1. SCOPE

This document sets out the principles and methodologies relating to the ratings applicable to standard system components.

For further clarification on any issues contained within this document, contact the System Design Group.

2. ISSUE RECORD

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Issue Date	Issue No	Author	Amendment Details
May 2013	4	D E G Carson	Inclusion of overhead line switchgear types and split phase pole mounted transformers. Update to new template. Correction of PICAS 11kV winter cable rating. LV single core cable rating tables updated for current availability.
	5		Minor update for cross reference to associated documents
December 2013	6	D E G Carson	Removal of system assessment section which is separated into ESDD-02-019.
August 2020	7	Mark Lyon	Planned review and update

3. ISSUE AUTHORITY

Author	Owner	Issue Authority
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4. REVIEW

This is a Controlled document and shall be reviewed as dictated by business / legislative change but at a period of no greater than 5 years from the last issue date.

5. DISTRIBUTION

This document is part of the SP Distribution and SP Manweb System Design Virtual Manuals maintained by Document Control but does not have a maintained distribution list.

SP Distribution DOC-00-206
SP Manweb DOC-00-310

CONTENTS

6. BACKGROUND

SP Distribution and SP Manweb have licence obligations to develop an economic and efficient distribution system and therefore it is essential that the system and connection requirements are matched by system equipment capabilities.

This document primarily addresses the equipment and components associated with the 33kV, 11kV and LV networks. The 132kV equipment, applicable in the SP Manweb distribution system and the transmission system of SP Transmission, are typically more bespoke applications and are addressed within the corresponding transmission guidance documentation.

A circuit, and by definition its capability, is constructed from a number of system components such as underground cable, overhead line, transformers, protection systems etc. Each component will have differing characteristics and ratings and when developing network changes or extensions these shall be considered. Coordination and matching of circuit components is considered further in Section 13.

The major individual components of the distribution system are considered in more detail in the following sections of this document.

7. RATINGS FOR UNDERGROUND CABLES

This section provides ratings for power cables from LV up to and including 33kV. It is the definitive declaration of cable ratings and complements the sub-set of data provided in ESDD-02-012, Appendix D.

The section also explains the need for specific "*SP Energy Networks Assigned Ratings*" and lays out the background to how these ratings are derived.

The cable rating data contained within this document are the *SP Energy Networks Assigned Ratings*, which assume the generic conditions discussed in Section 7.2.

The ***SP Energy Networks Assigned Rating*** is defined as the rating assigned to a particular cable design taking into account the installation and operating conditions specific to the SP Energy Networks system.

Where the laying conditions vary significantly from the generic assumptions, appropriate de-rating (or re-rating) factors shall be applied. For 11kV and 33kV cables, Engineering Recommendation P17 provides guidance on appropriate correction factors.

7.1 Fault Rating

All cables are considered to have a fault rating consistent with the fault level design limit for that voltage level. The cable is required to withstand the maximum fault current for a period of 3 seconds.

The capability of a cable to carry fault current is dependent on the cable to withstand the mechanical stresses associated with the passage of high levels of fault current and the capacity of the sheath conductor to transfer earth fault current without physical damage.

7.2 Basis of Cable Thermal Ratings

The current carrying capacity of an underground cable is determined by:-

a. Internal factors (cable construction, conductor design, insulation and sheath materials etc).
b. Factors dependant on Installation and Laying conditions (earthing and bonding, laying configuration, soil resistivity, ground temperature, proximity to heat sources, installation in ducts etc).
c. Operating conditions (sustained or cyclic loading, required earth fault capacity etc). The cable thermal ratings used within SP Energy Networks are based Load Curve G as specified in part 3 of ER P17.

Ratings quoted by manufacturers' data sheets consider item a. but calculations are based on generalised assumptions for b. and c. For this reason the ratings from manufacturers' data sheets cannot be assumed to be appropriate for the installation and operating conditions on the SPEN network.

The SP Energy Networks Assigned Ratings tabulated in this document are based on the installation and operating conditions outlined below.

7.3 Earthing and Bonding

Ratings quoted in this document assume single core cables are solidly bonded and earthed at both ends and are laid in touching trefoil throughout their length to minimise the de-rating effect of screen circulating currents.

Where single core cable installations are short (< 50m) it is acceptable to earth and bond the trefoil groups at one end only.

7.4 Installation Parameters

7.4.1 Ducted Installations

Where single core cables are installed in ducts, the ducted ratings are based on cables in individual ducts with the ducts installed in touching trefoil throughout their length. Ratings are calculated based on the duct diameters specified in CAB-15-003 "Handling and installation of cables up to and including 33kV".

Where a long cable run is laid direct with a short section of ducted installation (i.e. where the ducted section is less than 30m in length) the laid direct ratings may be used.

7.4.2 Depth of Laying

Ratings are based on the standard depth of cover given in CAB-15-003 "Handling and installation of cables up to and including 33kV".

7.4.3 Soil Thermal Resistivity

Ratings are calculated on an assumed soil thermal resistivity of 1.2 K.m/W.

7.4.4 Ground Temperature

Ratings are based on assumed ground temperatures of:

Winter	10°C	(November-April)
Summer	15°C	(May-October)

7.4.5 Thermal dependence

Ratings assume thermal independence, i.e. the cable is not installed within the zone of thermal influence of other cables or any other source of heat. If a cable is installed within the zone of thermal influence of any other heat source then appropriate de-rating factors will need to be applied.

It should be noted that de-rating is unnecessary where cables form part of a ring main or one circuit of a double circuit supply, as the normal loading is less than half the cable capacity.

7.5 Assigned Ratings for 11kV and 33kV XLPE Cables

11kV and 33kV XLPE cables have assigned ratings equivalent to the paper insulated cables, which they replaced.

To achieve the most economic XLPE cable designs, ratings are assigned which result in a maximum phase conductor temperature of 60°C at 11kV and 78°C at 33kV, as opposed to the manufacturer's maximum permissible temperature of 90°C. This enables the use of a smaller cross section of copper screen wires than would otherwise be required to achieve the necessary earth fault capacity resulting in a more cost effective cable design.

For this reason, the ratings detailed here are lower than the nominal maximum ratings quoted on manufacturers' data sheets. Manufacturer's ratings cannot be used directly as they are not based on the same earth fault requirements as those of SP Energy Networks.

7.6 Cyclic Ratings

Cyclic ratings for 11kV and 33kV cables are based on a cyclic rating factor derived from a typical winter daily load curve for the SPEN system. For LV cables the cyclic rating is based on a typical domestic housing 24 hour load cycle. Where the actual load cycle varies significantly from the standard cycle, the quoted cyclic ratings will need to be adjusted accordingly.

7.7 Unassigned Cable Ratings

As discussed in section 7.5, the assigned ratings for XLPE cables ensure that the phase core temperatures do not exceed the permitted value of 60°C for 11kV and 78°C for 33kV. However, **under controlled specific circumstances and where specifically approved by the relevant Design Authority**, cable ratings may be applied which utilise a phase conductor operating above the default temperature. Where such application is being considered or required, advice shall be sought from the Asset Strategy group.

7.8 3-Day Emergency Cyclic Ratings for 11kV Cables

Where an 11kV cable forming one side of an equally loaded two-legged ring or duplicate supply goes faulty, the load imposed on the other side is doubled, and it is this load which determines the size of cable needed for a particular design.

The appropriate cyclic rating, as defined in section 7.6 and detailed in the following tables, shall be used in determining the capability of cable sections for the purposes of assessing load duty under outage conditions.

Where it is considered that an 11 kV cable fault, on critical sections or circuits, can be reasonably located and repaired within three days, a 3-day emergency rating, more liberal than the cyclic rating, <u>may</u> be used for the design of such networks. Due diligence must be applied to ensure that the system is not exposed to potential cascade failures and the OCC should be made aware of the requirement to expedite an 11kV cable fault location and repair within the 72 hour return to service time. The 3-day emergency rating for 11kV cables is effectively 110% of the appropriate cyclic ratings provided in Table 4, Table 5, and Table 6 for winter ratings and in Table 16, Table 17 and Table 18 for the corresponding summer values.

Emergency cyclic ratings are not applicable to the design of open-ended interconnectors or three-and four-legged rings or single core cables.

8. SOURCES OF CABLE RATING INFORMATION

There are numerous sources of cable rating information, those used to establish the SP Energy Networks Assigned Ratings are discussed briefly here.

Because cable ratings are highly dependent not only on cable design but on load history, installation environment and required system performance, no single source can be relied upon to give ratings suitable for SP Energy Networks system operation in all cases. The ratings derived from each source need to be interpreted against a particular set of application criteria to ensure that appropriate ratings are assigned.

8.1 ENA Engineering Recommendation P17

ENA ER P17 consists of 3 parts:-

- ER P17 part 1 (1976) 11kV paper cables
- ER P17 part 2 (1976) 33kV solid paper cables
- ER P17 part 3 (2004) 11kV & 33kV cables with extruded insulation

ER P17 gives sustained rating and distribution or cyclic ratings based on defined cyclic daily load profiles. Correction factors are provided to allow calculation of modified ratings in different circumstances.

