IMP/001/909 - Code of Practice for Distribution System Parameters

1. Purpose

The purpose of this document is to define the parameters within which the distribution system of Northern Powergrid (Northeast) plc and Northern Powergrid (Yorkshire) plc, the licensed distributors of Northern Powergrid will operate. This document also describes, at a high level, how the system is designed to operate within acceptable margins of these parameters by defining minimum equipment ratings.

This policy helps to ensure the company meets its obligations under the Electricity Act 1989 (as amended by the Utilities Act 2000), the Electricity Safety, Quality and Continuity (ESQC) Regulations 2002 (including amendments)[1], the Electricity at Work (EAW) Regulations 1989, the Health and Safety at Work Act 1974, the Distribution Licences and the Distribution Code, by laying out the distribution system parameters within which Northern Powergrid's system will operate.

This document supersedes the following documents, all copies of which should be removed from circulation.

Document Reference	Document Title	Version	Published Date
IMP/001/909	CoP for Distribution System Parameters	4.0	Jan 2019

2. Scope

This document applies to the existing distribution system of Northern Powergrid and any future modifications to it, and to all providers of connections to the distribution system. The following system parameters are covered by this policy:

- System voltages and frequency;
- System phasing;
- Short-circuit levels and fault clearance times;
- Standard of security on the distribution system; and
- Power frequency and lightning impulse withstand to earth.

As the distribution system develops (through new connections, refurbishment of existing equipment, and reinforcement) consideration should be given to the harmonisation of operating parameters when it is economic to do so in order to improve safety, cost, security of supply and operational performance; for example, rationalising voltages to facilitate interconnection and hence improve security of supply.

This document defines high level ratings required for new equipment (primarily switchgear) based on the system parameters but does not include more detailed functional requirements of new switchgear, transformers, overhead lines or cables. These are included in the engineering standards and specifications relevant to that particular equipment class.

[1] This includes The ESQC (Amendment) Regulations 2006 (No. 1521, 1st October 2006) and The ESQC (Amendment) Regulations 2009 (No. 639, 6th April 2009).

2.1. Table of Contents

3. Policy

3.1. Assessment of Relevant Drivers

The key internal business drivers relating to establishing distribution system parameters within which the distribution system will operate are:

- Employee commitment: by establishing parameters within which the system operates and the use of adequately rated equipment to form the distribution system, will ensure that employees are not exposed to risks to their health as far as reasonably practicable.
- Financial strength: by defining standard parameters, financial gains may be made through economies of scale in the purchase of standard equipment and the adoption of standard designs and construction techniques.
- Regulatory integrity: by ensuring compliance with external regulations regarding distribution system parameters.

The external business drivers relating to distribution system parameters are detailed in the following sections.

3.1.1. Requirements of the Electricity Act 1989 (as amended)

The Electricity Act 1989 (as amended by the Utilities Act 2000) lays down the core legislative framework for Northern Powergrid's operations as a distributor. Specifically, section 9 (i) states 'It shall be the duty of a public electricity supplier to develop and maintain an efficient, co-ordinated and economical system of electricity supply.'

3.1.2. Requirements of the Electricity Safety, Quality and Continuity (ESQC) Regulations 2002 (including amendments 2006 and 2009)

The ESQC Regulations 2002 (as amended in 2006 and 2009) impose a number of obligations on the business, mainly relating to safety and quality of supply. All the requirements of the ESQC Regulations that are applicable to distribution system parameters shall be complied with, specifically:

Reg. No	Extract	Application to this Policy
3(1)(a)	…distributors…shall ensure that their equipment is sufficient for the purposes for and the circumstances in which it is used	The operating parameters and hence the maximum duties of equipment used on the distribution system will be defined to help ensure that any equipment procured is adequate for purpose.
3(1)(b)	…distributors…shall ensure that their equipment is so constructed…as to prevent danger…or interruption of supply, so far as is reasonably practicable	The prevention of danger will be achieved by defining maximum prospective short-circuit currents so that adequately rated standard equipment can be purchased and used to form the distribution system. Interruption of supply will be prevented, so far as reasonably possible, by ensuring that the normal standard of security applied is in accordance with Engineering Recommendation P2.

Reg. No	Extract	Application to this Policy
27(2)	Unless otherwise agreed in writing…the frequency shall be 50 hertz and the voltage declared in respect of a low voltage supply shall be 230 volts between the phase and neutral conductors at the supply terminals	This policy defines the nominal supply frequency and voltage.
27(3)	..the permitted variations are- (a) a variation not exceeding 1 per cent above or below the declared frequency; (b) in the case of a low voltage supply, a variation not exceeding 10 per cent above or 6 per cent below the declared voltage at the declared frequency; (c) in the case of a high voltage supply operating at a voltage below 132,000 volts, a variation not exceeding 6 per cent above or below the declared voltage at the declared frequency; and (d) in the case of a high voltage supply operating at a voltage of 132,000 volts or above, a variation not exceeding 10 per cent above or below the declared voltage at the declared frequency.	This policy defines the permitted variations in frequency and voltage.

3.1.3. Requirements of the Electricity at Work Regulations 1989

The Electricity at Work Regulations 1989 place obligations on Northern Powergrid relating to the safety of equipment used on the distribution system. Regulation 4 (1), Systems, work activities and protective equipment states: ‘All systems shall at all times be of such construction as to prevent, so far as is reasonably practicable, danger’ and regulation 5, Strength and Capability of Electrical Equipment states: ‘No electrical equipment shall be put into use where its strength and capability may be exceeded in such a way as may give rise to danger.’

This policy ensures compliance by setting parameters such that suitable equipment can be purchased and used to form the distribution system, hence ensuring that employees are not exposed to risks to their health as far as reasonably practicable.

3.1.4. The Health and Safety at Work Act 1974

Section 2(1) states that ‘It shall be the duty of every employer to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all his employees’. Section 3(1) also states that ‘It shall be the duty of every employer to conduct his undertaking in such a way as to ensure, so far as is reasonably practicable, that persons not in his employment who may be affected thereby are not thereby exposed to risks to their health or safety’.

This requirement is addressed in this policy through prescribing system short-circuit levels to ensure that prospective short-circuit current does not exceed equipment rating, thus reducing exposure to risk.

3.1.5. Requirements of Distribution Licences

Each Distribution Licence holder is required to hold, maintain and comply with the GB Distribution Code. The Distribution Licences contain a number of conditions that are relevant to the establishment of system parameters. In particular, Standard Licence Condition 20 requires DNOs to comply with the GB Distribution Code which 'is designed so as to permit the development, maintenance, and operation of an efficient, coordinated and economical system for the distribution of electricity'.

This requirement is addressed in this policy through the adoption of standard system voltages, phasing and short-circuit duties, where it is economic to do so, which enables the adoption of standard equipment and hence bring economies of scale. Harmonisation of feeder voltages and phasing may also provide cost-effective interconnection of the system and thus improve security of supply.

3.2. Key Requirements

The distribution system should be developed in such a way as to:

- Provide a safe working environment for employees and prevent, as far as reasonably possible, danger to employees or to the public.
- Provide an acceptable level of quality, security and availability of supply.
- Discharge the obligation under section 9 of the Electricity Act, 'to develop and maintain an efficient, co-ordinated and economical system of electricity distribution'.
- Provide benefits through economies of scale during purchasing. By establishing standard parameters, a standardised suite of equipment may be purchased which may be applied to any part of the distribution system and will operate within the specified parameters.
- Achieve harmonisation of voltage and phasing where the opportunity arises and it is economical to do so, and if it will create additional transfer capacity e.g. by upgrading an isolated 6kV system surrounded by and 11kV system.

