Industry NAVIGATOR

SUSTAINABLE DEVELOPMENT STRATEGIES FOR T&D

CONFERENCE 2025

Various Aspects of Harmonization of Specifications of Transformer Bushings

BY

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Yash Highvoltage Ltd. – Vadodara, India

Date: 10 April 2025

YASH HIGHVOLTAGE

Introduction

- Independent high voltage and high current transformer bushing manufacturer.
- Manufacturing and supplying bushings over two decades.
- 40,000+ bushings performing satisfactorily globally.
- On December 19, 2024, Yash® proudly celebrated successful IPO listing.

60+
Global installation

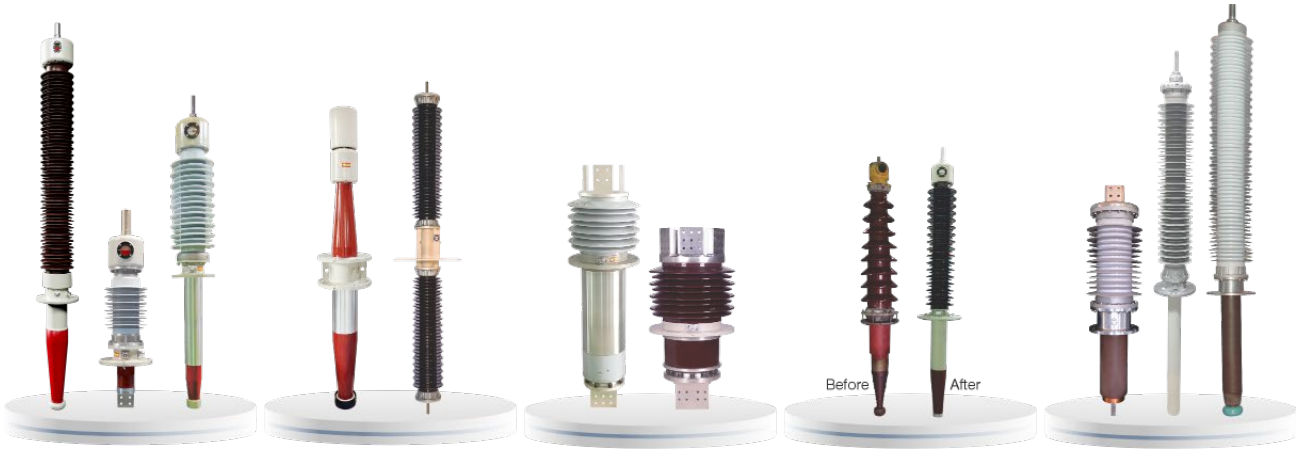
140+
Standardized mode type tests

120+
End user approvals

130+
Of combined experience in transformer bushings technology

150+
OEM served

25000 A
Highest current rating supplied



Bushing : Essential , Major & Critical Components of Transformer

- Growth in energy sector – growth in transformers market – quick availability of reliable and efficient bushings is a necessity.

- Quick availability of bushings
  - Sustainable supply chain : from “made to order” to “made to stock”.
  - Strategy: standardisation and harmonisation of specifications of transformer bushings.

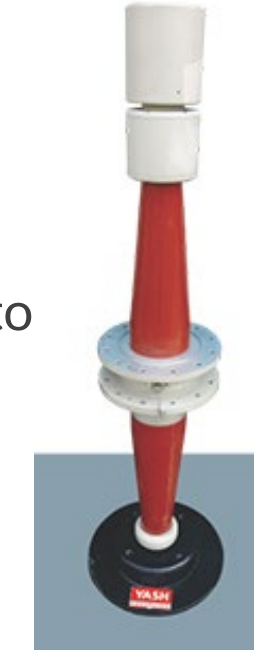
“Various aspects of harmonization of specifications of transformer bushings”

Transformer Bushing Types

Types of condenser graded bushings – used on transformers (transformer bushings)

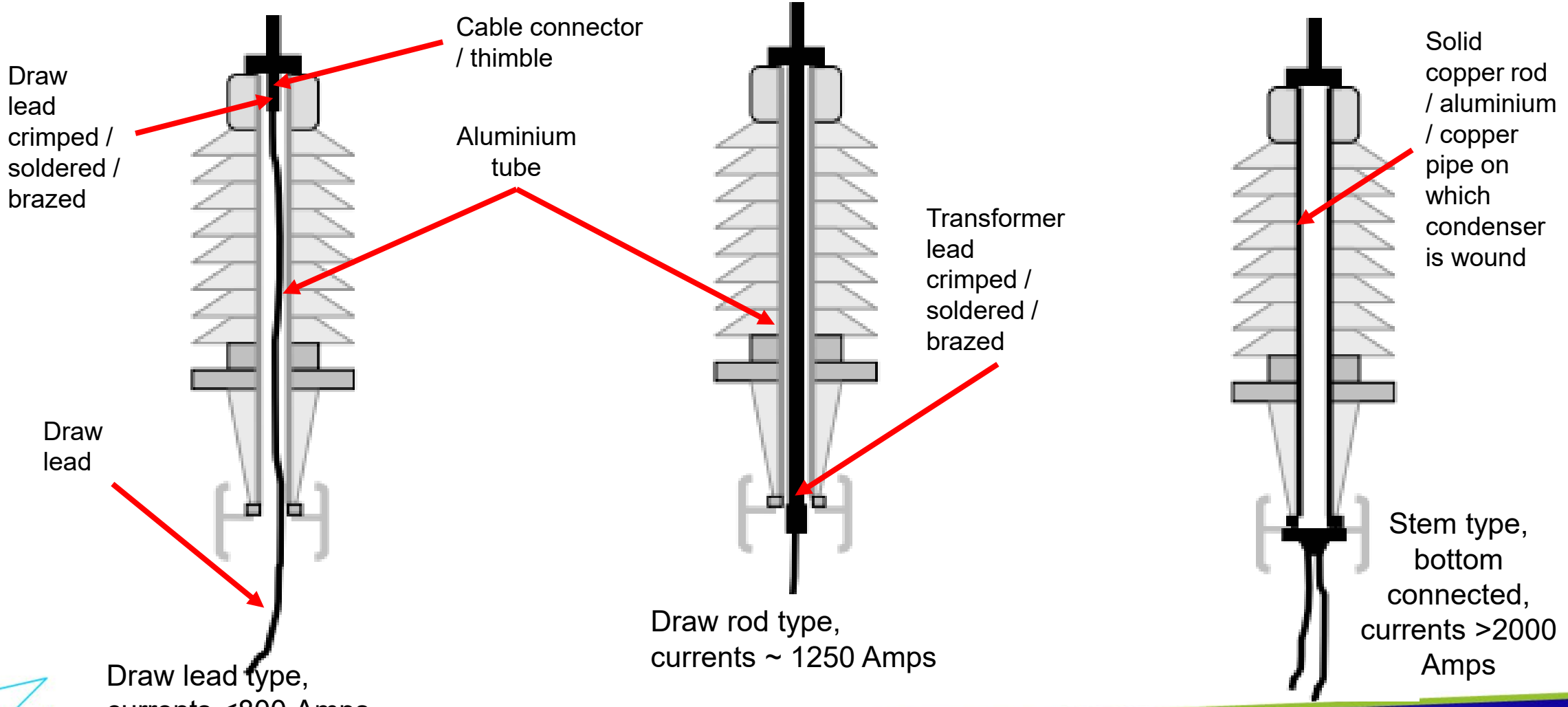
Air to oil
(currents up to
3150 Amps)

