Engineering Recommendation G101
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Voltage Measurements for Assessment of Compliance with Statutory Voltage Limits
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Foreword

This Engineering Recommendation (EREC) is published by the Energy Networks Association (ENA) and comes into effect from August, 2017. 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 G101”.

Introduction

The Electricity Safety, Quality and Continuity Regulations 2002 (ESQC Regulations 2002 [1]) and Electricity Safety, Quality and Continuity Regulations (Northern Ireland) 2012 [2] specify nominal values of frequency and voltage that shall be declared to consumers, together with permitted tolerances. For voltage, these permitted tolerance limits are referred to as 'Statutory Voltage Limits' and they shall be met save in exceptional circumstances. These limits apply unless otherwise agreed in writing.

This Engineering Recommendation has been prepared to ensure consistency in application of Statutory Voltage Limits at consumers’ Supply Terminals. It defines how the voltage is measured and what conditions are considered exceptional. It is not intended to have an impact on design standards or the way in which DNOs operate their networks.

1 Scope

This Engineering Recommendation applies to voltage measurements by distributors for the purposes of assessment of compliance with the Statutory Voltage Limits defined in the ESQC Regulations for GB and those for Northern Ireland[1],[2] at Supply Terminals.

This document does not apply to other types of voltage measurement, including measurement of:

- Voltage dips/swells caused by faults or switching.
- Interruptions or outages.
- Voltage (waveform) distortion (e.g. harmonics).
- Flicker (e.g. associated with motor starting, welding, poor connections etc).
- High-frequency events (e.g. transient overvoltage for example associated with switching of capacitance/inductance).
- Superimposed signalling.
- Radiated interference (e.g. radio frequency noise).
- Frequency variation.

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.


3 Standards publications

4 Terms and definitions

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

4.1 Consumer
Any person supplied or entitled to be supplied by a supplier, but in the ESQC Regulations for GB [1], Regulations 24, 25 and 26 shall not include, in respect of any supply to meet haulage or traction requirements, any person who is an operator of a network within the meaning of Part I of the Railways Act 1993.

4.2 Consumer’s Installation
The electric lines situated upon the consumer’s side of the supply terminals together with any equipment permanently connected or intended to be permanently connected thereto on that side.

4.3 Declared Voltage
At High Voltage, the Declared Voltage at the Supply Terminals shall be defined by the Distributor.

At Low Voltage, the Declared Voltage at the Supply Terminals shall be 230V between phase and neutral unless otherwise agreed in accordance with the ESQC Regulations [1], [2].

4.4 Distributor
A person who operates a network, except in GB for a network where that person is an operator of a network within the meaning of Part I of the Railways Act 1993.

4.5 High Voltage
Any voltage exceeding Low Voltage.

4.6 Low Voltage
In relation to alternating current, a voltage exceeding 50V measured between phase conductors (or between phase conductors and earth), but not exceeding 1,000V measured between phase conductors (or 600V if measured between phase conductors and earth), calculated by taking the square root of the mean of the squares of the instantaneous values of a voltage during a complete cycle.

4.7 Measured Voltage
Is the output of the whole measurement chain as described in this document.

4.8 Normal Operating Conditions
The normal operating condition for an electricity network is where the load and generation demands are met, system switching operations are made and faults are cleared by automatic protection systems, in the absence of exceptional circumstances, including:

a) temporary supply arrangement;

b) in the case of non-compliance of a consumer’s installation or equipment with the relevant standards or with the technical requirements for connection;

c) exceptional situations, such as:

1) exceptional weather conditions and other natural disasters;
2) third party interference;
3) acts by public authorities;
4) industrial actions (subject to legal requirements);
5) force majeure;
6) power shortages resulting from external events.

4.9 R.M.S. (Root Mean-Square) Value
The square root of the arithmetic mean of the squares of the instantaneous values of a quantity taken over a specified time interval and a specified bandwidth.

4.10 Statutory Voltage Limits
Voltage limits defined in ESQC Regulations [1],[2].

4.11 Supply Terminals
The ends of the electric lines at which the supply is delivered to a consumer’s installation.

5 Voltage measurement

5.1 Organization of the measurement
The electrical quantity to be measured may be either directly accessible, as is the generally the case in low voltage systems, or accessible via measurement transducers. The whole measurement chain is shown in Figure 1.