3.3. General Requirements

All equipment used on the distribution system must be capable of safe operation under all anticipated operating conditions and duties within the expected range of climatic conditions[2], and within the distribution system parameters set out in the table below. Each parameter is discussed in more detail in subsequent sections of this document. Appendix 4 details all distribution system parameters and new equipment ratings.

Table 1: General distribution system parameters

Parameter	132kV	66kV	33kV	20kV	11kV	6kV	LV
Nominal Voltage (kV) [3]	132	66	33	20	11	6	0.4/0.23 [4]
Rated Voltage (kV)	145	72.5	36	24	12	7.2	0.6/1
Rated Power Frequency Withstand Voltage (kV rms) To earth and between phases	275	140	70	50	28	28	3
Rated Lightning Impulse Withstand Voltage (kV peak) To earth and between phases	650	325	170	125	95	95	-
Rated Frequency (Hz)	50	50	50	50	50	50	50
Neutral Earthing Point	all ends	source	source	source	source	source	multiple
Earth Fault Factor	1.4	1.73	1.73	1.9	1.9	1.73	1.73

3.4. Standard Voltages

3.4.1. Distribution Voltages

The preferred standard nominal voltages used on the distribution system are:

- 132kV
- 66kV
- 33kV
- 20kV (Northern Powergrid (Northeast))
- 11kV
- 0.4/0.23kV [4]

Distribution voltages in the range 5.75kV - 6.6kV are non-preferred legacy voltages.

3.4.2. Declared Voltages and Frequency of Supply

Unless agreed in writing between the distributor, the supplier, and the consumer (and if necessary, between Northern Powergrid and any other distributor likely to be affected), the declared line voltages for supplies provided from the distribution system shall be:

- 132kV ± 10%
- 66kV ± 6%
- 33kV ± 6%

[2] Climatic conditions are not defined in this document; these may be included in future updates.

[3] 0.4kV phase-phase is equivalent to 0.23kV phase-earth (0.4/√3 ≈0.23).

[4] Some 0.23kV supplies are provided using a 0.46/0.23kV split phase arrangement.

- 25kV Railway traction single phase supply ± 6%
- 20kV (Northern Powergrid (Northeast)) ± 6%
- 11kV ± 6%
- 0.4kV +10/-6% (thus, the declared phase voltage for LV supplies shall be 0.23kV +10/-6%)

There are existing customers with supplies in the range 5.75kV - 6.6kV. Such supplies are acceptable, however when economic opportunities arise, consideration should be given to changing the supply voltage to a preferred standard voltage.

The frequency of the supply shall be 50Hz ± 1%.

3.5. System Phasing

3.5.1. Introduction

The adoption of standard phasing allows substations equipped with standard equipment to be established in all localities and permits interconnection at each voltage level. This results in benefits in terms of operational safety, efficiency and security of supply.

3.5.2. Standard Vector Relationships

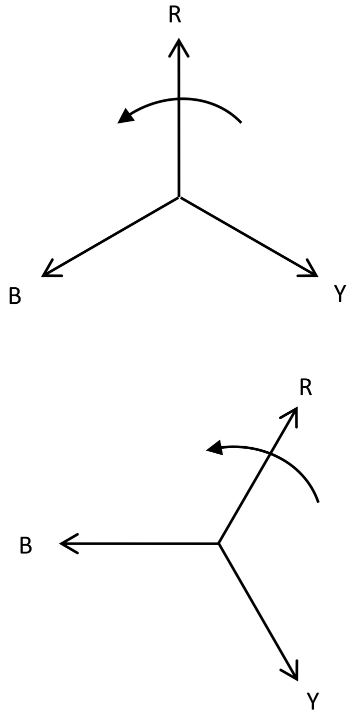
In this document, Red, Yellow and Blue, or the initials R, Y and B, represent the phase vectors and not the physical colouring of cable insulation or marking thread or any other labelling of conductors or terminations.

The phase sequence at each system voltage is represented vectorially by R-Y-B anticlockwise rotation except for the 11kV and LV system in the City of York and the LV system in Middlesbrough, which are represented by R-Y-B clockwise rotation.

The standard relationships of the voltage vectors at 66kV and 33kV, in relation to the reference 132kV vector, for the Northern Powergrid (Northeast) distribution system are shown in Figure 1. Northern Powergrid (Northeast) plc HV and LV phasor relationships are shown in Table 2.

The standard relationships of the voltage vectors at 66kV, 33kV, 11kV and 0.4kV, in relation to the reference 132kV vector, for the Northern Powergrid (Yorkshire) distribution system are shown in Figure 2[5].

[5] Interconnection at LV and HV voltages between Northern Powergrid (Northeast) and Northern Powergrid (Yorkshire) is unlikely to be viable because of the phase differences. Interconnection at 66kV would require a 90° phase shift. Interconnection at 33kV is most tenable since this could be achieved by rolling the connections.



400kV, 275kV, 132kV and 66kV Voltage Vectors

R	0°
Y	−120°
B	+120°

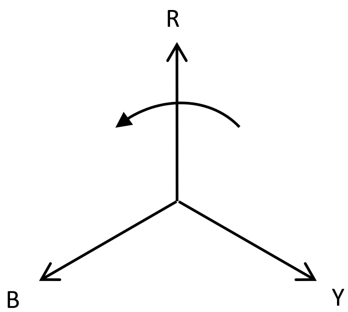
33kV Voltage Vectors

R	−30°
Y	−150°
B	+90°

Figure 1: Northern Powergrid (Northeast) 132kV and EHV vector relationships

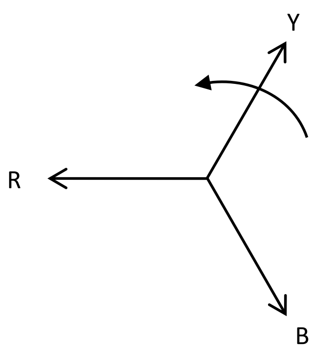
Table 2: Northern Powergrid (Northeast) HV and LV phasor relationships

Voltage (kV)	**20kV**	**11kV**	**6kV**	**Darlington 6kV**	**Sunderland 5kV**	**York**	**NESCo**	**Middlesbrough**	
								20kV	11kV
HV	0°	+30°	+30°	+90°	+30°	+120°R	+30°	0°	+30°
LV	−30°	+60°	+60°	+120°	+60°	+90°R	0°	+30°	−60°R



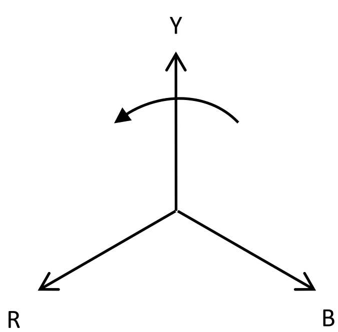
400kV, 275kV and 132kV Voltage Vectors

R	0°
Y	−120°
B	+120°



66kV and 33kV and 11kV Voltage Vectors

R	+90°
Y	−30°
B	−150°



0.4kV Voltage Vectors

R	+120°
Y	0°
B	−120°

Figure 2: Northern Powergrid (Yorkshire) standard vector relationships

3.5.3. Phase Identification and Connections

Phase relationships for the HV system and the LV system for Northern Powergrid (Northeast) are shown in Appendix 1a and Appendix 1b, respectively. A simplified diagram of plant connections and standard arrangement of plant and connections for Northern Powergrid (Yorkshire) plc are shown in Appendix 2a and 2b, respectively.

