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Guidance for working on cables under induced voltage conditions

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PUBLISHING AND COPYRIGHT INFORMATION

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Foreword

This Engineering Recommendation (EREC) 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 "EREC C99". It is not intended to be used as a specification.

This EREC is intended to be used as code of practice, providing guidance and recommendation to supervisors and operatives on how induced voltages can arise in insulated sheath power cables from adjacent power cables. Methods to calculate the expected induced voltage levels are provided in order to allow staff to make decisions on how to carry out work in a safe manner when working on such cable systems. The methods in this EREC for the calculation of induced voltages can also be applied to pilot, auxiliary and communication cables.

Guidance is provided on methods for safe working on cables in situations where the induced voltage is above the accepted levels. However, this EREC does not replace ENA Member Company safety rules and procedures, safety warning instructions and notices, nor does it preclude the need for attention to general safety e.g. the provision and maintenance of safe access to and from the place of work, a safe place of work, a safe working environment, safe methods of work and the correct use of personal protective equipment.

This EREC does not deal with safe working on pilot, auxiliary and communications Cables, which is the subject of a separate document ENA EREC S37 *Code of practice for the safe working on pilot, auxiliary and communications cables*. Nor does it not deal with the calculation of sheath voltages due to induced voltages in single-core power cables sheaths under balanced maximum full load or through-fault conditions that are required for system design purposes. The subject of the bonding and earthing to minimise the effects is dealt with in ENA EREC C55, *Insulated sheath power cable systems*.

The document is structured to:

- explain why and how induced voltages occur;
- provide guidance to enable an estimate of the magnitude of induced voltage levels, and;
- provide guidance on the methods to employ for appropriate and safe working on an insulated sheath cable system subject to high induced voltages.

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 normative element.

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Introduction

Load and fault current in a live power cable may induce voltages onto conducting parts of an adjacent power cable. Higher voltages may be induced during an earth fault on the live power cable. Voltages may also be impressed onto conducting parts during voltage rise occurrences in the electrical earth system. Such voltages may create a hazard to people and equipment. Although this EREC is concerned primarily with power cables the description and methods for calculating induced voltages given in Clauses 5 to 8 are also applicable to the calculation of induced voltages in pilot, auxiliary and communication cables.

Guidance is given in Clause 10 on the correct method of working to ensure any proposed work is carried out in a safe manner where the induced voltage is above the accepted levels. This guidance does not replace the need for compliance to company safety rules, which are normally based on the Model Distribution Safety Rules [N6]. The procedures discussed in Clause 10 are thus in addition to the general requirements for work on cable systems.

Generally, there are two effects that may cause voltages to appear on the conductive parts of power cables.

i. Induced voltage which is a direct result of current returning through the soil or phase currents/faults. This longitudinal voltage is proportional to the value of current and the distance over which the power circuits run in parallel.

ii. Earth potential rise (EPR) (also referred to as rise of earth potential, ROEP) at the site feeding the faulted power circuit. When an earth fault occurs, the entire area of a site where the fault current flows to earth may momentarily rise in potential with respect to the general mass of earth.

This EREC is concerned with the effects of induced voltage. EPR (or ROEP) is covered in separate documents; ENA EREC S34 [N2], ENA EREC S36 [N3] and ENA EREC S37 [N4].

NOTE: This EREC does not deal with safe working in pilot, auxiliary and communications cables, which is the subject of ENA EREC S37[N4] nor the calculation of sheath voltages induced in single-core power cables under balanced maximum full load, or through-fault fault which is the subject of ENA EREC C55 [N1].

The assessment of induced voltage in a cable should be undertaken as depicted in Figure 1. Annex G provides guidance on a risk assessment procedure to be used as indicated on the flow chart.

