

# CEEAMA Live Wire E-NEWSLETTER

Published by Consulting Electrical Engineers Association of Maharashtra

# Topic for July 2025 OUTDOOR SWITCHYARDS



"Inside: This month's hot topic and smart reads..

Do solve the quiz at the end..!!

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July 2025

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# CEEAMA Governing Council Directors



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#### From the Editors Desk.

#### **HAPPY MONSOON**

Rains are lashing India in full swing bringing happiness on the faces of peasants and giving respite to common man from the scorching hot summer!

Congratulations to our IMD for forecasting a surplus monsoon which is proving to be true. Our wells, lakes, rivers, reservoirs and all types of water bodies are getting filled with ample water for our consumption and electricity generation. While we rejoice in this nature's blessings, we as humble kids of our master must behave and conserve the nature in our best possible manner. Probably that's the reason we celebrate gratitude in the form of GURU PURNIMA and realise our worth only at the lotus feet of our teachers!

The rains also create havoc causing natural calamities like water logging, swelling of rivers endangering coastal lives, accidents, risks to structures especially due to lightning strikes! Last year we published a special issue on this subject to spread awareness on saving lives and property against lightning dangers! Same applies to electric shocks in moist whether esp. due to inadequate earthing. Do browse through our website in order to retrieve the archived newsletters!

While I mentioned in my last month's editorial about Mr. Narendra Duvedi, I would also like to mention that in the same MEP consultants meet organised by IEEMA in Cochin (Kochi) between 12th & 14th June 2025, another strong past president Mr. Vijay Limaye was felicitated at the meet alongwith his incredibly strong son who steps in his father's shoes with greater gaiety and strength! We wish Abhijit Limaye too a great and successful business career life!

Last month's LiveWire was praised by many for its articles on GIS substation, I am sure you will appreciate the hard work of our contributors this month too on Outdoor Switchyards. You are invited to contribute suitable articles for next month on Indoor Substations!

Wish you yet another month of safety and happiness!

Subhash L. Bahulekar Chief Editor – CEEAMA



#### From the President's desk:

Dear Friends,

Please join me in congratulating Mr. Narendra Duvedi for his achievement as the first National Level Chairman of the MEP consultant's division of IIEMA. Mr. Duvedi continues to inspire me as well as many others. Well done, Sir! We are proud of you!!

This month we focus on Air Insulated Substations (AIS). GIS (Gas Insulated Substation) was seen as a better alternative to AIS (Air Insulated Substation) primarily due to its compact design, reliability, and performance in harsh conditions. It addressed several limitations of AIS, especially in space-constrained and polluted environments. It shall however, be noted that AIS is the better option when land is available, budget is limited, non-polluting corrosion free atmosphere, environmental concerns (SF<sub>6</sub>-free) are prioritized, maintenance and upgrade flexibility is needed. The best examples of GIS could be in a relatively clean, rural, or semi-urban setting.

Friends, last month we came across the news of Power Grid Corporation of India Limited (POWERGRID) partnering with Punjab Engineering College, Chandigarh, to set up a state-of-the-art POWERGRID Centre of Excellence at PEC. The centre will offer advanced training and research facilities in power and energy engineering, strengthening hands-on learning and industry-relevant skills for students and faculty. This new facility aims to enhance PEC's electrical engineering curriculum through advanced labs focused on numerical relays Phasor measurement units (PMUs), inverters, cybersecurity, e-mobility, and real-time simulation tools. (Courtesy TOI – June 2025)

Last month also had a stellar news on EV batteries research in India. The Indian Institute of Technology (IIT), BHU has been selected as one of the seven key nodal centres under the govt of India's Mission for Advancement of High Impact Areas in Electric Vehicles (MAHA-EV), initiated by the Anusandhan National Research Foundation. Chosen from among 227 proposals submitted nationwide, IIT-BHU will lead a national facility focused on battery degradation diagnostics and the development of safe, sustainable, and efficient battery systems under the project name Te-MobiX (Tropical e-Mobility Excellence). The institute has been awarded a research grant of Rs. 55 crore to establish the National Facility for Battery Research on its campus. The project team at IIT-BHU includes experts from electrical, chemical, mechanical, biochemical, civil engineering, chemistry, and materials science departments, while collaborators from IIT Kharagpur, BHU, and ICT Mumbai are also playing key roles. (Courtesy TOI – June 2025).

A CEEAMA LFM recently suggested to me about integrating a smart ground continuity checker into our electrical panels or motor starters that automatically disables power if a proper earth connection is not detected. This uses continuous impedance monitoring to ensure earth wire is intact and connected properly. It triggers auto lockout (via contactor interlock or breaker trip) if grounding fails. It can include visual/audible alerts and optional SMS/ email notification via IoT. It is ideal for portable power tools, HVAC units, and critical hospital or industrial loads. Do check whether you apply this in your projects.

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.

This year the month of July has Ashadhi Ekadashi, Guru Purnima and Nag Panchami as prominent festivals. Have a safe July and beyond.

Mr. Chidambar Joshi Hon. President CEEAMA

#### **DISCLAIMER**

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#### From the Secretary's desk:

Dear Members,

As we continue to navigate the ever-changing landscape of the electrical engineering Industry, I wanted to take a moment to reflect on our association's progress and goals.

Our old memberships are getting renewed and new members are being inducted in the association.

New avenues are being tried to make our association CSR compatible. So that more activities can be planned tomorrow, a task force is formed to look into the CSR aspects.

In view of the latest industry trends and technological advancement as well as the changes taking place in Standards, Codes, and Regulatory frameworks, our association is positioned to support the members in navigating these changes, by organising Seminars, workshops and Factory visits.

For updating the knowledge of our members related to new product technologies, factory visits to some of the Industries like Apar, Siemens, Telawne Power Equipment, CTR, Crompton, Lucy Electric, Marine Electricals Goa, etc. are being planned and it is expected that our members will be benefitted from these events.

CEEAMATECH 25, a grand event of our association, is also under planning.

CEEAMA members are requested to get involved in the various activities, committees, or volunteer opportunities.

I express my gratitude to the members for their continued support and participation and reiterate the association's commitment to advancing the interests of Consulting Electrical Engineers and promoting excellence in the industry.

**Sincerely Yours** 

Mr. Ulhas Vajre Hon. Secretary CEEAMA





#### **OUTDOOR SWITCHYARD**



#### **DESIGN OBJECTIVES**

As an integral part of the transmission or distribution systems, the **substation or switching station** functions as a connection and switching point for:

- ✓ Generation sources
- ✓ Transmission or sub transmission lines
- ✓ Distribution feeders
- ✓ Step-up and step-down transformers

The design objective for the outdoor switchyard is to:

- ✓ Provide a high level of reliability and flexibility
- ✓ Satisfy system requirements
- ✓ Minimize total investment costs

#### INTRODUCTION: OUTDOOR SWITCHYARD

**Outdoor Switchyard** plays a pivotal role in the power system, ensuring the efficient and reliable transmission of electrical power from one point to another. These switchyards are critical nodes in the power grid, facilitating the transformation and distribution of power to meet the ever-growing demands of urban and industrial areas.