3.5.4. Marking of Busbars and Main Connections

The switchgear used on the distribution system shall have busbars and main connections marked in accordance with BS 159:1992, which states that busbars which are substantially in one plane shall be arranged in the sequence in which the phase voltages rise. Where the equipment of which they form a part has a clearly defined front or operating face the first phase, or red phase to UK practice, shall be positioned as follows:

a) When the run of the conductors is horizontal, the red shall be the top, or the left or farthest away as viewed from the front.

b) When the run of the conductors is vertical, the red shall be the left or farthest away as viewed from the front.

c) When the system has a neutral connection in the same plane as the phase connections, the neutral shall occupy an outer position.

Unless the neutral connection can be readily distinguished from the phase connections, the order shall be red, yellow, blue, black.

Note that the colours Red, Yellow and Blue, or the initials R, Y and B, represent the phase vectors and not the physical colouring of the cable insulation or marking thread or any other labelling of conductors or terminations.

Outdoor switchgear requires individual consideration and, where necessary, a diagram specifying the phasing and phase connections shall be prepared for the individual project.

3.5.5. Transformer Terminals and Phase Connections

The red phase vector on the 132kV system is the reference vector for phasing on the distribution system and is in phase with the red phase vector on the 400kV and 275kV system, all of which are taken to be at 0º. The phase connection of the terminals of a three phase transformer shall be as indicated in Tables a - g in Appendix 3.

Transformers shall be connected with the minimum crossings to achieve the required system phasing. A consistent method of connection shall be laid down within each operational area for each type of non-standard EHV/HV or HV/LV transformer. Details of non-standard connections should be recorded in the notes field of the appropriate asset register.

3.5.6. Implementation on 11kV, 20kV and LV System

When a new substation or three phase pole equipment is being introduced, or when major alterations are carried out on an existing non-standard section of the distribution system, phasing and phase connections shall be used in accordance with the respective Northern Powergrid (Northeast) / Northern Powergrid (Yorkshire) standard, provided it is economical to convert sufficient adjacent non-standard substations or pole equipment to maintain the requisite degree of interconnection and system security.

The only acceptable exception to the above is where a new substation is to be introduced into an 11kV feeder in which a group of substations with identical non-standard connections could, at a later date, be converted to standard phasing by making one or two phasing-out straight joints only. With this method, no other work would be required on the equipment at any of the group of substations, except for changing the colour marking on equipment, resulting in lower capital costs. In such a case, the new substations shall be connected in a similar way to adjacent substations following the approval of the System Design Manager. A durable notice shall be posted in the new substation to indicate the actual phasing until the complete feeder is changed to standard phasing.

3.5.7. Alterations at Existing Customers Premises

Where the change to standard system phasing results in a change in the phase sequence of the supply to an existing customer (HV or LV) with three phase motors, alterations must be made to the connections at the same time as the system connections are changed in order to avoid incorrect rotation of motors. Reversal of the phasing to restore correct rotation shall normally be made by interchanging two of the incoming phases at the customer’s intake point with suitable identification made on all phases.

To ensure that there is no adverse impact on metering equipment, the appointed metering agent should be informed, through liaison with the customer and their electricity supplier, of any proposed changes to system phasing.

3.6. Short-Circuit Levels

3.6.1. Introduction

The impedance of the system is the important factor which determines the maximum prospective short-circuit current and hence the short-circuit rating of equipment to be used on the system.

The selection of prospective system short-circuit current is a balance between several factors; a high fault level maintains power quality standards to customers by reducing flicker and ensures fast operation of protection, conversely, a low fault level reduces the safety implications of a fault and limits damage to equipment. In practice this balance results in short-circuit levels which are towards the upper end of the rating of the substation equipment.

Both customers' and distribution system equipment must be adequately rated for the maximum prospective short-circuit current which may include a back-feed component from rotating plant and from embedded generation.

3.6.2. Maximum Prospective System Short-circuit Currents

The key determinant of short-circuit currents at a point on the system is the Thévenin equivalent impedance, defined mainly by the impedance of transformers on the system and system earthing arrangements. Transformer impedances and system earthing arrangements need to be such that the short-circuit currents are within the equipment ratings at all times.

The majority of the Northern Powergrid system was designed to cater for the equipment ratings available in the middle of the 20th century. In general, the short-circuit capability of modern switchgear is greater than that of legacy equipment, whilst in general, the phase to earth short-circuit capability of modern cables is less than that of legacy cables.[6] Therefore, the switchgear short-circuit capability of legacy switchgear and the short-circuit capability of modern cables are generally the limiting factor when assessing the capability of the system. The design ratings are therefore based on the legacy switchgear capability and modern cable systems.

As the system develops e.g. by the connection of an additional system transformer or the connection of generation plant, short-circuit currents on the system could increase above the design rating. It is important to differentiate between the following two rating values:

- **Design ratings[7]** (Table 3): The majority of the equipment on the system has a rating equivalent to the design rating or greater. The key requirement, as defined in Section 3.1.3 (i.e. Electricity at Work Regulations 1989), is that the duty imposed on a piece of equipment should not exceed its capability. To confirm this, it will be necessary to compare the duty imposed on each piece of equipment against the actual equipment ratings (which may differ from that in Table 3); the design rating should only be used as an initial assessment of the capability of a piece of equipment and equipment ratings may be below the design rating, hence it is important to treat the design rating only as being indicative of the equipment rating. It is important to note that the 3 phase design rating in Table 3

[6] This is because the earth on modern cables is provided via a stranded copper wire sheath whilst the earth on legacy cables is provided via an extruded outer sheath of lead or aluminium.

[7] Design rating is sometime referred to as the design level.

Column 2 are set by the legacy circuit breaker capability and that the phase to earth design ratings in Table 3 Column 3 are set by the short-circuit capability of modern cables. It is to be noted that the 3 phase rating of many modern circuit breakers can be greater than the values in Table 3 Column 2 and the phase to earth rating of many legacy cables can be greater than the values in Table 3 Column 3.

- **New circuit breaker ratings:** (Table 4 and Appendix 5): All new circuit breakers forming part of the system shall be specified based on the higher ratings now available, so that in the long-term the capability of the system will increase as older equipment currently constraining short-circuit current capability on the system is removed or replaced.

As an example, consider a scenario where a new generation connection would result in a maximum short-circuit current of 20.3kA on the 66kV system. The 3 phase design rating is 20kA, and following a detailed review it is confirmed that the rating of all affected 66kV equipment is 25kA (and that the duty imposed on equipment connected at a higher and lower voltage supplied from the same system is within its capability). This connection is permissible on the basis that the capability of the equipment is not exceeded, despite the three phase short-circuit level exceeding the design rating. A similar assessment would need to be carried out to assess the phase to earth duty imposed on system cables.

Table 3: Short-Circuit Design Ratings

System Voltage (kV)	3 Phase (kA)	Phase to Earth (kA)	Equivalent 3ph Short-Circuit Level (MVA)
132	25	18.4[8]	5700
66	20	1	2286
33	20	1	1145
20	10.1	1	350
11	13.1	1	250
6	13.1	1	150
0.4	35.5	35.5	25

The short-circuit capability of cables and overhead lines are included in policies relevant to those assets, however, circuit breaker short-circuit ratings are presented in Table 4 because of the need to give consideration to the X/R ratio of the distribution system.

[8] Phase to fault current at 132kV may be as high as 31.5kA at installations equipped with modern switchgear.

