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Consulting Electrical Engineers Association of Maharashtra

CEEAMA *Live Wire*

E-NEWSLETTER

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Topic for February 2026

REGULATIONS AND STANDARDS

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Electrical Consultants Newsletter
Volume No. 4 Issue #56
February 2026

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Mr. Subhash L. Bahulekar
Chief Editor - CEEAMA LIVEWIRE

From the Editors Desk,

February often marks a period of renewed focus and sharper alignment—and this year, it arrives with both a thematic emphasis and a national direction that reinforces our collective engineering journey. Our theme for this month, "Regulations and Standards," could not be more relevant. As the electrical engineering landscape evolves with smarter grids, digital substations, distributed energy, and increasingly stringent safety protocols, adhering to robust standards is no longer optional—it is foundational to quality, reliability, and global competitiveness.

In this issue, we explore how evolving IEC and IEEE standards, national regulations, and industry-specific compliance frameworks continue to shape modern detail engineering. Whether it is harmonizing designs with IEC 61439 for LV assemblies, IEC 60947 for Switchgears, IEC 600079 for Equipment in Explosive environment, or IEC 60076 for Transformers, etc. according to global methodologies, today's engineer must be both technically sound and standards aware. Our contributors delve into practical interpretations and provide an insight in the form of SYNOPSIS of a few famous Standards.

Budget 2026: Signals for the Engineering & Infrastructure Sector

This month also brings with it the direction-setting Union Budget 2026–27, whose announcements carry significant implications for engineering, infrastructure development, manufacturing, and energy systems.

A few highlights worth noting:

- Sustained public capital expenditure: The government has increased public capex to ₹12.2 lakh crore to maintain strong momentum in national infrastructure development.
- Strategic sector initiatives: A major push has been announced for India Semiconductor Mission (ISM 2.0), focusing on equipment, materials, and a stronger domestic semiconductor ecosystem.
- Biopharma and advanced manufacturing boost: A ₹10,000 crore Biopharma SHAKTI initiative has been proposed to expand high-tech manufacturing capabilities over the next five years.
- Transport & connectivity expansion: Seven high-speed rail corridors including Mumbai–Pune, Hyderabad–Bengaluru, and Chennai–Bengaluru will be developed, strengthening national connectivity frameworks and future electrical load and traction requirements.
- Electronics manufacturing thrust: The outlay for the Electronics Components Manufacturing Scheme has been increased to ₹40,000 crore to support domestic supply chains and high value component processes.
- Taxation simplification: The new Income Tax Act, 2025 will come into effect from April 1, 2026, with an emphasis on simplification and reduced compliance burden—an important signal for industries managing complex project and procurement structures.

These developments collectively reflect a strong national push for infrastructure, manufacturing resilience, and technological self reliance. For engineers engaged in detail design, procurement, and project execution, these policy directions translate into new opportunities, stricter compliance norms, and greater alignment with global standards.

Looking Ahead

As we move through February, let us embrace this moment to reinforce our commitment to engineering excellence—grounded not only in innovation but also in the discipline of standards, codes, and regulatory clarity. The future of engineering will belong to teams who design with foresight, execute with precision, and comply with frameworks that ensure safety, interoperability, and sustainability.

We hope this issue energizes your thinking and strengthens your practice.

Stay informed. Stay compliant. Stay inspired.

Subhash L. Bahulekar
Chief Editor – CEEAMA

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From the President's desk:

The Cricket world cup is round the corner. By the time this edition of CEEAMA LiveWire reaches your desk, the World Cup may have already started. Power systems during major sporting events face significant challenges due to sudden, high-intensity energy demands, the temporary nature of infrastructure, and the necessity for zero-downtime reliability. These events require massive power for field lighting, broadcasting equipment, and spectator facilities, often resulting in peak demands that can strain local grids or cause power outages. For stadiums and such venues, DG sets are vital for backing up the main grid supply, preventing disasters during live matches. In some scenarios, they are used as the main power source for key equipment because their switch-over time in an emergency is much faster (approx. 2 seconds) compared to acting as secondary sources (25 - 30 seconds).

Happy Cricket Season to you!

Friends, electrical consultants need to keep abreast of the latest standards as well as take opportunity to comment on the standards to improve them from time to time. Safety forms the most important aspect of our designs. Very proud to inform you that our Secretary Mr. Ulhas Vajre has qualified as a Fire and Life Safety Auditor, by Directorate of Maharashtra Fire & Emergency Services, and is authorised to conduct Fire and Life Safety Audits all over Maharashtra. Please join me in Congratulating Mr. Vajre.

We had a factory visit to M/s Lauritz and Knudsen last week. This visit was quite informative and provided an insight into Air Circuit Breakers testing. We endeavour to have more such sessions in the future.

We take this opportunity to request you to please share your experiences by using the LiveWire platform. Every day we come across many professional challenges. Documenting them helps in honing our reporting skills as well as help the fraternity to learn from your experience. I am sure people will benefit by shared learning. I also request our Associate Members to kindly indicate whether we can have a factory visit conducted at your premises. We could decide based on mutually convenient dates and plan logistics accordingly.

In addition to the blockbuster India-Pakistan cricket match, there is Mahashivratri on 15th Feb. On 19th February we have the Chhatrapati Shivaji Maharaj Jayanti and on 28th Feb we have the National Science Day.

Do keep writing to CEEAMA about your experiences. Have a wonderful February 2026. Be safe be happy.

Mr. Chidambar Joshi
Hon. President
CEEAMA

Standards mentioned in this Newsletter

IEC	IS - equivalent	Description
IEC 60076-1: 2011	IS 2026 (Part 1) : 2011	Power Transformers
IEC 60947-2: 2024	IS/IEC 60947 (Part 2) : 2016	Low-Voltage Switchgear and Controlgear – Circuit Breakers
IEC 60079-0: 2017	IS/IEC 60079 (Part 0) : 2017	Explosive Atmospheres – Equipment – General Requirements
IEC 60034-1: 2022	IS/IEC 60034 (Part 1) : 2022	Rotating Electrical Machines – Rating and Performance
IEC 61439-1	IS/IEC 61439 (Part 1) : 2020	Low-Voltage Switchgear and Controlgear Assemblies – General Rules

From the Secretary's desk:

Dear Esteemeed Members,

Greetings from the Consulting Electrical Engineers Association of Maharashtra.

As we move through February 2026, the electrical engineering profession continues to evolve rapidly, influenced by changes in statutory regulations, increased focus on energy efficiency, integration of renewable energy systems, and the growing use of digital and smart technologies. In this changing landscape, the responsibility of consulting electrical engineers to deliver safe, compliant, and technically sound solutions has become more significant than ever.

CEEMA remains committed to supporting its members through technical programs, professional discussions, and interactions with authorities and subject experts. These initiatives aim to enhance practical knowledge, clarify regulatory requirements, and promote best engineering practices. Members are encouraged to actively participate and contribute by sharing their field experiences, which greatly enrich the collective learning of the Association.

I would also like to emphasize the importance of professional ethics, continuous skill upgradation, and adherence to applicable standards and codes. These values not only strengthen our profession but also enhance the confidence placed in us by clients, authorities, and society at large.

Indian Standards which are of interest to the Consulting Engineers fraternity, like IS/IEC 62305 Part 1 to Part 4 - Lightning Protection system, IS 7689 - Guide for control of undesirable static electricity, IS 5216-1 Recommendations on safety procedures and practices in electrical work part 1 General, IS 5216-2 Recommendations on Safety Procedures and Practices In Electrical Work Part 2 Life Saving Techniques, IS 3043-Code of practice for earthing, IS 4648 - Guide for electrical layout in residential buildings, IS 8061- Code of practice for design, installation and maintenance of service lines up to and including 650 V, IS 8923-Warning symbol for dangerous voltages, IS 2551-Danger Notice Plates, IS 5216: Part 1- Recommendations on safety procedures and practices in electrical work: Part 1 general, IS 5216: Part 2- Recommendation on safety procedures and practices in electrical work: Part 2 life saving techniques, IS 17512 - Requirements for Electrical Installations in Medical Locations etc., are undergoing revisions and happy to share that contributions are being made in revising these Standards from our end.

On behalf of the Governing Committee, I thank all members for their continued cooperation and support.

I look forward to your active involvement in CEEMA's upcoming activities.

Best Regards,

Mr. Ulhas Vajre
Hon. Secretary
CEEAMA

Regulations and Standards: The Technical Backbone of Safety, Reliability, and Global Compliance

INTRODUCTION

Codes and standards constitute the foundational technical framework that governs the design, qualification, installation, and lifecycle management of engineering systems by translating established safety principles and proven field experience into verifiable requirements. They provide uniform criteria for performance, test methodology, material selection, interface definition, marking, and documentation, thereby reducing ambiguity across manufacturers, integrators, regulators, and end users. In regulated or high-consequence applications—such as equipment intended for hazardous or explosive atmosphere standards further formalize ignition risk controls through explicit requirements on temperature limitation, mechanical integrity, electrostatic mitigation, and conformity assessment practices, ensuring consistent safety outcomes and global interoperability across diverse operating environments.

The structured application of these codes and standards enables engineering organizations to align product development and operational practices with internationally recognized benchmarks, thereby ensuring predictable performance under specified environmental, mechanical, and electrical stresses. By enforcing methodological rigor in verification, testing, and documentation, these frameworks support traceable conformity assessment and facilitate the safe integration of equipment into complex industrial systems, where even minor deviations in design or installation can have significant safety and reliability implications.

Regulations vs Standards: Compliance vs Best Practice

In engineering practice, regulations and standards serve complementary but fundamentally different roles:

- **Regulations** are legally enforceable requirements issued by government authorities or statutory regulators that define the minimum obligations for safety, environmental protection, and public welfare, and noncompliance can result in penalties, rejection of installations, or legal liability.
- **Standards**, by contrast, are consensus-based technical documents developed by standards bodies and industry experts that specify recommended methods, performance criteria, test procedures, and terminology to achieve consistent quality and safety

They are typically voluntary unless referenced by a regulation, contract, or certification scheme. In short, regulations state "**what must be achieved**", while standards describe "**how to achieve it**" through technically validated design and verification practices making standards the primary engineering tool for demonstrating conformity to regulatory intent during design reviews, testing, documentation, and audits.

Leading Standards Institutions Shaping Industrial Quality and Compliance

BIS — Bureau of Indian Standards

Develops Indian Standards, operates national certification schemes (ISI mark, Hallmarking), runs conformityassessment labs, and represents India in ISO/IEC committees.

ISO — International Organization for Standardization

Develops globally accepted voluntary standards for quality, safety, and efficiency across industries. BIS represents India within ISO and participates in technical committees.

IEC — International Electrotechnical Commission

Publishes international standards for electrical, electronic, and electrotechnology equipment (e.g., IEC 60079 for explosive atmospheres). BIS leads Indian participation in IEC committees.

IEEE — Institute of Electrical and Electronics Engineers

Develops globally accepted standards for electrical engineering, electronics, communications, and power systems.

ASTM International —American Society for Testing and Materials

Provides globally referenced material, mechanical, chemical, petroleum, and constructionrelated standards.

NEMA — National Electrical Manufacturers Association

Publishes performance and construction standards for electrical equipment used in power generation, transmission, distribution, and industrial systems.

ANSI — American National Standards Institute

Oversees and coordinates U.S. national standards and conformityassessment systems, accrediting standards developers (including NEMA) and representing the U.S. in ISO/IEC.

NFPA — National Fire Protection Association

Develops fire, lifesafety, and electrical safety codes, including NFPA 70 (NEC), widely used for safe electrical design, installation, inspection, and hazard prevention across industrial, commercial, and utility sectors.

NEC — National Electrical Code

Foundation safety code for electrical installation practices in the U.S., adopted by states as enforceable regulation; covers wiring, grounding, equipment installation, and electrical safety in hazardous locations.

These represent some of the major standard institutions influencing global industry practices, though many more specialized and regional bodies also contribute significantly to the worldwide standardization ecosystem.

