CORE ELECTRICAL SUPPLY · 45–60 MIN

Core Electrical Supply: From Approved Design to Energization

A system-level study of how design authority, ratings, interfaces, controlled documents, manufacturing evidence, logistics, commissioning and accountable handover turn equipment into an operable electrical system.

ORIGINAL METRO POWER PAPER

Second edition · 30 August 2026 · Review before project use

PUBLICATION CONTROL

A traceable educational edition.

This record separates publication authority from project approval. It identifies what was researched, what remains limited and when the source base must be reviewed again.

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NEXT SOURCE REVIEW

30 August 2027 or earlier if a controlling issuance changes

Earlier if a controlling issuance changes

ABSTRACT

What this paper examines.

This paper explains how approved design information becomes safely rated, documented, delivered, commissioned and supportable electrical equipment. It focuses on equipment boundaries, ratings, interfaces, document authority, manufacturing evidence, logistics, commissioning and handover rather than presenting a generic product catalog.

IN SCOPE

- Transformers, switchgear, instrument transformers, enclosures and supporting equipment
- Design-to-procurement-to-commissioning evidence chain
- Document, interface and handover control

LIMITATIONS

- Does not replace the approved single-line, protection study, specifications or licensed design
- Applicable IEC, IEEE, Philippine and utility requirements depend on equipment and project scope
- Catalog similarity is not proof of configuration compliance

PHILIPPINE APPLICABILITY AND SOURCE AUTHORITY

Guidance, drafts and controlling authorities are not interchangeable.

AUTHORITY · Energy Regulatory Commission

INSTRUMENT ·

Philippine Distribution Code

STATUS · **Philippine primary industry code · confirm controlling edition**

USE ·

Distribution planning, connection, operation and revenue-metering context

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AUTHORITY · IEC

INSTRUMENT ·

IEC 61439-1:2020

STATUS · **Published international standard**

USE ·

General rules for low-voltage switchgear and controlgear assemblies

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AUTHORITY · IEC

INSTRUMENT ·

IEC 60076 series

STATUS · **Published international standards · select applicable part and edition**

USE ·

Power-transformer requirements and tests

AUTHORITY · IIEE

INSTRUMENT ·

Philippine Electrical Code

STATUS · **Authorized national code publication · obtain controlling edition**

USE ·

Electrical installation requirements and professional review context

ACRONYMS AND WORKING TERMS

Use the same language at every decision gate.

BOQ	Bill of Quantities	**FAT**	Factory Acceptance Test
ITP	Inspection and Test Plan	**SAT**	Site Acceptance Test
SLD	Single-Line Diagram	**TDS**	Technical Data Schedule

REVISION HISTORY

What changed and when.

1.0	28 August 2026	Initial public web edition
2.0	30 August 2026	Research, technical-writing and editorial-control upgrade

SUGGESTED CITATION

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LEARNING OBJECTIVES

What you should be able to explain after reading.

01	Identify the approved design basis and controlling revision
02	Coordinate ratings and interfaces across major electrical equipment
03	Build evidence gates from submittal through production and delivery
04	Define commissioning and handover as part of the supply decision

FLAGSHIP TECHNICAL EDITION

Core electrical supply from design intent to safe energization

This paper connects studies, ratings, equipment interfaces, controlled documents, manufacturing, logistics, installation, commissioning and lifecycle support.

9 chapters **12 original figures** **3 worked cases** **45–60 minute study**

THE EQUIPMENT ARRIVED. THE SYSTEM STILL CANNOT ENERGIZE.

A switchboard can match its purchase order and still fail the project.

The transformer impedance in the approved study changed after the switchgear was ordered. The breaker interrupting rating was never rechecked. The cable entries conflict with the actual trench. Protection settings are missing. Factory tests passed at component level, but nobody owns the integrated sequence. Core electrical supply is not product delivery. It is the controlled translation of design intent into compatible equipment, installed interfaces and witnessed operating evidence. Nameplates matter. So do the studies, revisions, drawings, settings, logistics conditions and people that make those nameplates function together.

> A project is ready to energize only when equipment, interfaces, documents and operating responsibility agree.