Table 4: New Circuit Breaker Short-Circuit Ratings

System Voltage (kV)	Short-Circuit / Short-Time Current (kA rms)	Make (kA peak)[9]	Break and X/R Ratio (kA rms [X/R])
132	40	100	40 [14.14] 31.5 [37.70]
66	40	100	40 [14.14] 31.5 [37.70]
33	31.5	78.75	31.5 [14.14] [10] 20 [37.70]
20 (Primary)	20	50	20 [14.14] 12.5 [37.70]
20 (Distribution)	16	40	16 [14.14] 10 [37.70]
11 (Primary)	25	62.5	25 [14.14] 16 [37.70]
11 (Distribution)	20	50	20 [14.14] 12.5 [37.70]
6	25	62.5	25 [14.14] 16 [37.70]
0.4	35.5	-	35.5

Dual short-circuit break ratings (i.e. a rating at two X/R values) shall be specified for new circuit breakers. The short-circuit break rating at different X/R values have been selected from the standard IEC preferred R10 rating series (see Appendix 4). The standard dc time constant for a circuit breaker rating is 45ms (X/R ratio of 14.14)[11] and this corresponds well to the X/R ratio of a system comprising predominantly of overhead lines, but the X/R ratio of a system dominated by transformers is significantly higher and closer to 37.70 (dc time constant of 120ms). Therefore, short-circuit break ratings are specified at two dc time constants: 45ms and 120ms. These time constants can be expressed as X/R ratios of 14.14 and 37.70, respectively.

The use of dual short-circuit break ratings reduces the need to apply legacy 'rules of thumb' or undertake more detailed 'arc energy' calculations to establish the short-circuit capability of a circuit breaker at an X/R ratio other than that at which the circuit breaker was tested. For example, where a circuit breaker is tested at a dc time constant of 45ms (X/R ratio of 14.14) its capability at a dc time constant of up to and including 90ms (X/R ratio of 28.27) can be established by extrapolation. Similarly, where a circuit breaker is tested at a dc time constant of 120ms (X/R ratio of 37.37) its capability at a dc time constant of up to and including 270ms (X/R ratio of 84.84) can be established by extrapolation.

Where there is a need to establish, by extrapolation, the capability of a circuit breaker connected to a system with a dc time constant between 45ms and 90ms (inclusive) or between 120ms and 270ms (inclusive) the formulae on pages 9 and 10 in EREC G89 can be used. The graphs in figures 1 and 2 in EREC G106 help to illustrate the extrapolation process. Where there is a need to establish the capability of a circuit breaker connected to a system with a dc time constant between 90ms and 120ms, providing that there is evidence of performance at 45ms and 120ms, interpolation can be used to derive the circuit breaker rating between the

[9] Peak make ratings are based on a peak factor of 2.5 i.e. short-circuit current multiplied by 2.5.

[10] At 33kV, the use of circuit breakers with a dual rating of 25kA at an X/R ratio of 14.14 and 20kA at an X/R ratio of 37.70 is acceptable provided that the installation is sufficiently remote from the source 132kV/33kV substation and from areas of existing or increasing load / generation activities, such that both the short-circuit duty and X/R ratio are reasonably expected to remain below the lower switchgear capability. See IMP 001 913 for further details.

[11] Time constant can be converted to an X/R ratio using the following relationship: X/R = Time Constant x 2πf.

derived 90ms value and the tested 120ms value. Hence, requiring circuit breakers to be dual rated enables their capability to be established for use on a system with a dc time constant between 45ms and 270ms.

The short-circuit break ratings in Table 4 have been identified through extensive fault level studies,[12] undertaken by the ENA during the development of EREC G89, that assessed the relationships between circuit breaker derating factors and the dc time constants for 29,844 circuit breakers. Minimum short-circuit ratings were identified from the study and then enhanced to align with the most appropriate R10 series standard rating. The minimum short-circuit ratings at 132kV and 66kV were then further enhanced to allow for abnormal running arrangements during SGT outages when short-circuit currents may be higher than in system intact conditions.

3.6.3. Maximum Fault Clearance Times

The maximum fault clearance time which should be used to assess the short-circuit / short-time duty of items of equipment should be obtained by adding together the individual relay operating times and circuit breaker interruption times involved in interrupting fault current flowing through the equipment being assessed. All the equipment that carries fault current should be able to withstand the effect of a simultaneous system fault and a malfunction of protection or switchgear. The times used should therefore be those associated with backup protection, i.e. the network fault clearance times as shown in Table 5. The intention of defining these fault clearance times is to cover the low impedance, high energy faults (generally cleared by fast protection operation), and not the high impedance, low energy faults (generally resulting in slow protection operation). For the avoidance of doubt, the intention of this parameter is to determine the maximum duration for which an item of equipment could be subjected to the short-circuit current detailed above, and not the fault clearance time associated with 'fault level' studies concerned with break ratings, for which a minimum clearance time would be used (e.g. 80-100 ms).

Table 5: Maximum Fault Clearance Times

Voltage	Fault Clearance Time (seconds)
132kV	1
EHV	2
HV	2

The rated short-circuit / short-time duration of cables and overhead lines are included in the engineering standards or specifications relevant to those assets.[13] Switchgear is generally type tested to carry the rated short-circuit current for a minimum of 3 seconds; hence a short-circuit / short-time duration of 3 seconds should be used when specifying 6kV, 11kV, 20kV, 33kV, 66kV and 132kV switchgear.

3.7. Standards of Security on the Distribution System

Standard licence condition 24 requires that the distribution system is planned and developed to a standard of security not less than that laid down in the latest revision of Engineering Recommendation P2, except where otherwise approved by Ofgem.

The normal standard of security applied in the design of the distribution system shall generally, therefore, be in accordance with the latest revision of Engineering Recommendation P2 – Security of Supply.

[12] Further details of the study can be found in EREC G89.

[13] A summary of the rated duration of short-circuit times can be found in Appendix 5

3.8. Power Frequency and Lightning Impulse Withstand to Earth Testing

The power frequency withstand voltage (often referred to as "hipot" voltage) of a test object is a specified prospective voltage value (see Appendix 5) which characterises the insulation of the object with regard to a withstand test. The standard test requires that the test value (root mean square in kV) is applied for 1 minute at a frequency of 50Hz.

The lightning impulse withstand (often referred to as "Basic Impulse Level") of a test object uses a peak voltage (see Appendix 4) dependent on voltage level of the system and a standard impulse with a front time of 1.2µs and a time to half value of 50µs.

For these tests, the equipment must be set up as it will be in service, so far as all the main connections, earthed enclosures and insulation components are concerned. The method of carrying out the tests is the subject of BS 923-1:1990 (IEC 60060-1 1989). Corrections need to be made to the test voltage levels to correct to standard atmospheric conditions of temperature and humidity. Correction factors are given in the standards.

Note that switching impulse requirements are not defined in this Code of Practice, as the magnitudes of such impulses are such that they do not impact the insulation requirements, which are driven by lightning impulse and short term withstand voltages.