ER P17 presents ratings for 11kV and 33kV cables but does not cover LV or 132kV.

ER P17 has some weaknesses which need to be taken into account when assigning ratings:-

- ER P17 calculates all ratings at a depth of 800mm and assumes no variation between 0.6m and 3m depth. In fact, ratings can be up to 15% lower at 3m than at 0.6m.
- ER P17 seems to assume a screen cross sectional area of 35mm² for 33kV cables to BS 7870, circulating currents and therefore losses will be higher for a 50mm² screen as used in SP Energy Networks cables. This will result in ER P17 giving an overly optimistic rating.
- ER P17 has no ratings for the situation where the soil dries out around the cable or ducts.

8.2 EATL Cable Rating Software "CRATER"

CRATER is a spreadsheet-based cable rating calculation tool. It has been developed by EATL on behalf of a group of UK DNOs and is being widely used to establish ratings by most of these sponsoring companies.

CRATER is very flexible and provides a consistent, auditable approach to establishing appropriate cable ratings. CRATER also addresses some of the weaknesses of ER P17.

Caution - CRATER is a complex product with multiple inputs and interdependencies and can give misleading answers if used without due care and attention.

The ratings in this document have been calculated using CRATER and the figures quoted for some cables have a slight variance from previously utilised values.

8.3 IEC 60287 "Electric Cables – Calculation of the Current Rating"

IEC 60287 lays out the basis for calculation of cable current ratings. The principles detailed in IEC 60287 are used to calculate ratings in ER P17, CRATER and by manufacturers when assigning ratings to their cable designs. The principles in IEC 60287 apply at all voltages.

8.4 Manufacturers Data Sheets

Manufacturers' data sheets give sustained ratings based on a fixed set of assumed installation and operating conditions.

Although useful for guidance and to allow comparisons, the ratings published by manufacturers are only accurate for the specific set of installation and operating parameters assumed for the calculations.

De-rating factors may be provided to allow compensation for variations in some installation parameters, however, not all operating variables can be compensated for easily.

9. SPEN ASSIGNED CABLE RATINGS

Ratings are for Scottish Power Energy Networks (SPEN) standard cable designs in compliance with CAB-03-020.

The ratings detailed in Tables 1-12 are based on a ground temperature of 10°C and are therefore considered winter ratings. The corresponding ratings for the summer months are provided in Tables 13-24. The load profile shall be considered in relation to the seasonal ratings, i.e. if a load profile with a peak occurring during the winter months can be accommodated within the equipment winter rating, then the summer peak load also requires assessing to ensure that the summer peak load can be accommodated within the equipment summer rating. Clearly the reciprocal assessment requires to be made for load profiles with a summer peak. It should be noted that, at this time, the ratings for service cables are non-seasonal.

Data for legacy cable sizes are provided to facilitate consistent rating assessment for existing or composite circuits utilising existing cable sections. Legacy cable sizes are denoted by italics.

9.1 Winter Ratings for 33kV Cables

Table 1: Three Core 33kV Cables, Screened and Armoured

Conductor CSA		Conductor Material	Continuous Rating (MVA)		Cyclic Rating (MVA)	
In^2	mm^2		Laid Direct	Ducted	Laid Direct	Ducted
0.1		*Copper*	*12.17*	*10.71*	*13.52*	*11.9*
0.15		*Copper*	*14.87*	*13.1*	*16.54*	*14.57*
0.2		*Copper*	*17.26*	*15.18*	*19.34*	*17.01*
0.25		*Copper*	*19.66*	*17.26*	*21.22*	*18.63*
	185	*Copper*	*21.15*	*18.78*	*24.63*	*20.81*
0.3		*Copper*	*21.74*	*19.14*	*24.54*	*21.61*
0.4		*Copper*	*24.85*	*21.96*	*29.03*	*24.35*
	300	*Aluminium*	*21.94*	*19.34*	*24.75*	*21.82*
0.5		*Aluminium*	*22.78*	*20.07*	*25.69*	*22.64*
0.5		*Copper*	*27.32*	*24.07*	*32.12*	*26.81*

① The 300mm^2 Aluminium cable may be used to connect a 24MVA CERS transformer as the lower ambient temperature likely at times of peak demand will facilitate higher ratings.

Table 2: Single Core 33kV Un-armoured Cables in Trefoil

Conductor CSA		Conductor Material	Continuous Rating (MVA)		Cyclic Rating (MVA)	
In^2	mm^2		Laid Direct	Ducted	Laid Direct	Ducted
.3		*Copper*	*23.40*	*20.59*	*26.42*	*23.25*
	300	*Aluminium*	*23.50*	*20.70*	*26.52*	*23.35*
.5		*Aluminium*	*24.34*	*21.42*	*27.46*	*24.17*

Table 3: Single-core 33kV XLPE Cables

Conductor CSA (mm²)	Conductor Material	Continuous Rating (MVA)		Cyclic Rating (MVA)	
		Laid Direct	Ducted	Laid Direct	Ducted
150	Aluminium	17.50	16.70	20.30	19.30
150	*Copper*	*22.40*	*20.65*	*26.06*	*23.72*
240	*Copper*	*29.00*	*26.10*	*33.95*	*30.18*
240	Aluminium	22.90	21.20	26.70	24.70
400	Aluminium	29.40	26.50	34.60	31.10
500	Copper	41.20	36.00	48.98	42.24
630	Copper	45.90	40.00	54.99	47.10

9.2 Winter Ratings for 11kV Cables

Table 4: Three Core 11kV Paper Insulated Cables with Metallic Sheath

Cable Size		Conductor Material	Cable Construction	Continuous Rating (MVA)		Cyclic Rating (MVA)	
In²	mm²			Laid Direct	Ducted	Laid Direct	Ducted
.06		Copper	Belted, Lead Sheath, Steel Wire Armour	2.93	2.58	3.22	2.84
.1		Copper		4.13	3.64	4.54	3.99
.15		Copper		5.05	4.44	5.60	4.93
.2		Copper		5.86	5.16	6.57	5.79
.25		Copper		6.76	5.95	7.58	6.66
.3		Copper		7.47	6.57	8.37	7.36
.06		Copper	Screened, Lead Sheath, Steel Wire Armour	3.33	2.93	3.66	3.21
.1		Copper		4.35	3.83	4.78	4.21
.15		Copper		5.35	4.71	5.95	5.23
.2		Copper		6.36	5.60	7.12	6.27
.25		Copper		7.18	6.32	8.03	7.07
.3		Copper		7.98	7.03	9.01	7.93
.1		Aluminium	Belted, Lead Sheath, Steel Wire Armour	3.22	2.84	3.54	3.12
.15		Aluminium		3.94	3.47	4.38	3.85
.2		Aluminium		4.58	4.03	5.13	4.51
.25		Aluminium		5.28	4.64	5.91	5.20
.3		Aluminium		5.86	5.16	6.56	5.78
.5		Aluminium		7.57	6.66	8.70	7.65
.1		Aluminium	Screened, Lead Sheath, Steel Wire Armour	3.43	3.02	3.77	3.32
.15		Aluminium		4.14	3.65	4.60	4.05
.2		Aluminium		4.95	4.36	5.54	4.88
.25		Aluminium		5.55	4.89	6.22	5.47
.3		Aluminium		6.26	5.51	7.02	6.17
.5		Aluminium		7.97	7.02	9.17	8.07
	95	Aluminium	Belted, Lead Sheath, Steel Wire Armour	3.84	3.38	4.26	3.76
	185	Aluminium		5.64	4.96	6.32	5.56
	300	Aluminium		7.36	6.48	8.45	7.44
	95	Aluminium	Belted, Cor.Alum. Sheath, Armour (PICAS)	3.84	3.38	4.26	3.76
	185	Aluminium		5.64	4.96	6.32	5.56
	300	Aluminium		7.36	6.48	8.45	7.44
	95	Aluminium	Screened, Cor.Alum. Sheath, Armour	4.14	3.43	4.60	3.81
	185	Aluminium		5.96	5.05	6.67	5.65
	300	Aluminium		7.67	6.56	8.83	7.55

Table 5: Three-core 11kV XLPE Cables

Conductor CSA (mm²)	Conductor Material	Continuous Rating (MVA)		Cyclic Rating (MVA)	
		Laid Direct	Ducted	Laid Direct	Ducted
95	Solid Aluminium	3.80	3.21	4.34	3.49
185	Solid Aluminium	5.50	4.64	6.34	5.07
300	Solid Aluminium	7.30	6.08	8.44	6.71
300	Solid Alum. + separate earth ①	8.40	7.20	9.80	8.00

① Where a circuit capacity greater than the maximum rating of a 300mm² cable is required, the rating restriction arising from the cross section of copper screen wires can be mitigated by laying a continuous separate earth wire along with the HV cable. The separate earth wire will be connected to the cable screen wires at every joint position in order to achieve appropriate bonding and the necessary earth fault capacity. Bonding of the earth wire and all cable jointing shall be in accordance with jointing instructions and utilising approved materials and techniques. In such cases, additional measures may be required to mitigate against the risks arising from potential third-party interference which would compromise the rating.

