

Company Policy

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(Supersedes Company Policy (Network Asset Management) 9.2.10.am5)

9.2.10 NETWORK ASSET RATINGS

1.0 POLICY STATEMENT

Assets installed onto the electrical network must have a suitable power, voltage and current ratings for their purpose to safeguard the safe and reliable operation of that network. The ratings philosophy will be based on an assessment of risk by considering:

- costs;
- safety;
- reliability; and
- performance.

The ratings philosophy for electrical assets must be consistent for the purpose and location in the network.

The company will develop and maintain reference documentation for network asset ratings. This documentation will be the primary reference for asset ratings and other fundamental system data.

This policy covers all primary assets which are part of the electrical network including:

- overhead lines (bare, covered and insulated);
- overhead earth wires;
- underground cables;
- earthing systems;
- transformers and voltage regulators;
- circuit breakers and switchgear;
- busbars;
- fuses;
- re-closers;
- temporary network equipment;
- current and voltage transformers;
- capacitors and reactors;
- surge arresters;
- line traps; and
- frequency injection and coupling equipment.

2.0 PURPOSE

This policy provides the framework for standardising rating calculations (power, voltages and currents) and their application for equipment used on the network. This policy also defines the requirements for reference documents that contain various characteristics and parameters for network equipment ratings.

3.0 REFERENCES

Internal

[Company Policy \(Network\) 9.0](#) – Network Asset Management

[Company Policy \(Network\) 9.2.1](#) – Network Planning

[Company Policy \(Network\) 9.2.2](#) – Network Protection

[Company Policy \(Network\) 9.2.5](#) – Network Asset Design

External

AS 1824.1:1995 Insulation coordination – Definitions, principles and rules

AS 1026:2004 E- Electric cables – Impregnated paper insulated – For working voltages up to and including 19/33 (36) kV

AS 1429.1:2006 Electric cables – Polymeric insulated F – For working voltages 1.9/3.3 (3.6) kV up to and including 19/33 (36) kV

AS 1429.2:2009 Electric cables – Polymeric insulated – For working voltages above 19/33 (36) kV up to and including 87/15079/132 (17045) kV

AS 2374.1.2:2003 Power transformers – Minimum Energy Performance Standard (MEPS) requirements for distribution transformers

AS 2374.7:1997 Power transformers – Loading guide for oil-immersed power transformers

AS 3851:1991 The calculation of short-circuit currents in three-phase a.c. systems

AS 60076.1:2005 2014 Power transformers – General

AS 60076.2:2013 P Power transformers – Temperature rise for liquid-immersed transformers

AS 60076.7:2013 P Power transformers – Loading guide for oil-immersed power transformers

AS 62271.301:2005 High voltage switchgear and controlgear – Part 301 Dimensional standardisation of terminals

AS/NZS 7000:20160 Overhead line design – Detailed procedures

Cigre Technical Brochure 207: 2002 Thermal behaviour of overhead conductors

ENA EG1 – 2006 Substation Earthing Guide

ENA National Electricity Network Safety Code (Doc 01-2008)

ESAA D(b)5 – Current Rating of Bare Overhead Line Conductors

IEC 60071-1: 2011 - Insulation co-ordination - Part 1: Definitions, principles and rules

IEC 60287- 2-1 2015 – Electric Cables – Calculation of current rating

IEC 60853-1: 2008 – Calculation of the cyclic and emergency current rating of cables. Part 1: Cyclic rating factor for cables up to and including 18/30(36) kV

IEC 60853-2: 2008 – Calculation of the cyclic and emergency current rating of cables - Part 2: Cyclic rating of cables greater than 18/30 (36) kV and emergency ratings for cables of all voltages

IEC 60853-3: 2002 - Calculation of the cyclic and emergency current rating of cables - Part 3: Cyclic rating factor for cables of all voltages, with partial drying of the soil

4.0 DEFINITIONS

AAC

All Aluminium Conductor

ABC

Aerial Bundled Cable

Albedo

Amount of solar radiation reflected from the ground.

CCT

Covered Conductor Thick

Coastal region

Refers to that part of the company's supply area that falls generally between the sea and the escarpment from Helensburgh to Ulladulla.

Distribution network

The collection of assets (distribution lines, cables, substations and associated equipment) which distributes power from zone substations to distribution substations. For this policy, the term distribution network will also include the Low Voltage (LV) reticulation.

Distribution substation

A substation with a primary voltage of 11 kV, 22 kV or 12.7 kV and is part of the company's distribution network.