4. References

4.1. External Documentation

Reference	Title	Version and Date
	Electricity at Work Regulations	1989
BS 159	High-voltage busbars and busbar connections	1992
BS EN62271-100	HV switchgear and controlgear, HV AC circuit breakers	2001
BSEN60059:1999+A1:2009	IEC standard current ratings	15 October 1999
Cigre Technical Brochure	Guide for Application of IEC 62271-100 and IEC 62271-1	October 2006
Distribution Code	The Distribution Code of Licensed Distribution Network Operators of Great Britain	Version 51, October 2022
Distribution Licence	Gas and Electricity Markets Authority: Standard Conditions of the Electricity Distribution Licence	18 July 2022
Electricity Act	The Electricity Act	1989
ENATS 35-1	Distribution Transformers (from 16kVA to 1000kVA)	Issue 5 2007
ENATS 41-36	Switchgear for Service up to 36kV (Cable and Overhead Conductors Connected)	Issue 3, 2012
EREC G106	Fault Level Management	Issue 1, October 2021
EREC G5	Harmonic voltage distortion and the connection of harmonic sources and/or resonant plant to transmission systems and distribution networks in the United Kingdom	Issue 5, June 2020
EREC G89	Specification of d.c. time constants for switchgear	Issue 1, February 2011
EREC P2	Engineering Recommendation P2, Security of Supply	Issue 7, August 2019
EREC P25	The short-circuit characteristics of single-phase and three-phase low voltage distribution networks.	Issue 2, 2018
EREC P28	Voltage fluctuations and the connection of disturbing equipment to transmission systems and distribution networks in the United Kingdom	Issue 2, May 2019
EREC P29	Planning limits for voltage unbalance in the UK for 132kV and below	Issue 1, 1990
Grid Code	The Grid Code	Issue 6, Revision 14, October 2022
HSAWA	The Health and Safety at Work Act	1974
SI 2002 No. 2665	The Electricity Safety, Quality and Continuity Regulations	2002 including Amendments 2006 and 2009

4.2. Internal Documentation

Reference	Title	Version and Date
IMP 001 007	Code of Practice for Point of Connection assessment using Standard Design Rules for new and existing Low Voltage connections up to 69kVA	06/2020
IMP 001 010	Code of Practice for Standard Arrangements for Customer Connections	04/2021
IMP 001 011	Code of Practice for Overhead Line Ratings and Parameters	12/2017
IMP 001 013	Code of Practice for Underground Cable Ratings and Parameters	09/2022
IMP 001 014	Code of Practice for the Protection of Distribution Networks	02/2021
IMP 001 104	Code of Practice for the Management of Short Circuit Currents in Distribution Switchgear	03/2020

IMP 001 911	Code of Practice for the Economic Development of the LV System	11/2018
IMP 001 912	Code of Practice for the Economic Development of the HV System	07/2018
IMP 001 913	Code of Practice for the Economic Development of the EHV System	06/2020
IMP 001 914	Code of Practice for the Economic Development of the 132kV System	07/2020
IMP 001 915	Code of Practice for Managing Voltages on the Distribution System	02/2017
IMP 001 918	Code of Practice for Transformer Ratings	06/2017
IMP 007 011	Code of Practice for the Application of Lightning Protection	03/2020
IMP 010 011	Code of Practice for Earthing LV Networks and HV Distribution Substations	01/2018

4.3. Amendments from Previous Version

Reference	Amendment
3.6.2 & Table 3	Clarification of the application of design levels
3.6.2 & Table 4	Clarification of the application of dual circuit breaker ratings
All document	Minor editorial changes
Appendix 4	New appendix describing the R10 series
Appendix 5	Updated. Previously Appendix 4

5. Definitions

Term	Definition
Distribution Licence	Standard condition of the Electricity Distribution Licence based on Electricity Act 1989 for all electricity distributors.
Distributor	The term distributor is intended to encompass operators transmitting and distributing electricity under the terms of the Electricity Act 1989 (as amended by the Utilities Act 2000).
EHV	Extra High Voltage. Voltage equal to or greater than 22kV and less than 132kV.
HV	High Voltage. Voltage greater than 1kV and less than 22kV
LV	Low Voltage. Voltage up to and including 1000V.
Northern Powergrid	Northern Powergrid (Northeast) plc and Northern Powergrid (Yorkshire) plc.
R10 Series	R10 Series (Renard 10 series) is a system of preferred numbers that divide a range of values into 10 steps e.g. 10 to 20 into 10 steps.
Ofgem	The Office of Gas and Electricity Markets.

6. Authority for Issue

6.1. CDS Assurance

I sign to confirm that I have completed and checked this document and I am satisfied with its content and submit it for approval and authorisation.

		Date
Liz Beat	Governance Administrator	05/01/2023

6.2. Author

I sign to confirm that I have completed and checked this document and I am satisfied with its content and submit it for approval and authorisation.

Review Period - This document should be reviewed within the following time period.

Standard CDS review of 3 years?	Non Standard Review Period & Reason	
Yes	Period: N/A	Reason: N/A
Should this document be displayed on the Northern Powergrid external website?		Yes
		Date
Sam Turner	Smart Grid Development Engineer	06/01/2023

6.3. Technical Assurance

I sign to confirm that I am satisfied with all aspects of the content and preparation of this document and submit it for approval and authorisation.