01

DESIGN BASIS

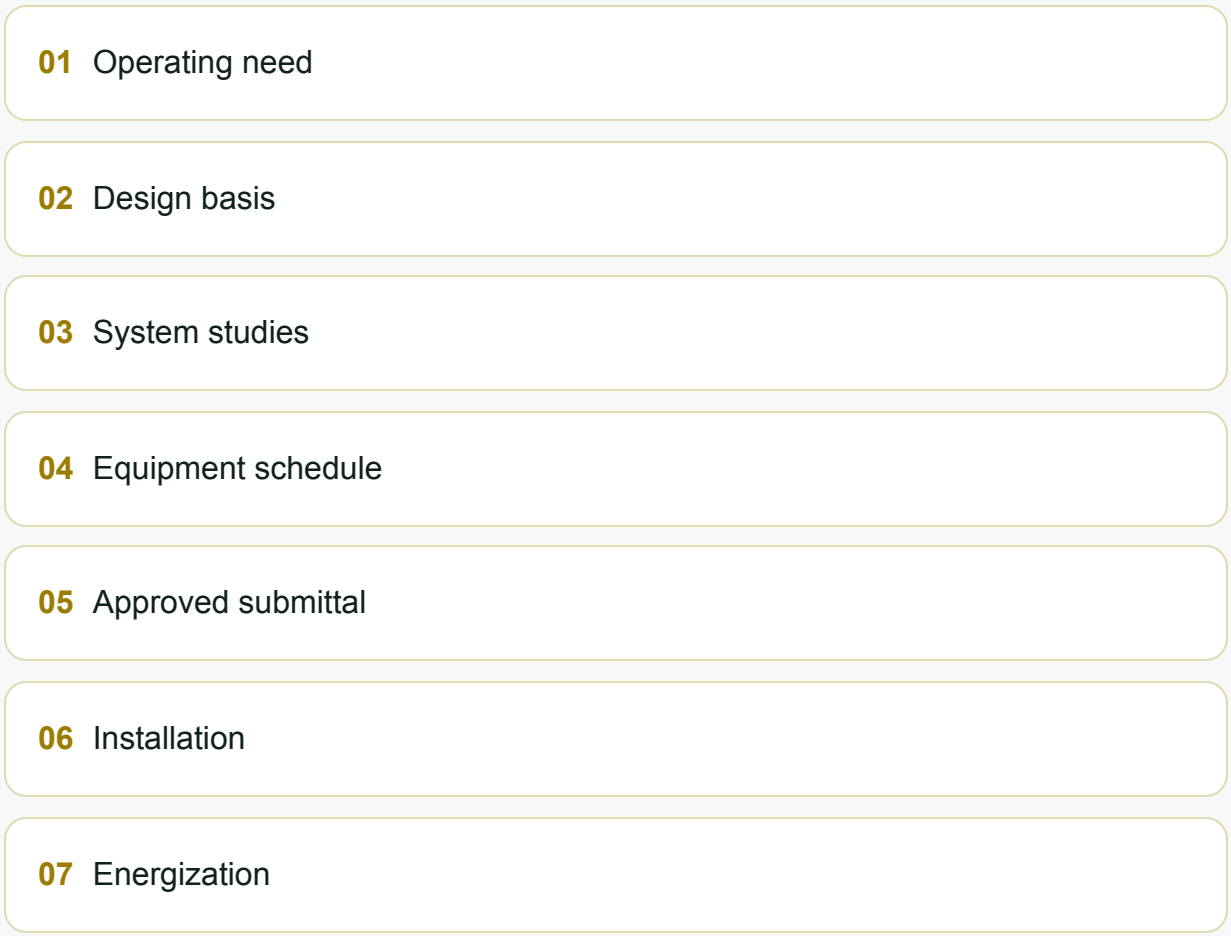
Begin with the system the equipment must serve.

The design basis records supply voltage and frequency, normal and contingency operating arrangements, load characteristics, growth, fault levels, grounding, environmental conditions, reliability targets, applicable codes and utility requirements. Load flow, short-circuit, protection-coordination, voltage-drop, grounding and other project studies translate that basis into equipment duties.

A product schedule without the study basis is incomplete. The same nominal voltage can hide different insulation, fault, earthing and protection requirements. The supplier should know which values are final, which are provisional and who has authority to approve changes.