Conformity Assessment & Certification Process

- Standards Identification & Applicability Review
- Review drawings, materials, and technical details to confirm that the product’s design meets required

safety and performance criteria before prototyping.

- Test the product under controlled conditions to verify electrical, mechanical, environmental, and safety compliance as defined in relevant standards.
- Assess the manufacturer's quality system to ensure consistent production, proper documentation, and reliable product repeatability.
- Compile all design files, test reports, procedures, and certifications into a technical file that proves compliance and supports audits.
- Once compliance is confirmed, an authorized body issues the certificate, and the product receives appropriate safety markings (CE, UL, ISI, ATEX, etc.).
- Perform periodic audits and testing to maintain certified status and ensure ongoing compliance throughout the product's lifecycle.

This is crucial because it significantly reduces the likelihood of failures and accidents by validating safety and performance before products reach the field. A certified product inspires greater trust among customers, regulators, and industry partners, strengthening credibility and acceptance.

Overall, conformity assessment promotes standardized, repeatable engineering practices that enhance product reliability and longterm operational safety.

CONTRIBUTED BY:

Kirti Rawal

L&T Technology Services

IEC 60076-1: 2011 (Edition 3.0)

Power Transformer-Part 1: General

A. SECTION 1: Introduction

IEC 600761 is the fundamental standard in the IEC 60076 series, setting out the general requirements, definitions, and principles for power transformers.

Applies to threephase and singlephase power transformers, including autotransformers.

Covers units with rated voltages above 1,000 V and rated powers above 1 kVA (singlephase) or 5 kVA (threephase).

The First Edition of IEC 600761 standard was published in 1976 and later revised in 1993. With continued advancements in transformer technology and evolving industry practices, a further revision was carried out in 2011 which is the current valid edition as of 2025

The document defines key rated quantities including voltage, current, power, and frequency, and provides detailed guidance on tapping arrangements, tapping factors, ranges, and tapchangers

It also specifies how losses (noload and load), shortcircuit impedance, voltage drop, and zerosequence impedance are determined, ensuring consistency in performance evaluation.

The standard describes winding connections such as star, delta, zigzag, and opendelta, introduces the concept of phase displacement using clock notation, and establishes conventional connection symbols.

Thermal limits, insulation requirements, and test classifications are also there, with routine tests applied to every transformer and type test conducted on representative units.

B. SECTION 2: BRIEF ASPECTS

a) General Terms
b) Normal service conditions
c) Information required for enquiry
d) Requirements for tapped winding transformers
e) Rating plates information
f) Tests

C. SECTION 3: TESTS

All transformer tests, except temperature rise tests, must be carried out at the manufacturer's works under controlled conditions, with the external cooling medium between 10 °C and 40 °C, and in accordance with IEC standards.

Routine tests for all transformers include a defined set of measurements, checks, and verifications specified in this standard.

Routine tests for all transformers include measurement of winding resistance, voltage ratio and phase displacement, short-circuit impedance and load loss, no-load loss and current, dielectric routine tests, tests on on-load tap-changers, leak testing with pressure for liquid-immersed transformers, tightness and pressure tests for gas-filled transformer tanks, checks of the ratio and polarity of built-in current transformers, and checks of core and frame insulation.

For transformers with Um > 72.5 kV, additional routine requirements include evaluation of capacitances, insulation resistance, dissipation factor, dissolved gases in dielectric liquid, and performance checks at different voltage levels.

Type tests for transformers include temperature-rise, dielectric, sound level determination, measurement of motor power consumption, and evaluation of no-load loss and current at specified voltage levels.

Special requirements for transformers beyond routine and type evaluations involve additional electrical, thermal, mechanical, and material assessments, covering aspects such as insulation performance, structural integrity, operational reliability, transport suitability, and compliance with agreed specifications. Other requirements may be defined for specialized transformer groups, and any methods not prescribed in the standard or specified in the contract must be mutually agreed upon between the manufacturer and purchaser.

The measurement of winding resistance is specified in this standard for both liquidimmersed and drytype transformers.

This standard specifies that shortcircuit impedance and load loss must be measured at rated frequency with stable temperature and corrected to reference conditions, including checks at principal and extreme tapping positions.

The standard requires measuring noload loss and current at rated frequency and voltage, with windings opencircuited, under ambient conditions, ensuring voltage symmetry and recording r.m.s. values without temperature correction.

Transformer tanks must undergo agreed leakproof testing to ensure reliability in service. If no agreement exists, a standard pressure test 30 kPa above normal liquid pressure for specified durations is applied, followed by visual inspection.

Core and frame insulation test ensures the integrity of insulation separating the core, frame, and tank in liquidimmersed transformers. Depending on accessibility of earth connections, the insulation must withstand either 500 V d.c. before tanking or 2500 V d.c. after filling, both for 1 minute without breakdown, thereby confirming safe and reliable insulation performance.

D. SECTION 3: RATING PLATE

1) Routine tests for all transformers include a defined set of measurements, checks, and verifications specified in this standard.

2) Information to be given in all cases:

a) Type of transformer (for example transformer, auto-transformer, series transformer, etc.).
b) Number of these standards.
c) Manufacturer’s name, country and town where the transformer was assembled.
d) Manufacturer’s serial number.
e) Year of manufacture.
f) Number of phases.
g) Rated power (in kVA or MVA).
h) Rated frequency (in Hz).
i) Rated voltages (in V or kV) and tapping range.
j) Rated currents (in A or kA).
k) Connection and phase displacement symbol.
l) Short-circuit impedance, measured value in percentage.
m) Type of cooling.
n) Total mass.
o) Mass and type of insulating liquid with reference to the relevant IEC standard.
p) Maximum system short-circuits power or current used to determine the transformer withstand capability if not infinite.

3) Additional rating plate information includes insulation levels for windings above 3.6 kV, detailed tapping data, guaranteed temperature rises (with altitude adjustments if needed), connection diagrams, transportation and untanking masses, vacuum withstand capability, loading restrictions for multiwinding units, WTI settings, current transformer details, minimum cooling medium temperature, and identification plates for auxiliary equipment such as bushings, tapchangers, CTs, and cooling systems.

E. SECTION 5: SERVICE CONDITION

1. The transformer shall be installed at an altitude not exceeding 1,000 m above sea level.
1. For air cooling, the temperature shall not exceed 40 °C at any time, 30 °C as the monthly average of the hottest month, and 20 °C as the yearly average.
2. The minimum air temperature shall be –25 °C for outdoor transformers and –5 °C for indoor transformers.
3. For water cooling, the temperature shall not exceed 25 °C at any time and 20 °C as the yearly average.
4. The supply voltage shall be sinusoidal with total harmonic distortion not exceeding 5% and even harmonics not exceeding 1%.
5. The load current harmonic content shall not exceed 5% of the rated current.
6. For threephase transformers, the voltage symmetry shall be maintained with phasetophase voltage difference not exceeding 1% continuously or 2% for short periods.
7. The installation environment shall have normal pollution levels, be nonseismic with ground acceleration less than 0.2 g, and ambient temperature not exceeding 40 °C in enclosures.

F. SECTION 6: Annex

- **Annex A:** Checklist of technical and specific information to be provided with enquiry and order, covering ratings, connections, environment, and parallel operation.
- **Annex B:** Examples of transformer specifications with different tapping arrangements (constant flux, variable flux, combined, and functional).
- **Annex C:** Defines SC impedance boundaries to ensure safe voltage drop and permissible fault currents.
- **Annex D:** Illustrates common and additional threephase transformer connections with standard symbols.
- **Annex E:** Provides formulas for correcting measured load losses to reference temperature for copper and

aluminium windings.

- **Annex F:** Lists facilities and sensors for future installation of transformer condition monitoring systems.
- **Annex G:** Outlines environmental and safety considerations across the transformer's lifecycle, from design to disposal.

G. SECTION 5: IMPORTANT TABLE

Disclaimer

This synopsis is compiled from IEC 60947-2:2024 consolidated edition. For compliance and design, always use the official standard and manufacturer documentation

Item	Tolerance
1. a) Total losses See Note 1	+10 % of the total losses
b) Measured component losses See Note 1	+15 % of each component loss, provided that the tolerance for total losses is not exceeded
2. Measured voltage ratio at no load on principal tapping for a specified first pair of windings or the extreme tappings, if specified	The lower of the following values: a) ±0,5 % of the specified ratio b) ±1/10 of the actual percentage impedance on the principal tapping
Measured voltage ratio on other tappings, same pair	±0,5 % of the design value of turns ratio
Measured voltage ratio for further pairs	±0,5 % of the design value of turns ratio
3. Measured short-circuit impedance for: – a separate-winding transformer with two windings, or – a specified first pair of separate windings in a multi-winding transformer	
a) principal tapping	When the impedance value is ≥10 % ±7,5 % of the specified value When the impedance value is <10 % ±10 % of the specified value
b) any other tapping of the pair	When the impedance value is ≥10 % ±10 % of the specified value When the impedance value is <10 % ±15 % of the specified value
4. Measured short-circuit impedance for: – an auto-connected pair of winding, or – a specified second pair of separate windings in a multi-winding transformer	
a) principal tapping	±10 % of the specified value
b) any other tapping of the pair	±10 % of the design value for that tapping
– further pairs of windings	To be agreed, but ≥±15 %
5. Measured no-load current	+30 % of the design value
NOTE 1 The loss tolerances of multi-winding transformers apply to every pair of windings unless the guarantee states that they apply to a given load condition. NOTE 2 For certain auto-transformers and series transformers the low value of their impedance may justify a more liberal tolerance. Transformers having large tapping ranges, particularly if the range is asymmetrical, may also require special consideration. On the other hand, for example, when a transformer is to be combined with	

Contributed by:

PATIL MANSI SATISH
PE-Electrical Engineer

L&T Technology Services


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REGULATIONS AND STANDARDS FOR LIGHT POLLUTION AND LIGHT TRESPASS

- Introduction

Light pollution refers to excessive or misdirected artificial light during night-time. Light trespass is a specific form of light pollution where light spreads beyond the intended area and enters neighboring properties, windows, or sensitive zones.

- Need for Regulations

Regulations and standards are essential to control light pollution and light trespasses to:

- Protect human health and visual comfort

- Prevent glare and sleep disturbance

- Reduce energy wastage

- Protect wildlife and night sky visibility

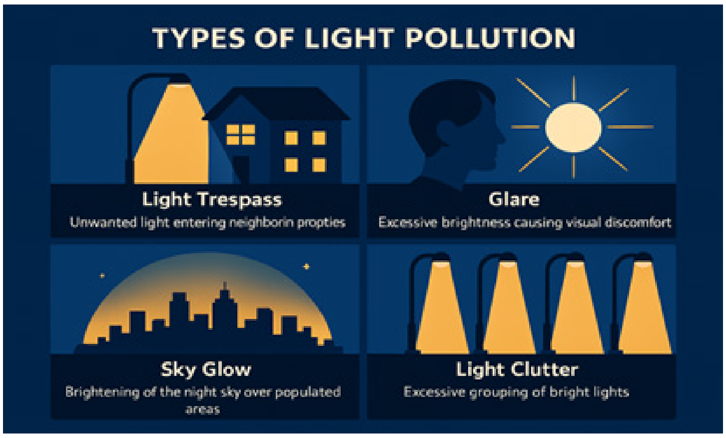
- Types of Light Pollution

Light Trespass – Occurs when unwanted artificial light spills into nearby homes or properties.

Glare – Results from overly bright or poorly shielded lights that create discomfort or reduced visibility.

Sky Glow – The widespread brightening of the night sky caused by excessive urban lighting.

Light Clutter – Formed by dense clusters of bright lights that create visual confusion and distraction.



- Design and Installation Best Practices

- Use fullcutoff luminaires with no upward light and install shielding where needed.
- Follow NEC Article 410 to ensure safe and compliant lighting installation practices.
- Choose warmwhite LED fixtures (3000 K or below) to reduce glare and environmental impact.
- Apply timers, dimmers, and motion sensors, and verify performance with postinstallation lux checks.