**Outdoor Switchyard** is a facility that transforms high-voltage electricity into lower voltages suitable for distribution. Unlike its counterpart, the **Gas Insulated Substation**, which uses gas for insulation, outdoor switchyard relies on air as its primary insulator.

#### **OUTDOOR SWITCHYARD AND GIS SUBSTATION DIFFERENCE**

Feature	Outdoor Switchyard	GIS Substation
Insulation Type	Air (Outdoor)	SF <sub>6</sub> Gas (Indoor)
Equipment Cost	Less than GIS	-
Overall Land Area	Large	Small
Reliability	Highly reliable	Very reliable
Exposure of Live Parts	Exposed	Fully Enclosed
Environmental Impact	Minimal	-Potential gas leaks -Low Environmental Impact



#### MINIMUM CLEARANCES IN OUTDOOR SWITCHYARD

Clearance Type	765 kV	400 kV	220 kV	132 kV	33 kV
Phase to Phase	9400	4200	2100	1300	320
Phase to Earth	6400	3500	2100	1300	320
Sectional Clearance	10300	6500	5000	3800	3000
<b>Ground Clearance</b>	14000	8000	5500	4800	3700

<sup>\*</sup>All Clearance distance is in mm.

#### **ADVANTAGES OF OUTDOOR SWITCHYARD**

#### 1. COST-EFFECTIVE

- ✓ **Lower initial cost:** outdoor switchyards are generally cheaper to build than GIS because they use air for insulation and require less specialized equipment.
- ✓ Easier maintenance: Components are accessible and can be repaired or replaced without complex procedures

#### 2. SAFETY

- ✓ Visual inspections are easy
- ✓ Faults can be spotted quickly

#### 3. SCALABILITY

✓ Easy to expand or upgrade as power demand grows

#### 4. SIMPLICITY IN DESIGN

- ✓ It has been used for decades and is well-understood by engineers and technicians.
- ✓ **Ease of operation:** Simple design makes it easier to operate and troubleshoot

#### 5. ACCESSIBILITY

- ✓ Components are open and easy to reach.
- ✓ No need for special tools or enclosures.

#### 6. ROBUSTNESS

- ✓ Performs well in harsh weather and environments
- ✓ Ideal for diverse regions across India

#### 7. ENVIRONMENTAL COMPATIBILITY

- ✓ Uses air instead of gas (no risk of gas leaks)
- ✓ Safer for the environment compared to GIS

#### **DISADVANTAGES OF OUTDOOR SWITCHYARD**

#### 1. LARGER SPACE REQUIREMENT

Outdoor Switchyard require significantly more land compared to compact indoor Gas-Insulated Substations (GIS).

#### 2. EXPOSURE TO ENVIRONMENTAL CONDITIONS

Being outdoors, these switchyards are more prone to faults due to:

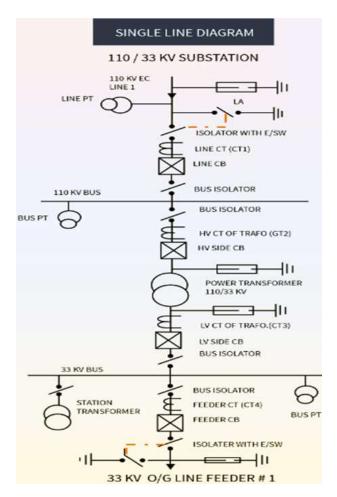
- a. Pollution
- b. Saline environments (e.g., coastal areas)
- c. Weather conditions like lightning, heavy rain, wind, and cyclones

This reduces their overall reliability compared to indoor GIS.

#### 3. HIGHER MAINTENANCE NEEDS

Due to exposure to the elements, outdoor switchyard requires regular inspection and maintenance. In contrast, GIS needs minimal maintenance and offers higher reliability.





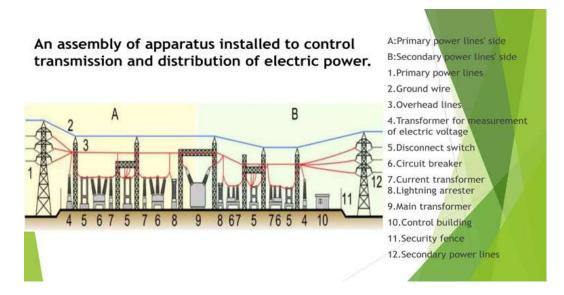
110 / 33 kV SWITCHYARD SINGLE LINE DIAGRAM



**PLAN VIEW** 



#### **SECTION VIEW**



#### **KEY COMPONENTS OF OUTDOOR SWITCHYARD**

#### 1. LIGHTNING ARRESTOR (LA)

It is a device used for the protection of electrical equipment against lightning strokes.

#### 2. VOLTAGE TRANSFORMER (VT / PT)

This is used to step down the voltage for measurement and they are connected in parallel with a transmission line.

#### 3. DISCONNECTORS (ISOLATORS)

Isolator switches are used for opening an electrical circuit in the no-load condition. It is not proposed to be opened while the current flows through the line.

They do not interrupt current like circuit breakers.

#### 4. EARTH SWITCH (ES)

Earthing switches are safety devices which are integral parts of Medium Voltage Switchgear. When a circuit breaker is removed and racked out, the circuit can be earthed by operating this earthing switch. Earthing switches are usually used in conjunction with isolators.

#### 5. CURRENT TRANSFORMER (CT)

This is used for stepping down the current for measurement and they are connected in series with the transmission line.

#### 6. CAPACITIVE VOLTAGE TRANSFORMER (CVT)

CVT is a device that steps down high transmission line voltages (i.e. 132 kV, 220 kV, 400 kV etc.) to a lower, measurable level suitable for metering and protection systems.

#### 7. CIRCUIT BREAKERS (CB)

These devices are crucial for protecting the electrical circuit from damage caused by overload or short circuits. Circuit breakers are among the most essential components in the outdoor switchyard. They act as the primary protection mechanism against electrical faults. When a fault occurs (e.g., short circuit or overload), the circuit breaker quickly interrupts the flow of electricity.

This prevents damage to equipment and ensures the safety of personnel.