Table 6: Single Core 11kV Cables, Un-armoured in Trefoil Formation

Conductor CSA		Conductor Material	Cable Construction	Continuous Rating (MVA)		Cyclic Rating	
In^2	mm^2			Laid Direct	Ducted	Laid Direct	Ducted
	95	Solid Al	XLPE	3.80	3.21	4.34	3.49
	185	Solid Al	XLPE	5.50	4.64	6.34	5.07
	300	Solid Aluminium	XLPE	7.30	6.08	8.44	6.71
	300	Copper	XLPE	12.30	10.92	14.14	12.56
.75	*500*	*Copper*	*PILC*	*13.57*	*11.98*	*15.60*	*13.77*
	500	Copper	XLPE	15.58	13.78	17.92	15.85

Where 2 cables per phase are required, e.g. for 24MVA 33/11kV transformer LV connections (assuming a minimum spacing of 450mm between cable groups), a de-rating factor of 0.88 shall be applied to the above ratings in reflection of the mutual heating arising from the close proximity of the adjacent cable. Where 2 cables per phase are employed, they shall be laid in two trefoil groups. Earthing and bonding of the installation shall be carried out as described in section 7.3.

For 11kV cables only, and provided that the conditions detailed in section 7.8 are achieved, a 3-day emergency rating can be applied. This can be assumed to be 110% of the corresponding cyclic rating.

9.3 Winter Ratings for LV Cables

Table 7: PILC LV Cables

Conductor CSA		Conductor Material	Continuous Rating (kVA)		Cyclic Rating (kVA)	
In^2	mm^2		Laid Direct	Ducted	Laid Direct	Ducted
.0225		*Copper*	*74.16*	*65.28*	*85.49*	*75.25*
.04		*Copper*	*104.03*	*91.57*	*108.15*	*95.19*
.06		*Copper*	*129.78*	*114.23*	*141.11*	*124.20*
.1		*Copper*	*178.19*	*156.85*	*199.82*	*175.89*
.15		*Copper*	*215.27*	*189.40*	*250.29*	*220.21*
.2		*Copper*	*255.44*	*224.75*	*306.94*	*270.06*
.25		*Copper*	*292.52*	*257.42*	*361.53*	*318.15*
.3		*Copper*	*329.60*	*290.05*	*415.09*	*365.28*
.5		*Copper*	*422.30*	*371.62*	*528.39*	*464.98*
.06		*Aluminium*	*99.91*	*87.92*	*115.36*	*101.52*
.1		*Aluminium*	*136.99*	*120.55*	*157.59*	*138.68*
.15		*Aluminium*	*166.86*	*146.88*	*208.06*	*183.14*
.2		*Aluminium*	*199.82*	*175.80*	*250.29*	*220.20*
.25		*Aluminium*	*229.69*	*202.08*	*287.37*	*252.83*
.3		*Aluminium*	*259.56*	*228.37*	*324.45*	*285.46*
.5		*Aluminium*	*333.72*	*293.65*	*417.15*	*367.07*
	70	*Aluminium*	*136.99*	*120.51*	*170.98*	*150.41*
	95	*Aluminium*	*166.86*	*146.86*	*208.06*	*183.12*
	120	*Aluminium*	*188.49*	*165.83*	*235.87*	*207.51*
	185	*Aluminium*	*244.11*	*214.78*	*305.91*	*269.15*
	300	*Aluminium*	*318.27*	*280.06*	*398.61*	*350.75*

Table 8: Three-core LV Waveform Cables (Combined Neutral/Earth (CNE))

Conductor CSA (mm²)	Conductor Material	Continuous Rating (kVA)		Cyclic Rating (kVA)	
		Laid Direct	Ducted	Laid Direct	Ducted
95	*Solid Aluminium*	*136.99*	*110.08*	*170.98*	*137.39*
185ⓘ	*Solid Aluminium*	*236.90*	*192.05*	*296.64*	*240.49*
300ⓘ	*Solid Aluminium*	*311.06*	*254.15*	*389.34*	*318.10*

ⓘ It should be noted that the neutral/earth conductors in three core waveform cables may have a smaller cross sectional area than the phase conductors. Where the neutral/earth conductor material is aluminium, the N/E conductor cross sectional area for both 185mm^2 and 300mm^2 cables is 185mm^2. For N/E copper conductors, the effective cross sectional area for both 185mm^2 and 300mm^2 cables is 120mm^2.

Table 9: Four Core LV Waveform Cables (Separate Neutral / Earth (SNE))

Conductor CSA (mm²)	Conductor Material	Continuous Rating (kVA)		Cyclic Rating (kVA)	
		Laid Direct	Ducted	Laid Direct	Ducted
95	Aluminium	180.25	158.62	207.03	182.19
185	Aluminium	253.00	222.62	312.89	275.32
240	Aluminium	305.00	268.40	387.71	341.19

Table 10: Single Core LV Cables

Conductor CSA (mm²)	Conductor Material	Continuous Rating (kVA)		Cyclic Rating (kVA)	
		Laid Direct	Ducted	Laid Direct	Ducted
480	Aluminium	429.51	404.05	498.23	468.70
500	*Copper*	*570.62*	*513.97*	*661.92*	*596.21*
600	*Aluminium*	*463.50*	*435.69*	*537.66*	*505.40*
740	Aluminium	585.04	548.99	678.65	636.83

Where 2 cables per phase are required, e.g. for secondary substation transformer LV connections (assuming a minimum spacing of 450mm between cable groups), a de-rating factor of 0.85 shall be applied to the above ratings in reflection of the mutual heating arising from the close proximity of the adjacent cable. Where 2 cables per phase are employed, they shall be laid in two trefoil groups. Earthing and bonding of the installation shall be carried out as described in section 7.3.

9.4 Winter Ratings for Service Cables

Table 11: PVC Insulated Split Concentric Neutral & Earth (SNE)

Conductor CSA (mm²)	Conductor Material and cable construction	Continuous Rating (kVA)			Cyclic Rating Laid Direct (kVA)
		Laid Direct	Ducted in Pipe	Ducted in Tube	
4 (1+N+E)	Stranded Copper Phase Conductor, Stranded Cu Split Concentric Neutral and Earth	12.70	12.20	11.20	14.70
16 (1+N+E)		27.60	26.60	24.30	32.00
25 (1+N+E)		36.00	34.60	31.70	41.70
16 (3+N+E)		70.50	67.90	62.20	81.80
25 (3+N+E)		93.40	89.90	82.30	108.30
35 (3+N+E)		135.00	156.60	119.00	156.60
25 (1+N+E)	Solid Alum Phase, Stranded Cu Split Concentric N & E	*27.60*	*26.60*	*24.30*	*32.00*
35 (3+N+E)		82.50	79.40	79.40	95.70

Table 12: PVC Insulated Combined Neutral & Earth (CNE)

Conductor CSA (mm²)	Conductor Material and cable construction	Continuous Rating (kVA)			Cyclic Rating Laid Direct (kVA)
		Laid Direct	Ducted in Pipe	Ducted in Tube	
10 (1+N/E)	*Solid Aluminium Phase Conductor, Stranded Copper Combined Neutral and Earth*	*16.60*	*16.00*	*14.70*	*19.30*
25 (1+N/E)		*27.60*	*26.60*	*24.30*	*32.00*
35 (1+N/E)		*33.60*	*62.40*	*29.60*	*39.00*
25 (3+N/E)		*69.80*	*67.20*	*61.60*	*81.00*
35 (3+N/E)		*82.80*	*79.60*	*73.00*	*96.00*

9.5 Summer Ratings for 33kV Cables

Table 13: Three Core 33kV Cables, Screened and Armoured

Conductor CSA		Conductor Material	Continuous Rating (MVA)		Cyclic Rating (MVA)	
In^2	mm^2		Laid Direct	Ducted	Laid Direct	Ducted
0.1		*Copper*	11.7	10.3	13	11.4
0.15		*Copper*	14.3	12.6	15.9	14
0.2		*Copper*	16.6	14.6	18.6	16.4
0.25		*Copper*	18.9	16.6	20.4	18
	185	*Copper*	*20.14*	*17.92*	*23.43*	*19.83*
0.3		*Copper*	20.9	18.4	23.6	20.8
0.4		*Copper*	*23.66*	*20.94*	*27.66*	*23.26*
	300	*Aluminium*	21.1	18.6	23.8	20.9
0.5		*Copper*	*25.99*	*22.95*	*30.58*	*25.55*
0.5		*Aluminium*	21.9	19.3	24.7	21.7

① The 300mm² Aluminium cable may be used to connect a 24MVA CERS transformer as the lower ambient temperature likely at times of peak demand will facilitate higher ratings.