- Light Trespass Technical Limits (Typical)

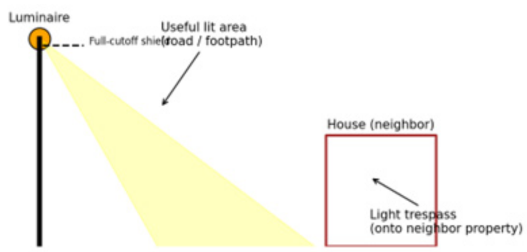
Area Type	Maximum Illuminance	Reference Standard
Residential Window	≤ 5 lux	AS/NZS 4282
Commercial Boundary	≤ 10 lux	AS/NZS 4282
Rural / Dark Zone	≤ 2 lux	IDA Guidance

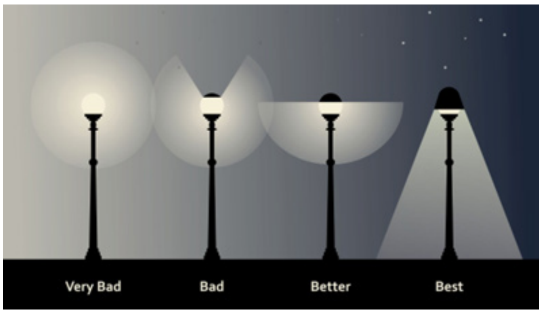
- International and National Standards

Standard / Code	Article / Clause	Region	Technical Scope
NFPA 70 (NEC)	Article 410	USA	Luminaires, lamp holders, wiring and installation safety
NFPA 70 (NEC)	Article 110	USA	Electrical installation and equipment requirements
IEC 62471	Clause 4–6	International	Photobiological safety of lamps and LEDs
IEC 60598	Clause 4	International	Luminaire construction and safety
EN 12464-2	Section 5	European Union	Outdoor workplace lighting and glare control
AS/NZS 4282	Clause 2–4	Australia/NZ	Limits for obtrusive light and trespass
IS SP 72: 2010	Part 1 & 2	India	National Lighting Code – design guidance
IS 10322	General	India	Lighting levels for outdoor areas

- Illustrative Diagram

The diagram below explains useful lighting and light trespass.





- Conclusion

Effective control of light pollution and light trespass requires a combination of proper design, compliance with international and national standards, and responsible installation practices. Adopting these measures improves safety, comfort, and environmental sustainability.

CONTRIBUTED BY:-

RUPENKUMAR PATEL
Discipline Lead (Electrical)
L&T Technology Services

SYNOPSIS - IEC 60947-2: 2024
Low-Voltage Switchgear and Controlgear – Part 2: Circuit-Breakers

SECTION 1: Overview of Circuit Breaker

IEC 60947-2 specifies the requirements for low-voltage circuit-breakers intended for use on systems not exceeding 1000 V a.c. or 1500 V d.c. It defines characteristic values, constructional features, performance criteria, and test methods so that circuit-breakers can safely make, carry, and break currents under normal service and fault conditions (overload and short-circuit).

The standard applies to circuit-breakers with or without integral protective functions, including residual current protection (CBRs), electronic over-current releases, and versions suitable for isolation. It addresses industrial/commercial environments and provides coordination guidance with other short-circuit protective devices to achieve discrimination or back-up protection.

SECTION 2: Definitions

- Circuit-breaker: mechanical switching device capable of making, carrying and breaking currents under normal circuit conditions, carrying for a specified time and breaking current under abnormal conditions such as short-circuit.
- Ue (Rated operational voltage), Ui (Rated insulation voltage), Uimp (Rated impulse withstand voltage).
- In (Rated current), Ith (Conventional thermal current), Icu (Rated ultimate short-circuit breaking capacity), Ics (Rated service short-circuit breaking capacity), Icm (Rated short-circuit making capacity), Icw (Rated short-time withstand current).
- Utilization categories: Category A (no intentional short-time delay) and Category B (with short-time delay and declared Icw).
- Suitability for isolation: breakers that meet leakage and contact separation requirements to isolate circuits.

SECTION 3: Types of Circuit Breaker

- Moulded-case circuit-breakers (MCCB): compact, enclosed construction for distribution feeders and equipment protection.
- Air circuit-breakers (ACB): open-type or enclosed, typically used as incomers/main breakers with higher breaking capacities and adjustable releases.
- Vacuum or gas-insulated types: specialized media for arc extinction; referenced where applicable.
- Category A vs Category B: functional classification by short-time delay capability rather than physical construction.
- Integrally fused circuit-breakers: composite devices combining a breaker and fuses to achieve selectivity and higher effective breaking capacities.

SECTION 4: Construction and Performance

Insulating parts retaining current-carrying components shall withstand glow-wire tests (typically 960°C for retaining parts; 650°C for others).

Clearances and creepage distances shall meet values appropriate to declared Uimp and pollution degree; guidance is provided when Uimp is not declared.

Terminals and connection means shall be designed to prevent loosening, overheating and ejecting incandescent particles during short-circuit operations; verification includes specific test arrangements.

Marking requirements: durable external markings include manufacturer, type designation, standard reference (IEC 60947-2), utilization category, Ue/Ui/Uimp, In, Icu/Ics at Ue, Icw (for Category B), and terminal identifications.

EMC: devices with electronic releases must meet immunity (ESD, RF, EFT/burst, surge, dips) and emission limits; non-electronic devices are assessed mainly for transient emissions during switching.

SECTION 5: Opening and Closing

Closing functions: dependent/independent manual closing; dependent/independent power closing; stored-energy closing. Verification is performed over specified control voltage ranges (typically 85–110% of rated).

Opening functions: trip-free operation ensures opening regardless of closing command. Over-current release accuracy is typically ±20% for short-circuit settings and ±10% for overload settings. Undervoltage and shunt releases are verified at their declared control voltages/frequencies.

Operating cycles and mechanical endurance: requirements include a number of no-load and load operations to verify reliability and contact wear limits.

SECTION 6: Temperature Rise Limit

Temperature-rise limits are defined for terminals, accessible parts, and non-accessible parts to prevent deterioration and hazards. Typical limits: terminals up to ~80 K; accessible metallic parts ~40–50 K; manual means ~25–35 K; non-accessible parts ~50–60 K (values depend on material and test conditions).
Compliance is checked after overload/short-circuit sequences to confirm thermal performance at rated currents and specified ambient conditions.

SECTION 7: Tests, Types of Tests and Test Sequence Scheme

Type tests and routine tests are organized into sequences to verify functional integrity and safety under service conditions. General test conditions specify mounting orientation, enclosure or free-air testing, use of metallic screens and polyethylene sheets near operating means during short-circuit tests and specified cable lengths for devices up to certain current ratings.

- Sequence I – General performance: tripping limits/characteristics, dielectric properties, mechanical operation, operational performance, overload performance, temperature-rise verification, and verification of overload releases; isolation suitability checks where declared.
- Sequence II – Service short-circuit breaking capacity (Ics): breaking tests at Ics followed by dielectric withstand and thermal verifications; operational capability reassessed.
- Sequence III – Ultimate short-circuit breaking capacity (Icu): breaking tests at Icu with subsequent dielectric and release verifications; applicable to Category A and B devices.
- Sequence IV – Short-time withstand current (Icw): applicable to Category B (and certain A per notes); verifies withstand at declared delays with associated checks for thermal rise and dielectric.
- Sequence V – Integrally fused circuit-breakers: staged verifications for composite units including selectivity limit current, take-over current, and Icu of the assembly.

SECTION 8: Clearance & Creepage

Minimum air clearances and creepage distances are specified according to Uimp, Ui, pollution degree (typically 3) and overvoltage category. Guidance is provided for devices without declared Uimp with conservative default values.
Design must avoid sharp points and tracking paths; insulating supports and barriers are dimensioned to prevent flashover and surface leakage under impulse and power-frequency tests.

SECTION 9: Circuit Breaker with Residual Current Protection

Annex B covers circuit-breakers incorporating residual current protection (CBRs/RCBOs). Preferred rated residual operating currents (IΔn) include 6 mA to 30 A; non-operating thresholds and time delays are defined for type AC and type A behaviors.
Operating times for non-time-delay types are verified at multiples of IΔn (e.g., ≤40 ms at 10×IΔn), with additional immunity tests for surge currents and behavior under DC components; EMC requirements are extended due to electronic sensing.

SECTION 10: Additional Requirements for Connection of Aluminum Conductor

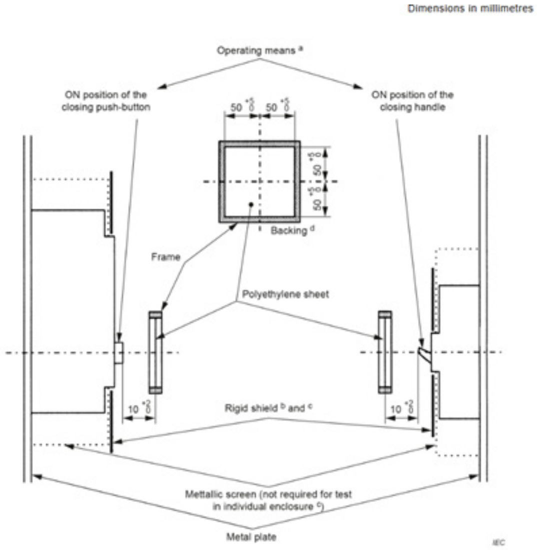
Terminals intended for aluminum conductors shall be designed to mitigate galvanic corrosion and cold flow. Requirements include suitable contact materials/coatings, defined tightening torques, and instructions for joint preparation (e.g., oxide removal and contact compound application).
Verification includes thermal cycling and temperature-rise checks at rated current with aluminum conductors of declared cross-section; terminals must maintain clamping force and not exhibit excessive heating or loosening.

ANNEXURE-1: IMPORTANT TABLES AND DIAGRAMS (Placeholders)

- Table 1: Relationship between Ics and Icu for typical ratings (insert manufacturer data).

Rated Ultimate Short-Circuit Breaking Capacity (Icu)	Rated Service Short-Circuit Breaking Capacity (Ics)
Icu ≤ 6 kA	Ics = 100 % of Icu
6 kA < Icu ≤ 10 kA	Ics = 75 % of Icu
10 kA < Icu ≤ 25 kA	Ics = 50 % of Icu
Icu > 25 kA	Ics = 25 % of Icu

- Figure 1: Short-circuit test arrangement showing polyethylene sheet and metallic screen.



- Table 2: Minimum Icw versus In and preferred short-time delays.

Rated current I_n A	Rated short-time withstand current I_{cw} – Minimum values kA
$I_n \leq 2\ 500$	$12\ I_n$ or 5 kA, whichever is the greater
$I_n > 2\ 500$	30 kA

- Table 3: Residual current operating/non-operating thresholds and time-delay classes (AC/A).

RCD Type	Non-Operating Current	Operating Current (IΔn)	Maximum Trip Time
Type AC	≤ 0.5 × IΔn	IΔn = 30 / 100 / 300 mA	≤ 300 ms (IΔn)
Type A	≤ 0.5 × IΔn	IΔn = 30 / 100 / 300 mA	≤ 300 ms (IΔn)
Type AC (Selective S)	≤ 0.5 × IΔn	IΔn as declared	130–500 ms
Type A (Selective S)	≤ 0.5 × IΔn	IΔn as declared	130–500 ms

Notes:
- RCDs shall not trip at ≤ 0.5 × IΔn.
- RCDs shall trip at IΔn within the specified time.
- Type AC: sinusoidal AC residual currents only.
- Type A: AC + pulsating DC residual currents.

Disclaimer

This synopsis is compiled from IEC 60947-2:2024 consolidated edition. For compliance and design, always use the official standard and manufacturer documentation.

