Digitalization:** Advanced SCADA, remote monitoring, and automation for real-time management.
- ✓ **Hybrid Solutions:** Combining air and gas-insulated components for cost and space optimization.

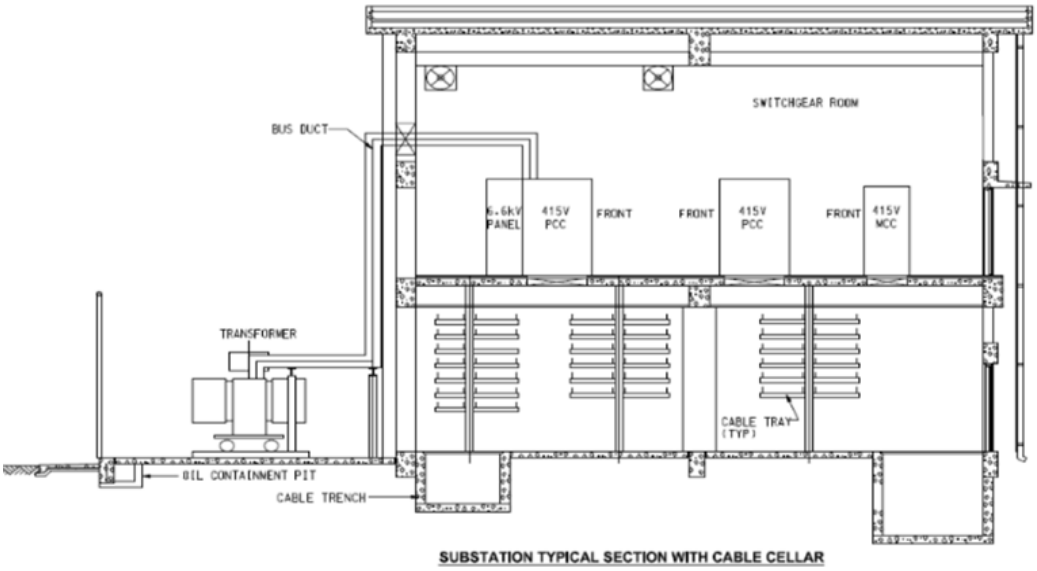
10.0 Common Applications

- City centers and commercial zones with limited outdoor space
- Industrial plants requiring controlled environments (clean rooms, chemical industries)
- Data centers and hospitals where reliability is paramount.
- Renewable integration: compact substations for solar/wind projects with minimal site disturbance

11.0 Plan view



12.0 Sectional view



SUBSTATION TYPICAL SECTION WITH CABLE CELLAR

13.0 Conclusion

Indoor substations are essential in modern power grids—especially where safety, reliability, and space efficiency are top priorities. With advances in compact design, prefabrication, and digital monitoring, they continue to evolve, supporting the growth of resilient, smart urban and industrial infrastructures.

14.0 Indoor Substation Safety and Standards

IEC / IEEE Standards

IEEE 979-2012 – Guide for Substation Fire Protection

Provides design and equipment recommendations to mitigate fire risks in substations, including:

- Fire detection and suppression system.
- Material selection for fire resistance

- Layout considerations to prevent fire spread.

IEEE 80 – Guide for Safety in AC Substation Grounding

Covers grounding system design to ensure personnel safety and equipment protection.

IEEE 525 – Guide for Design and Installation of Cable Systems in Substations

Offers best practices for cable routing, insulation, and fire protection in cable trenches.

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Outlines general requirements for electrical installations, including substations, with emphasis on safety, accessibility, and environmental protection.

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Includes standards for indoor switchgear used in substations, covering insulation, testing, and operational safety.