Document control

Employees who work with printed copies of documents must check the Business Management System Website regularly to monitor version control. Documents are considered "UNCONTROLLED IF PRINTED", as indicated in the footer.

Dynamic rating

Ratings for equipment that are based on real time or near real-time measurements of loading, ambient conditions and equipment temperature data.

Executive Leadership Team

Chief Executive Officer, Chief Operating Officer, Chief Financial Officer, General Manager Asset Management, General Manager Network Services, Chief Information Officer, General Manager Regulation & Corporate Affairs, General Manager Safety, Human Resources & Environment, General Manager Strategy & Development and Company Secretary.

High Voltage (HV) network

A voltage normally exceeding 1,000 Volts alternating current or 1,500 Volts direct current.

Inland region

Refers to the area within the company's supply area not otherwise described or covered by mountainous or coastal regions.

 I^2t

A measure of the amount of electrical energy dissipated as heat in the resistive elements of a piece of equipment during fault conditions. It is calculated as the integral of the square of the current for the duration that the current flows through the equipment.

Low Voltage (LV) network

The LV network in the company's area operates at 400V three-phase and 230V single-phase.

Mountainous region

Refers to the part of the company's supply area within the Blue Mountains falling to the west of Hazelbrook Zone Substation, and extending to the edge of the franchise area at Kandos. This region also applies to the network within the Southern Highlands area, which is confined to the east by the escarpment; to the north by Avon Dam Road, at Bargo; to the south by the township of Fitzroy Falls; and to the west by Marulan bulk supply point and the franchise area boundary.

Night

For this policy, night refers to the period after sunset when solar radiation is absent.

Review cycle

The review cycle is the frequency with which a document is reviewed. The review cycle risk rating displayed in the title block indicates the document has been risk assessed as follows:

Risk Rating	Review Cycle
High	1, 2, or 3 years
Medium	5 years
Low	As required

A review may be mandated at any time where a need is identified due to changes in legislation, organisational changes, restructures, occurrence of an incident or changes in technology or work practice.

RMS

Root Mean Square

Short circuit making and breaking capacities

The RMS value of symmetrical Alternating Current (AC) component of the maximum permissible short circuit current, which can be safely made and/or interrupted by fuse, circuit breaker, switches or fault throwers under external through fault conditions.

The breaking capacity of some equipment may be much lower than the corresponding making capacity.

Short time withstand current

The RMS value of the current that electrical equipment can carry or withstand for defined short time duration under specified external through fault conditions.

Single Wire Earth Return (SWER)

The SWER system, used in remote rural areas.

Standard voltage levels

Standard voltages are used throughout the company's network. These voltages are:

- transmission: 132 kV;
- sub-transmission: 132 kV, 66 kV, 33 kV;
- HV distribution: 22 kV, 11 kV, 12.7 kV SWER; and
- LV distribution: 400/230 V.

Sub-transmission network

The collection of assets (sub-transmission lines, cables, zone substations and associated equipment), whose purpose must distribute power in bulk from transmission substations to zone substations.

Summer

For this policy, the summer period will nominally cover the period between 1 October and 30 April. Summer ratings must apply on dates outside the specified period if the ambient air temperature exceeds 30°C.

Transmission network

The collection of assets (transmission lines, cables, substations and associated equipment) which transmits power in bulk from a TransGrid supply point to a transmission substation.

Within the context of this policy the term transmission refers to both the transmission and sub-transmission networks.

Winter

For this policy, the winter period will nominally cover the period between 1 May and 30 September.

XLPE

Cross Linked Polyethylene

Zone substation

A substation with a primary voltage of 132 kV, 66 kV, or 33 kV and a secondary voltage of 22 kV or 11 kV.

5.0 KEY REQUIREMENTS**5.1 General**

The transmission and distribution network must be planned, designed and operated to satisfy the following requirements:

- the network must not exceed the fault levels above those set out in this policy under normal and foreseeable emergency situations. However, the maximum fault levels may be exceeded for momentary periods during changeover operations;
- network equipment must be specified to withstand the foreseeable maximum fault levels as set out in this policy; and
- network equipment must operate within the thermal capability of primary plant under normal and foreseeable abnormal load conditions.

Dynamic ratings have been excluded from this policy. However, dynamic or real time ratings for individual plant may be evaluated on a case by case basis by Manager Asset Standards & Design.

5.2 Network asset reference resources

This policy prescribes four reference resources, listed in Table 1 – Network asset reference resources and applicable owner to be made available to assist in the management of asset ratings. These resources must be reviewed and updated (excluding design drawings) at frequency dictated by the extent and nature of the changes required.