Contributed by:

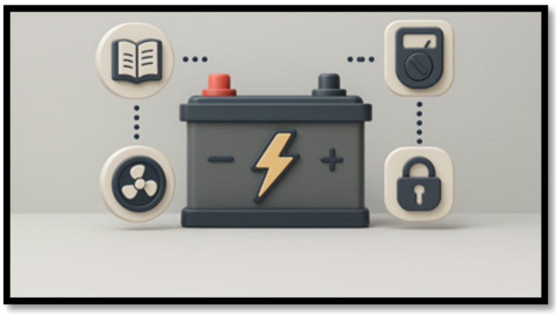
Adude Karan Balkishan
PE-Electrical Engineer

L&T Technology Services

Regulations and Standards for Battery Sizing

1. Introduction

This document presents an overview of the key regulations and standards governing battery sizing for backup power, UPS systems, renewable energy storage, and emergency lighting applications. It outlines how these standards shape critical design considerations such as capacity, voltage selection, ventilation, disconnect mechanisms, and compliance testing. A practical battery sizing methodology, supported by a realworld worked example, is also included to demonstrate its application in engineering design.



2. Why Standards Matter

Standards and codes are essential to ensure safety, interoperability, and regulatory compliance across batterybased power systems, defining requirements for performance, installation, ventilation, protective devices, and certification. They also establish the testing, labeling, and verification processes needed to confirm product reliability and conformity. To meet these requirements, designers must apply the appropriate standards for each battery chemistry and application ranging from IS and IEC safety specifications to NEC/ NFPA electrical installation rules in the U.S.

3. Key Standards for Battery Sizing

- **Bureau of Indian Standards (IS):** IS 16270 for storage batteries and the IS 16046 series for lithiumion cells and batteries together with additional IS documents for leadacid, primary cells, and test methods define key safety and performance requirements, ensuring battery systems meet rigorous reliability and compliance benchmarks.
- **NEC / NFPA (United States):** NEC Article 480 sets essential rules for stationary and storage batteries, covering disconnecting means, voltage limits for safe servicing, listing requirements, ventilation, and overcharge protection. Supporting NFPA standards such as NFPA 70E and NFPA 855, along with local jurisdictional codes, further strengthen electrical safety and installation compliance.
- **UL / IEC Standards & Manufacturer Specifications:** Standards including UL 1973, UL 9540A, IEC 62619, and the IEC 61000 EMC series define comprehensive testing, labeling, and certification requirements for cells, modules, and full energystorage systems. These documents, supported by manufacturer datasheets, govern safety validation, thermal behavior, system integration, and overall compliance during battery selection and design.

4. Regulatory Highlights That Affect Battery Sizing

- **Capacity & Required Duration:** Emergency system regulations often specify minimum runtimes such as the 90minute requirement for lifesafety lighting so batteries must be sized to meet these durations while accounting for allowable DoD, aging, capacity fade, and environmental derating to ensure longterm reliability.
- **Voltage Segmentation & Disconnects:** NEC rules require highvoltage battery strings to be

segmented for safe maintenance and emergency response, setting limits on serviceable voltage per segment and mandating disconnecting means and clear emergencyshutdown labeling, all which shape system architecture and wiring during battery sizing.

- **Ventilation, Location & Environmental Design:** Ventilation criteria vary widely across vented leadacid, VRLA, and lithiumion chemistries. Codes define minimum clearances, airflow, temperature control, and fire protection needs, which dictate installation locations, heatdissipation capacity, and feasible battery density.
- **Listing, Certification & Overcharge Protection:** Modern regulations require battery systems, including BMS and charge controllers, to be listed and certified to be applicable UL/IEC standards. They also mandate safeguards against overcharge, thermal runaway, and fault propagation, guiding the selection of certified BMS designs and influencing design margins in sizing calculations.

5. Battery Sizing Formula (Industry Standard Approach)

A widely accepted engineering expression for estimating battery bank capacity (in amperehours, Ah) is **Battery Ah = (Load Watts × Required Duration) / (Battery Voltage × System Efficiency × Allowable DoD).** This equation captures the essential parameters governing how much usable energy the battery must deliver.

Each term plays a specific role in determining the final capacity requirement:

- **Load Watts:** This is the total power (in watts) that the battery needs to provide when the power goes out.
- **Required Duration:** The amount of time (in hours) that the system must keep supplying power.
- **Battery Voltage:** The normal voltage level of the system (usually 12 V, 24 V, or 48 V). This choice affects how much current flows, the size of the wiring, which inverter you can use, and how the battery bank is set up.
- **System Efficiency:** This includes realworld energy losses from the inverter, converter, cables, and distribution. Using typical values (0.85–0.95) helps make sure the battery is sized to provide the needed usable power after these losses.
- **Allowable Depth of Discharge (DoD):** This is the percentage of the battery's total capacity that can be safely used without shortening the battery's life.

6. Battery Sizing methodology

To size the required battery bank, consider a 2-kW emergencylighting load that must operate for 1.5 hours using a 48 V DC battery system. Given a system efficiency of 90% and an allowable depth of discharge (DoD) of 60%, the required amperehour capacity can be determined using the standard sizing formula

Battery Ah = (2000W X 1.5 h)/(48V X 0.9 X 0.6)

Result: The required battery capacity is approximately 116 Ah at 48 V.

7. Best Practices and Compliance Checklist

- **Use Certified Components:** Make sure all battery cells, modules, and systems meet the required IS, IEC, and UL standards, backed by proper test reports from the manufacturer.
- **Apply Realistic Derating:** Adjust capacity for temperature, aging, and expected cycle life so the system performs reliably over time.
- **Install Safety Disconnects & Labels:** Provide all NEC/NFPArequired disconnect switches, safety labels, and emergency access points to ensure safe shutdown during emergencies.
- **Ensure Proper Ventilation & Room Safety:** Follow code requirements for ventilation, spacing, room design, and fire separation based on the battery type (leadacid, VRLA, Liion, etc.).
- **Keep Complete Documentation:** Maintain clear records of testing, inspections, maintenance, and all manufacturerrecommended procedures as required by NEC/NFPA and local authorities.

8. References

- Bureau of Indian Standards IS 16270 (storage batteries) and related IS/IEC battery standards.
- NFPA 70 (NEC) Article 480 and related NFPA guidance (70E, 855).
- IES RP guidance and UL/IEC product standards (UL 1973, UL 9540A, IEC 62619).

Contributed by:

Punit Dave
Sr. Engineer (Electrical) - PE

L&T Technology Services

SYNOPSIS - IEC-60079-0: 2017

(SERIES on STANDARDS / CODES / TECHNICAL SPECIFICATIONS)

Equipment in Explosive atmospheres – General requirements

A. SECTION 1: Introduction

a) This standard provides a comprehensive framework for preventing ignition sources, covering equipment design, construction, testing, marking, installation, and maintenance.

b) IEC 60079 includes detailed guidance on hazardous area classification, enabling organizations to correctly identify risk zones and select suitable equipment.

c) Equipment Protection Level (EPL) is a classification defined in this code that assigns a protection level to equipment based on its likelihood of becoming a source of ignition, clearly distinguishing between explosive gas atmospheres, explosive dust atmospheres, and mining environments susceptible to firedamp. EPL serves as a critical guideline for choosing suitable equipment in hazardous areas and minimizing explosion risks.

d) Equipment is classified into three groups based on the type of explosive atmosphere they are intended for. Group I covers equipment used in mining environments where firedamp (methane) or combustible dust may be present. Group II applies to surface industries with explosive gas atmospheres and is further subdivided into IIA, IIB, and IIC based on the ignitability of gases, with IIC representing the most easily ignitable gases such as hydrogen. Group III covers equipment for explosive dust atmospheres and is subdivided into IIIA, IIIB, and IIIC, distinguishing different types of dust such as combustible flying, non-conductive dust, and conductive dust. This grouping ensures that equipment is appropriately selected according to the specific nature and severity of the hazardous atmosphere.

e) For Group II electrical equipment, this code classifies maximum surface temperatures into six temperature classes to prevent ignition of surrounding explosive gases. These classes range from T1, allowing a maximum surface temperature of 450°C, down to T6, which limits surface temperature to 85°C, making it the safest category for highly sensitive atmospheres. The intermediate classes include T2 (≤300°C), T3 (≤200°C), T4 (≤135°C) and T5 (≤100°C), ensuring equipment selection is matched to the ignition temperature of the specific gas present.

f) This code also includes general requirements and threshold values for equipment radiating heat, electromagnetic, ultrasonic energy and Radio frequency sources.

g) This Code also includes requirements and qualifications for metallic/non-metallic enclosures, non-metallic parts of enclosures and fasteners to be used for equipment present in hazardous atmospheres and methods which are taken care to avoid electrostatic charge build up in such hazardous areas.

h) The Code ensure the safe design, construction, installation, and use of equipment in explosive atmospheres where flammable gases, vapors, or dust may be present. These standards provide comprehensive guidance on hazardous area classification, equipment requirements, and protection techniques to minimize ignition risks and enhance safety in industries such as oil and gas, chemicals, mining, and manufacturing. By setting globally accepted safety criteria, IEC 60079 helps organizations prevent explosions and maintain safer working environments.

B. SECTION 2: BRIEF ASPECTS

<u>This Code cover mainly the following aspects:</u>

a) General construction requirements for Ex Equipment
b) Mechanical strength, impact resistance, thermal endurance
c) Temperature classification & surface temperature limits
d) Creepage & clearance distances
e) Ingress protection (IP) requirements
f) Marking rules and identification of Ex protection types
g) Testing requirements including routine and type tests, and
h) Supplementary requirements for equipment intended for use outside standard atmospheric conditions.

C. SECTION 3: HIGHLIGHTS OF THE STANDARD

a) Defines requirements for construction, testing, and marking of Ex Equipment and Components.

b) Standard atmospheric limits provided (temperature, pressure, oxygen).

c) Additional tests required for equipment intended outside this envelope (especially protections requiring flame-quenching).

d) Mechanical strength, creepage/clearance distances, thermal stability, fasteners, bushings, non-metallic enclosure testing, marking durability, etc.

e) Entry point and branching point temperatures ≥70°C / 80°C require external marking.

f) Rotating machines normally tested without final cable glands; maximum internal air-space temperature is used to represent service conditions.

g) Mandatory Ex marking scheme indicating equipment group, category, temperature class, and protection type.

h) Marking must remain durable and legible throughout service life.

i) Type tests, routine tests, impact tests, thermal endurance, drop tests, IP tests, dielectric tests.

j) Non-metallic materials used in enclosures to undergo thermal endurance, UV resistance, impact tests, and surface resistance evaluations to ensure they do not degrade and become ignition sources in explosive atmospheres.

k) Equipment made of non-metallic parts must be evaluated for electrostatic charge accumulation, which can serve as an ignition source.

l) Designs may require surface treatments, conductive additives, or marking instructions to warn users of cleaning or maintenance-induced electrostatic hazards.

m) Fasteners critical to flameproof joints or safety-related enclosures must be non-loosening type, made of corrosion-resistant materials and should be non-interchangeable with unsafe alternatives.

n) This standard defines minimum electrical spacing requirements to avoid arcing or tracking in hazardous atmospheres.

o) Equipment must include dedicated earthing/grounding terminals designed to maintain low impedance and mechanical robustness.

p) Earth terminals must withstand specific torque requirements and corrosion exposure.

q) Testing includes humidity cycling, salt mist testing, and ageing tests.

r) Cable entries, glands, conduit interfaces, and terminal housings must ensure no ignition source escapes, cable insulation does not overheat, and mechanical stability is maintained.

D. SECTION 4: CONCLUSION

IEC 60079-0:2017 provides the essential engineering framework that ensures electrical equipment used in explosive atmospheres is designed, constructed, and tested to prevent ignition under defined atmospheric conditions, forming the baseline upon which all other protection techniques in the IEC 60079 series are built.