Oil to oil
(currents up to
3150 Amps)



Air to oil
(currents up to
40000 Amps)
GSU-transformers

Types Based on Current Carrying Paths

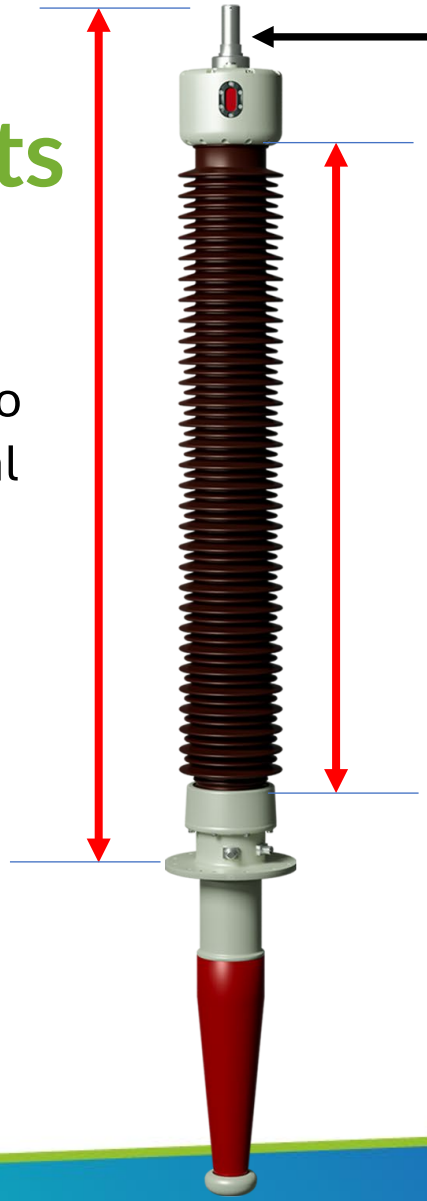


Major Parameters

Electrical Specifications:

- Rated voltage & frequency
- Rated current
- Insulation levels (one min AC, lightning impulse, switching impulse)
- Rated thermal short time current & rated dynamic current

Dimensional Requirements



HV terminal diameter & length

Mounting flange to top of HV terminal

Arcing distance (flange to flange)

Total creepage distance (along the insulator sheds between HV and earth)