FIGURE 1

Design intent becomes equipment duty through controlled studies



How to read this figure. Each arrow is a decision interface. A changed input can affect downstream ratings, settings, cost and schedule.

ENTRY GATE

Do not finalize selection until the controlling design basis, study values, applicable standard and approval authority are known or visibly classified as open.

02

RATINGS AND COORDINATION

A system is limited by its weakest applicable duty.

Voltage, continuous current, short-time withstand, interrupting capacity, making capacity, insulation level, temperature rise, enclosure, internal arc classification where required, mechanical duty and environmental performance answer different questions. A single “rated for 13.8 kV” statement cannot establish system suitability.

Protection devices must interrupt expected faults within their rated capability and coordinate with upstream and downstream devices according to the approved philosophy. Transformers influence fault current through impedance. Conductors and busbars must withstand thermal and mechanical stress for the clearing time. CT performance must support metering and protection functions without inappropriate saturation.

FIGURE 2

Ratings form a coordinated envelope

VOLTAGE

system maximum and insulation

CURRENT

continuous load and temperature

FAULT

withstand and interruption

ENVIRONMENT

heat, moisture, altitude, pollution

OPERATION

duty, interlocks, maintenance

How to read this figure. The operating point must remain inside every relevant boundary. Verify exact definitions and test bases under the controlling standard.

WORKED CASE 01

Transformer impedance changes the fault duty

A replacement transformer has the same kVA and voltage ratio but lower percent impedance than the study model.

01 Lower impedance can increase available secondary fault current, subject to the complete source network.

02 The change may affect switchgear interrupting duty, bus withstand, protection coordination and arc-flash analysis.

03 Submit the exact impedance and tolerances to the responsible engineer before approval.

04 Update affected studies, settings and documents through formal change control.

LESSON

“Same kVA” does not mean “same system behavior.”

03

INTERFACE ENGINEERING

Most integration risk lives between packages.

Transformer terminals must align with cable or bus interfaces. Switchgear control voltage must match station supply. CT ratios and classes must serve the connected relays and meters. Protection trips, permissives and interlocks must cross panels correctly. Physical interfaces include dimensions, weights, lifting points, clearances, cable bending radius, gland plates, foundation loads and access routes.

An interface-control document should name the boundary, exchanged information or power, ratings, drawings, connector or terminal details, owner, due date, test and acceptance evidence. “By others” is not an owner; it is an unresolved boundary.

FIGURE 3

Four interface classes must align

How to read this figure. Electrical compatibility alone does not guarantee that equipment can be installed, controlled or maintained.

FIGURE 4

Responsibility should reach acceptance

Boundary	Design	Supply/install	Accept
Transformer–switchgear	System engineer	OEMs and contractor	Commissioning authority
Relay–breaker	Protection engineer	Panel integrator	Witnessed trip test
Equipment–foundation	Civil/electrical team	Contractor	Dimensional inspection
Asset–operations	Owner/operator	Supplier and project	Handover review

How to read this figure. The same boundary can involve different parties at design, supply, installation and test. Assign every stage.

04

DOCUMENT AND DEVIATION CONTROL

The controlling revision must be knowable.

A robust register records title, number, revision, issuer, date, approval status, confidentiality, storage reference and supersession. A file with the newest timestamp is not necessarily approved. A drawing marked “for construction” does not automatically supersede a contract document unless authority and precedence establish it.

Deviations should state the requirement, proposed difference, reason, technical and commercial effect, affected interfaces, evidence, responsible reviewers and disposition. Approval of one deviation should not be stretched to cover adjacent changes.

FIGURE 5

Documents move through controlled states

How to read this figure. Only authorized status and revision determine use. Draft and unverified copies can inform review but cannot silently control work.

WORKED CASE 02

Two single-line diagrams disagree

A contractor holds Revision C by email; procurement attached Revision B to the purchase order.

01 Inventory both documents, issuers, dates, approval marks and contractual references.

02 Identify the changed clauses or equipment duties and all affected work.

03

Do not assume Revision C controls because it is newer.

