

Network Standard

NETWORK

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NW000-S0040

NS238 SUPPLY QUALITY



ISSUE

For issue to all Ausgrid and Accredited Service Providers' staff involved with the management of Supply Quality on the Network and is for reference by field, technical and engineering staff.

Ausgrid maintains a copy of this and other Network Standards together with updates and amendments on www.ausgrid.com.au.

Where this standard is issued as a controlled document replacing an earlier edition, remove and destroy the superseded document

DISCLAIMER

As Ausgrid's standards are subject to ongoing review, the information contained in this document may be amended by Ausgrid at any time.

It is possible that conflict may exist between standard documents. In this event, the most recent standard shall prevail.

This document has been developed using information available from field and other sources and is suitable for most situations encountered in Ausgrid. Particular conditions, projects or localities may require special or different practices. It is the responsibility of the local manager, supervisor, assured quality contractor and the individuals involved to make sure that a safe system of work is employed and that statutory requirements are met.

Ausgrid disclaims any and all liability to any person or persons for any procedure, process or any other thing done or not done, as a result of this Standard.

All design work, and the associated supply of materials and equipment, must be undertaken in accordance with and consideration of relevant legislative and regulatory requirements, latest revision of Ausgrid's Network Standards and specifications and Australian Standards. Designs submitted shall be declared as fit for purpose. Where the designer wishes to include a variation to a network standard or an alternative material or equipment to that currently approved the designer must obtain authorisation from the Network Standard owner before incorporating a variation to a Network Standard in a design.

External designers including those authorised as Accredited Service Providers will seek approval through the approved process as outlined in NS181 Approval of Materials and Equipment and Network Standard Variations. Seeking approval will ensure Network Standards are appropriately updated and that a consistent interpretation of the legislative framework is employed.

Notes: 1. Compliance with this Network Standard does not automatically satisfy the requirements of a Designer Safety Report. The designer must comply with the provisions of the Work Health and Safety Regulation 2017 (NSW - Part 6.2 Duties of designer of structure and person who commissions construction work) which requires the designer to provide a written safety report to the person who commissioned the design. This report must be provided to Ausgrid in all instances, including where the design was commissioned by or on behalf of a person who proposes to connect premises to Ausgrid's network, and will form part of the Designer Safety Report which must also be presented to Ausgrid. Further information is provided in Network Standard (NS) 212 Integrated Support Requirements for Ausgrid Network Assets.

2. Where the procedural requirements of this document conflict with contestable project procedures, the contestable project procedures shall take precedent for the whole project or part thereof which is classified as contestable. Any external contact with Ausgrid for contestable works projects is to be made via the Ausgrid officer responsible for facilitating the contestable project. The Contestable Ausgrid officer will liaise with Ausgrid internal departments and specialists as necessary to fulfil the requirements of this standard. All other technical aspects of this document which are not procedural in nature shall apply to contestable works projects.

INTERPRETATION

In the event that any user of this Standard considers that any of its provisions is uncertain, ambiguous or otherwise in need of interpretation, the user should request Ausgrid to clarify the provision. Ausgrid's interpretation shall then apply as though it was included in the Standard, and is final and binding. No correspondence will be entered into with any person disputing the meaning of the provision published in the Standard or the accuracy of Ausgrid's interpretation.