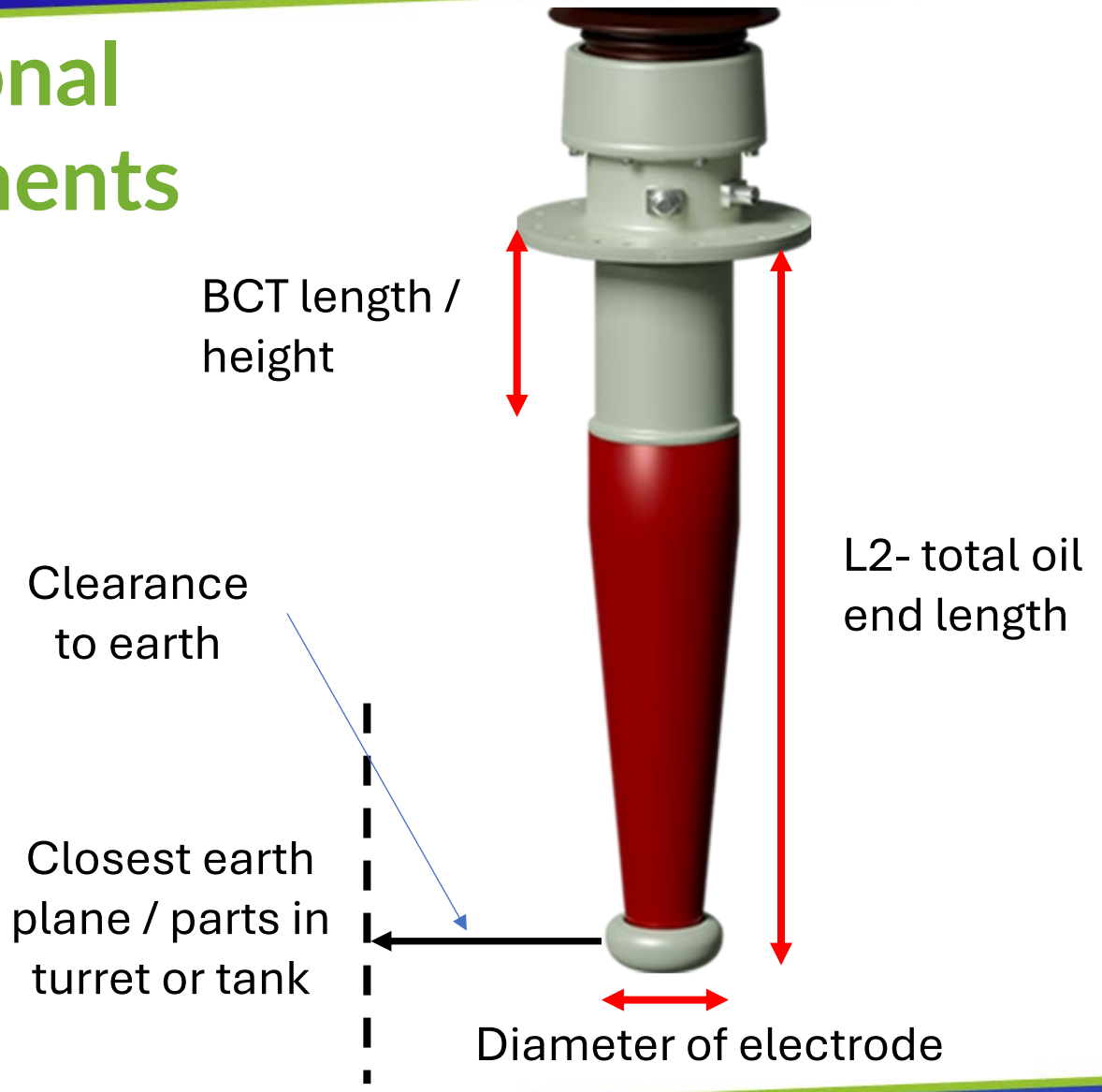
Air End Dimensions

Mounting flange

- No. of holes
- Hole diameter (Screw Size)
- PCD of holes
- OD of mounting flange
- thickness of mounting flange

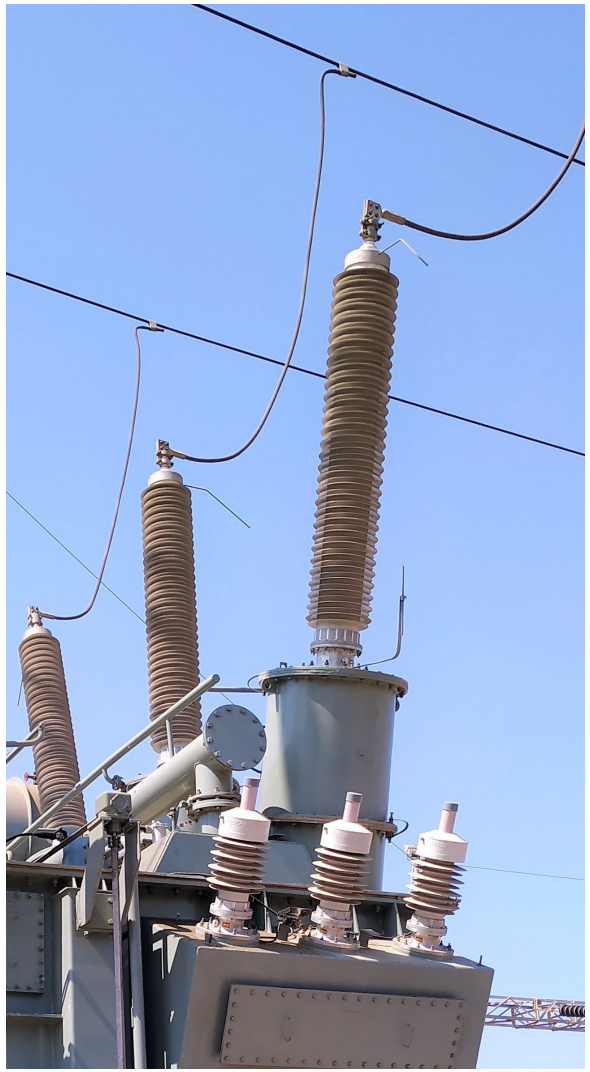
Dimensional Requirements

Oil End Dimensions



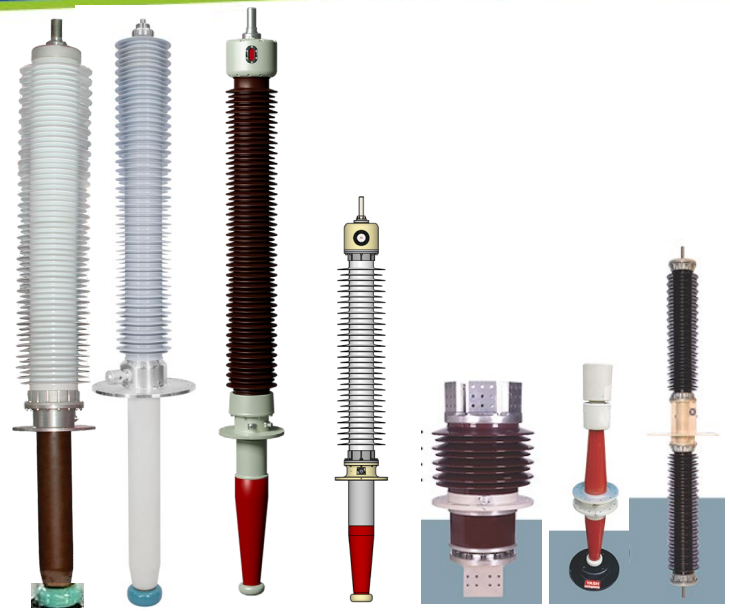
Site Usage Requirements

- Angle of mounting
- Minimum withstand cantilever load
- Altitude of mounting
- Ambient temperature range
- Temperature rise limits
- Seismic withstand
- Pollution requirements