Table 14: Single Core 33kV Un-armoured Cables in Trefoil

Conductor CSA		Conductor Material	Continuous Rating (MVA)		Cyclic Rating (MVA)	
In^2	mm^2		Laid Direct	Ducted	Laid Direct	Ducted
.3		*Copper*	*22.50*	*19.80*	*25.40*	*22.40*
	300	*Aluminium*	*22.60*	*19.90*	*25.50*	*22.40*
.5		*Aluminium*	*23.40*	*20.60*	*26.40*	*23.20*

Table 15: Single-core 33kV XLPE Cables

Conductor CSA (mm²)	Conductor Material	Continuous Rating (MVA)		Cyclic Rating (MVA)	
		Laid Direct	Ducted	Laid Direct	Ducted
150	Aluminium	16.90	16.10	19.50	18.60
150	*Copper*	*21.60*	*20.00*	*25.00*	*23. 00*
240	*Copper*	*27.90*	*24.90*	*32.60*	*29.00*
240	Aluminium	22.00	20.40	25.70	23.80
400	Aluminium	28.30	25.50	33.40	30.00
500	Copper	39.60	34.10	47.10	40.20
630	Copper	44.10	37.70	52.90	44.70

9.6 Summer Ratings for 11kV Cables

Table 16: Three Core 11kV Paper Insulated Cables with Metallic Sheath

Cable Size		Conductor Material	Cable Construction	Continuous Rating (MVA)		Cyclic Rating (MVA)	
In²	mm²			Laid Direct	Ducted	Laid Direct	Ducted
.06		*Copper*	*Belted, Lead Sheath, Steel Wire Armour*	*2.76*	*2.43*	*3.04*	*2.68*
.1		*Copper*		*3.90*	*3.43*	*4.28*	*3.76*
.15		*Copper*		*4.76*	*4.19*	*5.28*	*4.65*
.2		*Copper*		*5.53*	*4.87*	*6.20*	*5.46*
.25		*Copper*		*6.38*	*5.61*	*7.15*	*6.29*
.3		*Copper*		*7.05*	*6.20*	*7.90*	*6.95*
.06		*Copper*	*Screened, Lead Sheath, Steel Wire Armour*	*3.14*	*2.76*	*3.45*	*3.03*
.1		*Copper*		*4.10*	*3.61*	*4.51*	*3.97*
.15		*Copper*		*5.05*	*4.44*	*5.61*	*4.93*
.2		*Copper*		*6.00*	*5.28*	*6.72*	*5.91*
.25		*Copper*		*6.77*	*5.96*	*7.58*	*6.67*
.3		*Copper*		*7.53*	*6.63*	*8.50*	*7.48*
.1		*Aluminium*	*Belted, Lead Sheath, Steel Wire Armour*	*3.04*	*2.68*	*3.34*	*2.94*
.15		*Aluminium*		*3.72*	*3.27*	*4.13*	*3.63*
.2		*Aluminium*		*4.32*	*3.80*	*4.84*	*4.26*
.25		*Aluminium*		*4.98*	*4.38*	*5.58*	*4.91*
.3		*Aluminium*		*5.53*	*4.87*	*6.19*	*5.45*
.5		*Aluminium*		*7.14*	*6.28*	*8.21*	*7.22*
.1		*Aluminium*	*Screened, Lead Sheath, Steel Wire Armour*	*3.24*	*2.85*	*3.56*	*3.13*
.15		*Aluminium*		*3.91*	*3.44*	*4.34*	*3.82*
.2		*Aluminium*		*4.67*	*4.11*	*5.23*	*4.60*
.25		*Aluminium*		*5.24*	*4.61*	*5.87*	*5.16*
.3		*Aluminium*		*5.91*	*5.20*	*6.62*	*5.82*
.5		*Aluminium*		*7.52*	*6.62*	*8.65*	*7.61*
	95	*Aluminium*	*Belted, Lead Sheath, Steel Wire Armour*	*3.62*	*3.19*	*4.02*	*3.54*
	185	*Aluminium*		*5.32*	*4.68*	*5.96*	*5.24*
	300	*Aluminium*		*6.94*	*6.11*	*7.97*	*7.02*
	95	*Aluminium*	*Belted, Cor.Alum. Sheath, Armour (PICAS)*	*3.52*	*3.05*	*3.91*	*3.38*
	185	*Aluminium*		*5.14*	*4.38*	*5.76*	*4.91*
	300	*Aluminium*		*6.76*	*5.81*	*7.78*	*6.68*
	95	*Aluminium*	*Screened, Cor.Alum. Sheath, Armour*	*3.91*	*3.24*	*4.34*	*3.60*
	185	*Aluminium*		*5.62*	*4.76*	*6.29*	*5.33*
	300	*Aluminium*		*7.24*	*6.19*	*8.33*	*7.12*

Table 17: Three-core 11kV XLPE Cables

Conductor CSA (mm²)	Conductor Material	Continuous Rating (MVA)		Cyclic Rating (MVA)	
		Laid Direct	Ducted	Laid Direct	Ducted
95	Solid Aluminium	3.60	3.00	4.10	3.30
185	Solid Aluminium	5.20	4.50	6.00	4.90
300	Solid Aluminium	6.80	5.90	8.00	6.50
300	Solid Alum. + separate earth ①	8.10	7.00	9.50	7.70

① Where a circuit capacity greater than the maximum rating of a 300mm² cable is required, the rating restriction arising from the cross section of copper screen wires can be mitigated by laying a continuous separate earth wire along with the HV cable. The separate earth wire will be connected to the cable screen wires at every joint position in order to achieve appropriate bonding and the necessary earth fault capacity. Bonding of the earth wire and all cable jointing shall be in accordance with jointing instructions and utilising approved materials and techniques. In such cases, additional measures may be required to mitigate against the risks arising from potential third party interference which would compromise the rating.

Table 18: Single Core 11kV Cables, Un-armoured in Trefoil Formation

Conductor CSA		Conductor Material	Cable Construction	Continuous Rating (MVA)		Cyclic Rating	
In²	mm²			Laid Direct	Ducted	Laid Direct	Ducted
	95	Solid Al	XLPE	3.60	3.00	4.10	3.30
	185	Solid Al	XLPE	5.20	4.50	6.00	4.90
	300	Solid Aluminium	XLPE	6.80	5.90	8.00	6.50
	300	Copper	XLPE	11.60	10.30	13.50	11.90
.75	*500*	*Copper*	*PILC*	*12.80*	*11.30*	*14.80*	*13.00*
	500	Copper	XLPE	14.70	13.00	17.40	15.10

Where 2 cables per phase are required, e.g. for 24MVA 33/11kV transformer LV connections (assuming a minimum spacing of 450mm between cable groups), a de-rating factor of 0.88 shall be applied to the above ratings in reflection of the mutual heating arising from the close proximity of the adjacent cable. Where 2 cables per phase are employed, they shall be laid in two trefoil groups. Earthing and bonding of the installation shall be carried out as described in section 7.3.

For 11kV cables only, and provided that the conditions detailed in section 7.8 are achieved, a 3-day emergency rating can be applied. This can be assumed to be 110% of the corresponding cyclic rating.

9.7 Summer Ratings for LV Cables

Table 19: PILC LV Cables

Conductor CSA		Conductor Material	Continuous Rating (kVA)		Cyclic Rating (kVA)	
In²	mm²		Laid Direct	Ducted	Laid Direct	Ducted
.0225		*Copper*	*72.00*	*63.37*	*83.00*	*92.40*
.04		*Copper*	*101.00*	*88.90*	*105.00*	*92.40*
.06		*Copper*	*126.00*	*110.90*	*137.00*	*120.60*
.1		*Copper*	*173.00*	*152.28*	*194.00*	*170.70*
.15		*Copper*	*209.00*	*183.88*	*243.00*	*213.80*
.2		*Copper*	*248.00*	*218.20*	*298.00*	*262.20*
.25		*Copper*	*284.00*	*249.92*	*351.00*	*308.90*
.3		*Copper*	*320.00*	*281.60*	*403.00*	*354.60*
.5		*Copper*	*410.00*	*360.80*	*513.00*	*354.60*
.06		*Aluminium*	*97.00*	*85.36*	*112.00*	*131.10*
.1		*Aluminium*	*133.00*	*117.04*	*153.00*	*131.10*
.15		*Aluminium*	*162.00*	*142.60*	*202.00*	*163.70*
.2		*Aluminium*	*194.00*	*170.68*	*243.00*	*198.90*
.25		*Aluminium*	*223.00*	*196.19*	*279.00*	*198.90*
.3		*Aluminium*	*252.00*	*221.72*	*315.00*	*276.30*
.5		*Aluminium*	*324.00*	*285.10*	*405.00*	*365.20*
	70	*Aluminium*	*133.00*	*117.00*	*166.00*	*130.20*
	95	*Aluminium*	*162.00*	*142.58*	*202.00*	*162.80*
	120	*Aluminium*	*183.00*	*161.00*	*229.00*	*188.30*
	185	*Aluminium*	*237.00*	*208.52*	*297.00*	*249.00*
	300	*Aluminium*	*309.00*	*271.90*	*387.00*	*348.50*

Table 20: Three-core LV Waveform Cables (Combined Neutral/Earth (CNE))

