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Guidance on Practice for Power Transformers & Reactors

GP 12-05

BP GROUP
ENGINEERING TECHNICAL PRACTICES

Foreword

This is the first issue of Engineering Technical Practice (ETP) GP 12-05. This Guidance on Practice (GP) is based on the following heritage documents from merged BP companies:

Amoco (ACES)

A EL-TR-00-G	Electrical—Transformer—Guide
A EL-TR-00-E	Electrical—Transformers—Engineering Specification
A EL-TR-LI-P	Electrical—Transformers—Liquid-Immersed—Supply Specification
A EL-TR-OH-P	Electrical—Transformers—Overhead Type—Supply Specification
A EL-TR-PM-P	Electrical—Transformers—Pad-Mounted—Supply Specification

Arco (APCES)

ES 407-93	Outdoor Power Transformer
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BP GOMDW

1400-20-EL—SP-4018	Liquid Filled Power Transformers
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BP Chemicals US

CP 17-4-1	Power Transformers
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BP (RPSE)

RP 12-9	Electrical Systems and Installations – Transformers and Reactors
GS 112-5	Guidance for Specification GS 112-5 Transformers and Reactors

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1. Scope

This GP document provides guidance for engineering design, installation, operation, and maintenance of power transformers and reactors.

2. Normative references

The following normative documents contain requirements that, through reference in this text, constitute requirements of this technical practice. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this technical practice are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

American National Standards Institute (ANSI)

C57.12.10	American National Standard, For Transformers-230 kV and Below, 833/958 through 8333/10417 kVA, Single-Phase, and 750/862 through 60 000/ 80 000/ 100 000 kVA, Three-Phase Without Load Tap Changing; and 3750/4687 through 60 000/ 80 000/ 100 000 kVA with Load Tap Changing-Safety Requirements
C57.12.20	American National Standard, For Transformers-Standard for Overhead Type Distribution Transformers, 500 kVA and Smaller High Voltage, 34500 Volts and below Low voltage, 7970/13800Y Volts and Below
C57.12.21	American National Standard, For Transformers-Pad-Mounted, Compartmental-Type, Self-Cooled, Single-phase Distribution Transformers with High-Voltage Bushings; High Voltage, 34500/19920 Volts and below Low voltage, 240/120 Volts and smaller
C57.12.22	American National Standard, For Transformers-Pad-Mounted, Compartmental-Type, Self-Cooled Distribution Transformers with High-Voltage Bushings, 2500 kVA and Smaller High Voltage, 34 500 GRD Y/19 920 Volts and below Low Voltage, 480 Volts and below

BP

GIS 12-051	Guidance on Industry Standard for Power Transformers (IEC)
GIS 12-052	Guidance on Industry Standard for Power Transformers (ANSI)
GP 12-60	Guidance on Practice Hazardous Area Electrical Installations

International Electrotechnical Commission (IEC)

IEC 60076-1	Power transformers – Part 1: General
IEC 60076-2	Power transformers – Part 2: Temperature Rise
IEC 60076-3	Power transformers – Part 3: Insulation levels, dielectric tests and external clearances in air
IEC 60076-5	Power transformers – Part 5: Ability to withstand short circuit
IEC 60076-10	Power transformers – Part 10: Determination of sound levels
IEC 60354	Loading guide for oil-immersed power transformers
IEC 60726	Dry-type power transformers



Institute of Electrical and Electronic Engineers (IEEE)

- C57.12.00 IEEE Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
- C57.12.01 IEEE Standard General Requirements for Dry-Type Distribution and Power Transformers including those with Solid-Cast and/or Resin-Encapsulated Windings

National Fire Protection Association (NFPA)

- NFPA 70 National Electrical Code (NEC)

3. General transformer classification**3.1. Distribution and power transformers**

- a. Both IEC and ANSI classify single-phase and three-phase transformers with ratings up to 2 500 kVA and a high voltage rating up to 36 kV as “distribution transformers”. ANSI further classifies distribution transformer into two specific groups:
 1. Overhead transformers - up to 500 KVA
 2. Pad-mounted - up to 2 500 kVA
- b. Transformers above 2 500 kVA are classified as “power transformers” and are also sub-classified into two specific groups:
 1. Medium power transformers – above 2 500 kVA up to 100 000 kVA
 2. Large power transformers – above 100 000 kVA
- c. These classifications are not recognised as specific types in IEC but are roughly equivalent to pole-mounted and ground-mounted types, respectively.