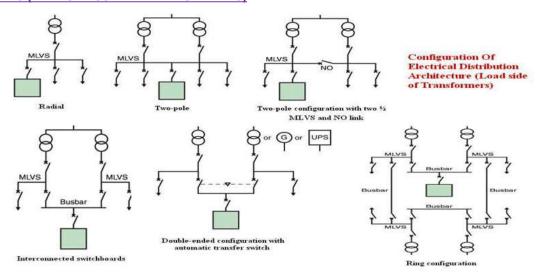
#### 8. TRANSFORMERS

It is an electrical static device that changes the voltage level of electricity in a power system. i.e. CT or PT. It works using the principle of electromagnetic induction. It also reduces fault level at switchgear by virtue of its impedance, thus reducing the requirement of downstream switchgear short time rating. It is also used for interconnecting two / three systems of different voltages.

#### 9. BUSBARS

Busbars are thick metal strips (usually copper or aluminum) used to conduct electricity within a substation. They help distribute power from incoming sources to outgoing feeders or transformers.

#### **BUS SCHEMES (TYPE OF BUSBAR ARRANGEMENTS)**



Bus Scheme	Advantages	Disadvantages
Single Bus	Simple, low cost	Low reliability (entire system down if bus fails)
Main & Transfer Bus	Maintenance possible without shutdown	Complex switching
Double Bus, Single Breaker	Flexible operation	Breaker failure affects both buses
Double Bus, Double Breaker	Very reliable and flexible	Expensive, needs more space
Ring Bus	Compact, good reliability	Complex protection
Breaker and a Half	Very reliable, supports critical loads	High cost and complexity

#### **OUTDOOR SWITCHYARD LAYOUT COMPONENTS**

#### 1. CONTROL ROOM

Contains monitoring, protection, and control systems. Operators manage the substation from here.

#### 2. TRANSFORMER AREA

Houses power transformers that step voltage up or down. Usually fenced or separated for safety.

#### 3. SWITCHYARD

The heart of the substation includes: Busbars (for power distribution), Circuit breakers (for protection), Isolators, CTs, and PTs

#### 4. MAINTENANCE ZONE

Clear paths and space for technicians to access equipment. May include storage for tools and spare parts.



#### **APPLICABLE STANDARDS**

**Grounding Design** IEEE 80 / IS: 3043 Lightning Design IS: 2309 / IEC 62305

**Short Circuit Force Calculation IEC 6086** Conductor Sizing (Rigid/Flexible) **IEEE 605 Insulation Coordination** IS / IEC 60071

Lighting Design IS: 3646 / IEC 60364 IEC 60044

**CT-PT Sizing** 

Clearance Diagram IS: 10118 / IEEE 1427

Section & Plan Layout IS: 10118/ CBIP SUBSTATION LAYOUT

Guide for Bus Design in AIS IEEE Std 605-2008 / 2010

High-voltage switchgear and control gear IEC 62271-100 Disconnectors and earthing switches IEC 62271-102

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#### **OUTDOOR SWITCHYARD (AIS)**



All outdoor switchyards for HV, EHV, comprised of AIS substation. An air-insulated substation (AIS) is one where the main circuit potential is insulated from the ground by air using porcelain or composite insulators and/or bushings.

An air-insulated substation (AIS) is composed entirely of air-insulated components such as circuit breakers, disconnectors, surge arresters, instrument transformers, power transformers, capacitors, and busbars, all interconnected using flexible conductors, tubes, or underground cables. AIS is the most widely used substation type globally, representing over 70% of installations. Its open-air design and standardized components make it a preferred choice for reliable and cost-effective power distribution.

#### **WORKING PRINCIPAL OF THE AIS SUBSTATION**

An Air-Insulated Substation (AIS) operates on the principle of spatial separation and atmospheric insulation, where ambient air serves as the primary dielectric medium between energized components.

Within this open-air framework, electrical energy enters the substation through high-voltage transmission lines and is systematically routed through a network of busbars, switches, and transformers.

Each component plays a distinct role—disconnectors isolate sections for maintenance, circuit breakers interrupt fault currents, and instrument transformers scale down electrical parameters for monitoring and protection.

The entire system is orchestrated to ensure seamless power flow, rapid fault response, and operational transparency, with the visible arrangement of components enhancing both safety and accessibility.

Unlike enclosed systems, AIS relies on the natural environment to insulate and cool its infrastructure, making it a robust and cost-effective solution for outdoor installations where space and visibility are advantageous.

#### **FUNCTION OF AIS SUBSTATION**

Air is used as an insulating medium between phases and between the phase and ground. Insulation between the phases is provided by the air; hence name "Air insulated switchgear" however, in a Gas Insulated Substation (GIS) insulation between phases is provided by SF6 gas.

Since insulation is provided by the air, a direct connection with transformers and overhead lines is possible but, for GIS bushing is required to make connection between transformers and overhead lines.

#### **TYPES OF AIS SUBSTATION**

- 1) Based on Voltage Level (As per IEEE 1427-2020)
- Low Voltage AIS (Up to 1kV): Used in residential or small commercial applications.
- Medium Voltage AIS (1kV-33kV): Common in industrial and urban distribution networks.
- High Voltage AIS (33kV-220kV): Used in transmission networks and large substations.



• Extra High Voltage AIS (220kV-800kV): For interconnecting large power grids.

#### 2) Based on Busbar Configuration

- Single Busbar: Simple and cost-effective. No redundancy: a fault can interrupt the entire system.
- **Double Busbar:** Two busbars allow switching between them for maintenance or fault isolation. Higher reliability.
- Main and Transfer Busbar: A transfer bus is used for maintenance without interrupting supply. Offers flexibility and reliability.
- Ring Bus: Each circuit is connected in a ring. Faults can be isolated without affecting the entire system.
- Breaker-and-a-Half Scheme: Three breakers for two circuits. High reliability and flexibility, used in critical substations.
- **Double Breaker Scheme:** Two breakers per circuit. Very high reliability, but expensive.

#### 3) Based on Installation

- Outdoor AIS Substation: Equipment is installed in open air. Requires more space but it is easier to maintain.
- **Indoor AIS Substation**: Equipment is housed in a building. Used in urban areas where space is limited or for aesthetic/noise reasons.

#### 4) Based on Application

- Step-Up Substation: Increases voltage from generation level to transmission level.
- Step-Down Substation: Reduces voltage for distribution to consumers.
- Switching Substation: No voltage transformation; used for routing and protection.
- **Distribution Substation:** Supplies power to local distribution networks.

#### **COMPONENTS / EQUIPMENT OF AIS SUBSTATION**

#### **Circuit Breakers:**

Circuit breakers are essential components in a substation, primarily responsible for interrupting current flow during fault conditions. In Air-Insulated Substations (AIS), they utilize either air or oil as the arc-extinguishing medium during current interruption.

#### **Disconnectors/Isolators:**

Disconnectors are manually operated switches used to isolate sections of an electrical circuit, ensuring they are completely de-energized for maintenance activities. In Air-Insulated Substations (AIS), they function in open air and provide a visible break in the circuit when opened, enhancing safety during service.