Conductor CSA (mm²)	Conductor Material	Continuous Rating (kVA)		Cyclic Rating (kVA)	
		Laid Direct	Ducted	Laid Direct	Ducted
95	*Solid Aluminium*	*133.00*	*106.88*	*166.00*	*145.00*
185	*Solid Aluminium*	*230.00*	*186.46*	*288.00*	*215.00*
300	*Solid Aluminium*	*302.00*	*246.74*	*378.00*	*284.00*

Table 21: Four Core LV Waveform Cables (Separate Neutral / Earth (SNE))

Conductor CSA (mm²)	Conductor Material	Continuous Rating (kVA)		Cyclic Rating (kVA)	
		Laid Direct	Ducted	Laid Direct	Ducted
95	Aluminium	175.00	154.00	201.00	195.40
185	Aluminium	245.00	215.58	303.00	283.40
240	Aluminium	295.00	259.60	375.00	329.10

Table 22: Single Core LV Cables

Conductor CSA (mm²)	Conductor Material	Continuous Rating (kVA)		Cyclic Rating (kVA)	
		Laid Direct	Ducted	Laid Direct	Ducted
480	Aluminium	417.00	392.28	483.72	455.05
500	*Copper*	*554.00*	*499.00*	*642.64*	*578.84*
600	*Aluminium*	*450.00*	*423.00*	*522.00*	*490.68*
740	Aluminium	568.00	533.00	658.88	618.28

Where 2 cables per phase are required, e.g. for secondary substation transformer LV connections (assuming a minimum spacing of 450mm between cable groups), a de-rating factor of 0.85 shall be applied to the above ratings in reflection of the mutual heating arising from the close proximity of the adjacent cable. Where 2 cables per phase are employed, they shall be laid in two trefoil groups. Earthing and bonding of the installation shall be carried out as described in section 7.3.

9.8 Summer Ratings for Service Cables

Table 23: PVC Insulated Split Concentric Neutral & Earth (SNE)

Conductor CSA (mm²)	Conductor Material and cable construction	Continuous Rating (kVA)			Cyclic Rating Laid Direct (kVA)
		Laid Direct	Ducted in Pipe	Ducted in Tube	
4 (1+N+E)	Stranded Copper Phase Conductor, Stranded Cu Split Concentric Neutral and Earth	12.*70*	12.*20*	11.*20*	14.*70*
16 (1+N+E)		27.*60*	26.*60*	24.*30*	32.*00*
25 (1+N+E)		36.*00*	34.*60*	31.*70*	41.*70*
16 (3+N+E)		70.*50*	67.*90*	62.*20*	81.*80*
25 (3+N+E)		93.*40*	89.*90*	82.*30*	108.*30*
35 (3+N+E)		135.*00*	129.*60*	119.*00*	156.*60*
25 (1+N+E)	Solid Alum Phase, Stranded Cu Split Concentric N & E	27.*60*	26.*60*	24.*30*	32.*00*
35 (3+N+E)		82.*50*	79.*40*	79.*40*	95.*70*

Table 24: PVC Insulated Combined Neutral & Earth (CNE)

Conductor CSA (mm²)	Conductor Material and cable construction	Continuous Rating (kVA)			Cyclic Rating Laid Direct (kVA)
		Laid Direct	Ducted in Pipe	Ducted in Tube	
10 (1+N/E)	*Solid Aluminium Phase Conductor, Stranded Copper Combined Neutral and Earth*	*16.60*	*16.00*	*14.70*	*19.30*
25 (1+N/E)		*27.60*	*26.60*	*24.30*	*32.00*
35 (1+N/E)		*33.60*	*32.30*	*29.60*	*39.00*
25 (3+N/E)		*69.80*	*67.20*	*61.60*	*81.00*
35 (3+N/E)		*82.80*	*79.60*	*73.00*	*96.00*

10. OVERHEAD LINE RATINGS

10.1 Adjustment of Overhead Line Ratings in line with ERP27

This Engineering Recommendation (ER) is the result of a statistical analysis of the risk of full load and overload excursions of distribution overhead lines in conjunction with design and operational temperature risk tests detailed in CERL Report RD/L/N/129/79

Two distinct circuit ratings are given, applied to 50°C, 65°C and 75°C conductor temperatures. The first of these is for Multi-Circuit Primary Supply Systems, where the maximum circuit load occurs after a circuit outage, such as duplicate transformer feeders at 33 kV or duplicate 11 kV circuits giving a firm supply.

The second circuit setting is applied to single circuit supply systems with a continuous or cyclic load and to LV circuits where there is a higher fault rate than at 33 kV, resulting in an increased risk of temperature excursion. The second rating is lower than recommended for duplicate circuits.

In practice new lines or refurbished lines can be constructed for design temperatures of 50°C, 65°C or 75°C. Company practice will be to retain 50°C working for new or refurbished lines, consequently there is some reduction in rating due to the continued use of 50°C working.

10.2 Single Circuit Supply Systems

The recommended rating for single circuit supply systems will provide a capability to supply maximum load, either continuous or cyclic, e.g. a typical three-hour peak load period on a daily load cycle, with negligible temperature excursion time.

10.3 Multi-Circuit Primary Supply Systems

In this type of supply system, the circuits may be called upon to supply maximum load in the event of a circuit outage. This arrangement is used most commonly for primary distribution, such as duplicate transformer feeders at 132kV and 33kV but may also comprise untapped secondary system voltage, e.g. 11kV circuits, providing a firm supply to an end load.

Use of the CERL continuous ratings with the selected excursion values stated in the above report takes account of the low risk of a circuit outage at the time of peak load and the unlikely occurrence of excess temperature. The ratings are greater than those recommended for single circuits.

10.4 Secondary Distribution Systems

The fault rate on the HV overhead secondary systems is high compared with the primary supply systems, which are largely untapped and unencumbered with distribution equipment. Although the NAFIRS performance figures indicate that due to faster repair and supply restoration times, the overall outage time is statistically no greater than that for the primary supply systems. It is considered, however, that in practice the high fault rate would most likely result in an unacceptable increased risk of temperature excursion and the recommended rating for circuits in a secondary distribution mode of operation is the same as that for single circuit supply systems.

10.5 Ratings for Overhead Lines

The following ratings are calculated in accordance with Engineering Recommendation P27 (November 1986) and CERL Report RD/L/N/129/79 and assume the following conditions:-

Wind Speed		0.5m/s
Ambient Temperature	(Winter)	2°C
Ambient Temperature	(Summer)	20°C
Solar Radiation		Nil
Maximum Conductor Temperature		50°C

Due to the reduced cooling effect outside the winter period, overhead line capacity is effectively de-rated for these months. Overhead line ratings are generally accepted as three-season rating components but for distribution applications they can be assumed to have two season ratings – Winter and Summer. For the purposes of this document, winter is considered to comprise of the months between October – April with Summer ratings (with an assumed ambient temperature of 20°C) consists of the months between May and September (see section 10.5.1)

Table 25: Overhead Line Winter Ratings

Conductor Size and Type					Circuit Rating (MVA)						
					Multi Circuit *		Single Circuit			1-Phase Systems	
Imperial	Metric	Material	Stranding	Code	11kV	33kV	LV	11kV	33kV	LV	11kV
	10	Ericsson	3x10/10	Excel	-	-	-	1.353	-	-	0.781
0.0225		HDC	7/.064		-	-	0.080	-	-	0.046	-
	14	HDC	7/1.6		-	-	0.078	-	-	0.045	-
0.025		HDC	3/.104		-	-	0.089	2.363	-	0.051	1.364
	16	HDC	3/2.65		-	-	0.089	2.363	7.088	0.051	1.364
	25	AAAC	7/2.34	Almond	-	-	0.094	-	-	0.054	-
	25	ACSR	6+1/2.36	Gopher	-	-	-	2.382	-	-	1.375
0.05		HDC	3/.147		-	-	0.140	3.715	-	0.081	2.145
	32	HDC	3/3.75		-	-	0.140	3.715	-	0.081	2.145
	35	HDC	7/2.5		-	-	0.141	3.734	-	0.081	2.156
	35	ABC	4x35/7		-	-	0.099	-	-	-	-
	35	ABC	2x35/7		-	-	-	-	-	0.068	-
0.058		HDC	7/.104		4.496	13.489	-	3.963	11.889	-	2.288
0.075		HDC	7/.116		5.182	-	0.173	4.573	-	0.100	2.640
	50	AAAC	7/3.3	Hazel	-	-	-	3.925	11.774	-	2.266
	50	ACSR	6+1/3.35	Rabbit	-	-	-	3.772	11.317	-	2.178
	50	AAC	7/3.1	Ant	-	-	0.166	-	-	0.096	-
	50	HDC	7/3.0		5.316	-	0.177	4.687	-	0.102	2.706
	50	ABC	4x50/19		-	-	0.121	-	-	-	-
	50	ABC	2x50/19		-	-	-	-	-	0.082	-
0.082		HDC	1/0		-	-	0.244	-	-	0.141	-
0.095		HDC	2/0		-	-	0.266	7.049	-	0.154	4.070
	70	ACSR	12+7/2.79	Horse	-	-	-	-	-	-	-
0.1		HDC	7/.136		6.402	19.205	-	5.640	16.919	-	3.256
	70	HDC	7/3.55			19.891	-	-	17.547	-	-
	95	ABC	4x95/19		-	-	0.193	-	-	-	-
	95	ABC	2x95/19		-	-	-	-	-	0.128	-
	95	Ericsson	3x95/25	Axces	-	-	-	3.811	-	-	2.200
	100	AAAC	7/4.65	Oak	-	-	-	6.173	18.519	-	3.564
	100	ACSR	6/4.72+7/1.57	Dog	6.687	20.062	-	5.925	17.776	-	3.421
	100	AAC	7/4.39	Wasp	-	-	0.262	-	-	0.151	-
0.15		HDC	7/.166		8.326	24.978	-	7.335	22.006	-	4.235
	100	HDC	7/4.3		8.516	25.549	-	7.526	22.577	-	4.345
0.2		HDC	7/.193		10.155	30.465	-	8.955	26.864	-	5.170
	150	AAAC	19/3.48	Ash	-	-	0.308	8.154	24.463	0.178	4.708
	150	ACSR	18+1/3.35	Dingo	-	-	0.303	8.021	24.063	0.175	4.631
	150	ACSR	30+7/2.59	Wolf	9.298	27.893	-	8.212	24.635	-	4.741
	160	AACSR	30+7/2.79	Keziah	-	-	-	-	-	-	-
	200	AAAC	37/2.87	Poplar	-	33.209	-	-	29.436	-	-
	300	AAAC	37/3.53	Upas	-	44.011	-	-	38.810	-	-
	400	AAC	37/3.78	Centipede	-	51.442	-	-	45.383	-	-