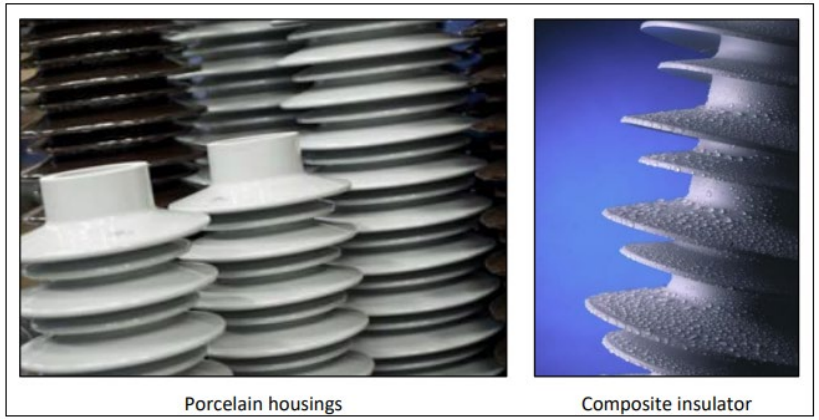


Varieties – Based on User Specifications / Insulation Technologies / Historical Requirements

Varieties



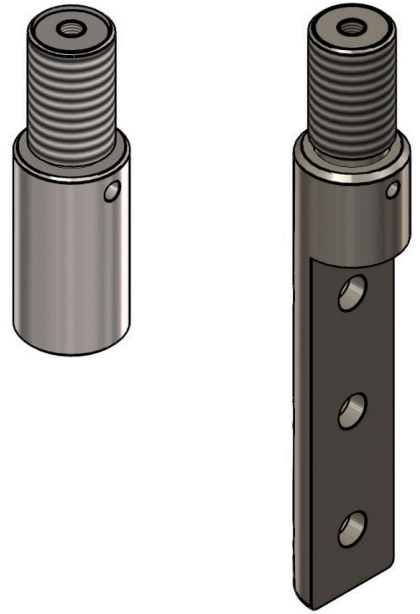
- Insulation –
  - OIP
  - RIP
  - RIS
  - RIF
  - RIG
- Insulator & total creepage distance
  - Porcelain
  - Polymer / composite
  - Total creepage distance – 25 mm/kV, 31 mm/kV, 40 mm/kV



Varieties (Current Rating & Current Carrying Parts)

- **Current Ratings:**
  - 800 A
  - 1250 A
  - 2000 A
  - 3150 A

- **HV Terminal material & sizes**
  - Defined by standards.
    - Usually copper.
  - Industry standard

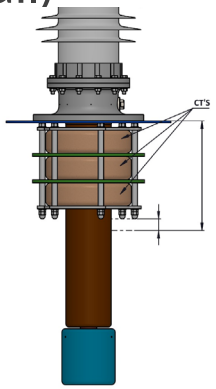


- **Transformer Lead connections:**
  - Draw lead (thimble-cable connector).
  - Draw rod (full draw rod / split draw rod).
  - Bottom connected.

Varieties (Dimensional Requirements& Applicable Standards)

- **Applicable product standard**
  - national standard e.g., is 12676
  - international standard – e.g., IEC 60137, IEEE C57.19.00/01, CLC/TS 50458, etc.
  - End User / utility's own specification.

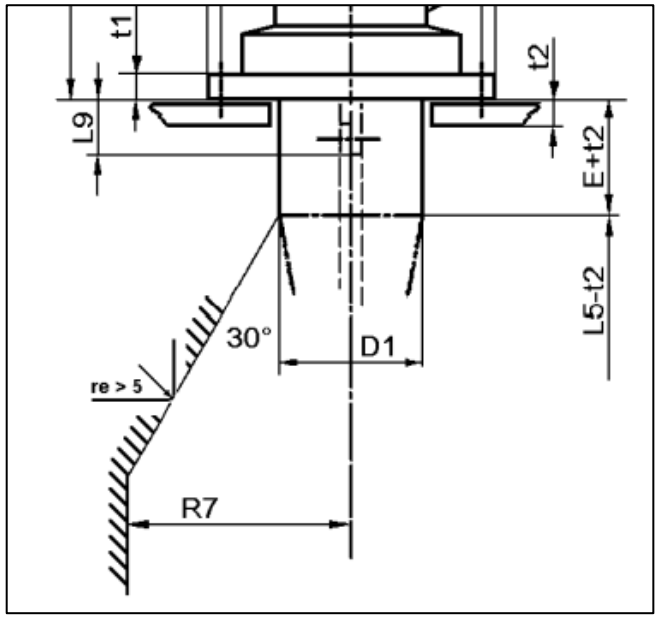
- **Oil End Length**
  - As per IEEE C57.19.01 or CLC/TS 50458 or IS 12676
  - End user / utility specifications (e.g., short tail)



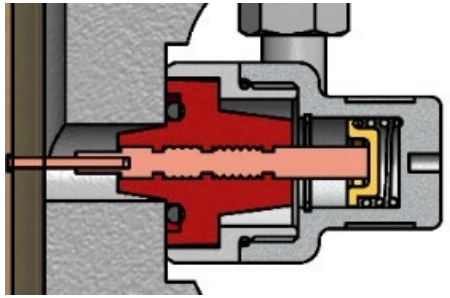
- Bushing CT Lengths
  - 0 mm
  - 100 mm / 300 mm
  - 400 mm / 500 mm
  - 534 mm / 584 mm / 600 mm

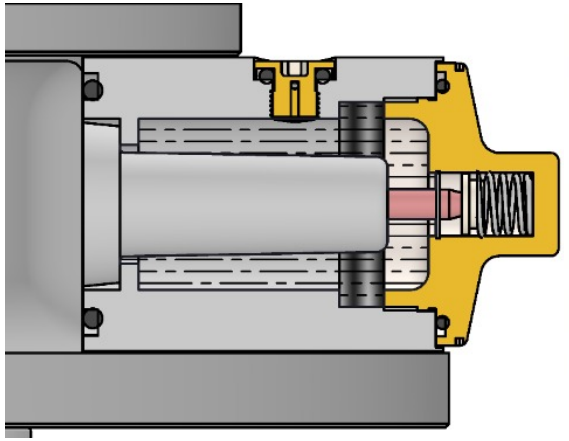
Varieties (Usage)

- **Oil end clearance (between HV and Earth):**
  - Only CLC/TS 50458 specifies it
  - Otherwise, bushing manufacturers recommend it