#### **Busbars:**

Busbars are conductive elements used to distribute electrical power to multiple outgoing feeders. In Air-Insulated Substations (AIS), they are exposed to the atmosphere and typically mounted on insulators. Their dimensions and current-carrying capacity are determined by the substation's voltage and load requirements.

#### **Instrument Transformers (Current and Voltage Transformers):**

These transformers are essential for metering and protection purposes. Current Transformers (CTs) reduce high current levels to standardized, measurable values, while Voltage Transformers (VTs) step down high voltages to levels suitable for protective relays and metering equipment.

#### **Surge Arresters:**

Surge arresters safeguard substation equipment against transient overvoltage caused by lightning strikes or switching operations. In Air-Insulated Substations (AIS), they are strategically positioned near transformers and circuit breakers to minimize the risk of equipment damage.

#### **Power Transformers:**

Transformers are essential for stepping up or stepping down the voltage levels for power transmission and distribution. In AIS substations, they are placed outdoors, insulated by air, and protected by various switchgear components.

#### **Insulators:**

Insulators are critical in preventing current leakage from conductors to the ground. In AIS substations, porcelain or polymer insulators are used to support live equipment, ensuring that the current remains confined within the conductors.

#### **Control And Relay Panels:**



These panels contain the systems responsible for protection, control, and metering. In Air-Insulated Substations (AIS), relay panels facilitate the automated operation of circuit breakers and deliver real-time data for effective monitoring and control.

#### **Earthing System:**

The earthing or grounding system ensures that fault currents are safely discharged into the ground, protecting both equipment and personnel. In AIS substations, proper earthing is essential to mitigate the risks associated with high-voltage systems.

#### **Lightning Protection Systems:**

To protect the AIS substation equipment from direct lightning strikes, lightning rods and conductors are installed, directing high-voltage discharges safely to the ground.

#### **ADVANTAGES OF AIS SUBSTATION**

It offers a practical and cost-effective solution for power distribution, especially in regions where land availability is not a constraint. Due to their compact structure, these devices can integrate seamlessly without compromising the aesthetics of the switchyard.

- Their open design allows for straightforward visual inspection and easier fault detection, which simplifies maintenance and enhances operational safety. The use of ambient air as the insulating medium eliminates the need for specialized gases, making AIS environmentally friendly and reducing long-term handling concerns.
- Technicians benefit from the clear visibility of components, which aids in training and troubleshooting.
- AIS substations strike a balance between reliability, affordability, and maintainability, making them a preferred choice for many utilities in rural and semi-urban settings.
- Installation is straightforward and modular.
- AIS substations can be easily expanded by adding more bays or equipment in open space.
- With proper maintenance, AIS components can last for decades.

#### **APPLICATION OF AIS SUBSTATION**

AIS substations are widely used in power systems due to their simplicity, cost effectiveness, and ease of maintenance. Among its applications we have:

- Long range power transmission
- Power Plants
- Industrial applications
- Power Transmission & Distribution
- Integration of Renewable Power Generation
- Data centers, Oil & Gas, Mining, Nuclear power, etc.
- Utilities Grid Support
- Railway Electrification
- Emergency and Backup Power Systems

#### AIR INSULATED SWITCHGEAR vs. GAS INSULATED SWITCHGEAR

AIS (Air-Insulated Switchgear) and GIS (Gas-Insulated Switchgear) are two types of switchgear used in electrical power systems for controlling, protecting, and isolating electrical equipment. Here are the key differences between them:

#### • Insulation Medium

AIS: Uses air as the insulating medium. The equipment is typically exposed to the atmosphere.

**GIS:** Uses gas (usually sulfur hexafluoride, SF6) as the insulating medium, which allows for a more compact design.

#### • Space Requirements

**AIS**: Requires more space due to larger physical dimensions and the need for clearance between live parts and the ground or other structures.

**GIS**: More compact and can be installed in smaller spaces, making it suitable for urban areas or locations with space constraints.

#### Maintenance

**AIS**: Requires regular maintenance, including cleaning and inspections, due to exposure to environmental conditions.



**GIS**: Generally, it requires less maintenance because the equipment is sealed and protected from environmental factors.

#### • Environmental Impact

AIS: More susceptible to environmental factors like pollution, which can affect performance.

GIS: Offers better protection against environmental impacts and is often more reliable in harsh conditions.

#### • Installation and Operation

AIS: Easier and quicker to install in open areas but can be more challenging in confined spaces.

GIS: More complex installation due to the need for specialized handling of the gas and components.

#### Applications

AIS: Commonly used in substations, especially in rural or less populated areas.

GIS: Preferred in urban areas, indoor substations, and places where land use is a concern.

#### **COMPARISON BETWEEN AIS & GIS SUBSTATION**

Sr no	Description	AIS substation	GIS substation
1	Design standards	IEC (IEC 62271-1, IEC 62271-100	0, IEC 62271-200, etc.)
2	Bus bar insulation	Air	SF <sub>6</sub> (Sulfur Hexafluoride) Gas
3	Switching	Oil, Air, Vacuum or SF6	Vacuum or SF6
4	Fault Detection	Easier due to visible layout	More complex due to enclosed systems
5	Operational Life	Moderate to long	Long, with minimal degradation over time
6	Sensitivity to external elements	Moderate	Excellent
7	Maintenance requirements	Easier access but more frequent due to exposure	Less frequent, but requires specialized handling
8	Monitoring of gas pressure	Only for switching devices that include SF6 gas	Switching devices and bus bars

#### **SAFETY MEASURES FOR AIS SUBSTATION**

Safety in Air-Insulated Substations (AIS) is critical due to the exposure of live components to the environment. Here are the key safety measures typically implemented:

#### 1. Physical Safety Measures

- Fencing and Restricted Access: High-security fencing and locked gates to prevent unauthorized entry.
- Clear Signage: Warning signs for high voltage, restricted zones, and emergency procedures.
- Safe Clearance Distances: Adequate spacing between live parts and walkways to prevent accidental contact.
- Barriers and Enclosures: Insulating barriers around live components to reduce risk of flashover.

#### 2. Electrical Safety Measures

- Earthing and Grounding System: Proper grounding of all equipment to prevent electric shock and ensure fault current dissipation.
- Surge Arresters: Protect equipment from lightning and switching surges.
- Circuit Breakers & Isolators: Ensure safe disconnection during maintenance or faults.
- Protective Relays: Automatically detect faults and isolate affected sections.

#### 3. Fire and Thermal Safety

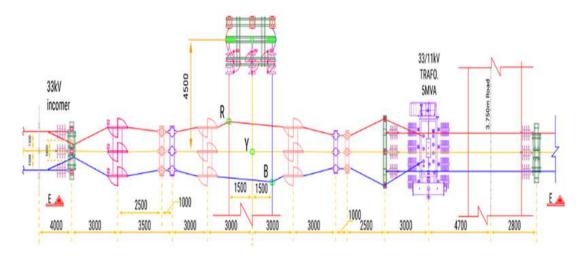
- Fire Extinguishers and Suppression Systems: Strategically placed for quick response.
- Temperature Monitoring: Sensors to detect overheating in transformers and switchgear.
- Thermal Imaging: Regular inspections to identify hot spots.