* For circuits in this mode of operation and intended to supply intensive industrial or commercial centre loads, apply a de-rating factor of 0.96.

Table 26: Overhead Line Summer Ratings

Conductor Size and Type					Circuit Rating (MVA)						
					Multi Circuit *		Single Circuit			1-Phase Systems	
Imperial	Metric	Material	Stranding	Code	11kV	33kV	LV	11kV	33kV	LV	11kV
	10	Ericsson	3x10/10	Excel				1.353			0.781
0.0225		HDC	7/.064				0.063			0.046	
	14	HDC	7/1.6				0.062			0.045	
0.025		HDC	3/.104				0.071	1.886		0.051	1.089
	16	HDC	3/2.65				0.071	1.886	5.659	0.051	1.089
	25	AAAC	7/2.34	Almond			0.075			0.054	
	25	ACSR	6+1/2.36	Gopher				1.905			1.100
0.05		HDC	3/.147				0.111	2.953		0.081	1.705
	32	HDC	3/3.75				0.111	2.953		0.081	1.705
	35	HDC	7/2.5				0.112	2.972		0.081	1.716
	35	ABC	4x35/7				0.084				
	35	ABC	2x35/7							0.068	
0.058		HDC	7/.104		3.601	10.803		3.182	9.545		1.837
0.075		HDC	7/.116		4.153		0.138	3.658		0.100	2.112
	50	AAAC	7/3.3	Hazel				3.144	9.431		1.815
	50	ACSR	6+1/3.35	Rabbit				3.010	9.031		1.738
	50	AAC	7/3.1	Ant			0.132			0.096	
	50	HDC	7/3.0		4.249		0.142	3.753		0.102	2.167
	50	ABC	4x50/19				0.103	2.725			1.573
	50	ABC	2x50/19					2.725		0.082	1.573
0.082		HDC	1/0				0.196			0.141	
0.095		HDC	2/0				0.213	5.640		0.154	3.256
	70	ACSR	12+7/2.79	Horse							
0.1		HDC	7/.136		5.125	15.375		4.515	13.546		2.607
	70	HDC	7/3.55			15.890			14.061		
	95	ABC	4x95/19				0.164				2.508
	95	ABC	2x95/19							0.128	
	95	Ericsson	3x95/25	Axces				3.811			2.200
	100	AAAC	7/4.65	Oak				4.954	14.861		2.860
	100	ACSR	6/4.72+7/1.57	Dog	5.411	16.233		4.820	14.461		2.783
	100	AAC	7/4.39	Wasp			0.210			0.151	
0.15		HDC	7/.166		6.668	20.005		5.887	17.662		3.399
	100	HDC	7/4.3		6.821	20.462		6.021	18.062		3.476
0.2		HDC	7/.193		8.135	24.406		7.183	21.548		4.147
	150	AAAC	19/3.48	Ash			0.247	6.535	19.605	0.178	3.773
	150	ACSR	18+1/3.35	Dingo			0.243	6.440	19.319	0.175	3.718
	150	ACSR	30+7/2.59	Wolf	7.469	22.406		6.592	19.777		3.806
	160	AACSR	30+7/2.79	Keziah							
	200	AAAC	37/2.87	Poplar		26.635			23.606		
	300	AAAC	37/3.53	Upas		35.323			31.208		
	400	AAC	37/3.78	Centipede		41.325			36.524		

* For circuits in this mode of operation and intended to supply intensive industrial or commercial centre loads, apply a de-rating factor of 0.96.

10.5.1 Consideration of Special Circumstances

The ratings detailed in Table 25: Overhead Line Winter Ratings are based on an ambient temperature of 2°C and are therefore winter ratings. If the maximum load is likely to occur during the summer months then the appropriate rating shall be selected from Table 26: Overhead Line Summer Ratings which will generally have a de-rating factor of 0.8 of the corresponding winter rating.

The current carrying capacity of new conductor is approximately 8% less than for weathered conductor; however, in most cases, the conductor will have weathered by the time the full load rating is reached.

Where P.V.C. covered conductors are used, the bare conductor rating may still be applied as the blanketing effect of the P.V.C. is offset by the increased surface area from which the conductor heat may be dissipated.

Overhead line conductors have a very small thermal inertia, and it is therefore very difficult to assign a cyclic rating to them. The values provided in the tables shall be regarded as the maximum for the conditions quoted. On existing overhead lines, the current ratings of joints and connectors may be less than the conductor ratings. On new lines, the ratings of joints and connectors shall match the conductor ratings.

If it is anticipated that the total load on two 33kV overhead lines will exceed 24MVA, with potentially little relief from cyclic load behaviour, a pair of overhead lines of appropriate size shall be selected without dependence on smaller conductors being loaded to (or beyond) rating.

11. RATINGS FOR 11KV AND 33KV SWITCHGEAR

The following table gives the nominal ratings of standard switchgear. These are extracted from ENATS 41-36 and exclude oil switches and fuse switches.

Table 27: Switchgear Ratings (From ENATS 41-36)

Circuit Definition	Normal Rating of Switchgear		Maximum Rating of Circuit (MVA)
	Amps	MVA	
11kV Feeder	630	12.0	9.17 ①
11kV Incomer (24MVA Transformer)	1,250	23.8	24.0 ②
11kV Bus Section (24MVA Transformer)	1,250	23.8	13.2 ③
11kV Incomer (40MVA Transformer)	2,000	38.1	40.0 ④
11kV Bus Section (40MVA Transformer)	1,250	23.8	22.0 ⑤
33kV Feeder (2x24MVA Circuits)	1,250	71.4	48.0 ⑥
33kV Bus Section (Two Section Switchboard)	1,250	71.4	78.0 ⑦
33kV Bus Section (Four Section Switchboard)	1,250	71.4	39.0 ⑧

① 3 day emergency cyclic rating of 300mm^2 cable
② & ④ Emergency rating of one system transformer. Busbars matching circuit breaker will cater for unbalance between two sections of switchboard
③ & ⑤ Assumes 10% unbalance between two sections of switchboard
⑥ Emergency rating of two system transformers
⑦ & ⑧ Assumes balanced load on each side of bus-section breaker

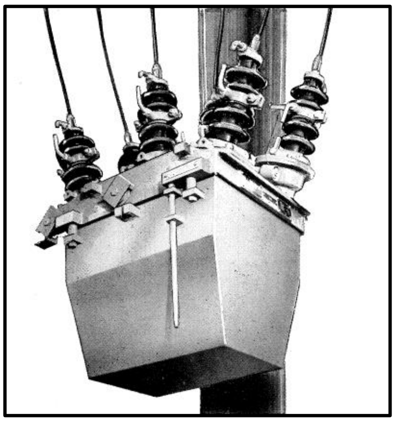
For applications where the load apportionment across the switchboard sections is substantially non-symmetrical, i.e. the degree of unbalance exceeds 10% as in notes above, the site-specific switchgear duty and loading pattern shall be considered to ensure that the design is valid and the switchgear will be required to operate within the design parameters.

It is important that the ancillary equipment of the installation complements the primary equipment and do not de-rate the installation for either thermal or short circuit capability. An example would be CT specification which should, where practical and possible, match the target fault level capability and therefore does not have the effect of de-rating the primary equipment to an unacceptable level.