ANNEXURE-1: IMPORTANT TABLES AND DIAGRAMS

Table 1 – Ambient temperatures in service and additional marking (Clause 5.1.1)

Electrical equipment	Ambient temperature in service	Additional marking
Normal	Maximum: +40 °C Minimum: −20 °C	None
Special	Specified by the manufacturer	T_a or T_{amb} with the special range, for example, −30 °C ≤ T_a ≤ +40 °C or the symbol "X"

Table 2 – Classification of maximum surface temperatures for Group II electrical equipment

Temperature class	Maximum surface temperature °C
T1	450
T2	300
T3	200
T4	135
T5	100
T6	85

Table 5 – Radio-frequency energy thresholds

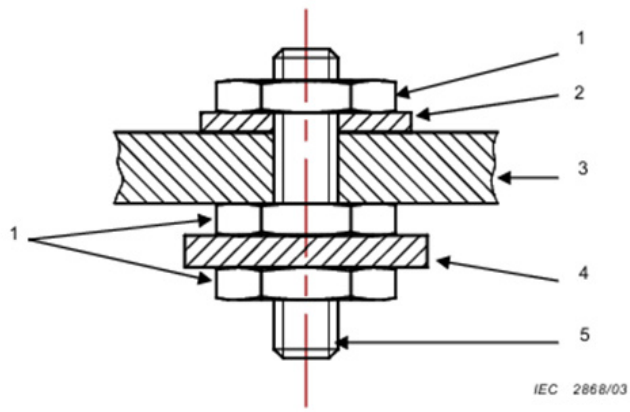
Equipment for	Threshold energy Z_{th} µJ
Group I	1 500
Group IIA	950
Group IIB	250
Group IIC	50
Group III	1 500

Table 6 – Limitation of surface areas

Maximum surface area mm^2				
Group I equipment	Group II equipment			
	Equipment protection level	Group IIA	Group IIB	Group IIC
10 000	EPL Ga	5 000	2 500	400
	EPL Gb	10 000	10 000	2 000
	EPL Gc	10 000	10 000	2 000

Table D.1 – Traditional relationship of EPLs to zones (no additional risk assessment)

Equipment protection level	Zone
Ga	0
Gb	1
Gc	2
Da	20
Db	21
Dc	22



Components

1 nut
2 earth plate
3 enclosure wall (non-metallic)
4 earth plate or part of earth plate
5 test bar

Figure 4 – Assembly of test sample for earth-continuity test

Table 14 – Text of warning markings

	Reference	WARNING marking
a)	6.3	WARNING – AFTER DE-ENERGIZING, DELAY *Y* MINUTES BEFORE OPENING (*Y* being the value in minutes of the delay required)
b)	6.3	WARNING – DO NOT OPEN WHEN AN EXPLOSIVE ATMOSPHERE MAY BE PRESENT
c)	18.2	WARNING – DO NOT OPERATE UNDER LOAD
d)	18.4 b), 19 21.2 b, 21.3 b)	WARNING – DO NOT OPEN WHEN ENERGIZED
e)	20.1 b)	WARNING – DO NOT SEPARATE WHEN ENERGIZED
f)	20.1 b)	WARNING – SEPARATE ONLY IN A NON-HAZARDOUS AREA
g)	7.4.2 g)	WARNING – POTENTIAL ELECTROSTATIC CHARGING HAZARD – SEE INSTRUCTIONS
h)	18.4 2) 21.2 2 21.3.2)	WARNING – LIVE PARTS BEHIND COVER – DO NOT CONTACT

Table D.2 – Description of risk of ignition protection provided

Protection afforded	Equipment protection level Group	Performance of protection	Conditions of operation
Very high	Ma Group I	Two independent means of protection or safe even when two malfunctions occur independently of each other	Equipment remains functioning when explosive atmosphere present
Very high	Ga Group II	Two independent means of protection or safe even when two malfunctions occur independently of each other	Equipment remains functioning in zones 0, 1 and 2
Very high	Da Group III	Two independent means of protection or safe even when two malfunctions occur independently of each other	Equipment remains functioning in zones 20, 21 and 22
High	Mb Group I	Suitable for normal operation and severe operating conditions	Equipment de-energized when explosive atmosphere present
High	Gb Group II	Suitable for normal operation and frequently occurring disturbances or equipment where malfunctions are normally taken into account	Equipment remains functioning in zones 1 and 2
High	Db Group III	Suitable for normal operation and frequently occurring disturbances or equipment where malfunctions are normally taken into account	Equipment remains functioning in zones 21 and 22
Enhanced	Gc Group II	Suitable for normal operation	Equipment remains functioning in zone 2
Enhanced	Dc Group III	Suitable for normal operation	Equipment remains functioning in zone 22

Contributed by:

Kirti Rawal
PE-Electrical
L&T Technology Services

SYNOPSIS

(SERIES on STANDARDS / CODES / TECHNICAL SPECIFICATIONS)

IS 60034: (Part - 1) Rotating Electrical Machine of Rating and Performances.

A. SECTION 1: Introduction

1. The International Electrotechnical Commission (IEC) published the IEC 60034 series to establish globally accepted standards for rotating electrical machines. Part 1 of this series, IEC 60034-1:2022, defines the fundamental requirements for rating and performance of these machines. It applies to all rotating electrical machines except those intended for rail and road vehicles, which are covered under IEC 60349. This standard ensures consistency in design, testing, and operational parameters, promoting safety, reliability, and interoperability across diverse applications.

2. The scope of IEC 60034-1 includes AC and DC motors, generators, synchronous machines, and synchronous compensators. These machines are widely used in industrial, commercial, and utility sectors. In addition, machines operating in specialized environments such as explosive atmospheres or marine installations may require compliance with supplementary standards like IEC 60079 and IEC 60092. This integration ensures that machines meet both general and application-specific safety and performance requirements.

3. The primary objective of IEC 60034-1 is to provide comprehensive guidelines for determining ratings, duty types, thermal limits, and performance characteristics under specified site and operating conditions. It addresses variations in voltage, frequency, and environmental factors such as ambient temperature and altitude. By defining these parameters, the standard ensures that machines operate efficiently and safely under normal and extreme conditions.

4. The principles outlined in the standard include proper assignment of ratings based on duty cycles, adherence to thermal performance limits according to insulation classes, and compliance with electrical and mechanical tolerances. These principles are critical for preventing failures, reducing downtime, and ensuring long-term reliability. The standard also specifies test methods for verifying compliance, including routine and type tests for electrical and thermal performance.

B. SECTION 2: BRIEF ASPECTS

<u>This Code cover the following aspects:</u>

a) Duty Types and Classification
b) Rating Principles and Allocation
c) Site and environmental Conditions
d) Electrical Operating Condition
e) Thermal Performances and Temperature Limits
f) Tests and Tolerances
g) Information and Documentation Requirements

C. SECTION 3: HIGHLIGHTS of the Standard

1. IEC 60034 defines all rating requirements for rotating electrical machines, including power, voltage, current, frequency, duty, insulation class, ambient temperature, and altitude. These parameters ensure that machines operate safely and consistently under standard site conditions. The standard provides a unified basis for assigning machine ratings globally.

2. The standard classifies machine duty types from S1 to S10, covering continuous duty, shorttime duty, intermittent duty, and cyclic operations with varying load patterns. These duty types help determine correct motor selection and avoid thermal overloading. Proper duty classification enhances machine life and performance.

3. IEC 60034one specifies maximum temperaturerise limits according to insulation classes A, E, B, F and H. These limits maintain thermal integrity and prevent overheating of winding during operation. It also includes correction factors for high ambient temperature or altitude.

4. The standard defines acceptable supply variations including ±5–10% voltage and ±2–5% frequency fluctuation. It also limits combined voltagefrequency deviation and supply harmonic distortion. These ensure safe machine operation under nonideal electrical supply conditions.

5. IEC 60034 1 provides limits for unbalanced supply through negative sequence current restrictions. This prevents overheating and vibration caused by phase imbalance. The standard ensures machines remain dependable even during supply asymmetry.

6. Vibration severity levels are defined based on machine size, type, and operating speed. These limits help in evaluating mechanical health and detecting imbalance, misalignment or bearing issues. Maintaining vibration within limits prevents premature mechanical failure.

7. The standard specifies permissible noise levels and includes methods for measurement. Noise control ensures user comfort and compliance with industrial limits. It also provides guidelines for identifying abnormal acoustic patterns.

8. Overspeed testing requirements verify the mechanical strength of the rotor by rotating it beyond rated speed. This test ensures structural safety during abnormal operating conditions. It is mandatory for confirming rotor integrity.

9. Overspeed testing requirements verify the mechanical strength of the rotor by rotating it beyond rated speed. This test ensures structural safety during abnormal operating conditions. It is mandatory for confirming rotor integrity.

10. IEC 60034 defines minimum torque values including starting torque, pullup torque, and breakdown torque. These torque parameters ensure the machine can start, accelerate, and operate under load demands. Proper torque capability prevents stalling and damage.

11. Performance tolerances are specified for efficiency, slip, power factor, temperature rise, torque and current. These tolerances allow small manufacturing differences while ensuring acceptable machine performance. They help verify compliance during testing.

12. Routine tests include winding resistance measurement, noload test, load test, insulation resistance test, and HV withstand test. These are conducted on every machine to ensure electrical soundness and performance consistency. Routine tests guarantee basic safety and reliability.

13. Type tests such as temperaturerise test, vibration measurement, overspeed test and lockedrotor test are performed on representative machines. These tests validate design performance and verify that the machine meets IEC standards. They are essential for type approval.

14. Special tests include noise measurement, shaft voltage testing and negative sequence tests when required by the application. These tests provide additional assurance in sensitive or critical environments. They help address specific operational concerns.

15. Nameplate information such as power rating, duty type, insulation class, IP protection, and standard reference is mandatory. Accurate nameplate data helps users install, operate, and maintain the machine correctly. It ensures traceability and safety compliance.

16. IEC 600034 defines enclosure protection levels using IP codes to protect machines from dust, water, and foreign objects. Proper enclosure selection ensures safe operation in environmental conditions. It extends machine life and prevents ingress damage.

17. Temperature monitoring guidelines include the use of sensors like RTDs, thermistors and thermal switches. These devices help detect overheating and protect the machine from insulation failure. Monitoring increases machine safety and operational life.

D. SECTION 4: Testing

1. Routine tests are performed at the manufacturer’s factory to check basic machine performance, including winding resistance, noload tests, and rotation direction.

2. Machinespecific tests include excitation tests for synchronous machines, opencircuit induced voltage for woundrotor induction machines, and commutation tests for DC machines.
3. Withstand voltage test applies high voltage between windings and the machine frame to verify insulation strength, with voltage held for one minute.
4. Test voltage levels follow standard formulas (e.g., 1000 V + 2× rated voltage), with shorter 1second tests allowed for small or lowvoltage machines.

Table 16 – Minimum routine tests for machines assembled and tested in the factory of the manufacturer

Item	Test	Induction machines (including synchronous induction machines) [a]	Electrically excited synchronous machines	Synchronous reluctance machines and PM excited synchronous machines	DC machines with separate or shunt excitation
1	Resistance of windings (cold)	Yes	Yes	Yes	Yes
2	No-load losses and current [d]	Yes	–	Yes	–
3a	No-load losses at unity power factor [c]	–	Yes [c]	–	–
3b	No-load excitation current at rated voltage by open-circuit test [c]	–	Yes [c]	–	–
4	Excitation current at rated speed and rated armature voltage	–	–	–	Yes
5	Open circuit secondary induced voltage at standstill (wound rotor)[b]	Yes	–	–	–
6	Direction of rotation (motors) or phase sequence (generators)	Yes	Yes	Yes	Yes
7	Withstand voltage test according to 9.2	Yes	Yes	Yes	Yes

[a] IEC 60050-411:1996, 411-33-04.

[b] For safety considerations this test may be performed at reduced voltage.

[c] Only one of the tests 3a or 3b is required.

[d] No stabilization of temperature required for measurement of no-load losses.