04

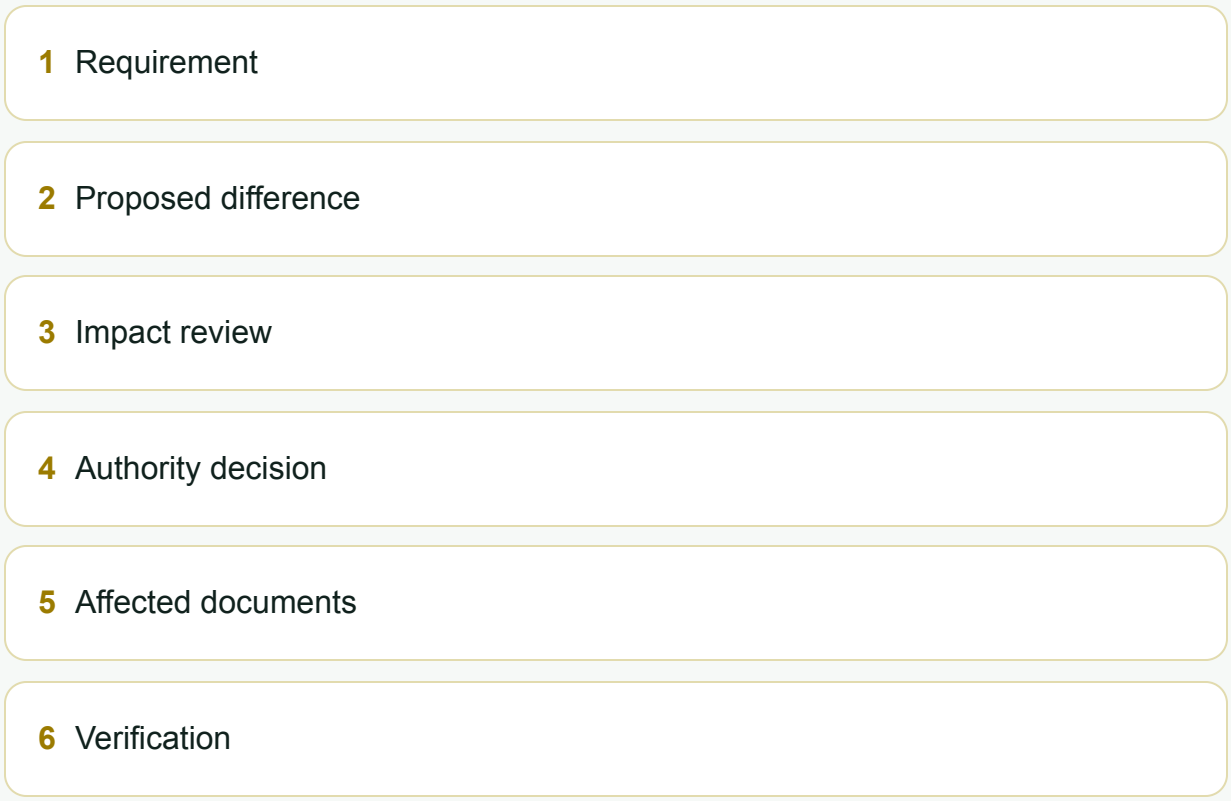
Request written confirmation from the authorized owner and process resulting commercial or technical change.

CONCLUSION

Until authority is established, controlling status is unknown and affected commitments should be held.

FIGURE 6

A deviation needs a visible disposition



How to read this figure. The record should preserve the original requirement and show who accepted the consequence.

05

SUBMITTALS AND MANUFACTURING EVIDENCE

Evidence must match the exact offered configuration.

Datasheets, general arrangement drawings, schematics, bills of material, calculations, certificates, type-test reports, routine-test procedures, quality plans and inspection plans serve different purposes. Match each claim to the exact model, rating, standard, revision and configuration. A catalogue family image does not prove the offered assembly.

The inspection and test plan should name hold, witness and review points; procedure; acceptance criteria; responsible parties; records; and treatment of nonconformity. Factory acceptance testing proves agreed functions within the factory setup. It does not prove site cabling, utility conditions or integrated operation.

FIGURE 7

Evidence grows from claim to installed proof

How to read this figure. Procurement confidence rises as evidence becomes more exact and system-specific.

EVIDENCE RULE

If a certificate or test report does not explicitly cover the exact offered product, record the gap. Obtain written manufacturer confirmation rather than inferring coverage.