- **Immersion medium (oil in transformer)**
  - Mineral oil
  - Natural ester oil
  - Synthetic ester oil

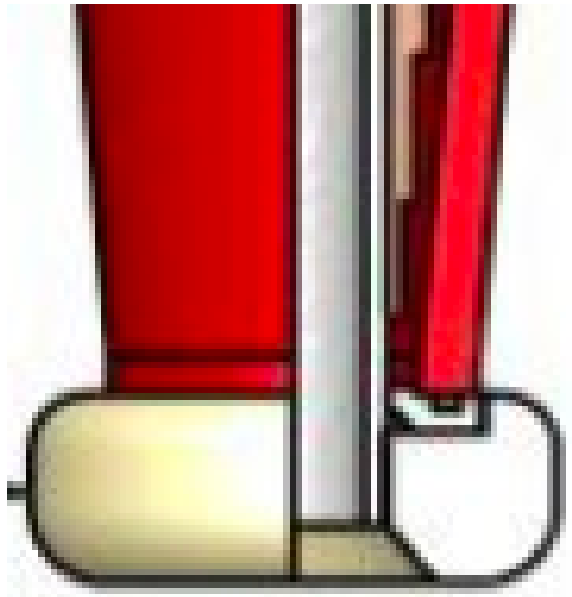


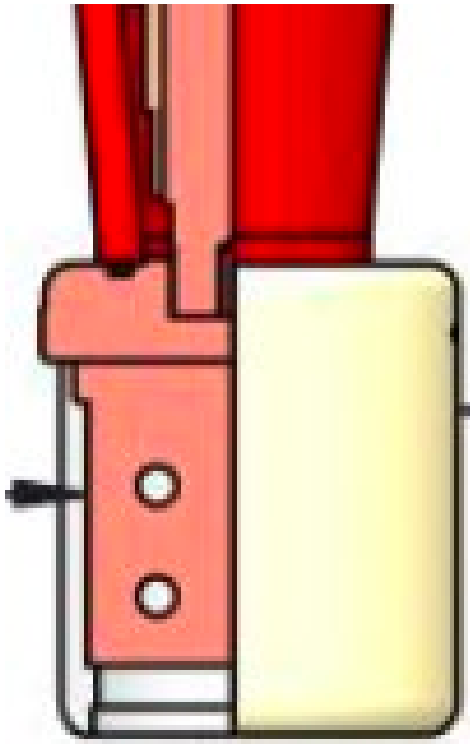


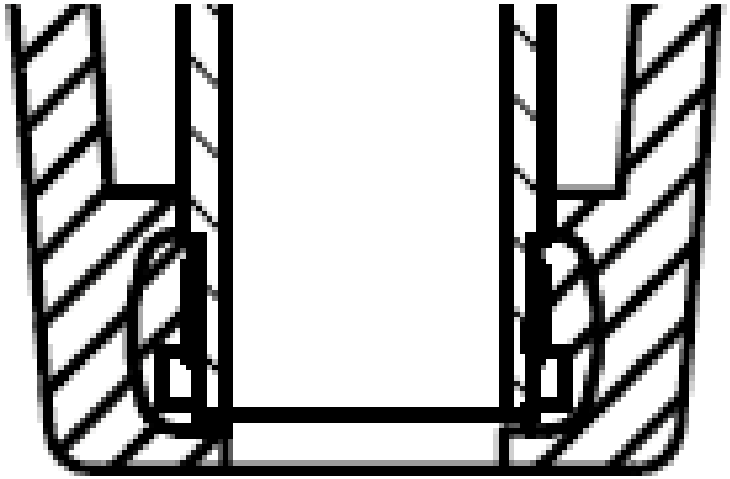
- **Measurement tap:**
  - Test tap
  - Voltage tap
  - Dimensional standardisation for standardisation of adopters for online monitoring

Varieties (Product Design)

- Oil end electrode

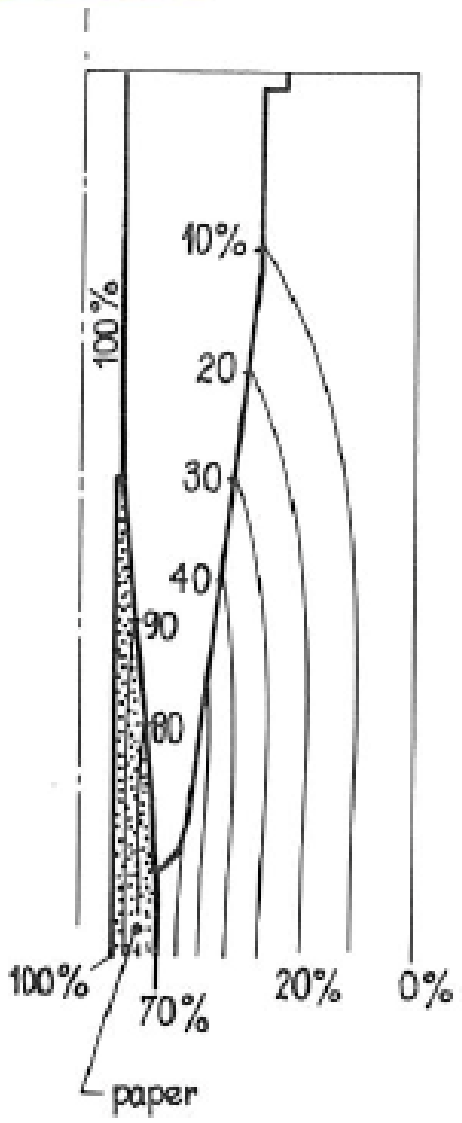






Varieties (Product Design)

- Re-entrant type bushings
  (shorter oil end length)



Product Standards (National and International)

Product Standards: Specifications

- Electrical specification requirements (kV Classes etc.)
- Dimensional requirements (air end, oil end)
- Environmental requirements (temperature, pollution)
- Mechanical withstand requirements (cantilever / seismic)
- Requirements based on analysis of performance in service