		Date
Alan Creighton	Senior Smart Grid Development Engineer	20/01/2023

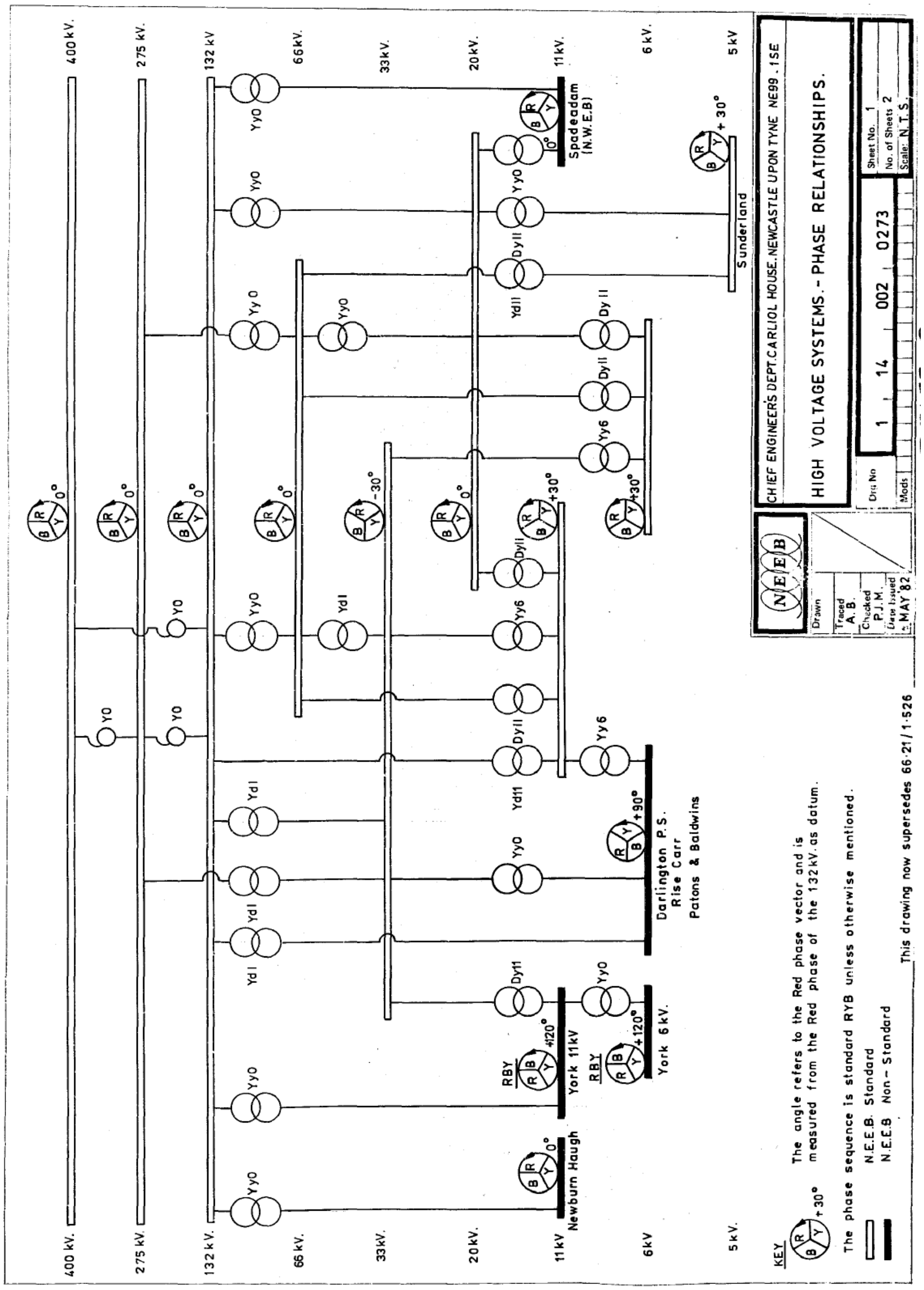
6.4. Authorisation

Authorisation is granted for publication of this document.

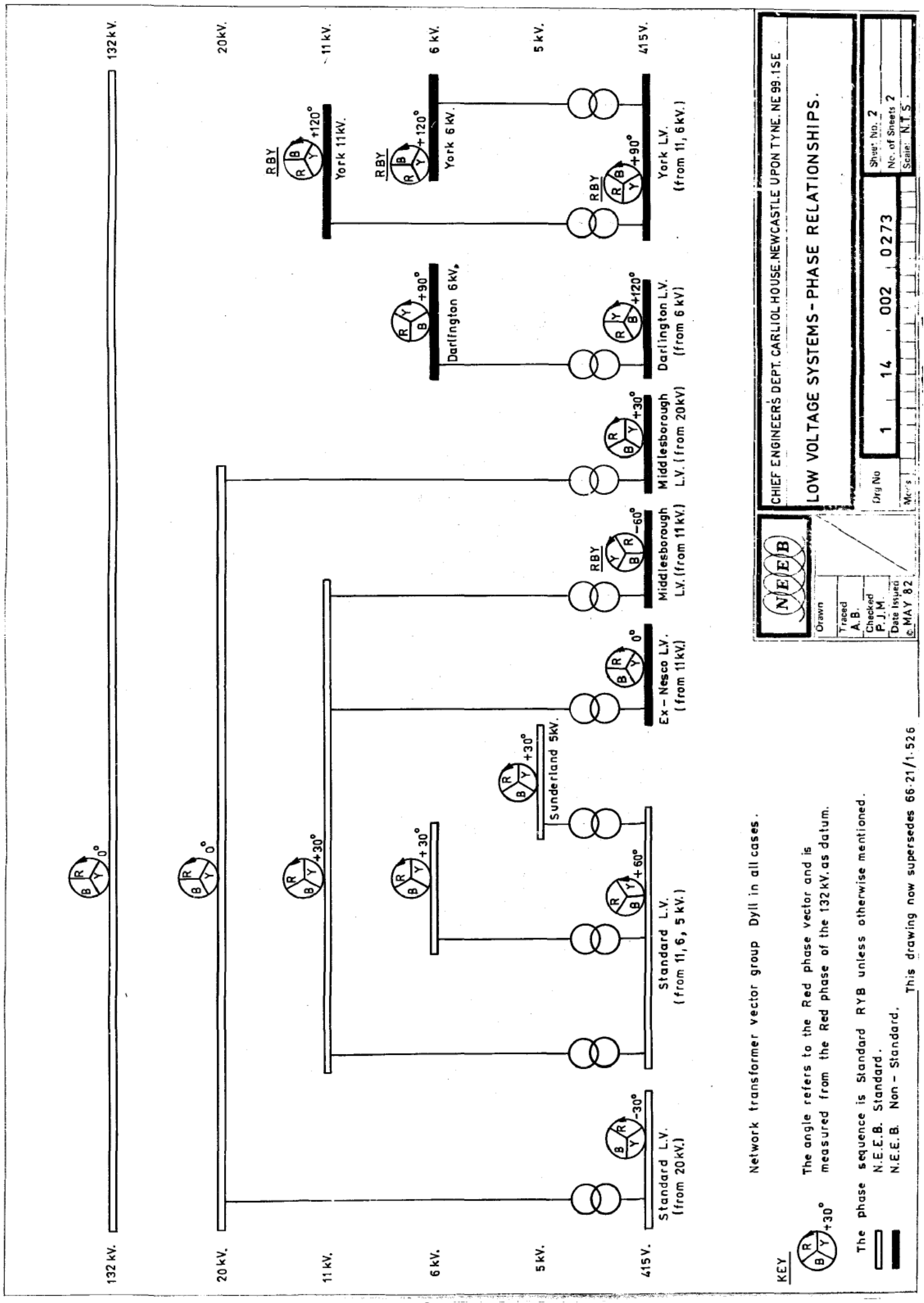
		Date
Mark Callum	Smart Grid Development Manager	08/01/2023