06

LOGISTICS AND SITE READINESS

Delivery conditions can change equipment condition and schedule.

Heavy electrical equipment requires route, lifting, unloading, storage, preservation and inspection planning. Confirm shipping dimensions and weight, center of gravity, lifting points, road and gate limits, crane position, floor loading, weather protection, shock or tilt indicators where used, and manufacturer storage requirements.

Site readiness should precede dispatch: foundations accepted, access clear, receiving team assigned, storage prepared, installation drawings approved and shortages resolved. On receipt, inspect packaging, identity, quantity, impact or moisture indicators, visible damage and accessories before accepting custody exceptions.

FIGURE 8

The shipment passes through risk gates

How to read this figure. Evidence at each custody transfer helps distinguish factory, transit, receiving and storage issues.

INSTALLATION AND COMMISSIONING

Energization is the final stage of a controlled sequence.

Installation verifies foundations, alignment, torque, clearances, cable preparation, grounding, control wiring, cleanliness and environmental protection against approved instructions. Pre-commissioning may include insulation and continuity tests, ratio and polarity checks, breaker mechanical operation, relay configuration, interlock checks and auxiliary supply verification as applicable.

Functional commissioning should move from isolated components to integrated sequences: local operation, remote control, permissives, trips, alarms, metering, communications, loss-of-supply behavior and restoration. Energization requires an approved plan, roles, switching authority, boundaries, readiness checklist, communications and contingency response.

FIGURE 9

Commissioning expands the tested boundary

How to read this figure. Skipping directly to an energized test makes diagnosis and safety control harder. Each gate should close its own exceptions.

WORKED CASE 03

A breaker opens locally but not from protection

Mechanical tests passed, yet the relay trip test does not open the breaker.

01 Confirm test boundaries and safe condition.

02 Trace relay output, test switch, wiring, trip-coil supply, interposing devices and breaker circuit.

03 Compare physical wiring and terminal numbers with the approved schematic.

04

Correct through controlled redline and retest the complete trip path, alarms and records.

LESSON

Component operation did not prove the protection interface. Integrated testing did.

08

HANDOVER AND LIFECYCLE

The owner inherits a system, not a delivery receipt.

Handover should include approved as-builts, settings, test records, certificates, manuals, asset register, spare-parts list, special tools, warranties, training, maintenance tasks, support contacts and open-item disposition. Documents should be searchable, revision-controlled and mapped to physical tags.

Lifecycle planning considers inspection, preventive maintenance, condition monitoring, consumables, firmware or relay-setting governance, spares obsolescence, warranty response and end-of-life replacement. A system that cannot be safely maintained is not fully delivered.

FIGURE 10

Handover transfers five capabilities

KNOW

training and operating limits

SEE

drawings, settings and records

ACT

procedures, authority and tools

RESTORE

spares and escalation

IMPROVE

maintenance and lifecycle data

How to read this figure. Documents alone are insufficient if the owner lacks authority, knowledge, tools or support.

09

PROCUREMENT AND DECISION GATES

Buy technical certainty in stages.

A disciplined procurement package contains the design basis, technical schedule, drawings, interface requirements, standards, submittal register, deviation process, quality and test requirements, documentation, delivery, installation boundaries, commissioning, training, warranty and commercial schedule. Evaluation separates compliance from preference and flags every dependency.

Release gates protect the project: bid basis confirmed, technical submittal approved, drawings frozen for manufacture, FAT exceptions closed, site ready for dispatch, receipt accepted, pre-commissioning complete, energization authorized and handover accepted. The project should never advance merely because calendar pressure made the unresolved item inconvenient.

FIGURE 11

Evidence gates control irreversible commitment

How to read this figure. As cost and reversibility decrease, the evidence threshold should rise.

FIGURE 12

The executive evidence ledger

VERIFIED FACTS

approved and traceable

ASSUMPTIONS

visible and tested

MISSING DATA

owner and due date

PRINCIPAL CONFIRMATION

exact written commitment

MANAGEMENT APPROVAL

commercial and residual risk

How to read this figure. Every important decision should expose what is known, assumed, missing, awaiting principal confirmation and reserved for management approval.

PROJECT REFERENCE

Minimum design and supply inputs.

These are decision inputs, not a substitute for project-specific engineering.