Product Standards:
(Manufacturers/Utilities/Researchers/Testing Organisations)

- IEC (technical requirements)
- ANSI / IEEE (technical and dimensional)
- IS (technical and dimensional)
- JEC (technical and dimensional)
- ABNT / NBR (technical)
- GB/T (technical and dimensional).
- NF / NF EN (technical)
- EN (technical)
- CLC/TS - CENELEC (specific needs / gaps in standardisation)
- CFE

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International Product Standards (Technical)


IEC

IEC 60137

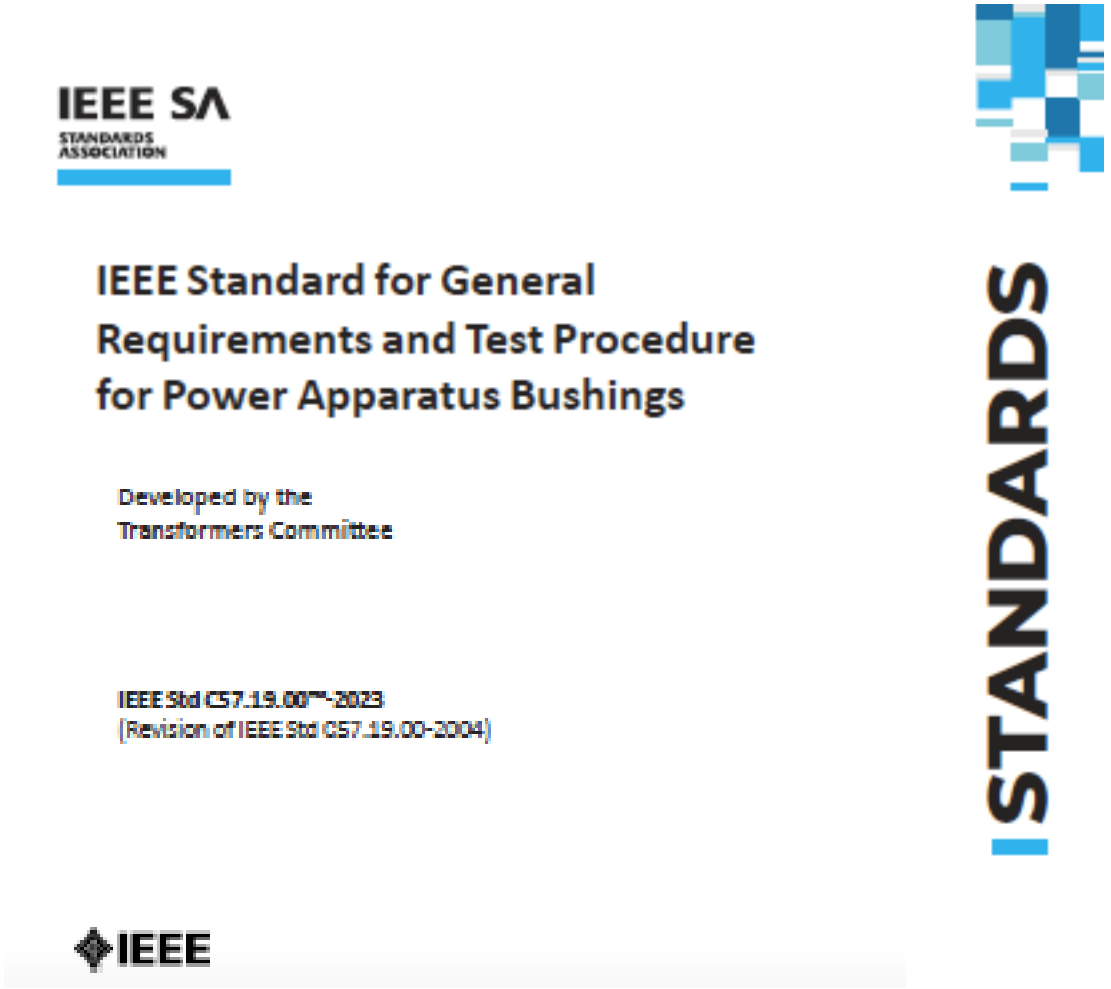
Edition 7.0 2017-06

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Insulated bushings for alternating voltages above 1 000 V

Traversées isolées pour tensions alternatives supérieures à 1 000 V


IEEE SA STANDARDS ASSOCIATION

IEEE Standard for General Requirements and Test Procedure for Power Apparatus Bushings

Developed by the Transformers Committee

IEEE Std C57.19.00™-2023
(Revision of IEEE Std C57.19.00-2004)

IEEE

STANDARDS

International Product Standards (Dimensional)

(Reaffirmed 2001)