3.2. Medium and large power transformers

- a. IEC classifies power transformers into three categories based on ratings described in Table 1A.

Table 1A – IEC Classifications

Classification (IEC 60354)	Category (IEC 60076-2)	Rating S_r (kVA)
Distribution	I	$S_r \leq 2\,500$
Medium Power	II	$2\,500 < S_r \leq 100\,000$
Large Power	III	$S_r > 100\,000$

- b. ANSI transformer categories with their rating limits are given in Table 1B.

Table 1B – ANSI classifications

Transformer Type	Rating (kVA)
Overhead - C57.12.20	500 and Smaller
Pad-mounted – C57.12.22	2 500 and Smaller
Medium Power – C57.12.10	Above 2 500 up to 100 000
Large Power -	100 000 and above



4. Transformer ratings

4.1. Standard ratings

- a. IEC and ANSI standard kVA ratings for transformers, up to 10 MVA, are shown in tables 2A and 2B. It will be necessary to select a rating appropriate to the particular standard area.

Table 2A
Standard IEC ratings

R10	100	125	160	200	250	315	400	500	630	800 etc.
Power (kVA)								5	6.3	8
	10	12.5	16	20	25	31.5	40	50	63	80
	100	125	160	200	250	300	400	500	630	800
	1000	1250	1600	2000	2500	3000	4000	5000	6300	8000
	10 000									

R10 numbers and rating (IEC 60076 & CENELEC)

Bold Values are preferred for Distribution Transformers in CENELEC countries (to HD 428 Standards). For Industrial purposes there may be merit in adopting common practices.

For the larger ratings consideration should also be given to transformer efficiency in order to minimise the cost of losses over the lifetime of the plant.

Table 2B
Standard ANSI ratings (3-phase)

TYPE	Overhead	Pad-mounted	Oil-immersed
Standard	C57.12.20	C57.12.22	C57.12.10
Rating (kVA)	30, 45, 75, 112.5, 150, 225, 300, 500	75, 112.5, 150, 225, 300, 500, 750, 1 000, 1 500, 2 000, 2 500	15, 30, 45, 75, 112.5, 150, 225, 300, 500, 750, 1 000, 1 500, 2 000, 2 500, 3 750, 5 000, 7 500, 10 000 ⁽¹⁾

Note: C57.12.10 includes transformers rated up to 60 000 kVA (ONAN) and 100 000 kVA (ONAF), where the rating should be selected on economical basis.

- b. Transformers should be rated for continuous operation. When determining transformer kVA rating, and load is firm, a minimum of 125% of connected load should be specified as an ONAN rating.

A consideration for load growth, where the more conservative ONAN rating is considered to be unduly costly, is to use transformers equipped for future forced-air cooling. Forced air (ONAF1), 2nd stage forced air (ONAF2) or forced oil and air (OFAF) cooling ratings allow for future load growth while meeting the temperature limits. Winter/summer load variations on transformer should be considered. Summer electrical loading at ambient temperature conditions is most often the primary factor in sizing a transformer.

It may also be specified that winding temperature rise should not exceed 55 °C when the transformer is loaded to base kVA rating (ONAN). An additional 12% of load can be added resulting in the winding temperature rising to 65 °C. This 'dual rating' has in the past been used to allow for additional load growth without replacing transformers or having a negative impact on insulation life.