![Figure 1: Measurement chain](image)

An 'instrument' usually includes the whole measurement chain. In this document, the normative part does not consider the measurement transducers and their associated uncertainty. BS EN 61000-4-30 [3] provides additional guidance if needed.

5.2 Electrical values to be measured
Measurements can be performed on single-phase or polyphase supply systems. Depending on the context, it may be necessary to measure voltages between phase conductors and neutral (line-to-neutral) or between phase conductors (line-to-line) or between neutral and earth. It is not the purpose of this document to impose the choice of the electrical values to be measured. Moreover, except for the measurement of voltage unbalance, which is intrinsically polyphase, the measurement methods specified in this document are such that independent results can be produced on each measurement channel.

5.3 Class of measurement performance
Three classes of measurement performance are defined in BS EN 61000-4-30 [3].
- Class A performance – is used where precise measurements are necessary, for example compliance with standards. Any measurements of a parameter carried out with two different instruments complying with BS EN 61000-4-30 [3], when measuring the same signals, will produce matching results with a specified uncertainty.

- Class B performance – relates to instruments that are not Class A or Class S. This includes instruments that use alternative algorithms to that defined by BS EN 61000-4-30 [3]. Class B methods are no longer employed on new instruments. However, Class B methods apply to existing instruments.

- Class S performance – is used for statistical applications such as surveys or power quality assessment, possibly with limited subset of parameters.

5.4 Measurement Accuracy
Measurement accuracy for voltage measurement instruments (excluding transducers) shall meet the following specification:

<0.25 per cent ±2 least significant bits.

Such accuracy is achieved by a Class A instrument to BS EN 61000-4-30[3].

5.5 Measurement Test Method
Voltage measurement shall be performed with a measurement instrument meeting the measurement accuracy requirement defined above.

The measurement instrument shall be connected at a position representative of the supply terminals.

The duration of the voltage measurement shall be sufficient to characterise the supply voltage variations (e.g. one week).

The measurement instrument shall record 10-minute mean R.M.S. values of supply voltage.

6 Statutory Voltage Limits

6.1 Low Voltage
As defined in the ESQC Regulations [1],[2], under Normal Operating Conditions the Low Voltage supply shall not exceed 10 per cent above or 6 per cent below the Declared Voltage at the declared frequency.

6.2 High Voltage
Under Normal Operating Conditions:

- for High Voltage supply operating at a voltage below 132,000V, the Measured Voltage shall not exceed 6 per cent above or below the Declared Voltage at the declared frequency.

- for High Voltage supply operating at a voltage of 132,000V or above, the Measured Voltage shall not exceed 10 per cent above or below the Declared Voltage at the declared frequency.

7 Assessment of Compliance with Statutory Voltage Limits

The assessment of compliance at all voltage limits includes a range that all values must fall within to account for the practical but infrequent voltage fluctuations which are seen on any
electricity network. The assessment then requires that for the majority of the time, 95%, the values must fall within the set statutory voltage limit ranges. All voltage measurements shall be taken in accordance with section 5.

7.1 Low Voltage
Under Normal Operating Conditions, during each period of one week:

- all 10-min mean R.M.S values of the Measured Voltage shall be within the range of 10 percent above to 15 per cent below the Declared Voltage.

  and:

- 95 per cent of the 10-min mean R.M.S. values of the Measured Voltage shall be within the appropriate Statutory Voltage Limits range.

7.2 High Voltage (below 132,000V)
For High Voltage supply operating at a voltage below 132,000V, under Normal Operating Conditions, during each period of one week:

- all 10-min mean R.M.S values of the supply Measured Voltage shall be within the range of 10 per cent above to 15 per cent below the Declared Voltage.

  and:

- 95 per cent of the 10-min mean R.M.S. values of the Measured Voltage shall be within the appropriate Statutory Voltage Limits range.

7.3 High Voltage (132,000V or above)
For High Voltage supply operating at a voltage of 132,000V or above, under Normal Operating Conditions, during each period of one week:

- none of the 10-min mean R.M.S. values of the Measured Voltage shall be above or below 15 per cent of the Declared Voltage.

  and:

- 99 per cent of the 10-min mean R.M.S. values of the Measured Voltage shall be above the appropriate lower Statutory Voltage Limit.

  and:

- 99 per cent of the 10-min mean R.M.S. values of the Measured Voltage shall be below the appropriate upper Statutory Voltage Limit.