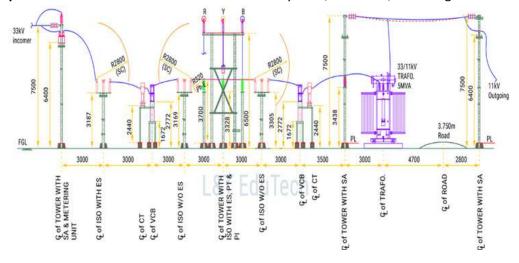
#### 4. Operational Safety

- Lockout/Tagout (LOTO): Procedures to ensure equipment is de-energized during maintenance.
- Personal Protective Equipment (PPE): Helmets, gloves, arc flash suits, and insulated tools for workers.
- Training and Drills: Regular safety training and emergency response drills for staff.

#### 5. Maintenance and Inspection



• Routine Inspections: Visual and technical checks to identify wear, corrosion, or damage.



- Cleaning of Insulators: Prevents flashovers due to dust or pollution.
- Testing of Protective Devices: Ensures reliability of relays, breakers, and alarms.

#### **PLAN**

#### **SECTION**

A Specific distance needs to be maintained two switchgears for safer operation.

For e.g. A specific distance needs to be maintained between a circuit breaker and a disconnector, and this distance increases with higher voltages, dielectric strength requirements increase and that can be achieved in AIS technology by increasing distance between two switchgears.



#### **SUBSTATION EQUIPMENT**



**Circuit Breaker** 





**Current Transformer** 



Isolators with and without earth switches



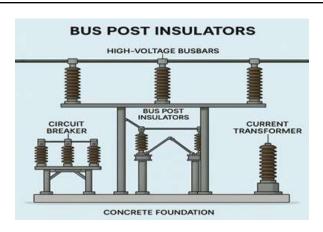
**Potential Transformer** 



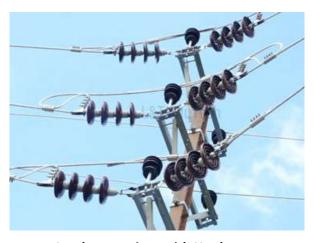
**Surge Arrestor** 



**Power Transformer** 



**Bus Post Insulators** 



**Insulators strings with Hardware** 



**ACSR Conductor** 



**Tubular Busbar** 

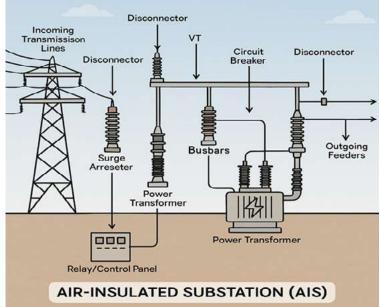


**Power Connectors** 



#### **GLIMPSE OF AIS SUBSTATION**





#### SPACE COMPARISION BETWEEN AIS & GIS SUBSTATION: -REFERENCE STANDARDS FOR AIS SUBSTATION





#### **REFERENCE STANDARDS FOR AIS SUBSTATION**

- IEEE Std 605-2008 / 2010: Guide for Bus Design in AIS.
- **IEEE Std C37.32:** Defines ratings & application guidelines for disconnect switches.
- IEEE Std 1427: Guide for AC high-voltage circuit breakers in AIS.
- IEC 62271: High-voltage switchgear and control gear.
- IEC 62271-100: High-voltage circuit breakers.
- IEC 62271-102: Disconnectors and earthing switches
- IEC 62271-200: Metal-enclosed switchgear of AIS.
- **IEC 61936-1:** Covers general design, safety, and installation practices for AIS.
- IEC 60071: Insulation coordination

#### **Contributed By**



VISHAL KUMAR SINGH ENGINEER (Chemical dept.)













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#### Standard Design of Outdoor Switchyard (T.N.E.B. Practice)

Typically, an outdoor switchyard design involves various parameters.

#### 1. STRUCTURES:

#### 1.1 Design loads:

• Wind pressure on structures:

122 kg/sq.m. on 1% times the projected area of members of one face for latticed structures and on single projected area in the case of other structures. In the coastal region the wind pressure may be assumed to be 170 kg/sq.m.

• Wind pressure on conductor:

73 kg/sq.m. on two-thirds projected area. In coastal areas 122 kg/sq.m. and in hills 88 kg/sq.m.

• Maximum tension:

Maximum tension in transmission line conductors strung from terminal tower to station structures or of strung buses for lines of 33 KV and above is 226.8 kg.

- Maximum spans adjacent to stations:
  - a) Lines rated 66 KV and above 152.40 m
  - b) Lines rated 33 KV and above 60.96 m
- Uplift on adjacent spans:

Maximum slope (mean of the 3-phase) at the point of attachment 1:8 above horizontal.

#### 1.2 Working Stresses:

for steel:

Bending - 1265 kg/sq.cm Sheer - 1265 kg/sq.cm

• for concrete – 1:2:4:

Bending - 52.7 kg/sq.cm

Sheer - 5.27 kg/sq.cm

Bend - 7.03 kg/sq.cm

Factor safety:

for steel - 2.5 based on maximum loading conditions (on elastic limit for tension members and crippling load for compression members).

- for RCC 3.5 on ultimate breaking load.
- factor of safety against overturning:

for Steel - 2.5

for R.C.C- 2.0

#### 1.3 Slenderness ratio (L/R):

Ratio of unsupported length (I) to radius of gyration (r) should not exceed:

- a) 140 for leg members.
- b) 200 for other members having calculated stress only and 250 for members having nominal stress only.

#### 1.4 Minimum thickness for steel members:

- a) Galvanized members:
  - o Main member of a lattice beam or stanchion 6.40 mm.
  - o BRACINGS 4.75 mm.
- b) Painted Members:
  - o ALL MEMBERS 6.40 mm.

#### 1.5 Material:

Steel employed for structures open hearth steel with a high yield point and an ultimate strength of not less than 3867 kg/sq.cm.

The following maximum stresses in lbs. per square inch are assumed for outdoor structures, fabricated out of steel section manufactured in India.

• Tension G - 18,000



- Compression -18,000-76 |/r where |/r is less than 150 and 13,000-48 |/r where |/r is more than 150.
- Shear on bolts 13,500
- Bearing on Bolts 27,000

#### 1.6 Standard Bay width (in meters):

Voltage in KV	Bay width in meters
400 KV	27
230 KV	14.6, 15.95
110 KV	9.5
66 KV	7
33 KV	4.6
22 KV	3.8
11 KV	3.5

#### 1.7 Foundations:

- Safe working bearing pressure One ton per sq. foot
- Weight of earth 90 lbs. per cubic foot
- Weight of concrete 125 lbs. per cubic foot.

