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Pad-mounted transformers

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Foreword

This Engineering Report (EREP) is published by the Energy Networks Association (ENA) and comes into effect from the date of publication. It has been prepared under the authority of the ENA Engineering Policy and Standards Manager and has been approved for publication by the ENA Electricity Networks and Futures Group (ENFG). The approved abbreviated title of this engineering document is “EREP 5”.

This is the first issue of this Engineering Report.

This Engineering Report has been prepared by the Energy Networks Association with direction from the ENA Standards Leaders Group.

This Engineering Report discusses the use of small ground-mounted transformers with limited HV functionality in place of the more conventional pole-mounted types or where a unit-type ground-mounted substation would be inappropriate. Although no restriction on capacity is given, it is expected that the most common sizes will be 50 kVA single-phase or smaller and 100 kVA three-phase or smaller. It is, however, understood that units up to 200 kVA are in use.

It should be noted that the term “pad-mounted” is used in the United States to denote any ground-mounted distribution substation. In order to avoid confusion, the term “pad-mounted transformer” is only used in this Engineering Report to denote compact ground-mounted, single-phase and three-phase units of limited functionality.

Transformers covered by this Engineering Report will typically conform to the International and National Standards listed. In the event that there is a desire that pad-mounted units are used more extensively in the UK, it may be necessary to develop a new Technical Specification to augment, amplify and / or clarify the specific requirements for use on the UK electrical distribution network.

This Engineering Report is a precursor to the development of an ENA Technical Specification for pad-mounted transformers. The intent of this Engineering Report is to evaluate whether differences in the design of the equipment and the operational practices of ENA Member Companies can be harmonised such that a common specification for pad-mounted transformers can be developed for use on UK electricity distribution networks.

The term ‘user’ relates to any user of this document.

Where the term “shall” or “must” is used in this document it means the requirement is mandatory. The term “should” is used to express a recommendation. The term “may” is used to express permission.

NOTE: Commentary, explanation and general informative material is presented in smaller type and does not constitute a requirement.

Introduction

Modern distribution transformers with rated voltages up to 36 kV within Member Companies are, typically, either of the ground-mounted or pole-mounted type. Ground-mounted transformers are usually three-phase in the range of 200 kVA to 2 000 kVA and often assembled as a package or unit substation. Pole-mounted substations usually fall in the range of 16 kVA to 200 kVA for single-phase and 25 kVA to 315 kVA for three-phase units.

A pad-mounted transformer is a compact, ground-mounted, cable-connected transformer typically comprising a conventional double-wound transformer, a high voltage (HV) cable compartment, a high voltage fusing arrangement and low voltage (LV) cable compartment. Various LV fusegear arrangements can be supplied. The entire assembly has a much smaller footprint than a conventional unit substation due to the lack of HV switchgear. Pad-mounted transformers are intended for use in publically accessible locations without any further physical protection or segregation, e.g. fenced enclosures.

The pad-mounted transformer design is extensively used in the United States and Europe but has limited penetration within the UK at present. Comprehensive US (ANSI) Standards are applicable to this type of design. However, US operational practices differ significantly from those within the UK and the application of UK operational practices to this equipment is discussed in this report.

ENA Member Companies would like to develop a common Technical Specification for pad-mounted transformers. However, amongst Member Companies that currently use pad-mounted transformers there are a number of differences in both the design of the equipment and in certain operational practices, i.e. earthing of HV cables.

The ENA Standards Leaders Group have proposed an initial stage to produce this Engineering Technical Report that captures these differences and recommends common designs and practices.

1 Scope

This Engineering Report discusses the design, safety and operational aspects associated with the use of pad-mounted transformers operating on the electricity distribution network, for use at highest voltage for equipment 7.2 kV, 12 kV, 24 kV and 36 kV[1].

2 Normative references

The following referenced documents, in whole or part, are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

International Standards publications

IEC 60529:1989, *Specification for degrees of protection provided by enclosures (IP code)*

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[1] A consensus on the appropriate voltages applicable, by Member Companies, would be determined during future development of an ENA Technical Specification for pad-mounted transformers.

IEC 62271-202:2014, *High voltage switchgear and control gear – Part 202. High voltage / low voltage prefabricated substations*

IEEE 386 – 2006, *IEEE standard for separable insulated connector systems for power distribution systems above 600 V*

IEEE C57.12.00, *Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers*

IEEE C57.12.22, *Standard for transformers – pad-mounted, compartmental type, self-cooled, three-phase distribution transformers with high voltage bushings, 2 500 kVA and smaller, high voltage 34 500 Grnd / 19 920 volts and below, low-voltage, 480 volts and below – requirements*

IEEE C57.12.26, *Standard for transformers – pad-mounted, compartmental type, self-cooled, three-phase distribution transformers for use with separable insulated high-voltage connectors, 34 500 Grnd / 19 920 volts and below, 2 500 kVA and smaller*

IEEE C57.12.28 – 2014, *Standard for Pad-Mounted Equipment--Enclosure Integrity*

IEEE C57.12.29 – 2014, *Standard for Pad-Mounted Equipment--Enclosure Integrity for Coastal Environments*