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BHARGAV KORIYA

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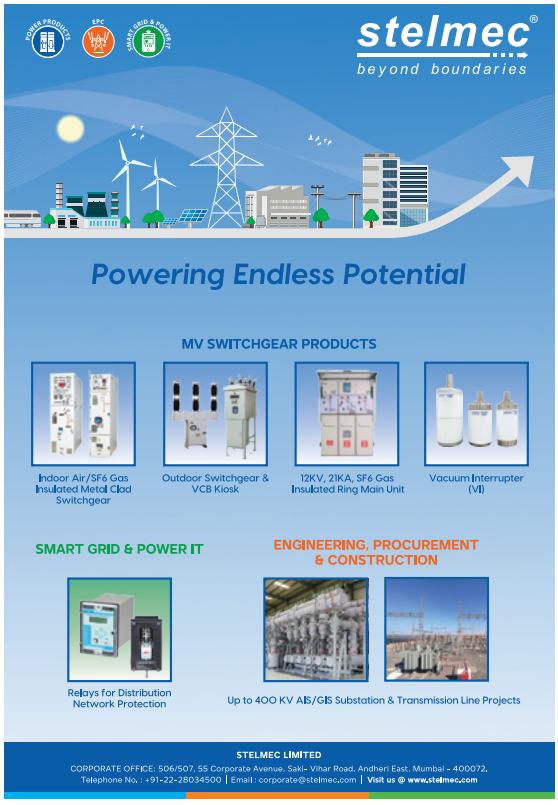
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Heartfelt Condolences

We deeply mourn the sad demise of Mr. Banale, a respected senior member of CEEAMA. His valuable contributions, guidance, and commitment to the association will always be remembered with gratitude.

On behalf of the CEEAMA fraternity, we extend our heartfelt condolences to his family in this time of grief. May his soul rest in eternal peace.

WINNERS OF QUIZ
JUNE 2025

HRISHIKESH MEHTA

MANGESH BHOSALE

VINAY YADAV

MAHESH GHARAT

KAILAS DESHMUKH

Congratulations

QUIZ AUGUST 2025

1. In 33kV System, Phase-to-Phase minimum clearance is?
   A. 2800mm
   B. 280mm
   C. 320mm
   D. 25mm

2. Lightning impulse withstand voltage of 33kV system:
   A. 70kV RMS
   B. 170kV peak
   C. 36kV RMS
   D. 90kV peak

3. Typical specification for Indoor metal enclosed switchgear 6.6kV to 33kV
   A. 12kV, 1250A, 25kA (3s) with VCBs
   B. 6.6kV, 250A, 50kA (1s) with SF6 CBs
   C. 33kV, 750A, 35kA (3s) with VCBs
   D. None of the above.

4. Arc Flash Study covers:
   A. Suggest required PPE
   B. Define four protection boundaries
   C. Calculates the incident energy
   D. All of the above

5. CEIG, CEA, TAC – Agencies/Authorities in:
   A. USA
   B. UK
   C. India
   D. France

6. Synchronous Motor runs with:
   A. 2% slip
   B. 0% slip
   C. Variable speed
   D. Torque dependent speed

7. Maximum Permissible temperature of 105oC is applicable to insulation Class:
   A. Y
   B. A
   C. E
   D. B

8. Recommended creepage distance for Pollution Level I at maximum L-L voltage:
   A. 20mm/kV
   B. 25mm/kV
   C. 16mm/kV
   D. 31mm/kV

9. Major electrical equipment are designed for an altitude of ___ AMSL:
   A. 500m
   B. 1000m
   C. 750m
   D. 1250m

10. Site fabricated cable trays
    A. Rung type Ladder trays
    B. Wire-mesh trays
    C. Perforated trays
    D. FRP trays

Rules for the QUIZ:

- The Quiz will be open for 10 days from the date of EMAIL.
- Each correct answer received on DAY 1 will get 100 points
- Next days the points will reduce as 90 – 80 – 70 and on 10th day points will be ZERO even if the
- answer is correct.
- All participants will receive E certificate signed by CEEAMA President with the points earned
- mentioned on the same.

Please use following google form link to participate in the QUIZ.

https://forms.gle/xRxayEY16KXJjC6W7

"Thank you all for the overwhelming response to the E-NEWS in general and E-Quiz in particular. MCQ based quiz is always tricky and surprisingly can take us aback when we realise our conceptions (misconceptions) about the subject / system / product.

The aim of the feature was to create inquisitiveness in your mind and help you check your technical quotient

quickly. The response will also help us to present articles and webinars on subjects which are important, but which

lack enough awareness / knowledge in general.