01

System basis

Nominal and maximum voltage, frequency, source and contingency arrangements, grounding, load profile, power factor, future growth, environmental conditions and reliability objective.

02

Study duties

Approved load-flow values, available fault current and X/R basis, protection philosophy, clearing time, voltage-drop limits, grounding results and any harmonic or motor-starting duty.

03

Equipment schedule

Continuous, short-time, interrupting, insulation, thermal, mechanical and environmental ratings; auxiliaries; interfaces; maintainability; spare policy; and exact applicable standard.

04

Physical coordination

General arrangements, foundations, weights, lifting, access, ventilation, cable entry and bending, bus or terminal interface, transport envelope and installation tolerances.

05

Control and protection

CT/VT data, relay functions, trip matrix, interlocks, control voltage, communication points, time synchronization, setting authority, cybersecurity boundary and fallback behavior.

06

Delivery evidence

Submittal register, deviation log, quality plan, inspection and test plan, approved drawings, type and routine evidence, FAT, logistics plan, site readiness, SAT and handover index.

FAILURE REFERENCE

Interface failures that product compliance alone cannot prevent.

Each example requires cross-package evidence and a named owner.

01

Fault duty exceeds rating

A source or transformer change increases available fault current beyond the assumptions used for switchgear. Control: rerun affected studies before approval and verify interrupting and withstand duties.

02

Protection does not trip the breaker

The relay function is correct but control voltage, test switch, wiring or trip coil interrupts the path. Control: test the end-to-end trip circuit and record every interface.

03

Equipment cannot be installed

Cable entry, access route, lifting capacity, foundation or clearances conflict with the delivered arrangement. Control: complete multidisciplinary drawing review and site verification before manufacture and dispatch.

04

Approved drawing is not controlling

A later file exists but authority and contractual precedence are unclear. Control: classify status as unknown, identify affected commitments and obtain issuer confirmation.

05

FAT passes, site sequence fails

Factory scope proves the assembly but excludes external sensors, SCADA, protection or utility signals. Control: distinguish FAT from SAT and integrated commissioning in the test plan.

06

Handover cannot support operation

Settings, as-builts, credentials, spares or training are incomplete. Control: treat operational capability as an acceptance gate, not an administrative closeout item.

WORKING GLOSSARY

Terms to use precisely.

Design basis

The controlled assumptions, requirements and operating conditions from which engineering decisions are made.

Available fault current

The prospective current at a point for a defined network condition; the study basis and X/R characteristics matter.

Interrupting rating

A switching device capability to interrupt specified fault current under defined standard conditions.

Short-time withstand

The ability of equipment to carry fault current for a stated duration without unacceptable damage.

Insulation coordination

Selection of insulation strength and protective levels in relation to expected overvoltages and system characteristics.

Selectivity

Coordination intended to isolate the affected part of a system while preserving unaffected service, within the approved protection philosophy.

Hold point

A defined stage where work cannot proceed until the designated authority releases it.

Witness point

A stage offered for observation; the governing plan determines whether work may proceed if the witness does not attend.

FAT

Factory acceptance testing of agreed functions within the factory test boundary.

SAT

Site acceptance testing after installation, including site-specific interfaces within the agreed scope.

As-built

The authorized record of the installation as actually completed, including approved changes.

Punch item

A documented incomplete or nonconforming item with classification, owner, due date and acceptance consequence.

APPLY THE PAPER

Questions for a real electrical-supply decision.

01 Which design basis, studies and revisions control today?

02 What exact system duty does each rating address?

03 Who owns every power, control, physical and information interface?

04 Which deviations remain open and who has authority to accept them?

05 Does evidence cover the exact offered configuration?

06 Is the site ready to receive, preserve and install the equipment?

07 What integrated tests prove protection and operating sequences?

08 Can the owner operate, maintain and restore the system after handover?

SOURCE REGISTER

Primary references for continued study.

This is an original Metro Power synthesis. Confirm the applicable Philippine rules, utility requirements, project specifications and exact standard editions with qualified professionals.

01

IEC 62271 series: High-voltage switchgear and controlgear

International Electrotechnical Commission

Standards catalogue for high-voltage switchgear; confirm applicable part and edition.