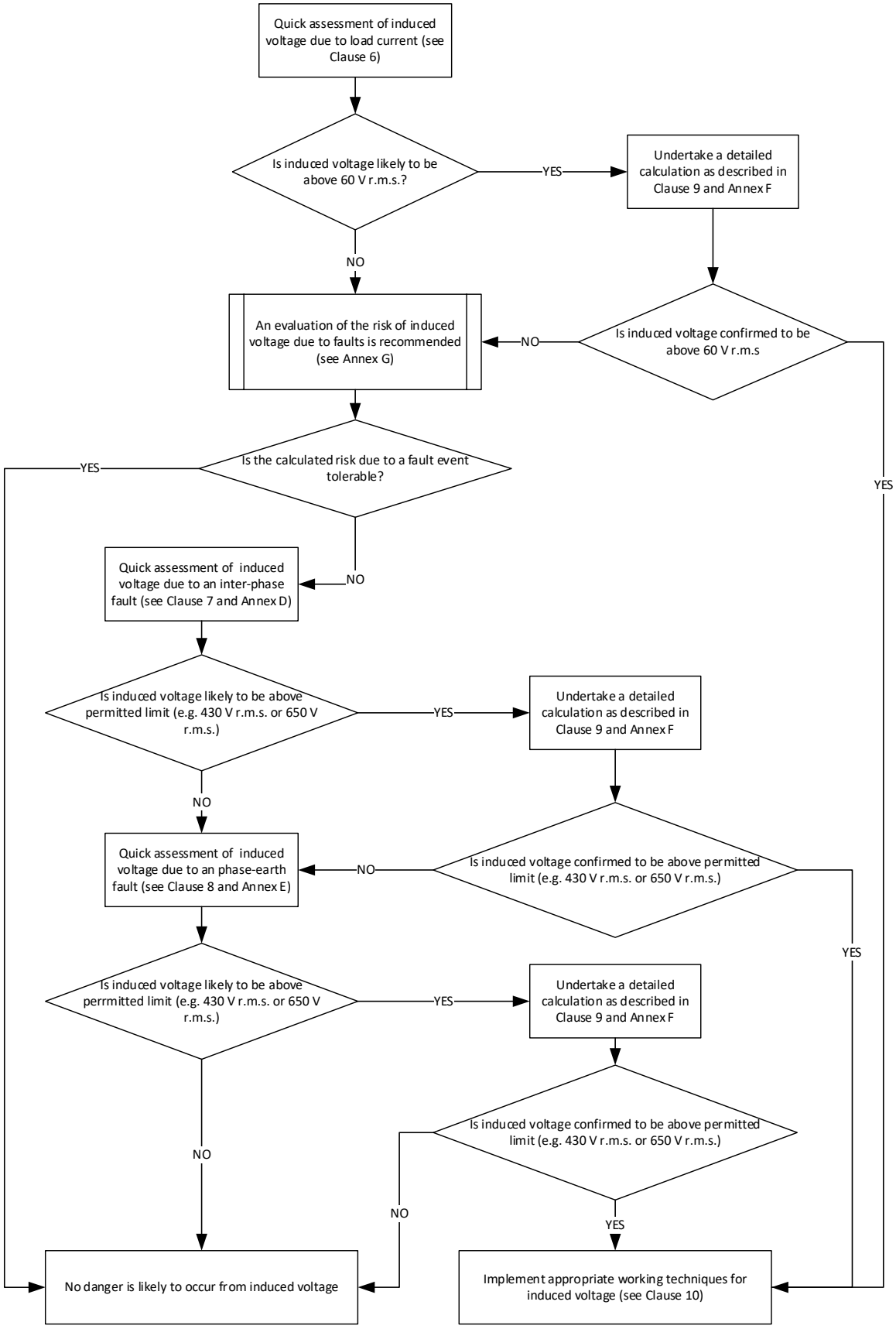

Figure 1 – Assessment process for induced voltage conditions

1 Scope

This EREC applies to insulated sheath power cables, which are subject to induced voltage due to being laid in proximity to power cables. Guidance is given on calculating the expected voltage levels to enable decisions to be made on the correct method of working to ensure any proposed work is carried out in a safe manner.

The extreme case of the hazards associated with the discharge of lightning energy caused by direct strike is not covered.

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.

[N1] ENA EREC C55, *Insulated sheath power cable systems*

[N2] ENA EREC S34, *A guide for assessing the rise of earth potential at substation sites*

[N3] ENA EREC S36 *Procedure to identify and record 'hot' substations*

[N4] ENA EREC S37, *Code of practice for the safe working on pilot, auxiliary and communications cables*

[N5] ENA TS 41-24 Guidelines for the Design, Installation, Testing and Maintenance of Main Earthing Systems in Substations

[N6] ENA SHEC 010: 2010 *Model Distribution Safety Rules*

[N7] National Grid UK Electricity Transmission plc, National Safety Instruction and Guidance document: NSI 5, *Cable Systems*

3 Terms and definitions

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

3.1
danger
risk to health or of bodily injury

3.2
high security circuit
electricity circuit with fast acting protection which, in the majority of cases, limits the fault duration to less than 200 milliseconds

3.3
high voltage (HV)
voltage exceeding 1,000 volts a.c. r.m.s.

3.4
impressed conditions
conditions which may cause dangerous induced voltages or currents, differences in earth potential or voltage differences across any break in the conductive path.

3.5
induced voltage
longitudinal voltage induced in cable as a direct result of the flow of current from an adjacent power system line or cable.

3.6
Limit of Earth Fault Current (LEFC)
minimum value of earth fault current which would need to flow via a fault on a power system through the earth to induce such a hazardous voltage in an adjacent cable.

3.7
low voltage (LV)
voltage not exceeding 1,000 volts a.c. r.m.s.

3.8
parallelism
situation where two circuits are extending in the same direction within a range of separation distance where the magnitude of induced voltage may be significant

4 Danger due to induced voltage

Induced voltages or currents in an insulated sheath cable may be caused by the flow of current associated with an adjacent parallel cable or overhead line. The magnitude of the induced current and/or voltages will depend on the current level, the length of parallelism and the separation but can be sufficiently high to create a hazard to people and equipment. The induced voltage will frequently be highest during the flow of fault current in the adjacent cable(s) but hazardous levels of induced voltage levels can occur due to load current and this condition must always be evaluated. These induced voltages may be additional to EPR voltages being caused by the flow of current through an earth electrode.