It can open a pandora box for our discussions and arguments and probable solutions. Engineering evolves with conception. It gets fuelled with community discussions and capitalist actions. All stakeholders start realising the need to take a closer look and help improve standards as we have seen in the past century. Surely it makes the world a better place.

Wish you all a better luck this time.

Do spread the word.

July 2025 Quiz Answers

1. B. Gang Operated Device
2. D. All of the above
3. C. Differential Protection
4. B. Monitoring the operability of relay
5. C. Both A&B
6. B. Better than
7. A. SF6
8. C. Higher
9. D. All of the above
10. A. Rung type Ladder trays

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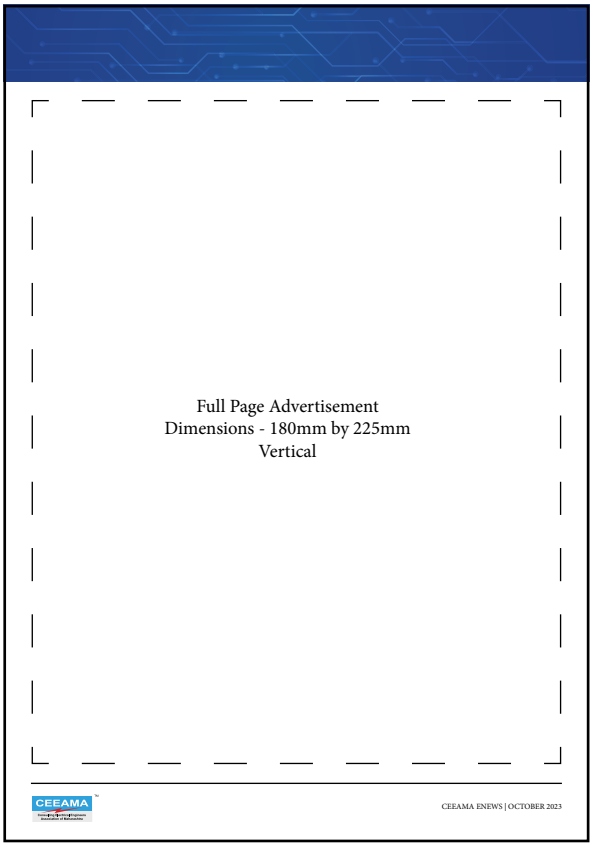

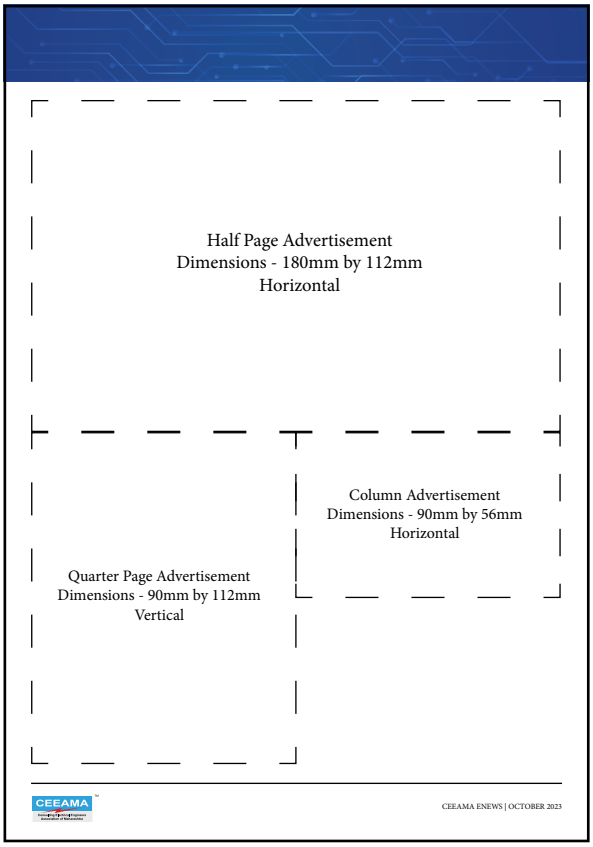

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E-NEWSLETTER

Published by Consulting Electrical Engineers Association of Maharashtra

Electrical Consultants Newsletter
Volume No. 4 Issue #51
AUGUST 2025

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