#### 2. BUS BAR

#### 2.1. Bus bar material:

The material normally used for bus bars and connectors are copper and aluminum.

#### 2.2. The diameter of Bus bar:

Normally employed will be a 50mm IPS\* Aluminum tube for Voltage rating up to 66 KV, 75mm IPS\* Aluminum tube for Voltage rating from 110 to 230 KV and 100mm IPS\*Aluminum tubes for voltage rating of 400 KV. (\*IPS – International Pipe Standard)

#### 2.3 Diameter of Strung buses:

To keep corona losses within limits the minimum diameter of conductors and jumpers on the sub-station structures and equipment should be like 110 KV - 15.6 mm and 230 KV - 28.0 mm

#### 2.4 Bus bar deflection:

The deflection of busbar supported on post insulators should not exceed half the diameter of the bus bars or 1/120 inches (where 1 is the span in feet) whichever is less.

#### 2.5 Current density:

Maximum current density in copper busbars and connections in direct contact with air should be such as not to exceed the following operating temperature:

Maximum permissible temperature: 70 °C

Maximum hot spot temperature: 75 °C

For Aluminum bus bar, the current density of 61% of copper is usually permissible. Maximum permissible current density under short circuit should not exceed 18,600 amps/sq.cm.

#### 2.6 Bus bar connections:

The insulators, busbars and connections should not be stressed to more than 1/4th of the breaking load or 1/3rd of their elastic limit whichever is lower.

#### 2.7 Bus bar joints:

The efficiency of the bus bar joints depends on certain essential preconditions which are:

- The contact pressure must be ample and well maintained.
- The surfaces of the conductors must be clean.
- With flat conductors the overlap should be equal to or greater than the width of the bars or ten times the bar thickness, whichever is greater.
- Joints between aluminum conductors must be treated to exclude moisture.

#### 2.8 Circuit configuration for high & medium voltage switchgear installation:

#### The most common ones are:

#### • Single busbar:

Suitable for smaller installations, a bus sectionalizer allows the station to be split into two separate parts and the parts to be disconnected for maintenance purposes.

Double busbar:



Provides for the possibility of cleaning and maintenance without interrupting supply. Possibility of separate operation of station sections. Bus bar sectionalizing increases Operational flexibility.

#### Main and transfer bus bar:

Duplicate bus bars with one spare breaker allow considerable flexibility for maintenance.

#### • Two breaker method:

Switchgears are duplicated in each branch. Busbar interchange and isolation of one bus is possible without interruption. Considerable flexibility.

#### • 1½ breaker method:

Fewer breakers are needed for the same flexibility as in two breaker method.

#### • Ring (MESH) method:

Each branch requires only one breaker and yet each breaker can be isolated without interrupting the power supply in the outgoing feeders.

#### 2.9 Electromagnetic force on Bus bar:

On a 3-phase system, the peak force between conductors parallel to each other during, a symmetrical three phase short circuit and is given by

$$Fp = \frac{25 \times L \times I^2}{S} \times 10^{-8} \text{ lbs}$$

Where Fp – peak value of electromagnetic force in pounds on span length L

I – symmetrical three-phase short circuit current. (r.m.s value)

L- Length of span of bus bar between centers of supports in inch.

S – Spacing of phases center to center in inches.

#### 3. Clearances:

Clearances in switchyards are critical to ensure safety and prevent electrical flashovers. Two main types of clearances are:

- Phase-to-phase clearance: Distance between live conductors of different phases.
- Phase-to-earth clearance: Distance between live conductors and grounded parts.

The required values are governed by voltage level, pollution class, altitude, and installation type. Clearances also account for creepage distance, especially in polluted environments, and must allow space for maintenance operations.

#### The clearances as per TNEB practice,

Valtage (VV)	For Equipment and rigid conductor in air		
Voltage (KV)	Ph.to Ph. (mm)	Ph. to Earth (mm)	
400	7000	4750	
230	4000	1700	
110	2800	1000	
33	1200	600	
22	1000	450	
11	900-1000	300	
0.4	400	300	



#### 4. Transformers:

#### **4.1** The temperature rises specified by the board are as below:

Temperature rise of oil by thermometer	40°C over an ambient of 50°C (Max)	
Temperature rise by resistance of winding	a) 50°C for air-cooled transformers over an ambient of 50°C (Max) b) 60°C for water cooled transformers with cooling water temperature of 25°C	

**4.2** The clearances in air between live conductive parts and earthed structures should be followed.

#### 5. Earthing system:

#### **5.1** Earth resistance: (TNEB Practice)

Station	Combined resistance of earth in the station – ohms (maximum)
Large power station	0.5
Major sub station	1.0
Small station	2.0

#### **5.2 Earthing electrode: (TNEB Practice)**

Material	M.S. Round rod 40 mm	
Depth of bore	3 to 12 M	
Twin electrode	400 KV SS	
Single electrode	11 to 230 KV SS	
Soil treatment	Bentonite powder, common salt, charcoal etc. mixed with clay/red soil tightly packed 150mm dia bore.	
Moto of deep bore	By driving electrodes of depth 10 to 12M, attempt made to reach the moist earth for lowering individual earth resistance.	

#### 6. Insulators:

- 6.1 Test voltage for post insulators for busbars and switches is done based on the nominal voltage of the insulator and an impulse withstand test is also done.
- 6.2 Power frequency and impulse test voltage for line insulators as per (BSS 137-1960) is followed.



Insulator nominal voltage (3 Phase)	Impulse withstand test	Power frequency momentary withstand dry test	Power frequency withstands wet test	Power frequency withstands puncture test on units	Visible discharge test
3.3	50	20	16		3
6.6	75	30	22	1.3 times the actual dry flashover voltage	5.5
11	95	40	30		9
22	150	75	55		18
33	200	110	80		27
66	350	190	150	of the unit	53
110	450	245	195		88
132	550	300	240		105
220	900	470	385		154

#### 7. Air breaker switch:

Air-break isolator provides isolation for equipment from bus or live apparatus or for sectionalizing buses or circuits or for transfer of loads are not intended to break load currents except under special conditions or in limited amounts.

Rated voltage (KV)	Size of copper rod to be used (S.W.G)	Nearest size of brass or G.I. Rods (dia. In mm.)
110	2/0	9.52
66	0	7.94
33	1	6.35
22	2	6.35

#### 7.1 Breaking capacity of switches:

Breaking current of ASEA switches-Empirical formula

- I = K\*(L/E) where,
- I Breaking current in amps
- K 0.06 when breaking a capacitor or unloaded cable.
  - 0.15 when breaking an unloaded overhead transmission line.
  - 0.20 when breaking unloaded transformer
  - 0.40 when breaking load current.
- L Center to center phase distance in mm.
- E Breaking voltage, main voltage KV.