E. SECTION 4: Annex

- **Annex A:** Checklist of machine data to include in enquiry/order — ratings, duty type, insulation class, cooling method, IP rating, and environmental conditions.
- **Annex B:** Examples of duty cycle selection (S1–S10) showing how load patterns affect thermal performance and rating choice.
- **Annex C:** Summary of temperaturerise limits for different insulation classes with altitude/ambient correction factors.
- **Annex D:** Limits for acceptable voltage/frequency variations, harmonics, and unbalanced supply (negativesequence component).
- **Annex E:** Tolerances for key performance parameters like efficiency, slip, torque, current, and temperature rise.
- **Annex F:** List of routine, type, and special tests including insulation, load/noload, overspeed, vibration, and noise tests.
- **Annex G:** Mechanical construction requirements covering vibration limits, noise levels, shaft/bearing design, and overspeed strength.

F. **SECTION 4: Conclusion**

For determining compliance with IEC 60034 – 1 requirement, all measured or calculated values obtained during testing such as efficiency, temperature rise, torque, current, vibration, or insulation resistance shall be evaluated using the relevant tolerance limits specified in the standard. The final values used for assessment should be rounded off in accordance with internationally accepted rounding rules to ensure consistency and accuracy in reporting test results.

Disclaimer

This synopsis has been compiled from the content of IEC 60034 1 and related reference material for study and overview purposes only. For design, testing, certification, or compliance, users must always refer to the official IEC 60034 1 standard and the original manufacturer's documentation, as only the official published documents contain the complete and authoritative requirements.

Contributed by

Neha R. Wasekar
Ps No. 40047765
PE-Electrical Engineer

L&T Technology Services


POWERING PROGRESS
SINCE THREE DECADES
CABLES
BY VARSHA CABLES PRIVATE LMITED
MANUFACTURERS OF WIRES & CABLES
CUSTOMISED CABLE SOLUTIONS
PRODUCT RANGE
BMS Cables
Fire Survival Cables
Flexible Cables
Solar Cables
Control Cables
Panel Wiring
Industrial Automation Cables
Instrumentation Cables
Submersible Flat Cables
Power Cables
House Wiring
Special Application Cables
PRODUCT FEATURES
Heavy Duty LV Cables
PVC
FRLS
LSZH
Copper
XLPE
HR
TPE
Aluminium
XLPO
ZHFR
TPU
TRUSTED LEGACY 30 YEARS TRUSTED LEGACY
APPLICATIONS
Metro Rail
Airports
Oil & Gas
Infrastructure
Data Centers
Industrial Automation
Solar
Wind
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IS 694 / IS 1554 / IS 7098
ISO 9001
ISO 14001
ISO 45001
Send Your Enquiry Instantly
We're Exhibiting at
ELAsia 2026
INTERNATIONAL EXHIBITION ON POWER, ELECTRICAL AND LIGHTING
MAY 14-17, BANGALORE
HALL - 2 | STALL F20
sales@vcables.com
www.varshacables.com
0821-4282013
V Cables | Varsha Cables Private Limited

Power quality standards related to "Voltage dips"– *critical for complex loads*

With globalization and uplifting of Indian economy, lot of complex manufacturing Industries are coming to India (Including electronic chip manufacturing) which require "Good Quality Power". Hospitals with enhanced electronically supported medical equipment, Hyper scale Data centers is also another area where "Good power quality" is basic requirement. "Voltage dips and surges" are major cause of concern for reliable and consistent operation of this equipment.

This article makes an attempt to introduce related international standards which define:

a) Responsibilities of Electrical power suppliers in terms of maintenance of power quality at consumers doorsteps.

b) Minimum tolerance to input power supply parameters (ride through) and expectations from critical equipment design within which equipment will not malfunction or will not get damaged.

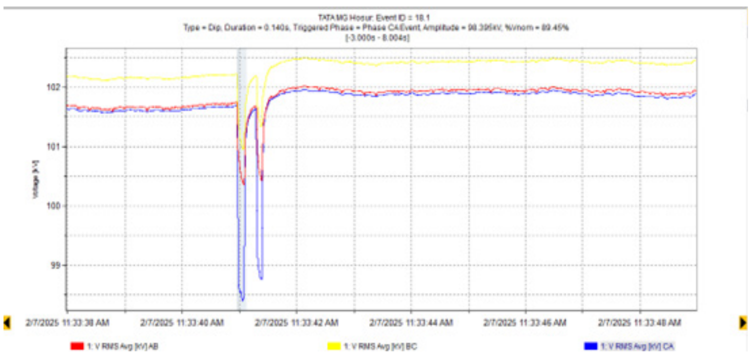
We all know that due to upstream operational requirements like line switching, capacitors, transformer charging, etc. in AC circuits, transient voltage disturbances are generated. Another reason for such disturbances is faults in electrical network. Both these types of disturbances can be minimized; however, they cannot be avoided completely. Such events result into 'drawing' of excessive currents, and most of the time result in voltage dips. The resulting voltage dips expressed in the form of "remaining voltage" and "time width" are important parameters of such disturbances. Similarly, when large loads are removed from the grid, there is a possibility of surges and voltage swells.

In view of smooth operation of equipment connected to AC power supply, characteristics of such disturbances are important.

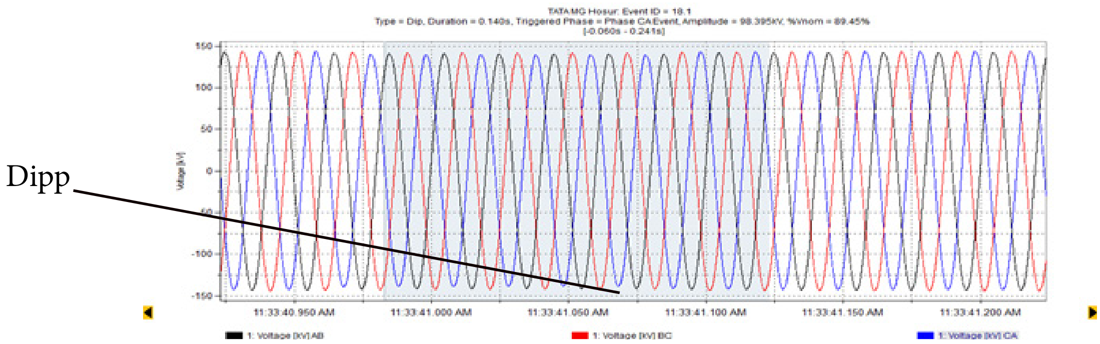
Example: Recording of a voltage dip on 110KV line.

RMS voltage trace showing a voltage dip.

Voltage wave form during the disturbance



Remaining voltage was 89.45% (98.39KV) of nominal and the dip prevailed for 140 msecs – this is beyond -10% value.



The disturbance shown above is less severe. However, disturbances where only 50% of rated voltage remains available are also seen on grid lines. The operation of critical equipment which includes – CNC machines, plant automation, robots, Semiconductor manufacturing machines, medical diagnostic equipment, surgical robots, etc. can suffer due to such disturbances.

Practically speaking ideal electrical supply with absolutely "No Disturbance" is not possible from a shared utility grid and also from the output of power conditioning equipment like UPS – due to 'Second order response of R-L–C circuits' when switched ON or OFF and also due to their internal impedances. The voltage and current parameters stabilize after "Circuit time constant" once exposed to any disturbance. During dynamic period the voltages can be low or high.

These facts give rise to defining some standards of compliance. Available Power supply should satisfy some minimum requirements so also the equipment getting connected should also show resilience and tolerance to some specific values of such disturbances. Such arrangement ensures economic viability of this ecosystem under practical and theoretical limitations of the science behind the respective technologies.

The standards have mandated limit of 7 days continuous monitoring of available electrical supply parameters using measuring instruments capable of capturing and recording these disturbances. The disturbances are then compared with limits specified in standards for deciding qualification of quality of available electrical supply.

Following are major standards which define requirements.

1) **EN 50160:** Voltage Characteristics of Public Distribution Systems - adopted by Central electricity Authority in India vide respective grid code.

Significance: Electricity distribution companies in India are expected to follow provisions of EN 50160 while supplying electrical energy to its Bonafide consumers – This defines long term and short-term RMS voltage level disturbance limits. EN 50160 also considers "Statistical analysis" of occurrences of disturbances in 7 days.

2) **ITIC, CBMA curves and tolerance curves as per SEMI F42 series of standards particularly providing limits for Voltage sags, swells and dips:**

Significance: The critical loads drawing power from supply (Compliant with EN 50160) should provide "Ride through" for voltage disturbances limited by ITIC, CBMA, SEMI F 42 curves.

Critical load tolerances are mainly governed by "Semiconductor manufacturing Industry" or "Data center loads" as the world has mandated that these are most critical applications which are sensitive to power quality disturbances.

So, in summary we can state that:

a) Transient or dynamic conditions on AC power systems which can change voltage parameters such as RMS voltage, waveform are not uncommon. b) The durations and depths (sags) or rise (swell) of such disturbances depend on system impedance and associated system time constant. c) They are initiated due to switching and faults. d) The durations can be as short as 10 msecs (half cycle) to as long as few seconds.	This boils down to - points 'a,b,c,d' should be kept with in limits as specified in EN50160 by "Power system designers".
e) Sensitive machinery involving combination of electrical and electronic systems besides mechanical actuators are required to be designed for some tolerance / ride through capabilities – typically using surge voltage protection for higher voltages and sufficient internal energy storage for sustaining with lower voltages.	"Equipment and machinery designers" should provide tolerance – ride through capabilities as specified in ITIC,CBMA,SEMI F42 curves.

It also should be noted that electronic voltage sources like UPS systems / inverters (which are not synchronous machines) behave differently. Their dynamic V/I response characteristics are governed by technology used and by respective international standards. These responses are given in their catalogues, specification sheets, etc. – which should be carefully studied before ordering them and expecting power quality corrections from them.

Considering all above engineering facts, it becomes necessary to develop a **stake holder concept** to generate healthy installations of critical loads and avoid abrasions after commissioning.

"Stake holders" concept related to power quality issues.

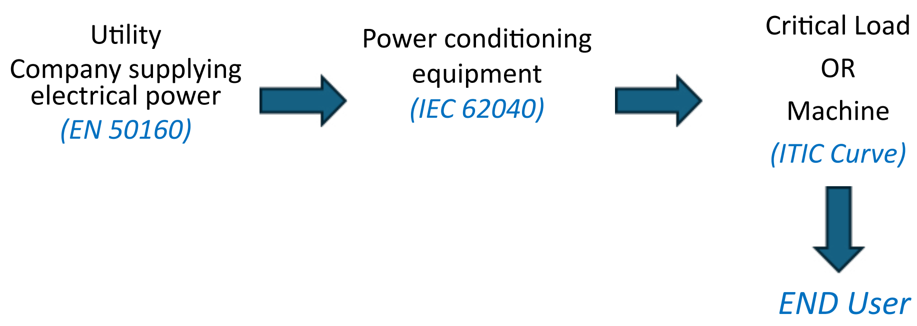
In AC (alternating current type) electrical systems using "bulk electrical power" form an interconnected power distribution network, the network parameters (Resistance, Inductance and capacitance) of such network are decided by system designers and exist physically when the system is installed. Physical forms of these parameters for example are transformer impedances, cable impedances, generator – motor impedances, etc. Voltage drop and

power transfer calculations are ”Vector calculations” and are performed using complex mathematics.
Transient / dynamic conditions like long distance transmission line switching, faults on such lines due to short circuits, starting of large motors, etc. demand currents which are very large compared to normal loads currents and create abnormal ”voltage dips” which can affect working of critical loads. Such conditions can not be completly avoided, however can be minimized in quantity. The system design can ensure that their effects on available voltage at last mile are minimum.

Many times depending upon criticality of the application, user decides to use various power conditioning equipment such as stabilizers, UPS systems, etc. to combat these disturbances. However, depending on technology and design these equipment also have their own limitations.
Thus, following are the stake holders under ”Critical Load installation” who have to comliment each other within their limitations to ensure smooth operation of ”Critical Load” for maximum possible time.