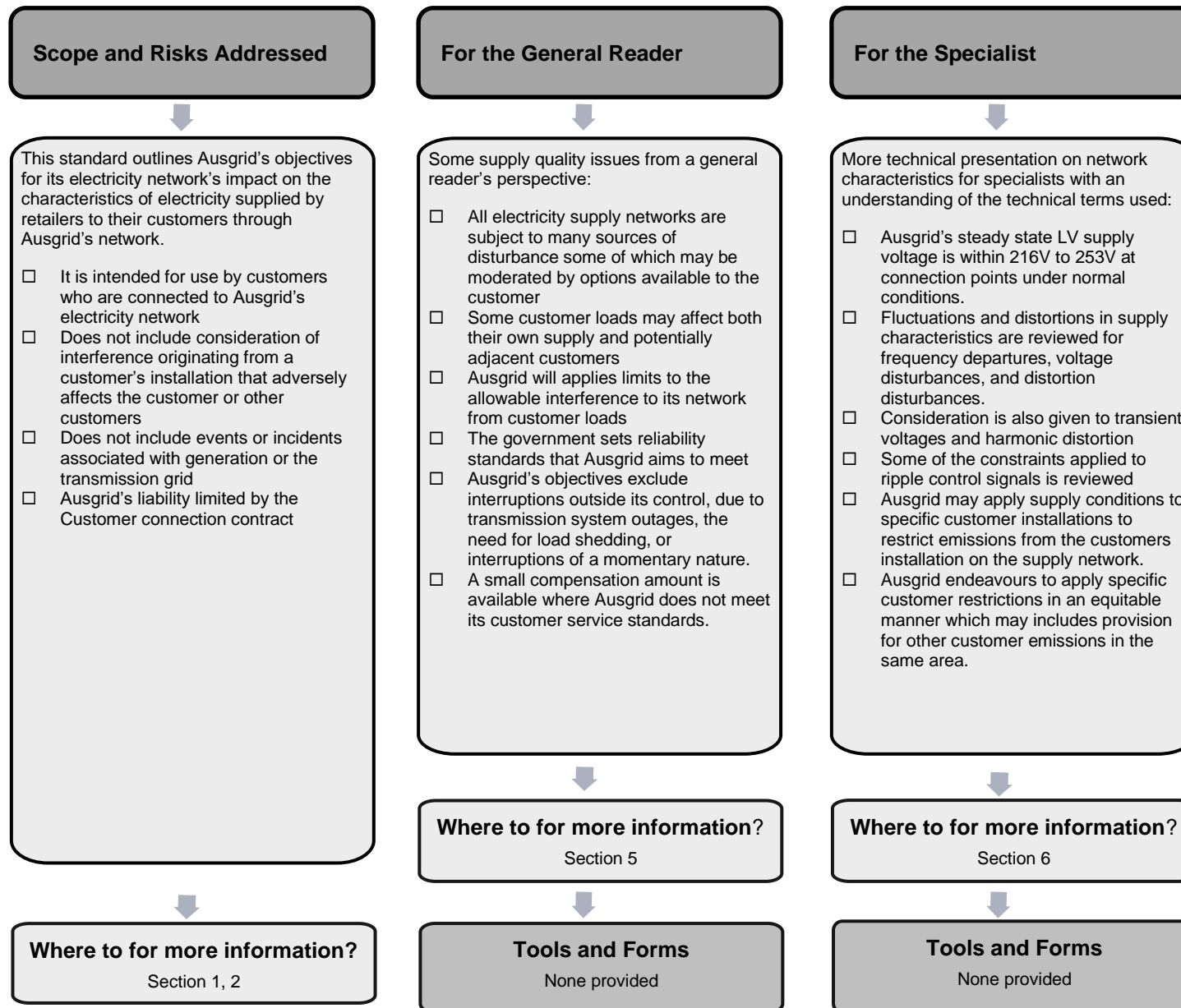
KEYPOINTS

This standard has a summary of content labelled "KEYPOINTS FOR THIS STANDARD". The inclusion or omission of items in this summary does not signify any specific importance or criticality to the items described. It is meant to simply provide the reader with a quick assessment of some of the major issues addressed by the standard. To fully appreciate the content and the requirements of the standard it must be read in its entirety.

AMENDMENTS TO THIS STANDARD

Where there are changes to this standard from the previously approved version, any previous shading is removed and the newly affected paragraphs are shaded with a grey background. Where the document changes exceed 25% of the document content, any grey background in the document is to be removed and the following words should be shown below the title block on the right hand side of the page in bold and italic, for example, Supersedes – document details (for example, "Supersedes Document Type (Category) Document No. Amendment No.").

KEY POINTS OF THIS STANDARD



Network Standard NS238 Supply Quality

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1.0 PURPOSE

Ausgrid operates an extensive network which brings the electricity supplied by your retailer to your home or business.

Our aim in this document is to:

- provide tips on how you can protect your electrical installations and your electrical equipment and appliances connected to our network from the potential problems that unprotected equipment can suffer because of variations to electricity supplied through our network, and
- help you understand the operating environment of our network, and explain why the electricity supplied through it has particular characteristics.

We set out Ausgrid's objectives for the impact that our network has on the characteristics of the electricity supplied through it by your retailer.

This Network Standard is in two parts. Part A (Section 5) is designed for the general reader. Part B (Section 6) is for use by specialists, and contains technical material in technical language.

2.0 SCOPE

This guideline states Ausgrid's objectives for its electricity network's impact on the characteristics of electricity supplied by retailers to their customers through its electricity Network. It replaces the Electricity Network Operation Standards (ENOS) document.

This document is intended for use only by customers who are connected to Ausgrid's electricity network and should be read in conjunction with the following publication issued by the ENA (Energy Networks Association), which provides definitions and information essential for understanding this document:

- ENA Customer Guide to Electricity Supply.

The latest edition of this document is available on our website www.ausgrid.com.au.

In stating its objectives for its network, Ausgrid does not include:

- interference originating from a customer's installation that adversely affects the installation and equipment of that customer or other customers; and
- events or incidents associated with generation or the transmission grid.

Although Ausgrid intends to use all reasonable efforts to address departures from the objectives specified in this standard, there could be circumstances which affect Ausgrid's ability to meet them. Accordingly:

- each objective must be read subject to the limit of liability specified in the Contract; and
- this document and the ENA publication referred to above do not constitute a representation or warranty by Ausgrid that the electricity supplied by retailers to customers through its network will be of a particular quality, or that it will be available at all times.

3.0 REFERENCES

All work covered in this document shall conform to all relevant Legislation, Standards, Codes of Practice and Network Standards. All work covered in this document shall conform to all relevant Legislation, Standards, Codes of Practice and Network Standards. Current Network Standards are available on Ausgrid's Internet site at www.ausgrid.com.au.

3.1 Ausgrid documents

- Company Form (Governance) - Network Document Endorsement and Approval
- Company Procedure (Governance) - Production / Review of Network Standards
- Company Procedure (Governance) - Network Document Endorsement and Approval
- Electrical Safety Rules
- Electricity Network Safety Management System Manual
- NS181 Approval of Materials and Equipment and Network Standard Variations
- NS212 Integrated Support Requirements for Ausgrid Network Assets
- Public Electrical Safety Awareness Plan

3.2 Other standards and documents

- AS 4777 Grid connection of energy systems via inverters
- AS 61000.3.100 Steady state voltage limits in public electricity systems
- AS/NZS 3000 Electrical installations (known as the Australian/New Zealand Wiring Rules)
- AS/NZS 61000.2 Electromagnetic compatibility (EMC) – Environment
- AS/NZS 61000.2.2 Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems
- AS/NZS 61000.2.12 Compatibility levels for low-frequency conducted disturbances and signalling in public medium-voltage power supply systems
- AS/NZS 61000.3 Electromagnetic compatibility (EMC) - Limits
- AS/NZS 61000.3.2 Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)
- AS/NZS 61000.3.3 Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection
- AS/NZS 61000.3.6 Assessment of emission limits for distorting loads in MV and HV power systems
- AS/NZS 61000.3.7 Assessment of emission limits for fluctuating loads in MV and HV power systems
- AS/NZS 61000.3.11 Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems - Equipment with rated current less than or equal to 75 A and subject to conditional connection
- AS/NZS 61000.3.12 Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16 A and ≤ 75 A per phase
- ENA Doc 001-2008 National Electricity Network Safety Code
- HB 264 Power quality - Recommendations for the application of AS/NZS 61000.3.6 and AS/NZS 61000.3.7
- SA/SNZ TR IEC 61000.3.14 Assessment of emission limits for harmonics, interharmonics, voltage fluctuations and unbalance for the connection of disturbing installations to LV power systems
- TR IEC 61000.3.13 Assessment of emission limits for the connection of unbalanced installations to MV, HV and EHV power systems

3.3 Acts and regulations

- Electricity Supply (General) Regulation 2014 (NSW)
- Electricity Supply (Safety and Network Management) Regulation 2014
- Work Health and Safety Act 2011 and Regulation 2017