Appendix 1 – Northern Powergrid (Northeast) Phase Relationships

a. High Voltage System – Phase Relationships

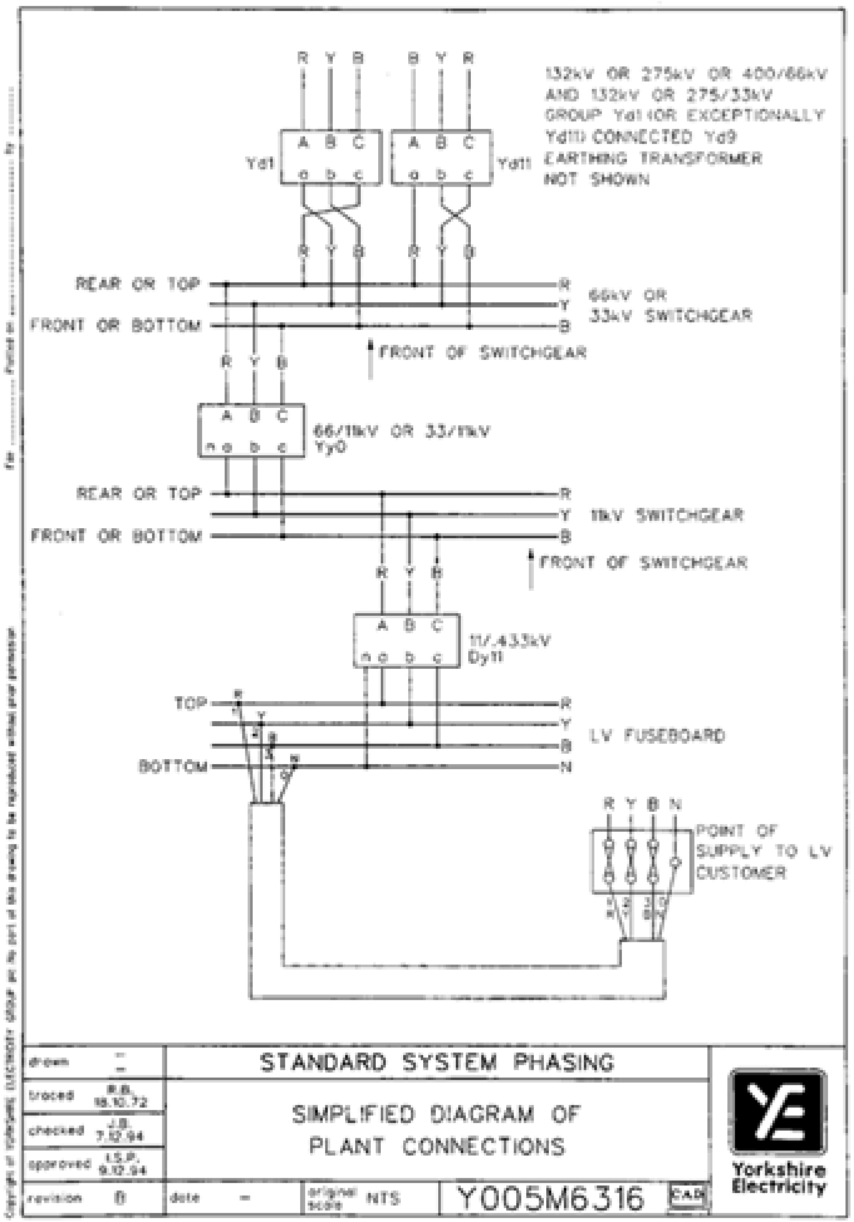


b. Low Voltage System – Phase Relationships

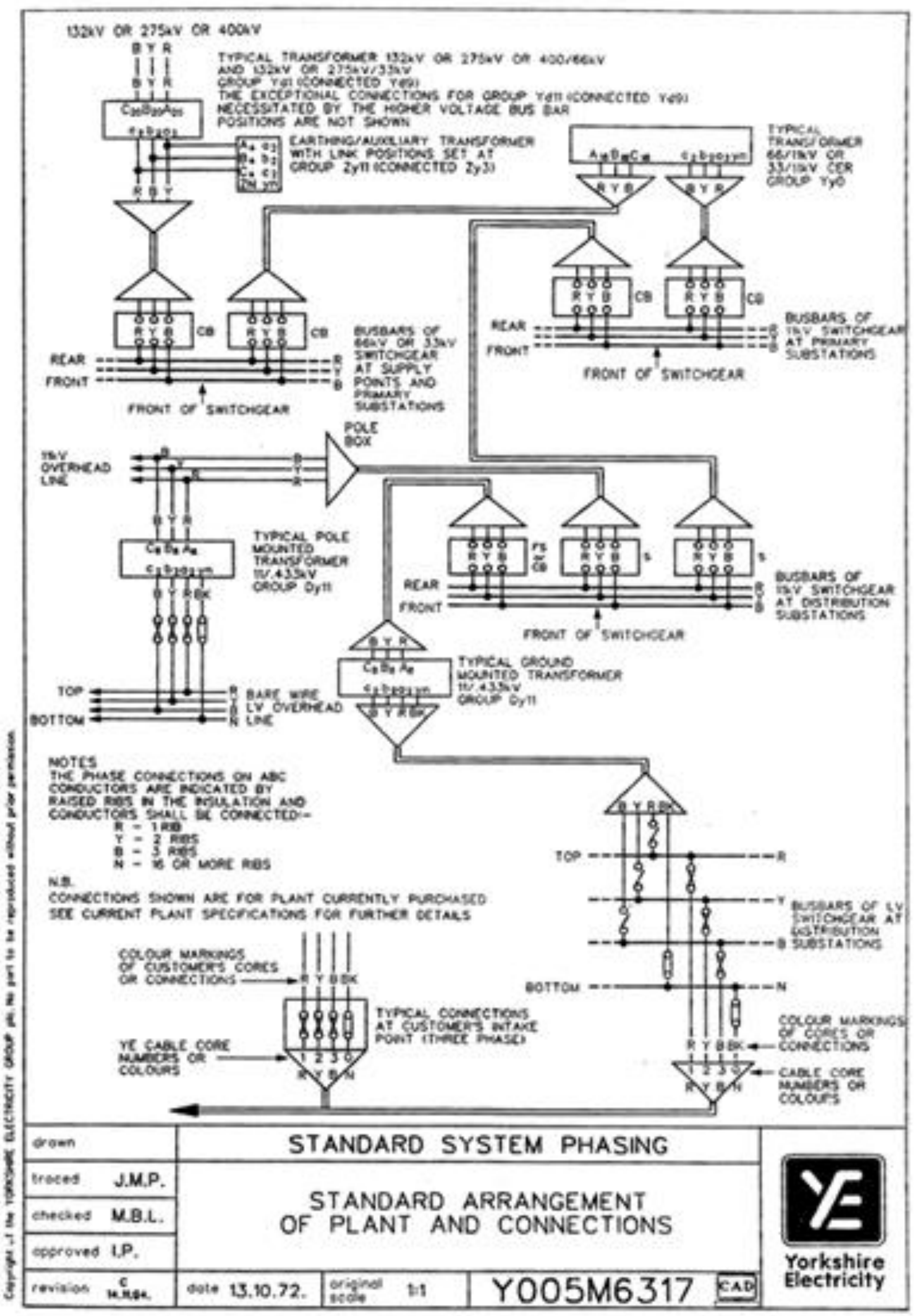


Appendix 2 – Northern Powergrid (Yorkshire) Plant Connections

a. Simplified Diagram of Plant Connections (drawing No Y005M6316)



b. Standard Arrangement of Plant and Connections (drawing No Y005M6317)



Appendix 3 – Vector Groups, Connections and Phase Shifts

Table a: Northern Powergrid (Northeast) plc Standard EHV and HV System

Ratio (kV)	Vector Group	Connected as	Transformer Terminal Markings						Phase shift	
			Primary			Secondary				
			A	B	C	a	b	c	from	to
132/66	Yy0	Yy0	R	Y	B	r	y	b	0°	0°
132/33	Yd1	Yd1	R	Y	B	r	y	b	0°	-30°
	Yd11	Yd1	B	Y	R	b	y	r	0°	-30°
132/11	Yd11	Yd11	R	Y	B	r	y	b	0°	+30°
66/33	Yd1	Yd1	R	Y	B	r	y	b	0°	-30°
	Yd11	Yd1	B	Y	R	b	y	r	0°	-30°
66/HV	Dy11	Dy11	R	Y	B	r	y	b	0°	+30°
33/HV	Yy6	Yy10	Y	B	R	r	y	b	-30°	+30°
	Yy6	Yy10	R	B	Y	b	y	r	-30°	+30°
33/LV	Dy11	Dy9	B	Y	R	r	b	y	-30°	+60°
HV/LV	Dy11	Dy11	R	Y	B	r	y	b	+30°	+60°

Note: HV refers to a 'standard' 11kV, Tyneside[14] 5.75kV, and Sunderland[15] 6 kV systems.

Table b: Northern Powergrid (Northeast) plc 20kV System

Ratio (kV)	Vector Group	Connected as	Transformer Terminal Markings						Phase shift	
			Primary			Secondary				
			A	B	C	a	b	c	from	to
66/20	Yy0	Yy0	B	Y	R	b	y	r	0°	0°
33/20	Dy11	Dy11	R	Y	B	r	y	b	-30°	0°
20/11	Dy11	Dy11	R	Y	B	r	y	b	0°	+30°
20/6	Dy11	Dy11	R	Y	B	r	y	b	0°	+30°
20/LV	Dy11	Dy1	B	Y	R	b	y	r	0°	-30°

Note: This system will not parallel with others.