#### 8. Capacitors:

#### 8.1 Impulse test:

Voltage rating of capacitor. Volts	Impulse test, Crest KV
216-1199	30*
1200-4500	60
4501-8000	75
8001-13800	95



#### 8.2 Line-to-line and line-to-case strength tests:

It will be held at the factory on each individual capacitor unit. Line-to-line tests may be made with either alternating or direct-current voltage. If made with alternating current, the test voltage having the rms sinusoidal value shown in the following table, or an equivalent value, shall be applied for at least 10 seconds at a frequency of 20 to 70 cycles. If made with direct current, the test voltage shown in the following table shall be applied for at least 10 seconds.

Voltage Rating of Capacitor Units, Volts	Line-to-line Test Voltage, volts (Alternating Current)	Line-to-line Test Voltage, volts (Direct Current)	Line-to-case Alternating-Current Test Voltage, Volts (Indoor)	Line-to-case Alternating-Current Test Voltage, Volts (Outdoor)
240	500	1000	3000	10000
480	1000	2000	5000	10000
600	1250	2500	5000	10000
2400	5000	15000	19000	19000
4160	9000	27000	19000	19000
4800	10000	30000	26000	26000
7200	15000	45000	26000	26000
7960	16600	49800	26000	26000
12470	25000	75000	34000	34000
13800	28800	86400	34000	34000

#### 9. Circuit Breakers:

#### 9.1 Ratings of the breakers ordered by TNEB 230 KV

Rated voltage	230 KV
Rated continuous voltage for rated breaking capacity	245 KV
Rated continuous current	2000A
Rated short circuit current	40 KA
Rated circuit making current	100 KA
Rated short time current	3 sec for 40 KA
Rated operating duty	O-0.3 sec-CO-3 min-CO
Rated insulation level 1.One minute power frequency with stand voltage. 2.Impulse with stand test voltage	460 KV 1050 KV

#### **10. Instrument Transformers:**

#### **10.1 Voltage Transformer:**

#### 10.1.1 Voltage error (Ratio error):

Voltage error = (Kn \*(Us-Up) \*1000)/ Up where, Kn = rated transformation ratio. Us = the actual secondary voltage when UP is applied Up = actual primary voltage.



#### 10.1.2 Limits of voltage error and phase displacement:

Class	Percentage voltage (Ratio) error %	Phase displacement
0.1	± 0.1	±05
0.2	±0.2	±10
0.5	±0.5	±30
1.0	±1.0	±40
3.0	±3.0	±0

#### **10.2 Current Transformer:**

#### 10.2.1 CT types:

Types of CTs are Wound type, Bar type, Dry type, Oil type, Ring type, Live tank design, Dead tank type.

#### 10.2.2 Current Error (Ratio error):

Current Error Percent = (Kn (Is – Ip) \*100)/Ip

Where Kn = rated transformation ratio

Ip = actual primary current

Is = secondary current when Ip is flowing.

#### 10.2.3 Phase displacement, Burden and Saturation factors:

The difference in phase between the primary and secondary current vectors, the direction of the vectors being so chosen that the angle is zero for a perfect transformer.

The impedance of the secondary circuit is in ohms and power factor. The burden usually expressed as the apparent power in VA absorbed at a specific power factor at secondary current. The rated saturation factors shall be 5,10 and 20.

10.2.4 Current error and phase displacement limits of:

Accuracy	± Percentage Current (Ratio) Error at % of Rated Current							
	5	20	100	120	5	20	100	120
0.1	0.4	0.2	0.1	0.1	15	8	5	5
0.2	0.75	0.35	0.2	0.2	30	15	10	10
0.5	1.5	0.75	0.5	0.5	90	45	30	30
1.0	3.0	1.5	1.0	1.0	180	90	60	60

#### 10.3 Capacitor Voltage transformer:

#### 1.3.1 Voltage ratio:

$$\frac{C_1 + C_2}{C_1}$$

C1 and C2 include the stray capacitances, which are generally negligible.



#### 10.4 Creepage distance (for instrument transformer):

For outdoor insulation sensitive to pollution, the required minimum creepage distance measured on the insulation surface is given by

Pollution level:	Minimum nominal specific creepage distance between phase and earth
Light	16
Medium	20
Heavy	25
Very heavy	31

#### 11. Insulation co-ordination:

Insulation co-ordination comprises the selection of the electric strength of equipment and its application in relation to the voltage which can appear on the system. To reduce to an economically and operationally acceptable level the probability that resulting in voltage stress.

- Over voltages
- o Impulse wave shape
- Protective devices
  - Surge diverters: Non-linear resistor-type, Expulsion type, spark gaps
  - Linear or Non-linear shunt reactors. (Only for EHT systems)
  - Opening and closing resistors at circuit breakers. (Only for EHT systems)

#### 12. Application of different protective devices

- Protective with surge arresters.
- Protection with spark gaps.
- o Protection against direct strokes.
- $\circ \quad \hbox{Protection with closing resistor.}$

#### 13. Spacing for standard ROD-GAP:

$$d = 0.386 \times \frac{P}{(273 + t)}$$

where, P is barometric pressure in mm Hg. t is temperature in C.

#### 14. Protection against travelling waves:

Rated system voltage (KV)	Maximum distance between Lightning arrester and transformer bushing terminal		
voitage (KV)	Maximum distance (Meters)	Maximum distance (Feet)	
230	60.0	197	
110	36.50	(120)	
66	24.50	(80)	
33	18.30	(60)	
22	15.25	(50)	
11	12.20	(40)	

#### **15.** Guide for selection of Lightning arrester:

Type A system is those whose neutrals are well grounded and with less reactance and resistance ratios than for Type B system.

Type B systems are those for which reactance ratio X0/X1 and is less than 3 and ratio R0/X1 is less than 1, at any point of the system. These limits denote an 'effectively grounded' system.



Type C systems whose neutral are grounded through some form of resistance or reactance. R0/X1 exceeds 3 or R0/X1 exceeds 1 or both are exceeded.

Lightning Arrester	Maximum three-phase voltage on which arrester should be used					
rating	System with neutral grounded					
	А	В	С			
	Volts (rms)					
175	260	220				
650	650	650	650			
9000	12800	11250	9000			
kV (rms)						
20		25	20			
30		37	30			
60		73	60			
97	Type 'A' systems do not usually occur in these voltages	121	97			
109	these voltages	136	109			
195		245	195			

#### 16. Switching surges:

If interruption of a low-power factor circuit occurs at current-zero, the peak surge voltage 'es' across the first phase to be interrupted may have.

$$e_s = 1.5 \times 2 \times \left(\frac{E}{\sqrt{3}} \times \sqrt{2}\right) = 2.45E$$

Where E is the r.m.s, phase to phase voltage of the system. The peak value of earth is 66 % of this value. It is considered that, in normal service conditions, the overvoltage produced by the interruption of low-power-factor circuits will seldom cause a peak voltage to earth higher than:

$$4 \times \left(\frac{E}{\sqrt{3}} \times \sqrt{2}\right) = 3.3 E.$$

The normal system insulation should therefore be designed to withstand, without distress, surge overvoltage of this magnitude.