IEEE C57.12.34 – 2009, *Standard for Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 5 MVA and Smaller; High Voltage, 34.5 kV Nominal System Voltage and Below; Low Voltage, 15 kV Nominal System Voltage and Below*

IEEE C57.12.38 – 2014, *Standard for Pad-Mounted-Type, Self-Cooled, Single-Phase Distribution Transformers 250 kVA and Smaller: High Voltage, 34 500 GrdY/19 920 V and Below; Low Voltage, 480/240 V and Below*

IEEE C57.12.38 – 2014, *IEEE Standard for Pad-Mounted-Type, Self-Cooled, Single-Phase Distribution Transformers 250 kVA and Smaller: High Voltage, 34 500 GrdY/19 920 V and Below, Low Voltage, 480/240 V and Below*

National Standards publications

BS EN ISO 13732-1:2006, *Ergonomics of the thermal environment – Methods for the assessment of human responses to contact with surfaces. Part 1: Hot surfaces (ISO 13732-1:2006)*

BS EN 50180-1:2015, *Bushings above 1 kV up to 52 kV and from 250 A to 3,15 kA for liquid filled transformers. General requirements for bushings*

BS EN 50216-5:2005, *Power transformer and reactor fittings. Liquid level, pressure and flow indicators, pressure relief devices and dehydrating breathers*

BS EN 50464-2-1:2007, *Three-phase oil immersed distribution transformers 50 Hz from 50 kVA to 2 500 kVA with highest voltage for equipment not exceeding 36 kV. Distribution transformers with cable boxes on the high voltage and / or low voltage side. General requirements*

BS EN 60214-1:2014, *Tap-changers. Performance requirements and test methods*

BS EN 62271-1: 2008 + A1: 2011, *High voltage switchgear and control gear. Common requirements*

European publications

Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of eco-design requirements for energy-related products (Commission Regulation (EU) No 548/2014 for small, medium and large power transformers)

Industry publications

ENA SHEC 010: 2010 *Model Distribution Safety Rules*

ENA TS 12-08: 2014 *The application of fuse-links to 11 kV / 400 V and 6.6 kV / 400 V underground distribution networks*

ENA TS 12-11: 2012 *Dry cable terminations in HV switchgear for service at rated voltages 12, 24 and 36 kV*

ENA TS 26-1: 1977 *Insulating foam-filled tube and solid rod for live working*

ENA TS 26-2: 1978 *Insulated tools for live working on high voltage overhead lines*

ENA TS 35-1: 2014 *Distribution transformers. Part 1. Common clauses*

ENA TS 35-1: 2014 *Distribution transformers. Part 2. Ground mounted transformers – not close coupled*

ENA TS 35-1: 2014 *Distribution transformers. Part 3. Ground mounted transformers – close coupled*

ENA TS 35-1: 2014 *Distribution transformers. Part 4. Pole mounted transformers*

ENA TS 37-1: 2012 *Public electricity network distribution assemblies*

ENA TS 41-36: 2012 *Switchgear for service up to 36 kV (cable and overhead conductor connected)*

ENA EREC G81 Part 1: 2016 *Framework for new low voltage housing development installations. Part 1 Design and planning*

ENA EREC G81 Part 4: 2016 *Framework for new industrial and commercial underground connections. Part 4 Design and planning*

ENA ER G88: 2014 *Principles for the planning, connection and operation of electrical distribution networks at the interface between Distribution Network Operators (DNOs) and Independent Network Operators (IDNOs)*

ENA EREC P5: 2016 *Low voltage underground networks for new housing estates*

Statutory publications

The Electricity At Work Regulations 1989

Electricity Supply, Quality and Continuity Regulations 2002

The Construction (Design and Management) Regulations 2015

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
substation
any premises or part thereof which contains equipment for either transforming or converting energy to or from high voltage (other than transforming or converting solely for the operation of switching devices or instruments) or for switching, controlling or regulating energy at high voltage, but does not include equipment mounted on a support to any overhead line

[Electricity Safety, Quality and Continuity Regulations 2002, Clause 1 (1)]

3.2
pad-mounted transformer
compact ground-mounted cable-connected double-wound transformer complete with high-voltage and low-voltage cable compartments and with a maximum size of 100 kVA single-phase, 200 kVA split-phase and 200 kVA three-phase

3.3
model distribution safety rules (MDSR)
set of generic rules that the Electricity Companies may use as the foundation of their safety management system for operating on their network

4 Equipment

4.1 Pole-mounted transformers

Pole-mounted transformer installations have changed little since nationalisation in 1947. Transformer capacity has increased slightly but, typically, the transformer is mounted on a conventional wooden pole support carrying an overhead line, with the transformer either hanging from the pole or being supported by a small platform. Larger transformers may need a ‘H’ pole support arrangement.

The transformers have external HV and LV bushings to allow connection. Transformers can be either single-phase or three-phase and range between 16 kVA to 200 kVA for single-phase units and between 25 kVA to 315 kVA for three-phase units.

It is generally accepted that pole-mounted transformers do not, because of their rural or semi-rural location and because they are installed out of reach, require the same level of local HV protection as for conventional ground-mounted transformers.