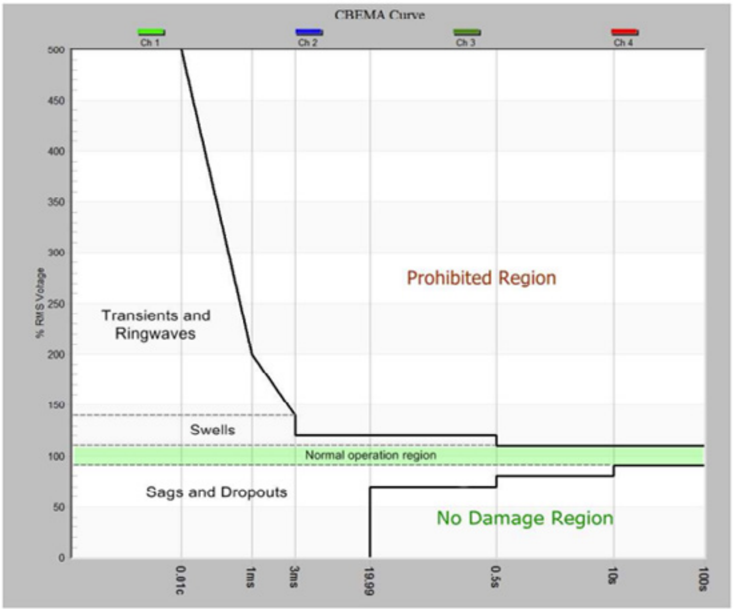
The standards in “Blue” provide “tolerable” limits in each case.

1) Utility company is expected to deliver power quality at “Point of common coupling” with consumer as per EN50160.
2) Power conditioning equipment accepts raw power; conditions using electronics and gives output. The dynamic response for such equipment is governed by IEC 62040 series of standards.
3) It is expected that critical loads unless their manufacturers demand more stringent power quality requirements, would provide “ride through” for above disturbances, which are within limit of EN 50160. If they do not demand “Power conditioning”, the equipment should function satisfactorily if input power parameters comply with EN 50160.
4) More stringent demands may be fulfilled using special power conditioning equipment.
5) In the interest of project, these stake holders should sit together before the equipment commercials are finalized and sort this out.



Explanation of ITIC (Information technology Industry Council) Curve.

% RMS Voltage



Time period

Salient observations based on above curve:

1. Any equipment should work satisfactorily if **available input RMS voltage is within +/-10% of the nominal voltage** specified by equipment manufacturer. (Yellow band above)
2. **Sags down to 70% of the nominal voltage** should be acceptable for maximum **duration of 0.5 Secs.** (Remaining voltage 70%)
3. **Sags down to 80% of the nominal voltage should be acceptable for maximum duration of 10 secs**. (Remaining voltage 80%)
4. Voltages down to less than 70% upto 0% should be acceptable for a time period of less than 1 cycle – 20 msecs. Typically these are transients and inrush black outs.
5. No damage region as shown above expects that if the applied voltage is in this region, the equipment may not function properly but should not get damaged.
6. Voltage swells of upto 120% of nominal should be tolerable upto 0.5 Secs. Any other voltage rise if less than 1 cycle time – then the same should be tolerable.
7. All other voltage swells falling in prohibited region i.e. available voltage beyond 120% for a period beyond 1 cycle time can damage the equipment.

All other curves and their explanations are available on internet resources. It is important that the equipment manufacturer should be made aware of these tolarance / ride through requirements and the stake holders have a consensus related to quality of power available and expected performance of the equipment which is supposed to work on the available power supply.

Some very critical applications demand equipment with heavy investments for power conditioning. For example “Semiconductor FAB tools” require DRUP UPS for power conditioning to ensure continuity as well as steady voltage profile complying to SEMI F 42 requirements. A large upcomming semiconductor project in India is investing over Rs.300crs for getting around 70MW power compliance with SEMI F 42.

Apart from above the equipment manufacturer should specify

- Maximum tolerable voltage distortion, frequency tolerance.
- Detail earthing requirements. Is body earth and signal / sensitive earth segregated inside panel ?
- Requirement of earth – neutral voltage limit.

Power analysers FLUKE 1777 or equivalent are capable of recording power quality parameters with required accuracy at GPS syncronised time stamps. The software tools available with these analyzers also provide direct compliance reports as per EN 50160, and all above curves considering all requirements of respective standards.

While designing Industrial or commercial electrical power distribution systems, now it has become unavoidable for the designer to understand intricasies of all above requirements and also understand nature and requirements of various critical loads very clearly. This will enable the designer to deliver a healthy equipment ecosystem to client which will have minimum operational issues.

Contributed by:

Narendra Duvedi

SYNOPSIS

(SERIES on STANDARDS / CODES / TECHNICAL SPECIFICATIONS)

IEC 61439-1 : Low-Voltage Switchgear and Controlgear Assemblies.

A. SECTION 1: Introduction

1. IEC 614391 is an international standard that specifies the general rules for lowvoltage switchgear and controlgear assemblies. Published by the International Electrotechnical Commission (IEC), this standard provides a unified framework for the design, construction, verification, and performance of electrical assemblies operating at rated voltages up to 1000 V AC or 1500 V DC. It replaces and supersedes the earlier IEC 60439 series, introducing a more structured and safetyoriented approach to compliance.
2. The primary objective of IEC 614391 is to ensure a high level of safety, reliability, and performance consistency across lowvoltage assemblies used in industrial, commercial, and infrastructure applications. The standard defines essential requirements related to electrical, mechanical, and thermal characteristics, including dielectric properties, temperature rise limits, shortcircuit withstand strength, and protection against electric shock. It also establishes clear responsibilities for manufacturers through the concepts of design verification and routine verification, thereby reducing ambiguity and improving product quality.
3. IEC 614391 serves as the foundation standard for the IEC 61439 series and is intended to be used in conjunction with the relevant productspecific parts, such as those covering power switchgear assemblies, distribution boards, and assemblies for construction sites. By promoting standardized verification methods and clear documentation practices, it supports safer installations, regulatory compliance, and improved confidence for manufacturers, panel builders, and end users.

B. SECTION 2: BRIEF ASPECTS

a) Service Conditions
b Constructional Requirements
c) Protection Against Electric Shock
d) Electrical Characteristics
e) ShortCircuit Withstand Strength
f) Electromagnetic Compatibility
g) Mechanical Strength and Durability
h) Design Verification and Routine Verification
i) Documentation, Marking, and Identification
j) Internal Separation
k) Temperature Rise and Thermal Performance
l) Incorporation of Components
m) Accessibility and Maintainability

C. SECTION 3: HIGHLIGHTS Of The Standard

1. IEC 614391 defines the general requirements for lowvoltage switchgear and controlgear assemblies up to 1000 V AC / 1500 V DC, covering safety, performance, construction, and verification aspects.
2. It serves as the base standard for the entire IEC 61439 series and must always be read together with the relevant productspecific part (such as IEC 614392 for power assemblies).
3. The standard replaces the traditional switchboard concept with the term “assembly” and introduces clear definitions for assemblies, functional units, and separation, ensuring consistent interpretation across manufacturers and users.
4. Responsibilities are clearly divided between the Original Manufacturer, who is responsible for the

reference design and design verification, and the Assembly Manufacturer (panel builder), who is responsible for manufacturing and routine verification of each panel.

5. A major change is the introduction of design verification, replacing the earlier typetested and partially typetested approach, ensuring that the design complies with all safety and performance requirements before production.

6. Design verification may be carried out using testing, calculation/measurement, or design rules, depending on the characteristic being verified, with some characteristics requiring physical testing.

7. Verification must cover essential characteristics such as strength of materials, degree of protection (IP), insulation clearances and creepage distances, protection against electric shock, temperature rise, shortcircuit withstand strength, and mechanical operation.

8. Temperature rise limits ensure that all conductors and components operate within their permitted limits under rated conditions, taking into account enclosure design, ventilation, rated current, and rated diversity factor.

9. Shortcircuit performance requirements ensure the assembly can safely withstand thermal and mechanical stresses during fault conditions, including both shorttime and peak withstand currents.

10. The standard defines rated characteristics such as operational voltage, insulation voltage, rated current of the assembly, frequency, and shortcircuit ratings, all of which must be clearly declared and documented.

11. Internal separation forms (Form 1 to Form 4) are defined to improve safety, limit fault propagation, and allow safer maintenance, with the selection based on application requirements rather than being mandatory.

12. Protective bonding and earthing are mandatory, requiring all exposed conductive parts to be effectively bonded and protective conductors to be capable of carrying fault currents safely.

13. Components may be from different manufacturers, provided they are used within their specified limits and the complete assembly is covered by design verification, including any necessary derating.

14. Routine verification is required on every manufactured assembly to confirm correct construction, wiring, protective circuits, dielectric properties where applicable, and mechanical operation before the assembly is put into service.

15. Proper documentation and marking are mandatory, ensuring traceability, safe installation, operation, maintenance, and compliance with regulatory and audit requirements.

D. SECTION 4: Testing

1. **Design verification testing** is carried out on a representative assembly to prove that the design is safe and compliant with IEC 614391. These tests confirm the mechanical strength of materials, degree of protection (IP), clearances and creepage distances, protection against electric shock, correct incorporation of devices, internal wiring integrity, dielectric strength, temperaturerise limits, shortcircuit withstand capability, and electromagnetic compatibility. Design verification is normally done once for a particular design unless changes are made.
2. **Routine verification testing** is performed on every manufactured assembly before dispatch. These tests ensure correct workmanship and assembly quality. They include visual inspection, verification of wiring, functional testing of control and interlock circuits, dielectric routine testing, and continuity testing of protective earth circuits. Routine tests confirm that the finished panel matches the approved design and drawings.
3. **Special or optional tests** may be carried out when required by the customer or project

specification. These can include internal arc fault tests, seismic tests, and environmental tests such as humidity or saltmist testing. Such tests are not mandatory under IEC 614391 unless specifically agreed.

E. SECTION 5: Verification Requirements

Verification ensures that assemblies comply with all **safety and performance requirements** of the standard.

1. **Design verification** – performed once per design
2. **Routine verification** – performed on every manufactured assembly
3. **Design verification methods:**
4. Verification by **testing**
5. Verification by **comparison** with a reference design
6. Verification by **assessment** (calculations and design rules)
7. **Characteristics subject to verification:**
8. Strength of materials and parts
9. Degree of Protection (IP)
10. Clearances and creepage distances
11. Protection against electric shock
12. Incorporation of devices and components
13. Internal circuits and connections
14. Terminals for external conductors
15. Dielectric properties
16. Temperaturerise limits
17. Shortcircuit withstand strength
18. Electromagnetic compatibility (EMC)
19. Mechanical operation
20. Routine verification includes visual inspection, protective circuit continuity, dielectric withstand (where applicable), and functional checks.

F. SECTION 6: ANNEX

1. **Annex A:** Guidance on verification methods
2. **Annex B:** Temperaturerise assessment principles
3. **Annex C:** Clearances and creepage distance guidance
4. **Annex D:** Design verification examples

G. SECTION 7: Conclusion

1. IEC 61439 establishes a unified framework for the safe design, construction, and verification of lowvoltage switchgear and controlgear assemblies.
2. Its clear definition of responsibilities, verification methods, and service conditions ensures improved safety, reliability, and consistency.
3. Overall, the standard provides global harmonization and a robust basis for modern lowvoltage assembly applications.

*Disclaimer:This synopsis is summarized interpretation of IEC 614391 and does not replace the **official IEC standard**. For design, manufacturing, testing, certification, or compliance purposes, users shall always refer to the **latest published edition of IEC 614391** and any applicable local regulations. The compiler assumes no responsibility for errors, omissions, or misuse of the information contained herein.*

Contributed by:

Aryan Pramod Nomulwar
PE-Electrical Engineer
L&T Technology Services

CEEAMA Consultants meet at Mahape

Date: 30th January 2026

LK Senior Management: Mr. Apar Maheshwari
LK Team: Mr. D. S. Gharpure, Mr. Rayomand Medhora, Mr. Ritesh Ranjan, Mr. Ashishsingh Negi, Ms. Rashmi Shivrame PMM team and STL team.