Table c: Northern Powergrid (Northeast) plc York[16] 11kV System

Ratio (kV)	Vector Group	Connected as	Transformer Terminal Markings						Phase shift	
			Primary			Secondary				
			A	B	C	a	b	c	from	to
132/11	Yy0	Yy8	R	Y	B	b	y	r	0°	+120°R
			B	Y	R	r	y	b	0°	+120°R
33/11	Dy11	Dy7	R	Y	B	b	y	r	-30°	+120°R
	Dy1		B	Y	R	r	y	b	-30°	+120°R
11/LV	Dy11	Dy11	R	Y	B	r	y	b	+120°R	+90°R

Note: This system will not parallel with others.

[14] Wardley and Hebburn.

[15] Cloisters.

[16] Poppleton / Melrosegate / Foss Islands.

Table d: Northern Powergrid (Northeast) plc Darlington[17] 6kV System

Ratio (kV)	Vector Group	Connected as	Transformer Terminal Markings						Phase shift	
			Primary			Secondary				
			A	B	C	a	b	c	from	to
132/6	Yd1	Yd9	R	Y	B	y	b	r	0°	+90°
33/6	Yy0	Yy8	B	R	Y	r	y	b	-30°	+90°
6/LV	Dy11	Dy11	R	Y	B	r	y	b	+90°	+120°

Note: This system will not parallel with others.

Table e: Northern Powergrid (Northeast) plc Middlesbrough LV System

Ratio (kV)	Vector Group	Connected as	Transformer Terminal Markings						Phase shift	
			Primary			Secondary				
			A	B	C	a	b	c	from	to
20/LV	Dy11	Dy11	R	Y	B	r	y	b	0°	+30°
11/LV	Dy11	Dy3	R	Y	B	y	r	b	+30°	-60°R

Note: This LV system will not parallel with others.

Table f: Northern Powergrid (Northeast) plc Ex-NESCo LV System

Ratio (kV)	Vector Group	Connected as	Transformer Terminal Markings						Phase shift	
			Primary			Secondary				
			A	B	C	a	b	c	from	to
11/LV	Dy11	Dy1	B	Y	R	b	y	r	+30°	0°

Note: This LV system will not parallel with others.

Table g: Northern Powergrid (Yorkshire) plc Standard System

Ratio (kV)	Vector Group	Connected as	Transformer Terminal Markings						Phase shift	
			Primary			Secondary				
			A	B	C	a	b	c	from	to
132/66	Yd1	Yd9	R	Y	B	y	b	r	0°	+90°
132/66	Yd11	Yd9	B	Y	R	r	b	y	0°	+90°
132/33	Yd1	Yd9	R	Y	B	y	b	r	0°	+90°
132/33	Yd11	Yd9	B	Y	R	r	b	y	0°	+90°
132/11	Yd1	Yd9	R	Y	B	y	b	r	0°	+90°
132/11	Yd11	Yd9	B	Y	R	r	b	y	0°	+90°
66/11	Yy0	Yy0	R	Y	B	r	y	b	+90°	+90°
33/11	Yy0	Yy0	R	Y	B	r	y	b	+90°	+90°
11/LV	Dy11	Dy11	R	Y	B	r	y	b	+90°	+120°

[17] Darlington PS / Rise Carr.

Appendix 4 – R10 Series Current Ratings

The R10 series of standard current ratings is set out in BS EN60059:1999+A1:2009 IEC standard current ratings and is replicated below. The values used in respect of the short-circuit current capability set out in Table 4 are shown in italic font.

Standard Current Ratings (A)									
1	1.25	1.6	2	2.5	3.15	4	5	6.3	8
10	12.5	16	20	25	31.5	40	50	63	80
100	125	160	200	250	315	400	500	630	800
1,000	1,250	1,600	2,000	2,500	3,150	4,000	5,000	6,300	8,000
10,000	*12,500*	*16,000*	*20,000*	*25,000*	*31,500*	*40,000*	50,000	63,000	80,000
100,000	125,000	160,000	200,000	250,000	315,000	400,000	500,000	630,000	800,000

Appendix 5 – Distribution System Parameters and New Equipment Ratings

			Rated power frequency withstand voltage (kV rms)		Rated lightning impulse withstand voltage (kV peak)				Short-circuit design rating		short-circuit new plant rating					
Voltage	**Nominal voltage (kV)**	**Rated voltage (kV)**	**To earth and between phases**	**Across isolating distance**	**To earth and between phases**	**Across isolating distance**	**Rated frequency (Hz)**	**Continuous current options (A)**	**Three phase (kA) *(3ph MVA equivalent)***	**Single phase (kA) *(3ph MVA equivalent)***	**Short-time current (kA rms)**	**Duration of short-circuit (sec)**	**Make (kA peak)**	**Break and X/R Ratio (kA rms [X/R])**	**Neutral earthing point**	**Earth fault factor**
132kV	132	145	275	315	650	750	50	2000, 1250	25 *5700*	18.4 *4206*	40	3 (swgr & Tx) 1 (cables)	100	40 [14.14] 31.5 [37.70]	all ends	1.4
66kV	66	73	140	160	325	375	50	2500, 2000, 1600, 1250	20 *2286*	1 *114*	40	3 (swgr) 2 (cable)	100	40 [14.14] 31.5 [37.70]	source	1.7
33kV	33	36	70	80	170	195	50	2500, 2000, 1250, 800, 630	20 *1145*	1 *57.1*	31.5	3 (swgr) 2 (cable)	78.75	31.5 [14.14] 20 [37.70]	source	1.7
20kV (Primary)	20	24	50	55	125	145	50	2000, 1250, 800, 630	10.1 *350*	1 *34.6*	20	3 (swgr)	50	20 [14.14] 12.5 [37.70]	source	1.9
20kV (Distribution)	20	24	50	55	125	145	50	2000, 1250, 800, 630	10.1 *350*	1 *34.6*	16	3 (swgr)	40	16 [14.14] 10 [37.70]	source	1.9
11kV (Primary)	11	12	28	32	95	110	50	**Ground:** 630, 800, 1250, 2000, 2500 **Pole:** 200, 400, 630	13.1 *250*	1 *19*	25	3 (swgr)	62.5	25 [14.14] 16 [37.70]	source	1.9
11kV (Distribution)	11	12	28	32	95	110	50	**Ground:** 200, 630 **Pole:** 200, 400, 630	13.1 *250*	1 *19*	20	3 (swgr)	50	20 [14.14] 12.5 [37.70]	source	1.9
6kV	6	7.2	28	32	95	110	50	**Ground:** 630, 800, 1250, 2000, 2500 **Pole:** 200, 400, 630	13.1 *150*	1 *10.4*	25	3 (swgr)	62.5	25 [14.14] 16 [37.70]	source	1.7
0.4kV	0.4/0.23	0.6/1	3	-	-	-	50		35.5 *25*	35.5 *25*	35.5	-	-	35.5	multiple	1.7

Note 1: This Appendix is valid for ground mounted switchgear (specifically, circuit breakers), and values for other equipment types are included where available. Future updates of this document will expand on the parameters for different equipment types.
Note 2: Lightning impulse and power frequency withstand values are higher for pole mounted equipment and are not listed in this Appendix. For example, 11 kV ground mounted equipment has a lightning impulse to earth withstand rating of 28kV, whereas equipment on an overhead line should be rated at 50kV (dry).
Note 3: The short-circuit / short-time ratings are different for different equipment types and nominal voltages. For further information, refer to relevant equipment specification.