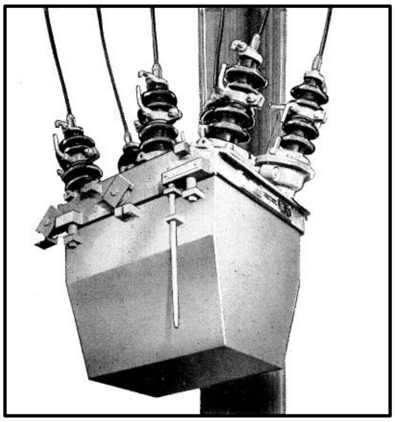
12. RATINGS FOR 11KV OVERHEAD LINE SWITCHGEAR

12.1 Legacy Pole Mounted Auto-Reclosing Circuit Breakers (PM ARCB)

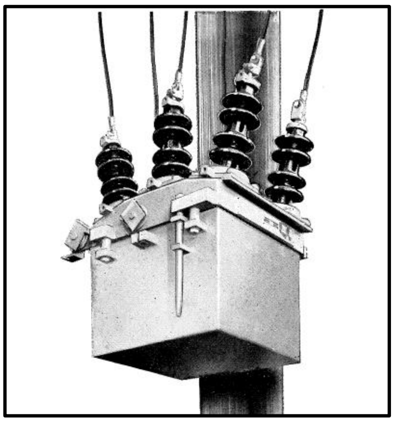
REYROLLE OYT 11	
Rated Maximum Voltage	14.4kV
Rated Continuous Current	250A
Fault Making Capacity RMS	8.0kA
Fault Breaking Capacity	5.2kA
Short Time Current (3 seconds)	6.0kA
Lightning Impulse Withstand	110kV



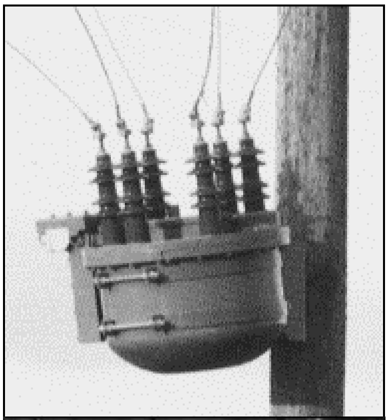
REYROLLE OYT 22	
Rated Maximum Voltage	14.4kV
Rated Continuous Current	400A
Fault Making Capacity RMS	10.0kA
Fault Breaking Capacity	6.6kA
Short Time Current (3 seconds)	6.0kA
Lightning Impulse Withstand	180kV



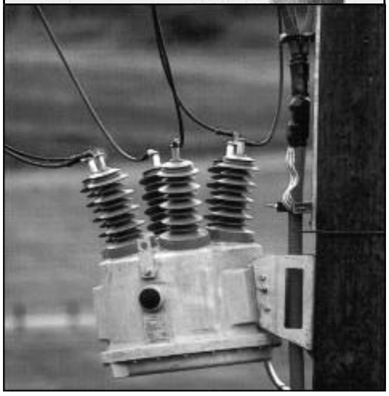
REYROLLE OYS	
Rated Maximum Voltage	14.4kV
Rated Continuous Current	200A
Fault Making Capacity RMS	10.6kA
Fault Breaking Capacity	-
Short Time Current (3 seconds)	7.0kA
Lightning Impulse Withstand	110kV



REYROLLE ESR 400/6 (SF6)	
Rated Maximum Voltage	14.4kV
Rated Continuous Current	400A
Fault Making Capacity RMS	6.0kA
Fault Breaking Capacity	6.0kA
Short Time Current (3 seconds)	6.0kA
Lightning Impulse Withstand (Surge Arrestors installed)	110kV



WHIPP & BOURNE (GAS VACUUM RECLOSER 15)	
Rated Maximum Voltage	15.5kV
Rated Continuous Current	630A
Fault Making Capacity RMS	12.5kA
Fault Breaking Capacity	12.5kA
Short Time Current (3 seconds)	12.5kA
Lightning Impulse Withstand (Surge Arrestors installed)	110kV

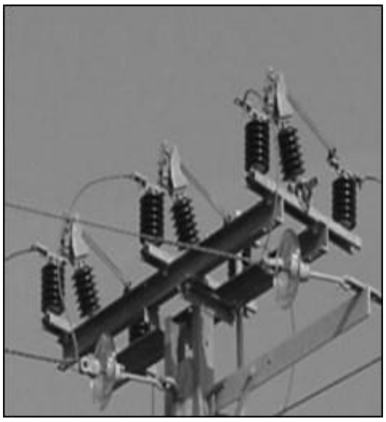


12.2 Pole Mounted Auto-Reclosing Circuit Breakers (PM ARCB)

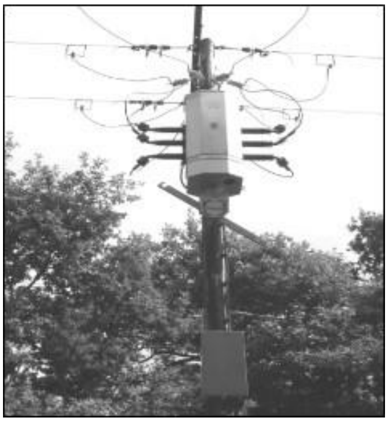
NOJAPOWER - NOJA 15 (GAS VACUUM RECLOSER)	
Rated Maximum Voltage	15.5kV
Rated Continuous Current	630A
Fault Making Capacity RMS	16.0kA
Fault Breaking Capacity	16.0kA
Short Time Current (3 seconds)	16.0kA
Lightning Impulse Withstand (Surge Arrestors installed)	110kV

12.3 12kV Disconnectors & Switch Disconnectors

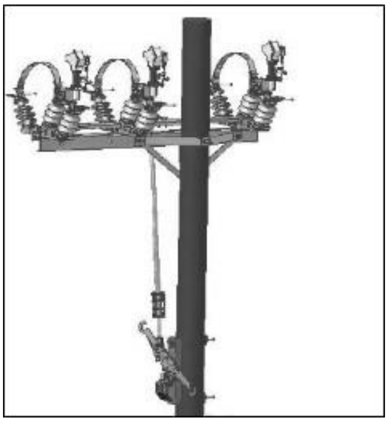
MORRIS LINE EQUIPMENT "RXL"	
Rated Maximum Voltage	12kV
Rated Continuous Current	630A
Fault Making Capacity RMS	3kA
Fault Breaking Capacity	None
Short Time Current (3 seconds)	25kA
Lightning Impulse Withstand (Surge Arrestors installed)	150kV



NOVEXIA AUGUSTE SOULE (SF6)	
Rated Maximum Voltage	24kV
Rated Continuous Current	400A
Fault Making Capacity RMS	12.5kA
Fault Breaking Capacity	None
Short Time Current (3 seconds)	12.5kA
Lightning Impulse Withstand (Surge Arrestors installed)	125kV



GEVEA GDS 15 HOOK STICK (DEPENDENT MANUAL)	
Rated Maximum Voltage	15kV
Rated Continuous Current	630A
Fault Making Capacity RMS	3kA
Fault Breaking Capacity	None
Short Time Current (3 seconds)	7kA
Lightning Impulse Withstand	110kV



GEVEA GDS 15 HOOK STICK (DEPENDENT MANUAL)	
Rated Maximum Voltage	15kV
Rated Continuous Current	630A
Fault Making Capacity RMS	10kA
Fault Breaking Capacity	None
Short Time Current (3 seconds)	7.0kA
Lightning Impulse Withstand	110kV

STICK OPERATED FUSE UNIT	
Rated Maximum Voltage	11.0kV
Rated Continuous Current	100A
Fault Making Capacity RMS	7.88kA
Fault Breaking Capacity	7.88kA
Short Time Current (3 seconds)	7.88kA
Lightning Impulse Withstand (Surge Arrestors installed)	95kV

STICK OPERATED SOLID-LINK UNIT	
Rated Maximum Voltage	11.0kV
Rated Continuous Current	100A
Fault Making Capacity RMS	7.88kA
Fault Breaking Capacity	None
Short Time Current (3 seconds)	7.88kA
Lightning Impulse Withstand (Surge Arrestors installed)	95kV

12.3.1 Switch Disconnector Categorisation

Pole mounted switch disconnectors are categorised in a standardised manner to denote their generic functionality and their capability with respect to their duty appropriate with their location on the system. The disconnector category relates to the type (or lack of) disconnector arc suppression while the equipment fault making capability, for the point of installation on the network, is denoted.

Disconnector Category	
1	Interrupter heads installed
2	Arcing horns installed
3	No arc suppression installed, negligible current break only

Fault Making Capability	
M	Make fault within Equipment Rating
- (no marking)	Fault Making duty out-with Equipment Rating

Typical examples of disconnector categories are:

C1M (Category 1M) Disconnector with interrupter heads fitted and capable of making fault current at the point on the system that it is fitted

C2 (Category 2) A plain break disconnector and unsuitable for making fault current at the point on the system that it is fitted

13. RATINGS FOR TRANSFORMERS AND REACTORS

There are a variety of system components which are generically wound components. This encompasses conventional two-winding power transformers, one-to-one transformers (voltage regulators) and single winding devices such as reactors.