Table 1 – Network asset reference resources and applicable owner

Resource	Owner
Transmission network characteristics reference document	Manager Asset Strategy & Planning
Project design drawings	Manager Asset Standards & Design
Network asset ratings document	Manager Asset Standards & Design
Network fault level ratings model	Manager Asset Strategy & Planning

5.2.1 Transmission network characteristics reference document

The information listed in Table 2 – The information required for the transmission network characteristics document must be included in the transmission network characteristics reference document depending on the classification below:

- Essential** Information that must be contained within the transmission network characteristics document for all specified assets.
- As required** Information that must be contained within the transmission network characteristics document where necessary to achieve the operational and planning requirements.

Table 2 – The information required for the transmission network characteristics document

Category	Essential	As required
Impedances	Positive, negative and zero sequence components of the resistive and the reactive impedances.	-
	Zero sequence mutual coupling among overhead lines routed in parallel.	
Overhead lines	Continuous current rating.	Contingency and emergency current ratings.
	Lengths, conductor size and material, designed maximum conductor operating temperature, rated voltage and operating voltage.	
Underground cables	Continuous current rating.	Contingency, cyclic and emergency current ratings.(transmission cables)
	Lengths, conductor size and material, screen size and material, short circuit current rating and rated voltages.	
Power transformers	Continuous power rating, cooling methods and power rating.	Cyclic and emergency current ratings.
	Relevant transformer tested parameters and data supplied by manufacturers.	
	Vector group, neutral earthing, rated voltages, tapping steps and range, impedances, losses and manufacture date.	

Category	Essential	As required
Power sources	Active/reactive power ratings, voltage control scheme and settings, equivalent positive/negative/zero sequence impedance and short circuit time constants.	-
Reactive plant	Continuous power rating, inductance, capacitance, resistance, tuned frequency and manufacture date.	Contingency current ratings.
Rating limiting factors	The limiting rating conditions of the feeder.	-

Where the negative sequence impedances of bulk transmission sources feeding into the company's network is unknown, a fair approximation can be derived from the corresponding positive sequence impedance. However, such an approximation may not be acceptable in the proximity of embedded generators or large AC motors, where source impedances must be calculated by considering the sub-transient impedance of machines and the characteristics of excitation controllers.

It is understood that the full set of data for specifying existing historic installation and site conditions does not exist for many assets or cannot be located and verified. Where specific data is not readily available, reference parameters must be used for the calculation of asset ratings provided the risk of overloading or breaching conductor clearances are assessed. Reference parameters for the calculation of ratings are set out in Section 5.4 of this policy.

The transmission network characteristics document must be made available on the intranet.

5.2.2 Project design drawing

The project design drawings must include the additional information in Table 3 – The minimum information to be recorded on a design to allow for ratings to be reviewed in the future.

Table 3 – The minimum information to be recorded on a design

Category	Detailed information
Transmission overhead lines details	Construction, lengths, design temperature, phase orientation and transposition, earth wire, exposure to mutual coupling and date of installation.
Transmission underground cables details	Design/installed backfill thermal resistivity, lengths, cable depth profile, construction, insulation level, laying, mounting, earthing and sheath bonding arrangements, proximity to other cables and date of installation.

5.2.3 *Network asset ratings document*

A network asset ratings document defining the application of generic rating information to specific network assets must be maintained. This ratings document must provide the relevant requirements and procedures to determine specific plant ratings for:

- overhead conductors;
- underground cables;
- transformers in distribution substations; and
- transformers in zone and transmission substations.

The network asset ratings document must be made available on the intranet.

5.2.4 *Network fault level model*

The transmission network characteristics document must be used to develop and maintain a model of the network capable of calculating the maximum existing and foreseeable fault levels for the various voltages and locations within the network. This must include the fault levels for 132 kV, 66 kV, 33 kV, 22 kV and 11 kV busbars in both transmission and zone substations under normal operating conditions and credible contingencies.

The network fault level model is maintained by the Manager Asset Strategy & Planning and must provide corresponding fault levels on request.

5.3 **Rating types**

For all rating types, the maximum rating for any network element must be taken as the lowest rating of the components within that network element. The component with the lowest rating must be clearly identified to develop appropriate mitigation strategies.

Under continuous and contingency operating conditions, operation of network assets must not result in a breach of statutory safety clearances to adjacent network assets, third party properties, vehicles and/or ground. In addition, all primary functions of the asset must be able to be performed without sustaining damage or being subject to accelerated ageing (averaged over one year for transformers).