Customers: Top Consultants from across Mumbai, Thane, Pune, Nasik & Navi Mumbai Chidambar Joshi, Narendra Duvedi, Indranil Ghosh, Kailas Deshmukh, Vikas Sanghavi, Pradip Chandmal Goliya, Basavaraj.M.Pavate, Jaywant Shivaji Thorat, Jyoti A Rahalkar, Viraj Jadhav, Manoj Kshirsagar, Abhijeet V Limaaye, Jivan Gangawane, Krishna S. Chandavar, Sukumar Badave, Kamakshi Badave, Rajan Varma, Subhash G Mainkar, Jitendra Pawar, Samidha Choudhari, Kishor Ayare, Satish Karhadkar, Rakesh S Gupta, Prakash Mahadeo Kanekar, Rupesh Joshi, Hemant Patil, Milind Chincholikar, Vijay Joshi, Purushottam P Karhade, Hitendra Borde, Niraj Rathod, Sarvesh Tejpal, Rucha Gramopadhye, Deepak Kumar Deep, Ajay Shah, Pardeshi Chaitanya Prabhusingh, Sharadchandra Narayan Gogate, Sarang Pande, Girish Mahajan, Dinesh Desale, Rahul Ramakant Shah

On Technology Day at Mahape, a groundbreaking success, showcasing our cutting-edge technological solutions Smartcomm to a diverse audience of 40 consultants, Energy Auditors, Panel Builders, Contractors from various industries, including Residential, Real Estate, Pharma, and Healthcare.

The event sparked valuable discussions on collaboration opportunities, optimized solutions, and cost-effectiveness, further solidifying our relationships with consultants and driving future growth.

Key Highlights and Customer Appreciations:

1. Smartcomm Platform:

- **Thermal Monitoring and Digital Twins:** These features were particularly appreciated for their advanced capabilities in monitoring and simulation. The thermal monitoring system allows for real-time tracking of temperature variations, ensuring optimal performance and safety. Digital twins provide a virtual replica of physical assets, enabling predictive maintenance and efficient management.

- **ACB and MCCB Platform:** Customers were impressed by the comprehensive platform, which supports multiple protocols and add-ons, covering a wide range of applications. The platform›s versatility and extensive range make it suitable for various applications.

- **Smartcomm Predict:** Customers appreciated the platform and the screens we made for various processes of Smartcomm PMS and prediction using AI & ML.

2. Smartcomm Design:

This aspect attracted considerable attention, with customers expressing a strong interest in detailed explanations and hands-on guidance for their current projects. They were particularly keen on using Smartcomm Design for voltage drop calculations, discrimination/selectivity, and breaker selection. Our team is ready to provide comprehensive support and training to ensure customers can fully leverage Smartcomm Design in their projects.

3. Power Quality Solutions (PQS):

The redundancy in the architecture of our PQS was highly valued by many customers, highlighting the reliability and robustness of our solutions. Redundancy ensures continuous operation and minimizes downtime, which is crucial for maintaining power quality and preventing disruptions.

4. Variable Frequency Drives (VFDs):

The detailed presentation and demo of our newly launched VFDs garnered significant interest. VFDs are essential for controlling motor speed and improving energy efficiency. Many customers requested further presentations at their respective offices to involve their teams and explore the benefits of VFDs in their operations.

5. E House:

All-electric houses offer superior energy efficiency with optimized heating/cooling systems, smart technologies, and Energy Star appliances reducing bills. Initial installation costs are higher, but long-term savings abound with lower operational and maintenance expenses. The E House was appreciated by many industry and data centre customers.

6. Switchgear Testing Laboratories (STL):

The STL session included demonstrations of our in-house capabilities, such as Short Circuit testing, Mechanical & Electrical Endurance tests, and a visit to the temperature rise setup. Customers appreciated the facilities and the detailed explanations provided by the STL team. These tests are crucial for ensuring the reliability and safety of switchgear products, and our state-of-the-art facilities demonstrate our commitment to quality.

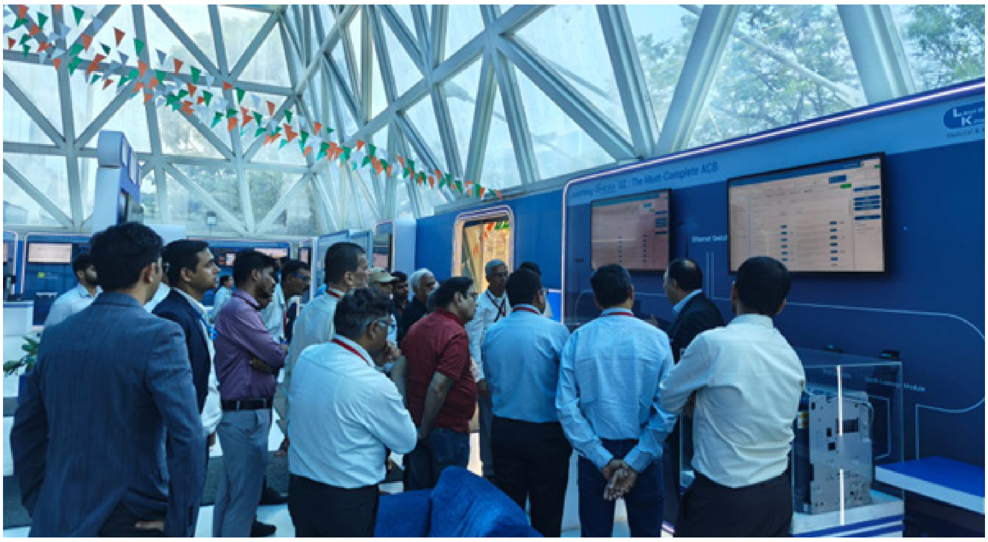
The event was concluded by High Tea & vote of Thanks by Apar sir.

Overall, Technology Day at Mahape for consultants was a great success, leaving our customers impressed with our technological advancements and eager for further collaboration. The positive feedback and enthusiastic participation from our customers highlight the impact of our innovative solutions and the potential for future growth and partnerships. Many customers expressed their interest in visiting again with their teams.

Acknowledgement:

We extend our heartfelt gratitude to our CEEAMA Team & Prabha Engineering for their invaluable guidance and support. Their collaboration with our consultants has been instrumental in showcasing Lauritz Knudsen's technological prowess.


CEEAMA



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RUPEN PATEL

KIRTI RAWAL

RADHIKA VAZE

SHARAD DHANGAR

MAHESH GHARAT

Congratulations

QUIZ - FEBRUARY 2026

1. In a power system study, the primary objective of a load flow analysis is to:
    - A. Determine short circuit current
    - B. Calculate voltage profile and power flow in the network
    - C. Size transmission lines
    - D. Select protection relay settings

2. Which IEC standard primarily covers Low Voltage switchgear assemblies?
    - A. IEC 61439
    - B. IEC 60034
    - C. IEC 60204
    - D. IEC 60947

3. The key criterion used for sizing HV cables based on thermal withstand during fault is:
    - A. Voltage drop
    - B. Short circuit rating
    - C. Derating factor
    - D. Pulling tension

4. Arc flash energy calculations are generally performed according to:
    - A. IEEE 1584
    - B. IEEE 519
    - C. IEC 60364
    - D. NFPA 79

5. Which motor starting method results in the lowest inrush current?
    - A. Direct-on-line
    - B. Star Delta
    - C. Auto transformer starter
    - D. VFD

6. In a substation, the primary purpose of a busbar differential protection is:
    - A. Overload protection
    - B. External fault clearance
    - C. Internal zone fault detection
    - D. Ground fault coordination

7. A typical earthing resistance target for large substations is:
    - A. < 15 Ω
    - B. < 5 Ω
    - C. < 1 Ω
    - D. < 0.5 Ω

8. Harmonic limits in industrial networks are defined by:
    - A. IEEE 519
    - B. IEC 60204
    - C. IEC 61850
    - D. IEEE 80

9. Which reactive power compensation device offers continuous smooth control?
    - A. Fixed capacitor bank
    - B. SVC
    - C. Feeder capacitor
    - D. Harmonic filter

10. The primary purpose of a CT knee point voltage specification is to ensure:

A. Correct ratio
B. Accuracy under load
C. Avoid saturation during faults
D. Safe installation

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 this month's QUIZ.
https://forms.gle/R46cLDkaTczsr2eS9

"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.

January 2026 Quiz Answers

1. C) Terminal voltage and internal voltage
2. C) TCSC
3. A) Increasing generator inertia
4. A) Sending end
5. A) 0
6. D) QAM
7. B) Line is long and lightly loaded
8. B) Increase in frequency
9. B) Leakage reactance and magnetizing reactance
10. C) Nuclear

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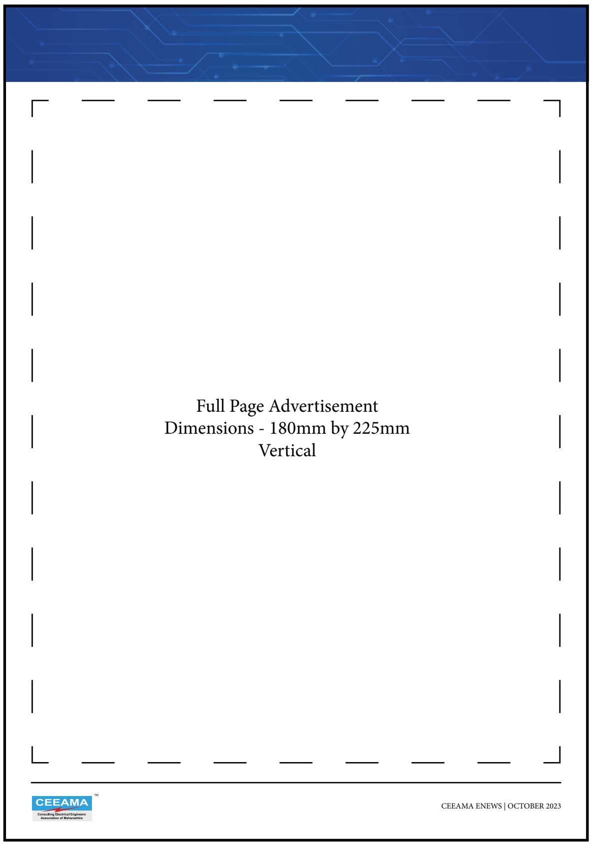

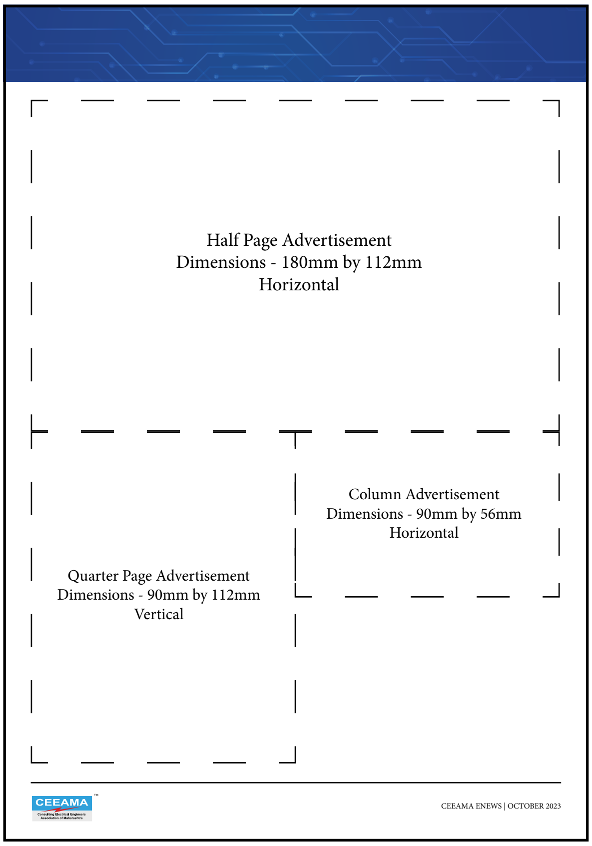

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CEEAMA Live Wire

E-NEWSLETTER

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Email: admin@ceeama.org