#### 17. Standard Insulation levels:

Highest Voltage for Equipment	Rated lightning impulse withstand voltage (Peak)	Rated Power-Frequency short duration withstand voltage (RMS)
3.6 KV	40 KV	10 KV
7.2 KV	60 KV	20 KV
12 KV	75 KV	28 KV
	95 KV	38 KV
24 KV	125 KV	50 KV
36 KV	170 KV	70 KV
72.5 KV	325 KV	140 KV



· · · · · · · · · · · · · · · · · · ·		
123 KV	450 KV	185 KV
	550 KV	230 KV
145 KV	450 KV	185 KV
	550 KV	230 KV
	650 KV	275 KV
Highest Voltage for	Rated lightning impulse	Rated Power-Frequency short
Equipment	withstand voltage (Peak)	duration withstand voltage (RMS)
Equipment 245 KV	withstand voltage (Peak) 650 KV	_
		(RMS)
	650 KV	(RMS) 275 KV
	650 KV 750 KV	(RMS) 275 KV 325 KV

Reference: Power Engineer's Handbook – T.N.E.B. Engineer's association (6<sup>th</sup> edition)

#### **Contributed By**



**SRIRAMACHANDRAN K** 





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#### First Light: The Story of A. Lalitha

Madras. 1930s. A girl is married at 15. A mother by 18.

And a widow - four months after her baby is born.

No noise. No answers. Just silence.

And a baby in her arms.

But her story did not end there.

It began there.

Her name was Ayyalasomayajula Lalitha.

And what she did next? India was not ready for it.

Her father - Pappu Subba Rao, a professor of electrical

engineering -

saw a spark in her eyes. He did not just console her. He rebooted her future.

He walked her into College of Engineering, Guindy.

A fortress of men.

No woman had ever entered.

Until she did.

1943

She walks out with a degree in Electrical Engineering.

India's first woman engineer.

No quotas. No campaigns. Just courage.

While others whispered,

she designed transmission lines for India's biggest dam.

Bhakra Nangal.

When nations were building walls -

she was lighting them up.

She joined Associated Electrical Industries (AEI).

Calcutta.

Worked for three decades.

Designing systems.

Fixing failures.

Bridging two worlds -

British hardware and Indian ambition.

No site visits - because widows "should not travel."

So she sent brilliance instead.

From behind her desk, she powered grids.

She was not loud.
She did not fight.

She just outperformed - every day.

1964. New York.

The First International Conference of Women Engineers

and Scientists.
She is there.
In a saree.

Representing a country that barely knew her name.

By 1966, she becomes a full member of the Institute of

Electrical Engineers (London). N0t just an Indian story. A global statement.

But ask your textbooks.

Ask your engineering colleges.

Ask your dams and grids.

They will remember the voltage.

But forget her name.

So the next time someone asks:

"Was engineering always a man's world?"

Just smile.
And whisper:

"Before we had panels and policies -

Lalitha broke the current."

She did not rebel.

She redesigned what rebellion looked like.

With no protest. Just precision.

Her name was A. Lalitha.

And every circuit she drew -

was a quiet slap to the rules.

Empowerment is not a gift.

It's inbuilt / nurtured by parents..



# WINNERS OF QUIZ JUNE 2025

SNEHA INDALKAR

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VINAY YADAV

Congratulations



# QUIZ JULY 2025

1.	What is GOD in	outdoor DP structure?		
	A. Good O	perated Disk		
	B. Gang O	perated Device		
	C. Greased	d Operational Device		
		Open Distribution		
2.	Generally Oil co	ooled Transformer is provided with		
		lling Panel		
	B. Bucholz			
	C. OLTC &			
		ne above		
_	Hadi Baalaadaa	/		
3.		(against internal fault)?		
	A. IDMT O			
		e Release Valve		
		ntial Protection		
	D. Overloa	ad Protection		
4.	Trip Circuit relay	v helps in:		
-T-		g Circuits which are malfunctioning		
		ring the operability of relay		
		ng back-up power supply to relay		
		ne above		
	D. All OI ti	ie above		
5.	Rectifier rating i	in an UPS is equal to:		
		Charging input		
	B. UPS out			
	C. Both A8			
		f the above		
6.	Motor running	PF is starting PF:		
	A. Same a	S		
	B. Better t	:han		
	C. Poorer	than		
	D. Variable	e & depends upon type of motor		
7.		substation equipment:		
	A. SF6			
	B. CO2			
	C. H2O			
	D. Vacuum	ו		
8.	Cost of GIS subs	station is (than) AIS substati	on:	
	A. Same	<i>,</i>		
	B. Lower			
	C. Higher			
		e w.r.t. location		
9.		ht fittings are arranged in such a w	ay as to provide:	
		ed lighting		
		n illumination		
		nt savings		
	D. All of th	ne above		



- 10. Site fabricated cable trays
  - A. Rung type Ladder trays
  - B. Wire-mesh trays
  - C. Perforated travs
  - 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/R11b8qvPSGcXweeh8

"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.

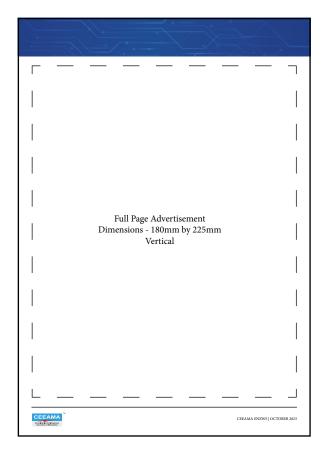
Do spread the word.

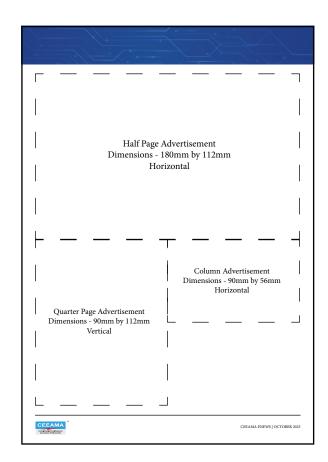
#### June 2025 Quiz Answers

- 1. A. 8-12 x cable diameter
- 2. B. Telecommunications infrastructure
- 3. C. L&T Electrical & Automation
- 4. D. All of the above
- 5. D. All of the above
- 6. A. Lumen (lm)
- 7. B. 1970 & 2016
- 8. A. Short, Medium, Long
- 9. C. Hazardous Area Classification in an explosive environment
- 10. C. Both A & B



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