When calculating the cyclic, contingency and emergency ratings, consideration must be given to any adjacent equipment that will also be subject to increased loading. Limitations due to associated components with negligible short thermal time constants, such as current transformers, circuit breakers, cable joints, end terminations, and bushings must be taken into consideration.

5.3.1 *Continuous rating*

The continuous rating of an asset is defined as the maximum current that can be allowed to flow indefinitely through that asset without suffering damage or accelerated ageing.

Continuous ratings for equipment must be calculated in accordance with this policy and, where applicable, must take manufacturer recommendations into account.

Where nameplate values indicate more than one continuous rating, unless otherwise de-rated, the rating of the asset must be taken as the highest rating appropriate to the cooling method employed.

5.3.2 *Cyclic rating*

The cyclic rating of an asset is defined as the maximum rating, based on actual or generic load and ambient temperature cycles which can be sustained without unreasonable accelerated ageing of the asset. Operating equipment to cyclic ratings must not result in a rate of thermal ageing greater than that of operation at the continuous rating (averaged over one year for transformers).

Cyclic ratings for network assets must be considered to address any existing or forecasted network constraints.

The cyclic ratings will be calculated and approved by the Manager Asset Strategy & Planning as required by operational and planning requirements (on a case-by-case basis) for the following assets:

- transformers in distribution substations;
- transformers in zone and transmission substations; and
- transmission cables.

All cyclic ratings must be endorsed by the Manager Asset Standards & Design before being implemented on the network.

Where network constraints are managed through cyclic ratings, the cyclic ratings will need to be reassessed for significant changes in annual load factor by the Manager Asset Strategy & Planning.

5.3.3 *Contingency rating*

The contingency rating of an asset is defined as the ability of the asset to withstand loading resulting from the prolonged outage of some system elements that will not be reconnected before a steady state temperature rise is reached within the asset. This is not a normal operating condition however, it may persist for weeks or months (determined by operation and practical requirements) and may lead to accelerated ageing of the asset.

Contingency ratings are applied in alignment with this policy for:

- overhead lines; and
- underground cables.

5.3.4 *Emergency rating*

The emergency rating describes the ability of plant to withstand unusually heavy loading due to the occurrence of one or more unlikely events that seriously disturbs normal system loading causing asset hot spots to reach potentially dangerous levels. This type of loading is expected to occur rarely and must be rapidly reduced or the plant disconnected within a short time to avoid plant failure. Emphasis must be given to temperature rise within the asset to avoid risk of immediate failure.

Typically, emergency rating will apply for times less than the thermal time constant of the asset. The emergency rating must be specified by combining a specified duration and a maximum permissible loading level or step load change. The emergency rating may not be applied for longer than the time specified with the rating.

Assessment of an asset's emergency rating must consider any connected equipment that will also be subject to increased loading, especially any equipment with a short thermal time such as current transmission, circuit breakers, cable joints and end terminations, and bushings, and the impact on the ground clearances for overhead lines.

Emergency ratings will be calculated for the following assets per operational and planning requirements on a case-by-case basis:

- transformers in zone and transmission substations;
- overhead lines; and
- underground cables.

5.3.5 Fault rating

The fault rating of an asset is defined as the capability of the asset to carry or interrupt through fault currents. The value of the through fault current must be specified as the short time withstands current or short circuit making/breaking capacity.

All permanent and temporary network asset installations, including all forms of earthing, portable earths, earth-wires, and cable screens, must be selected so that the maximum fault level does not exceed the equipment fault rating, as outlined in Section 5.5.

A short time withstand current must be assigned to all network assets. In addition to the short time withstand current, Circuit Breakers (CB), switches and fuses must have fault making and breaking capacities assigned.

5.3.6 Seasonal rating variations

Where any of the above ratings are affected by ambient conditions, the four combinations of winter/summer and night/day ratings must be calculated. Where other clearly understandable environmental conditions are identified to influence the rating, a rating for each of the environmental conditions must also be calculated.

5.4 Reference rating parameters

This policy defines the sets of parameters to be used for the calculation of ratings for assets. These parameters are selected to reflect the common practices of the company in the areas of:

- planning criteria;
- design standards and installation methods;
- operational procedure and emergency response time; and
- correlation of seasonal and geographical weather patterns.

The reference rating parameters have been selected with acknowledgment of the safe operation, equipment ageing and an acceptable level of risk to the company. The rare risk of over-estimating ratings under extremely unfavourable operating conditions must be mitigated by exercising appropriate operational precaution, such as monitoring equipment temperature and boosting the efficiency of cooling where required.