4.0 DEFINITIONS

Accredited Service Provider (ASP)	An individual or entity accredited by the NSW Department of Planning and Environment, Energy, Water and Portfolio Strategy Division, in accordance with the Electricity Supply (Safety and Network Management) Regulation 2014 (NSW).
Authorised electrician	A person who is authorised under the Home Building Act 1989 to do electrical wiring work.
Business Management System (BMS)	An Ausgrid internal integrated policy and procedure framework that contains the approved version of documents.
Connection point	The point at which a distribution system connects to an electricity installation or equipment that serves the premises of one or more customers.
Contract	The connection contract between Ausgrid and the customer.
Customer	A person who buys or wants to buy electricity from a retailer
Disconnection	An action to prevent the flow of electricity to the premises, but does not include an interruption.
Document control	Ausgrid employees who work with printed copies of document must check the BMS regularly to monitor version control. Documents are considered “UNCONTROLLED IF PRINTED”, as indicated in the footer.
Electricity laws	National and State and Territory laws and rules relating to electricity and the legal instruments made under those laws and rules.
Emergency	An emergency due to the actual or imminent occurrence of an event that in any way endangers or threatens to endanger the safety or health of any person, or normal operation of the distribution system or transmission system, or that destroys or damages, or threatens to destroy or damage, any property.
GSL scheme	Has the meaning given in the National Energy Retail Law.
Interruption	A temporary unavailability or temporary curtailment of the supply of electricity from a distribution system to a customer, but does not include disconnection.
National Electricity Rules (NER)	The rules made under the National Electricity Law. The NER govern the operation of the National Electricity Market.
Network	Ausgrid's electricity distribution system.
Network Standard	A document, including Network Planning Standards, that describes the Company's minimum requirements for planning, design, construction, maintenance, technical specification, environmental, property and metering activities on the distribution and transmission network. These documents are stored in the Network Category of the BMS repository.
Power system	The integrated assets of the national grid associated with the generation, transmission and distribution of electricity.
Premises	The address at which customer connection services are provided to you and, to avoid doubt, may include your electrical installation
Relevant authority	Any person or body who has the power under law to direct us, including the Australian Energy Market Operator and State or Federal Police.
Retailer	A person/company that is authorised to sell electricity to customers

Review date	The review date displayed in the header of the document is the future date for review of a document. The default period is three years from the date of approval however a review may be mandated at any time where a need is identified. Potential needs for a review include changes in legislation, organisational changes, restructures, occurrence of an incident or changes in technology or work practice and/or identification of efficiency improvements.
Supply voltage	The voltage, from phase to neutral or phase to phase, at the connection point.
Surge	An increase in voltage of short duration. The term tends to be loosely applied to all voltage increases.
Sustained interruption	A reduction in the steady state supply voltage to less than 10%, for greater than one minute duration.

The following publication issued by the ENA provides additional definitions and information essential for understanding this document and is also available on our website www.ausgrid.com.au:

- ENA Customer Guide to Electricity Supply

5.0 PART A FOR THE GENERAL READER

5.1 Electrical equipment and your electricity supply

Ausgrid is committed to bringing you a safe and reliable electricity service and maintaining a high quality power supply to customers.

All electricity networks experience interruptions to supply, most often when power lines are brought down by storms, bushfires and accidents. It is also normal for power supply to fluctuate.

Electricity users can take steps to minimise the possible effects of supply variations.

Ausgrid wants to alert customers to the fact that some electrical equipment on the market does not have adequate tolerance to supply variations. Many businesses, and a growing number of private users, now have a range of data processing, control and instrumentation equipment that is highly sensitive to variations in the electricity supply. While most electrical products have been designed to withstand some variation in supply, very few are designed to withstand the range of voltage fluctuations that are a common feature of distributed electricity.

When buying electrical equipment it is always important to check that it is able to tolerate variations in electricity supply and seek independent advice whether you need additional protection. This can be done by increasing the capacity of your electrical installation to withstand voltage disturbances, or through additional protective devices on the particular piece of equipment, or both.

Resetting digital clocks and timers can be a source of frustration. A flashing alarm clock usually represents a momentary interruption or a network switching event that results in a reduction in the voltage supply for less than a few seconds (called a voltage 'dip') rather than a sustained interruption. By buying appliances with an in-built battery backup, customers can avoid the need to reset digital clocks and timers when these very short duration events occur.

Customers who need to establish whether they have sufficient protective measures in place or assess all the risks of loss or damage arising out of different supply conditions must seek their own independent expert advice. Commercial and industrial users must seek expert advice, particularly because they will generally need to consider additional methods to protect data or sensitive equipment against particular supply conditions. There are specialist consultants in the field of equipment installation, control and protection and power conditioning. Ausgrid can provide guidance on supply quality issues.

The Energy Networks Association (ENA) publication ENA Customer Guide to Electricity Supply provides comprehensive information that will assist you to understand the causes of supply variability, the risks to particular equipment and available protective measures.

The table below contains some examples of protective measures commonly employed to avoid or guard against typical variations in supply conditions which either arise from the network or are generated by a customer's equipment or installation. The list is not exhaustive – it is offered for interest's sake and you should not use it as a substitute for the ENA publication or independent expert advice if you need to buy or install protection equipment. Subsections can