IS 12676 : 1989

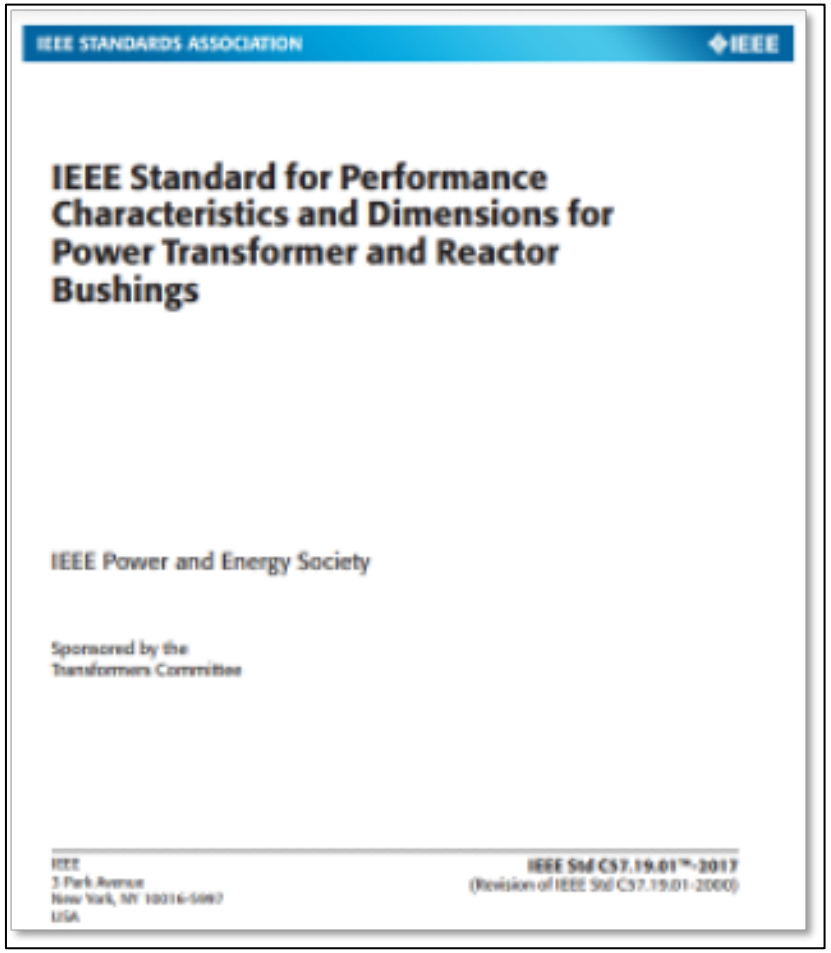
Indian Standard

OIL IMPREGNATED PAPER INSULATED CONDENSER BUSHINGS — DIMENSIONS AND REQUIREMENTS

भारतीय मानक

तेल-संसेचित कागज रोधित संधारित्र बुशिंग — आयाम और अपेक्षाएं

UDC 621'315'626 : 621'315'614'6 : 006'78 : 621'319'4



IEEE STANDARDS ASSOCIATION ◆IEEE

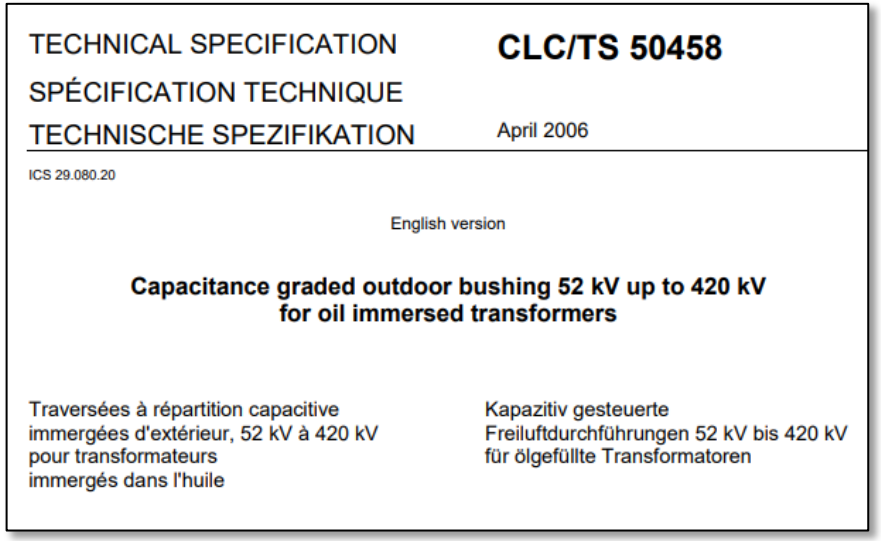
IEEE Standard for Performance Characteristics and Dimensions for Power Transformer and Reactor Bushings

IEEE Power and Energy Society

Sponsored by the Transformers Committee

IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std C57.19.01™-2017
(Revision of IEEE Std C57.19.01-2000)



TECHNICAL SPECIFICATION
SPÉCIFICATION TECHNIQUE
TECHNISCHE SPEZIFIKATION

CLC/TS 50458

April 2006

ICS 29.080.20

English version

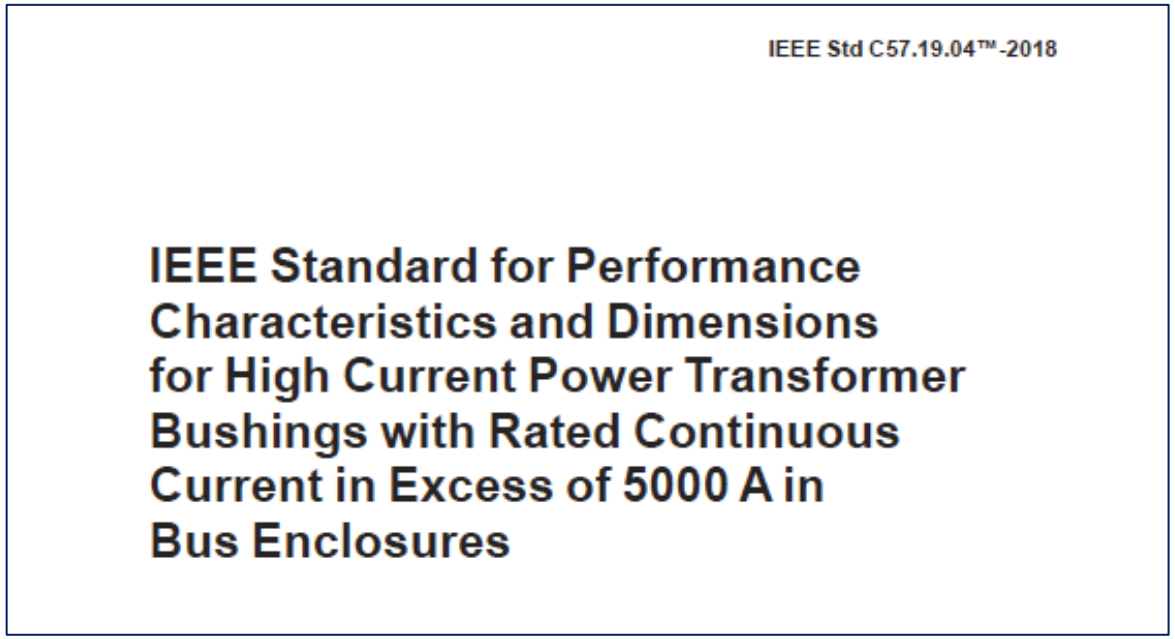
Capacitance graded outdoor bushing 52 kV up to 420 kV for oil immersed transformers

Traversées à répartition capacitive immergées d'extérieur, 52 kV à 420 kV pour transformateurs immergés dans l'huile

Kapazitiv gesteuerte Freiluftdurchführungen 52 kV bis 420 kV für ölgefüllte Transformatoren

No IEC Standard for Dimensional Requirements

International Product Standards (Technical + Dimensional)



No IEC standard for high current bushings >5000 Amps.