5.4.1 Overhead line rating parameters

The documents listed in Table 4 – Documents used to calculate the applicable rating for overhead lines must be used to calculate the continuous, contingency and short circuit ratings of overhead lines.

Table 4 – Documents used to calculate the applicable rating for overhead lines

Rating	Document used to calculate rating
Continuous	ESAA D (b) 5 – Current Rating of Bare Overhead Line Conductors.
Contingency	ESAA D (b) 5 – Current Rating of Bare Overhead Line Conductors
Short circuit	Cigre Technical Brochure 207: 2002 Thermal behaviour of overhead conductors

Reference temperature for conventional conductors (AAAC, AAC, ASCR, and copper) must be as shown in Table 5. However, a maximum conductor operating temperature of 120°C may apply only to legacy ACSR conductors, constructed on lattice steel tower transmission lines, where the design clearance is known to be 120°C or higher.

The design clearance must be considered for all lines.

For legacy constructions a clearance temperature must:

- be used to meet the design clearance; and
- not exceed continuous and/or contingency temperatures listed in Table 5 – Reference temperatures for overhead lines.

For lines with joint use poles and situations where there are lines in the same vertical plane, design and specification of ratings must consider the requirements of AS 7000: 2016 – Overhead line design, Section 3.7.

Table 5 – Reference temperatures for overhead lines

Network	Type	Maximum conductor temperature (°C)	
		Continuous	Contingency
Distribution	Bare conductor	75	n/a
	LV ABC	80	
	HV ABC	90	
	CCT	80	
Transmission	Bare conductor	75	100

Values for solar radiation, albedo (ground reflection coefficient), conductor solar absorption and conductor emissivity are provided in Table 6 – Reference radiation parameters for overhead conductors for use as default values.

Table 6 – Reference radiation parameters for overhead conductors

Parameters	Winter & Summer	
	Day	Night
Direct solar radiation (W/m ²)	1000	0
Indirect solar radiation (W/m ²)	100	0
Albedo	0.2	
Solar absorption	Bare: 0.8	
	Covered/Insulated: 0.5	
Conductor emissivity	Bare: 0.65	
	Covered/Insulated: 0.9	

Standard reference values for ambient temperature, wind speed, elevation, and their regional variations are given in Table 7 – Reference parameters for overhead conductors. For calculating overhead conductor ratings, the company's network is divided into three geographic regions:

- inland;
- coastal; and
- mountainous.

Table 7 – Reference parameters for overhead conductors

			Inland	Coast	Mountainous
Ambient temperature (°C)	Summer	Day	40	30	
		Night	30	20	
	Winter	Day	20	25	20
		Night	5	10	5
Transverse wind speed (m/s)			0.5	1.0	
Altitude (m)			0 - 1000		> 1000

Standard reference values for use in fault ratings and voltage drop calculations must be in accordance with those provided in Table 8 – Reference temperatures for overhead line fault and voltage drop calculations and Table 9 – Reference temperatures for overhead conductors under short circuit conditions.

Table 8 – Reference temperatures for overhead line fault and voltage drop calculations

Network	Type	Conductor operating temperature (°C)	
		Pre-fault temperature for fault calculation	Voltage drop calculation
LV distribution	Bare conductor	n/a	60
	LV ABC		70
HV distribution	Bare conductor	50	50
	CCT		75
	HV ABC		70
Transmission	Phase conductor	50	n/a
	Earth wire		

Table 9 – Reference temperatures for overhead conductors under short circuit conditions

Conductor type	Maximum conductor temperature for fault calculations (°C)
Bare copper, aluminium, aluminium alloy, and steel-cored conductor	200
Bare steel conductor	300
CCT	210
Non-metal screened HV ABC	250
OPGW	Limited by fibre cores – refer to specification.

5.4.2 Underground cable rating parameters

The documents listed in Table 10 – Documents used to calculate the applicable rating for underground cables must be used to calculate the continuous, cyclic, contingency and emergency ratings of overhead lines.

Table 10 – Documents used to calculate the applicable rating for underground cables

Rating	Reference document for calculation
Continuous	IEC 60287 – Electric cables – Calculation of the current rating.
Cyclic	IEC 60853 – Calculation of the cyclic and emergency current rating of cables
Contingency	IEC 60287 – Electric cables – Calculation of the current rating.
Emergency	IEC 60853 – Calculation of the cyclic and emergency current rating of cables

Standard reference ratings of underground cables must be based on the parameter values shown in Table 11 – Underground cable reference installation parameters and Table 12 – Underground cable seasonal reference backfill parameters. In addition, where rating calculations require ambient air temperatures (for example cable risers or substation basements) values must be selected from Table 7 for overhead conductors in the respective geographic region.