Table 1 - Examples of Protective Measures

Condition	Protective Measures
Voltage too low or too high	<ul style="list-style-type: none"> Use line conditioning equipment (e.g. Un-interruptible Power Supplies – UPS) and/or equipment designed to operate on a wider range of voltage levels. Switch off major equipment and restart it when supply is restored. Install under or over voltage protection equipment.
Brownout (For example, half voltage)	<ul style="list-style-type: none"> Follow recommendations for Voltage too high or too low (see above), Deploy equipment designed to operate at lower voltages to minimise impact of brownouts; or Install undervoltage relay and circuit breaker to interrupt power supply
Voltage dips	<p>Use:</p> <ul style="list-style-type: none"> equipment designed to tolerate and ride through voltage dips; UPS for critical equipment; or equipment with battery back-up.
Rapid voltage transients (e.g. flicker)	<ul style="list-style-type: none"> Use a line filter or, in extreme cases, a UPS. Install lighting that is less sensitive to flicker (e.g. Compact Fluorescent Lighting)
Lightning surges	<ul style="list-style-type: none"> Where practicable, unplug equipment from the supply before the storms get too close. <p>Use:</p> <ul style="list-style-type: none"> surge diverters on switchboards; small surge diverters in equipment; and/or power boards or plug-in devices with surge protection for small equipment. <p>Note: These measures are normally only appropriate in lightning prone locations or where critical equipment is used.</p>
Surges generated by customers' equipment	<p>Use:</p> <ul style="list-style-type: none"> a plug-in surge diverter at source appliance and/or at critical equipment; or UPS for critical equipment.
Harmonic distortion	Use a power conditioning device, eg, line filter or UPS for critical equipment.
Interruptions for a few seconds	<p>Use either:</p> <ul style="list-style-type: none"> equipment designed to tolerate or ride through short interruptions; UPS for critical equipment; equipment with battery back-up; or undervoltage relay to switch off equipment prone to damage.
Interruptions longer than a few seconds	Use UPS or equipment with battery backup.
Voltage unbalance	<p>Use a phase-failure relay on equipment prone to damage, and an over temperature relay on induction motors. The relay will interrupt power supply to avoid damage if excessive unbalance occurs.</p> <p>Customers must ensure their load is balanced.</p>

Note:

- Some protective devices can be obtained from hardware stores, electrical supply outlets or specialist suppliers.
- Good quality equipment and appliances will have a number of these protective measures incorporated in their design or 'built in'.
- If a protective device requires a fixed electrical installation (that is, not plugged into a power point), the NSW Electricity (Consumer Safety) Act, requires that an authorised electrician must install it.

5.2 Obligations to other customers and the network

Under their Contract with Ausgrid, customers are required to comply with the requirements of the Service and Installation of NSW and any other reasonable requirements imposed by Ausgrid. Consistent with those Rules and its rights under the Contract, Ausgrid requires the customer to ensure that:

- their electrical installation does not adversely affect Ausgrid's network or the customers' installations; and
- that any audible or electronic noise generated by their electrical installation does not breach relevant laws or adversely affect others.

If required, Ausgrid will establish overall limits for the interference by a customer, and customers who exceed their limits are required to rectify the situation. This will usually be as a "Power Quality Allocation" which specifies the amounts of flicker, harmonics and unbalance that the customer is allowed to emit onto the network – see section 6.2.4 for more details on this.

Ausgrid takes particular interest in any connection which

- supplies any item of equipment that is rated at greater than 75A
- contains a total of 100kW or more of variable speed drives or other inverters (including embedded generation)
- takes a fluctuating load (e.g. Lifts, welders, pumps, cranes, x-ray, MRI or similar type medical equipment)
- is supplied at voltages greater than 1000V

as they pose the greatest risk to the network and other customers.

All electrical equipment connected within an electrical installation is to comply with the relevant Australian Standards including those mandated in the Service and Installation Rules of NSW.

5.3 Ausgrid's reliability objectives

5.3.1 Ausgrid's standards for network reliability

Ausgrid's objective is to achieve the best possible overall reliability of our electricity network, given the condition and utilisation of existing network assets and the funding available to maintain and augment the electricity network. In addition Ausgrid also aims to use all reasonable and practicable efforts to ensure that in any financial year, it meets the targets set by the government in respect of reliability standards and individual feeder standards.

In stating the above objectives, Ausgrid excludes the following types of interruptions:

- momentary interruptions (interruptions of one minute or less);
- interruptions occurring on major event days, including major natural or third party events (such as storms, bushfires etc.);
- transmission system outages;
- load shedding due to insufficient generation to meet system load;
- automatic load shedding controlled by under frequency relays following an occurrence of a power system under frequency condition;
- faults in a customer's premises or equipment;
- compliance with directions from grid system operators or emergency services;
- planned interruptions; or
- interruptions agreed to by the customer.

Customers must plan around the possibility that the electricity supply may not be available at all times and that interruptions could occur without notice, or with notice in accordance with the Contract.

Customers who may suffer loss or damage if a supply interruption occurs are responsible for installing and maintaining sufficient back-up power supplies if they wish or need to mitigate such

loss or damage. This particularly applies to customers with time-critical activities or equipment, e.g. hospitals, or customers who need to maintain accurate time or have electronic devices which maintain settings and information in volatile memory.

Note: Customers with life support equipment should notify Ausgrid of their situation and should also ensure that an alternative means of electricity supply is available should a loss of electricity be life threatening.

If there is electronic data important to a customer, particularly business data, then the customer is responsible for backing up that data to non-volatile storage in accordance with prudent business practice and at least on a daily basis.

5.3.2 Ausgrid's reliability reports for network performance

Ausgrid's reliability reports utilise the definitions of normalised interruptions contained in the paper National Regulatory Reporting for Electricity Distribution and Retailing Businesses, March 2002, published by the ACCC, and includes all recorded interruptions on the network. The definitions have been amended by the Design, Reliability and Performance Licence Conditions imposed on Distribution Network Service Providers by the Minister for Energy on 1 August 2005 and revised on 1 December 2007. The Licence Conditions are available on the IPART website www.ipart.nsw.gov.au.

5.3.3 Ausgrid's customer service standards for network performance

At Ausgrid, we are committed to providing the best possible service to our 1.6 million customers across Sydney, the Central Coast and the Hunter.

If an interruption to your electricity supply does occur we try to minimise the inconvenience to homes and businesses. Our frontline staff are on call 24 hours to respond to emergencies or outages as they occur.

Customer service standards have been established by the NSW Government setting out the level of service that Ausgrid and other electricity businesses are expected to meet.

If we do not meet our customer service standards, you may be entitled to claim a payment from us. You may be entitled to this payment if you experience too many interruptions in one year or an interruption that lasts too long.

Any electricity account holder who is connected to Ausgrid's electricity distribution network in Sydney, the Central Coast and the Hunter Region, may apply for a payment under the customer service standards, regardless of their choice of energy retailer.

Further information regarding customer service standards is available from Ausgrid's website or by phoning Ausgrid on 1800 069 952.

6.0 PART B FOR SPECIALISTS

6.1 Steady state supply voltage

6.1.1 Range of supply voltage

Supply voltage is the voltage, from phase to neutral or phase to phase, for electricity that is supplied at a connection point. Maintaining this steady state supply voltage is important to ensure appropriately designed equipment does not malfunction and is not damaged.