The main sub-group of wound components in general use is that of distribution power transformers. This sub-group also readily split into a further two sub-groups, Secondary Substation Transformers and Primary Substation Transformers. The specifications to which equipment in each of these groups is procured, has changed over time.

13.1 Existing Transformer Specifications

The current specifications for transformer purchase are as follows:

Secondary Substation Transformers: the transformers in this category deployed on the Scottish Power Distribution system are specified in the Energy Networks document “Specification for Distribution Transformers 6.6kV-11kV, 25kVA-1,000kVA” which is based on the industry standard document, ENA Technical Specification 35-1 “Distribution Transformers (from 16kVA to 2000kVA)”

Primary Substation Transformers: similarly, for primary substation transformers, the Scottish Power Energy Networks (“Specification for 33kV System Transformers“) is based on the industry standard document ENA Technical Specification 35-2 “Emergency Rated System Transformers 33/11.5kV”. The topic is covered further in section 13.3.

13.2 Legacy Transformer Capabilities

Secondary Substation Transformers: in general terms, secondary substation transformers are simple in design application terms and ancillary systems. As a result their rating can be considered as independent of design specification or age and effectively provide transformation to the kVA or MVA limits of their nameplate.
Primary Substation Transformers: Primary Substation transformers are more complex in design, ancillary systems and application than those applies in secondary substation situations.
There are also a considerable number of legacy units operating on the system which are to previous specifications and a variety of rating system nomenclatures, the most commonly used of which include:

Table 28: Transformer Rating Nomenclature

Term	System
ERS	Emergency Rating System
CER	Continuous Emergency Rating
CERS	Continuous Emergency Rating System
CMR	Continuous Maximum Rating
CMRS	Continuous Maximum Rating System
ONAN	Oil Natural, Air Natural (Natural oil convection, no assistance on radiator banks)
ONAF	Oil Natural, Air Forced (Natural oil convection, fan assistance on radiator banks)
OFAN	Oil Forced, Air Natural (Pumped oil circulation, no assistance on radiator banks)
OFAF	Oil Forced, Air Forced (Pumped oil circulation, fan assistance on radiator banks)
AFB	Air Forced Blast (Fan assistance on radiator banks)

13.3 Primary Transformer Ratings

The capability of primary transformers is generally identified by two ratings, one applicable under normal circumstances and a higher rating to accommodate emergency situations, generally with enhanced oil cooling functionality enabled. The current specification defines the latter value as the Continuous Emergency Rating or CER. CER is defined as the continuous load level at which the transformer can operate and remain within the specified temperature limitations defined in the ENATS 35-2 (i.e. winding hot spot not exceeding 140^{0}C at prescribed ambient temperatures). It is accepted that at this CER rating, loss of life will be significantly accelerated but it is also expected that the transformer will be required to run at its CER for only a few weeks in its whole operating life. The increased loss of life should not therefore seriously reduce the life of the transformer, unless the CER is abused over long periods of time.

It is essential that the rating and basis of the rating for any site under consideration is fully appreciated to ensure that the duty imposed is acceptable. For example, some 12/24MVA primary transformers have a 12MVA rating under normal circumstances, 24MVA under emergency circumstances but are only rated for 19MVA on a continuous maximum rating basis.

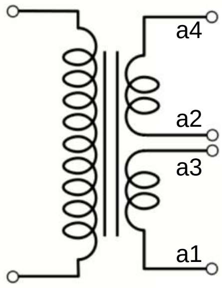
13.4 Split Winding Transformers

Most distribution transformers are of a two-winding arrangement, i.e. and HV and an LV winding. However, there are some legacy pole mounted units which enable greater capacity or higher LV voltage (i.e. 460-480V) from a single phase 11kV overhead line for rural / commercial / industrial or agricultural uses.

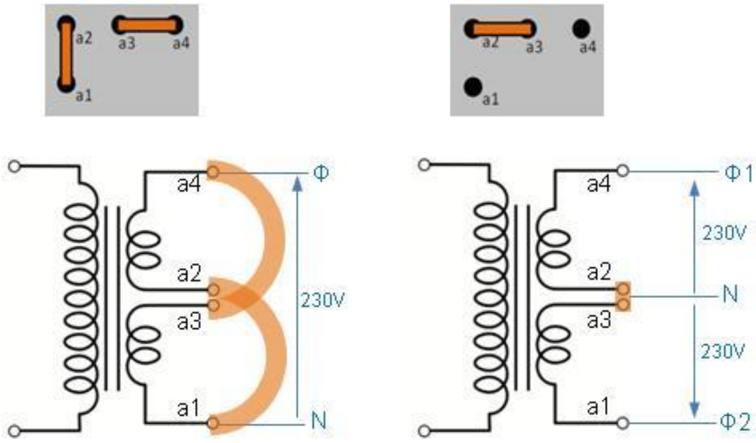
Modern 11kV pole mounted transformers towards the upper end of the capacity band (50MVA and 100MVA) are also capable of operating as a split phase unit. Most can be selected either to a single phase LV supply of the full capacity of the transformer, two single phase supplies of half transformer capacity or a single two-phase supply for specialist equipment of approximately 480V operation.

These transformers may be deployable for generation connections to facilitate the connection of higher capacities of generation onto a single phase 11kV overhead line without the need to establish a second PTE.

Typically, although other configurations and notations are possible, the windings area arranged as indicated in the following figure.



The method of achieving split phase operation will vary with manufacturer but a typical example is shown in the following figures. The left figure shows the link arrangement and resultant winding connections for a conventional LV single phase supply with the schematic on the right indicating the link arrangement and resultant winding connectivity for split phase operation.



As the figures indicate, the 'conventional' link arrangement provides a single phase supply of 50kVA or 100kVA from a 50kVA or 100kVA transformer respectively. The split phase operation either provides a 50kVA (or 100kVA) two phase 480V supply or more commonly two 25kVA (or 50kVA) single phase supplies. It should be noted that winding arrangement indicated results in a phase angle difference of 180^0 for the two windings and therefore external paralleling the connections is not possible.

13.5 Reactors

Reactors are generally applied to the HV or EHV system to control load flow, manage voltage levels or limit prospective short circuit currents.

The application of reactors generally break down to two application types, series application or shunt application. Series applications, which have the reactor connected in series with a primary circuit, effectively increase the impedance of that primary circuit to facilitate improved load sharing with parallel circuits or to reduce the fault level of the remote site. Shunt applications can be:

- True shunt devices connected to absorb reactive power and therby lower system voltage at that node under specific conditions, or
- Alternative-series devices, such as busbar-coupling reactors, which shunt the (open) bus-section circuit breaker to facilitate lower system fault levels.

Further information on such applications can be found in section 9b of the SPD and SPM Design Virtual Manuals.

These devices are unlikely to be standard in terms of rating or impedance and therefore each application will be bespoke in terms of equipment specification. When considering the required ratings for any installation, the rating shall take account of the site specific requirements. In general terms, series reactors will require to be fully rated to match the full load or cyclic capability of the associated primary component (cable, overhead line or transformer). Busbar-coupling reactors however can have lower capacities due to the fact that the duty is likely to be balancing as opposed to full load.

13.6 Voltage Regulators

Voltage regulators can be applied to the distribution system to:

- Temporarily resolve non-compliant voltage issues pending resolution by enduring system reinforcement schemes
- Permanent application to enable the connection of embedded generation without a detrimental impact on existing and adjacent customers.

The temporary nature of the application to resolve system voltage issues reflects both the potentially temporary nature of the issue but essentially, prohibits long-term dependence on the equipment due to the onerous maintenance and spares issues.

Where the connection of a generator to existing circuits results in unacceptable voltage performance, resolution is normally achieved by construction of new circuits (or re-conductoring/rebuilding existing equipment) at significant cost. However, a less robust and lower cost solution utilising voltage regulation may be applied. Permanent application of voltage regulation for generation connections is permitted on the proviso that the customer connection agreement makes clear that strategic spares are not generally available and that, under maintenance of the unit or following terminal failure of the unit, the generation will be constrained to an output level which ensures compliance with our voltage range obligations. In extreme circumstances, this may result in embedded generation being constrained for some months until a replacement item of plant can be procure/repaired and installed. The contractual arrangement and customer communication should ensure that this possibility is clear and acknowledged by the customer.

Regulators can be applied at 33kV or 11kV and can, for 11kV and depending on physical constraints, be pole mounted. Ground mounted applications require the usual access and accommodation requirements appropriate to distribution substations.

Some regulators can be three-phase two-winding power transformers with a nominal 1:1 ratio and tap change control to facilitate step-up or step-down conditions around the nominal voltage.

Some less complex voltage regulators are effectively independent single-phase devices (with shunt and series windings), which can be connected to a three-phase system to effect three-phase voltage regulation. It is essential that these single-phase devices are correctly connected to ensure appropriate and safe operation. Guidance on the connection of the single-phase devices can be found in section 13 of the SPD and SPM Design Virtual Manuals (ESDD-02-008 – “Quality of Supply, System Voltages and Voltage Regulation”).