Table 11 – Underground cable reference installation parameters

		Maximum Conductor Temperature (°C)		
Insulation	Rating	Transmission	HV Distribution	LV Distribution
Paper	Continuous and Cyclic	65	Paper - Belted: 65 Paper - Other: 70	80
	Contingency	75		
	Emergency			
XLPE	Continuous and Cyclic	90		
	Contingency			
	Emergency	105		90

Table 12 – Underground cable seasonal reference backfill parameters

Parameter	Summer	Winter
Soil/backfill temperature (°C)	25	18
Soil/backfill thermal resistivity (°C.m/W)	1.2	
Concrete encasement thermal resistivity (°C.m/W)	1.0	

The emergency operation temperature of 105°C, for XLPE transmission and HV distribution cables are permitted for periods that do not exceed 36 hours and average one period per year over several years with no more than three periods in any 12 consecutive months. In addition, the following must be considered before operating a cable under emergency conditions:

- existing condition;
- loading history;
- impact on joints and terminations; and
- premature aging of assets.

Other site specific parameters to consider for calculating cable ratings and any de-rating factors include, but are not limited to:

- number of cables in group;
- depth of burial;
- presence of ducts;
- ambient and soil temperature variation;
- variation in soil or backfill resistivity;
- soil dry out around the cables;
- mutual heating;
- screen current;
- construction per the standard design dimensions; and
- the load sharing factor where two sets of cables (different in size, route or length) are bonded in parallel to form a single higher rating circuit.

Properly selected cable jointing and termination material and components must achieve joint rating equal to or above the rating of the cables being jointed.

5.4.3 Transformer rating parameters

The documents listed in Table 13 – Documents used to calculate the applicable rating for transformers must be used to calculate the continuous, cyclic and emergency ratings for transformers.

Table 13 – Documents used to calculate the applicable rating for transformers

Rating	Reference document for calculation
Continuous	Clause 4.1 of AS 2374.1.2:2003 Power transformers – Minimum Energy Performance Standard (MEPS) requirements for distribution transformers
Cyclic	AS 60076.7: 2013 Power transformers – Part 7: Loading guide for oil-immersed power transformers, including the limits supplied for Normal cyclic loading in Table 4
Emergency	Table 4 of AS 60076.7:2013 – Power transformers – Loading guide for oil-immersed power transformers

Transformers must be classified per the cooling medium and circulation mechanism employed in accordance with AS 60076.2:2013 Power transformers – Temperature rise for liquid immersed transformers.

Previously approved cyclic ratings that have been determined in accordance with AS 2374.7:1997 Power transformers – Loading guide for oil-immersed power transformers, will remain valid.

Emergency ratings must be calculated on a case by case basis depending on the asset capability and protection systems. In calculating emergency ratings, the temperatures listed in Table 15 –

Maximum top oil and winding hotspot temperatures for power and distribution transformers must be the maximum allowable for power transformers in transmission and zone substations:

Table 14 – Maximum top oil and winding hotspot temperatures for power and distribution transformers

Top oil temperature	Winding hotspot temperature
95 °C	130 °C.

Alternative temperatures for top oil and winding hotspot may be selected where equipment capability provides, and is supported by equipment specifications and test reports. Approval for use of alternative top oil and hotspot temperatures is subject to approval by the General Manager Asset Management or his nominee.

All thermal characteristic parameters used in the assessment of cyclic and emergency ratings must be obtained from the transformer test report. Where this data is not available, values may be selected from Table E.1 of AS 60076.7:2013 Power transformers – Loading guide for oil-immersed power transformers.

For oil immersed distribution transformers, a list of cyclic ratings for all distribution substations installation types (for example pole, padmount, cottage and indoor substation) must be calculated, published and maintained.

Where a transformer is operated within an enclosure, the appropriate ambient temperature correction must be applied in accordance with Table 6 of AS 60076.7:2013 Power transformers – Loading guide for oil-immersed power transformers.

All relevant thermal characteristic parameters (such as, the top oil to hot spot gradient, and thermal time constant) must be obtained from transformer manufacturers at the time of purchase and can be verified using optical temperature sensors.

5.4.4 Busbar rating parameters

The documents listed in Table 15 – Documents used to calculate the applicable rating for busbars must be used to calculate the continuous, contingency and short circuit ratings of indoor and outdoor busbars.