When Ausgrid identifies or is notified that the steady state supply voltage is outside the specified target range, Ausgrid will take reasonable steps to modify the network to ensure that the voltage will be maintained at the required level and achieve Ausgrid's steady state voltage supply objective.

6.1.1.1 *Low voltage supply*

Ausgrid's objective for the operation of its network is to maintain a target steady state phase to neutral supply voltage (measured as a ten-minute average in accordance with AS 61000.3.100 Limits – Steady State voltage limits in public electricity systems) within the range of 216V to 253V at connection points under normal operating conditions. This range is the nominal voltage range of 230V in Australian Standard AS 60038 Standard Voltages, with a tolerance of +10%/- 6% to allow for voltage regulation within the network.

It should be noted that due to system operational constraints and physical network limitations, it may not be possible to maintain the target steady state supply voltage range for all of the time at a given connection point.

Where the above target steady state supply voltage range cannot be maintained, particularly under abnormal network arrangements such as may occur during maintenance, Ausgrid's objective is to maintain a steady state voltage within the range 207V to 262V at all times. This range excludes situations arising from faults or voltage interruptions.

Following an Energy Networks Association review in 2011, Ausgrid commenced migration from a nominal voltage of 240V to 230V. Over time, the normal average Ausgrid network voltage will be reduced from around 250V to around 240V.

6.1.1.2 *Medium/high voltage supply*

Ausgrid's medium/high voltage distribution network operates at several voltage ranges (Typically 11kV, 22kV, 33kV, 66kV and 132kV). Accordingly, high voltage customers must obtain, from Ausgrid, the network operating objective for supply voltage applicable to their location, particularly before proceeding with any project expenditure or commitments.

6.2 Fluctuations and distortions in supply characteristics

The types of fluctuations, disturbances and distortions in the characteristics of electricity supplied from an electricity network can be divided into three areas (each of which is discussed):

- (a) **Frequency departures** – where the frequency falls outside the normal range.
- (b) **Voltage disturbances** – where voltage shape is maintained but the voltage magnitude falls outside the normal range,
- (c) **Distortion disturbances** – where the voltage shape is non-uniform or distorted (non sinusoidal).

Ausgrid's objective with regard to fluctuations, disturbances and distortions is to manage the network planning, maintenance and construction process so as to comply with:

- The latest editions of the National Electricity Rules (NER) and the NSW Service and Installation Rules
- Relevant Standards Australia documents
- Relevant Energy Networks Association guidelines.

The handbooks and guidelines, will be utilised where applicable and any other occurrences outside this will be treated on a case by case basis by Ausgrid.

6.2.1 Frequency departures

Ausgrid does not control the frequency on the electricity supplied through its electricity network, as this standard is set during the electricity generation process. The Australian Energy Market Operator (AEMO) establishes standards and regulates the frequency of supply on the national grid. If Ausgrid becomes aware of frequency excursions in excess of AEMO's standards, Ausgrid will endeavour to bring these to AEMO's attention.

6.2.2 Voltage disturbances

A voltage disturbance is where the voltage shape is maintained but the voltage magnitude is outside the steady state supply voltage range described in Section 5.1. Voltage disturbances can be categorised as

- Short duration variations - includes short duration interruptions, sags (dips) and swells of up to one minute;
- Long duration variations - includes sustained interruptions (covered in Section 5), under-voltage and over-voltages of duration greater than one minute;
- Voltage unbalance – where the magnitude or phase separation of the three phase voltages is not equal;
- Voltage differences between Neutral and Earth.

Voltage disturbances such as voltage unbalance, under and over-voltage are described in the ENA publication Customer Guide to Electricity Supply. The publication also includes aturbance customers can expect on Australian networks as well as action customers can take to minimise any impact of these disturbances.

6.2.2.1 Voltage sags (Dips)

A voltage sag (dip) is a short duration reduction in supply voltage to between 10% and 90% of the steady state supply voltage for less than one minute but generally lasting less than one second.

A momentary or short duration interruption is a drop in supply voltage to a level of less than or equal to 10% of steady state supply voltage for up to one minute in duration.

Refer to Figure 1 below.

Voltage sags and short duration interruptions are one of the main issues of concern to industry. This is because equipment and digital systems are often unable to withstand the reduction in supply voltage even though the reduction may be small or the duration of the disturbance typically less than a few seconds.

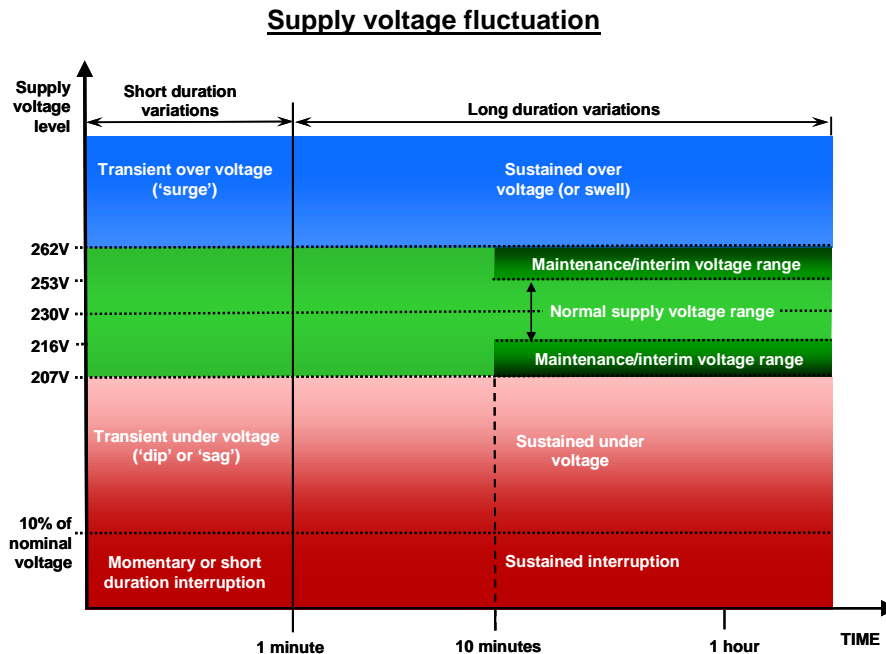


Figure 1 : Supply voltage fluctuations (not to scale)

The ENA publication ENA Customer Guide to Electricity Supply contains information on the typical voltage sags experienced on Australian electricity networks and how customers can mitigate the risks of equipment maloperation because of sags.