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Summarised Standard Requirements

Parameter	IEC 60137	IEEE C57.19.00	IEEE C57.19.01	CLC/TS 50458	IS12676
Coverage	All Technical Parameters & Routine + Type Test Procedures	All Technical Specifications & Routine + Type Test Procedures	Dimensional Requirements & Technical Parameters	Dimensional Requirements & Standardised Current Rating	OIP – Dimensional Requirements & Standardised Current Rating
Standard BCT	---	---	534 mm/584 mm	0, 300, 500 mm	100, 300, 600 mm
Standard Terminals	Material Not Specified	---	Copper / Brass	Material Not Specified	Copper
Oil End Length	---	---	1188 mm (145 kV/584 BCT)	590 mm (145 kV/0 BCT-With Electrode)	600 mm (145 kV/100 BCT With Electrode)
Oil End Active Part Diameter	---	---	248 mm (Max) (145 kV/584 BCT)	180 mm (Max) 145 kV	165 mm (Max) 145 kV

Short Tail Bushing : 145 kV/0 BCT: Oil End Length = 417 mm - Long Term Reliability!

Harmonization

Transformer Bushings: Need for Harmonization of Specifications / Requirements

- Ready Availability of Bushings & Reduced Manufacturing Lead Time.

  - Reduced number of product varieties through standardisation.
  - IEEE – up to and including 230 kV – eight kV ratings , for each kV class four current ratings; standard BCT length & hence 8 x 4 = 32 product varieties.
  - CLC/TS 50458 – up to and including 245 kV – seven kV classes, 23 varieties based on current, 3 BCT varieties & hence total 69 varieties.
  - IS 12676 – up to and including 245 kV, four kV ratings, 11 varieties based on current, with standardised BCT ratings per kV classes, total 24 varieties.
    - We should aim at one or max 3 varieties per kV class.

At Yash – Bushings up to 245 kV: Market served through 140+ varieties (OIP+RIP+RIS)

Transformer Bushings: Need for Harmonization of Specifications / Requirements

- Ease of replacement at site in the event of urgency
  - Replacement due to product failure / assessment indicating tending to failure
  - Replacement due to transit damage of new bushings
  - Dimensional standardisation on oil end and air end for OIP / RIP / RIS
    - OIP can be interchanged with RIP or RIS & vice versa without any modification
      - Shorter oil end length bushings?
      - Re-entrant type bushings?
- Standard bushings suitable for Different immersion medium
  - Transformer filled with mineral oil / natural ester / synthetic ester (Bushings suitable for all liquids in transformer)
    - In service transformers – mineral oil replacement by ester oils

Transformer Bushings: Need for Harmonization of Specifications / Requirements

- Test tap vs voltage tap – specify test tap only for all kV classes
  - IEEE Standard specifies voltage tap for all kV classes above 115kV Class
  - At present test tap is used for voltage measurement & online monitoring
  - Standard size of test tap construction , to enable standard adapter for test tap
    - Standard dimensions of test tap area (only IEEE specifies dimensions of test tap area)

- Transformer lead termination on “thimble / cable connector – draw rod connector” by crimping rather than brazing / soldering

- Arcing horns – not required to be specifically mentioned

Transformer Bushings: Need for Harmonization of Specifications / Requirements

- Standardised clearances between oil end electrode & tank / turret wall (i.e. earth)
  - only specified in CLC/TS standard.

- Standardised BCT (Bushing CT) length
  - 0 mm / 100 mm / 300 mm / 400 mm/ 500 mm / 534 mm / 584 mm / 600 mm

Harmonization Effects:

- Decreasing the number of products to be developed and maintained
- Leveraging economy of scale: positive effect on product cost & quality
- Reducing inventories and lead times
- Simplifying the purchasing process (for bushing manufacturers & transformer manufacturers)
- Interchangeability of bushings produced by different manufacturers
- Retrofitting of old bushings with new bushings (advanced technologies)

Harmonization of Specifications / Requirements: Efforts by WG of International Standards

- IEC TS 63493-2 ED1 Transformer bushings dimensional standardization - Part 2: High voltage bushings.
- PT 63634 General requirements for tap adapter of capacitance graded bushing.
- WG PC57.19.01 Performance Characteristics and Dimensions for Transformer and Reactor Bushings.
- WG PC57.19.04 Standard Requirements for Bushings above 5000 A in Bus Enclosures

- Necessary to have a joint WG between IEC and IEEE & arrive at dimensional standardisation for new bushings.
- Co-opting IEC or IEEE Product Standard e.g. IEC can co-opt IEEE C57.19.04 for HC.

Approach by Indian customers: adopting dimensional standardisation of OIP bushings for RIP / RIS bushings.

Harmonization (Approach of “IEC TS 63493-2 ED1”)

Focus on standardizing mainly those parts of the bushing representing the interfaces with the surrounding components (with special attention to the transformer tank, the winding exit leads, etc.)

- End users to define their standardized variants by specifying only a limited number of parameters
- Bushings manufacturers to design different product variants by exchanging only a few parts, while keeping others unchanged

Summary

- Harmonization – bushing requirements / specifications aligned with IEC TS 63493-2, IEEE C57.19.01 and IS12676 & reduction in varieties

- End users to define their standardized variants by specifying only a limited number of parameters. (e.g., 145 kV/800 A/300 mm)

- Bushings manufacturers to design different product variants by exchanging only a few parts, while keeping others unchanged

- Main focus on future interchangeability (standardise for new bushings & maintain other varieties for replacements of earlier bushings)

Thank You