Table 15 – Documents used to calculate the applicable rating for busbars

Rating	Reference document for calculation
Continuous	ESAA D (b) 5 – Current Rating of Bare Overhead Line Conductors.
Contingency	ESAA D (b) 5 – Current Rating of Bare Overhead Line Conductors
Short circuit	Cigre Technical Brochure 207: 2002 Thermal behaviour of overhead conductors

Busbars are rated using similar requirements to Section 5.4.1 – Overhead line rating parameters however, the conductor geometry will affect the convective heat loss component of the heat balance equation and the equations for overhead conductors may not be directly applicable.

Table 16 – Guide to conductor absorptivity and emissivity lists the parameters for indoor and outdoor busbars where the absorption and emissivity are dependent on the busbar location and colour.

Table 16 – Guide to conductor absorptivity and emissivity

Busbar location	Conductor Colour	Absorptivity	Emissivity	Wind (m/s)
Outdoor	Bright	0.3	0.6	See Table 7
	Grey	0.8	0.8	
	Black	1.0	1.0	
Indoor	All colours	0	0	0

Maximum conductor operating temperatures must be applied per the busbar material. For aluminium or copper busbars of either stranded or tubular construction, the maximum conductor operating temperature must not exceed 90°C due to palm operating temperature limits (refer to AS62271.301:2005 – High Voltage switchgear and controlgear – Part 301 Dimensional standardisation of terminals).

5.5 Standard fault levels

The maximum short circuit fault level for the network under any fault condition (single-line to ground or three-phase to ground fault) is outlined in Table 17 – Standard reference fault levels.

Table 17 – Standard reference fault levels

Voltage	Network component	Short circuit current (kA)	Duration (s)
11 kV	Network	13.1*	1.0
	Zone substations	20	
22 kV	Network	13.1	
	Zone substations	20	
33 kV	Network	26.2	
	Zone substations	26.2	
	Transmission substations	31.5	
66 kV	Network	24	
	Zone substations	24	
	Transmission substations	31.5	
132 kV	Network	40	
	Zone substations	31.5	
	Transmission substations	40	

5.5.1 Fault rating for equipment

The minimum short circuit currents and duration for equipment specifications are shown in Table 17 – Standard reference fault levels (with the exemption of temporary network equipment which uses the short circuit currents listed in Table 18 – Temporary network equipment short circuit current ratings). However, a lower short circuit current rating may be used where:

- a risk assessment is conducted and finds the likelihood to be rare for the foreseeable short circuit current to increase;

* Drop out fuses currently have a maximum fault current of 8kA at 11kV.

- equipment (such as fuses, pole-mounted auto-re-closers, and regulators) are protected by an adequate series impedance (for example impedance of line, cable, series reactor or earthing resistor) between all feasible sources and the point of installation that adequately reduces the short circuit current below the equipment short circuit current rating; and
- the fault clearance time of a circuit breaker or fault limiting fuse installed at all feasible upstream positions of the equipment adequately protects the equipment.

Care must be taken to consider all alternative paths to the source(s) and must be coordinated with the equipment short circuit current rating and I^2t joule integral rating for the most constraining equipment.

A minimum withstand time of 0.5 second must be specified for distribution equipment below 1,000 Volts

5.5.1.1 Circuit breakers, fuses and switches

The specification for fuses, circuit breakers, circuit switches, earthing switches and fault throw switches must be selected to satisfy the following:

- the fault make and/or break capacity in accordance with Table 17 – Standard reference fault levels;
- the asymmetrical fault current breaking capability must be selected in accordance with the X/R ratio of source impedance relevant to that device;
- any limits on the permissible number of fault interruptions at full breaking capacity or capacitor switching cycles, wherever relevant, before the next maintenance or overhaul of circuit breaker must also be stated; and
- the faulted part of the network can be safely and effectively disconnected from the system in accordance with Company Policy 9.2.2 – Network Protection.

5.5.1.2 Temporary network equipment

Temporary network equipment includes:

- portable earths; and
- temporary bridges/bonds.

Temporary network equipment must have minimum nominal ratings as shown in Table 18 below. Multiple sets of portable earths must be applied in parallel where the system fault level exceeds the rating of a single set of portable earths.

Table 18 – Temporary network equipment short circuit current ratings

Location	Short circuit current (kA)	Duration (s)
Transmission and sub-transmission network	24	0.5
Distribution network	16	0.5

5.5.2 Network fault level

The design of the network, particularly the choice of impedance for transformers, will be selected to maintain the maximum prospective fault current below those specified in Table 17 – Standard

reference fault levels under all credible operating configurations and worst case fault conditions (that is line-to-earth or three phase fault). The maximum prospective fault current is the initial symmetrical AC short-circuit current (I_k) calculated in accordance with AS 3851:1991 The calculation of short-circuit currents in three-phase a.c. systems.