6.2.2.2 **Voltage unbalance**

Voltage unbalance is a condition in which the RMS values of the phase voltages and/or the phase angles between consecutive phases are not equal. It is measured as the ratio of negative to positive sequence voltage. Voltage unbalance arises from customers drawing unequal loads on each phase, from differing numbers of customers being connected to each phase, and from differences in the impedances of each phase on the network. High levels of voltage unbalance can damage three phase equipment.

Ausgrid’s objective is to limit voltage unbalance to less than the compatibility levels for low voltage networks in AS/NZS 61000.2.2, and the indicative planning levels for medium and high voltage networks in TR IEC 61000.3.13. For Ausgrid’s low voltage network, the compatibility level for negative sequence voltage is 3%. When notified that a customer’s equipment is adversely affected by voltage unbalance Ausgrid will take reasonable steps within its power to:

- (a) investigate and test for the unbalance;
- (b) require an affecting customer to rectify the situation;
- (c) correct, where practicable, unbalance of the voltage at the customer’s point of supply, where it is outside the limits set by the relevant Australian Standard.

Ausgrid expects its customers to install adequate protection on equipment that may be adversely affected by high levels of voltage unbalance, including over-temperature protection on three phase

motors as per AS/NZS 3000. Customers are responsible for minimising voltage unbalance caused by their installation, and ensuring their installation complies with relevant rules, particularly the Service and Installation Rules of NSW.

Please also refer to section 6.2.4 of this document for a description of the allocation process which is used to define unbalance emission limits for customers.

6.2.2.3 ***Voltage and current differences between neutral and earth***

Although neutral conductors are nominally near earth voltage, minor voltage differences will occur between neutral and earth. The voltage differences may be steady state, temporary or transient, or combinations of these components. Maintaining the voltage difference between neutral and earth within limits specified is important to minimise zero sequence voltage unbalance in multi phase systems and to assist in meeting steady state voltage requirements. Exceeding these limits may affect the operation of sensitive three phase equipment, generate waveform distortion and cause the network to operate irregularly, affecting network reliability.

A direct current component in the neutral conductor has the effect of offsetting the sinusoidal waveform and can be caused by equipment that has different operating characteristics in each half of the voltage cycle. Limiting the direct currents in the neutral to acceptable limits is important because such current can cause corrosion of the network and a customer's earthing system, possibly leading to unsafe operating conditions. Customers with equipment that causes DC current flow may need to install isolation transformers and should seek advice accordingly.

Ausgrid's objective for its network is to limit both alternating and direct voltage differences between neutral and earth to less than 10 Volts steady state (ten-minute average) at the connection point.

During electrical earth faults on the HV and LV networks, voltage levels at or near points where the current flows to earth may elevate. A voltage rise on the LV neutral conductor may be experienced as a 'touch' voltage at exposed bonded metalwork (e.g. taps connected to metallic water pipes). Maintaining earth fault voltages within appropriate limits is important to reduce the risk of electric shock and damage to electrical equipment. Particular care must be taken in relation to any electrical installation in the vicinity of swimming pools, including domestic pools, and other wet areas.

Ausgrid's objective for its network is to not exceed the applicable levels outlined in the Energy Networks Association of Australia (ENA) publication ENA EG-0 Power System Earthing Guide Part 1: Management Principles. To achieve this Ausgrid designs its earthing systems to comply with the general requirements of this publication as well as several other related Australian Standards including: AS3835 regarding Telco EPR coordination and AS4853 regarding hazards on metallic pipelines.

6.2.2.4 ***Flicker and voltage fluctuations***

Voltage fluctuations are small increases or decreases in the steady state supply voltage for a short period, caused by changes in load or by tap changes on network equipment. When these voltage fluctuations occur regularly, they are measured as "flicker". Flicker is a measure of the magnitude of the voltage variation and the frequency with which it occurs, and is related to how perceptible the fluctuations are in lighting. If flicker levels are too high, changes in the brightness of incandescent lighting can become noticeable, or irritating. High levels of flicker can be caused by an air conditioner pump cycling on and off quickly, for example.

Ausgrid's objective is to limit flicker to less than the compatibility levels for low voltage networks in AS/NZS 61000.2.2. For Ausgrid's low voltage network, the compatibility level for short term flicker is $P_{st} = 1$, and for long term flicker $P_{lit} = 0.8$. When notified that a customer's equipment is adversely affected by flicker, Ausgrid will take reasonable steps within its power to:

- (a) investigate and test for the distortion;
- (b) require an affecting customer to rectify the situation;

- (c) correct, where practicable, distortion of the voltage at the connection point, where it is outside the limits set by the relevant standards (AS/NZS 61000.2.2 for Low Voltage; AS/NZS 61000.2.12 and AS/NZS 61000.3.7 for MV/HV installations).

Customers are responsible for minimising flicker caused by their installation, and ensuring their installation complies with relevant rules, particularly the Service and Installation Rules of NSW.

Refer to the ENA publication and Section 5 of this document for protective measures that may assist customers in minimising any impact of these disturbances.

Please also refer to section 6.2.4 of this document for a description of the allocation process which is used to define flicker emission limits for customers.

6.2.3 Distortion disturbances

Under normal conditions, the voltage delivered by the network has a sinusoidal shape. Distortion disturbances are where the voltage shape is non-uniform or non-sinusoidal. They can be broken into the following categories:

- Transients – very short term events (with a duration of less than 1/10 second);
- Waveform distortion (including harmonics and interharmonics);

6.2.3.1 *Transients*

Voltage transients are usually large but very short term changes (lasting less than about 1/10 second) to the voltage shape and can be caused by events such as lightning, switching operations on the network or switching within customers' equipment. Care should be taken by customers when switching highly reactive loads within an installation as these are a major contributor to voltage transients. Transients can damage electronic components, if they are not adequately protected. Additional information on switching transients and lightning can be obtained from the ENA publication.