Open source ↗

02

IEC 60076 series: Power transformers

International Electrotechnical Commission

Standards catalogue for power transformers.

Open source ↗

03

IEC 60947 series: Low-voltage switchgear and controlgear

International Electrotechnical Commission

Standards catalogue for low-voltage equipment.

Open source ↗

04

IEEE C37 standards collection

IEEE Standards Association

Official standards catalogue for switchgear, protection and related systems.

Open source ↗

05

Philippine Electrical Code

Institute of Integrated Electrical Engineers of the Philippines

National electrical-code publication context; obtain the controlling authorized edition.

Open source ↗

06

National Grid Code and Distribution Code resources

Energy Regulatory Commission Philippines

Official regulatory resources; verify applicability and current issuance.

Open source ↗

SECOND-EDITION TECHNICAL REVIEW

Second-edition evidence review: ratings, interfaces and energization authority

Electrical equipment becomes a system only when ratings, interfaces, documents, installation and commissioning evidence agree with the approved design basis.

01

System voltage, frequency, fault level, earthing, environment, load duty, protection philosophy and expansion assumptions must be approved before product selection.

02

Transformer terminals, switchgear cable entries, CT/VT circuits, protection contacts, auxiliary supplies, communications and physical clearances cross supplier boundaries.

03

Approved submittals, factory evidence, receiving inspection, installation records, site tests, settings and as-builts each prove a different boundary.

The equipment schedule should state the decision evidence, not only the item description.

Package

Transformer

Controlling inputs

Capacity, ratio, vector group, impedance, losses and environment

Key interface

Protection, cables, neutral and foundation

Acceptance evidence

Approved drawing, FAT and site tests

Package

Switchgear

Controlling inputs

Voltage, continuous current, fault duty and protection scheme

Key interface

Bus, cables, relays, interlocks and control power

Acceptance evidence

Design verification, FAT, settings and functional tests

Package

Instrument transformers

Controlling inputs

Ratio, burden, accuracy, insulation and application

Key interface

Meter or relay circuit and grounding

Acceptance evidence

Certificates, polarity/ratio tests and secondary injection

Package

Enclosures and meter bases

Controlling inputs

Form, terminals, conductor, sealing and environment

Key interface

Meter, service conductors and mounting

Acceptance evidence

Dimensional review, inspection and fit check

Package

Documentation

Controlling inputs

Approved revision and deviation status

Key interface

Every package and field record

Acceptance evidence

Master index, as-builts and handover register

WORKED EVIDENCE CASE

Why equal kVA does not make two transformers interchangeable

A project calls for a 500 kVA transformer. A substitute has the same capacity and voltage ratio but a different impedance and vector group.

- Capacity and ratio alone do not define fault current, voltage regulation or system phase relationship.
- Different impedance can change available fault current and protection coordination.
- Different vector group can make parallel operation or downstream phasing unacceptable.
- Dimensions, terminals, losses, temperature rise, noise and accessories may affect the approved installation.
- The substitute requires a documented deviation review against the complete technical schedule and studies.

DECISION LESSON

A product match is established against the controlled design basis and interfaces, not a single headline rating.

FAILURE-MODE REVIEW

What to challenge before commitment.

Correct equipment is built to the wrong requirement

Evidence: Transmittal, revision and approval register

Equipment duty may be inadequate or unjustified

Evidence: Approved fault study and rating schedule

Installation and system interfaces remain unproven

Evidence: SAT, functional tests and as-built record

Owner cannot operate or recover the system

Evidence: Controlled configuration and access handover

VERIFIED CONTEXT

- The Philippine Distribution Code establishes distribution planning, connection, operation and revenue-metering context
- Applicable electrical work requires the controlling Philippine and authority requirements

VERIFY FOR THE PROJECT

- Current code edition and project authority
- Utility-specific design and equipment approval
- Environmental, building, fire, electrical and local permit pathway
- Exact IEC or IEEE part and edition for each equipment package

PROJECT GATE

Do not release for production until approved drawings, technical schedules, deviations, interface ownership, tests and document status are reconciled.

Educational publication only. This paper does not certify equipment, establish project compliance, replace professional engineering or guarantee performance, savings, approval or commercial outcome. Confirm the controlling TOR, current regulations, site data, selected configuration and responsible authority before procurement, installation or operation.