In parts of the existing network where the fault level has already been exceeded, equipment with a higher short circuit rating must be used.

Wherever specific data to determine the line-to-earth fault current of a delta star transformer (with solidly earthed neutral on its star connected terminals) is not available, a value of 115% of the corresponding three phase fault current may be used.

5.6 Standard reference insulation levels

The values for standard reference insulation levels shown in Table 19 – Standard reference insulation levels (based on AS1824.1:1995 Insulation Coordination – Definitions, Principles and Rules) must apply.

Table 19 – Standard reference insulation levels

Nominal system voltage level (Volts RMS)	Highest system voltage level for equipment (kV RMS)	Standard short duration – one (1) minute power frequency withstand voltage (kV RMS)	Standard lightning impulse withstand voltage (kV peak)
<1,000	–	1 - 3	8
11,000	12	28	95
12,700 SWER	–	50	95
22,000	24	50	125/145 [†]
33,000	36	70	170
66,000	72.5	140	325
132,000	145	275	650

6.0 ACTIONS TO ACHIEVE IMPLEMENTATION OF THIS POLICY

- The revision and update of the network characteristics reference document must be carried out on a regular basis.
- The network asset ratings document and network fault level model will be maintained.
- Record installation specific information in the design drawings to allow asset ratings to be recalculated in the future.
- Standards must be developed for the installation methods for underground cables to maintain consistent ratings in accordance with this policy. All standards must be reviewed in accordance with appropriate division procedures.
- The calculation of equivalent source sequence impedances, X/R ratio and maximum fault level values for a range of network operating conditions must be carried out on a regular basis to verify that the appropriate reference document is current in this regard. Verification of I^2t levels

[†] 125kV applies to distribution substations, 145kV applies to zone substations.

for installed and portable equipment with respect to the prevailing fault levels and fault clearing (for example by fuse or circuit breaker with relay time) must be carried out on a regular basis.

- The calculation of continuous, cyclic, contingency, and emergency ratings for all appropriate network assets must be carried out as required. The results of all such studies must be recorded in the network characteristics reference document.

7.0 AUTHORITIES AND RESPONSIBILITIES

Chief Operating Officer has the authority and responsibility for approving this policy.

General Manager Asset Management has the authority and responsibility for managing the appropriate processes, standards and procedures are in place to meet the objectives and specific requirements of this policy.

General Manager Network Services has the authority and responsibility for complying with the requirements of this policy for tasks delivered by employees within the Network Services Division.

Manager Asset Strategy & Planning has the authority and responsibility for:

- planning the network in accordance with this policy; calculating or acquiring, from TransGrid, generators and other parties, the equivalent source impedance at bulk supply points and power stations for all credible network and generator operating configurations which might affect the company's equipment and customers;
- maintaining the transmission network characteristics document, and verifying it is reviewed, published and distributed regularly in accordance with this policy;
- calculating and approving cyclic ratings for transformers in zone and transmission substations; and
- reassessing the calculated cyclic ratings where significant change occurs in the annual load factor.

Power Quality & Reliability Planning Manager has the authority and responsibility for:

- maintaining the network model used to calculate the prospective fault level; and
- providing calculated fault level information to stakeholders on request.

Manager Asset Standards & Design has the authority and responsibility for:

- developing and reviewing equipment specifications and design standards in accordance with this policy;
- providing approval to use cyclic ratings for XLPE cables;
- endorsing the approval to use cyclic ratings for transformers in zone and transmission substations;
- maintaining the network asset ratings document in accordance with this policy; and
- evaluating dynamic or real time ratings for individual plant on a case-by-case basis.

Manager System Control has the authority and responsibility for:

- operating the network to maintain that the maximum fault levels are not exceeded in accordance with this policy; and
- maintaining that assets are not loaded above their maximum ratings in accordance with this policy.

Mains & Civil Design Manager has the authority and responsibility for:

- calculating ratings for specific assets using installation specific data for inclusion in the transmission network characteristics reference document;
- documenting installation information within design drawings to allow for ratings to be reviewed in the future; and
- providing the plant data relating to new assets for inclusion in the transmission network characteristics reference document.

8.0 DOCUMENT CONTROL

Content Coordinator : Manager Asset Standards & Design

Process Coordinator : GRC Process Coordinator