Ausgrid's objective is to limit network switching transients to less than two times the normal supply voltage. When notified that a customer's equipment is adversely affected by voltage transients Ausgrid will take reasonable steps within its power to:

- (a) investigate and test for the distortion;
- (b) require an affecting customer to rectify the situation;
- (c) correct, where practicable, distortion of the voltage at the customer's connection point, where it is outside the limits set by the AS/NZS 61000.3 series of standards.

Refer to the ENA publication and Section 5 of this document for protective measures that may assist customers in minimising any impact of these disturbances.

6.2.3.2 *Waveform distortion (including harmonic distortion)*

Voltage waveform distortion including harmonic distortion results from the operation of appliances or equipment that draw non-sinusoidal currents from the network. Harmonic distortion can cause the supply voltage to depart from a sine wave in a repetitive manner. Maintaining waveform distortion within acceptable limits is important because it can otherwise cause interference and damage to sensitive customer and network equipment. This form of distortion can also cause light flicker, incorrect operation of ripple control devices (used for off peak electric hot water) and computers, audible noise in television, radio and audio equipment and vibration in induction motors. Customers with sensitive equipment may need to install devices to protect it, e.g. a line filter or an appropriately designed uninterruptible power supply.

Note: Signals injected into the network by distributors to control off peak loads are designed as higher level harmonics and should not normally cause interference.

When notified that a customer's equipment is adversely affected by voltage waveform distortion, Ausgrid's objective is to take reasonable steps within its power to:

- (a) investigate and test for the distortion;

- (b) use reasonable and practical efforts to minimise interference to radio and television reception emanating from components of Ausgrid’s network and abide by rulings of the Australian Communications Authority to correct problems associated with the generation of electromagnetic noise;
- (c) require an affecting customer to rectify the situation;
- (d) to correct, where practicable, distortion of the voltage at the customer’s connection point, where it is outside the compatibility limits set by AS/NZS 61000.2.2.

Additional information on harmonics and noise can be obtained from the ENA publications including action customers can take to minimise any impact of these disturbances.

Table 2- Compatibility levels for individual harmonic voltages in low voltage networks (reproduced from AS/NZS61000.2.2).

Odd harmonics, non-multiple of 3		Odd harmonics, multiple of 3		Even harmonics	
Harmonic order (h)	Harmonic voltage (%)	Harmonic order (h)	Harmonic voltage (%)	Harmonic order (h)	Harmonic voltage (%)
5	6	3	5	2	2
7	5	9	1.5	4	1
11	3.2	15	0.4	6	0.5
13	3	21	0.3	8	0.5
$17 \leq h \leq 49$	$2.27 \times (17/h) - 0.27$	$21 < h \leq 45$	0.2	$10 \leq h \leq 50$	$0.25 \times (10/h) + 0.25$
Corresponding compatibility level for the total harmonic distortion is THD = 8%					

Please refer to section 6.2.4 for a description of the allocation process which is used to define harmonic emission limits for customers.

6.2.3.3 Mains signalling (ripple control signals)

Ausgrid uses low level signal voltages (“ripple control signals”) injected into the Distribution Network at various frequencies primarily for the control of off peak appliances.

Ripple control signals can interact with the network’s impedance and cause a resonance condition, which can result in higher than normal ripple control signals at various points throughout the network. This condition is difficult to predict or resolve, so some customers may experience ripple control signals that are higher than the limits outlined in this document, and it may not be practical for Ausgrid to reduce the ripple signal magnitude. Furthermore, not all equipment is designed to meet the requirements of the Meister curve, so some equipment may malfunction despite normal magnitudes of ripple control signals being present on the network. In these cases, customers may install line filters to reduce the effects of the signal on their equipment.

When notified that a customer’s equipment is adversely affected by ripple control signals, Ausgrid’s objective is to take reasonable steps within its power to:

- (a) investigate and test for the ripple control signal amplitudes;
- (b) maintain the mains signalling voltage below 20V, and where practical below the levels specified by the Meister curve in AS/NZS 61000.2.2 (see Figure 2);
- (c) require an effecting customer to rectify the situation;

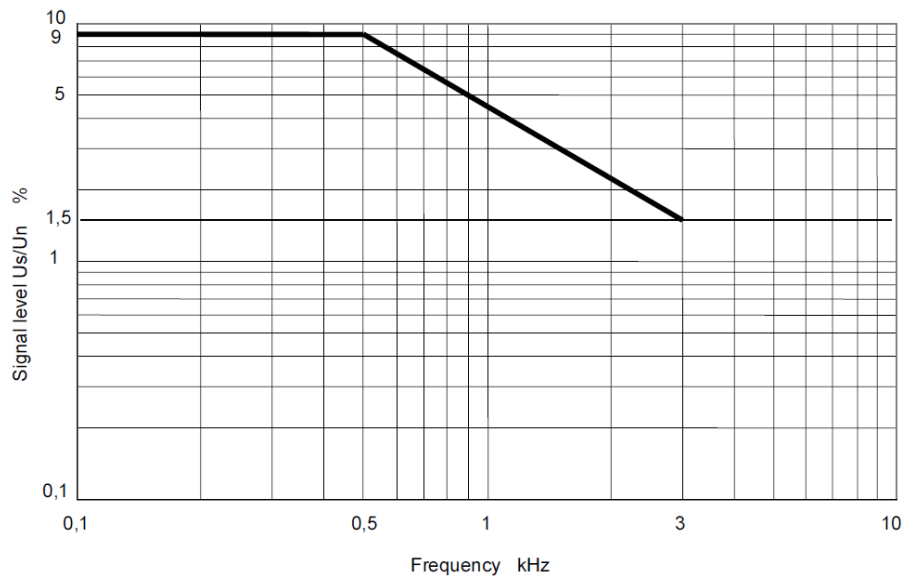
Meister curve ripple control systems

Figure 2: Meister curve for ripple control systems in public networks (reproduced from AS/NZS61000.2.2)

6.2.4 Allocation of power quality emissions to customers by Ausgrid

This document describes the types of disturbances that can occur on the network, and indicates where customers have a responsibility to manage their emissions onto Ausgrid's network. There will be occasions when Ausgrid will specify a set of site specific limits for specific limits for particular parameters. Most commonly this will apply to

- Harmonic Distortions
- Flicker
- Unbalance

Ausgrid aims to equitably allocate the pool of allowable emissions available for a particular network, to the customers connected to that portion of the network. Because of this, the document that outlines the emission limits for a customer is referred to as a "Power Quality Allocation"

6.2.4.1 Low voltage connections

Although Ausgrid can apply individual emission limits to any connection limits, it is not usually required for any connection which has a service fuse of less than 200A. For connections of 200A service fuse or greater, Ausgrid has a particular interest in (though not limited to) installations where

- Any individual piece of equipment is rated at greater than 75A
- It takes a fluctuating load (e.g. Lifts, welders, pumps, cranes, x-ray, MRI or similar type medical equipment)
- There are large variable speed drives
- There are large concentrations of computers or other electronic equipment

Low voltage allocations are given using the process defined in SA/SNZ TR IEC 61000.3.14. If a customer has a dedicated substation, they may be given a high voltage connection allocation

For any connection that does not have explicit emission limits, all equipment installed in an installation is to comply with the relevant equipment standards for:

- Harmonics (AS/NZS 61000.3.2 or AS/NZS 61000.3.12) and
- Flicker (AS/NZS 61000.3.3 or AS/NZS 61000.3.11)

The installation is also required to not have an adverse impact on the Ausgrid network, and other customers connected to that network.

6.2.4.2 **Low voltage connections with embedded generation**

The same requirements apply as for other LV connections, with the additional requirement that all inverters must be compliant with AS 4777.

6.2.4.3 **Medium voltage (MV) and high voltage (HV) connections**

For the purpose of this section, an MV or HV connection is one that takes a voltage level of 1000V or greater. Ausgrid reviews all such connections and issues a set of power quality emission limits where appropriate.

The limits for a particular connection are generated using the process defined in the following:

- AS/NZS 61000.3.6
- AS/NZS 61000.3.7
- TR IEC 61000.3.13
- HB 264 and relevant ENA guidelines
- National Electricity Rules

Even if an MV/HV connection does not have explicit limits set, the installation is still required to not have an adverse impact on the Ausgrid network, and other customers connected to that network.

7.0 RECORDKEEPING

The table below identifies the types of records relating to the process, their storage location and retention period.

Table 3 – Recordkeeping

Type of Record	Storage Location	Retention Period*
Approved copy of the network standard	BMS Network sub process Standard – Company	Unlimited
Draft Copies of the network standard during amendment/creation	TRIM Work Folder for Network Standards (Trim ref. 2014/21250/82)	Unlimited
Working documents (emails, memos, impact assessment reports, etc.)	TRIM Work Folder for Network Standards (Trim ref. 2014/21250/82)	Unlimited

* The following retention periods are subject to change eg if the records are required for legal matters or legislative changes. Before disposal, retention periods should be checked and authorised by the Records Manager.

8.0 AUTHORITIES AND RESPONSIBILITIES

For this network standard the authorities and responsibilities of Ausgrid employees and managers in relation to content, management and document control of this network standard can be obtained from the Company Procedure (Network) – Production/Review of Network Standards. The responsibilities of persons for the design or construction work detailed in this network standard are identified throughout this standard in the context of the requirements to which they apply

9.0 DOCUMENT CONTROL

Content Coordinator : Manager – Reliability Supply Quality and Ratings

Distribution Coordinator : Senior Engineer - Guidelines, Policies and Standards

Annexure A – Sample Compliance Checklist



Network Standard Checklist Form

NS238 Supply Quality

Project Identification:	
Prepared by: <Name & Position Title>	Date:

This checklist is for internal Ausgrid use only and does not apply to ASPs or contractors who have specific compliance requirements in relation to Contestable project works. The checklist is unique for each network standard and is available within BALIN and the BMS as a separate form that can be amended as required, completed and saved in TRIM with the other project documentation.

This section is used to identify compliance checks that when applied to the work associated with this Network Standard will satisfy an audit process to establish that the requirements of the standard have been followed. It is expected that applicable items would normally be checked as Comply (Yes) as non-compliance is generally not tolerated.

Where non-compliance is the result of specific site conditions or design decisions this needs to be identified in the notes section of the form for each non-compliance and approval sought from an appropriately authorised Ausgrid manager responsible for design approval per NS261 Compliance Framework for Network Standards.

Should additional information be available to document non-compliance decisions, these can be attached to the checklist form. The checklist and any attached explanatory notes should be saved in the project document repository.

Item	Description	Refer Clause	Completed/ Actioned
Scope			
	This document is intended for use only by customers who are connected to Ausgrid's electricity network		
	Does not include interference originating from the customers' installation or events associated with generation or the transmission grid		
For the General Reader			
1	Examples of protective measures for use to limit/moderate supply variability	5.1	Yes/No/NA
2	Customer installation complies with Service and Installation Rules of NSW	5.2	Yes/No/NA
3	Ausgrid has nominated overall limits of interference by a customer and advised a Power Quality Allocation	5.2	Yes/No/NA
4	Ausgrid supply service standards within limits set by the government	5.3.1	Yes/No/NA
5	Customers with life support requirements are subject to special service provisions	5.3.1	Yes/No/NA
For Specialists			
6	LV Supply voltage at connection points under normal conditions 216V-253V	6.1.1.1	Yes/No/NA
7	Medium and HV customers have a customer specific operating objective for supply voltage dependent on supply conditions on the network at the point of supply.	6.1.1.2	Yes/No/NA
8	Compliance with AEMO regulated frequency of supply	6.2.1	Yes/No/NA
9	Compliance with Australian and international standards for voltage disturbances	6.2.2	Yes/No/NA

10	Power Quality allocation shared equitably among customers at a particular network location	6.2.4	Yes/No/NA
11	Emission limits for LV customer emissions within limits recommended by Australian and international standards	6.2.4	Yes/No/NA
12	Emission limits for Med/HV customer emissions within limits recommended by Australian and international standards	6.2.4	Yes/No/NA

[Notes:

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The signatures panel of this document has been removed for privacy considerations. The remainder of the document is unchanged.

Attachment: 1. Name of document attached